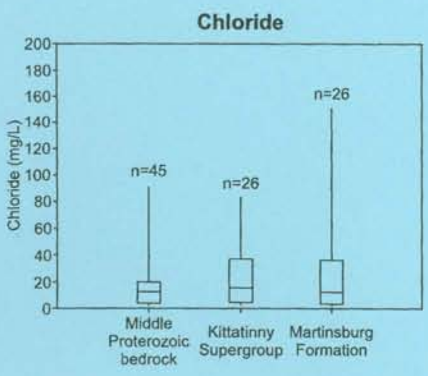
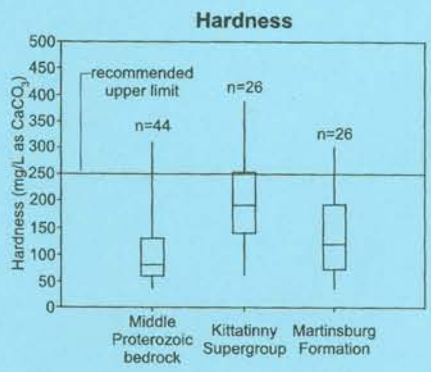
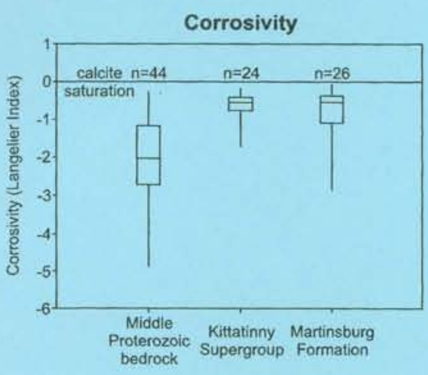
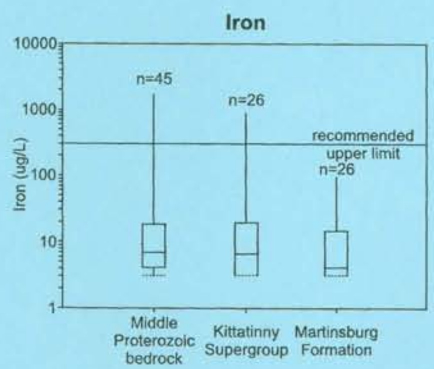
New Jersey Geological Survey
Geological Survey Report GSR 39

GROUND-WATER QUALITY IN THE BEDROCK AQUIFERS OF THE HIGHLANDS AND VALLEY AND RIDGE PHYSIOGRAPHIC PROVINCES OF NEW JERSEY









New Jersey Department of Environmental Protection

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

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Cover illustration: Box-and-pin diagrams showing characteristics and constituents of ground-water samples from the Martinsburg Formation, Kittatinny Supergroup and the Middle Proterozoic bedrock (figure 3).

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GROUND-WATER QUALITY IN THE BEDROCK AQUIFERS OF THE HIGHLANDS AND VALLEY AND RIDGE PHYSIOGRAPHIC PROVINCES OF NEW JERSEY

by

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GROUND–WATER QUALITY IN THE BEDROCK AQUIFERS OF THE HIGHLANDS AND VALLEY AND RIDGE PHYSIOGRAPHIC PROVINCES OF NEW JERSEY

ABSTRACT

Chemical analyses of samples collected from 105 wells in the major bedrock aquifers of the Highlands and Valley and Ridge Physiographic Provinces in New Jersey indicate that ground-water quality is very good for most purposes. Locally though, it may require treatment for undesirable characteristics and constituents. The most common quality problems are associated with the state recommended secondary drinking water standards. The percentage of samples exceeding the secondary drinking water standards in the (1) Middle Proterozoic metamorphosed crystalline rocks, (2) Cambro-Ordovician sedimentary rocks of the Kittatinny Supergroup and (3) Martinsburg Formations respectively are: hardness (13, 0, and 11.5 percent are less than 50 mg/L and 4.5, 30.8 and 11.5 percent are greater than 250 mg/L), iron (6.7, 3.8 and 0 percent are greater than 0.300 mg/L), manganese (16.3, 7.7 and 23.1 percent are greater than .05 mg/L), pH (30.2, 0 and 0 percent are less than pH 6.5 and 0.0, 7.7 and 15.4 are greater than pH 8.5), sodium (0, 0 and 15.4 percent are greater than 50 mg/L). Gross alpha particle activity exceeded the primary drinking water standard of 15 picocuries per liter in 4 of 21 or 19 percent of samples from the Middle Proterozoic crystalline aquifer.

INTRODUCTION

The purpose of this report is to summarize data on ground-water quality in the major aquifers of the Highlands and Valley and Ridge Physiographic Provinces in New Jersey (figure 1). This information will provide all interested parties with concentration ranges for many water-quality parameters. Uses for this data include establishing baselines for assessing potential groundwater pollution and assisting local governments, water companies, drillers, industry and private well owners in recognizing the potential for water-quality problems. Ground water is an extremely important resource for the State of New Jersey. It provides approximately 40 percent of the state's potable water (Hoffman and Mennel, 1997); of this, 78 percent is from public supplies and 22 percent from domestic wells. In addition, ground water provides base flow to streams and is important to the ecology of New Jersey's wetlands. The Highlands and Valley and Ridge Provinces include some of the least densely populated areas of the state. Ground water supplies the majority of residents in these areas with water (Hoffman and Mennel, 1997).

Natural ground-water quality is mainly a function of the composition and mineralogy of the aquifer matrix and the residence time of ground water in the aquifer. Other important factors include (1) the composition of the precipitation recharging the ground-water system, and (2) the conditions precipitation encounters at the land surface and in the unsaturated zone before entering the ground-water system. Anthropogenic impacts from nonpoint and point sources of pollution can also affect ground-water quality. The data here are presented in association with the geologic unit from which the water is drawn because geology has the greatest effect on natural ground-water quality.

Undesirable constituents in ground water are not always anthropogenic in origin and federal and state primary and secondary drinking water standards are often exceeded under natural conditions. Defining natural ground-water quality, however, can be difficult. Additional dissolved constituents in ground water can originate from widely distributed nonpoint sources such as sodium and chloride from road salting or nitrate from agricultural activities, lawn applications or septic systems. Limited additions of these constituents to ground water may be indistinguishable from natural background concentrations.

In some areas of the Highlands and Valley and Ridge Provinces, iron, hardness, pH, sulfate and total dissolved solids in excess of secondary drinking water standards have long been recognized as natural (Kasabach, 1966; Miller, 1974). More recently, a study

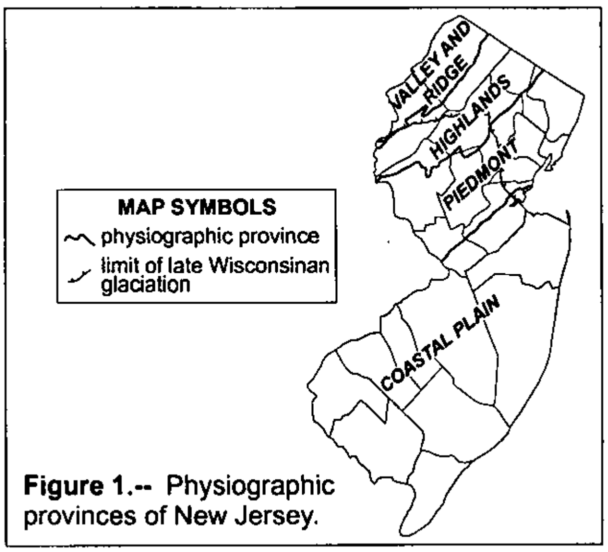

Figure 1.-- Physiographic provinces of New Jersey.

based on sampling 154 wells in the middle Proterozoic bedrock of the Highlands indicated that most radon levels in that ground water exceed the United States Environmental Protection Agency (USEPA) proposed primary drinking water standard of 300 pCi/L for radon-222 (Bell and others, 1992). The data in this report were obtained under a New Jersey Geological Survey (NJGS) and United States Geological Survey (USGS) cooperative project called the Ambient Ground Water Quality Network (AGWQN). The goal of the network during the collection of this data was to determine, as close as is possible, natural ground-water quality as a function of geology. Most of the ground-water samples were analyzed for volatile organic compounds (VOC's). Samples that contained such compounds were not used in this study because the quality obviously did not represent natural conditions. Additional ground-water quality data for the Kittatinny Supergroup were obtained from Nicholson and others (1996).

Acknowledgments

The Ambient Ground Water Quality Network (AGWQN) is a cooperative project between the New Jersey Department of Environmental Protection (NJDEP) and the USGS; it is supported by a grant from the USEPA and by the NJDEP. Appreciation is extended to all involved in the network, particularly the samplers Rich Fenton from the Bureau of Water Monitoring in the NJDEP and Mike Deluca from the United States Geological Survey. I thank Eric Vowinkle of the USGS and retired USGS and NJGS editor I.G. (Butch) Grossman for their thorough reviews of this report. Special thanks go to graduate intern Eugenia Bruno who compiled much of the data in this report.

HYDROGEOLOGY

The Highland and Valley and Ridge Provinces trend southwest to northeast and transect the northern part of New Jersey (figure 1). Both are characterized by southwest to northeast trending ridges that are separated by broad valleys. The terminal moraine of the Wisconsinan glaciation extends from west to east approximately midway through the Highlands Province. North of the moraine, much of the bedrock is scoured and covered with unconsolidated glacial sediments. South of the moraine, sediments of older glacial epochs and weathered bedrock cover the bedrock units.

Ground water in the Highlands and Valley and Ridge occurs under unconfined, semi-confined and confined conditions. Ground-water flow is generally from the upland areas down into the valleys where it discharges to surface water or flows down-valley as ground water. Local flow within valley systems dominate (New Jersey Department of Environmental Protection, 1985). Three other factors controlling flow include: (1) the orientation, density, degree of connectedness and openness of fractures and foliation planes in bedrock; (2) the permeability and distribution of overlying glacial sediments; and (3) pumpage of ground water from production wells.

The ridges in the New Jersey Highlands consist of more resistant Middle Proterozoic (1600 to 900 million years old) metamorphosed igneous and sedimentary rocks. These rocks are in fault and unconformable contact with lenses and elongate belts of generally less resistant Paleozoic (570 to 360 million years old) sedimentary rocks in the valleys (figure 2). The dominant Middle Proterozoic metamorphosed rocks are: quartz-oligoclase-gneiss, charnockitic gneiss, amphibolite, pyroxene gneiss, hornblende granite, and pyroxene syenite (Volkert, 1989). Lesser amounts of Middle Proterozoic marble also occur in the Highlands and can be a significant source of ground water. Three analyses of ground water from wells in marble are given in tables 7a and 7b (nos. 98-100). The crystalline rocks are a major source of water for domestic, industrial, and municipal consumers in the Highlands; 16.4 billion gallons were reportedly withdrawn from these aquifers in 1996 (Hoffman, 2000).

The Valley and Ridge province is comprised mostly of a thick sequence of Paleozoic sedimentary rocks ranging in age from 570 to 374 million years. Sedimentary rock types include dolomite, limestone, sandstone, shale (often metamorphosed to slate) and siltstone. Aerially, the dominant geologic units are the Kittatinny Supergroup and the Martinsburg Formation as shown in figure 2.

The Kittatinny Supergroup and to a lesser extent the Martinsburg Formation are major sources of water for domestic, industrial, and municipal consumers in the Valley and Ridge; 17.6 billion gallons were reportedly withdrawn from these aquifers in 1996 (Hoffman, 2000).

The Paleozoic rocks are folded and faulted with the most intense deformation occurring to the southeast. Glacial stratified drift deposits occur throughout the area but are generally only productive aquifers north of the Wisconsinan Terminal Moraine (figure 2).

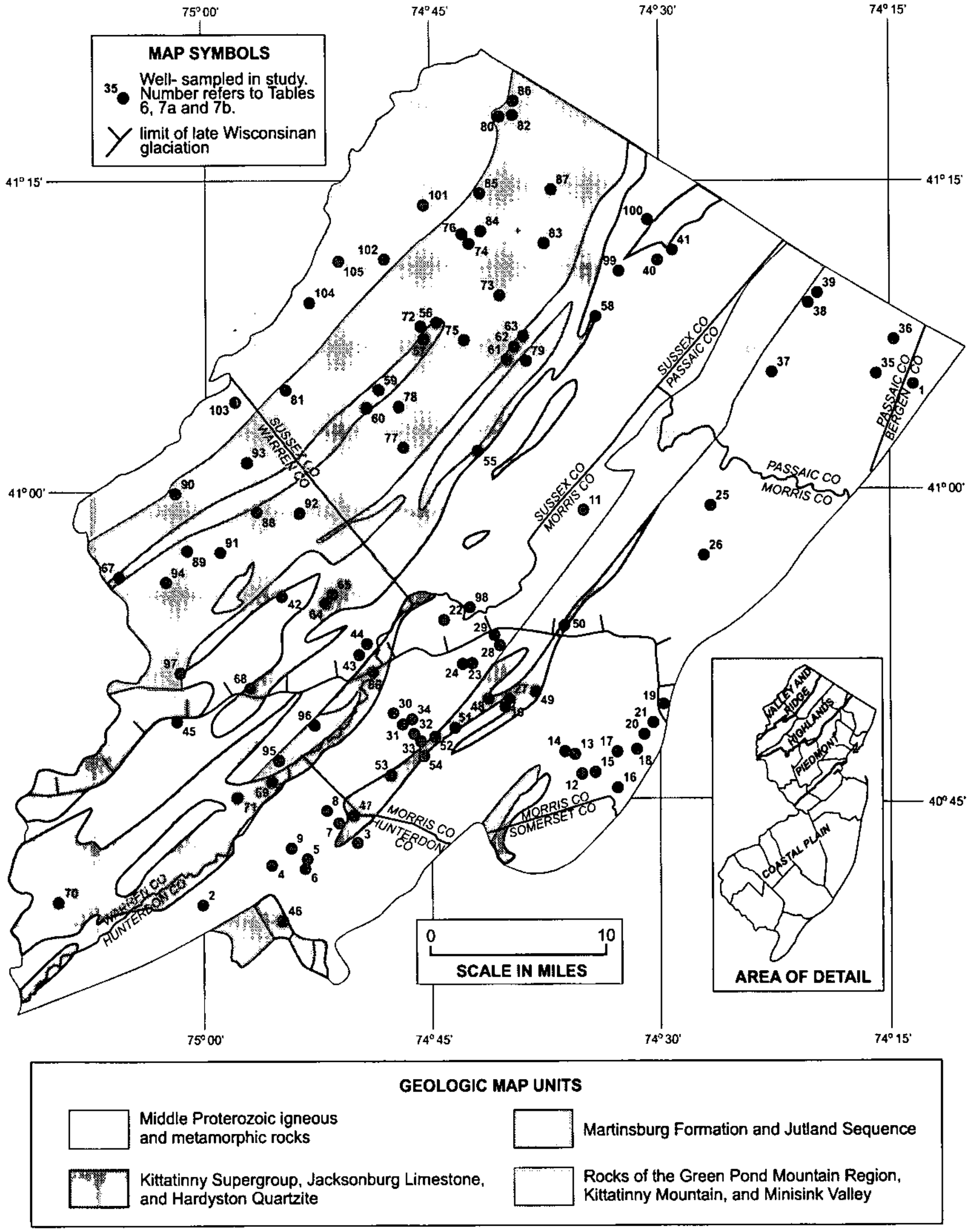

Figure 2.-- Generalized geologic map of the Highlands and Valley and Ridge Provinces showing the location of wells sampled in this study.

