Quality of Ground Water in Idaho

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By JOHNSON J. S. YEE and
WILLIAM R. SOUZA

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CONTENTS

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's computerized data-processing and retrieval system)

QUALITY OF GROUND WATER IN IDAHO

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

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 the 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.

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 a few places, temporal bases. Where data are not sufficient, the water quality can be described only in general terms or not at all.

This report presents 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 the 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 where 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 where no correlations can be made between sites.

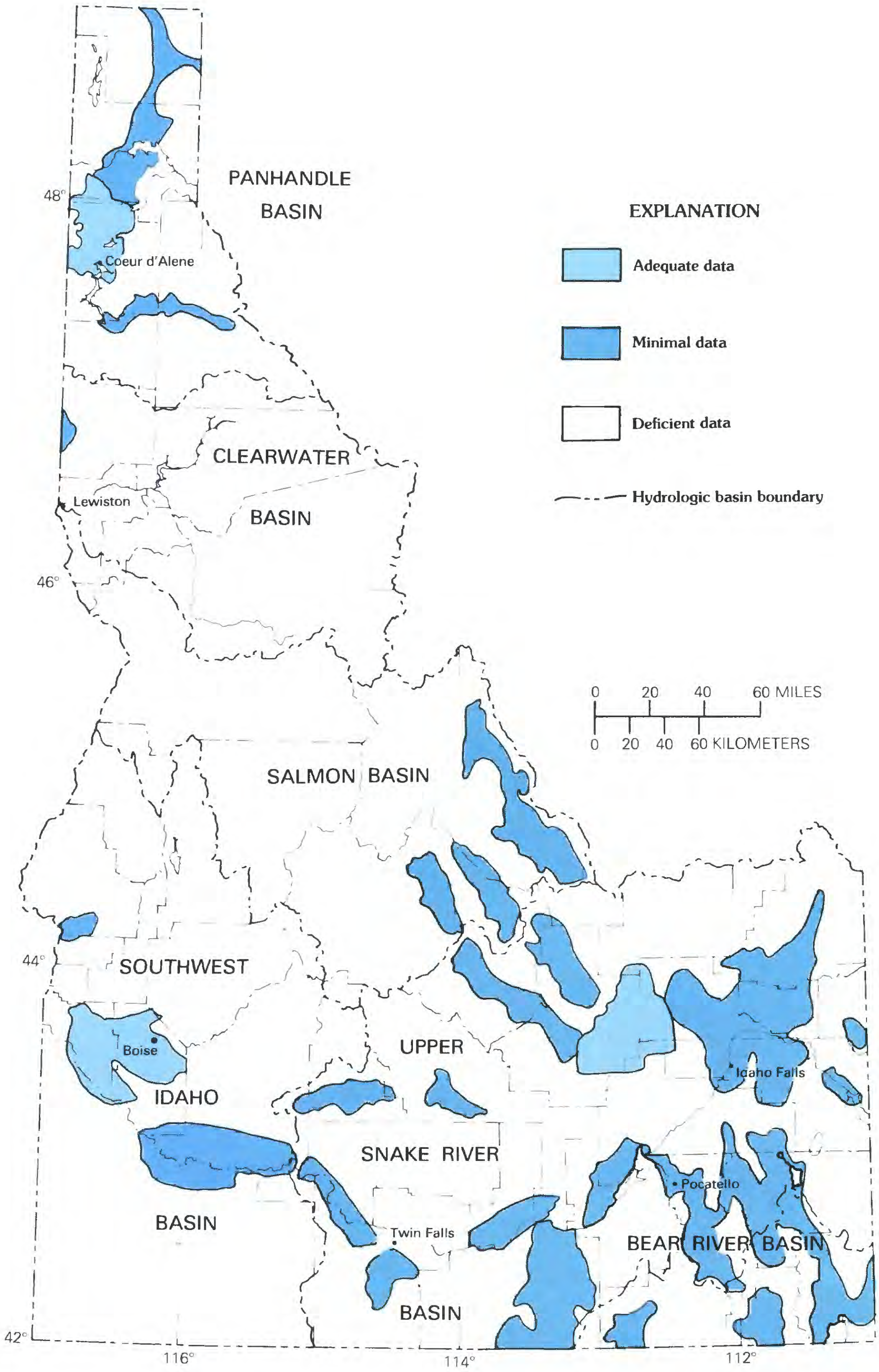


Figure 1.0. Areas of Idaho with adequate, minimal, or deficient data on ground-water quality.

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, ground water supplies an ever-increasing portion of the water used for irrigation. Ground-water 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 6,341 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 public water supplies, the quality of ground water must be protected. As shown in figure 2.0, ground water supplies varying proportions of the water for the major water uses in Idaho. In 1980, ground water's contribution ranged from 26 percent of the water used for irrigation to 94 percent of the water needed for industrial use.

Self-supply industrial use of water in Idaho is exceedingly high in comparison to that of other States in the Nation. This apparent high use occurs because the portion attributed to ground water includes natural discharge from springs, some of 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 using public supplies, 592,000 persons, or 83 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. On the basis of 4,060 Mgal/d withdrawn for irrigation in 1980 (see fig. 2.0), withdrawal averaged about 0.003 (Mgal/d)/acre.

	Million Gallons Per Day	Percent
SELF-SUPPLY INDUSTRIAL		
Ground water	2,080	94
Surface water	123	6
	2,203	
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	

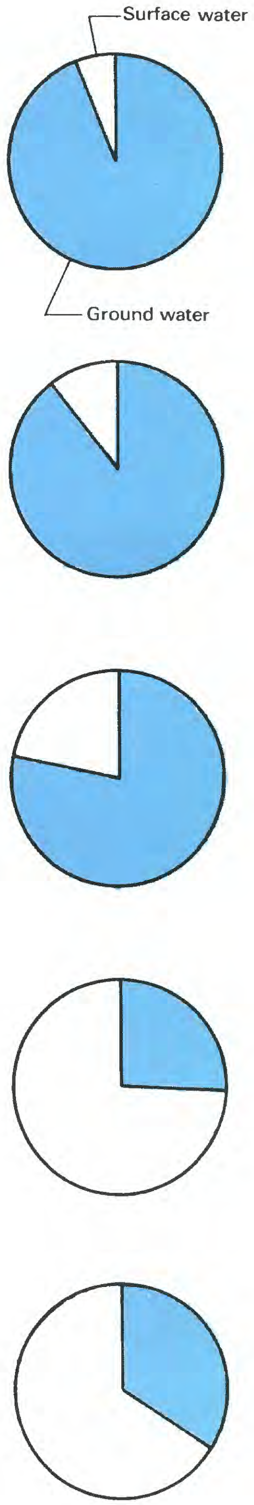


Figure 2.0. Water withdrawn from ground- and surface-water sources in Idaho during 1980.

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 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. The sources of wastes and associated types of contaminants most likely to affect ground-water quality in Idaho 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, or 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 and phosphates.
Nuclear facilities	Radiochemicals, heat, dissolved solids.
Urban activities (storm and sanitary sewers, sewage-disposal plants, cesspools and septic tanks, and 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 ***Wat***er Data ***Sto***rage and ***Re***trieval System was used as the primary source of data for evaluating ground-water quality in the State. Other sources of data included EPA's ***Sto***rage and ***Ret***rieval System (STORET), water-quality files of the 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 this file contains the most data. At the time of the study (1981–82), chemical analyses were available in this file for about 2,800 ground-water sites in Idaho. The number of sites in each county is 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, also were 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. The system is similar to WATSTORE, and STORET's users include Federal and State agencies.

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

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

IDHW deals with problems related to water pollution, er vironmental protection, health, and the Safe Drinkin Water Act in Idaho. Many of IDHW's data are ir cluded in file records and in STORET.

INEL is a testing facility for nuclear reactors. The USG operates a network of observation wells to monit the effects of INEL operations on ground-water qua ity. The water-quality data collected are available i WATSTORE.

NURE project collects water-quality data to evalua uranium resources in the continental United State The NURE data are available through published r ports and on computer tapes.

USBR investigates ground-water quality as part of t agency's water-management studies. The data a available through STORET.

