QUALITY OF GROUND WATER IN IDAHO

U.S. GEOLOGICAL SURVEY

Open-File Report 83-50

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By Johnson J. S. Yee and William R. Souza

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CONVERSION FACTORS

Inch-pound units are used in this report. The conversion factors to convert to International System of Units (SI) are listed below.

Concentration units for chemical data are given in milligrams per liter (mg/L), or micrograms per liter (µg/L). Specific conductance is expressed as micromhos per centimeter at 25 degrees Celsius (µmho/cm).

To convert degrees Celsius (°C) to degrees Fahrenheit (°F), use the equation:

$$°F = 9/5°C + 32.$$

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon (gal)	3.785	liter (L)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
million gallons per day per acre [(Mgal/d)/acre]	0.1083	cubic meter per second per hectare [(m^3/s)ha]
micromho per centimeter (µmho/cm)	1.000	microsiemens per centimeter (µS/cm)

LIST OF ABBREVIATIONS USED IN THIS REPORT

EPA -------- U.S. Environmental Protection Agency

IDHW ------- Idaho Department of Health and Welfare, Division of Environment

IDWR ------- Idaho Department of Water Resources

INEL ------- Idaho National Engineering Laboratory

NURE ------- National Uranium Resource Evaluation

STORET ----- Storage and Retrieval System (EPA's computerized data-management system)

USBR ------- U.S. Bureau of Reclamation

USGS ------- U.S. Geological Survey

WATSTORE --- National Water Data Storage and Retrieval System (USGS computerized data-processing and retrieval system)

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ABSTRACT

The major aquifers in Idaho are categorized under two rock types, sedimentary and volcanic, and are grouped into six hydrologic basins. Areas with adequate, minimally adequate, or deficient data available for ground-water-quality evaluations are described.

Wide variations in chemical concentrations in the water occur within individual aquifers, as well as among the aquifers. The existing data base is not sufficient to describe fully the ground-water quality throughout the state; however, it does indicate that the water is generally suitable for most uses. In some aquifers, concentrations of fluoride, cadmium, and iron in the water exceed U.S. Environmental Protection Agency's drinking-water standards. Dissolved solids, chloride, and sulfate may cause problems in some local areas.

Water-quality data are sparse in many areas, and only general statements can be made regarding the areal distribution of chemical constituents. Few data are available to describe temporal variations of water quality in the aquifers.

Primary concerns related to special problem areas in Idaho include: (1) protection of water quality in the Rathdrum Prairie aquifer, (2) potential degradation of water quality in the Boise-Nampa area, (3) effects of widespread use of drain wells overlying the eastern Snake River Plain basalt aquifer, and (4) disposal of low-level radioactive wastes at the Idaho National Engineering Laboratory.

Shortcomings in the ground-water-quality data base are categorized as: (1) multiaquifer sample inadequacy, (2) constituent coverage limitations, (3) baseline-data deficiencies, and (4) data-base nonuniformity.

1.0 INTRODUCTION

Report Summarizes Current Quality of Ground Water Conditions in Idaho

This report provides information about the current quality of ground water in the major aquifers in Idaho and describes that quality on areal and temporal bases to the level of detail possible from the available data.

In Idaho, as in the rest of the nation, the quality of ground-water resources can be degraded by human activities. To describe current conditions of ground-water quality and to assess potential changes, an adequate data base is essential. Where sufficient data are available, water quality in the major aquifers can be described on areal and, in few places, temporal bases. Where data are not sufficient, the water quality can only be described in a general manner, or not at all.

The purpose of this report is to present the results of a study whose primary objectives were to: (1) obtain and examine existing water-quality data and assess their value for use in representing natural and current water-quality conditions in particular aquifers or basins, (2) identify possible deficiencies in existing data and (3) suggest ways to improve data base.

Areas of Idaho with adequate, minimally adequate, or deficient data are shown in figure 1.0. Specific statistical criteria could not be applied to every aquifer to assess current water-quality conditions or to judge adequacy of the data. Each major aquifer was evaluated individually in relation to areal extent and representativeness of data. Data are considered adequate where they are sufficiently abundant to confidently define variations in one or more water-quality indicators in space and time over a major part of an aquifer. Data are considered minimally adequate where they are sparse and only general statements can be made regarding the areal distribution of the indicators. Data are deficient where they are absent or can be used only to indicate conditions at isolated sites and no correlations can be made between sites.

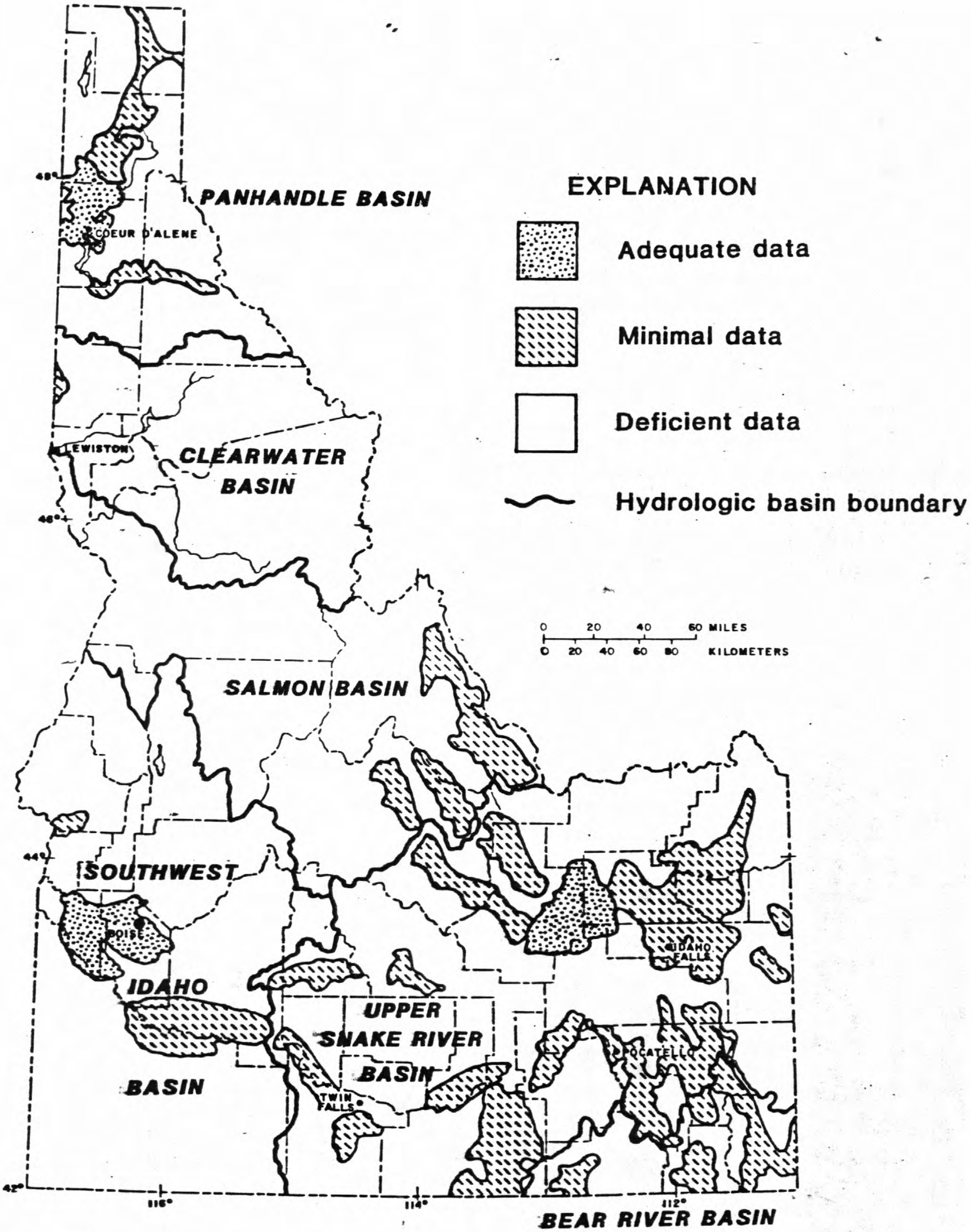


Figure 1.0. — Areas of Idaho with adequate, minimal, or deficient data on quality of ground water.

Ground-Water Sources Supply More Than One-Third of the Water Used in Idaho

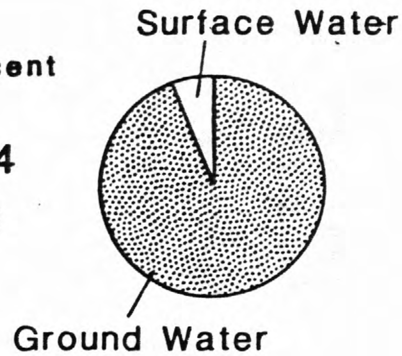
Ground water is an important source for all major water uses and constitutes 90 percent of the public water supply in Idaho.

Ground water is the principal source of industrial, public, and rural water supplies in Idaho. In addition, it supplies an ever-increasing part of water used for irrigation. The resources can be divided into two major types: cold water and thermal water. Thermal water is used for space heating, health spas, recreation, and irrigation. In 1980, the total rate of ground-water withdrawal from all sources was about 6,340 Mgal/d. Water for public supply and rural domestic uses serves the largest number of people and is potentially most sensitive to contamination. By far, the largest amount of water used in Idaho is for industry and agriculture. For these uses, the quantity of water is generally more essential than quality; but, because the water is drawn from the same sources as are the public water supplies, the quality of ground water must be protected. Figure 2.0 shows that the percentage of ground water for the major water uses in Idaho ranges from 26 percent for irrigation to 94 percent for industrial use.

Self-supply industrial use of water in Idaho is exceedingly high in comparison to other states in the nation. This is because the portion attributed to ground water includes natural discharge from springs, which is used for fish farming.

Public water supply served a total of 709,000 people in Idaho during 1980 (K. J. Reid, oral commun., 1982), which accounts for 75 percent of the state population. Of the total number on public supplies, 592,000 persons, or 84 percent, were served from ground-water sources. Also, in 1980, 4 million acres of land were under irrigation in Idaho, about one-third of which was irrigated with ground water. Based on the 4,060 Mgal/d withdrawn for irrigation as shown on figure 2.0, this amounts to an average withdrawal of about 0.003 (Mgal/d)/acre.

	Million Gallons Per Day	Percent
SELF-SUPPLY INDUSTRIAL		
Ground water	2,080	94
Surface water	123	6
	2,230	
PUBLIC SUPPLY		
Ground water	148	90
Surface water	16	10
	164	
RURAL USE		
Ground water	53	79
Surface water	14	21
	67	
IRRIGATION		
Ground water	4,060	26
Surface water	11,600	74
	15,660	
TOTAL WATER USE		
Ground water	6,341	35
Surface water	11,753	65
	18,094	



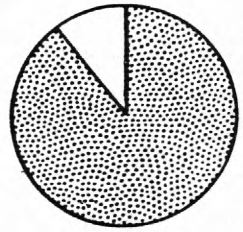
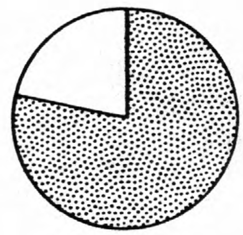
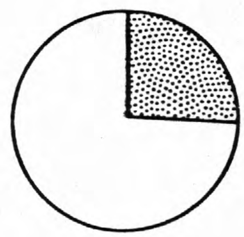
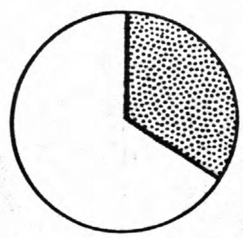





Figure 2.0. -- Water withdrawn from ground- and surface-water sources in Idaho during 1980.

3.0 FACTORS AFFECTING GROUND-WATER QUALITY

Ground-water Quality Affected by

Natural Influences and Human Activities

Ground-water quality may vary greatly from aquifer to aquifer. Variations are caused by contact with the geologic environment and by man's activities.

The quality of ground water is affected by the processes of nature and by man's activities. Natural factors that affect the initial quality of the water include: (1) chemistry of precipitation; (2) dissolution of organic and mineral substances from vegetation, soil, and rocks as the water infiltrates the land surface and percolates through earth materials; and (3) length of time of contact with soil and rocks. These factors determine the concentrations of dissolved minerals in ground water.

Man's activities cause changes in water quality either by withdrawing water from the ground-water system or by adding chemicals and contaminants directly into the aquifers. Contaminants are added to the ground-water system primarily through waste discharges from agricultural, industrial, and urban sources. In Idaho, the sources of wastes and associated types of contaminants most likely to affect ground-water quality are listed in table 3.0.

Table 3.0 Natural and human factors affecting ground-water quality

Natural factors

Natural source	Types of contaminant
Precipitation	Dissolved gases, dust and emission particles.
Infiltration through: Vegetation, Swamps, Soil and rocks (above water table).	Biochemical products, organic materials, color and minerals.
Aquifer rocks	Minerals content (increases with time of contact).
Interaquifer mixing of cold water and thermal water.	Minerals and gases.

Human factors

Waste source	Types of contaminant
Agricultural activities	Fertilizers, pesticides and herbicides.
Mining operations:	
Ore-processing plants	Metallic trace elements, phosphates.
Nuclear facilities	Radiochemicals, heat, dissolved solids.
Urban activities: Storm and sanitary sewers, Sewage-disposal plants, Cesspools and septic tanks, Sanitary landfills	Organic materials, dissolved solids, suspended solids, detergents, bacteria, phosphate, nitrate, sodium, chloride, sulfate, metallic trace elements, and others.
Industrial facilities: Food processors	Biochemical oxygen demand, suspended solids, sodium, chloride.
Geothermal activities	Heat, dissolved solids, fluoride, metallic trace elements.
Hazardous waste- and toxic waste-disposal sites	Toxic metals, hazardous chemicals, organic compounds.

Computerized Data-Management Systems Provide Data on Ground-Water Quality

WATSTORE, the USGS's National Water Data Storage and Retrieval System was used as the primary source of data for evaluating ground-water quality in the state. Other sources of data included EPA's Storage and Retrieval System (STORET), water-quality files of Idaho Department of Water Resources and Idaho Department of Health and Welfare, and published reports by Idaho State and Federal agencies.

WATSTORE is a computerized data-management system used by the USGS to store, analyze, synthesize, and retrieve water-resources information. For this study, the WATSTORE Water-Quality File was used as the primary source to evaluate ground-water quality because it contains the most data. At the time of study (1981-82), chemical analyses were available in this file for about 2,800 ground-water sites in Idaho. The number of these sites in each county are shown on figure 4.0. Data from all of the sites were used to make the evaluations presented in this report. Data from other sources, where available and relevant, were also used. Limitations of time and large variations in data format precluded combining information from all data sources into WATSTORE for a single-system evaluation.

STORET is EPA's computerized data-management system. It is similar to WATSTORE and is used nationally by several users, including other Federal and State agencies.

Reports and water quality data are available from the following agencies:

IDWR is the principal State agency responsible for water-resources planning and regulation in Idaho. Most of the IDWR ground-water-quality data are collected in cooperation with USGS and are available in file records, published reports, and WATSTORE.

IDHW deals with problems related to water pollution, environmental protection, health, and the Safe Drinking Water Act in Idaho. Many of their data are included in file records and in STORET.

INEL is the Nation's testing ground for nuclear reactors. USGS operates a network of observation wells whose primary purpose is to monitor the effects of INEL operations on ground-water quality. The water-quality data collected are available in WATSTORE.

NURE project collects water-quality data to evaluate uranium resources in the continental United States. The NURE data are available through published reports and on computer tapes.

USBR investigates ground-water quality as part of their water-management studies. Their data are available through STORET.

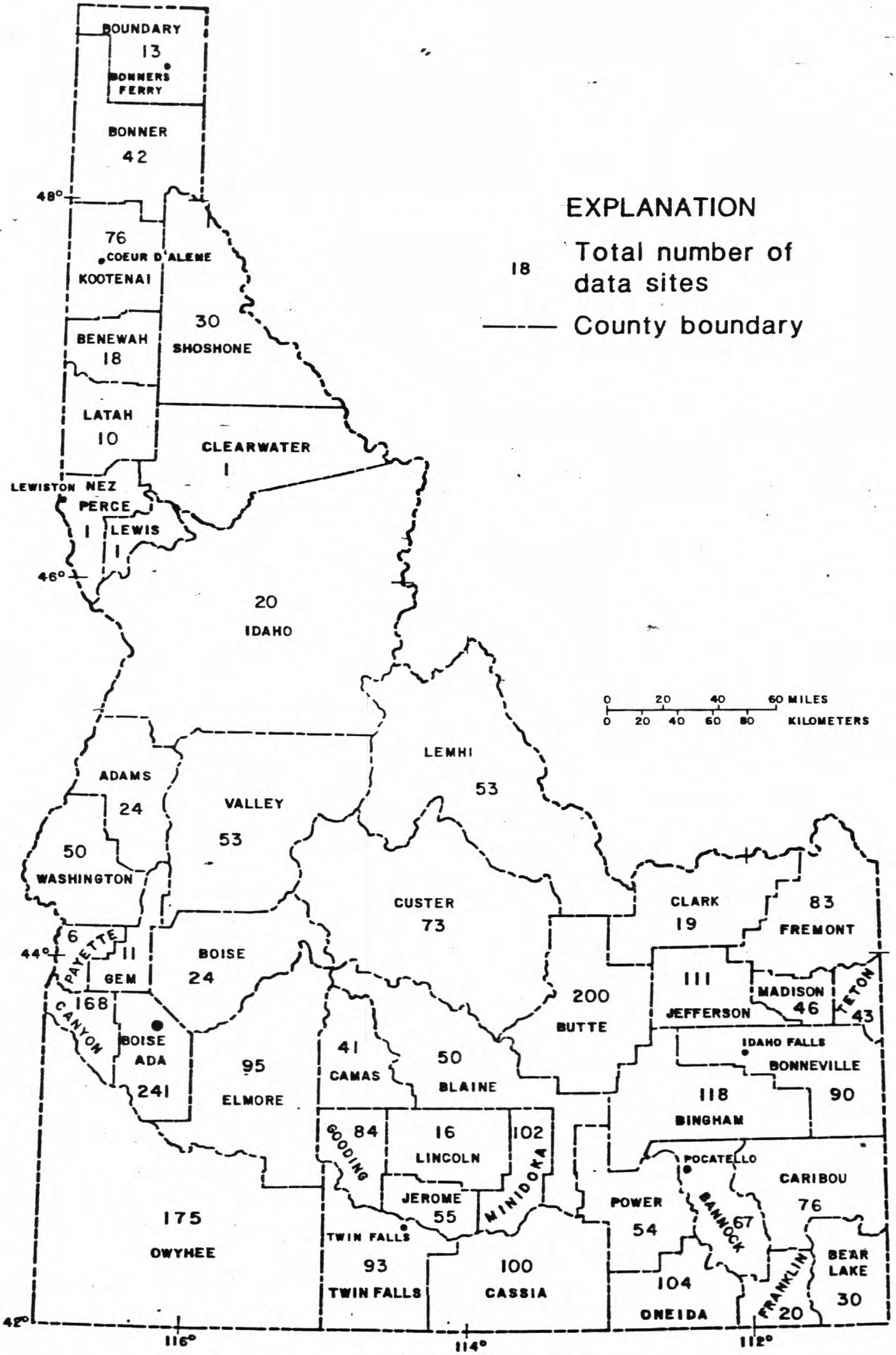


Figure 4.0. -- Number of sites in each county for which chemical analyses of ground water are available in WATSTORE.