Ground-water flow is through fractures in all rock types, solution channels in limestones and dolomites, and pores in the unconsolidated stratified drift and unstratified drift. Most ground-water storage in these bedrock aquifers is restricted to the first 300 feet below the land surface (Kasabach, 1966; Miller, 1974). The structural controls on local and regional ground-water flow in these rocks are complex and discussed in some detail in Herman (1989).

Moderate to large supplies of water are obtained from stratified drift, cavernous limestones and dolomites, and in shear zones near faults, with lesser yields from crystalline rocks, non-cavernous limestones and dolomites, and shales (Miller, 1974).

GROUND-WATER CHEMISTRY

Evolution of ground-water chemistry

Ground water is mainly recharged by precipitation in New Jersey. Ground-water quality is a reflection of: (1) the starting composition of precipitation (2) the solubility and composition of the materials the precipitation contacts on the land surface, in both unsaturated and saturated zones, and (3) the duration of that contact.

Precipitation is normally a dilute, acidic, oxidizing solution. The chemistry of precipitation is controlled by natural and anthropogenic dissolved atmospheric gases and airborne particulates. Specific conductance is a direct indicator of the amount of dissolved ionic material in water. Although specific conductances in precipitation greater than 100 microsiemens per centimeter (uS/cm) have been reported in urban areas, values less than 50 uS/cm are more normal (Hem, 1985). Ambient atmospheric carbon dioxide concentrations produce an acidic pH of about 5.7 in rainwater. Acidic components from anthropogenic processes have lowered this value in New Jersey and elsewhere.

For illustration purposes, the chemical analyses of precipitation collected weekly during 1996 at Washington Crossing State Park in Mercer County, New Jersey is summarized in table 1 below (National Atmospheric Deposition Program, 1997). Although this precipitation-sampling station is not in the study area, it should be somewhat representative of precipitation falling there.

As water from precipitation percolates from the land surface through the unsaturated zone and flows through the ground-water system, it generally becomes less oxidizing and more alkaline and mineralized due to chemical interactions with the materials it contacts. For example, in the soil zone dissolved oxygen (O_2) reacts with organic material producing carbon dioxide (CO_2). The carbon dioxide reacts with water (H_2O) producing carbonic acid (H_2CO_3). A hydrogen ion (H^+) in carbonic acid reacts with mineral material producing bicarbonate (HCO_3^-) and releasing various mineral derived ions into the soil water. Therefore, the concentration of dissolved oxygen decreases and the alkalinity and concentration of total dissolved solids increase in the water.

To illustrate these generalizations, the median values of dissolved oxygen, alkalinity, and specific conductance for ground waters in the Proterozoic cyrstalline metamorphic bedrock (PCMB), Kittatinny Supergroup (KTTN) and Martinsburg Formations (MRBG) units from tables 2, 3 and 4 are compared with the median precipitation values in table 1. Information about the wells used in this report are in table 6. Tables 7

Table 1.-- Chemical analysis of precipitation collected weekly at Washington Crossing State Park in 1996.

Percentiles (n = 47; n = 46 for pH)	pH (lab standard)	Conductivity (µS / cm)[1]	Major Ions (milligrams per liter)							
			Ca	Mg	K	Na	NH_4	NO_3	Cl	SO_4
minimum	3.51	4.7	.01	.006	.003	.030	.02	.03	.06	.36
25th	4.21	16.2	.04	.013	.006	.088	.11	.89	.15	.99
median	4.40	24.7	.08	.031	.015	.159	.19	1.67	.31	1.65
75th	4.59	35.3	.16	.070	.030	.287	.35	2.53	.59	2.83
maximum	5.86	169.2	.41	.272	.273	2.21	1.60	9.36	4.00	15.34

[1] microsiemens per centimeter

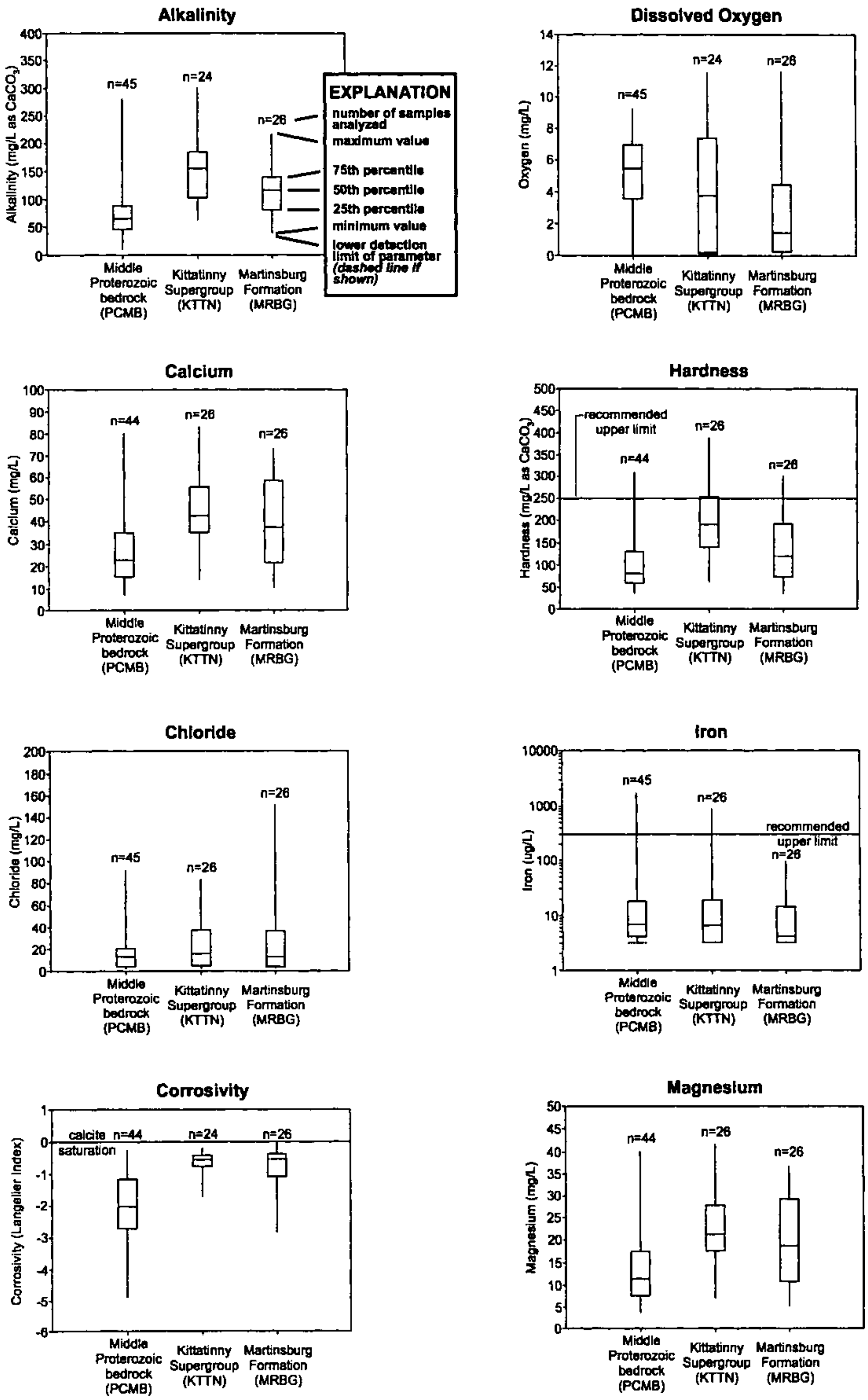

Figure 3.-- Box-and-pin diagrams showing characteristics and constituents of ground-water samples from the Martinsburg Formation, Kittatinny Supergroup and the Middle Proterozoic bedrock.

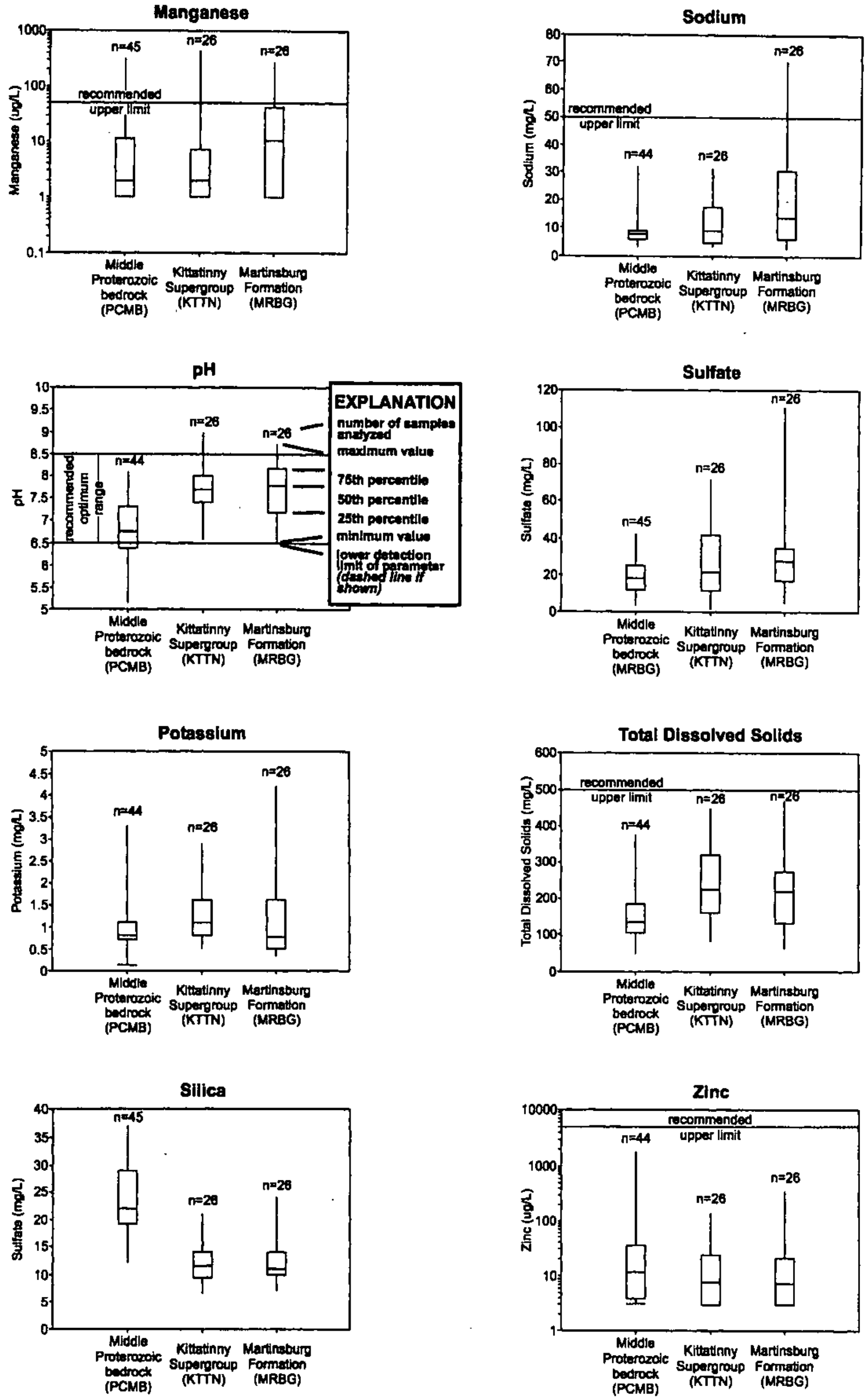

Figure 3. (cont.)– Box-and-pin diagrams showing characteristics and constituents of ground-water samples from the Martinsburg Formation, Kittatinny Supergroup and the Middle Proterozoic bedrock.

and 7b contain all the chemical analytical data that were used.

The greater the concentration of dissolved oxygen in water the more oxidizing the solution. Rain water is in direct contact with the atmosphere and the dissolved oxygen concentration will vary from approximately 14 milligrams per liter at 0°C to 8.5 milligrams per liter at 25°C (American Water Works Association, 1975).

In ground water the concentration of dissolved oxygen at median temperatures between 11 and 12 degrees Celsius is 5.5, 3.8 and 1.5 milligrams per liter in PCMB, KTTN and MRBG units respectively.

The median pH for precipitation is 4.40 which is equivalent to zero alkalinity, while in ground water the median values for alkalinity are 64, 153 and 112.5 milligrams per liter for PCMB, KTTN and MRBG respectively. The specific conductance increases from a median value of 24.7 microsiemens per centimeter in precipitation to 214, 408 and 376.5 microsiemens per centimeter in ground water in PCMB, KTTN and MRBG respectively.

Pollution Sources

Sources of ground-water pollution can be separated into two general types: (1) point-source pollution, and (2) nonpoint-source pollution. Point-source pollution is from a single identifiable source, such as a chemical spill, leaking underground storage tank or an infiltration lagoon. In the AGWQN, efforts were made to select wells that are not impacted by pollutants from known point sources. Also, a volatile organic contaminant scan was performed on most of the samples. Those that contained these pollutants were not used in this report.

Nonpoint-source pollution is from diffuse sources that do not have a single identifiable point of origin. This type of pollution can adversely impact the quality of water in the hydrologic cycle over large areas. For example, the release of emissions to the atmosphere from the burning of fossil fuels can alter the quality of precipitation. Once the precipitation contacts the land surface it can be further altered by pollutants associated with agricultural, urban and suburban land uses.

Because nonpoint-source pollution is so widespread it is difficult to avoid in vulnerable aquifers, generally those that are unconfined. Two common indicators of nonpoint-source pollution in ground water are: (1) nitrogen compounds which are derived from agricultural and lawn fertilization, septic tank discharge and animal wastes and, (2) chlorides from road salting and septic tank discharges. Some of the well-water samples used in this study contain elevated concentrations of nitrogen compounds and chloride. Therefore, they were probably impacted by nonpoint sources of pollution.

Geologic Variation

Chemical parameter concentration ranges suitable for presentation in box and pin diagrams are shown in figure 3 for the three major stratigraphic units. The variations in concentration ranges between these units are mainly attributable to the different minerals the water contacts. The most obvious differences are discussed below:

The major differences between the ground-water chemistry in the Proterozoic crystalline metamorphic bedrock (PCMB) and the other two units are: 1) A higher dissolved oxygen concentration, 2) lower pH, 3) lower alkalinity, 4) lower total dissolved solids content, 5) lower major ion concentration, and 6) higher silica concentration. The ground-water chemistry is more similar to precipitation than the other two units. The first five differences above indicate relatively limited water-rock chemical interactions. The dissolved oxygen concentration is higher because unlike the other two units there is a lack of organic matter in the aquifer matrix for oxygen to react with. Minerals making up the PCMB rock types mainly include aluminosilicates, such as feldspars, micas, amphiboles and pyroxene, and, quartz. Reactions between their minerals and water influence the type and concentration of ions in water. Aluminosilicate minerals react with hydrogen ions and water producing clay mineral products. During this hydrolysis process silica and cations, such as Na, K, Mg and Ca, are released into solution. In the PCMB, silica released during the dissolution of aluminosilicates and quartz makes up a high proportion of the soluble products.