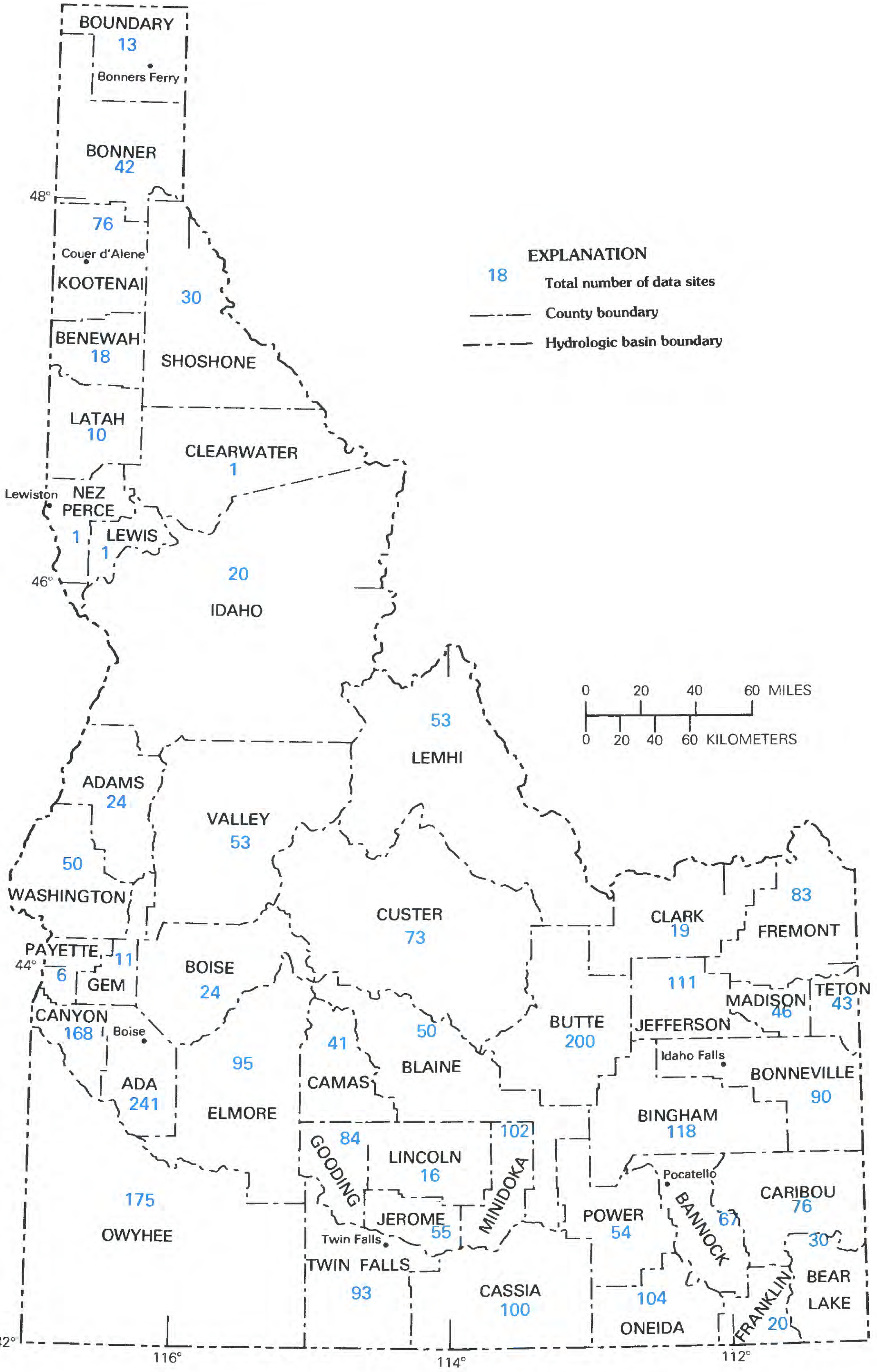


Figure 4.0. Number of sites in each county for which chemical analyses of ground water are available in WATSTORE.

Water-Quality Data Analyzed by 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. (See figure 7.2 for a statistical summary of key indicators for water in a glacial deposits aquifer. For each constituent within an aquifer, the summary lists the 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; specific conductance varies with the amount of dissolved solids in the water. It is used to approximate the dissolved-solids content.
pH	pH values range from 0 to 14 and indicate acidity or basicity. Water with a pH of 7.0 is neutral; water with a pH value less than 7.0 is acid, and water with a pH value greater than 7.0 is basic or alkaline.
Temperature	Temperature affects solubility in and viscosity of 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 for many industrial uses.
Nitrogen, nitrite plus nitrate	Nitrogen content is an indicator of sewage and agricultural contamination. Water containing more than 10 mg/L may cause methemoglobinemia in infants.
Sulfate	Sulfate is dissolved in water from rocks and soils containing sulfur compounds and from industrial wastes. More than 250 mg/L is objectionable in drinking water supplies.
Hardness	Hardness in water is caused primarily by 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 (Ca or Mg contents in mg/L)
Soft	0–60
Moderately hard	61–120
Hard	121–180
Very hard	More than 180

Constituent	Significance
Silica	Silica is 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 indicates contamination from human or animal wastes. Fecal coliforms are present in the intestines and feces of warmblooded 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	Iron is dissolved from practically all soils and rocks. Iron is derived also from industrial wastes, corroded well casings, and 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.

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); these divisions are based on hydrologic units (U.S. Geological Survey, 1975). The generalized areal extent of major aquifers and the boundaries of the hydrologic basins are shown on figure 6.0. Data are sufficient to describe water-quality conditions at various levels of detail only in selected aquifer groupings; these groupings 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 data for the glacial deposits aquifer (described in section 7.2 of this report).

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

The Southwest Idaho basin is the most populous basin A great deal of water-quality data is available, and mos is from the Boise area. 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, phosphate ore-processing operations and nuclear reactor facilities are in the basin. Population centers agricultural development, and water use are concentrated near the Snake River. Data are too few to make any detailed descriptions of water quality except for 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.

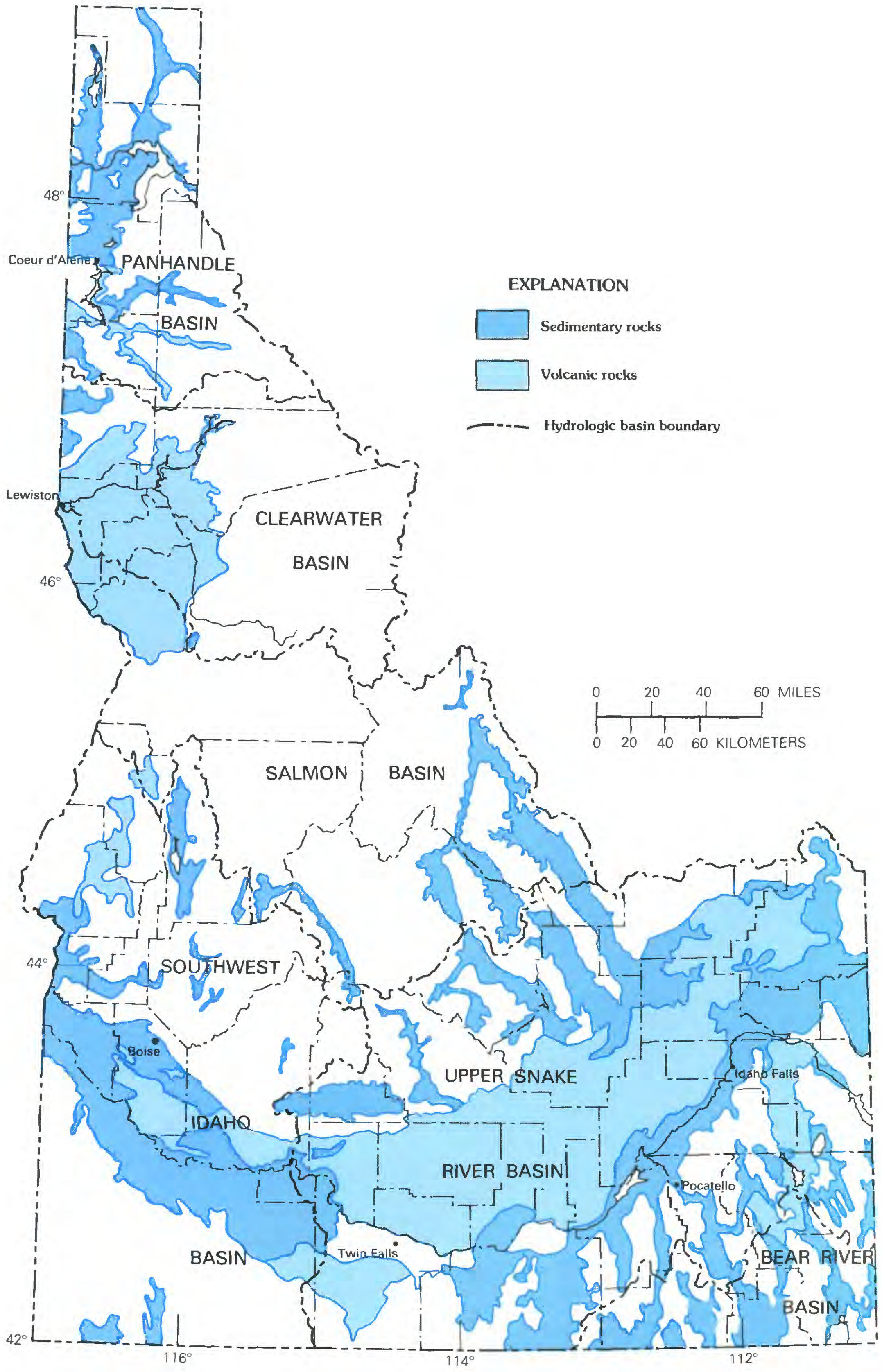


Figure 6.0. Hydrologic basins and generalized areal extent of major aquifers in Idaho.

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

Sufficient data to determine chemical mean composition of the water are available for only three of the aquifers in the Panhandle basin. On the basis of available analyses, the water type in these three aquifers can be classified as calcium bicarbonate.

Five aquifers have been identified in the Panhandle basin by Parliman and others (1980) on the basis of geologic units. They are in (1) Quaternary alluvium (and colluvium), (2) Quaternary glacial deposits, (3) the Tertiary Columbia River Basalt Group, (4) Tertiary and Cretaceous granitic rocks, undifferentiated, and (5) Cambrian and Precambrian sedimentary, igneous, and metamorphic rocks, undifferentiated. Sufficient data to determine the chemical mean composition of the water are available for 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 includes the Rathdrum Prairie aquifer, 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 the three quantifiable aquifers is shown in figure 7.1. 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.

Insufficient data are available to classify the water with any degree of confidence in the Tertiary and Cretaceous granitic aquifer and the Cambrian and Precambrian rocks aquifer. However, in the few analyses available, the percentages of calcium and bicarbonate suggest that these two may also contain calcium bicarbonate type water.