5.0 DATA ANALYSIS

Water-quality Data Analyzed using SAS
to Produce Statistical Summaries

SAS[1/] (Statistical Analysis System) is used to compute descriptive statistics for selected water-quality constituents.

SAS is a computer-software system that contains programs for statistical analysis of data. The system, available through WATSTORE or STORET, is used to retrieve and summarize data into interpretable formats. The SAS UNIVARIATE procedure was used to produce the descriptive statistics of water-quality data in this report. A statistical summary of key indicators for water in a glacial deposits aquifer is shown on figure 7.2. For each constituent within an aquifer, the summary lists number of analyses evaluated, minimum and maximum values in the data, median or middle value of each data set, mean or arithmetic average, and standard deviation.

Constituents selected for SAS evaluation and their significance as water-quality indicators are listed in table 5.0.

[1/] The use of brand names in this report is for identification purposes only and does not constitute endorsement.

Table 5.0 Constituents of water and their significance as water-quality indicators

Constituent	Significance
Specific conductance	Specific conductance is a measure of the electrical conductivity of water. It varies with the amount of dissolved solids, and is used to approximate the dissolved-solids content.
pH	pH values range from 0 to 14. It is an indicator of acidity or basicity. Water with a pH of 7.0 is neutral. Water with pH values less than 7.0 is acid, and values greater than 7.0 is basic of alkaline.
Temperature	Temperature affects solubility in and viscosity of the water. As used by Whitehead and Parliman (1979), and for purposes of this report, water temperatures above 18°C indicate a thermal-water source; temperatures at or below 18°C indicate a cold-water source.
Dissolved solids	Mineral constituents dissolved in water constitute dissolved solids. Water having concentrations greater than 500 mg/L is undesirable for drinking and many industrial uses.
Nitrogen, nitrite plus nitrate	An indicator of sewage and agricultural contamination. Water containing more than 10 mg/L has been suspected to cause methemoglobinemia in infants.
Sulfate	Dissolved from rocks and soils containing sulfur compounds. Also from industrial wastes. More than 250 mg/L is objectionable in drinking water supplies.

Table 5.0 Constituents of water and their significance as water-quality indicators--Continued

Constituent	Significance
Hardness	Hardness in water is caused mostly by the calcium and magnesium concentrations. Hard water consumes soap and synthetic detergents. Hardness of water is classified by Durfor and Becker (1964) as follows:

Description	Hardness range (mg/L)
Soft	0-60
Moderately hard	61-120
Hard	121-180
Very hard	More than 180

Constituent	Significance
Silica	Dissolved from rocks and soil. Together with calcium and magnesium, silica forms scale in boilers and steam turbines.
Fecal coliform bacteria	The presence of fecal coliform bacteria in water indicate contamination from human or animal wastes. Fecal coliforms are present in the intestines and feces of warm-blooded animals.
Total coliform bacteria	Total coliform densities are used to indicate sanitary conditions for drinking water. The absence of total coliforms is evidence of a bacteriologically safe water.
Iron	Dissolved from practically all soils and rocks. Also derived from industrial wastes, corroded well casings, pipes, pumps and other cast iron or steel objects in contact with water. Iron concentration greater than 0.3 mg/L (300 µg/L) is not recommended for public water supply without treatment.

6.0 HYDROLOGIC BASINS AND MAJOR AQUIFERS

Major Aquifers Categorized Under Two Rock Types, Sedimentary and Volcanic

Areas of similar geology and hydrology allow the major aquifers to be grouped into six hydrologic basins. Data are sufficient to describe water-quality conditions at various levels of detail in only selected aquifer groups.

Seventy major ground-water flow systems have been identified in Idaho by Graham and Campbell (1981). Data are not sufficient to make water-quality evaluations for all of these systems. For this study, systems with similar geology and hydrology are combined into single aquifers and categorized under two rock types; sedimentary and volcanic. To facilitate the evaluations and to allow ease of comparison, the aquifers are grouped within six hydrologic basins, five of which drain to the Columbia River and one to the Great Salt Lake in Utah. The basin boundaries generally follow the divisions used by the IDHW (1980a), which were based on hydrologic units (U.S. Geological Survey, 1975). The generalized areal extent of major aquifers and boundaries of the hydrologic basins are shown on figure 6.0. Data are sufficient to describe water-quality conditions at various levels of detail in only selected aquifer groupings, which are discussed in Sections 7.0-12.0 of this report.

The northernmost basin is the Panhandle basin, which consists of five counties and includes the important Rathdrum Prairie-Coeur d'Alene area. Data from this basin are minimal except for the glacial deposits aquifer described in Section 7.2 of this report.

The Clearwater and Salmon basins, comprising the lower panhandle and north-central parts of the State, have limited water development, small population and little agriculture. Data for these basins are too few to describe ground-water quality in any great detail.

The Southwest Idaho basin is the most populous. A large number of water-quality data are available, most of which are from around Boise. Water-quality conditions in parts of this basin can be described in some detail.

The Upper Snake River basin is the largest of the six basins. This area is farmed extensively and is heavily irrigated with both surface and ground waters. In addition to agriculture, there are phosphate ore-processing operations and nuclear reactor facilities within the basin. Population centers, agricultural development, and water use are concentrated near the Snake River. Data are minimal to make any detailed descriptions of water quality except in the INEL area (for location, see fig. 11.2).

The Bear River basin, in the southeastern corner of Idaho, drains to the Great Salt Lake. Historically, the basin area has been heavily irrigated and, more recently, influenced by phosphate mining and waste disposal near Soda Springs. Data are generally minimal to describe ground-water quality.

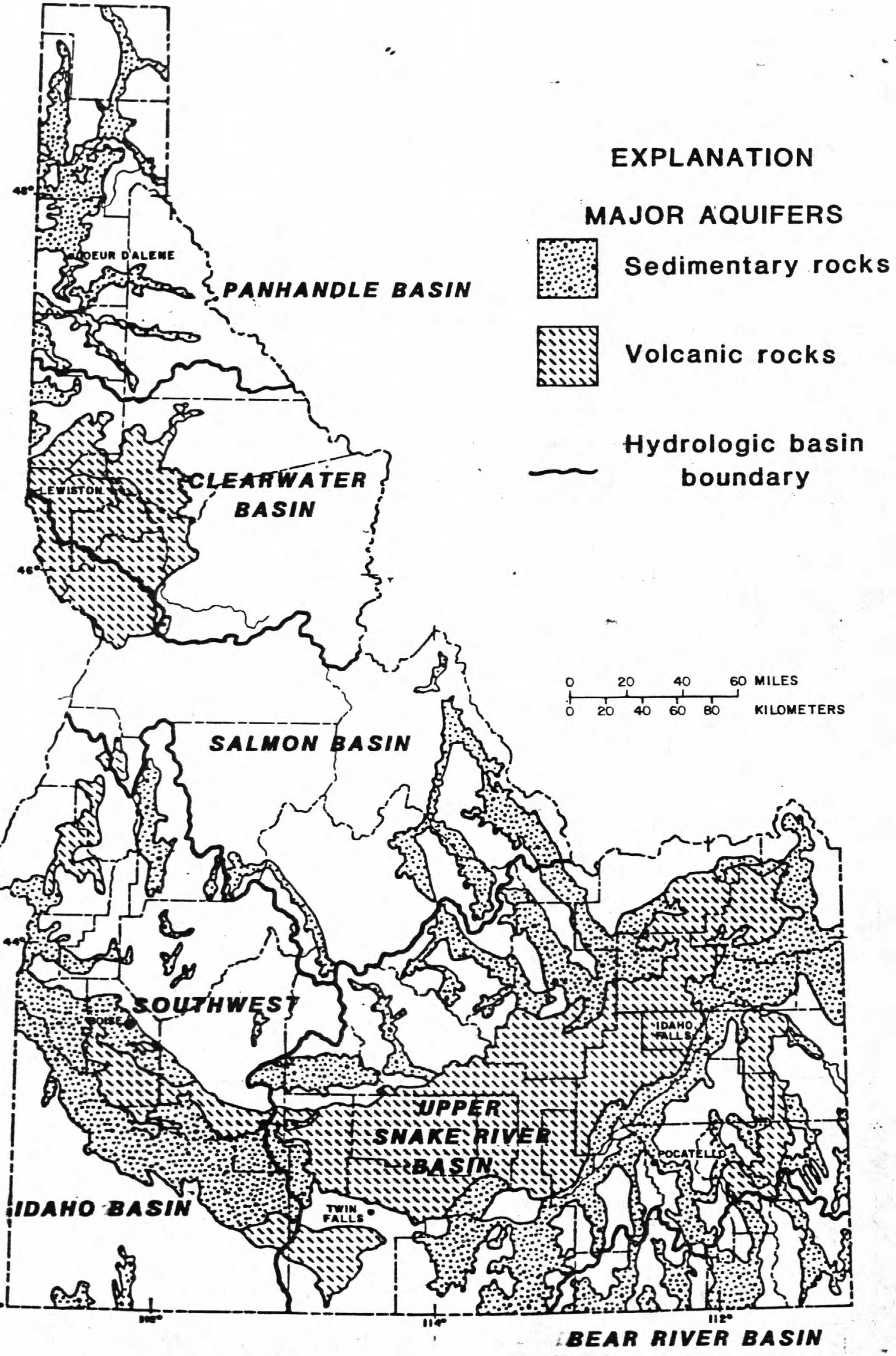


Figure 6.0. — Hydrologic basins and generalized areal extent of major aquifers in Idaho.

7.0 PANHANDLE BASIN

7.1 CHEMICAL CHARACTERISTICS OF WATER IN MAJOR AQUIFERS

Five Aquifers Ranging in Age from Quaternary to Precambrian Have Been Identified in the Panhandle Basin

A sufficient number of analyses with which to determine chemical mean composition of the water are available for only three of the aquifers in the Panhandle basin. Based on available analyses, the water type in these three aquifers can be classified as calcium bicarbonate.

Based on geologic units, five aquifers have been identified in the Panhandle basin by Parliman and others (1980). They are in: (1) Quaternary alluvium (and colluvium); (2) Quaternary glacial deposits; (3) Tertiary Columbia River Basalt Group; (4) Tertiary and Cretaceous granitic rocks, undifferentiated; and (5) Cambrian and Precambrian sedimentary, igneous, and metamorphic rocks, undifferentiated. An adequate number of analyses are available to determine the chemical mean composition of the water in only three of the aquifers. These three are: (1) the Quaternary alluvial aquifer, which occurs as valley fill along the Coeur d'Alene River; (2) the glacial deposits aquifer, which covers large parts of north Kootenai, Bonner, and Boundary Counties; and (3) the Columbia River Basalt aquifer, which crops out mostly along and between the Saint Maries and Saint Joe Rivers and around Coeur d'Alene Lake.

The chemical mean composition of water from these aquifers is shown in figure 7.1. Statistical summaries of key indicator constituents are given in figures 7.2 and 7.3. In the water in all three aquifers, calcium composes about 50 percent of the total cations and bicarbonate about 90 percent of the total anions. The water types, therefore, are classified as calcium bicarbonate.

An inadequate number of analyses are available to classify the water with any degree of confidence in the other two aquifers. However, in the few analyses available, the percentages of calcium and bicarbonate suggest that these two may also contain calcium bicarbonate type water.

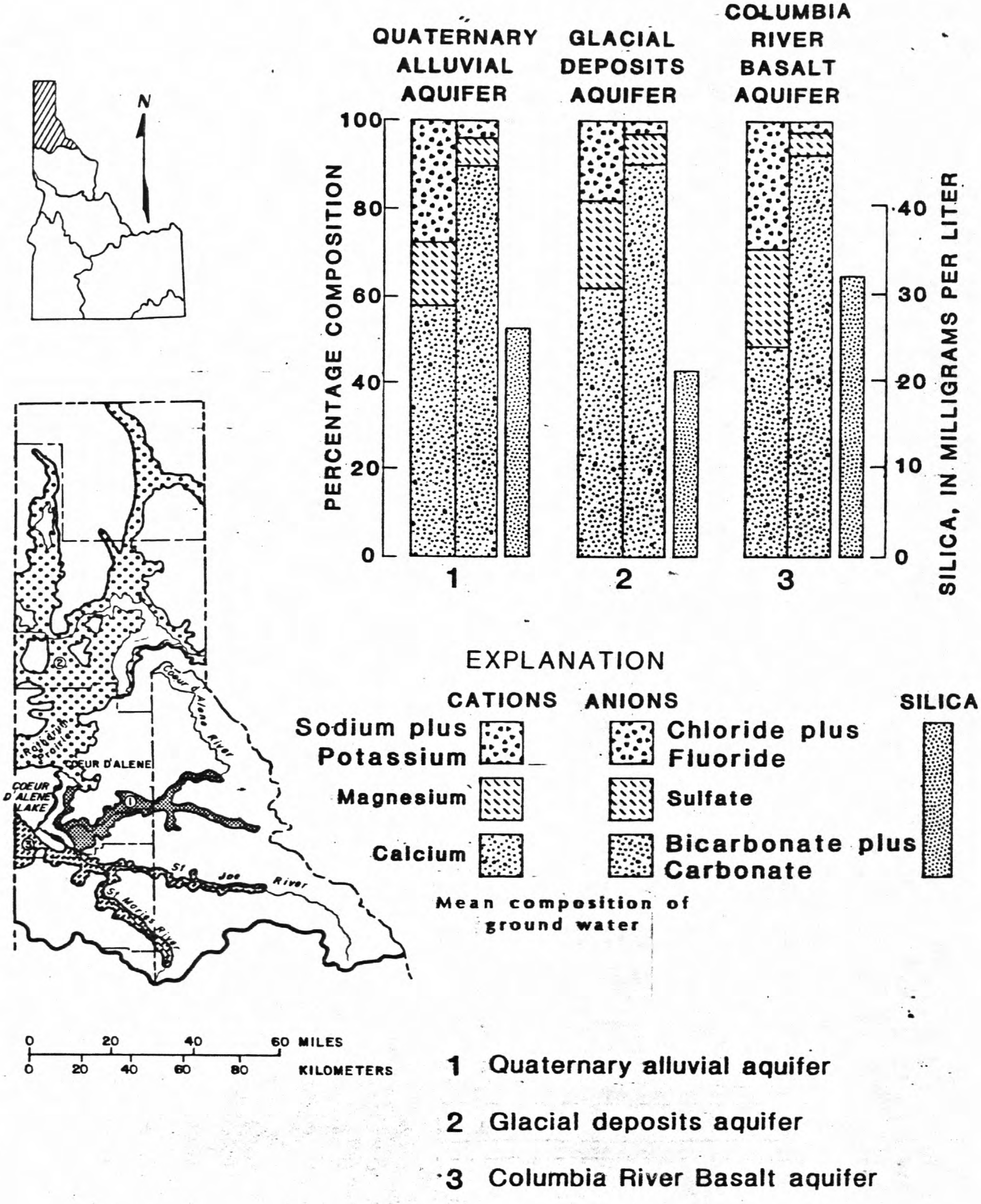


Figure 7.1. — Chemical characteristics of water in major aquifers, Panhandle basin, Idaho.

7.2 QUALITY OF WATER IN GLACIAL DEPOSITS AQUIFER

Aquifer Particularly Susceptible to Contamination from Surface Sources

The glacial aquifer is composed, in large part, of coarse grained, unconsolidated deposits and is the only aquifer in the Panhandle basin where data are sufficient to describe the water quality in some detail. The part of the aquifer in the Rathdrum Prairie area is designated as a "Sole or Principal Source Aquifer" and is not to be jeopardized as a drinking-water supply.

The glacial deposits aquifer, underlying much of the northern part of the Panhandle basin, is north of the city of Coeur d'Alene and includes the important Rathdrum Prairie area. The aquifer is mainly glaciofluvial in origin and is composed, in large part, of coarse grained, unconsolidated deposits, which extend from near land surface to several hundred feet below. Vertical permeability of these deposits is high and no intervening areally extensive confining beds are known to be present. Therefore, water in the aquifer is particularly susceptible to contamination from surface pollutant sources.

The glacial deposits aquifer is the only one with sufficient data to describe the water quality in some detail. A total of 127 analyses were available, most of which represent water in the southern part of the aquifer. Only 10 analyses were available for Boundary County. Most of these showed a high concentration of dissolved solids relative to concentrations in other parts of the aquifer. The 10 analyses are identified in the bar graph of figure 7.2. The graph shows that seven of the nine highest concentrations (greater than 240 mg/L) of dissolved solids were from the part of the aquifer located in Boundary County. The analysis having the highest dissolved solids also had a nitrogen concentration of 25 mg/L. The other analyses showed nitrogen concentrations of no more than 2.9 mg/L.

Within the extent of the glacial deposits aquifer, the Rathdrum Prairie area is of primary concern. Here, the aquifer, locally called Rathrum Prairie aquifer, has been designated by EPA as a "Sole or Principal Source Aquifer." This designation established an area within which EPA monitors all federally-assisted projects to assure that the projects will not degrade water quality or jeopardize the source as a drinking water supply.

The quality of water in the glacial deposits aquifer within the area, Rathdrum Prairie area, as determined from WATSTORE data, is good and suitable for domestic use. Dissolved-solids concentrations, determined as the sum of constituents in the water, did not exceed 230 mg/L. Total and fecal coliform bacteria are seldom detected in the water. Concentrations of dissolved iron sometimes exceeded the secondary drinking-water standard of 300 µg/L (Graham and Campbell, 1981).