The Kittatinny Supergroup (KTTN) mainly consists of the mineral dolomite, $CaMg(CO_3)_2$. Chemical differences between this supergroup and the other two units include (1) a higher alkalinity, and (2) higher concentrations of calcium and magnesium. Dolomite is a relatively soluble mineral in the near surface environment. When it dissociates, Ca, Mg and carbonate (CO_3^{-2}) ions are released into the water. Within the pH range of most ground water, the carbonate will react with a hydrogen ion forming the bicarbonate ion (HCO_3^{-1}). The bicarbonate and carbonate ions produce most of the alkalinity in water.

Table 2.-- Statistical summary of analyses of ground-water from the Middle Proterozoic (noncarbonate) bedrock in New Jersey.

1Characteristic or Constituent	Number of Samples	Percentiles: minimum	25th	median	75th	maximum	Maximum Contaminant Level (MCL)	Percent exceeded MCL
Characteristics								
Temperature (°C)	45	10	10.5	11	12	18	--	--
Specific Conductance (µs/cm)	44	74	168	214	294	599	--	--
Oxygen, dissolved (mg/L)	45	0.05	3.6	5.5	7	9.3	--	--
pH (standard units)	44	5.1	6.4	6.75	7.3	8.1	6.5 to 8.5	30.2<(6.5), 0>(8.5)
Field Alkalinity (mg/L as $CaCo_3$)	45	10	44.5	64	87	281	--	--
Solids, dissolved (mg/L)	44	47	105	135	165	377	500 (s)	0
[1] Corrosivity (pH units)	44	-4.98	-2.73	-2.04	-1.18	-0.29	1 to 1	84<(-1), 0>(1)
Hardness (mg/L as $CaCO_3$)	44	34	60	80	130	310	250 (s)	4.5>(250)
Major and Minor Dissolved Constituents (mg/L)								
Calcium	44	8.4	15	22.5	34.5	80	--	--
Magnesium	44	1.1	5.3	6.8	10	36	--	--
Sodium	44	2.8	5.6	7.5	8.7	32	50 (s)	0
Potassium	44	<.1	0.7	0.8	1.1	3.3	--	--
Chloride	45	1.1	4.2	13	20	91	250 (s)	0
Sulfate	45	3.2	12	18	25	42	250 (s)	0
Fluoride	45	<.1	<.1	0.1	0.3	2.3	4 (p)	0
Silica	45	12	19	22	29	37	--	--
Nutrients, Dissolved (mg/L)								
Nitrogen, NH_3 (as N)	45	<.01	<.01	<.01	0.01	0.03	--	--
Nitrogen, NO_2 (as N)	45	<.01	<.01	<.01	<.01	1	1 (p)	0
Nitrogen, NH_3 + Organic (as N)	45	<.2	<.2	0.06	0.4	1.2	--	--
Nitrogen, NO_2 + NO_3 (as N)	45	<.1	0.19	0.76	1.3	5.7	10 (p)	0
Nitrate, (NO_2 + NO_3) - (NO_2)	45	<.1	0.19	0.76	1.3	4.7	10 (p)	0
Phosporous Ortho (as P)	44	<.01	<.01	0.01	0.02	0.08	--	--
Phosporous (as P)	41	<.01	<.01	0.02	0.03	0.09	--	--
Trace and Minor Dissolved Constituents (µg/L)								
Aluminum	45	<10	<10	<10	<10	50	200 (s)	0
Arsenic	45	<1	<1	<1	<1	<1	50 (p)	0
Cadmium	45	<1	<1	<1	<1	2	5 (p)	0
Chromium	45	<1	<1	<1	<1	2	100 (p)	0
[2] Copper	45	<1	1	2	4	76	1300 (p)	0
Iron	45	<3	4	7	18.2	1700	300 (s)	6.7
[2] Lead	45	<1	<1	<5	1	8	15 (p)	0
Manganese	45	<1	<1	2	11.25	320	50 (s)	16.3
Mercury	44	<.1	<.1	<.1	<.1	0.3	2 (p)	0
Zinc	44	<.3	4	12	35.5	1800	5000 (s)	0
Organic Constituents								
Carbon, organic (mg/L as C)	45	.1	.3	.4	.5	.5	--	--
Phenols, total (mg/L)	39	<1	<1	<1	2	12	--	--
Radioactivity (pci/L)								
Gross Alpha	21	<.4	0.95	1.3	2.8	85	15 (p)	19

(p) - primary drinking water standard
(s) - secondary drinking water standard
µs/cm - microsiemens per centimeter
mg/L - milligrams per liter
µg/L - micrograms per liter
[1] No longer has a New Jersey Drinking Water Standard. pH unit below or above $CaCO_3$, saturation defined as zero using the Langelier Index (American Water Works Association, 1975)
[2] Drinking Water Standards for these constituents are action levels.

Table 3.-- Statistical summary of analyses of ground-water from the Kittatinny Supergroup in New Jersey.

Characteristic or Constituent	Number of Samples	Percentiles					Maximum Contaminant Level (MCL)	Percent exceeded MCL
		minimum	25th	median	75th	maximum		
Characteristics								
Temperature (°C)	26	10	11	11.25	11.5	13.5	--	--
Specific Conductance (µs/cm)	26	144	273	408	575	878	--	--
Oxygen, dissolved (mg/L)	24	<.1	0.25	3.8	7.45	11.6	--	--
pH (standard units)	26	6.6	7.4	7.7	8	9	6.5 to 8.5	0<6.5, 7.7>8.5
Field Alkalinity (mg/L as $CaCo_3$)	24	61	100.5	153	183	299	--	--
Solids, dissolved (mg/L)	26	81	160	225	320	448	500 (s)	0
[1] Corrosivity (pH units)	24	-1.77	-0.78	-0.57	-0.44	-0.21	1 to 1	12.5<(-1), 0.0>(1)
Hardness (mg/L as $CaCO_3$)	26	61	140	190	254	390	250 (s)	30.76>250
Major and Minor Dissolved Constituents (mg/L)								
Calcium	26	13	35	42	55	83	--	--
Magnesium	26	5.5	12	21.5	28	46	--	--
Sodium	26	2.9	4.2	8.55	17	31	50 (s)	0
Potassium	26	0.5	0.8	1.1	1.6	2.9	--	--
Chloride	26	2.5	4.4	15.5	37	83	250 (s)	0
Sulfate	26	1.6	11	20.5	41	71	250 (s)	0
Fluoride	26	<.1	<.1	0.1	0.1	0.5	4 (p)	0
Silica	26	6.5	9.4	11.5	14	21	--	--
Nutrients, Dissolved (mg/L)								
Nitrogen, NH_3 (as N)	26	<.01	<.01	<.01	0.01	0.22	--	--
Nitrogen, NO_2 (as N)	26	<.01	<.01	<.01	<.01	0.02	1 (p)	0
Nitrogen, NH_3 + Organic (as N)	26	<.2	<.2	<.2	<.2	0.6	--	--
Nitrogen, NO_2 + NO_3 (as N)	26	<.05	0.072	0.395	2.4	5.6	--	--
Nitrate, (NO_2 + NO_3) - (NO_2)	26	<.05	0.067	0.39	2.4	5.6	10 (p)	0
Phosporous Ortho (as P)	26	<.01	<.01	<.01	<.01	0.04	--	--
Trace and Minor Dissolved Constituents (µg/L)								
Aluminum	21	<10	<10	<10	<10	20	200 (s)	0
Arsenic	25	<1	<1	<1	<1	<1	50 (p)	0
Barium	16	5	10.25	17	29.5	69	2000 (p)	0
Cadmium	26	<1	<1	<1	<1	1	5 (p)	0
Chromium	26	<5	<5	<5	<5	<5	100 (p)	0
[2] Copper	26	<1	<1	<10	2	14	1300 (p)	0
Iron	26	<3	<3	6.5	19	870	300 (s)	3.84
[2] Lead	26	<1	<1	<1	<1	2	15 (p)	0
Manganese	26	<1	<1	2	7	430	50 (s)	7.69
Mercury	18	<.1	<.1	<.1	<.1	1	2 (p)	0
Selenium	26	<1	<1	<1	<1	<1	50 (p)	0
Silver	16	<1	<1	<1	<1	2	10 (s)	0
Zinc	26	<3	<3	8	25	140	5000 (s)	0
Organic Constituents								
Carbon, organic (mg/L as C)	26	<.1	0.2	0.3	0.4	1.8	--	--
Radioactivity (pci/L)								
Gross Alpha	18	<.6	0.8	1.1	2.2	3.1	15 (p)	0

(p) - primary drinking water standard
(s) - secondary drinking water standard
µs/cm - microsiemens per centimeter
mg/L - milligrams per liter
µg/L - micrograms per liter
[1] No longer has a New Jersey Drinking Water Standard. pH unit below or above $CaCO_3$, saturation defined as zero using the Langelier Index (American Water Works Association, 1975)
[2] Drinking Water Standards for these constituents are action levels.

Table 4.-- Statistical summary of analyses of ground-water from the Martinsburg Formation in New Jersey.

Characteristic or Constituent	Number of Samples	Percentiles: minimum	25th	median	75th	maximum	Maximum Contaminant Level (MCL)	Percent exceeded MCL
Characteristics								
Temperature (°C)	26	10	11	12	12.5	21	--	--
Specific Conductance (µs/cm)	26	86	237	376.5	480	864	--	--
Oxygen, dissolved (mg/L)	26	<.1	0.3	1.5	4.5	8.3	--	--
pH (standard units)	26	6.5	7.2	7.75	8.2	8.7	6.5 to 8.5	0<6.5, 15.38>8.5
Field Alkalinity (mg/L as $CaCo_3$)	26	34	78	112.5	136	214	--	--
Solids, dissolved (mg/L)	26	62	132	219.5	272	470	500 (s)	0
[1] Corrosivity (pH units)	26	-2.91	-1.12	-0.575	-0.4	-0.1	1 to 1	.9<(-1), 0.0>(1)
Hardness (mg/L as $CaCO_3$)	26	35	72.8	119.15	190	302.63	250 (s)	11.4>(250)
Major and Minor Dissolved Constituents (mg/L)								
Calcium	26	9.7	21	37	58	73	--	--
Magnesium	26	2.5	5.2	6.75	15	29	--	--
Sodium	26	1.9	5.5	13	30	70	50 (s)	15.38
Potassium	26	0.3	0.5	0.75	1.6	4.2	--	--
Chloride	26	1.1	3.4	12.25	36	150	250 (s)	0
Sulfate	26	3.3	16	27	34	110	250 (s)	0
Fluoride	26	<.1	<.1	<.1	0.2	1.6	4 (p)	0
Silica	26	7	10	11	14	24	--	--
Nutrients, Dissolved (mg/L)								
Nitrogen, NH_3 (as N)	26	<.01	<.015	0.02	0.09	0.36	--	--
Nitrogen, NO_2 (as N)	26	<.01	<.01	<.01	<.01	0.03	1 (p)	0
Nitrogen, NH_3 + Organic (as N)	26	<.2	<.2	<.2	<.2	0.4	--	--
Nitrogen, NO_2 + NO_3 (as N)	26	<.05	<.05	0.165	1.5	5.3	--	--
Nitrate, (NO_2 + NO_3) - (NO_2)	26	<.05	<.05	0.16	1.5	5.3	10 (p)	0
Phosporous Ortho (as P)	26	<.01	<.01	<.01	.01	0.17	--	--
Trace and Minor Dissolved Constituents (µg/L)								
Aluminum	25	<1	<10	<10	<10	10	200 (s)	0
Arsenic	26	<1	<1	<1	<1	3	50 (p)	0
Barium	21	<2	6	25	63	400	2000 (p)	0
Cadmium	26	<1	<1	<1	<1	<1	5 (p)	0
Chromium	26	<1	<1	<1	<1	<1	100 (p)	0
[2] Copper	26	<1	<1	2	11	120	1300 (p)	0
Iron	26	<3	<10	4	14	92	300 (s)	0
[2] Lead	26	<1	<1	<1	<1	1	15 (p)	0
Manganese	26	<1	<1	10.5	41	260	50 (s)	23.08
Mercury	16	<.1	<.1	<.1	0.2	28	2 (p)	6.25
Selenium	21	<1	<1	<1	<1	3	50 (p)	0
Silver	26	<1	<1	<1	<1	<1	10 (s)	0
Zinc	26	<3	<10	7.5	21	350	5000 (s)	0
Organic Constituents								
Carbon, organic (mg/L as C)	26	<.1	0.2	0.3	0.5	0.6	--	--
Radioactivity (pci/L)								
Gross Alpha	25	<.6	<2	0.8	1.6	3.8	15 (p)	0

(p) - primary drinking water standard
(s) - secondary drinking water standard
µs/cm - microsiemens per centimeter
mg/L - milligrams per liter
µg/L - micrograms per liter
[1] No longer has a New Jersey Drinking Water Standard. pH unit below or above $CaCO_3$, saturation defined as zero using the Langelier Index (American Water Works Association, 1975)
[2] Drinking Water Standards for these constituents are action levels.

The Martinsburg Formation (MRBG) has a lower dissolved oxygen concentration and higher manganese concentration than the other units. Dissolved oxygen is consumed during reactions with organic material and reduced minerals such as pyrite (FeS) in the aquifer matrix. This formation is mainly slate, which is a low grade metamorphic equivalent of shale. Shale can have a relatively high organic matter content compared to other rocks. Therefore, dissolved oxygen will be consumed more readily than in other water-rock interactions, resulting in a lower concentration.

Pyrite is a common accessory mineral in shales and slates. During the dissolution of pyrite and other iron-bearing minerals, iron will be released into solution. Likewise, manganese may be released into solution when minerals containing it decompose. In a highly oxidizing environment both iron and manganese will form insoluble compounds. However, because of a slight difference in oxidation potential, there is a limited pH-oxidation range where iron will form an iron oxyhydroxide precipitate while the manganese remains dissolved (Hem, 1985). The iron complexes will adsorb to the aquifer matrix and yield proportionally higher concentrations of manganese than iron in ground water.

Piper diagrams (fig. 4) are used to classify ground water as a function of the percentages of total equivalents per liter of major and minor cations and anions. The water type is determined by the major ion percentages. Most of the ground water derived from bedrock in the Highlands and Valley and Ridge is of the calcium-magnesium bicarbonate type. However, two samples from the PCMB units are of the sodium-calcium-magnesium chloride type suggesting they may have been influenced by road salting. The KTTN samples have a significant proportion of magnesium and calcium. This would be expected since the major mineral making up this carbonate is dolomite, a calcium-magnesium carbonate. The MRBG has the most variable chemical water types. Other than calcium bicarbonate types there are two each of the calcium sulfate, calcium chloride, calcium-sodium-magnesium chloride, and sodium bicarbonate types. There is also one sodium sulfate type water. The chloride rich waters are probably related to anthropogenic impacts. However, the other unusual water chemistry is probably associated with natural processes.