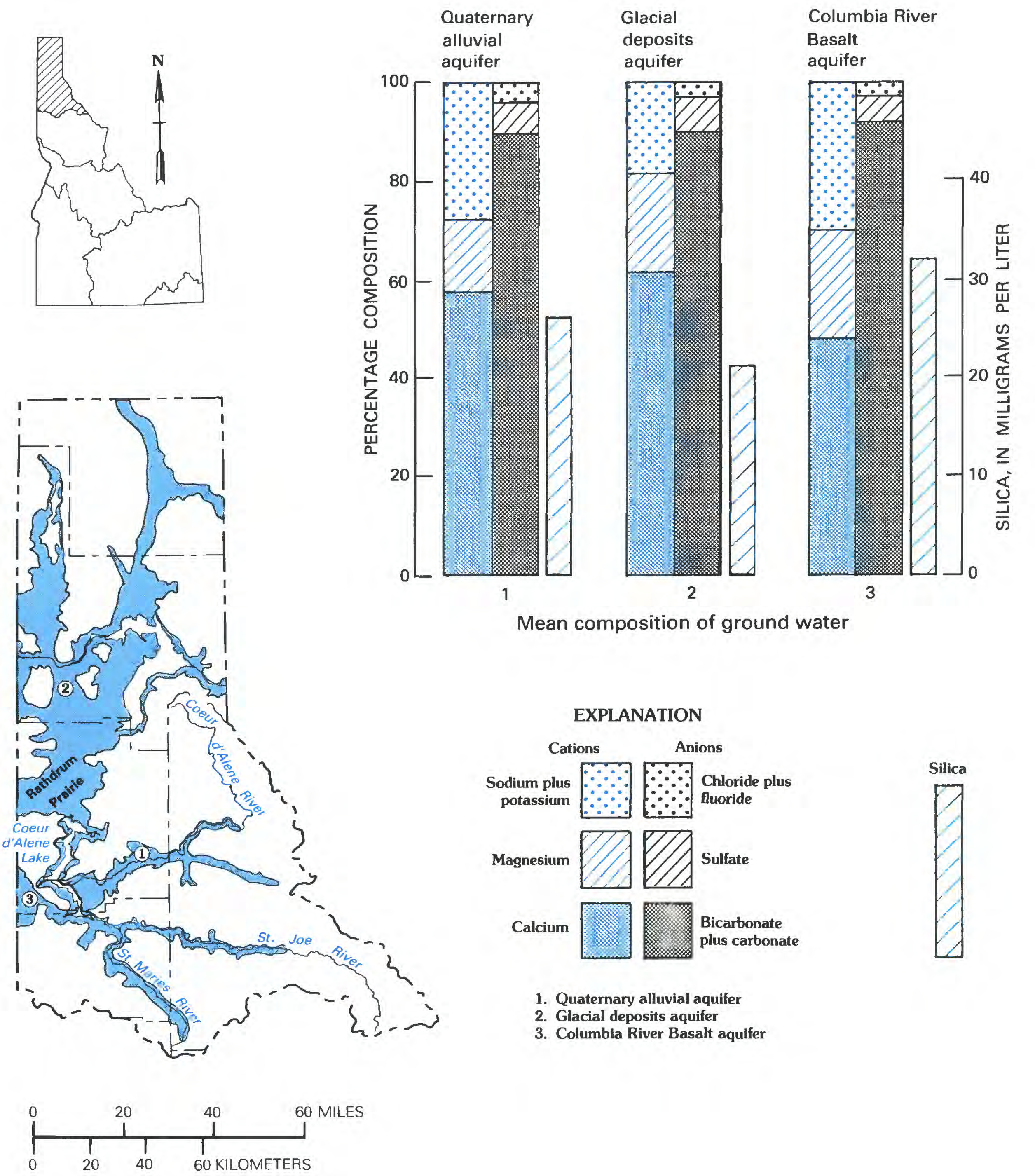


Figure 7.1. Chemical characteristics of water in major aquifers, Panhandle basin, Idaho.

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, because it is a drinking-water supply, is monitored by the EPA.

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 that extend from near land surface to several hundred feet below. Vertical permeability of these deposits is high, and no known intervening areally extensive confining beds are present. Therefore, water in the aquifer is particularly susceptible to contamination from surface pollutant sources.

The glacial deposits aquifer is the only aquifer with sufficient data to describe the water quality in some detail. Analyses totaling 127 were available, most of which described water in the southern part of the aquifer. Only 10 analyses were available for Boundary County. Most of the analyses for Boundary County showed a high concentration of dissolved solids relative to concentrations in other parts of the aquifer (*see* fig. 7.2). The graph in figure 7.2 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 remaining analyses showed nitrogen concentrations of no more than 2.9 mg/L.

Within the glacial deposits aquifer, the Rathdrum Prairie area is of primary concern. Here, the aquifer, locally called Rathdrum Prairie aquifer, has been designated by the EPA as a "Sole or Principal Source Aquifer." Within this designated area, 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.

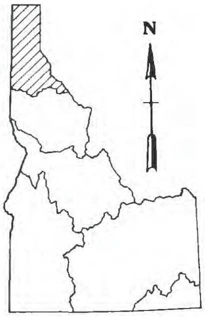
The quality of water in the glacial deposits aquifer within the Rathdrum Prairie area, as determined from WATSTORE data, is good and suitable for domestic use. Dissolved-solids concentrations, determined as the sum of constituents in the water, did not exceed 376 mg/L. Total and fecal coliform bacteria 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).

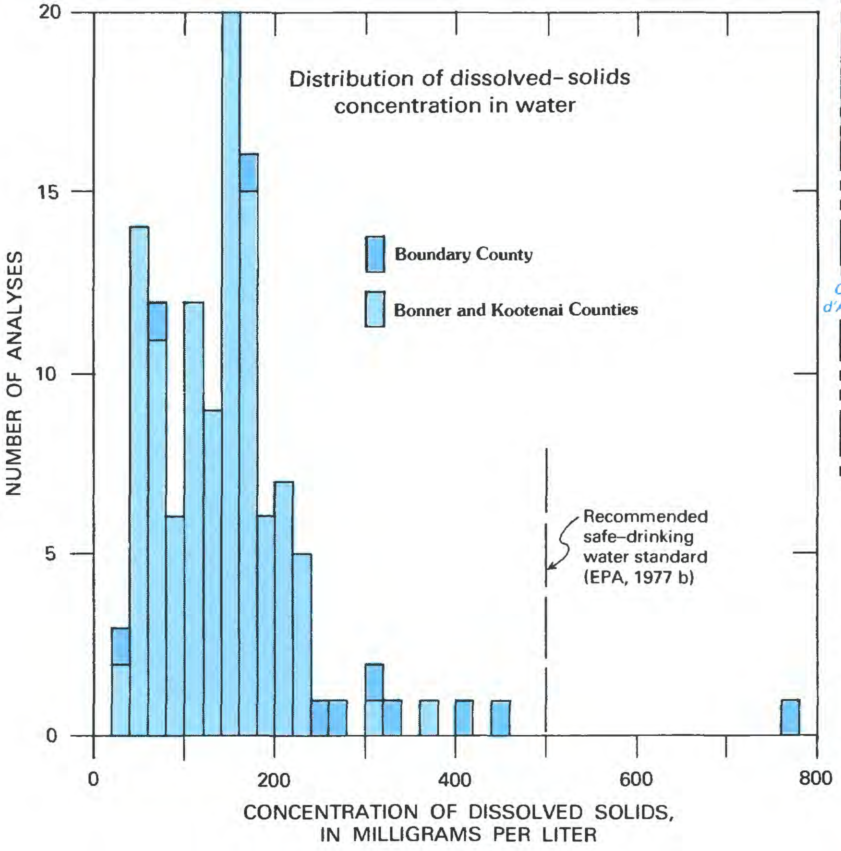
STATISTICAL SUMMARY

Glacial deposits aquifer

Constituent	Number of analyses	Minimum	Maximum	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	.1	25	.1	.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]< 1	[1]< 1	--	--
Coliform, total (colony/100 mL) -------	51	[1]< 1	19	[1]< 1	--	--
Iron, dissolved (µg/L as Fe) ----------	51	.0	5300	20	349	894

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





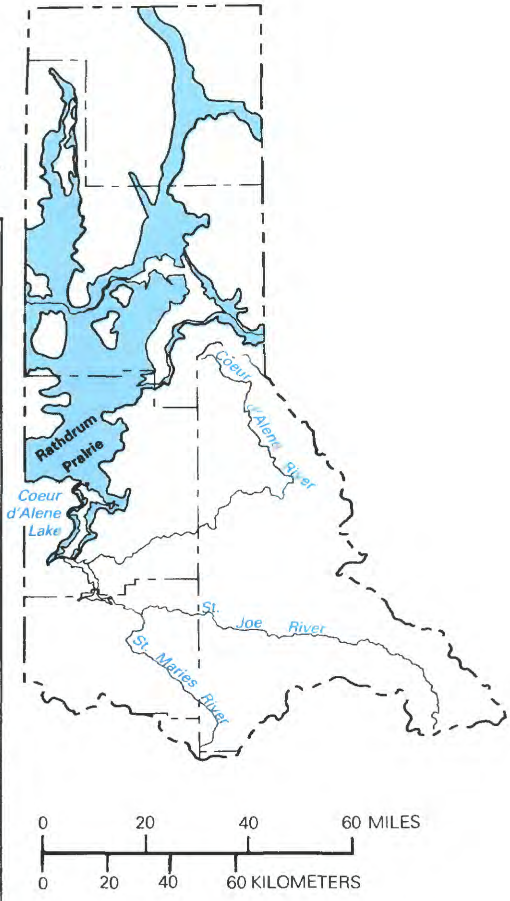


Figure 7.2. Statistical summary of key indicators for water quality in the glacial deposits aquifer, Panhandle basin, Idaho.