STATISTICAL SUMMARY

Glacial deposits aquifer

Constituent	Number of analyses	Mini-mum	Maxi-mum	Median	Mean	Standard deviation
Specific conductance (μmho/cm)	127	32	1050	221	231	149
pH (units)	108	6.0	8.3	7.4	--	--
Temperature (°C)	122	3.0	20	8.8	9.3	2.6
Dissolved solids (mg/L)	119	28	773	149	149	96
Nitrogen, $NO_2 + NO_3$ (mg/L as N)	84	0.1	25	0.1	0.7	2.7
Sulfate (mg/L as SO_4)	127	.7	100	8.9	11	13
Hardness (mg/L as $CaCO_3$)	58	14	610	104	120	104
Silica (mg/L as SiO_2)	51	9.7	49	19	21	8.9
Coliform, fecal (colony/100 mL)	58	< 1	< 1	< 1	--	--
Coliform, total (colony/100 mL)	51	< 1	19	< 1	--	--
Iron, dissolved (μg/L as Fe)	51	.0	5300	20	349	894

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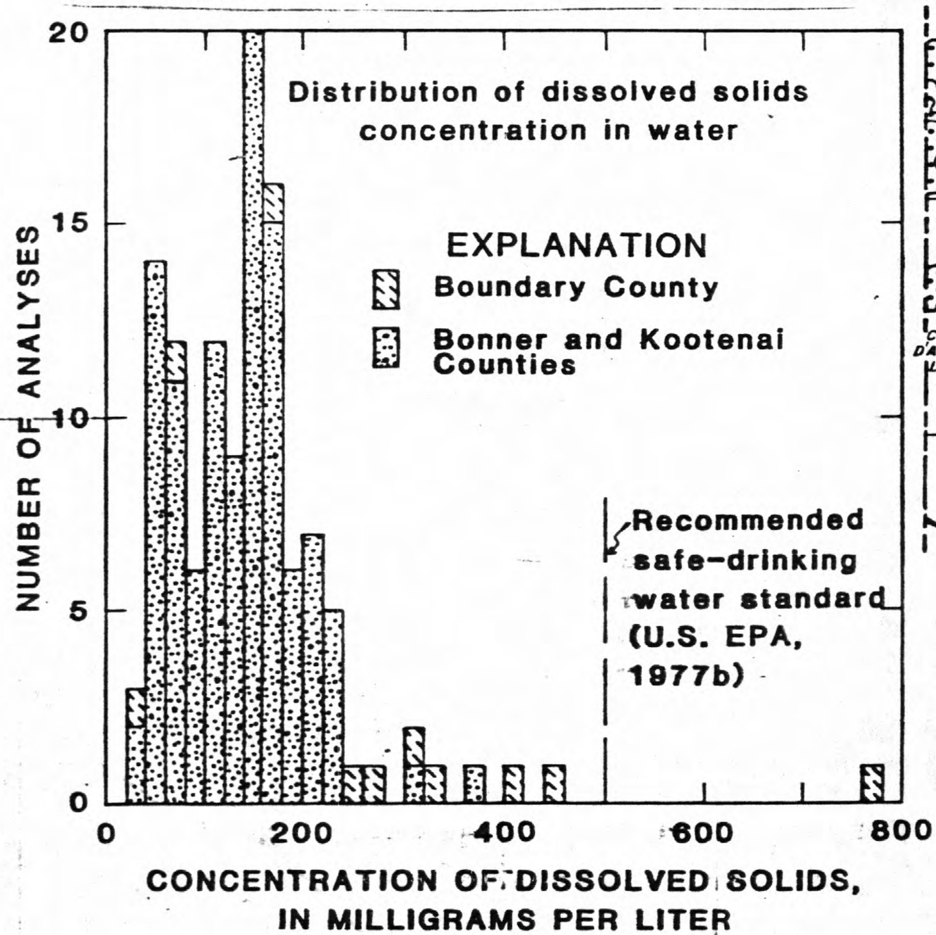


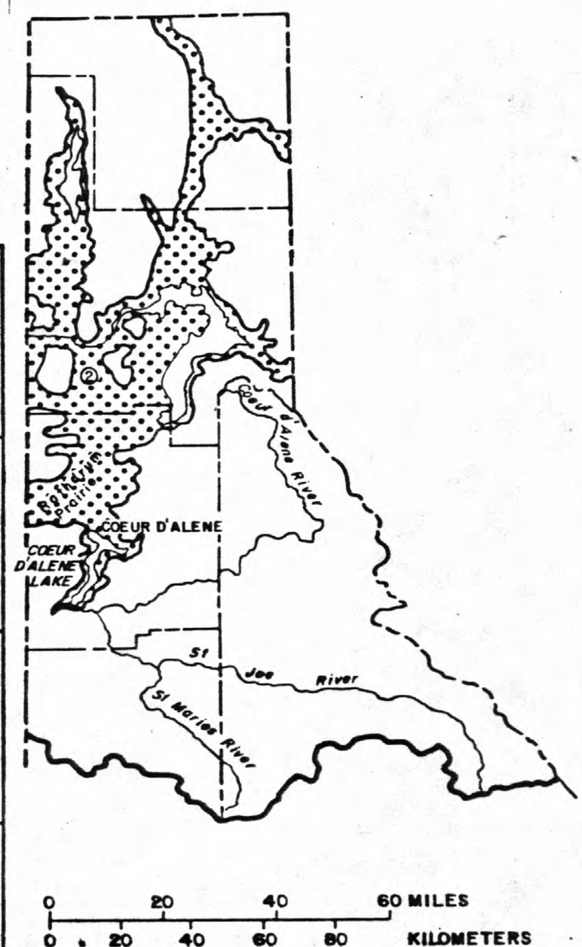


Figure 7.2. -- Statistical summary of key indicators for quality of water in the glacial deposits aquifer, Panhandle basin, Idaho.

7.3 DISSOLVED-SOLIDS CONCENTRATIONS IN RATHDRUM PRAIRIE AQUIFER

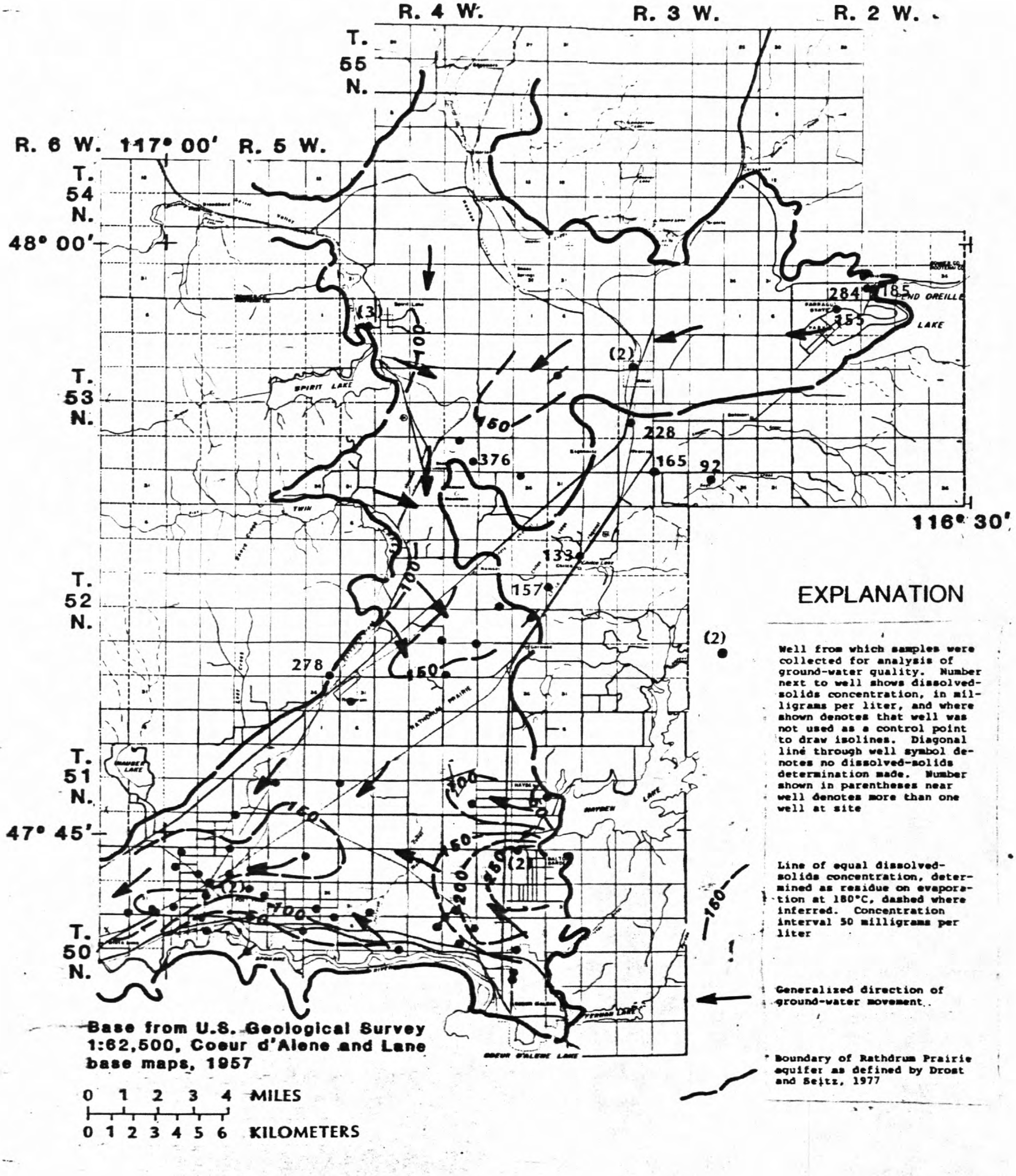
Data Collected from Wells Sampled Between July 1975 and April 1979 Used to Define Dissolved-Solids Distribution

> The distribution of dissolved solids shows that water of relatively low mineral content (dissolved-solids concentration less than 100 mg/L) is introduced to the aquifer at major places of recharge. As the water moves toward the central axis of the aquifer, dissolved-solids concentrations increase to levels generally near 150 mg/L. Relatively high concentrations occur near suburban areas.

The distribution of dissolved-solids concentrations, measured as residue on evaporation at 180°C, in water in the Rathdrum Prairie aquifer is shown in figure 7.3. Data to draw the distribution were retrieved from STORET for 58 wells that are completed in the aquifer. Six of the wells are outside the boundary of the aquifer, as defined by Drost and Seitz (1977), and data from them are not used to define the equal-concentration lines on the figure. Well sites where no dissolved-solids data were available are also plotted to show where other water-quality data for this aquifer are available in STORET. The number of samples periodically collected and analyzed for each site ranged from 1 to 22, between July 1975 and April 1979. For sites having two or more dissolved-solids analyses, an average value was calculated to define the distribution.

With the exception of a few locally high concentration levels, the distribution of dissolved solids shows a characteristic pattern. Water of relatively low mineral content is introduced to the aquifer at major places of recharge, which include the Spokane River and Coeur d'Alene, Hayden, Spirit, and Twin Lakes. (The data do not show this same occurrence at Pend Oreille Lake; local conditions near the wells may be the reason.) As the water moves toward the central axis of the aquifer, dissolved-solids concentrations increase to levels generally near 150 mg/L. Concentrations in excess of 150 mg/L occur near the suburban areas of Post Falls and Dalton Gardens, where land-surface derived wastes probably contribute to the excess. The mound of concentrations over 200 mg/L between Coeur d'Alene and Dalton Gardens is based on only two data points, so its areal extent is inferred.

Data from about 40 additional sites having dissolved-solids determinations for water in the aquifer in Rathdrum Prairie area are available in WATSTORE. These data are included in the Statistical Summary shown on figure 7.2. They were not included in drawing the dissolved-solids-concentration lines shown on figure 7.3 because the determinations are reported as calculated sum of constituents, not as residue on evaporation at 180°C, as reported in STORET. Thus, although similar, the dissolved-solids data stored in these two different storage systems are not entirely comparable for the uses made in this report.



EXPLANATION

(2) ● Well from which samples were collected for analysis of ground-water quality. Number next to well shows dissolved-solids concentration, in milligrams per liter, and where shown denotes that well was not used as a control point to draw isolines. Diagonal line through well symbol denotes no dissolved-solids determination made. Number shown in parentheses near well denotes more than one well at site

—150— Line of equal dissolved-solids concentration, determined as residue on evaporation at 180°C, dashed where inferred. Concentration interval 50 milligrams per liter

← Generalized direction of ground-water movement

Boundary of Rathdrum Prairie aquifer as defined by Drost and Seitz, 1977

Figure 7.3. — Dissolved-solids concentration in water in the Rathdrum Prairie aquifer, based on data collected from July 1975 to April 1979.

7.4 QUALITY OF WATER IN QUATERNARY ALLUVIAL AND COLUMBIA RIVER BASALT AQUIFERS

Dissolved-Solids Concentrations in Water from the Columbia River Basalt Aquifer are Much Lower than in Water from the Quaternary Alluvial Aquifer

A minimal amount of data is available to describe the quality of water in the Quaternary alluvial and Columbia River Basalt aquifers; however, in both aquifers the water-quality characteristics that were analyzed meet drinking-water standards in most places.

The Quaternary alluvial aquifer, consisting of valley-fill material, is located mostly in the Coeur d'Alene River valley. The Columbia River Basalt aquifer, as described in this basin, is located south of the city of Coeur d'Alene, primarily around the Saint Maries area.

The data available for the Quaternary alluvial aquifer are from sources scattered throughout the Coeur d'Alene River valley. These include less than 10 analyses. About the same number of data are available for the Columbia River Basalt aquifer.

The limited amount of data from both aquifers are not areally extensive and are not adequate to describe the overall water quality. However, in general, the water quality characteristics that were analyzed meet drinking-water standards in most places. In the few analyses available, concentrations of trace metals were negligible with the exception of one sample in which the cadmium concentration exceeded the acceptable level of 10 µg/L. That sample contained 23 µg/L cadmium and was taken from a well completed in the Quaternary alluvial aquifer and underlying undifferentiated sedimentary rocks that occur near the municipality of Kellogg, in the Coeur d'Alene mining district (see fig. 13.0).

Statistical summaries of water quality in both aquifers by use of key indicators are shown in figure 7.4. Generally, water in the Columbia River Basalt aquifer has much lower dissolved-solids concentrations than water in the Quaternary alluvial aquifer.

STATISTICAL SUMMARY

Quaternary alluvial aquifer

Constituent	Number of analyses	Mini- mum	Maxi- mum	Median	Mean	Standard deviation
Specific conductance (umho/cm) -------------	4	36	631	284	309	245
pH (units) -------------	3	6.7	7.3	7.1	--	--
Temperature (°C) -------	8	6.9	13	9.4	9.9	2.4
Dissolved solids (mg/L)-	7	188	458	318	324	111
Nitrogen, $NO_2 + NO_3$ (mg/L as N) -----------	8	0.1	.47	.20	.21	.18
Sulfate (mg/L as SO_4)---	8	2.3	56	8.6	19	20

STATISTICAL SUMMARY

Columbia River Basalt aquifer

Constituent	Number of analyses	Mini- mum	Maxi- mum	Median	Mean	Standard deviation
Specific conductance (umho/cm) -------------	9	45	463	159	171	129
pH (units) -------------	5	7.1	8.1	7.6	--	--
Temperature (°C) -------	8	3.5	13	10	9.9	3.0
Dissolved solids (mg/L)-	5	56	132	124	118	53
Nitrogen, $NO_2 + NO_3$ (mg/L as N) -----------	5	.00	.35	.09	.11	.14
Sulfate (mg/L as SO_4)---	9	2.3	9.3	6.4	5.2	2.5

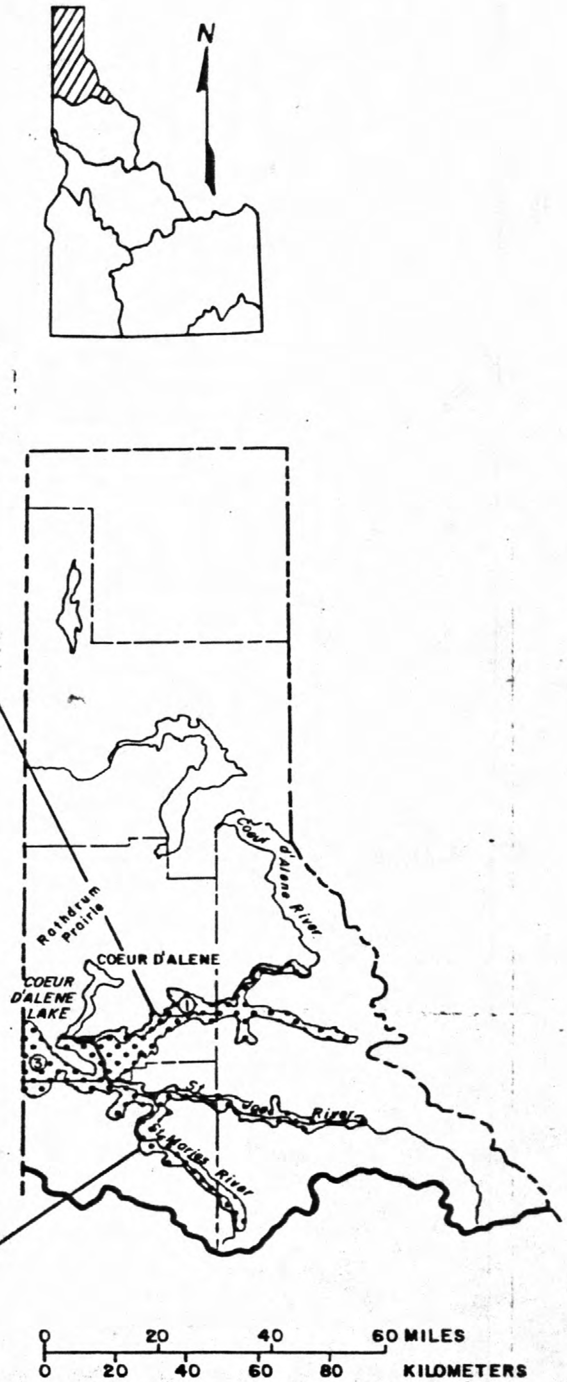


Figure 7.4. -- Statistical summary of key indicators for quality of water in Quaternary alluvial and Columbia River Basalt aquifers, Panhandle basin, Idaho.

8.0 CLEARWATER BASIN

8.1 CHEMICAL CHARACTERISTICS OF WATER IN MAJOR AQUIFERS

Two Water Types can be Classified in the Clearwater Basin

Water in four separate aquifers in the Columbia River Basalt Group is predominantly of the sodium calcium bicarbonate type. Water from thermal springs discharging from the Idaho batholith is classified as sodium bicarbonate type.