GROUND-WATER QUALITY

Ground-water quality in bedrock formations of the Highland and Valley and Ridge is generally very good, but locally may require treatment for undesirable characteristics and constituents. As shown in tables 2-4, the state-recommended secondary drinking water standards are exceeded far more often than the health-based primary standards (N.J.A.C. 7:10-1.1 through 7.3). Information about the wells sampled for this study is shown in table 6. Chemical and analytical data are in tables 7a and 7b.

Secondary drinking water standards

Secondary drinking water standards are recommended standards that protect the public welfare from characteristics and constituents that affect the aesthetic quality of the water. Examples include its appearance, taste or odor. The reduction of undesirable characteristics and constituents in water are performed on public and private water supplies using various treatment systems. Federal and state drinking water standards, and water testing and treatment options are given in Shelton (1991). Compiled from table 1, the number and percent of water analyses exceeding the secondary maximum drinking water standards (also known as secondary contaminant levels or SMCL's) are shown on table 5.

Corrosivity

Although corrosivity is discussed here, a standard for it is no longer used in New Jersey. Rather, the action levels for lead and copper concentrations are used to directly assess the corrosion of plumbing materials. Corrosivity and scaling potential are measured using the Langelier Index: a calculation that uses pH, alkalinity, TDS calcium concentration and water temperature to determine a water's "pH unit." A pH unit of 0 indicates that the water is in equilibrium with calcium carbonate. If the pH unit is less than 0 calcium carbonate will dissolve, if greater than zero it will precipitate (American Water Works Association, 1975). Normally acceptable corrosivity ranges between slightly corrosive (-1 pH unit) to slightly encrusting (+1 pH unit). If the water is too corrosive (-1 pH unit) it can corrode plumbing systems releasing harmful metals such as lead and copper and decrease the life of the system. If the water is slightly scaling (0 to +1 pH unit), calcium carbonate will precipitate out and encrust the inside of the plumbing system with a protective coating. However, if the Langelier index is greater than 1, too

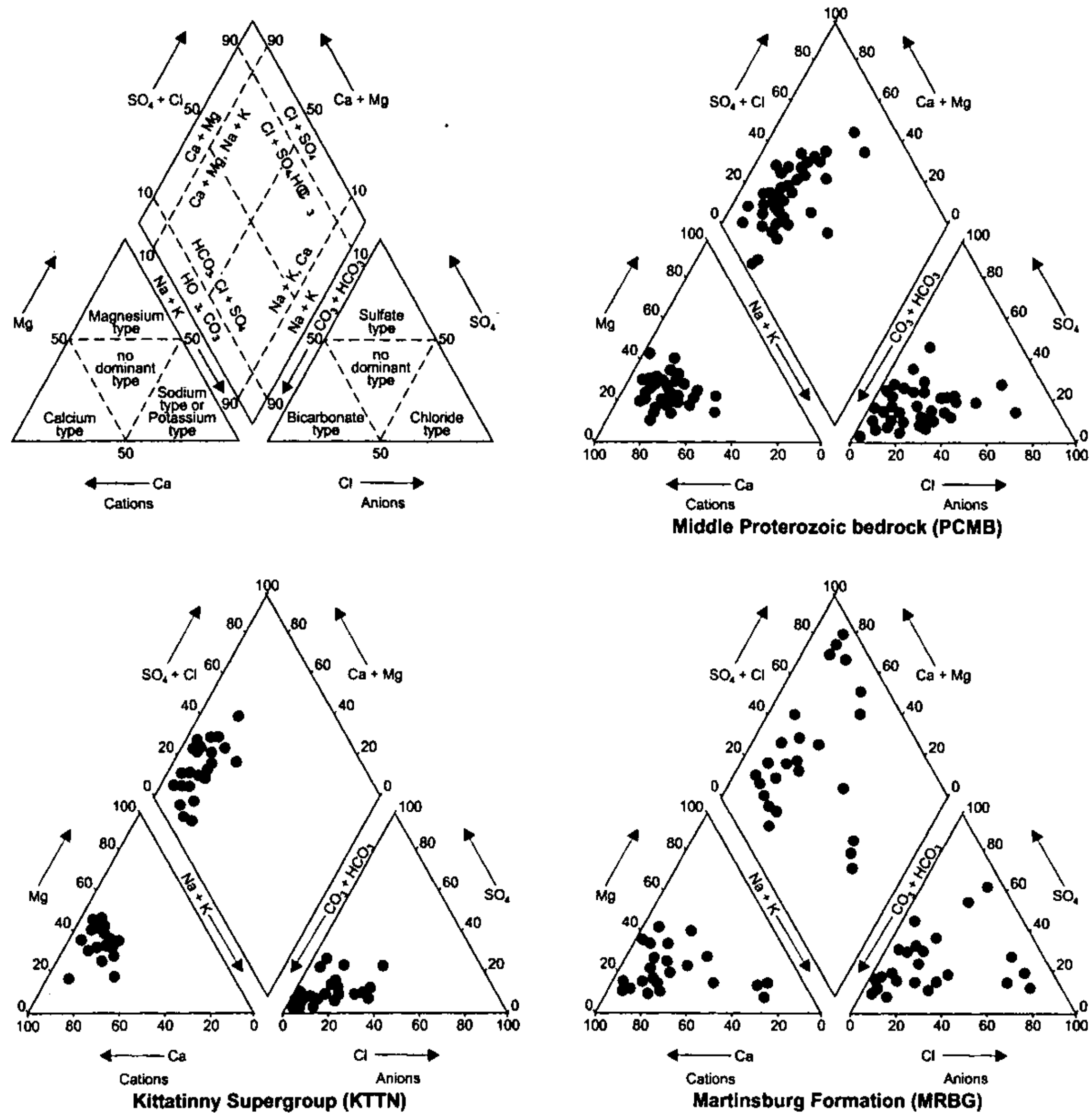

Figure 4.-- Piper diagrams showing the chemical water types in the Martinsburg Formation, Kittatinny Supergroup and the Middle Proterozoic bedrock.

Table 5.-- Chemical parameters exceeding the secondary drinking water standards.

Characteristic or Constituent	Secondary Drinking Water Standard (mg/L)[1]	Proterozoic Metamorphic Bedrock (PCMB)		Kittatinny Supergroup (KTTN)		Martinsburg Formation (MRBG)	
		Number of Samples	Percent exceeded	Number of Samples	Percent exceeded	Number of Samples	Percent exceeded
[2] Corrosivity	-1 to 1	44	84<-1, 0>1	24	12.5<-1, 0>1	26	29.9<-1, 0>1
Hardness	250	44	4.5	26	30.8	26	11.5
Iron	.300	45	6.7	26	3.8	26	0
Manganese	.05	45	16.3	26	7.7	26	23.1
pH	6.5 to 8.5	44	30.2<6.5, 0>8.5	26	0<6.5, 7.7>8.5	26	0<6.5, 15.38>8.5

[1] milligrams per liter
[2] LI - Langlier Index (no longer used as a standard in New Jersey)

much scale can build up. This will impede the flow of water and degrade the heat conducting properties of boilers and water heaters. Generally, ground water in the PCMB is very corrosive with 84 percent of sample results less than -1 pH unit. In the KTTN and MRBG, however, water is predominantly less corrosive than this. Only 12.5 percent of the KTTN and 26.9 percent of the MRBG yielded sampling results less than -1 pH unit.

Hardness

Hardness is mainly the result of calcium and magnesium dissolved in water. High hardness affects lather formation in soaps and can indicate a potential scale problem in hot water heaters and boilers. Calcite ($CaCO_3$) and dolomite ($Ca,Mg[CO_3]_2$) are common minerals that contribute calcium and magnesium to water as they dissolve. However, plagioclase feldspars, pyroxenes and amphiboles which are more common in the crystalline rocks probably contribute most of the calcium and magnesium to ground water in these rocks. In this study 4.5 percent of the samples in the PCMB, 30.8 percent in the KTTN and 11.4 percent in the MRBG are above the upper standard of 250 mg/L and 13.6 and 11.5 percent in the PCMB and MRBG units respectively, and 0 percent of the KTTN, are lower than the lower standard of 50 mg/L.

Iron and Manganese

Iron and the less abundant manganese are generally associated in rock and water because they have similar chemical properties. Some manganese generally substitutes for iron in iron-bearing minerals. For example, pyrite (FeS), biotite (hydrous iron aluminum silicate), and some pyroxenes and amphiboles may contain iron with some manganese. Generally, the lower the concentration of dissolved oxygen in water the higher the concentration of dissolved iron and manganese. When iron and manganese in water come into contact with oxygen, or an oxidizing agent such as the chlorine in bleach, they oxidize and precipitate out of solution leaving red and black stains, especially on laundry and plumbing fixtures. High iron and manganese also affect the taste of the water. Ground water exceeded the standard of .300 mg/L for iron in 6.7 percent of the PCMB and 3.84 percent of the KTTN samples. The standard of .05 mg/L for manganese is exceeded in 16.3 of the PCMB, 7.69 percent of the KTTN and 23.08 percent of the MRBG samples.

pH

Hydrogen ions are very reactive in water and their concentration controls the solubility of many compounds such as $CaCO_3$. The concentration of hydrogen ions in water is reported on a pH scale that ranges from 1, which is extremely acidic, to 14, which is extremely alkaline. A pH of 7 is considered neutral. The lower the pH the higher the concentration of hydrogen ions. Generally, the pH of infiltrating soil water is below a pH of 7.0 and is therefore acidic. Water becomes more alkaline as the hydrogen ions are consumed in weathering reactions as it flows through the ground-water system. A high pH may impart a bitter taste to the water and is generally more encrusting than a low pH water, which is usually more corrosive. Of those wells sampled, only water from the PCMB units (30.2 percent) contain water having a pH below 6.5. Ground water exceeded the upper limit of a pH of 8.5 in 7.7 percent of the KTTN and 15.4 percent of the MRBG samples.

Sodium

High sodium can have an adverse health impact on people with high blood pressure and other sodium-sensitive ailments. Sodium occurs in many minerals, for example halite (NaCl) and the plagioclase feldspars (sodium-calcium-aluminum silicates). Three ground-water samples from the MRBG had a sodium concentration above the maximum limit of 50 mg/L. Only one of the three had an associated high chloride concentration. This suggests that the other two values are natural and not anthropogenic.

PRIMARY DRINKING WATER STANDARDS

Primary drinking water standards target contaminants that may have an adverse effect on human health. At a minimum these standards apply to public water supplies. In this study, gross alpha particle activity in the PCMB units is the only primary drinking water standard exceeded.

Radionuclides

Minerals containing radioactive elements are found in a variety of crystalline rocks in the Highlands and therefore the potential exists for radionuclide release to ground water (Volkert, 1989). Potassium-rich granite, granite pegmatites, alaskite and some quartzofeldspathic gneisses are associated with elevated radionuclides (Muessig and others, 1992). Gross-alpha particle activity, which measures the alpha-radiation activity emitted from radionuclides in a sample of water, exceeded the drinking water standard of 15 picocuries per liter (pCi/L) in two or 10.5 percent of the 19 water samples tested for it in 1990. Gross-alpha particle activities of 18.6 and 27.5 (pCi/L) were measured in wells drawing water from hornblend-quartz-feldspar gneiss bedrock in Vernon, New Jersey. Samples collected from PCMB wells in White Township (1992) and Frelinghuysen (1993) in Warren County had gross-alpha particle activities of 85.2 and 18 picocuries per liter respectively. If these values are combined with the 1990 data then 19 percent of the 21 PCMB wells exceeded the standard.

In 1987, 154 wells in the crystalline rocks were sampled by the DEP for radon-222 (Bell and others, 1992). The radon values in that sampling ranged from 36 to 24,000 pCi/L with a median value of 1600 pCi/L. Of the wells sampled, 90 percent exceeded the EPA proposed primary drinking water standard for radon-222 of 300 pCi/L.

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Table 6.-- Information on wells used in this report. Wells correspond to figure 2.

Well Number	USGS Unique Value[1]	County[2]	Municipality	Latitude (dd mm ss)[3]	Longitude (dd mm ss)[3]	Altitude of Land Surface (feet)[4]	Depth of Well (feet)[5]	Top of Open Interval (feet)[6]	Bottom of Open Interval (feet)[6]	NJ Permit Number	Primary Use of Water[7]
Middle Proterozoic (non carbonate) Bedrock											
1	30236	3	Mahwah	41 05 08	74 13 39	780	86	21	86	2303576	T
2	190272	19	Bethlehem	40 40 03	75 00 08	825	275	51	275	2419879	T
3	190245	19	Califon	40 42 59	74 49 58	570	265	50	265	2412793	P
4	190273	19	Gln Gardnr	40 41 57	74 55 38	600	300	50	300	2420828	T
5	190248	19	Lebanon	40 42 04	74 53 19	840	330	72	330	4400040	P
6	190274	19	Lebanon	40 41 53	74 53 24	680	200	102	200	2425173	U
7	190010	19	Lebanon	40 43 55	74 51 11	690	545	52	545	2406598	P
8	190246	19	Lebanon	40 44 32	74 51 56	900	200	68	200	2419521	H
9	190275	19	Lebanon	40 42 44	74 54 17	880	275	60	275	2419949	C
10	271190	27	Chester	40 49 34	74 40 05	820	200	87-89	200	2533678	U
11	271136	27	Jefferson	40 59 09	74 35 11	990	232	55	232	2220087	U
12	271139	27	Mendham	40 46 21	74 35 22	520	560	69	560	2521843	U
13	271138	27	Mendham	40 47 20	74 36 10	520	325	88	325	2521199	P
14	271319	27	Mendham	40 47 17	74 36 02	530	400	50	400	2522422	U
15	271194	27	Mendham	40 46 28	74 34 30	540	400	50	400	2524129	I
16	271193	27	Mendham	40 45 44	74 33 05	480	96	55	96	2514113	N
17	271318	27	Mendham	40 47 24	74 33 06	360	247	28	247	2534783	U
18	271306	27	Morris	40 48 16	74 31 20	330	543	85	543	2533467	U
19	271059	27	Morris	40 49 41	74 30 06	410	155	50	155	2514034	P
20	271305	27	Morris	40 47 31	74 31 47	340	222	120	222	2534784	U
21	271307	27	Morris	40 48 46	74 30 46	330	293	92	293	2534779	U
22	271189	27	Mt Olive	40 53 48	74 44 15	980	470	52	470	2609869	U
23	271142	27	Mt Olive	40 51 40	74 42 28	1100	647	50	647	2526567	P
24	271141	27	Mt Olive	40 51 40	74 43 13	1100	422	50	422	2518429	N
25	271196	27	Rockaway	40 59 18	74 26 51	930	275	50-58	275	2534869	U
26	270432	27	Rockaway	40 56 54	74 27 17	630	123	50	123	2221055	N
27	271145	27	Roxbury	40 50 06	74 40 20	770	345	164	345	2520124	U
28	271146	27	Roxbury	40 52 36	74 40 43	1140	100	52	100	2531835	U
29	271178	27	Roxbury	40 52 58	74 41 04	1162	400	50	400	2521867	U
30	271148	27	Washington	40 49 15	74 47 42	1050	349	58	291	2412615	U
31	271147	27	Washington	40 48 35	74 46 58	1030	200	50	200	2406606	P
32	271120	27	Washington	40 48 13	74 46 17	1040	123	49.5	123	2519871	N
33	271161	27	Washington	40 47 51	74 45 56	590	298	58.5	298	2520299	N
34	271149	27	Washington	40 49 00	74 46 25	1060	450	50	450	2414476	U
35	310058	31	Ringwood	41 05 37	74 15 56	420	413	25	413	2302761	T
36	310009	31	Ringwood	41 07 20	74 14 42	440	186	50	186	2304903	P
37	310054	31	W Milford	41 05 45	74 22 48	970	206	18	206	2208312	P
38	310055	31	W Milford	41 09 09	74 20 20	650	360	54	360	2213327	P
39	310060	31	W Milford	41 09 33	74 19 45	660	300	55	300	2307160	P

[1] from U.S. Geological Survey Ground Water Site Inventory
[2] 3 - Bergen County, 13 - Essex, 19 - Hunterdon, 27 - Morris, 31 - Passaic, 37 - Sussex, 41 - Warren
[3] dd - degree, mm - minute, ss - second
[4] above sea level
[5] below land surface
[6] depth below land surface
[7] C - commercial, F - fire, H - domestic, I - irrigation, N - industrial, P - public supply, R - recreation, S - stock, T - institutional, U - unused
[8] actual well location in Piedmont adjacent to Highlands

Table 6.-- Information on wells used in this report. Wells correspond to figure 2.