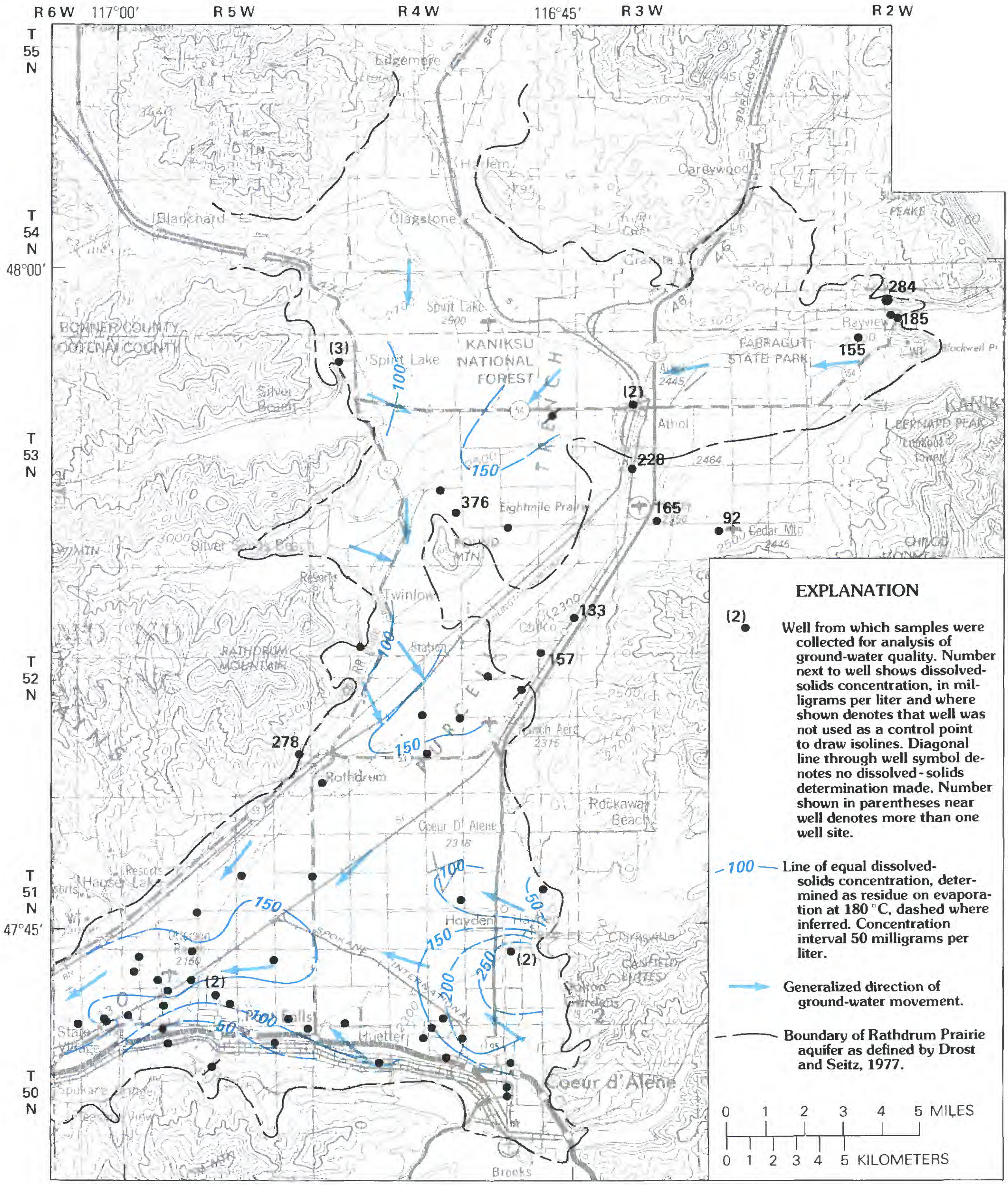
Data Collected from Wells Sampled Between July 1975 and April 1979 Used to Define Dissolved-Solids Distribution

The distribution of dissolved solids shows that water of relatively low mineral content (dissolved-solids concentration less than 100 mg/L) is introduced into 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 for figure 7.3 were retrieved from STORET for 58 wells 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 in figure 7.3. Well sites for which no dissolved-solids data were available, but where other water-quality data are available in STORET, also are plotted in figure 7.3. The number of samples periodically collected and analyzed (July 1975–April 1979) for each site ranged from 1 to 22. 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 derived from only two data points, and so its areal extent is inferred.

Data from about 40 additional sites in the Rathdrum Prairie area having dissolved-solids determinations 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.



Base from U. S. Geological Survey 1:250,000,
Spokane 1980; Sandpoint 1966

Figure 7.3. Dissolved-solids concentration in water in the Rathdrum Prairie aquifer (data collected from July 1975 to April 1979).

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 for most localities.

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 data involve fewer than 10 analyses. About the same amount of data is available for the Columbia River Basalt aquifer.

The limited amount of data from both aquifers is not areally extensive and not adequate to describe the overall water quality. However, in general, the water-quality characteristics that were analyzed meet drinking-water standards in most localities. 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 of cadmium. The sample 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 the Quaternary alluvial and Columbia River Basalt aquifers are shown in figure 7.4. Generally, water in the Columbia River Basalt aquifer has much lower dissolved-solids concentrations than does 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 (μmho/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	.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 (μmho/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

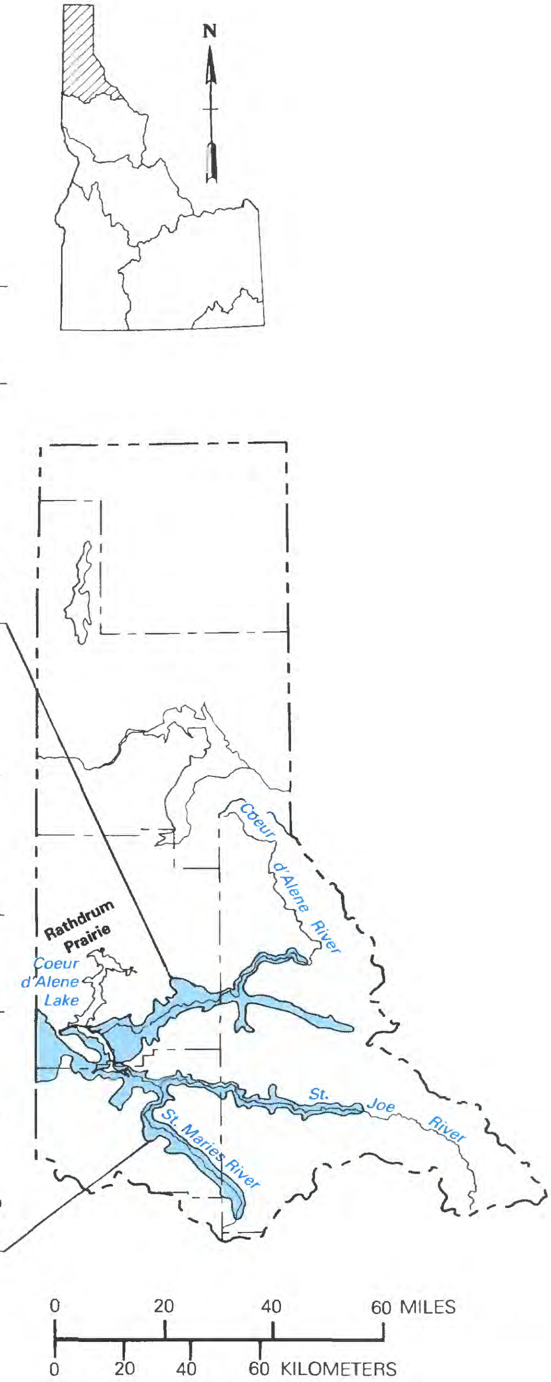


Figure 7.4. Statistical summaries of key indicators for water quality in Quaternary alluvial and Columbia River Basalt aquifers, Panhandle basin, Idaho.

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. On the basis of 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 for the Clearwater basin 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 all of central Idaho (Ross, 1963). Sodium comprises 93 percent of the cations, and bicarbonate 53 percent of the anions.

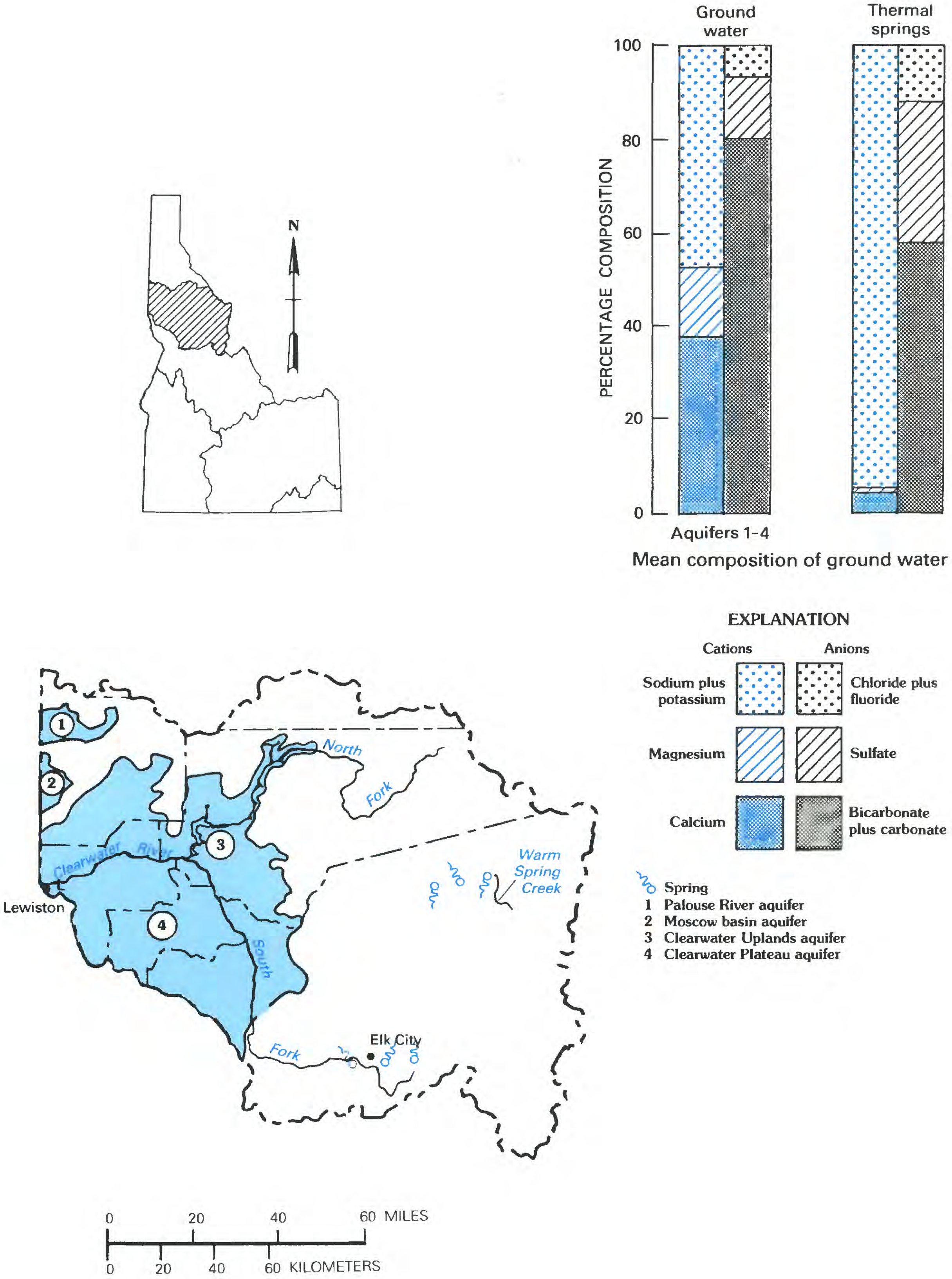


Figure 8.1. Chemical characteristics of ground water and thermal springs in the Clearwater basin, Idaho.