In the Clearwater basin, the Columbia River Basalt Group is the major rock unit for which water-quality data are available. Little is known about the geology and hydrology of the unit; however, four separate aquifers have been identified within the Columbia River Basalt Group (Graham and Campbell, 1981), as shown on the map in figure 8.1. They are (1) the Palouse River aquifer, (2) the Moscow basin aquifer, (3) the Clearwater Uplands aquifer, and (4) the Clearwater Plateau aquifer. Based on the composition of dissolved constituents, all water in the four aquifers in the Columbia River Basalt Group can be classified as sodium calcium bicarbonate type.

Other available water-quality data are from thermal springs near Warm Springs Creek and Elk City. The spring water is predominantly of the sodium bicarbonate type and discharges from the Idaho batholith, a complex of granitic intrusions occupying almost the whole of central Idaho (Ross, 1963). Sodium comprises 93 percent of the cations and bicarbonate 53 percent of the anions.

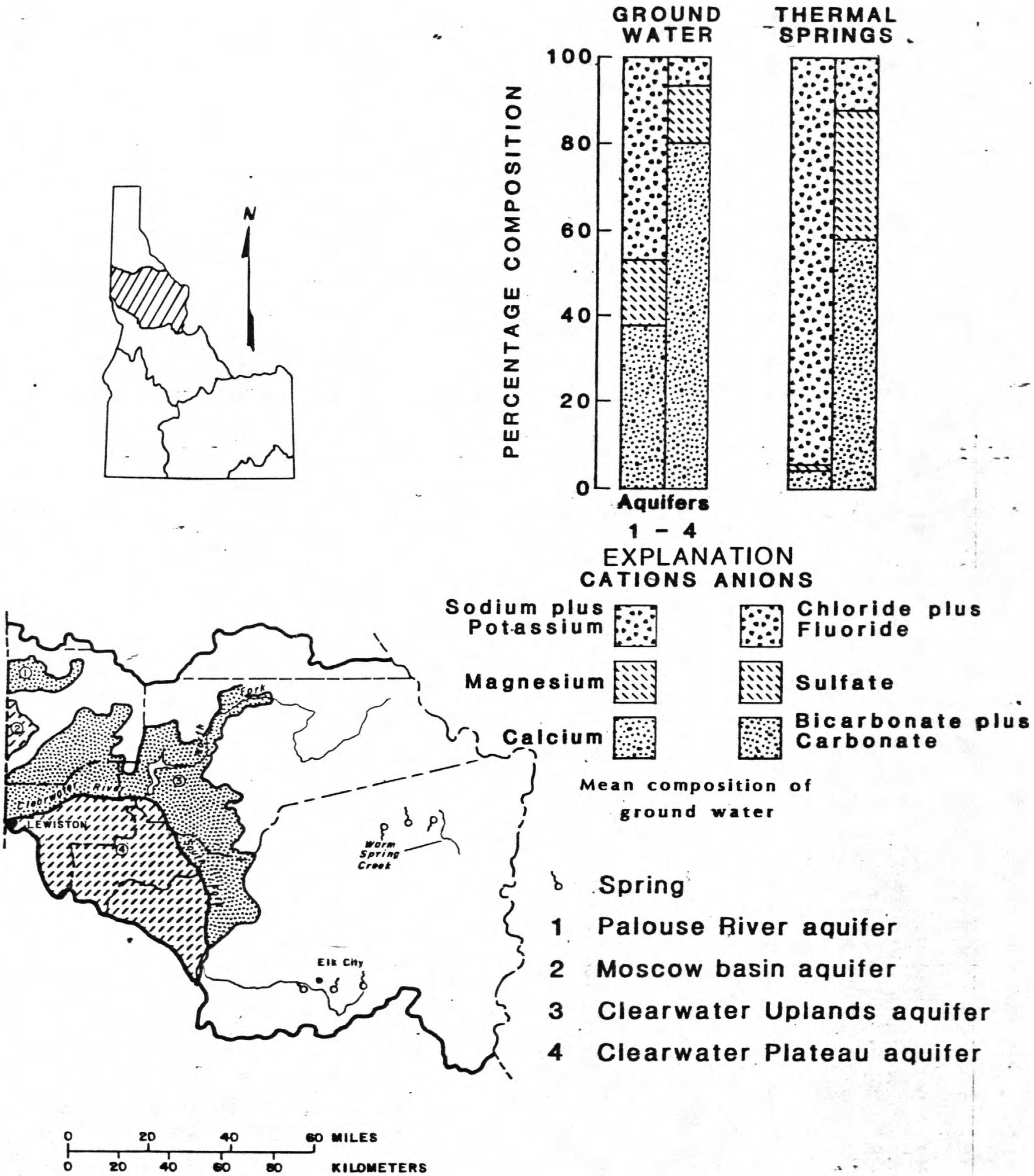


Figure 8.1. -- Chemical Characteristics of ground water and thermal springs in Clearwater basin, Idaho.

8.2 QUALITY OF WATER IN AQUIFERS IN COLUMBIA RIVER BASALT GROUP AND IDAHO BATHOLITH

Dissolved-Solids Concentrations Range from 51 to 680 mg/L in the Four Aquifers in the Columbia River Basalt Group, and from 134 to 286 mg/L in the Idaho Batholith Aquifer

The amount of data available is insufficient to describe the ground-water quality in the Clearwater basin. Although most of the available analyses are of water from the four aquifers in the Columbia River Basalt Group, they are from scattered locations and show a wide variation in concentrations of indicator constituents. The few data from the Idaho batholith aquifer suggest a more uniform water quality than that in the four aquifers.

The Columbia River Basalt Group contains four individual aquifers, as shown on the map in figure 8.2. Of these, the Palouse River and Moscow basin aquifers are in the northwest corner of the Clearwater basin and are overlain by alluvium. The Clearwater Upland and Clearwater Plateau aquifers are adjacent to each other and cover much of the western half of the basin. The latter two aquifers, separated by the Clearwater River, are recharged by water from different drainage basins.

A total of 68 analyses from the IDWR are available for the four aquifers in the Columbia River Basalt Group. However, most of the analyses are from scattered locations; and, waters in the individual aquifers have differing concentrations of dissolved solids, nitrate plus nitrite, and sulfate. The bar graphs of figure 8.2 show a wide variation in concentrations of these indicator constituents. Data for specific conductance and temperature were not published by IDWR and, thus, are absent in the statistical summary (fig. 8.2). Because of insufficient data, no conclusions about the water quality in the four aquifers were made in this study.

Although only few data are available from the Idaho batholith aquifer, the water quality seems to be more uniform than that in the four aquifers, being characterized by a consistently high temperature, a small range in dissolved-solids concentration, and a low level of dissolved minerals. All samples were obtained from thermal springs.

STATISTICAL SUMMARY

Constituent	Aquifers in Columbia River Basalt Group[1/] Number of analyses	Minimum	Maximum	Mean	Idaho batholith aquifer Number of analyses	Minimum	Maximum	Mean	Standard deviation
Specific conductance (μmho/cm) -------------	--	--	--	--	8	136	393	243	138
pH (units) -------------	68	6.0	8.4	--	8	8.4	9.5	--	--
Temperature (°C) -------	--	--	--	--	6	45	55	49	4.5
Dissolved solids (mg/L) ---------	68	51	680	273	8	134	286	217	61
Nitrogen, $NO_2 + NO_3$ (mg/L as N) ----------	68	0	9.4	0.32	3	0.0	0.04	0.03	.01
Sulfate (mg/L as SO_4)---	68	0.2	260	38	7	12	48	32	15

[1/] Modified from Graham and Campbell, 1981.

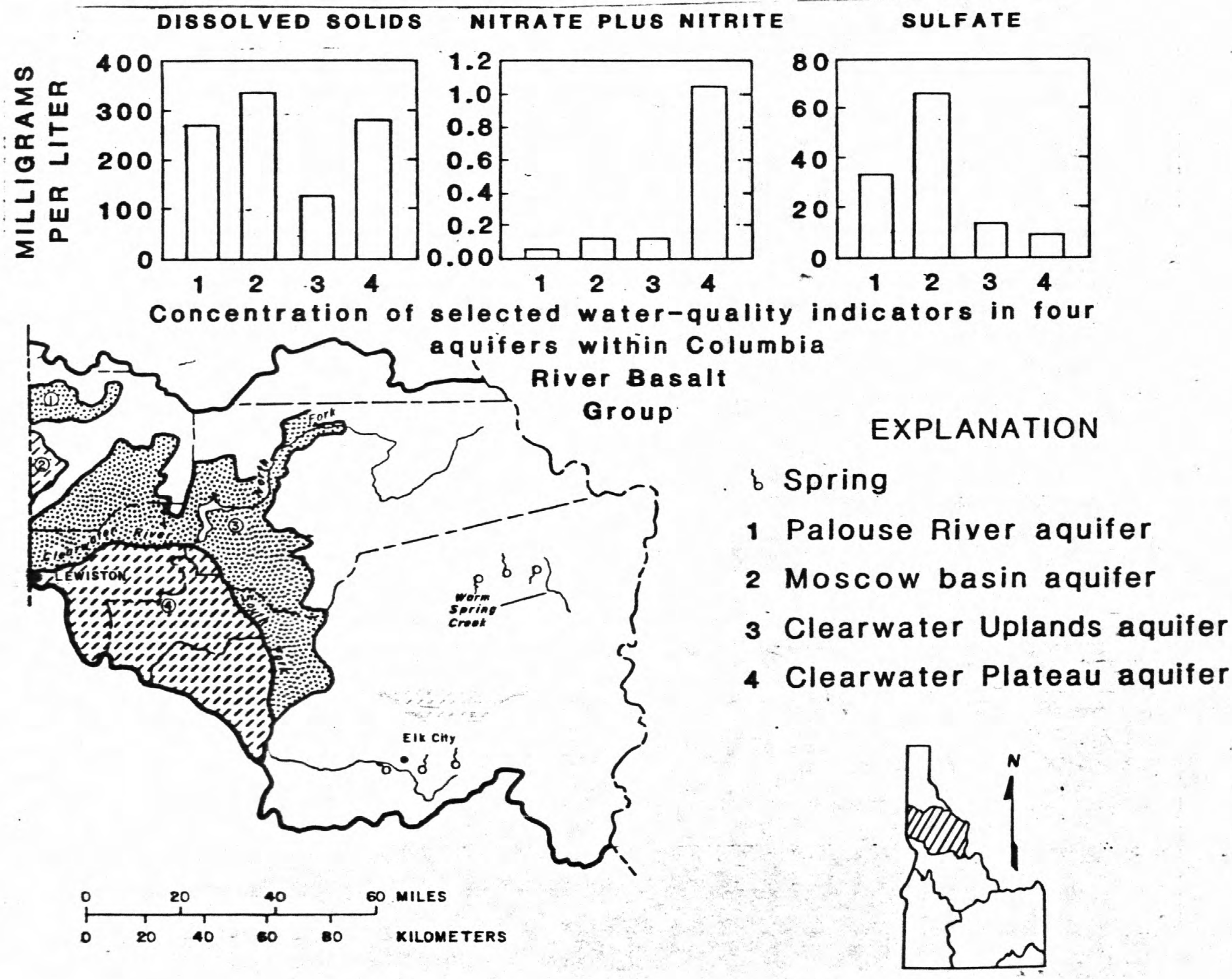


Figure 8.2. -- Summary of selected water-quality indicators in ground water in Clearwater basin, Idaho.

9.0 SALMON BASIN

9.1 CHEMICAL CHARACTERISTICS OF WATER FROM MAJOR AQUIFERS AND SPRINGS

Three Different Types of Ground Water

Classified in the Salmon Basin

Waters of different chemical composition occur in three different aquifers and are classified as sodium bicarbonate, calcium bicarbonate, and sodium calcium bicarbonate types. Also, thermal-water springs contain sodium bicarbonate type water and cold-water springs contain calcium bicarbonate type.

Most of the water-quality data available for the Salmon basin are from three aquifers that are located in the eastern part of the basin. These aquifers are composed primarily of unconsolidated valley-fill deposits and are identified in this report as (1) Lemhi, (2) Pahsimeroi, and (3) Round Valley aquifers, as shown on the map in figure 9.1.

The major source of recharge for all three aquifers is percolation of rain and snowmelt. Runoff from the surrounding mountains also contributes to recharge.

Each of the three aquifers contains water of a different chemical composition, which allows for classification of three different water types in the basin. In the Lemhi Valley aquifer, the water is predominantly sodium bicarbonate type; in the Pahsimeroi Valley aquifer, it is mostly calcium bicarbonate type; and, in the Round Valley aquifer, it is a sodium calcium bicarbonate type.

Many springs are located throughout the central part of the Salmon basin. They can be grouped into two categories: thermal-water and cold-water springs. The first category includes springs that have temperatures exceeding 18°C. The water from these springs is similar in quality to the thermal spring water from the Idaho batholith (sec. 8.2 of this report) and can be classified as sodium bicarbonate. The silica concentration ranges from 18 to 95 mg/L, and the temperature of the water ranges from 28° to 78°C.

The second category includes springs that have temperatures of 18°C or less. Water from these can be classified as calcium bicarbonate. Silica concentration of water in the cold-water springs averages less than one-fifth that of the thermal springs.

Areal distribution of the cold-water springs is similar to that of the thermal springs and no geographic division can be made between the two categories. The chemical compositions of water from both types of springs are shown in the bar graph of figure 9.1.

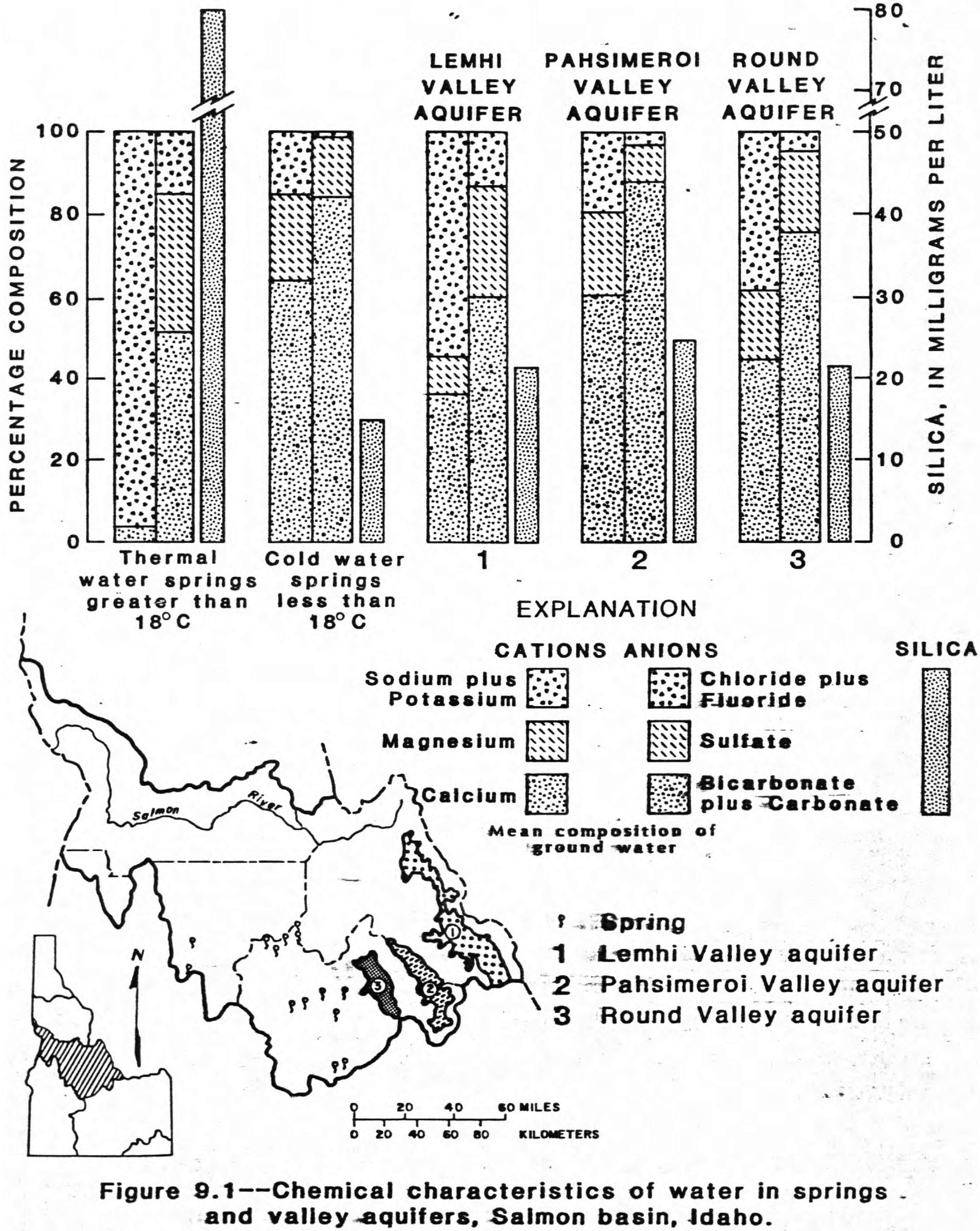


Figure 9.1--Chemical characteristics of water in springs and valley aquifers, Salmon basin, Idaho.

9.2 QUALITY OF WATER IN VALLEY AQUIFERS

Dissolved-Solids Concentrations in Water in Three Valley Aquifers Range From 62 to 2,632 mg/L

The highest dissolved-solids concentrations occur in water in the Lemhi Valley aquifer and the lowest occur in water in the Pahsimeroi Valley aquifer. The amount of data available to describe the quality of water in the valley aquifers in the basin is minimal.

Within the Salmon basin, water is developed mostly from aquifers in the valley-fill deposits within Lemhi, Pahsimeroi, and Round Valley areas. Nearly 2,900 people rely on ground water for their domestic water supply (Graham and Campbell, 1981). The quality of water is generally suitable for domestic use. In some local areas within Lemhi Valley, the dissolved-solids concentrations of ground water exceeded EPA's 500 mg/L-limit recommended for safe drinking-water standards. Water-quality conditions in these areas may not be representative of the entire aquifer, however (Whitehead and Parliman, 1979).

A total of 65 analyses is available in WATSTORE for the three valley aquifers. Most of these analyses are from scattered locations, and the waters in the individual aquifers contain a wide range in concentrations of dissolved solids, sulfate, nitrate, and other constituents. Data from these analyses are not areally extensive, thus the amount of data available to describe water quality in the valley aquifers is considered to be minimal.

Statistical summaries of water in the three valley aquifers, based on the minimal amount of data, are shown in figure 9.2.