Well Number	USGS Unique Value[1]	County[2]	Municipality	Latitude (dd mm ss)[3]	Longitude (dd mm ss)[3]	Altitude of Land Surface (feet)[4]	Depth of Well (feet)[5]	Top of Open Interval (feet)[6]	Bottom of Open Interval (feet)[6]	NJ Permit Number	Primary Use of Water[7]
Middle Proterozoic (non carbonate) Bedrock (continued)											
40	370212	37	Vernon	41 11 19	74 30 07	720	400	70	400	2219411	U
41	370213	37	Vernon	41 11 55	74 29 05	570	100	23	100	2206818	F
42	410276	41	Frlinghuysn	40 54 58	74 54 56	980	400	50	400	2428117	P
43	410252	41	Indpndnce	40 52 07	74 49 40	700	136	34	136	2402413	P
44	410253	41	Indpndnce	40 52 30	74 49 25	800	123	80	123	2411961	P
45	410269	41	White	40 49 52	75 01 59	400	448	53	448	2414170	H
Kittatinny Supergroup											
46[8]	190300	19	Clinton	40 39 23	74 54 33	205	115	55	115	2418383	P
47	190256	19	Lebanon	40 44 31	74 49 58	550	198	58.8	198	2421886	C
48	272727	27	Mt Olive	40 49 54	74 41 22	650	297	164	288	2535848	P
49	271144	27	Randolph	40 50 20	74 38 07	690	708	603	708	2532501	U
50	271123	27	Roxbury	40 53 30	74 36 38	725	307	297	307	2533036-5	U
51	271106	27	Washington	40 48 31	74 43 38	625	450	48	450	2524130	I
52	271118	27	Washington	40 48 11	74 45 15	640	200	163	200	2527789	H
53	271156	27	Washington	40 46 24	74 48 03	520	175	99.5	175	2423094	H
54	271303	27	Washington	40 47 12	74 45 47	600	118	97.6	118	2535149	U
55	370257	37	Andover	41 02 16	74 42 37	600	275	208	275	2232508	U
56	370002	37	Branchville	41 08 51	74 44 43	540	170	54	170	2203214	P
57	370236	37	Frankford	41 07 27	74 45 23	515	340	101	340	2231827	P
58	370214	37	Hamburg	41 09 14	74 34 23	460	300	99.5	300	2213545	P
59	370205	37	Hampton	41 04 49	74 48 33	514	148	50	148	2107722	U
60	370218	37	Hampton	41 03 47	74 48 43	585	699	--	699	2215345	P
61	370219	37	Lafayette	41 06 54	74 39 59	585	173	50	173	2219567	H
62	370220	37	Lafayette	41 07 13	74 39 37	565	102	50	102	2219015	H
63	370371	37	Lafayette	41 07 52	74 39 26	570	200	50	200	2220329	T
64	410257	41	Allamuchy	40 54 53	74 51 50	540	495	256.5	495	2406895	P
65	410258	41	Allamuchy	40 54 59	74 51 34	540	502	179.5	502	2411199	P
66	410260	41	Hacktstwn	40 51 12	74 48 52	550	143	65.83	143	2407213	P
67	410313	41	Knowlton	40 55 56	75 05 57	320	350	115	350	2424822	H
68	410017	41	Liberty	40 50 17	74 56 48	455	215	150	215	2411747	Q
69	410274	41	Mansfield	40 45 48	74 55 42	520	400	144	400	2416177	P
70	410247	41	Pohatcong	40 40 08	75 09 27	320	230	37.5	230	--	P
71	410021	41	Washington	40 45 19	74 57 36	460	407	152	407	2416653	P
Martinsburg Formation											
72	370237	37	Frankford	41 07 40	74 45 29	560	156	20	156	2210416	T
73	370362	37	Frankford	41 09 30	74 40 28	460	300	51	300	2230804	H
74	370363	37	Frankford	41 12 01	74 42 33	810	300	57	300	2231233	H
75	370367	37	Frankford	41 07 21	74 42 49	525	597	50	597	2232959	H

[1] from U.S. Geological Survey Ground Water Site Inventory
[2] 3 - Bergen County, 13 - Essex, 19 - Hunterdon, 27 - Morris, 31 - Passaic, 37 - Sussex, 41 - Warren
[3] dd - degree, mm - minute, ss - second
[4] above sea level
[5] below land surface
[6] depth below land surface
[7] C - commercial, F - fire, H - domestic, I - irrigation, N - industrial, P - public supply, R - recreation, S - stock, T - institutional, U - unused
[8] actual well location in Piedmont adjacent to Highlands

Table 6.-- Information on wells used in this report. Wells correspond to figure 2.

Well Number	USGS Unique Value[1]	County[2]	Municipality	Latitude (dd mm ss)[3]	Longitude (dd mm ss)[3]	Altitude of Land Surface (feet)[4]	Depth of Well (feet)[5]	Top of Open Interval (feet)[6]	Bottom of Open Interval (feet)[6]	NJ Permit Number	Primary Use of Water[7]
Martinsburg Formation (continued)											
76	370368	37	Frankford	41 12 34	74 42 54	905	500	62	500	2234086	P
77	370369	37	Fredon	41 02 10	74 47 00	890	600	51	600	2108860	H
78	370258	37	Hampton	41 04 06	74 47 08	660	382	23	382	2100777	T
79	370370	37	Lafayette	41 06 29	74 39 24	690	200	55	200	2232452	H
80	370372	37	Montague	41 18 55	74 40 03	1575	500	52	500	2227630	H
81	370235	37	Stillwater	41 04 52	74 54 47	980	250	105	250	2107838	R
82	370217	37	Wantage	41 18 27	74 40 17	520	180	50	180	2219449	H
83	370221	37	Wantage	41 12 02	74 37 40	440	147	42	147	2207269	C
84	370263	37	Wantage	41 12 39	74 41 46	760	248	--	248	2221814	H
85	370265	37	Wantage	41 14 24	74 41 03	1020	320	50	320	2221624	R
86	370366	37	Wantage	41 18 17	74 40 04	418	600	89	600	2229216	P
87	370373	37	Wantage	41 14 35	74 37 00	630	300	58	300	2228648	I
88	410001	41	Blairstown	40 58 35	74 56 38	355	318	--	318	--	P
89	410259	41	Blairstown	40 57 10	75 01 03	590	135	50	135	2104475	T
90	410273	41	Blairstown	40 59 55	75 02 14	925	125	18.8	125	2102303	R
91	410312	41	Blairstown	40 57 02	74 58 52	685	400	60	400	2107422	H
92	410277	41	Frlinghuysn	40 58 59	74 53 46	680	245	60	245	2108746	H
93	410256	41	Hardwick	41 01 25	74 57 07	765	300	50	300	2104207	R
94	410255	41	Knowlton	40 55 39	75 02 25	662	310	50	310	2408045	R
95	410272	41	Mansfield	40 46 53	74 55 02	640	198	60	198	2415589	C
96	410275	41	Mansfield	40 48 38	74 53 08	660	333	103	333	2411687	T
97	410270	41	White	40 51 47	75 00 56	405	270	50	270	2417382	N
Middle Proterozoic Marble											
98	370255	37	Stanhope	40 54 14	74 42 46	780	225	173	225	2521153	U
99	370262	37	Vernon	41 10 35	74 32 36	430	130	126	130	2220147	T
100	370264	37	Vernon	41 12 56	74 30 30	585	239	--	239	2218793	R
Paleozoic Unit (High Falls)											
101	370216	37	Sandyston	41 14 00	74 45 30	860	130	21.3	130	2205298	H
102	370215	37	Sandyston	41 11 17	74 48 04	760	185	85	185	--	H
103	410266	41	Hardwick	41 04 22	74 57 51	650	172	100	172	2104959	H
Paleozoic Unit (Bossardville)											
104	370202	37	Walpack	41 09 14	74 53 04	480	95	42	95	--	U
Paleozoic Unit (Esopus)											
105	370004	37	Sandyston	41 11 51	74 51 07	535	300	123	300	--	R

[1] from U.S. Geological Survey Ground Water Site Inventory
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[8] actual well location in Piedmont adjacent to Highlands

Table 7a.-- Chemical analyses of water samples from wells in bedrock of the Highlands and Valley and Ridge physiographic provinces of New Jersey (field parameters and major dissolved constituents). Wells correspond to figure 2.

Well Number	USGS Unique Number	Sample Collection Date	Temperature (°C)	Specific Conductance (µs/cm)	Oxygen, dissolved (mg/L)	pH (standard units)	Corrosivity (pH units)	Field Alkalinity (mg/L as $CaCO_3$)	Solids, total dissolved sum of constituents (mg/L)	Hardness (mg/L as $CaCO_3$)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)	Potassium (mg/L as K)	Chloride (mg/L as Cl)	Sulfate (mg/L as SO_4)	Fluoride (mg/L as F)	Silica (mg/L as SiO_2)	Nitrogen, ammonia (mg/L as N)	Nitrogen, nitrate (mg/L as N)	Nitrogen, ammonia + organic (mg/L as N)	Nitrogen, $NO_2 + NO_3$ (mg/L as N)	Phosphorus (mg/L as P)	Phosphorus, ortho (mg/L as P)
Middle Proterozoic (non carbonate) Bedrock																								
1	30236	09/28/89	10.5	74	7.1	6.5	-3.06	27	59	35	12	1.1	3.2	0.6	1.2	10	1.1	13	0.01	<0.1	0.4	<0.10	<.01	<.01
2	190272	08/27/90	12	174	8.3	6.2	-3.44	21	116	56	13	5.8	7.5	0.9	3.9	25	<.1	23	0.03	<.01	0.6	5.7	0.02	<.01
3	190245	11/22/88	10.5	212	7.5	6.5	-2.73	40	132	77	20	6.6	7.9	0.9	18	19	<.1	27	<.01	0.02	<0.20	2.3	0.02	0.03
4	190273	09/06/90	10.5	154	6.5	6.2	-3.43	25	96	49	12	4.5	10	1	17	13	<.1	22	0.02	<.01	0.2	0.3	<.01	0.01
5	190248	09/19/89	11	212	6.9	7.1	-1.78	70	145	89	25	6.4	9.1	0.8	11	16	0.3	28	<.01	<.01	0.3	1.2	<.01	0.021
6	190274	09/25/90	10.5	202	6.4	6.1	-3	51	140	77	21	6	8.6	0.8	20	15	<.1	34	<.01	<.01	<0.20	0.9	0.03	0.02
7	190010	11/23/88	11.5	226	0.3	6.8	-2.04	71	155	88	26	5.7	10	0.7	14	38	0.2	22	<.01	<.01	0.3	0.22	<.01	<.01
8	190236	09/29/89	10.5	94	5.5	6.3	-3.43	27	86	31	8.4	2.5	6.7	0.8	5	13	0.1	29	<.01	<.01	0.6	0.76	0.03	0.04
9	190275	09/14/90	12	185	8.4	5.1	-4.98	10	111	42	10	4.1	14	1.4	26	20	<.1	15	<.01	<.01	0.6	3.3	<.01	<.01
10	271190	09/28/90	11	136	7.1	6.7	-2.53	51	90	45	14	2.4	5.7	1.5	2.7	10	0.4	20	<.01	<.01	<0.20	0.5	0.04	0.03
11	271136	08/28/89	15	134	6.4	6.6	-2.56	48	85	51	14	4	6.8	0.8	10	8	0.1	12	0.021	<.01	0.3	<0.10	<.01	<.01
12	271139	06/06/89	12	305	1.9	7.3	-1.11	139	244	140	39	10	21	1.2	13	40	0.3	36	<.01	<.01	0.5	0.23	0.02	0.02
13	271138	12/01/88	12	286	5.8	7	-1.57	110	186	130	32	13	8.7	0.8	13	12	0.2	29	<.01	<.01	0.4	2.3	0.03	0.03
14	271319	09/27/90	12	346	4.2	7.2	-1.2	141	223	160	40	14	8.7	1.1	19	20	0.2	28	0.01	<.01	<0.20	1.6	0.09	0.08
15	271194	09/05/90	12	276	8	7.2	-1.49	85	184	110	32	7.5	10	1	6.9	42	0.3	31	<.01	<.01	<0.20	0.4	0.01	<.01
16	271193	09/04/90	10	169	6.5	6.1	-3.33	41	107	54	12	5.9	6.2	0.5	10	14	<.1	32	<.01	<.01	<0.20	0.4	0.04	0.03
17	271318	09/26/90	11	311	3.7	6.5	-2.17	84	189	140	36	11	8	0.8	36	15	<.1	26	<.01	<.01	<0.20	1.1	<.01	<.01
18	271306	09/24/90	11	233	1.6	7.7	-1.1	83	161	110	26	10	7.7	0.7	7.2	26	0.1	31	<.01	<.01	0.2	0.8	0.06	0.06
19	270159	09/12/90	11.5	331	5.8	6.4	-2.62	43	199	120	31	9.3	17	1.9	41	26	0.4	29	<.01	<.01	0.5	4.2	0.02	0.01
20	271305	09/19/90	10.5	590	5.1	7.3	-0.75	176	356	270	80	17	14	1.1	65	27	0.2	37	<.01	<.01	<0.20	1.8	--	–
21	271307	09/27/90	11	303	0.5	8.1	-0.8	79	199	79	23	5.2	32	0.7	20	38	2.3	29	<.01	<.01	<0.20	0.6	0.07	0.06
22	271189	04/05/89	11.5	190	4	6.4	-2.58	64	121	77	20	6.6	6.2	0.9	1.9	24	0.1	19	0.01	<.01	<0.20	1.1	0.02	0.02
23	271142	04/12/89	11	150	4.1	6	-3.28	39	110	61	17	4.4	5.1	3.3	4.4	29	0.1	20	0.02	0.01	<0.20	0.37	<.01	<.01

Table 7a.-- Chemical analyses of water samples from wells in bedrock of the Highlands and Valley and Ridge physiographic provinces of New Jersey (field parameters and major dissolved constituents). Wells correspond to figure 2.