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 Thermal Springs of the Idaho Batholith

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, these analyses are from scattered locations and show a wide variation in concentrations of indicator constituents. The few data from the thermal springs of the Idaho batholith 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. These two aquifers, separated by the Clearwater River, are recharged by water from different drainage basins.

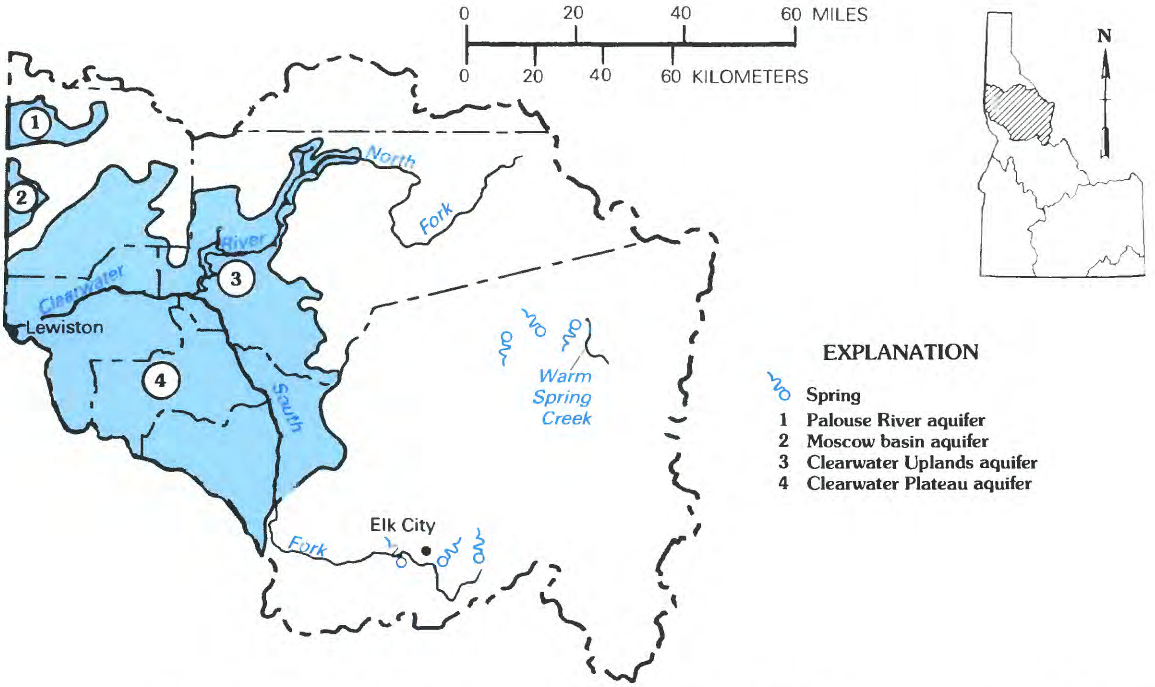
A total of 68 analyses from the IDWR are available for the four aquifers in the Columbia River Basalt Group. However, most of the analyses are from scattered locations, and waters in the individual aquifers have differing concentrations of dissolved solids, nitrate plus nitrite, and sulfate. The bar graphs in figure 8.2 show a wide variation in concentrations of these indicator constituents. Data for specific conductance and temperature for the Columbia River Basalt aquifers 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 few data are available for thermal springs in the Idaho batholith, the water quality there seems to be more uniform than that in the four Columbia River aquifers. The water is characterized by a consistently high temperature, a small range in dissolved-solids concentrations, and a low level of dissolved minerals.

STATISTICAL SUMMARY

Constituent	Aquifers in Columbia River Basalt Group[1/] Number of analyses	Minimum	Maximum	Mean	Thermal springs of the Idaho batholith 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	.32	3	.0	.04	.03	.01
Sulfate (mg/L as SO_4)	68	.2	260	38	7	12	48	32	15

1/ Modified from Graham and Campbell, 1981.



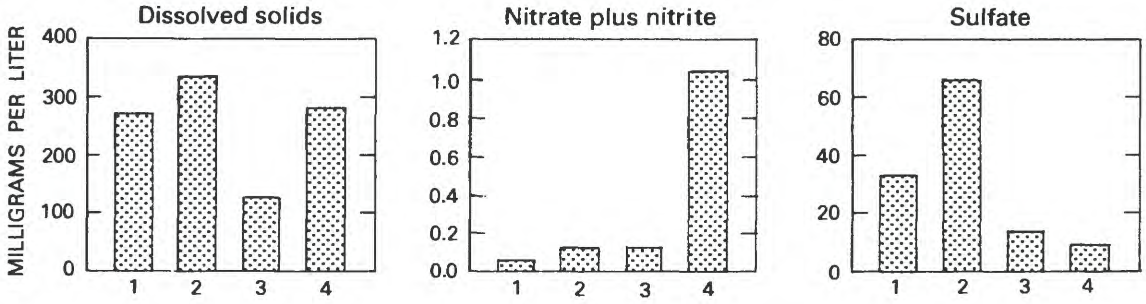


Figure 8.2. Summary of selected water-quality indicators in ground water and thermal springs in the Clearwater basin, Idaho.

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 in the Salmon basin 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 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 (see map, fig. 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 is 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 (cold-water springs) includes springs that have temperatures of 18 °C or less. Water from these is 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 graphs in figure 9.1.

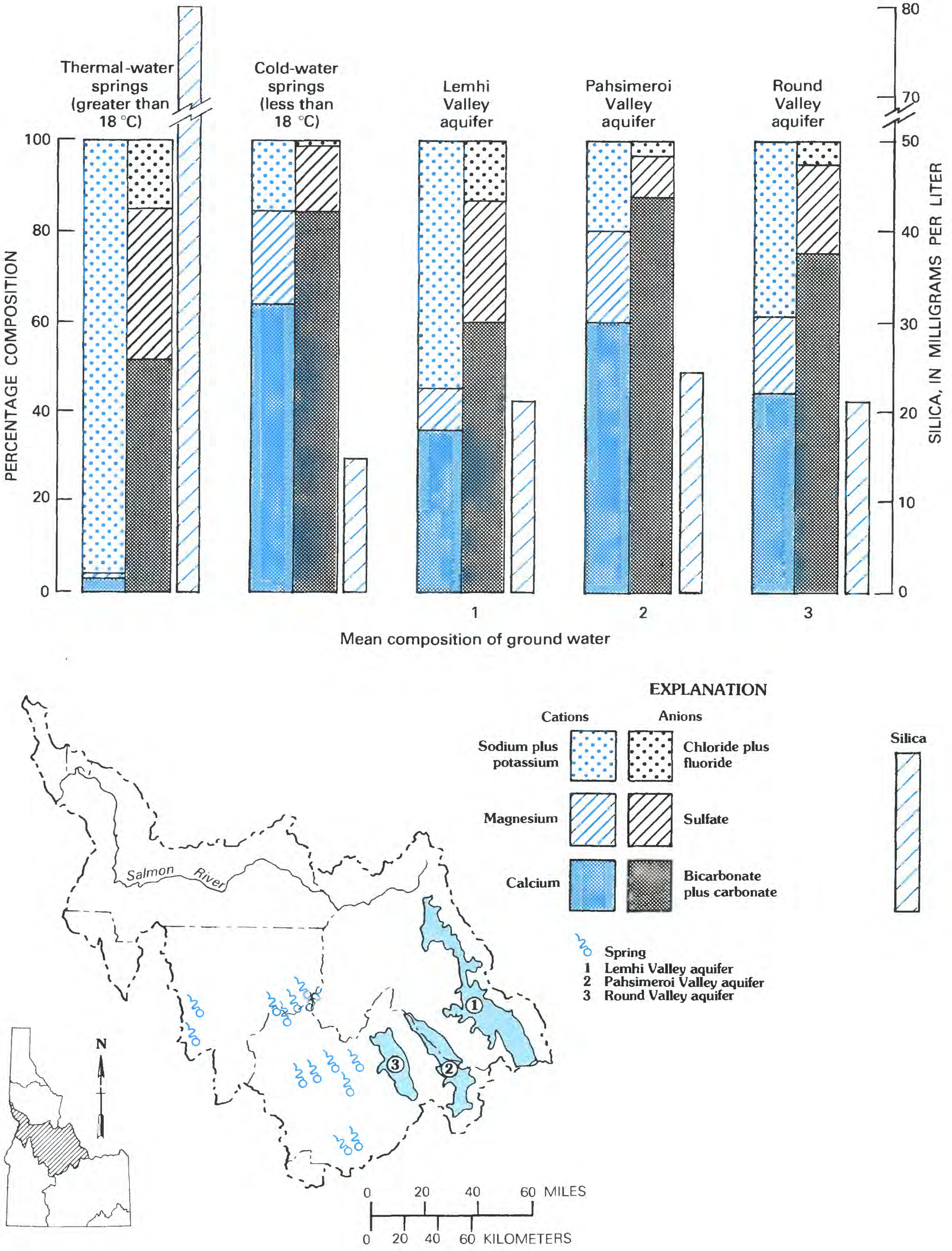


Figure 9.1. Chemical characteristics of water in springs and valley aquifers, Salmon basin, Idaho.