STATISTICAL SUMMARY

Round Valley aquifer

Constituent	Number of analyses	Minimum	Maximum	Median	Mean	Standard deviation
Specific conductance (µmho/cm)	11	99	1090	465	481	257
pH (units)	11	7.4	8.1	7.7	--	--
Temperature (°C)	10	10	13	11.8	11.6	.9
Dissolved solids (mg/L)	11	141	654	270	298	144
Nitrogen, $NO_2 + NO_3$ (mg/L as N)	11	0.12	3.8	1.2	1.4	1.0
Sulfate (mg/L as SO_4)	11	3.5	200	25	55	63

STATISTICAL SUMMARY

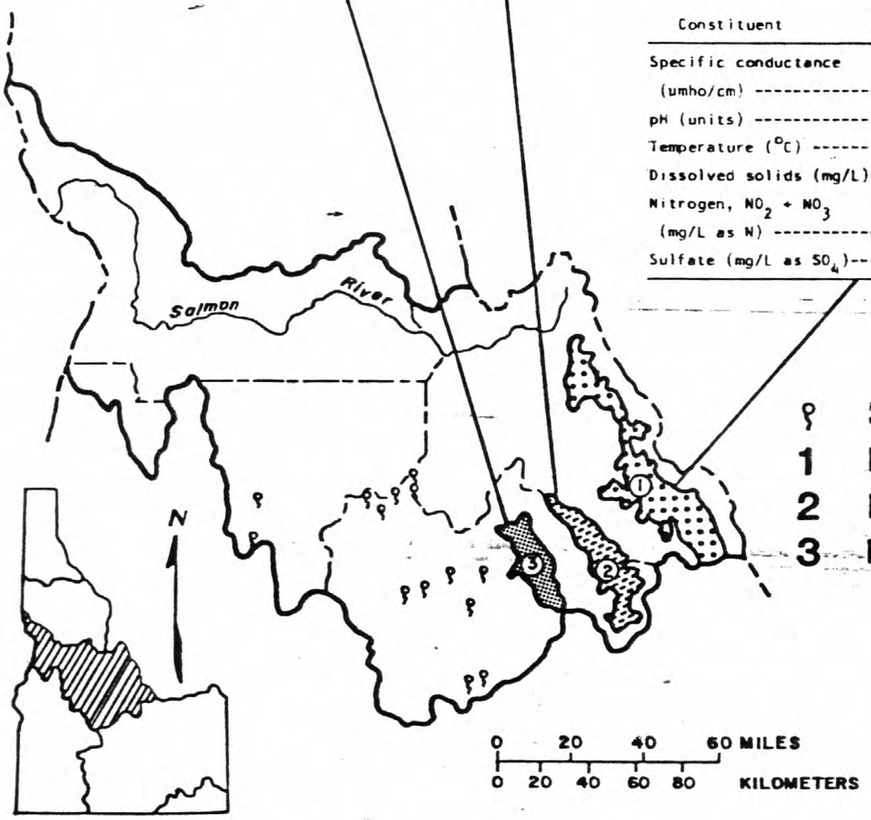
Pahsimeroi Valley aquifer

Constituent	Number of analyses	Minimum	Maximum	Median	Mean	Standard deviation
Specific conductance (µmho/cm)	23	96	567	434	389	137
pH (units)	24	7.1	8.0	7.6	--	--
Temperature (°C)	24	9.0	14.5	12.0	11.8	1.6
Dissolved solids (mg/L)	24	62	346	229	223	76
Nitrogen, $NO_2 + NO_3$ (mg/L as N)	20	0.13	17	0.52	1.3	3.7
Sulfate (mg/L as SO_4)	24	2.7	66	19	22	15

STATISTICAL SUMMARY

Lemhi Valley aquifer

Constituent	Number of analyses	Minimum	Maximum	Median	Mean	Standard deviation
Specific conductance (umho/cm)	30	137	4070	540	846	878
pH (units)	30	6.4	8.9	7.4	--	--
Temperature (°C)	30	6.6	12.5	11	10.7	1.7
Dissolved solids (mg/L)	30	133	2632	322	543	598
Nitrogen, $NO_2 + NO_3$ (mg/L as N)	26	0.10	6.9	0.44	0.82	1.4
Sulfate (mg/L as SO_4)	30	3.8	1000	23	125	260



EXPLANATION

- ⚲ Spring
- 1 Lemhi Valley aquifer
- 2 Pahsimeroi Valley aquifer
- 3 Round Valley aquifer

Figure 9.2--Statistical summary of key indicators for quality of water in valley aquifers, Salmon basin, Idaho.

10.0 SOUTHWEST IDAHO BASIN

10.1 CHEMICAL CHARACTERISTICS OF WATER IN MAJOR AQUIFERS

Ground-Water-Quality Analyses Available for 16 Geologic Units. Most of the Analyses are From Five Major Units.

Chemical analyses have been made of water from 16 geologic units in the Southwest Idaho basin. For many of the units, only a few analyses are available. Most of the analyses were made of water from five major units.

Chemical analyses are available for water from 16 geologic units in the Southwest Idaho basin. Most of the analyses are from samples collected from five major units located near the Snake River. These are shown in figure 10.1 as (1) Idaho Group, undivided of late Tertiary and Quaternary age; (2) Younger Holocene terrace gravel; (3) Older Pleistocene terrace gravel; (4) Glenns Ferry Formation of the Idaho Group; and (5) Bruneau Formation of the Idaho Group.

Chemical composition of water from the Idaho Group and the two terrace-gravel units is similar. The water is classified as sodium bicarbonate type because sodium comprises about 60 percent of the cations, and bicarbonate comprises about 70 percent of the anions.

Water from the Glenns Ferry Formation is also classified as sodium bicarbonate type, with even higher percentages of sodium and bicarbonate than in the water in the above groups. Water in the Bruneau Formation can be classified as sodium calcium bicarbonate type.

The chemical compositions of water in the major aquifers in the Southwest Idaho basin are shown in figure 10.1.

Analyses of water from the other 11 geologic units are few in number. Some have only 1 analysis, and few have more than 10. Waters in these units seem to be of the sodium bicarbonate type.

Water quality in the Idaho batholith, Columbia River Basalt Group, and alluvial aquifers in the Southwest Idaho basin may not resemble the water quality in aquifers of similar geology in other basins. For example, the water in Columbia River Basalt Group of the Southwest Idaho basin has almost twice the concentration of silica, and twice the concentration of sodium, as that in the water from Columbia River Basalt Group in the Panhandle basin. However, the thermal waters from the Idaho batholith aquifer are similar regardless of the basin in which they occur.

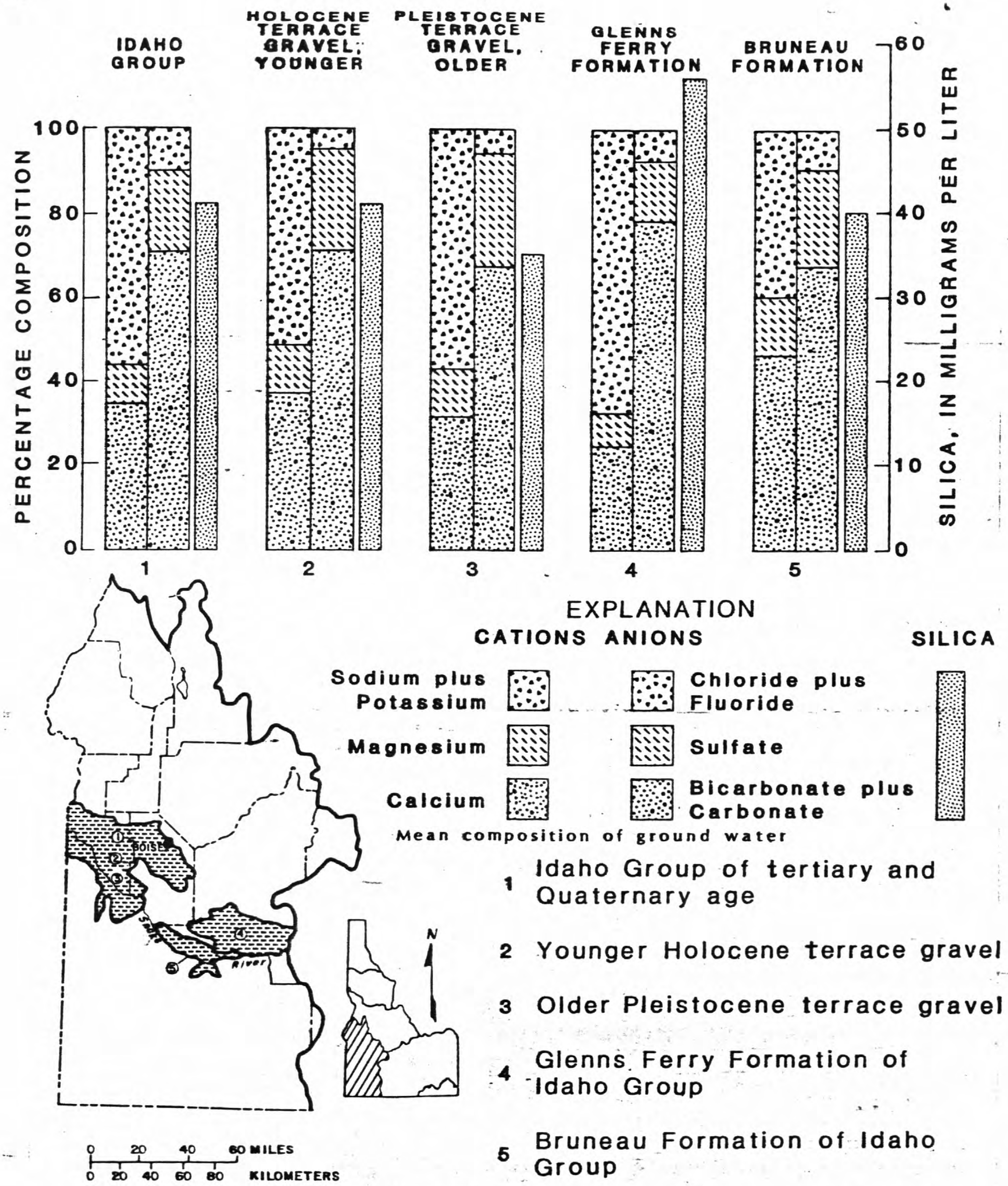


Figure 10.1. -- Chemical characteristics of water in major aquifer units, Southwest Idaho basin.

10.2 CHLORIDE CONCENTRATIONS IN PART OF SHALLOW, UNCONSOLIDATED ROCK AQUIFER UNDERLYING THE BOISE-NAMPA AREA

Chloride Concentrations Ranged from 1.3 to 41 mg/L in 1980

Chloride concentrations in water in the shallow, unconsolidated rock aquifer underlying the Boise-Nampa area during September-November 1980 ranged from 1.3 to 41 mg/L as determined by specific-ion-probe analyses.

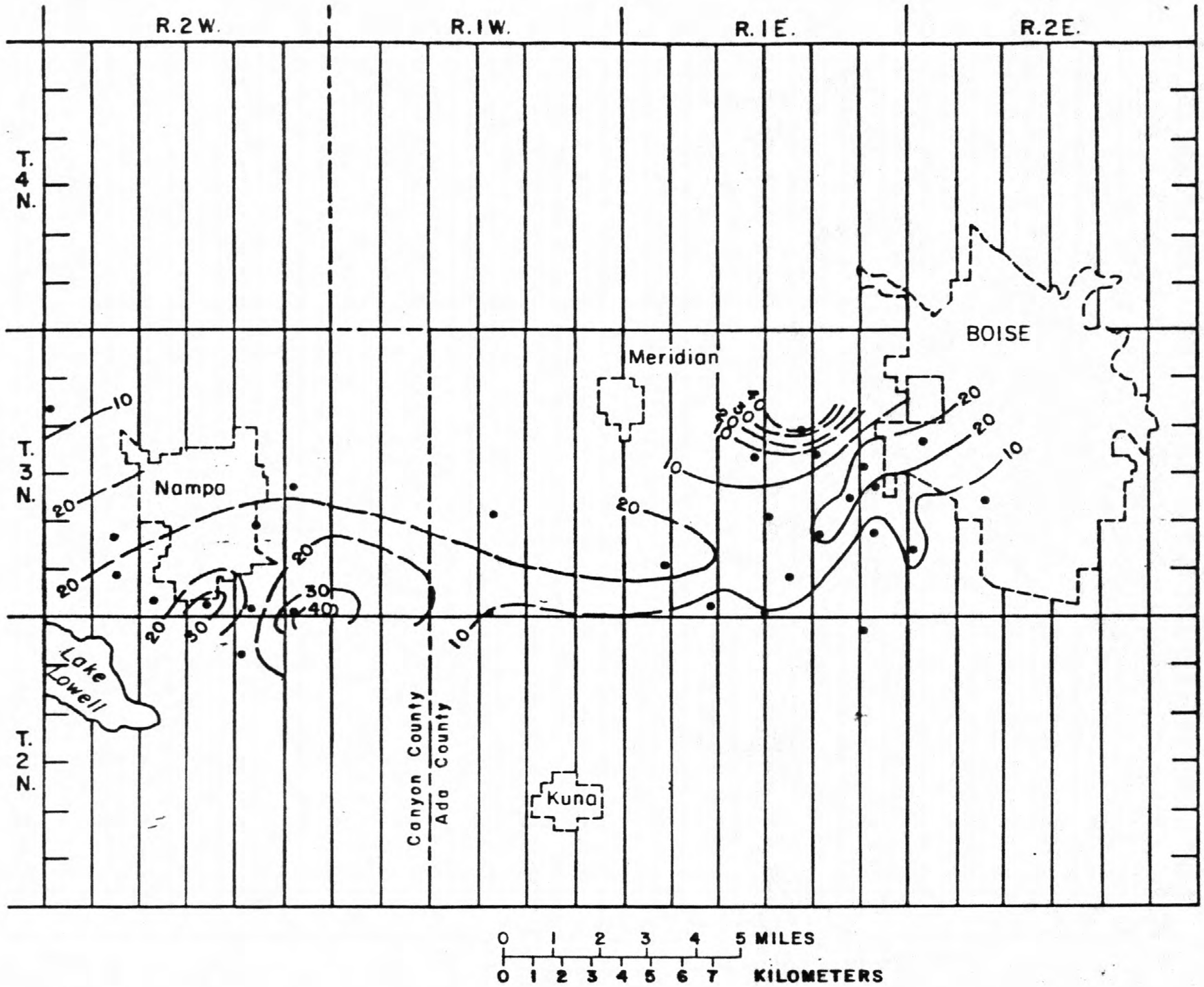
In April 1978, the IDWR began monitoring selected chemical and biological constituents in a network of 28 domestic wells completed in the shallow, unconsolidated rock aquifer that underlies the Boise-Nampa area in southwestern Idaho. The wells range in depth from 7 to 300 feet below the land surface, but for the purpose of insuring use of comparable data, only the wells having depths of 47 to 196 feet are considered in this report.

Of the initial 28 wells, 2 were subsequently dropped from the network and 5 were added. Prior water-quality analyses of water samples collected from 26 of these wells in the summer of 1970 are contained in a report by Dion (1972). Subsequent comparisons made in this report between the 1970 data, which were determined by laboratory analysis, and the more current data, determined by ion-probe analysis, are assumed to be valid. However, it should be understood that some unknown amount of error may be introduced in making the comparisons because of the different methods of analysis used.

Analyses were made of water from the network wells in spring, summer, and fall during the period April 1978 to November 1980. Specific ion probes were used to make the analyses. During this period, chloride concentrations in the selected wells ranged from 1.0 to 44 mg/L, far below the recommended maximum contaminant level of 250 mg/L for drinking water (U.S. Environmental Protection Agency, 1977b). During the final round of analyses in September-November 1980, chloride concentrations ranged from 1.3 to 41 mg/L. The median concentration was 16 mg/L. In comparison, the 1970 summer data show chloride concentrations ranging from 1.0 to 52 mg/L, with a median concentration of 15 mg/L. It seems that little, if any, overall change has occurred in chloride concentrations in the water in this part of the aquifer over the 10-year period.

Small amounts of chloride may be dissolved from rocks and soils, but the greater amounts in the Boise-Nampa area probably come from animal wastes, sewage (includes septic system effluent), and industrial wastes. Once dissolved in the water, chloride generally remains in solution unless precipitated by evaporation.

The spatial distribution of chloride in the ground water is shown in figure 10.2. Relatively high concentrations (greater than 30 mg/L) occur in local areas west of Boise and south and southwest of Nampa. In these areas, housing developments are not connected to central sewer systems; thus, septic systems are a probable source of the chloride. In the areas west of Boise and south and southeast of Nampa, only a single well in each area is used for control, so the extent of the chloride mounds shown in the figure is inferred.



EXPLANATION

• Well in which chloride determination was made by use of specific-ion-probe analysis

20 — Line of equal chloride, in milligrams per liter; dashed where inferred; concentration interval 10 milligrams per liter

Area served by municipal water system in 1970 (from Dion, 1972, fig. 9)

Figure 10.2. -- Distribution of chloride in water in the unconsolidated rock aquifer underlying part of the Boise River valley, September-November 1980.