Well Number	USGS Unique Number	Sample Collection Date	Temperature (°C)	Specific Conductance (µs/cm)	Oxygen, dissolved (mg/L)	pH (standard units)	Corrosivity (pH units)	Field Alkalinity (mg/L as $CaCO_3$)	Solids, total dissolved sum of constituents (mg/L)	Hardness (mg/L as $CaCO_3$)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)	Potassium (mg/L as K)	Chloride (mg/L as Cl)	Sulfate (mg/L as SO_4)	Fluoride (mg/L as F)	Silica (mg/L as SiO_2)	Nitrogen, ammonia (mg/L as N)	Nitrogen, nitrate (mg/L as N)	Nitrogen, ammonia + organic (mg/L as N)	Nitrogen, $NO_2 + NO_3$ (mg/L as N)	Phosphorus (mg/L as P)	Phosphorus, ortho (mg/L as P)
Middle Proterozoic (non carbonate) Bedrock (continued)																								
24	271141	06/27/89	11	500	6	6.6	-2.58	29	243	130	34	11	28	2.7	91	28	0.1	22	0.02	<.01	0.3	2.1	0.02	<.01
25	271196	09/18/90	10	167	5.4	7.8	-1.31	73	106	65	14	7.4	5.1	0.6	2.8	11	<.1	22	<.01	<.01	<0.20	<0.10	0.02	<.01
26	270432	09/27/89	11	161	6.7	6.3	-2.97	45	115	65	15	6.6	6.2	1	16	12	0.1	26	<.01	<.01	0.3	1.3	0.02	0.01
27	271145	11/28/88	11.5	125	6.1	7.3	-1.73	69	101	56	16	4	6.4	0.7	1.1	3.2	0.2	27	<.01	<.01	0.2	0.22	0.03	0.03
28	271146	09/20/89	11	--	7.2	--	--	55	--	--	--	--	--	--	7.3	15	<.1	17	0.01	<.01	1	2.1	<.01	0.01
29	271178	09/27/89	11	269	<0.1	7.4	-1.15	93	166	130	39	7	6.2	0.7	15	20	0.1	20	<.01	<.01	0.4	0.41	<.01	<.01
30	271148	11/16/88	12	181	4	6.4	-2.72	53	121	68	17	6.2	7.8	1.1	16	12	0.2	22	0.02	<.01	<0.20	1.5	0.01	<.01
31	271147	11/30/88	10.5	273	4.9	6.7	-2.26	59	175	110	26	12	8.5	0.9	33	20	0.1	34	<.01	<.01	<0.20	1.3	0.03	0.03
32	271120	09/28/89	10.5	108	5.4	5.9	-3.87	19	77	42	11	3.5	5	0.6	12	12	<.1	16	<.01	<.01	0.7	1.3	0.03	0.02
33	271161	08/29/89	12	180	0.8	8	-0.93	57	124	78	25	3.8	6.7	0.5	1.9	26	0.1	18	0.01	<.01	0.3	<0.10	--	<.01
34	271149	11/17/88	11.5	160	2.2	7.6	-1.41	63	124	70	19	5.5	7.1	3.2	2	14	0.1	35	0.02	<.01	0.4	<0.10	0.02	0.02
35	310058	09/11/90	18	274	7.2	7	-1.37	102	176	130	39	7.7	5.6	1	13	24	0.2	18	<.01	<.01	0.5	0.9	0.02	<.01
36	310009	09/26/89	12	350	4.4	7.4	-0.92	127	206	160	49	10	7.5	0.7	26	11	0.1	20	<.01	<.01	1.2	1.1	0.01	0.02
37	310054	08/25/89	11	216	9.3	6.4	-2.73	45	128	87	22	7.8	8.8	0.6	24	16	0.2	19	0.021	<.01	0.2	0.49	<.01	<.01
38	310055	08/25/89	12	236	4.1	7.3	-1.64	65	134	100	22	11	8.6	0.5	21	11	0.7	20	<.01	<.01	<0.20	<0.10	<.01	0.02
39	310060	09/12/90	12.5	176	1.1	7.3	-1.79	62	109	61	15	5.6	7.8	0.6	9.9	12	1.3	20	<.01	<.01	<0.20	<0.10	<.01	<.01
40	370212	09/12/90	10.5	444	0.6	7.4	-0.62	221	266	250	66	20	4.4	1.9	4.2	18	1.9	15	<.01	<.01	<0.20	<0.10	<.01	<.01
41	370213	10/02/90	12	419	3.4	7.7	-0.69	121	225	180	47	16	5.6	1.9	43	20	0.6	14	0.01	<.01	<0.20	0.8	<.01	0.01
42	410276	08/25/93	11	256	0.1	7.4	-1.25	100	147	120	30	11	5.4	1	1.4	18	0.9	19	0.01	<.01	<.2	<.05	--	<.01
43	410252	09/11/90	10	192	9.1	6.7	-2.41	65	118	60	16	9.8	5.1	0.8	6.2	18	<.1	23	<.01	<.01	<0.20	0.1	0.02	<.01
44	410253	09/28/90	12	599	9	7.6	-0.29	281	336	310	66	36	2.8	0.7	20	25	0.1	13	<.01	<.01	<0.20	0.8	<.01	0.01
45	410269	09/10/92	15	268	5.9	8	-0.51	94	157	130	35	9.8	4.8	1.3	4.2	35	<.1	14	0.01	<.01	<.2	1	--	<.01

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Well Number	USGS Unique Number	Sample Collection Date	Temperature (°C)	Specific Conductance (µs/cm)	Oxygen, dissolved (mg/L)	pH (standard units)	Corrosivity (pH units)	Field Alkalinity (mg/L as $CaCO_3$)	Solids, total dissolved sum of constituents (mg/L)	Hardness (mg/L as $CaCO_3$)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)	Potassium (mg/L as K)	Chloride (mg/L as Cl)	Sulfate (mg/L as SO_4)	Fluoride (mg/L as F)	Silica (mg/L as SiO_2)	Nitrogen, ammonia (mg/L as N)	Nitrogen, nitrate (mg/L as N)	Nitrogen, ammonia + organic (mg/L as N)	Nitrogen, NO_2 + NO_3 (mg/L as N)	Phosphorus (mg/L as P)	Phosphorus, ortho (mg/L as P)
Kittatinny Supergroup																								
46	190300	09/11/91	12.5	474	3.9	7.3	-0.89	165	242	200	43	22	13	1.1	25	18	<.1	14	<.010	<.010	<.2	1.3	0.02	<.01
47	190256	11/02/89	10.5	406	10.2	7.4	--	--	228	212	44	24	3	2.2	7.1	18	0.1	7.5	<.010	<.010	0.6	4.4	--	<.01
48	271727	09/30/92	11.5	154	7.5	8.2	-0.83	72	94	75	16	8.5	4.2	0.6	3.2	1.6	0.1	16	0.01	<.010	<.2	0.22	--	0.02
49	271144	05/15/89	11	144	5.3	9	-0.21	61	91	61	13	6.9	4.8	0.7	4.3	3	0.2	17	0.03	0.02	<.2	1.1	0.03	0.02
50	271123	10/25/89	11	150	2.6	8.6	-0.5	75	98	86	14	5.9	6.9	0.8	3.2	3	0.1	14	<.010	<.010	<.2	0.23	--	0.03
51	271106	08/24/88	12.5	269	1.2	8.1	-0.49	123	158	147	26	17	3.7	0.8	3.6	11	0.1	12	<.010	<.010	0.4	0.41	--	<.01
52	271118	11/02/89	11.5	216	8	7.3	-1.7	69	131	95	19	8.8	6.6	0.9	12	11	0.1	21	<.010	<.010	0.6	2.4	--	0.02
53	271156	10/27/89	10.5	343	3.7	7.9	-0.53	149	196	186	35	21	3.6	1.4	7.6	15	0.1	11	<.010	<.010	<.2	1.7	--	<.01
54	271303	09/20/94	11	238	8.5	7.7	-1.13	91	132	120	23	14	3.1	1.4	5.8	5.1	<.1	13	<.010	<.010	<.2	2.9	--	<.01
55	370257	08/24/93	11.5	368	6	7.7	--	--	205	190	40	21	3.5	1.1	10	27	0.1	10	<.010	<.010	<.2	1	--	<.01
56	370002	05/09/91	11	878	0.1	7.3	-0.47	299	459	390	81	46	22	1.7	78	44	<.1	6.5	<.010	<.010	<.2	0.072	<.01	<.01
57	370236	08/13/93	12	460	0	8	-0.4	134	244	190	40	22	17	1	49	22	0.5	11	0.01	<.010	<.2	<.050	--	<.01
58	370214	04/17/91	10.5	509	--	6.6	-1.77	126	282	170	50	12	31	1.7	53	28	<.1	9	<.010	<.010	0.2	4.9	<.01	<.01
59	370205	09/09/91	11	512	0.3	7.3	-0.77	175	314	270	70	24	10	1.1	22	71	0.1	8.4	0.18	<.010	0.4	0.085	0.02	<.01
60	370218	09/20/91	11.5	371	0.2	7.7	-0.62	155	211	180	43	17	3.7	0.7	2.5	41	0.3	9.2	<.010	<.010	<.2	<.050	<.01	<.01
61	370219	09/10/91	12.5	273	--	7.8	0.78	88	150	120	40	5.5	5.2	0.5	4.4	30	0.1	11	0.01	0.02	<.2	0.18	<.01	<.01
62	370220	04/04/91	10.5	322	11.6	7.6	-0.79	162	179	140	38	11	15	0.9	2.6	5.7	0.1	9.4	<.010	<.010	<.2	<.050	0.03	0.04
63	370371	09/27/95	13	575	1.3	8	-0.35	110	299	230	54	22	20	1.3	58	59	<.1	10	<.015	0.01	<.2	2	--	<.01
64	410257	09/23/92	11.5	601	0.2	7.6	-0.42	232	330	290	59	34	12	1.6	33	43	0.1	10	0.01	<.010	<.2	<.050	--	<.01
65	410258	09/23/92	11	586	0.2	7.6	-0.48	214	320	280	58	33	11	1.6	28	49	0.1	9.8	<.010	<.010	<.2	<.050	--	<.01
66	410260	08/26/92	11	355	6	7.7	-0.69	151	210	190	40	21	9.6	0.6	16	19	<.1	12	<.010	<.010	<.2	0.38	--	0.01
67	410313	09/14/95	13.5	581	0.4	7.7	-0.39	191	302	250	55	28	21	1.6	37	37	0.4	7.8	<.015	<.010	<.2	0.12	--	<.01
68	410017	09/22/92	10	607	6.7	7.5	-0.47	255	329	300	66	33	7.4	1.1	22	26	<.1	10	<.010	<.010	<.2	2.5	--	<.01

Table 7a.-- Chemical analyses of water samples from wells in bedrock of the Highlands and Valley and Ridge physiographic provinces of New Jersey (field parameters and major dissolved constituents). Wells correspond to figure 2.

Well Number	USGS Unique Number	Sample Collection Date	Temperature (°C)	Specific Conductance (µs/cm)	Oxygen, dissolved (mg/L)	pH (standard units)	Corrosivity (pH units)	Field Alkalinity (mg/L as $CaCO_3$)	Solids, total dissolved sum of constituents (mg/L)	Hardness (mg/L as $CaCO_3$)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)	Potassium (mg/L as K)	Chloride (mg/L as Cl)	Sulfate (mg/L as SO_4)	Fluoride (mg/L as F)	Silica (mg/L as SiO_2)	Nitrogen, ammonia (mg/L as N)	Nitrogen, nitrate (mg/L as N)	Nitrogen, ammonia + organic (mg/L as N)	Nitrogen, NO_2 + NO_3 (mg/L as N)	Phosphorus (mg/L as P)	Phosphorus, ortho (mg/L as P)
Kittatinny Supergroup (continued)																								
69	410274	09/17/93	11	585	7.9	8	-0.25	165	309	250	51	30	19	1.6	67	19	<.1	11	0.02	<.010	<.2	2.8	--	<.01
70	410247	04/11/91	11.5	519	0.2	7.2	-0.69	232	448	340	83	33	22	2.9	83	44	<.1	15	0.22	<.010	0.3	<.050	0.01	<.01
71	410021	09/30/91	11.5	410	7.4	7.6	-0.73	172	213	200	41	23	7.5	1.4	15	13	<.1	14	0.02	<.010	0.02	5.6	0.04	<.01
Martinsburg Formation																								
72	370237	08/13/93	12.5	480	3.1	7.6	-0.67	117	286	180	61	7.4	30	0.9	56	48	<.1	10	0.01	<.010	<.2	0.22	--	<.01
73	370362	08/24/95	12	365	1.6	8.6	-0.32	136	219	47	12	4.2	63	0.7	16	28	0.6	11	0.21	<.010	<.2	0.07	--	<.01
74	370363	08/22/95	11	535	0.3	7.6	-0.64	119	272	220	71	9.2	16	1	66	27	<.1	10	0.04	<.010	<.2	<.050	--	<.01
75	370367	09/19/95	12	296	3.1	8.6	-0.15	100	164	79	23	5.3	32	0.5	4.8	28	0.2	11	0.11	<.010	<.2	0.16	--	<.01
76	370368	09/26/95	12	426	0.8	8.4	-0.39	148	236	63	15	6.2	70	1.4	23	19	0.9	11	0.27	<.010	0.3	0.17	--	0.03
77	370369	09/20/95	12.5	864	0.5	7.6	-0.59	134	443	260	67	23	60	1.6	150	44	<.1	10	<.015	0.01	<.2	1.9	--	<.01
78	370258	08/17/93	21	423	3.2	7.1	-0.95	126	233	170	58	5.6	19	0.7	41	21	<.1	9.8	0.02	<.010	<.2	0.37	--	<.01
79	370370	09/25/95	11.5	630	3.8	7.6	-0.36	214	330	300	73	29	13	0.8	35	26	<.1	12	<.015	<.010	<.2	2.8	--	0.01
80	370372	09/18/95	10.5	184	1.4	8.5	-0.56	65	96	73	17	7.3	5.5	3	3.4	12	<.1	9.7	0.1	<.010	<.2	<.050	--	0.03
81	370235	08/12/93	13.5	213	0.3	8.1	-0.57	84	124	91	28	5.2	8.3	0.5	1.1	16	0.1	14	0.01	<.010	<.2	<.05	--	0.01
82	370217	03/22/91	10	86	8.2	7.2	-2.24	46	61	46	10	5.2	1.9	0.6	1.6	6.9	<.1	7.2	<.010	<.010	<.02	<.050	0.07	0.07
83	370221	04/25/91	10	476	0.3	7.2	-1.12	148	254	190	50	15	21	2.7	54	12	0.1	9.7	0.14	<.010	0.2	<.050	0.01	<.01
84	370263	06/23/93	12	417	0.2	8.7	-0.27	97	243	63	15	6.1	59	4.2	20	55	0.8	11	0.05	0.07	<.2	3	--	<.01
85	370265	08/23/93	12	243	0.1	7.4	-1.37	72	151	93	30	4.3	12	2.4	4.3	29	1.6	24	<.010	<.010	<.2	<.05	--	<.01
86	370366	08/21/95	12.5	594	0.1	8.2	-0.22	130	320	180	40	20	44	3.2	89	34	0.2	11	0.36	<.010	0.4	<.050	--	0.02
87	370373	08/23/95	12	267	6.1	7.2	-1.42	78	147	120	39	4.8	4.7	0.4	7.5	25	0.2	12	<.015	<.010	<.2	1.5	--	<.01
88	410001	09/25/91	12	486	8.2	7.7	-0.58	146	264	210	49	21	20	1.8	36	31	<.1	11	0.09	0.03	0.5	1.5	0.18	0.17
89	410259	09/16/92	11	237	4.5	6.5	-2.33	55	133	110	35	4.4	3.5	0.4	4.1	27	<.1	9.3	<.010	<.010	<.2	3.7	--	<.01

Table 7a.-- Chemical analyses of water samples from wells in bedrock of the Highlands and Valley and Ridge physiographic provinces of New Jersey (field parameters and major dissolved constituents). Wells correspond to figure 2.