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 derived mostly from aquifers in the valley-fill deposits within the Lemhi, Pahsimeroi, and Round Valley areas. Nearly 2,900 people there 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 the EPA's 500-mg/L limit recommended for safe drinking-water standards. Water-quality conditions in these areas, however, may not be representative of the entire aquifer (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 a 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	.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	.13	17	.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 (µmho/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	.10	6.9	.44	.82	1.4
Sulfate (mg/L as SO_4)	30	3.8	1000	23	125	260

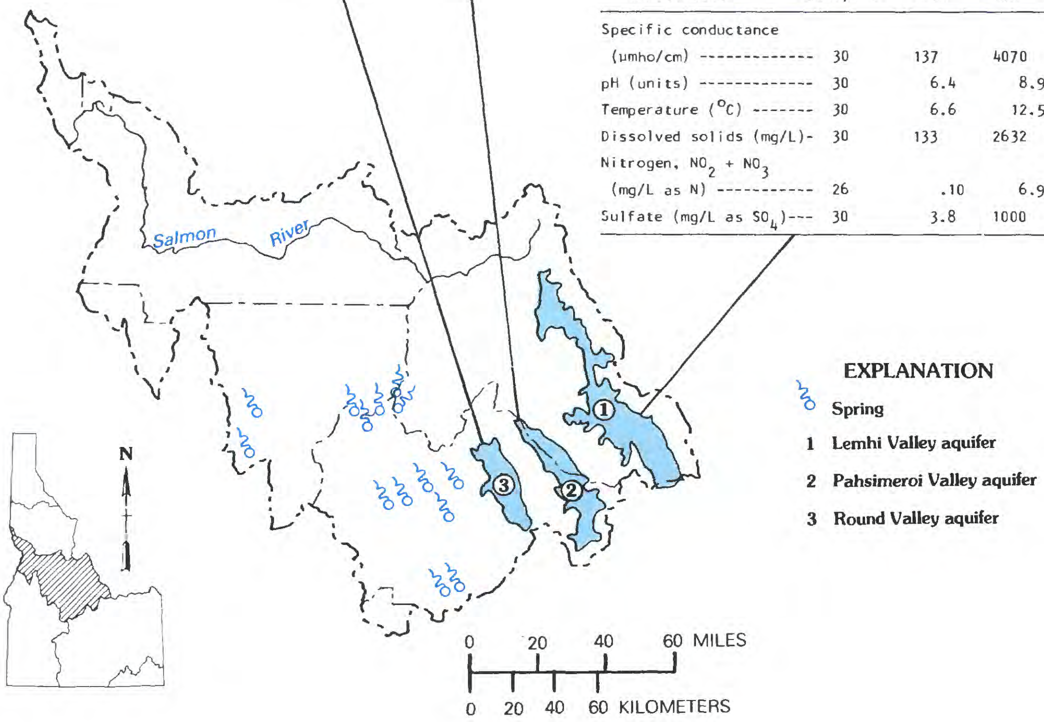


Figure 9.2. Statistical summaries of key indicators for water quality in valley aquifers, Salmon basin, Idaho.

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 Tertiary and Quaternary age 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 also is classified as sodium bicarbonate type, with even higher percentages of sodium and bicarbonate than in the other sodium bicarbonate type waters. 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 remaining 11 geologic units in the basin are few. Some units have only 1 analysis, and few have more than 10. Waters in these units seem to be 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 the 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 the Columbia Basalt Group in the Panhandle basin. However, the thermal waters from the Idaho batholith are similar regardless of the basin in which they occur.

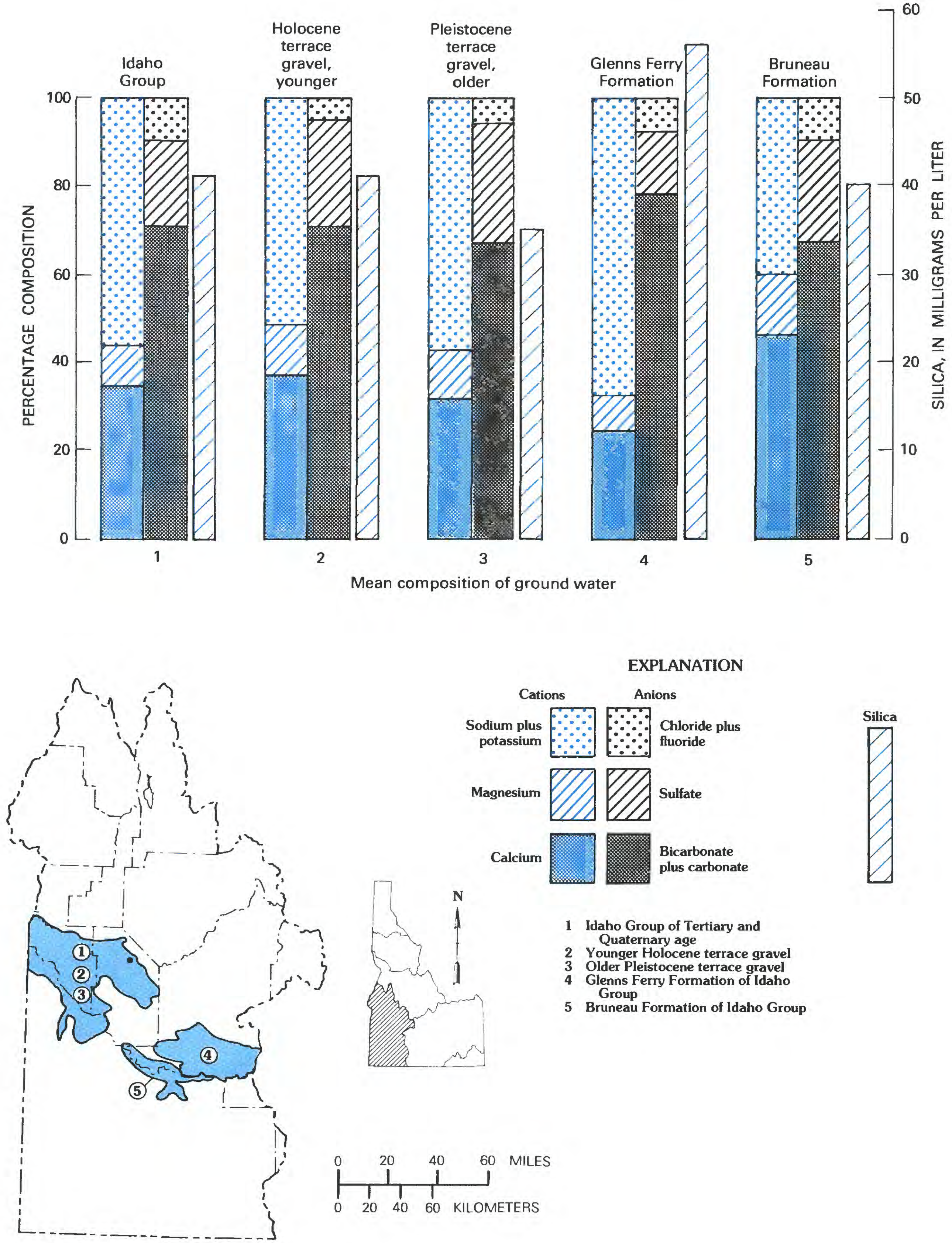


Figure 10.1. Chemical characteristics of water in major aquifer units, Southwest Idaho basin.

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 ranged from 1.3 to 41 mg/L during September–November 1980, 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; to insure comparability of data, however, 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, some unknown amount of error may have been 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, from 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 showed chloride concentrations that ranged from 1.0 to 52 mg/L, with a median concentration of 15 mg/L. Little, if any, overall change seems to have 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 principal sources in the Boise-Nampa area probably are animal wastes, sewage (including 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 (September–November 1980) 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 was used for control, and so the extent of the chloride mounds shown in figure 10.2 is inferred.