10.3 NITRATE CONCENTRATIONS IN PART OF SHALLOW, UNCONSOLIDATED ROCK AQUIFER UNDERLYING THE BOISE-NAMPA AREA

Nitrate Concentrations Ranged from 0.4 to 10.5 mg/L in 1980

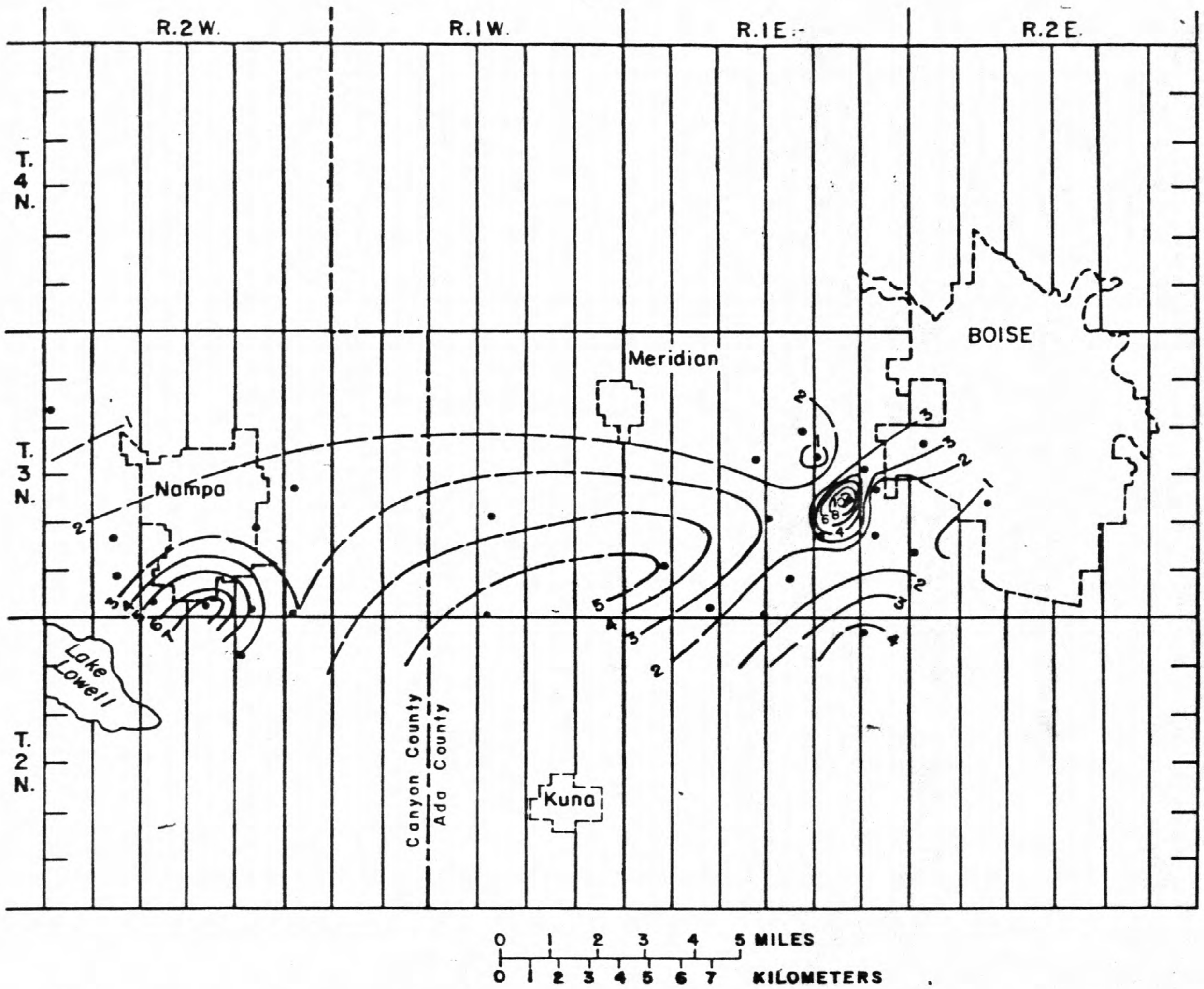
Nitrate concentrations in water in the shallow, unconsolidated rock aquifer underlying the Boise-Nampa area during September-November 1980 ranged from 0.4 to 10.5 mg/L as determined by specific-ion-probe analyses.

For water in the same network of wells and under the same sampling conditions described in section 10.2 of this report, nitrate (as N) concentrations ranged from 0.2 to 14 mg/L during the period April 1978 to November 1980. During the final round of analyses made in these wells in September-November 1980, nitrate concentrations ranged from 0.4 to 10.5 mg/L. The median concentration was 2.6 mg/L. In comparison, the 1970 summer data show nitrate concentrations ranging from 0.2 to 13 mg/L, with a median concentration of 3.0 mg/L. It seems that little, if any, overall change has occurred in nitrate concentrations in this part of the aquifer over the 10-year period. However, changes have occurred locally. Nitrate concentrations in the water have increased in some wells, whereas, in others, they have decreased. In only one well, from which periodic samples were taken during 1978-1980, did the concentrations consistently remain slightly under or above the maximum contaminant level of 10 mg/L for public water supply (U.S. Environmental Protection Agency, 1977a).

Some small amount of nitrate may be derived from soils and aquifer rocks; however, principal sources in the Boise-Nampa area include barnyard and feedlot wastes, closely spaced septic systems, and commercial fertilizers. Other sources may include buried garbage dumps and industrial wastes.

The spatial distribution of nitrate (as N) in the ground water is shown in figure 10.3. Historic (prior to land-use development) baseline levels of nitrate in the Boise-Nampa area have not been determined. Whitehead and Parliman (1979, p. 10) showed that in 169 analyses of water samples from unconsolidated rock aquifers in Idaho, nitrate (as N) concentrations ranged from 0 to 19 mg/L and had a mean value of 2.20 mg/L, with a standard deviation of 3.3. Nitrate concentrations exceed this mean in some parts of the Boise-Nampa area (fig. 10.3), especially south of Nampa, and should be some cause for concern.

In the high-nitrate area southwest of Boise, only one well is used for control, so the extent of the nitrate mound shown in the figure is inferred.



EXPLANATION

• Well in which nitrate determination was made by use of specific-ion-probe analysis

20 Line of equal nitrate (as N), in milligrams per liter; dashed where inferred; concentration interval is 1 and 2 milligrams per liter, as shown

Area served by municipal water system in 1970 (from Dion, 1972, fig. 9)

Figure 10.3. -- Distribution of nitrate in water in the unconsolidated rock aquifer underlying part of the Boise River valley, September-November 1980.

10.4 LONG-TERM CHANGES IN CHLORIDE AND NITRATE CONCENTRATIONS IN PART OF SHALLOW, UNCONSOLIDATED ROCK AQUIFER UNDERLYING THE BOISE-NAMPA AREA

Changes in Chloride and Nitrate Concentrations not Exceedingly Great Over 10-Year Period (1970-80)

Changes in chloride and nitrate concentrations can be used as indicators of either degradation or improvement in ground-water quality. In general, long-term (10-year) changes in these constituents were not great in the Boise-Nampa area.

Changes in chloride and nitrate concentrations in the ground water underlying the Boise-Nampa area can be used as indicators of either degradation or improvement in water quality where that quality has been affected by waste-disposal and land-use practices. In some wells (see section 10.2), these concentrations show rising and falling trends over the long-term (10-year) period and fluctuate over the short-term (seasonal) period. However, in general, changes in the concentrations were not exceedingly great in the area.

In 14 wells, where 1970 data represented one extreme in chloride concentrations (that is, the highest or lowest recorded value during the period of sampling, 1970-80), 7 wells showed increases in concentrations that ranged from 2.6 to 27 mg/L and 7 showed decreases from 35 to 2.5 mg/L. In 11 wells, where 1970 data represented one extreme in nitrate concentrations, 6 wells showed increases in concentrations that ranged from 1.1 to 4.2 mg/L and 3 showed decreases from 3.5 to 2.4 mg/L. Two wells showed an increase or decrease of 1 mg/L or less. Over the long-term period, only four wells showed increases in both constituents and two wells showed decreases in both. No definite area of large extent was discernible where both constituents either increased or decreased.

The manner in which concentrations of these two constituents changed over long- and short-term periods is depicted in figure 10.4. Well A (SW1/4SE1/4NW1/4 sec. 18, T. 3 N., R. 2 E.) shows a general long-term decline in both constituents. It is located in west Boise, where many residences were formerly dependent on individual septic systems for sewage disposal but now are connected to a central sewage system. Well B (NE1/4SE1/4SW1/4 sec. 34, T. 3 N., R. 2 W.) shows a general long-term rise in both constituents. It is located in south Nampa, where the municipal sewer system has recently (past two years) been extended to some residential subdivisions, but not to all.

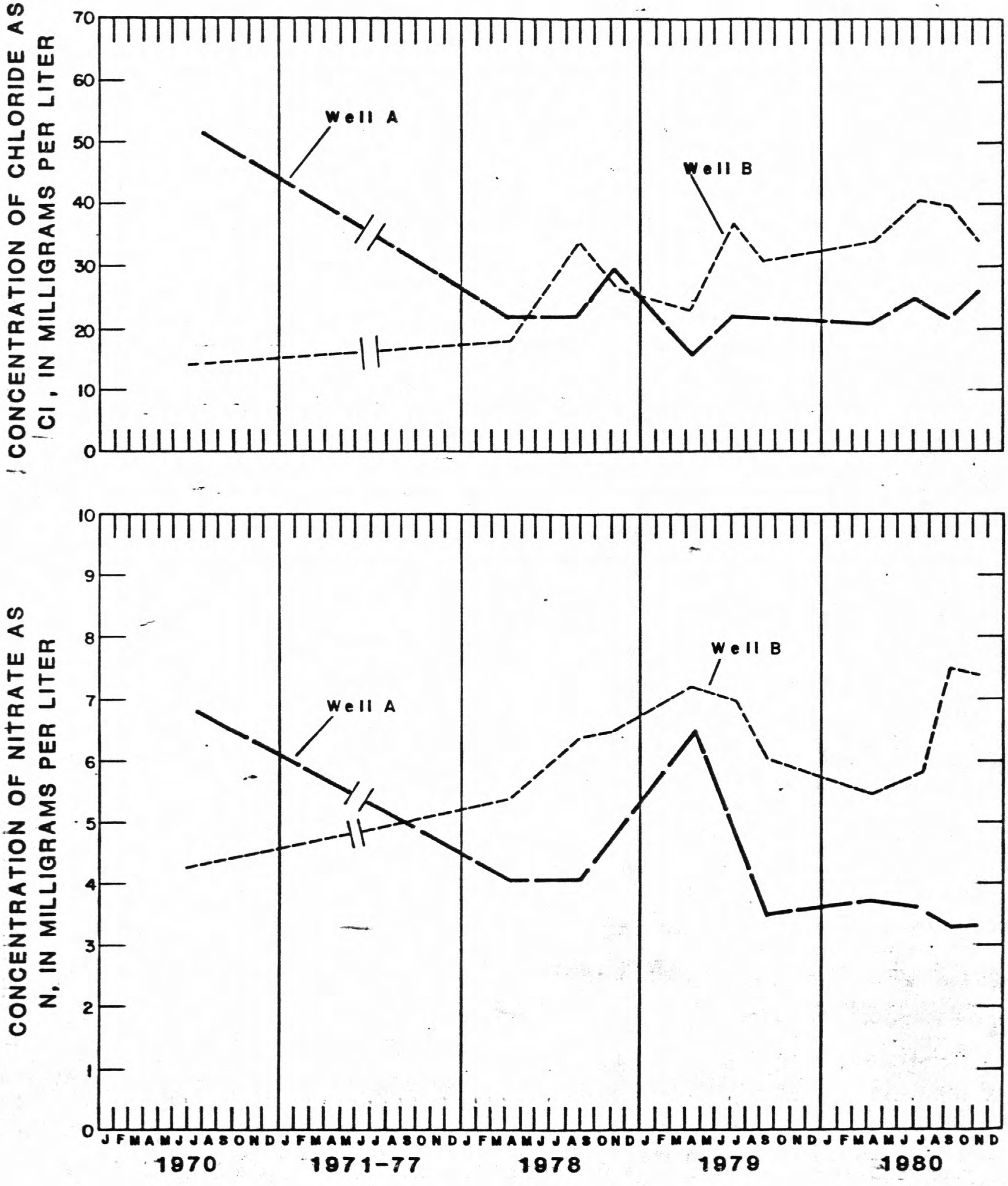


Figure 10.4. — Changes in selected chemical constituents in water in two wells in the Boise-Nampa area.

11.0 UPPER SNAKE RIVER BASIN

11.1 CHEMICAL CHARACTERISTICS OF WATER IN MAJOR AQUIFERS

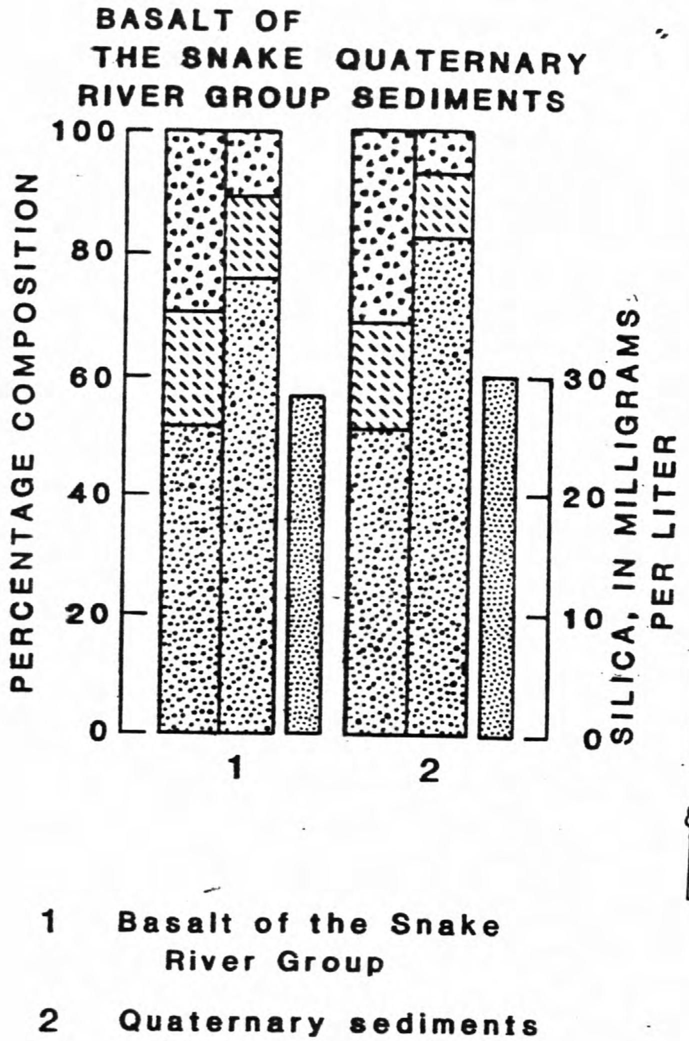
Dissolved-Solids Concentrations Average 282 mg/L in the Basalt of the Snake River Group and 263 mg/L in the Quaternary Sediments

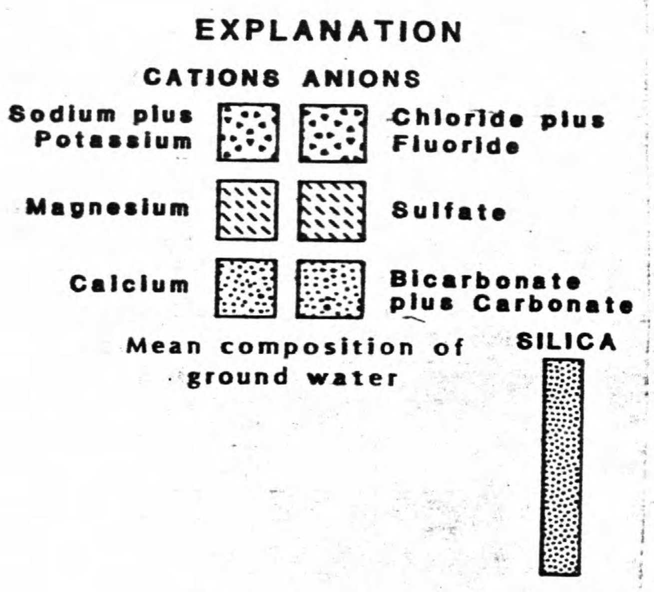
Water in the Snake River Plain aquifer occurs mostly within the basalt of the Snake River Group and the Quaternary sediments. Dissolved-solids concentrations of the water averages 282 mg/L in the basalt, and 263 mg/L in the sedimentary materials. The water is mostly calcium bicarbonate type.

The Snake River Plain aquifer extends in a northeasterly direction, approximately 200 miles from Bliss to near Ashton (fig. 11.1). It is the highest yielding aquifer in Idaho and discharges about 6.5 million acre-ft of water annually into the Snake River (Norvitch and others, 1969). The aquifer is composed of basalt in the Snake River Group of Quaternary age and interflow beds of Quaternary sediments.

Chemical characteristics of water in the aquifer are determined primarily by the chemical characteristics of the water that recharges the aquifer. The sources of recharge are deep percolation from excess irrigation water, seepage from streams, underflow from tributary basins and precipitation. Most of the recharge water has low dissolved-solids concentrations, which average less than 250 mg/L. The dissolved-solids concentrations average 282 mg/L for water in the basalt of the Snake River Group and 263 mg/L in the Quaternary sediments. These relatively low dissolved-solids concentrations indicate that the dissolution of minerals within the aquifer is slight.

Water in the Snake River Plain aquifer is mostly calcium bicarbonate type. The chemical characteristics of water from the basalt of the Snake River Group and the Quaternary sediments are similar. Both contain about 50 percent calcium and about 80 percent bicarbonate. The bar graph in figure 11.1 shows the similarity in chemical composition of water from the two rock units. The tabulation in figure 11.1 lists the statistical summary of inorganic constituents in water from the two rock units.



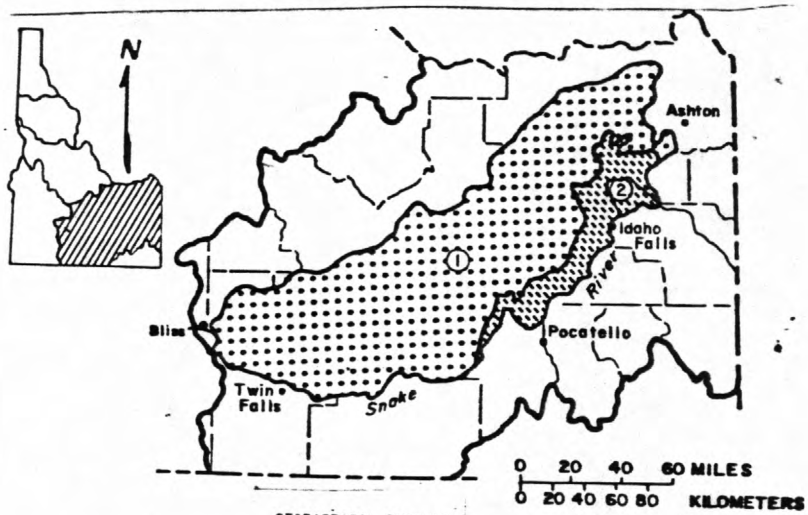


STATISTICAL SUMMARY

Basalt of the Snake River Group

Constituent	Number of analyses	Mini-mum	Maxi-mum	Median	Mean	Standard deviation
Specific conductance (µmho/cm)	810	35	2840	402	443	194
pH (units)	668	6.3	12	7.9	--	--
Temperature (°C)	765	1.3	41	14	13	2.9
Dissolved solids (mg/L)	567	28	2290	251	282	146
Nitrogen, $NO_2 + NO_3$ (mg/L as N)	214	0.1	13	1.1	1.3	1.1
Sulfate (mg/L as SO_4)	690	.2	498	29	35	34
Hardness (mg/L as $CaCO_3$)	683	17	499	170	177	62
Silica (mg/L as SiO_2)	590	.8	64	29	28	8.8
Coliform, fecal (colony/100 mL)	100	< 1	13	< 1	--	--
Coliform, total (colony/100 mL)	58	< 1	180	< 1	--	--
Iron, dissolved (µg/L as Fe)	284	0	1400	--	57	124

< Actual value is known to be less than the value shown.