Well Number	USGS Unique Number	Sample Collection Date	Temperature (°C)	Specific Conductance (µs/cm)	Oxygen, dissolved (mg/L)	pH (standard units)	Corrosivity (pH units)	Field Alkalinity (mg/L as $CaCO_3$)	Solids, total dissolved sum of constituents (mg/L)	Hardness (mg/L as $CaCO_3$)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)	Potassium (mg/L as K)	Chloride (mg/L as Cl)	Sulfate (mg/L as SO_4)	Fluoride (mg/L as F)	Silica (mg/L as SiO_2)	Nitrogen, ammonia (mg/L as N)	Nitrogen, nitrate (mg/L as N)	Nitrogen, ammonia + organic (mg/L as N)	Nitrogen, $NO_2 + NO_3$ (mg/L as N)	Phosphorus (mg/L as P)	Phosphorus, ortho (mg/L as P)
Martinsburg Formation (continued)																								
90	410273	08/12/93	13.5	418	0.2	7.8	-0.44	108	275	200	68	8.2	6.4	0.5	3.1	110	<.1	13	0.02	<.010	<.2	<.05	--	<.01
91	410312	09/14/95	12.5	554	2.1	7.8	-0.35	148	314	260	64	25	6.8	0.5	22	71	0.1	13	<.015	<.010	<.2	5.3	--	<.01
92	410277	09/17/93	13.5	304	8.3	8.2	-0.41	133	176	120	22	16	18	0.9	2	18	0.2	18	0.05	<.010	<.2	0.05	--	<.01
93	410256	09/30/91	11	314	0.7	6.5	-1.89	108	177	150	51	5.3	5.3	0.5	8.5	27	<.1	14	<.010	<.010	<.2	0.57	0.02	<.01
94	410255	03/15/91	10	178	7.3	8.6	-0.22	85	114	99	23	10	1.9	0.4	4	12	<.1	7	0.02	<.010	<.2	0.9	0.02	0.01
95	410272	08/12/93	12.5	95	7	6.6	-2.91	34	70	35	9.7	2.5	4.2	1.2	3.3	3.3	<.1	16	<.010	<.010	<.2	2	--	0.02
96	410275	09/16/93	13.5	157	0.1	8.2	-0.69	66	100	71	21	4.6	6.2	0.6	1.3	13	0.2	14	0.01	<.010	<.2	<.05	--	<.01
97	410270	09/16/92	12	388	<.1	7.8	-0.47	156	238	180	47	15	13	0.3	16	39	<.1	14	0.09	<.010	<.2	<.050	--	<.01
Middle Proterozoic Marble																								
98	370255	06/22/93	12	731	3	7.3	-0.76	154	393	310	84	25	18	1.6	96	40	0.1	26	0.02	<.01	<.2	2.5	--	0.03
99	370262	09/17/93	11.5	1220	7.8	7.5	-0.16	302	663	440	110	40	84	1.7	180	31	<.1	12	0.02	<.01	<.2	5	--	<.01
100	370264	09/16/93	12.5	345	6.4	7.8	-0.44	171	215	170	45	14	10	1.7	7.3	9.2	0.2	21	0.01	<.01	<.2	0.64	--	0.01
Paleozoic Unit (High Falls)																								
101	370216	09/18/91	10.5	459	6.4	7.3	-0.54	236	286	270	92	9.1	1.5	0.5	7.8	27	0.1	4.9	<.010	<.010	<.2	0.084	<.01	0.02
102	370215	04/16/91	11.5	552	7	7.4	-0.57	240	305	280	64	30	6.3	1.3	13	23	<.1	11	<.010	<.010	0.4	2.7	0.02	<.01
103	410266	09/17/92	11	229	2.2	8.1	-0.59	104	121	110	26	12	3.3	0.8	0.5	7.4	<.1	7.9	<.010	<.010	<.2	<.050	--	0.01
Paleozoic Unit (Bossardville)																								
104	370202	05/15/91	10.5	588	9.4	7.1	-0.84	265	297	300	65	34	5.5	0.6	11	14	<.1	5.8	0.01	<.010	0.3	0.39	<.01	<.01
Paleozoic Unit (Esopus)																								
105	370004	04/24/91	11	1010	1.7	7	-0.59	412	563	470	99	54	38	1.7	69	47	<.1	6.6	0.01	0.06	<.2	0.53	<.01	<.01

Table 7b.-- Chemical analyses of water samples from wells in bedrock of the Highlands and Valley and Ridge physiographic provinces of New Jersey (minor and trace dissolved constituents). Wells correspond to figure 2.

Well Number	USGS Unique Number	Sample Collection Date	Aluminum (µg/L as Al)	Arsenic (µg/L as As)	Barium (µg/L as Ba)	Cadmium (µg/L as Cd)	Chromium (µg/L as Cr)	Copper (µg/L as Cu)	Iron (µg/L as Fe)	Lead (µg/L as Pb)	Manganese (µg/L as Mn)	Mercury (µg/L as Hg)	Selenium (µg/L as Se)	Silver (µg/L as Ag)	Zinc (µg/L as Zn)	Carbon, organic (mg/L as C)	Phenols, total (mg/L)	Gross Alpha, dissolved (pCi/L as U - Natural)	Gross Alpha, dissolved (pCi/L as Th - 230)
Middle Proterozoic (non carbonate) Bedrock																			
1	30236	09/28/89	50	<1	--	<1	<1	3	150	2	3	<0.1	--	--	170	0.5	<1	--	--
2	190272	08/27/90	<10	<1	--	<1	<1	10	6	<1	3	<0.1	--	--	9	0.4	<1	--	--
3	190245	11/22/88	<10	<1	--	<1	<1	4	4	<5	2	<0.1	--	--	270	0.3	<1	--	--
4	190273	09/06/90	<10	<1	--	<1	<1	5	6	4	<1	<0.1	--	--	8	0.5	12	1.9	--
5	190248	09/19/89	<10	<1	--	<1	<1	<1	4	<1	<1	0.2	--	--	3	0.4	2	--	--
6	190274	09/25/90	<10	<1	--	<1	<1	2	150	<1	7	<0.1	--	--	<3	0.4	<1	1.4	--
7	190010	11/23/88	<10	<1	--	<1	<1	2	960	<5	120	<0.1	--	--	5	0.4	1	--	--
8	190236	09/29/89	<10	<1	--	<1	<1	9	<3	3	8	<0.1	--	--	640	0.3	<1	--	--
9	190275	09/14/90	20	<1	--	<1	<1	76	16	3	5	<0.1	--	--	12	0.3	<1	1.8	--
10	271190	09/28/90	20	<1	--	<1	<1	1	6	<1	<1	<0.1	--	--	<3	0.4	1	<0.4	--
11	271136	08/28/89	<10	<1	--	<1	<1	3	42	<1	100	0.3	--	--	24	1.5	--	--	--
12	271139	06/06/89	20	<1	--	1	<1	1	17	<1	21	<0.1	--	--	25	0.5	<1	--	--
13	271138	12/01/88	<10	<1	--	<1	1	3	<3	<5	<1	0.2	--	--	4	0.4	3	--	--
14	271319	09/27/90	<10	<1	--	<1	<1	7	5	1	<1	<0.1	--	--	28	0.4	<1	1.4	--
15	271194	09/05/90	<10	<1	--	<1	1	3	6	1	25	0.1	--	--	310	0.4	3	<0.4	--
16	271193	09/04/90	<10	<1	--	<1	1	15	11	<1	<1	<0.1	--	--	16	0.4	<1	3	--
17	271318	09/26/90	20	<1	--	<1	1	<1	14	1	2	<0.1	--	--	6	0.5	7	2	--
18	271306	09/24/90	<10	<1	--	<1	<1	<1	<3	<1	2	<0.1	--	--	4	0.3	<1	2.5	--
19	270159	09/12/90	<10	<1	--	<1	<1	2	9	1	<1	<0.1	--	--	<3	0.1	7	2	--
20	271305	09/19/90	<10	<1	--	<1	1	1	19	<1	2	<0.1	--	--	9	0.3	4	1.9	--
21	271307	09/27/90	<10	<1	--	<1	<1	1	9	<1	4	<0.1	--	--	<3	0.4	<1	1.8	--
22	271189	04/05/89	<10	<1	--	<1	<1	3	7	<5	4	0.1	--	--	26	2.3	<1	--	--
23	271142	04/12/89	<10	<1	--	<1	<1	2	1400	<5	120	<0.1	--	--	52	0.9	<1	--	--

Table 7b.-- Chemical analyses of water samples from wells in bedrock of the Highlands and Valley and Ridge physiographic provinces of New Jersey (minor and trace dissolved constituents). Wells correspond to figure 2.

Well Number	USGS Unique Number	Sample Collection Date	Aluminum (µg/L as Al)	Arsenic (µg/L as As)	Barium (µg/L as Ba)	Cadmium (µg/L as Cd)	Chromium (µg/L as Cr)	Copper (µg/L as Cu)	Iron (µg/L as Fe)	Lead (µg/L as Pb)	Manganese (µg/L as Mn)	Mercury (µg/L as Hg)	Selenium (µg/L as Se)	Silver (µg/L as Ag)	Zinc (µg/L as Zn)	Carbon, organic (mg/L as C)	Phenols, total (mg/L)	Gross Alpha, dissolved (pci/L as U - Natural)	Gross Alpha, dissolved (pci/L as Th - 230)
Middle Proterozoic (non carbonate) Bedrock (continued)																			
24	271141	06/27/89	<10	<1	--	<1	<1	2	1700	<1	320	<0.1	--	--	18	0.5	3	--	--
25	271196	09/18/90	<10	<1	--	<1	<1	3	<3	<1	<1	<0.1	--	--	9	0.3	<1	0.7	--
26	270432	09/27/89	<10	<1	--	<1	<1	20	3	1	3	<0.1	--	--	4	0.5	<1	--	--
27	271145	11/28/88	<10	<1	--	<1	<1	1	12	<5	5	0.1	--	--	7	0.3	2	--	--
28	271146	09/20/89	<10	1	--	<1	2	20	<3	1	<1	0.1	--	--	12	0.5	<1	--	--
29	271178	09/27/89	<10	<1	--	<1	<1	1	150	<1	190	<0.1	--	--	4	0.5	<1	--	--
30	271148	11/16/88	<10	<1	--	<1	<1	1	66	<5	50	<0.1	--	--	22	4	2	--	--
31	271147	11/30/88	<10	<1	--	<1	<1	4	7	<5	<1	<0.1	--	--	130	0.4	<1	--	--
32	271120	09/28/89	<10	<1	--	<1	<1	15	<3	1	<1	<0.1	--	--	7	0.5	<1	--	--
33	271161	08/29/89	20	<1	12	<1	<5	<10	4	<10	2	--	--	<1	<3	0.3	--	--	--
34	271149	11/17/88	<10	<1	--	<1	<1	1	11	8	<1	0.1	--	--	30	0.3	2	--	--
35	310058	09/11/90	10	<1	--	2	<1	10	9	1	6	<0.1	--	--	1800	0.2	<1	1.1	--
36	310009	09/26/89	20	<1	--	<1	<1	<1	7	1	<1	<0.1	--	--	17	0.7	<1	--	--
37	310054	08/25/89	<10	<1	--	<1	<1	4	4	2	<1	<0.1	--	--	<3	0.7	--	--	--
38	310055	08/25/89	10	<1	--	<1	<1	1	4	<1	<1	<0.1	--	--	25	0.4	--	--	--
39	310060	09/12/90	<10	<1	--	<1	<1	1	290	1	84	<0.1	--	--	52	<0.1	8	2.8	--
40	370212	09/12/90	<10	<1	--	<1	<1	1	44	3	57	<0.1	--	--	560	0.2	12	27	--
41	370213	10/02/90	<10	<1	--	<1	<1	1	4	1	<1	<0.1	--	--	120	0.5	<1	40	--
42	410276	08/25/93	<10	<1	3	<1	<1	<1	18	2	110	0.1	<1	<1	10	0.4	--	--	18.0
43	410252	09/11/90	30	<1	--	2	1	1	3	1	<1	<0.1	--	--	5	0.2	<1	1	--
44	410253	09/28/90	<10	<1	--	<1	<1	1	<3	<1	<1	<0.1	--	--	<3	0.5	<1	7.1	--
45	410269	09/10/92	<1	<1	7	<1	<1	4	6	<1	<1	<.1	<1	<1	190	0.2	--	--	86.0

Table 7b.-- Chemical analyses of water samples from wells in bedrock of the Highlands and Valley and Ridge physiographic provinces of New Jersey (minor and trace dissolved constituents). Wells correspond to figure 2.