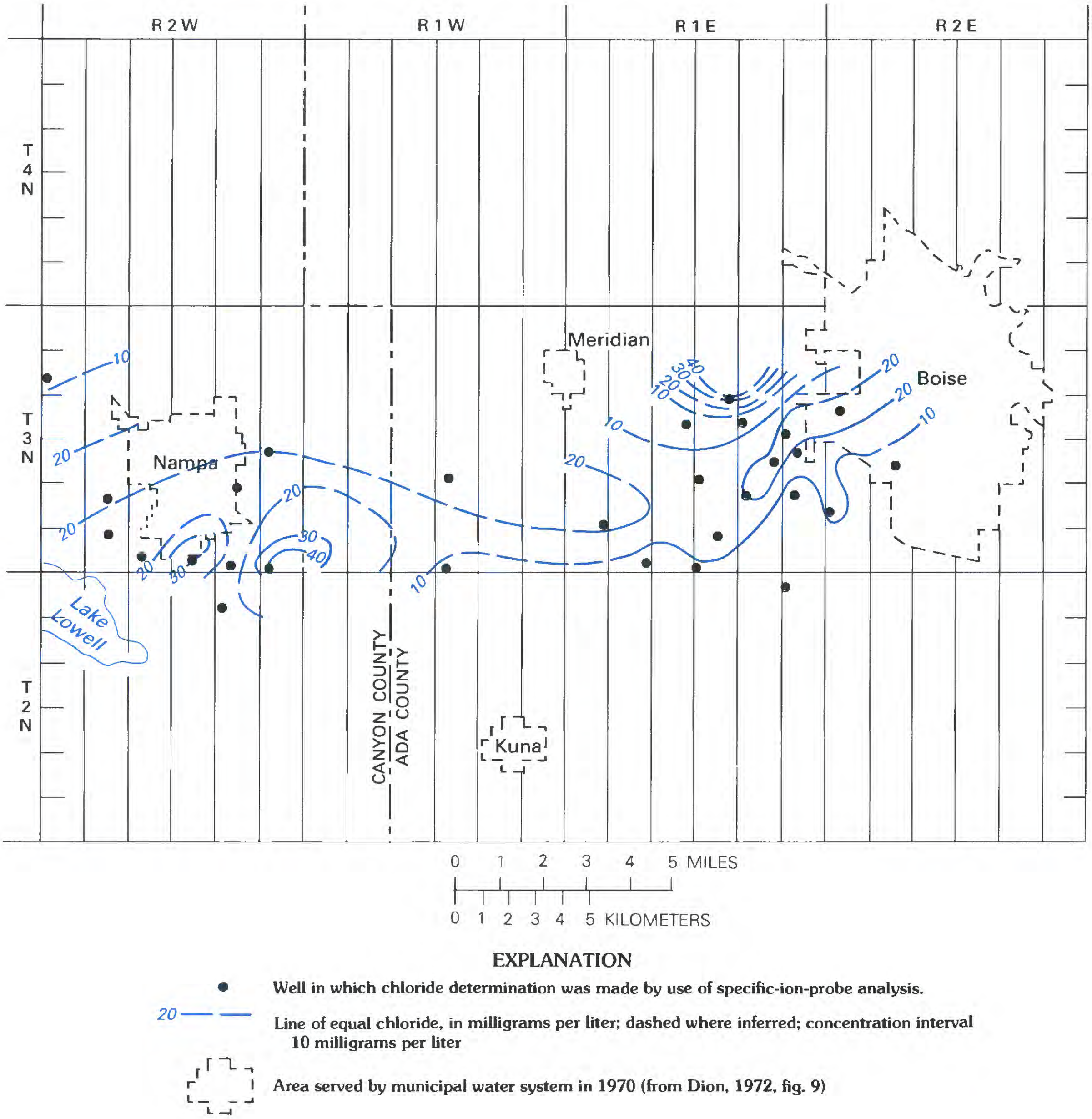


Figure 10.2. Distribution of chloride in water in the unconsolidated rock aquifer underlying part of the Boise River valley, September-November 1980.

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 ranged from 0.4 to 10.5 mg/L during September–November 1980 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, data collected in the summer of 1970 show nitrate concentrations ranging from 0.2 to 13 mg/L, with a median concentration of 3.0 mg/L (Dion, 1972). Little, if any, overall change seems to have 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 1978–80, 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 (September–November 1980) 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 are cause for concern. In the high-nitrate area southwest of Boise, only one well was used for control, so the extent of the nitrate mound shown in the figure is inferred.

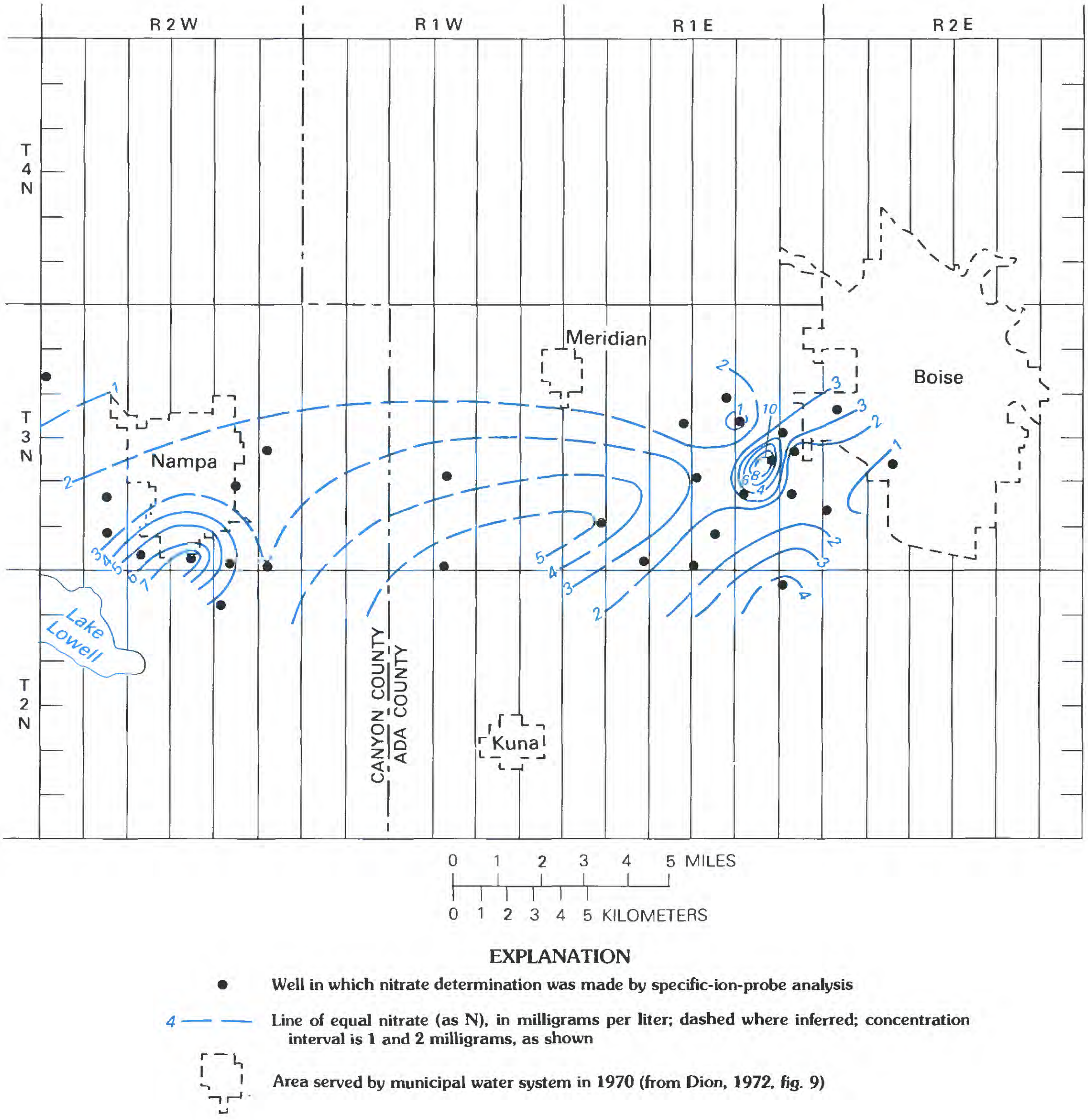


Figure 10.3. Distribution of nitrate in water in the unconsolidated rock aquifer underlying part of the Boise River valley, September-November 1980.

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* sections 10.2 and 10.3), 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 (Dion, 1972) 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 (Dion, 1972) 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.

Changes in concentrations of these two constituents over long- and short-term periods are 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. Well A 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. Well B is located in south Nampa, where the municipal sewer system has recently (past 2 years) been extended to some residential subdivisions, but not to all.

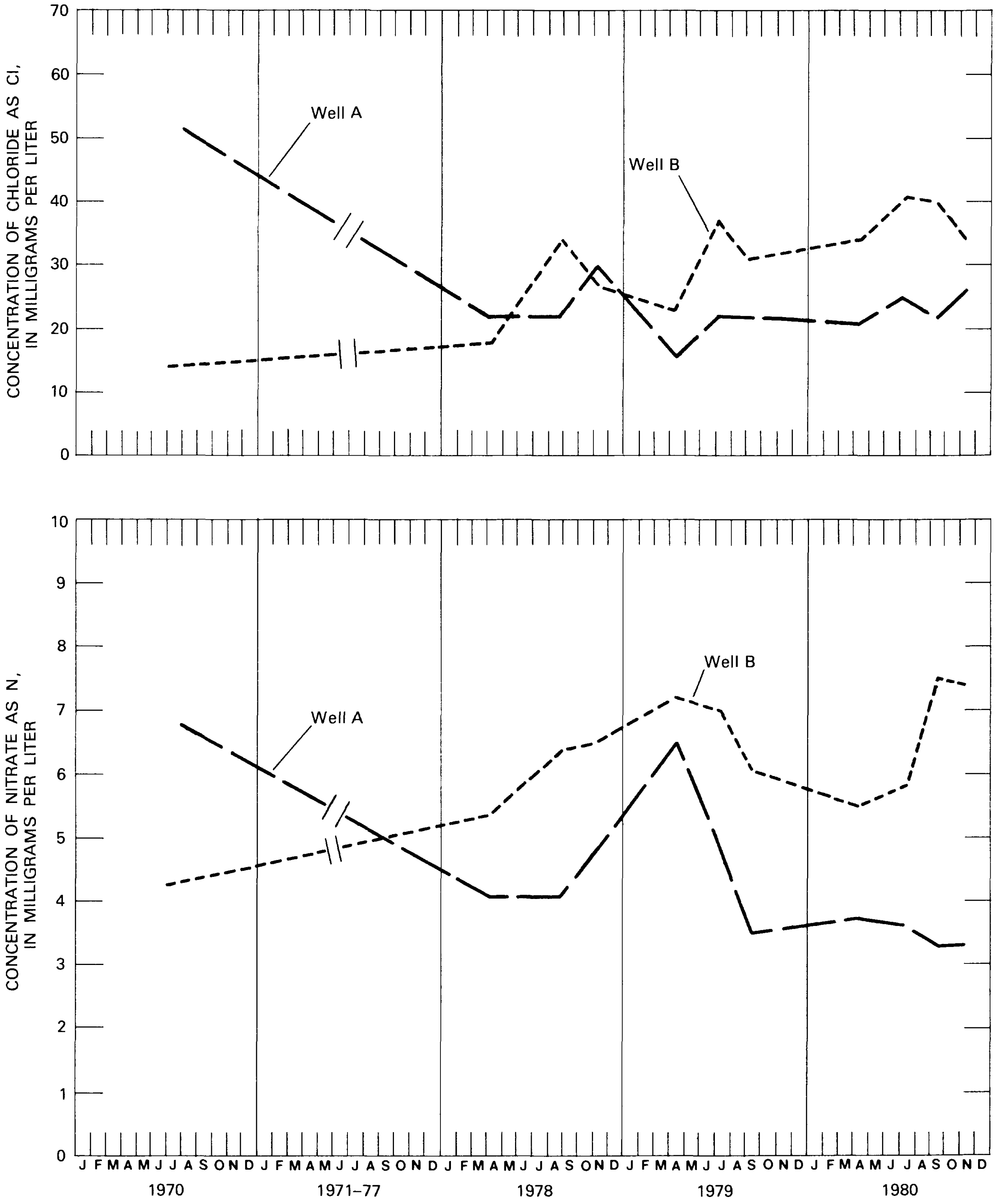


Figure 10.4. Changes in selected chemical constituent concentrations in water in two wells in the Boise-Nampa area.