STATISTICAL SUMMARY

Quaternary sediments

Constituent	Number of analyses	Mini-mum	Maxi-mum	Median	Mean	Standard deviation
Specific conductance (µmho/cm)	53	107	1330	322	412	291
pH (units)	53	6.8	8.5	7.5	--	--
Temperature (°C)	53	9.5	40	13	14	5.0
Dissolved solids (mg/L)	52	82	982	224	263	180
Nitrogen, $NO_2 + NO_3$ (mg/L as N)	29	0.02	19	0.8	2.3	4.1
Sulfate (mg/L as SO_4)	53	.5	2.0	6.5	27	42
Hardness (mg/L as $CaCO_3$)	52	8.0	600	120	164	132
Silica (mg/L as SiO_2)	52	.6	72	26	30	17
Coliform, fecal (colony/100 mL)	11	< 1	1	< 1	--	--
Coliform, total (colony/100 mL)	11	< 1	250	< 1	--	--
Iron, dissolved (µg/L as Fe)	33	10	18000	--	700	3117

< Actual value is shown to be less than the value shown.

Figure 11.1--Chemical characteristics of water in major aquifers, Upper Snake River basin, Idaho.

11.2 CHLORIDE MOVEMENT IN PART OF SNAKE RIVER PLAIN AQUIFER UNDERLYING THE IDAHO NATIONAL ENGINEERING LABORATORY

Chloride Ions Move Slowly Through Aquifer

Migration of chloride ions is a good indication of the potential spread of pollutants in ground water beneath the Idaho National Engineering Laboratory.

Nuclear activities at the INEL (formerly the National Reactor Testing Station) began in 1952. Waste-chloride solution has been discharged to shallow ponds and to shallow or deep wells since that time and has been detected about six miles downgradient from disposal points. This movement amounts to a transport rate of about two-tenths of a mile per year, which indicates that lateral movement of waste chloride in the basalt aquifer is relatively slow. Through the use of a solute-transport model developed by Robertson (1974), the predicted downgradient migration of chloride was estimated to be eight miles by 1980, as shown in figure 11.2.

The INEL covers an area of 890 mi^2 of the eastern Snake River Plain and overlies the Snake River Plain aquifer. The USGS has made hydrologic studies and monitored water levels and water quality at the site since the beginning of operations in 1949. The current (1982) observation-well network consists of 163 wells, of which 19 are used to monitor perched water bodies and 144 to monitor the Snake River Plain aquifer. Water samples are collected from 92 of these wells on a quarterly or semiannual schedule and are analyzed for chemical and radioactive constituents. Some of the radioactive constituents include strontium-90, cesium-137, plutonium-238-239-240, iodine-129, cobalt-60, and tritium, which are waste byproducts generated at the site. As a means for predicting the probable spread of these pollutants, a solute-transport model of the Snake River Plain aquifer that underlies the INEL was developed by J. B. Robertson (1974). Robertson's (1974) initial model was later evaluated by Lewis and Goldstein (1982). The model simulated a chloride plume in the aquifer as it would appear by the year 1980. This simulation is compared to the actual waste-chloride plume, as determined by water-quality analyses, in figure 11.2. Chloride was used to calibrate the model because chloride is a conservative element; that is, its original state is little changed in the ground water or by contact with the rocks of the aquifer matrix. Thus, given similar times of introduction into the aquifer, migration of waste chloride should represent the near maximum migration of almost any pollutant that is moving with the ground water, with the possible exception of tritium, which seems to be most mobile in this particular aquifer. Some variation in plume configurations for other constituents would be expected because of the different dispersive properties of different constituents.

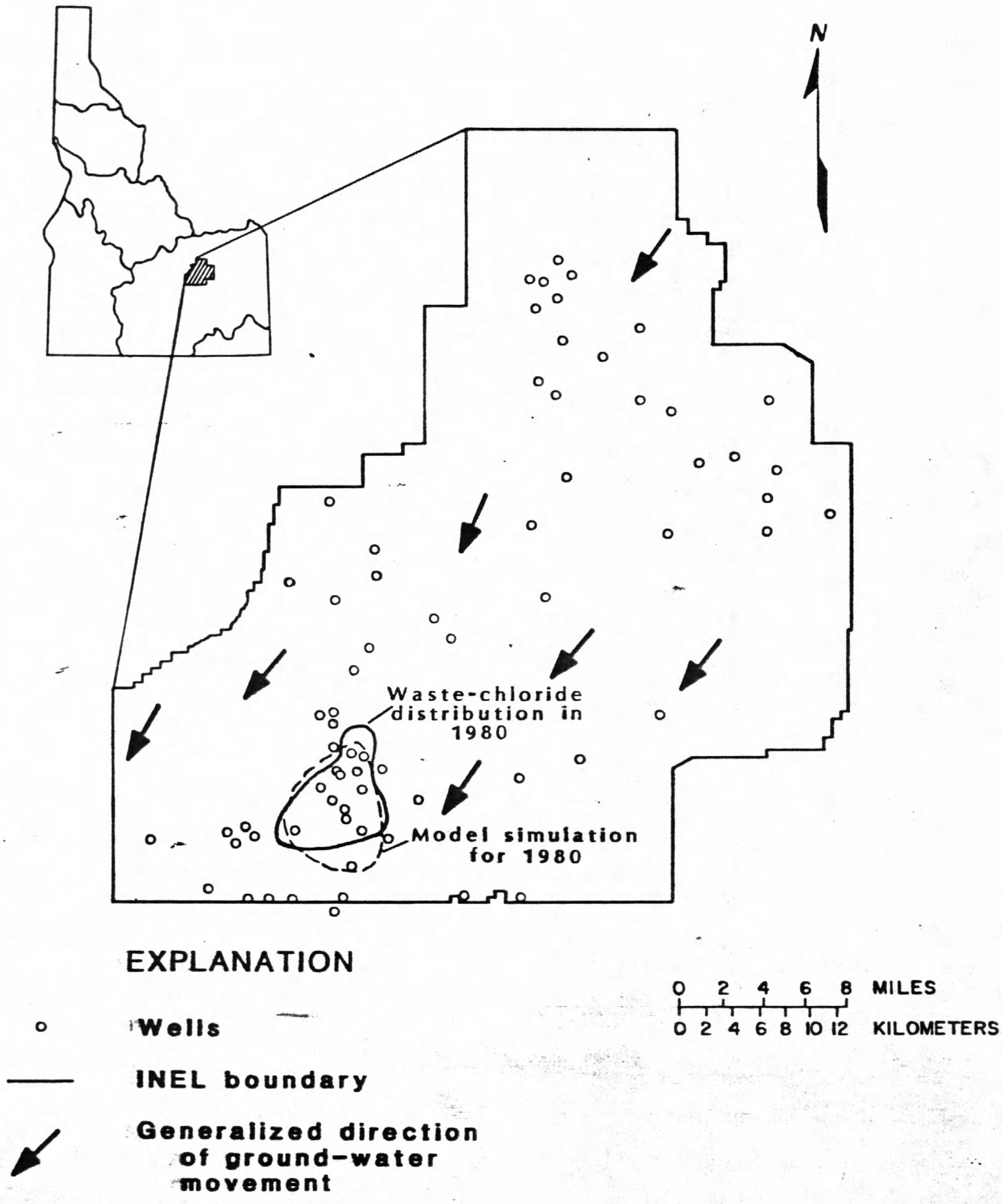


Figure 11.2--Distribution of waste-chloride and model-projected distribution in the Snake River Plain aquifer beneath the Idaho National Engineering Laboratory, 1980.

12.0 BEAR RIVER BASIN

12.1 CHEMICAL CHARACTERISTICS OF WATER IN MAJOR AQUIFERS

Three Different Types of Ground Water Classified in the Bear River Basin

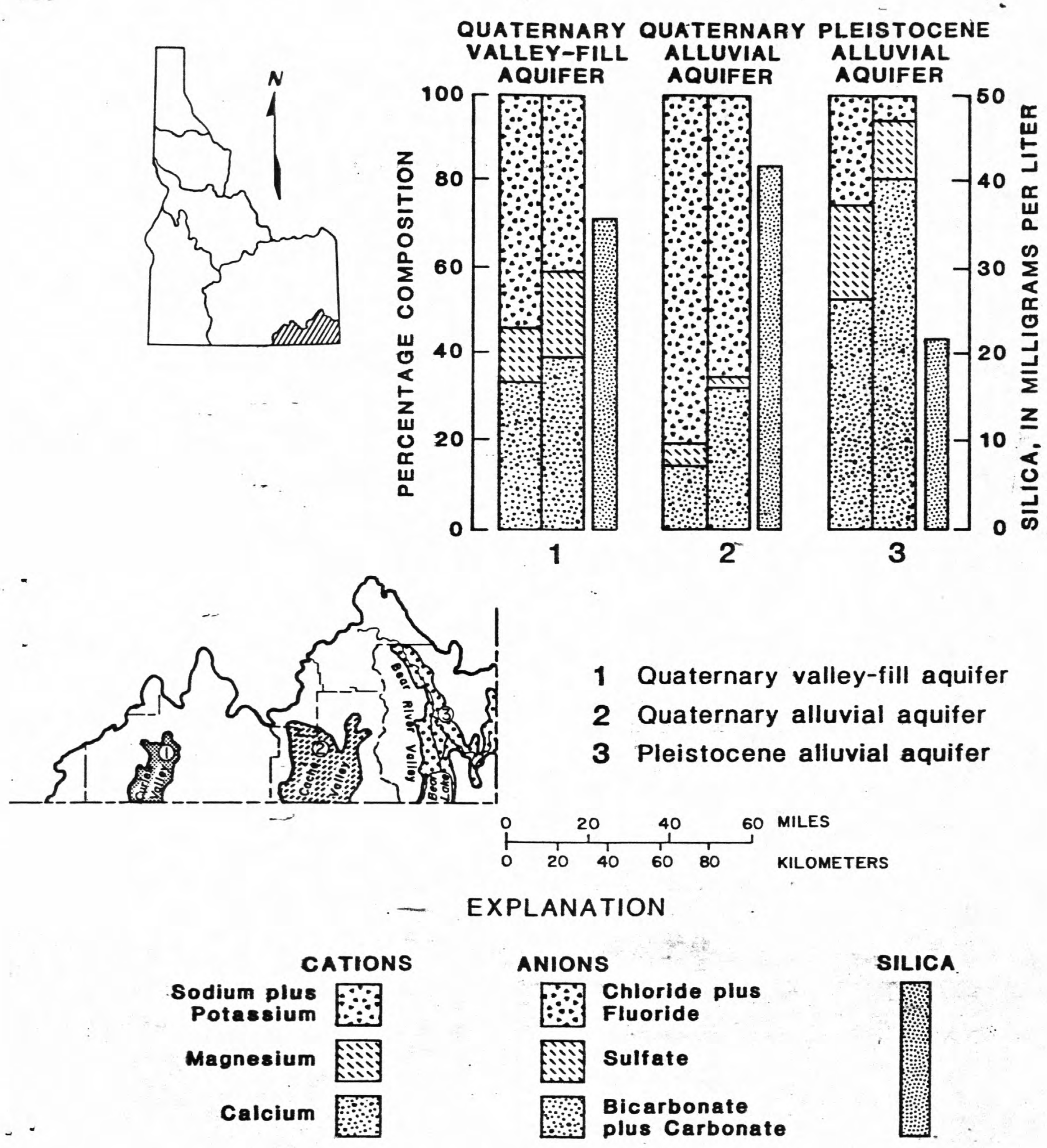
> Waters of different chemical composition occur in the aquifers in Curlew, Cache, and Bear River Valleys and are classified as sodium bicarbonate chloride, sodium chloride, and calcium bicarbonate types, respectively.

Most of the water-quality data for the Bear River basin are from three major aquifers that are located within three major valleys, the Curlew, Cache, and Bear River. The aquifers are composed of stream-deposited, unconsolidated materials and volcanic rocks that fill the valley lowlands. The generalized areal extents of the aquifers and the chemical mean composition of the different waters are shown in figure 12.1.

Ground water in Curlew Valley is mostly from the Quaternary valley fill aquifer. The water is classified as sodium bicarbonate chloride type. Sodium comprises about 53 percent of the total cations and bicarbonate and chloride about 80 percent of the total anions.

In Cache Valley, most ground water is from the Quaternary alluvial aquifer. The water is classified as sodium chloride type. Sodium comprises 80 percent of the total cations and chloride about 65 percent of the total anions.

In Bear River Valley, ground water is mostly from the Pleistocene alluvial aquifer. The water is classified as calcium bicarbonate. Sodium comprises about 53 percent of the total cations, and bicarbonate about 80 percent of the total anions.



Mean composition of ground water

Figure 12.1.—Chemical characteristics of water in major aquifers in Bear River basin, Idaho.

12.2 QUALITY OF WATER IN VALLEY FILL AND ALLUVIAL AQUIFERS

Water in Bear River Valley Aquifer Has Much Lower Dissolved-Solids Concentrations Than Water in Curlew and Cache Valley Aquifers

A minimal amount of data is available to describe the quality of water in the valley fill and alluvial aquifers. Dissolved-solids concentrations range from 347 to 2,720 mg/L in the Quaternary valley fill; from 292 to 9,830 mg/L in the Quaternary alluvium; and from 260 to 592 mg/L in the Pleistocene alluvium. Water having the highest dissolved-solids concentrations is from thermal-water sources.

The Quaternary valley fill aquifer in Curlew Valley is a source of domestic water supply for approximately 190 people. Based on available data, the quality of water is within EPA's criteria for primary drinking-water standards. However, dissolved solids, chloride, and sulfate concentrations commonly exceeded the secondary standards (Graham and Campbell, 1981).

Within Cache Valley, water in the Quaternary alluvial aquifer is a source of domestic supply for about 8,100 people. The water is generally suitable for domestic use, but concentrations of dissolved cadmium occasionally exceeded the primary drinking water standard (0.01 mg/L), and dissolved solids and dissolved iron frequently exceeded secondary standards (Graham and Campbell, 1981). Water with the highest dissolved solids is from thermal-water sources that have temperatures greater than 18°C.

Water in the Pleistocene alluvial aquifer is a source of domestic supply for about 5,200 people. Based on the data available, the water is suitable for domestic use, but Graham and Campbell (1981) report that concentrations of nitrate sometimes exceeded the primary drinking water standard (10 mg/L).

Figure 12.2 shows statistical summaries of water quality in the three aquifers by use of selected indicators. Only a minimal amount of data is available to describe the water quality in these aquifers. Generally, the water in the Pleistocene alluvial aquifer in Bear River Valley has a much lower dissolved-solids concentration than water in the Quaternary aquifers in Curlew and Cache Valleys.

STATISTICAL SUMMARY

Pleistocene alluvial aquifer

Constituent	Number of analyses	Mini-mum	Maxi-mum	Median	Mean	Standard deviation
Specific conductance						
(μmho/cm) -------------	16	409	1040	592	663	188
pH (units) -------------	16	7.2	7.9	7.5	--	--
Temperature (°C) -------	16	8.5	56	10	17	17
Dissolved solids (mg/L)-	16	260	592	356	387	102
Nitrogen, $NO_2 + NO_3$						
(mg/L as N) -----------	13	0.0	7.9	1.2	1.9	2.2
Sulfate (mg/L as SO_4)---	16	1.6	190	38	53	47

STATISTICAL SUMMARY

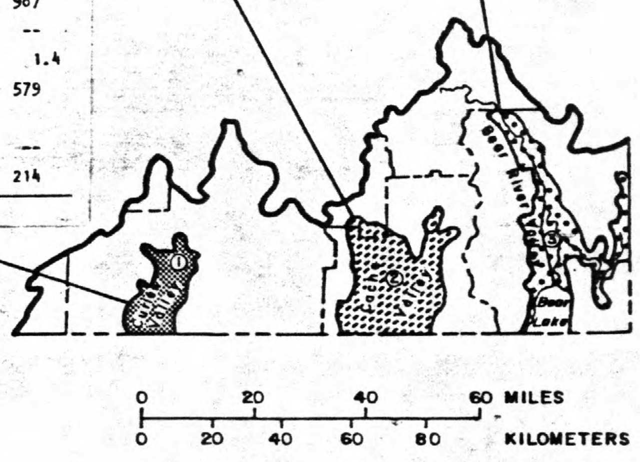
Quaternary alluvial aquifer

Constituent	Number of analyses	Mini-mum	Maxi-mum	Median	Mean	Standard deviation
Specific conductance						
(μmho/cm) -------------	20	472	16400	876	3199	4743
pH (units) -------------	18	6.5	7.9	7.7	--	--
Temperature (°C) -------	17	11	77	24	29	22
Dissolved solids (mg/L)-	16	292	9830	466	1868	3114
Nitrogen, $NO_2 + NO_3$						
(mg/L as N) -----------	4	0.8	1.5	1.2	1.2	.4
Sulfate (mg/L as SO_4)---	19	.0	241	26	47	57

STATISTICAL SUMMARY

Quaternary valley fill aquifer

Constituent	Number of analyses	Mini-mum	Maxi-mum	Median	Mean	Standard deviation
Specific conductance						
(μmho/cm) -------------	25	530	4390	1190	1522	987
pH (units) -------------	12	7.1	8.0	7.6	--	--
Temperature (°C) -------	26	8.0	14	11	11	1.4
Dissolved solids (mg/L)-	30	347	2720	687	897	579
Nitrogen, $NO_2 + NO_3$						
(mg/L as N) -----------	0	--	--	--	--	--
Sulfate (mg/L as SO_4)---	30	16	994	52	135	214



EXPLANATION

1 Quaternary valley fill aquifer

2 Quaternary alluvial aquifer

3 Pleistocene alluvial aquifer

Figure 12.2. — Statistical summary of selected indicators for quality of water in Quaternary valley fill, Quaternary alluvial, and Pleistocene alluvial aquifers, Bear River basin, Idaho.

13.0 SPECIAL PROBLEM AREAS

Ground-Water-Quality Problem Areas Identified in Idaho

> Primary concerns in Idaho include: (1) Protection of water quality in the Rathdrum Prairie aquifer, (2) potential degradation of water quality in the Boise-Nampa area, (3) effects of widespread use of drain wells overlying the basalt in the eastern Snake River Plain aquifer, and (4) disposal of low-level radioactive wastes at the INEL.