Well Number	USGS Unique Number	Sample Collection Date	Aluminum (µg/L as Al)	Arsenic (µg/L as As)	Barium (µg/L as Ba)	Cadmium (µg/L as Cd)	Chromium (µg/L as Cr)	Copper (µg/L as Cu)	Iron (µg/L as Fe)	Lead (µg/L as Pb)	Manganese (µg/L as Mn)	Mercury (µg/L as Hg)	Selenium (µg/L as Se)	Silver (µg/L as Ag)	Zinc (µg/L as Zn)	Carbon, organic (mg/L as C)	Phenols, total (mg/L)	Gross Alpha, dissolved (pci/L as U - Natural)	Gross Alpha, dissolved (pci/L as Th - 230)
Kittatinny Supergroup																			
46	190300	09/11/91	<10	<1	--	<1	<1	<1	7	<1	<1	<.1	--	--	<3	0.5	2	1.8	--
47	190256	11/02/89	<10	<1	34	<1	<5	<10	<3	10	<1	--	--	2	14	0.4	--	--	--
48	271727	09/30/92	<10	<1	7	<1	<1	<1	5	<1	<1	<.1	<1	<1	<3	0.3	--	--	<0.6
49	271144	05/15/89	<10	<1	--	<1	<1	1	19	<1	7	<.1	--	--	<3	0.4	<1	--	--
50	271123	10/25/89	--	<1	5	<1	<5	<10	10	<10	<1	--	--	<1	<3	0.3	--	--	--
51	271106	08/24/88	--	--	20	<1	<5	<10	<3	<10	14	--	--	<1	130	0.4	--	--	--
52	271118	11/02/89	--	<1	8	<1	<5	<10	<3	<10	<1	--	--	<1	<3	0.4	--	--	--
53	271156	10/27/89	--	<1	13	<1	<5	<10	<3	<10	<1	--	--	<1	62	0.5	--	--	--
54	271303	09/20/94	<10	<1	22	<1	<1	<1	9	<1	4	<.1	<1	<1	<3	0.2	--	--	0.9
55	370257	08/24/93	<10	<1	17	<1	<1	<1	17	<1	3	<.1	<1	<1	<3	0.2	--	--	1
56	370002	05/09/91,	<10	<1	--	<1	<1	1	5	<1	5	<.1	--	--	7	0.4	1	3.6	--
57	370236	08/13/93	<10	<1	69	<1	<1	<1	27	<1	4	0.2	<1	<1	<3	<.1	--	--	2.2
58	370214	04/17/91	10	<1	--	<1	<1	6	4	1	<1	1	--	--	9	0.7	<1	--	<0.6
59	370205	09/09/91	<10	2	--	<1	<1	<1	870	<1	250	<.1	--	--	<3	1.8	1	1.2	--
60	370218	09/20/91	<10	<1	--	<1	<1	<1	6	<1	2	<.1	--	--	11	0.2	1	2.8	--
61	370219	09/10/91	<10	<1	--	<1	<1	<1	15	<1	5	<.1	--	--	24	0.5	2	1.0	--
62	370220	04/04/91	<10	<1	--	1	<1	2	<3	<1	1	<.1	--	--	88	0.3	<1	1.7	--
63	370371	09/27/95	<10	<1	<100	<1	<1	5	20	<1	10	<.1	<1	<1	60	0.2	--	--	--
64	410257	09/23/92	20	<1	28	<1	<1	1	240	<1	45	<.1	<1	<1	3	0.3	--	--	4.7
65	410258	09/23/92	<10	<1	26	<1	<1	2	58	<1	35	<.1	<1	<1	25	0.2	--	--	4.6
66	410260	08/26/92	10	<1	11	<1	1	3	<3	<1	<1	<.1	<1	<1	<3	0.2	--	1	1
67	410313	09/14/95	<10	<1	47	<1	<1	--	10	<1	2	<.1	<1	<1	--	0.2	--	--	<3.0
68	410017	09/22/92	<10	<1	17	<1	<1	3	<3	1	<1	<.1	<1	<1	10	0.3	--	--	<0.6

Table 7b.-- Chemical analyses of water samples from wells in bedrock of the Highlands and Valley and Ridge physiographic provinces of New Jersey (minor and trace dissolved constituents). Wells correspond to figure 2.

Well Number	USGS Unique Number	Sample Collection Date	Aluminum (µg/L as Al)	Arsenic (µg/L as As)	Barium (µg/L as Ba)	Cadmium (µg/L as Cd)	Chromium (µg/L as Cr)	Copper (µg/L as Cu)	Iron (µg/L as Fe)	Lead (µg/L as Pb)	Manganese (µg/L as Mn)	Mercury (µg/L as Hg)	Selenium (µg/L as Se)	Silver (µg/L as Ag)	Zinc (µg/L as Zn)	Carbon, organic (mg/L as C)	Phenols, total (mg/L)	Gross Alpha, dissolved (pCi/L as U - Natural)	Gross Alpha, dissolved (pCi/L as Th - 230)
Kittatinny Supergroup (continued)																			
69	410274	09/17/93	<10	<1	45	<1	<1	<1	<3	2	<1	<.1	<1	<1	16	0.4	--	--	1.1
70	410247	04/11/91	<10	<1	--	<1	<1	1	180	1	430	<.1	--	--	35	0.4	<1	3.2	--
71	410021	09/30/91.	--	<1	--	<1	<1	13	<3	1	<1	0.2	--	--	<3	0.3	<1	1.2	--
Martinsburg Formation																			
72	370237	08/13/93	<10	<1	27	<1	<1	<1	13	<1	120	0.2	<1	<1	4	0.3	--	--	3.3
73	370362	08/24/95	10	<1	60	<1	<1	<1	4	<1	4	<.1	<1	<1	<10	0.2	--	--	<3
74	370363	08/22/95	2	1	25	<1	<1	<1	71	<1	260	<.1	<1	<1	12	0.5	--	--	<3
75	370367	09/19/95	<10	<1	<100	<1	<1	14	<10	<1	<10	<.1	<1	<1	10	0.2	--	--	<3
76	370368	09/26/95	10	<1	<100	<1	<1	<1	<10	<1	20	<.1	<1	<1	40	0.1	--	--	<3
77	370369	09/20/95	<10	3	<100	<1	<1	6	<10	<1	10	<.1	<1	<1	<10	0.6	--	--	<3
78	370258	08/17/93	<10	<1	44	<1	<1	16	11	<1	40	<.1	<1	<1	320	0.4	--	--	1.2
79	370370	09/25/95	10	<1	<100	<1	<1	3	<10	<1	<10	<.1	<1	<1	<10	0.5	--	--	<3
80	370372	09/18/95	<10	<1	100	<1	<1	2	<10	<1	30	<.1	<1	<1	70	0.5	--	--	<3
81	370235	08/12/93	<10	<1	9	<1	<1	<1	14	1	58	<.1	<1	<1	<3	0.2	--	--	0.9
82	370217	03/22/91	<10	<1	--	<1	<1	1	5	<1	<1	.1	--	--	<3	0.4	<1	1.3	--
83	370221	04/25/91	<10	<1	--	<1	<1	2	92	<1	160	0.2	--	--	7	0.5	<1	0.9	--
84	370263	06/23/93	10	1	72	<1	<1	<1	7	<1	11	<.1	<1	<1	<3	0.4	--	--	1.7
85	370265	08/23/93	<10	<1	5	<1	<1	2	14	<1	190	<.1	<1	<1	80	0.3	--	--	1.7
86	370366	08/21/95	<10	<1	400	<1	<1	<1	54	<1	53	<.1	<1	<1	11	0.5	--	--	<3
87	370373	08/23/95	<10	<1	6	<1	<1	--	<3	<1	<1	<.1	<1	<1	--	0.5	--	--	<3
88	410001	09/25/91	<10	<1	--	<1	<1	<1	3	<1	<1	<.1	--	--	12	0.3	1	--	1.5
89	410259	09/16/92	<10	<1	3	<1	<1	11	<3	<1	<1	<.1	<1	<1	4	0.3	--	--	<.6

Table 7b.-- Chemical analyses of water samples from wells in bedrock of the Highlands and Valley and Ridge physiographic provinces of New Jersey (minor and trace dissolved constituents). Wells correspond to figure 2.

Well Number	USGS Unique Number	Sample Collection Date	Aluminum (µg/L as Al)	Arsenic (µg/L as As)	Barium (µg/L as Ba)	Cadmium (µg/L as Cd)	Chromium (µg/L as Cr)	Copper (µg/L as Cu)	Iron (µg/L as Fe)	Lead (µg/L as Pb)	Manganese (µg/L as Mn)	Mercury (µg/L as Hg)	Selenium (µg/L as Se)	Silver (µg/L as Ag)	Zinc (µg/L as Zn)	Carbon, organic (mg/L as C)	Phenols, total (mg/L)	Gross Alpha, dissolved (pci/L as U - Natural)	Gross Alpha, dissolved (pci/L as Th - 230)
Martinsburg Formation (continued)																			
90	410273	08/12/93	<10	<1	27	<1	<1	23	<3	<1	41	0.2	<1	<1	6	0.2	--	--	1.5
91	410312	09/14/95	<10	<1	42	<1	<1	3	4	<1	7	<.1	3	<1	21	0.2	--	--	3.6
92	410277	09/17/93	10	<1	77	<1	<1	120	13	<1	5	--	<1	<1	<3	0.2	--	--	--
93	410256	09/30/91	--	<1	--	<1	<1	12	<3	<1	<1	<.1	--	--	160	0.4	<1	3.4	--
94	410255	03/15/91	<10	<1	--	<1	<1	2	4	<1	<1	<.1	--	--	6	0.3	<1	<0.6	--
95	410272	08/12/93	<1	<1	<2	<1	<1	7	<3	<1	<1	0.2	<1	<1	<3	<.1	--	--	<0.6
96	410275	09/16/93	<10	<1	21	<1	<1	1	24	<1	23	<.1	<1	<1	5	0.1	--	--	1.5
97	410270	09/16/92	<10	2	100	<1	<1	<1	42	<1	12	<.1	<1	<1	16	0.1	--	--	5.6
Middle Proterozoic Marble																			
98	370255	06/22/93	<10	<1	24	<1	<1	5	<3	<1	<1	<.1	1	<1	8	0.6	--	--	0.7
99	370262	09/17/93	<10	<1	56	<1	<1	4	10	<1	<1	<.1	<1	<1	110	0.4	--	--	4
100	370264	09/16/93	<10	1	19	<1	<1	1	<3	<1	<1	<.1	<1	<1	33	<.1	--	--	<0.6
Paleozoic Unit (High Falls)																			
101	370216	09/18/91	<10	<1	--	<1	<1	3	8	<1	<1	<.1	--	--	7	0.5	1	0.7	--
102	370215	04/16/91	10	<1	--	<1	<1	4	<3	2	<1	<.1	--	--	5	0.5	<1	1.6	--
103	410266	09/17/92	<10	<1	91	<1	<1	26	<3	<1	<1	<.1	<1	<1	8	0.1	--	--	1.8
Paleozoic Unit (Bossardville)																			
104	370202	05/15/91	<10	<1	--	<1	<1	2	<3	<1	<1	<.1	--	--	3	0.6	1	1.5	--
Paleozoic Unit (Esopus)																			
105	370004	04/24/91	<10	<1	--	<1	<1	1	9	<1	3	<.1	--	--	34	0.7	1	4.4	--

GLOSSARY

Alkalinity - A measure of the buffering capacity of a solution to hydrogen ions. Measured by titrating a known concentration of acid into a specific volume of sample until the pH of the sample solution drops to a defined end point. In most natural waters alkalinity is produced by the dissolved carbon dioxide species bicarbonate and carbonate. It is usually reported in mg/L as $CaCO_3$.

Anion - A negatively charged ion or radical.

Anthropogenic - Involving human impact on nature.

Calcite - A common rock-forming mineral composed of calcium carbonate ($CaCO_3$). Usually colorless or white, but exceptionally, may be red, yellow or blue.

Cation - A positively charged ion or radical.

Celsius or centigrade (°C) - Temperature scale that defines zero as the freezing point of water and 100 degrees as the boiling point. It is related to the Fahrenheit scale by the formula °C = 5/9(°F - 32).

Conductance (specific) - A measure of the ability of the water to conduct an electrical current. It is inversely proportional to electrical resistance and is related to the total concentration of ionizable solids in the water. It is usually reported as microsiemens per centimeter (µS/cm) at 25 degrees Celsius.

Dissolved oxygen - A measure of the concentration of gaseous oxygen dissolved in water. For water in contact with the atmosphere, the concentration is a function of temperature, atmospheric pressure and, to a lesser extent solute concentration. Dissolved oxygen is usually reported in mg/L.

Gross alpha particle activity - A measure of alpha radiation activity (positively charged helium nuclei) emitted from radionuclides in a sample of water.

Langelier Index - Estimates the degree of saturation of water with respect to calcium carbonate. Water that is undersaturated with respect of calcium carbonate would be considered corrosive because there would not be a protective deposit of calcite on plumbing. Water that is oversaturated with respect to calcium carbonate would be considered scale producing because calcite is being deposited. A Langelier index of zero indicates that the water is in equilibrium with calcium carbonate (see corrosivity).

Lithification - Hardening of soft sediment into rock.

Major constituent (ground water) - Constituents with concentration generally greater than 5 mg/L.

Micrograms per liter (µg/L) - Unit expressing the weight of solute per unit volume of water. Generally 1.0 µg/L is equivalent to one part solute in one billion parts water.

Microsiemen (µS) - Unit for specific electrical conductance. One microsiemen is equivalent to one micromho reciprocal, the electrical resistance unit microohm.

Milliequivalent per liter (meq/L) - Unit expressing the concentration of valance charge contributed by a particular chemical constituent (for example: Na^{+1} and Cl^{-1}) in one liter of water. The sum of the milliequivalents of cations and anions in a solution should equal zero.

Milligrams per liter (mg/L) - Unit expressing the weight of solute per unit volume of water. Generally 1.0 mg/L is generally equivalent to one part solute in one million parts water.

Minor constituent (ground water) - Constituents with concentrations generally between 0.01 and 10 mg/L.

Nutrients - Wastewater term applied to phosphorous and nitrogen in water.

Picocuries per liter (pCi/L) - A unit for reporting radioactivity in water. One picocurie per liter is equal to 0.037 disintegrations per second in a liter of sample.

pH - The negative base 10 logarithm of the hydrogen ion activity in moles per liter. A pH of 7 is considered neutral, less than 7 is acidic, and greater than 7 is alkaline.

Primary drinking water standard - Federal- and state-regulated Maximum Contaminant Levels allowed in public drinking water supplies to protect the health of persons.

Secondary drinking water standard - Federal- and state-recommended Lower and Maximum Contaminant Levels regulated to protect the public welfare, usually set to regulate aesthetic qualities of water, such as taste, odor, or color.

Total dissolved solids - A measure of the dissociated organic and inorganic matter, dissolved and in the form of particulates, in water. It is obtained by weighing the residue left after evaporating a known quantity of water at a prescribed temperature. Total dissolved solids is usually reported in mg/L.

Trace constituent (ground water) - Constituents with concentrations generally less than 0.1 mg/L.

Volatile organic compound (VOC) - Any organic compound that participates in atmospheric photochemical activity. Many such compounds are ubiquitous ground-water pollutants.

GROUND-WATER QUALITY IN THE BEDROCK AQUIFERS OF THE HIGHLANDS AND VALLEY AND RIDGE PHYSIOGRAPHIC PROVINCES OF NEW JERSEY
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GROUND WATER QUALITY IN THE

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