Although the overall quality of ground water in Idaho is suitable for most uses, problem areas occur where the water in the aquifers is partially degraded and is subject to degradation owing largely to man's activities. The generalized location and extent of the more notable of these areas, as they occur in the six major drainage basins discussed previously in this report, are shown in figure 13.0. Also shown (see EXPLANATION, fig. 13.0) are the major contaminants that threaten the quality of ground water in these areas. For purposes of this report, the sources of the contaminants are itemized under seven main categories: (1) septic-tank drain fields, sewerage-system leakage, sewerage ponds, and sanitary landfills; (2) agricultural (mainly use of fertilizers and pesticides) and livestock wastes; (3) urban runoff; (4) industrial processing; (5) mining and related activities; (6) geothermal-resource development; and (7) nuclear activities. Items 1-5 are significant in all of the major drainage basins. Item 6 is significant mostly in the Southwest Idaho and Upper Snake River basins, and item 7 is significant only in the area of INEL, in the Upper Snake River basin. A brief description of the special problem areas in each of the major drainage basins follows.

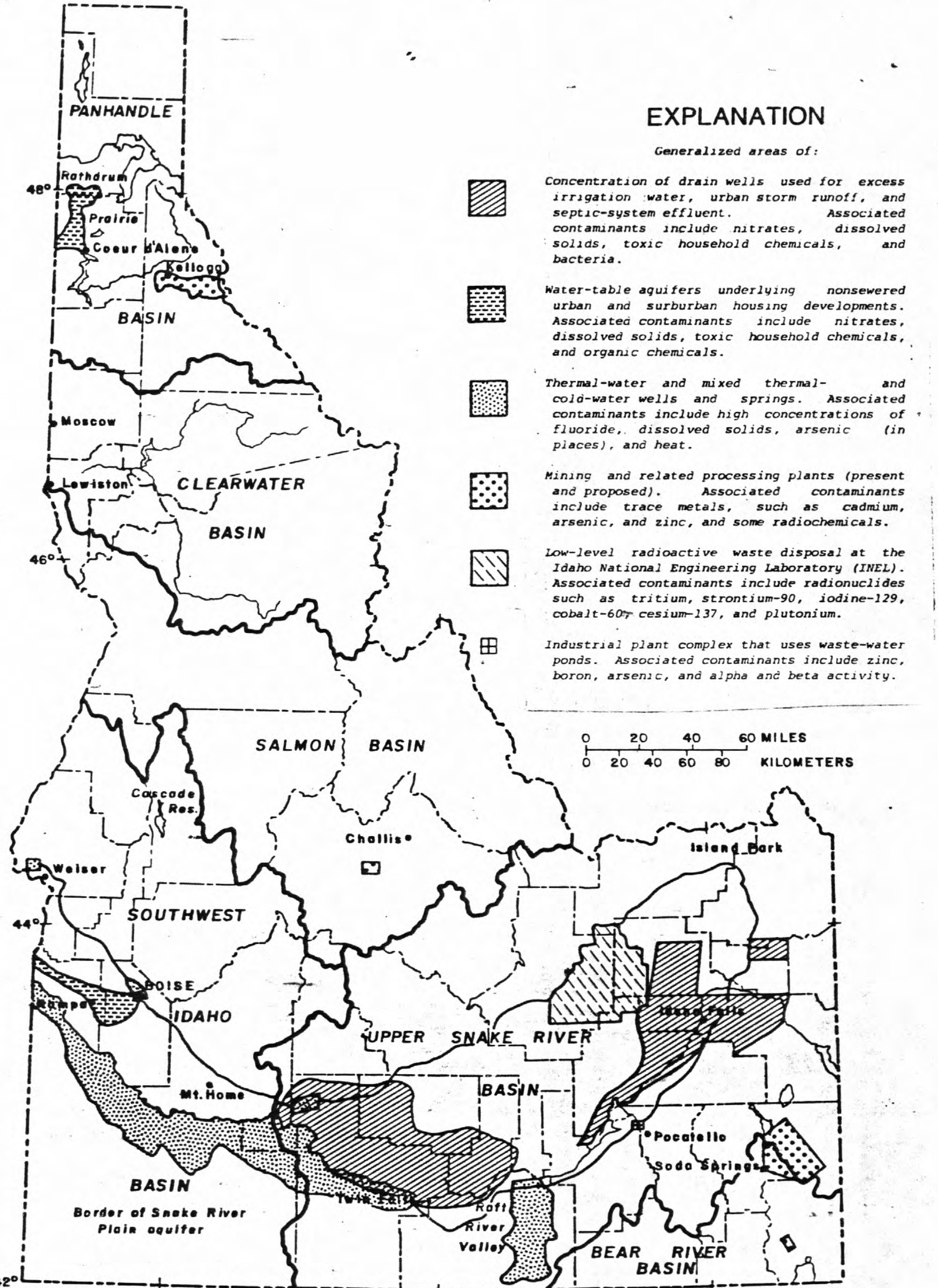
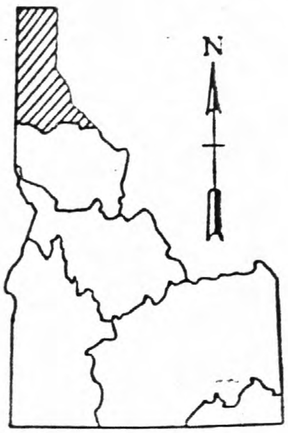


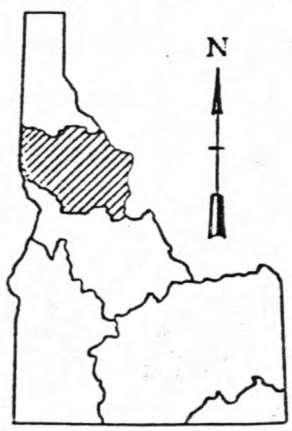
Figure 13.0. — Generalized areas where potential exists for degradation of ground-water quality.



Panhandle basin

In the Panhandle basin, a primary concern is protection of water quality in the Rathdrum Prairie aquifer, designated as a "sole source" water supply (see section 7.2 of this report). Use of septic-tank systems in rapidly spreading housing developments has reportedly caused rises in nitrate concentrations in localized parts of the aquifer. The Panhandle Health District (Coeur d'Alene headquarters) is currently monitoring a network of 25-30 observation wells on a quarterly basis (S. Tanner, oral communication 1982). Constituent determinations include nitrate, chloride, pH, specific conductance, and volatile organic materials. These data are stored in the STORET system of the EPA.

Another concern is elevated trace metals concentrations in ground water in the Coeur d'Alene mining district near Kellogg. Some of these concentrations may be naturally occurring; however, leachates from mining and smelting operations in the mining district also may be contributors (Parliman and others, 1980, p. 28).

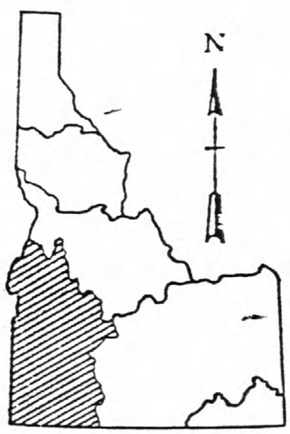


Clearwater basin

In the Clearwater basin, ground-water quality problems are not known to be pronounced. Thermal-water springs in the Idaho batholith part of the basin contain somewhat high fluoride concentrations, but they are not known to have affected water quality in the cold-water systems.

Salmon basin

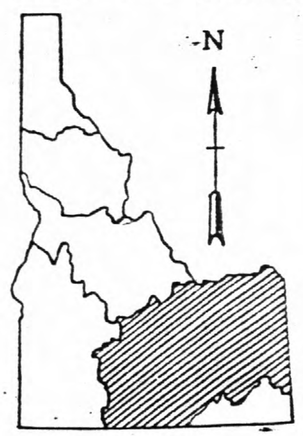
Similarly, in the Salmon basin, ground-water problems are not known to be severe. Mining operations, particularly a rather large one recently started southwest of Challis (fig. 13.0), might impact water quality in the valley-fill aquifers. However, water-quality monitoring is not yet sufficient to document this potential impact. Thermal springs issuing from the Idaho batholith contain waters having high fluoride concentrations, but these waters are not known to have affected the cold-water systems.



Southwest Idaho basin

In the Southwest Idaho basin, a primary concern is degradation of water quality in the shallow aquifer in the Boise-Nampa area (see section 10.3 of this report). Nitrate concentrations are somewhat high in this aquifer and probably are due to contaminant sources 1-4 listed above. Land use in this area is rapidly changing from agricultural to urban and suburban. Although some monitoring has been done, no formal network of observation wells has been established to document water-quality changes. Also in both Boise and Nampa, large quantities of petroleum products have infiltrated to the water table in localized areas. Current operations are underway to physically remove these contaminants from the aquifer.

Another problem in this basin that warrants concern is the influx of thermal waters, high in fluoride and other undesirable constituents, into the cold-water aquifers. Part of this is naturally occurring, for in some places the hydraulic head in the deep thermal system is higher than in the shallower cold-water system; thus, the potential exists for the thermal water to move upward. However, in places where the thermal waters are being developed for use, particularly for irrigation, many wells are being drilled that are open to both thermal-and cold-water aquifers. This facilitates mixing of the two waters, which can result in degradation of quality in the cold-water aquifers.



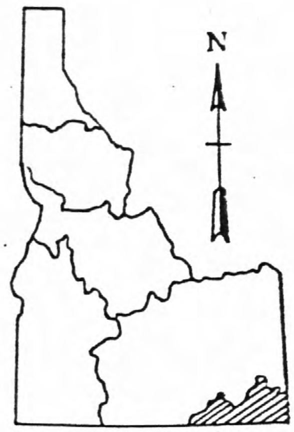
Upper Snake River basin

In the Upper Snake River basin, two primary areas of concern include widespread use of drain wells and disposal of low-level radioactive wastes at the INEL (fig. 13.0). Several thousand (exact number is not known) drain wells are used to dispose of excess irrigation water, urban storm runoff, and septic-system effluent from lands overlying the basalt of the eastern Snake River Plain aquifer. Contaminants introduced by some of the drain wells have reportedly degraded the water in nearby domestic wells. The data derived in a study by Seitz and others (1977) indicate that drain-well inflow does move appreciable distances through the aquifer and can be detected in downgradient wells.

Low-level radioactive wastes are disposed of in ponds and by deep-well injection into the basalt of the Snake River Plain aquifer underlying the INEL (see section 11.2 of this report). Monitoring wells, operated by the USGS, have been used to trace the spread of contaminants at the INEL since the early 1950's. The most mobile of these contaminants (tritium) has migrated downgradient about 7.5 mi from the source areas and covers an area of about 30 mi^2 (Schneider and Trask, 1982, p. 86). This problem is fully recognized by both State and Federal officials.

Development of the geothermal resources is progressing rather rapidly in the vicinity of Twin Falls. The water is used primarily for space heating, recreation, and irrigation. The problem is similar to that in the Southwest Idaho basin, discussed above. In the Raft River Valley, multiaquifer penetration of thermal wells is not so much the problem as is the lowering of water levels in the cold-water aquifers owing to pumping for irrigation. This lowering tends to increase the head differences between the thermal- and cold-water systems, thus increasing the potential for the waters to mix by natural means.

In addition to the above, mining and processing of phosphate ores pose a potential problem in the area northeast of Soda Springs. Aquifers in this area are not well defined and the possible impact on ground water, if indeed it exists, is not known. An industrial plant complex related to the processing of phosphate ores for fertilizers is in operation immediately northwest of Pocatello (fig. 13.0). Water in the shallow alluvial aquifer underlying this complex has been degraded locally with increased levels of arsenic, zinc, boron, and alpha and beta activity. This problem area is currently being investigated by the USGS in cooperation with the Shoshone-Bannock Indian Tribes of the Fort Hall Indian Reservation.



Bear River basin

In the Bear River basin, ground-water problems are not known to be pronounced, but phosphate mining problems may occur, similar to those mentioned above.

In addition, several localized water problems exist throughout the State. Notable among these is the occurrence of coliform bacteria in shallow alluvial aquifers where summer-home development and large tourist populations flourish, for example, in the vicinities of Island Park and Cascade Reservoir (fig. 13.0). Other problem areas and concerns in the State are mentioned in a report by the Idaho Department of Health and Welfare (1980b), which specifically addresses the status of water-quality conditions in Idaho.

With the possible exception of the observation-well network operated by the Panhandle Health District in the Rathdrum Prairie area and the network operated by the USGS at the INEL, there is no monitoring of ground-water quality on an areal basis being carried on in Idaho. A study was made to design a statewide ground-water quality network for Idaho (Whitehead and Parliman, 1979), but the network proposed in that study has not yet been implemented.

14.0 SUMMARY AND CONCLUSIONS

Ground-Water Resources in Idaho are Suitable for Most Uses; However, Shortcomings are Recognized in the Ground-Water-Quality Data Base

Ground-water resources in Idaho include both cold and thermal waters. The quality of these waters is suitable for most intended uses. Mixing of thermal waters with cold waters could become a major concern. Shortcomings in the ground-water-quality data base are categorized as: (1) Multiaquifer-sample inadequacy, (2) constituent-coverage limitations, (3) baseline-data deficiencies, and (4) data-base nonuniformity.

Unlike many other states in the nation, ground-water resources in Idaho are divisible into two major types: cold water and thermal water. In general, the quality of the cold water is suitable for most intended uses, which primarily include drinking (for people and stock), irrigation, food processing, and various industrial applications. Only in a few local places is the water reportedly unsuitable for use. In these places, bacteria, petroleum products, nitrate and trace elements (such as cadmium and arsenic) are generally among the contaminating constituents. The quality of the thermal water is also generally good for most intended uses, which primarily include space heating, health spas, recreation, and irrigation. However, some thermal water mixes with the cold water. This could become a major concern because the thermal water in some areas contains high concentrations of fluoride, arsenic, boron, and dissolved solids, which could degrade the cold water, primarily restricting its use for drinking.

In evaluating the ground-water-quality conditions in Idaho, a number of conclusions were derived as to the worth of the available data to make such an evaluation. In sections 7-12 of this report, interpretations of the water quality were made only to the extent warranted by the available data. Further interpretations were curtailed by shortcomings in the data base. These shortcomings are categorized as: (1) Multiaquifer-sample inadequacy, (2) constituent-coverage limitations, (3) baseline-data deficiencies, and (4) data-base nonuniformity.

Multiaquifer-sample inadequacy.--The largest part of the available data base for Idaho was derived from samples collected in wells used for other than water-quality observation. Many of these wells, primarily those that penetrate consolidated rocks, are open to more than one water-bearing unit. Therefore, samples collected in them do not represent water in a single aquifer, but rather a composite of the aquifers. The inferred problem is assumed to be minimal in Idaho, for most of the consolidated rocks penetrated are volcanic in origin and contain waters with similar mineral content. However, where wells penetrate both cold- and thermal-water aquifers, a composite sample would not be representative of either aquifer. Collection of samples in only those wells for which reliable construction and geologic logs are available and from wells designed and constructed solely for observation purposes would enhance the data base.

Constituent-coverage limitations.--In the past, most water analyses included only the major inorganic constituents and a few selected physical properties. These are good for geochemical interpretations but are of little help in detecting pollution that results from land-surface-derived wastes. The more basic contaminants that are fairly common in Idaho but generally absent in most of the analyses include trace metals, bacteria, pesticides, herbicides, and other organic compounds. With the exception of ground-water-quality monitoring networks for the Rathdrum Prairie aquifer and to some extent, for the aquifer underlying the INEL, few of these constituents have been analyzed for in Idaho ground waters. The addition of several, if not most, of the above contaminants to the water-analysis schedules, would greatly improve the ability of the hydrochemist to detect hazardous and toxic wastes, and thus allow planning for remedial action.

Baseline-data deficiencies.--Baseline data are deficient in relation to (1) natural conditions, (2) time span, and (3) quantity. As to (1), few data are available that represent natural conditions, particularly in the cold-water system. This is because the natural water in most cold-water aquifers in Idaho was affected by recharge from irrigated farmlands long before any great number of samples were collected for water-quality analysis. In contrast, most thermal-water data are representative of natural conditions primarily because the samples were collected from springs in remote, undeveloped areas and from aquifers having pressure heads that resist downward recharge. Thus, for most cold-water aquifers, any selected number of analyses taken in the past, or at present, would represent some status of water-quality conditions for a particular time or period of time and not natural conditions. This hinders making a true appraisal of man's effects on ground-water quality. Nothing practical can be done to rectify this data deficiency.

As to time span (2), the bulk of data used to make the evaluation of this report spanned about a 25-year period, from the mid-1950's to 1980. Ideally, an evaluation of ground-water quality should be made with data collected in as short a time period as possible. In addition, water-quality conditions in many aquifers change seasonally, particularly in aquifers that underlie irrigated lands. These changes can be substantial locally; but, they are or have been (see fig. 10.4) monitored in only a few places. Alleviation of this deficiency can be accomplished by establishing water-quality-monitoring networks that are operated on a scheduled basis. One such network of statewide scale is proposed by Whitehead and Parliman (1979).

As to quantity (3), data is lacking for all except the Rathdrum Prairie aquifer. The data are lacking on areal, vertical, and temporal bases. Implementation of a statewide network would be a good start in solving this deficiency.

Data-base nonuniformity.--Ground-water-quality data are collected by different agencies for different purposes. This results in difficulties when any one entity attempts to assimilate all data from all data bases for any one purpose. Each group of collectors uses its own sampling techniques, analytical methods, and quality-control procedures which leads to incompatibility of data, and precludes the use of all available data for certain interpretations and appraisals. There are continual improvements being made in sampling techniques, analytical methods, and accuracy standards. These result in doubt, even within groups, when making comparisons between old and new data. For example, apparent changes in constituent concentrations determined from repeated sampling may actually be caused by improved accuracy in laboratory determinations. Therefore, time-trend analyses made of long-term (10 years or more) data are sometimes suspect.

In addition to the above, there are differences in data-management systems. This is emphasized by the fact that data in two of the largest water-quality systems, STORET and WATSTORE, are difficult to merge. Programs applicable in one system will not work in the other without considerable adaptation. More cumbersome than this is the fact that data available from some sources are not stored in computers which discourages any massive use of these data.

Alleviation of the above difficulties could be accomplished by standardization of all water-quality sampling and analysis techniques, use of similar quality-control standards, complete merger of data files amongst computer systems, and computerization of all data.

In spite of the recognized shortcomings, the evaluation made on the current quality of Idaho's ground water is reasonably accurate and will be of practical value to water managers and users.

15.0 REFERENCES

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