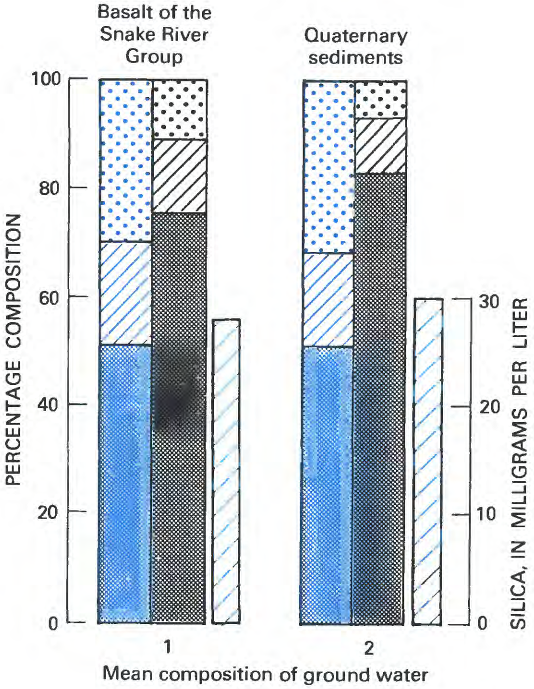
Dissolved-Solids Concentrations Average 282 mg/L in the Basalt of the Snake River Group and 263 mg/L in the Quaternary Sediments

Water in the Snake River Plain aquifer occurs mostly within the basalt of the Snake River Group and in the Quaternary sediments. Dissolved-solids concentrations of the water average 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 Quaternary age Snake River Group 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 primarily calcium bicarbonate type. The chemical characteristics of water from the basalt of the Snake River Group and from the Quaternary sediments are similar. Both contain about 50 percent calcium and about 80 percent bicarbonate. The bar graphs in figure 11.1 show the similarity in chemical composition of water from the two rock units. Statistical summaries of key indicator constituents for water from the two rock units are also presented in figure 11.1.

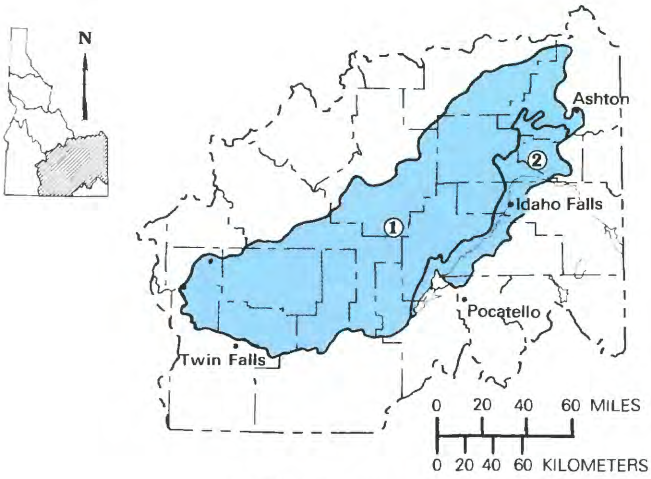


STATISTICAL SUMMARY

Basalt of the Snake River Group

Constituent	Number of analyses	Minimum	Maximum	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	.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]< 1	13	[1]< 1	--	--
Coliform, total (colony/100 mL)	58	[1]< 1	180	[1]< 1	--	--
Iron, dissolved (µg/L as Fe)	284	0	1400	--	57	124

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



STATISTICAL SUMMARY

Quaternary sediments

Constituent	Number of analyses	Minimum	Maximum	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	.02	19	.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	[1]< 1	--	--
Coliform, total (colony/100 mL)	11	[1]< 1	250	[1]< 1	--	--
Iron, dissolved (µg/L as Fe)	33	10	18000	--	700	3117

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

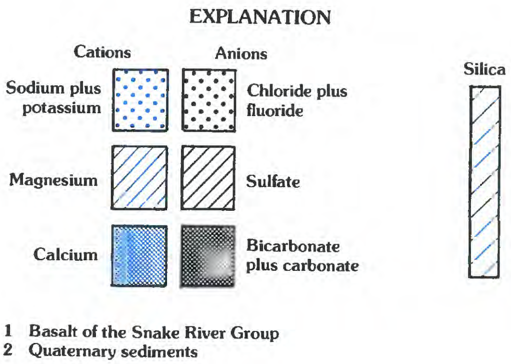


Figure 11.1. Chemical characteristics of water in major aquifers, Upper Snake River basin, Idaho.

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 6 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. A solute-transport model developed by Robertson (1974) predicted a downgradient migration of chloride of 8 miles by 1980 (see fig. 11.2).

The INEL covers an area of 890 mi^2 in 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 are 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). Robertson's model simulated a chloride plume in the aquifer as the plume 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.

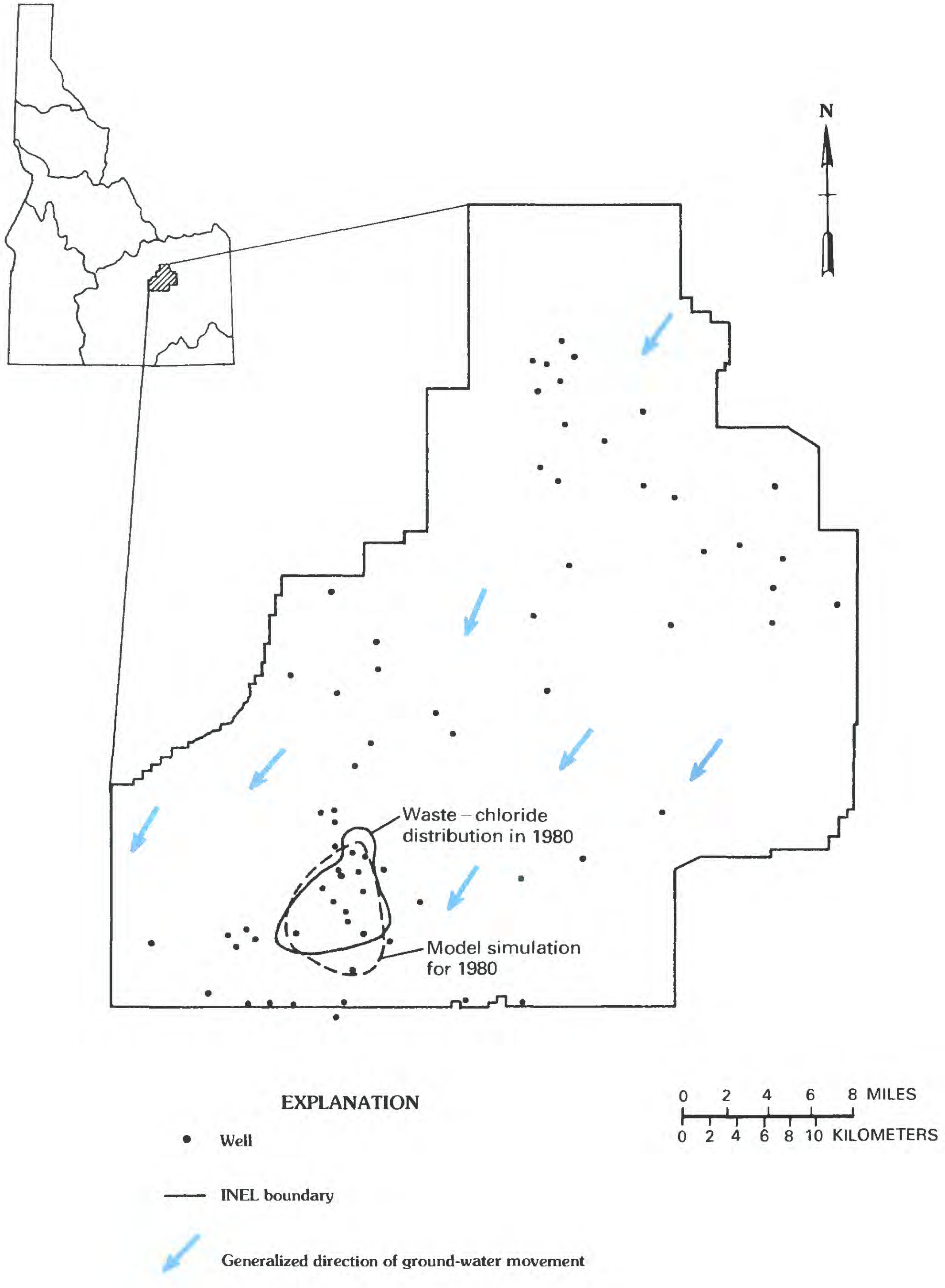


Figure 11.2. Distribution of waste chloride and model-projected distribution in the Snake River Plain aquifer beneath the Idaho National Engineering Laboratory, 1980.

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.

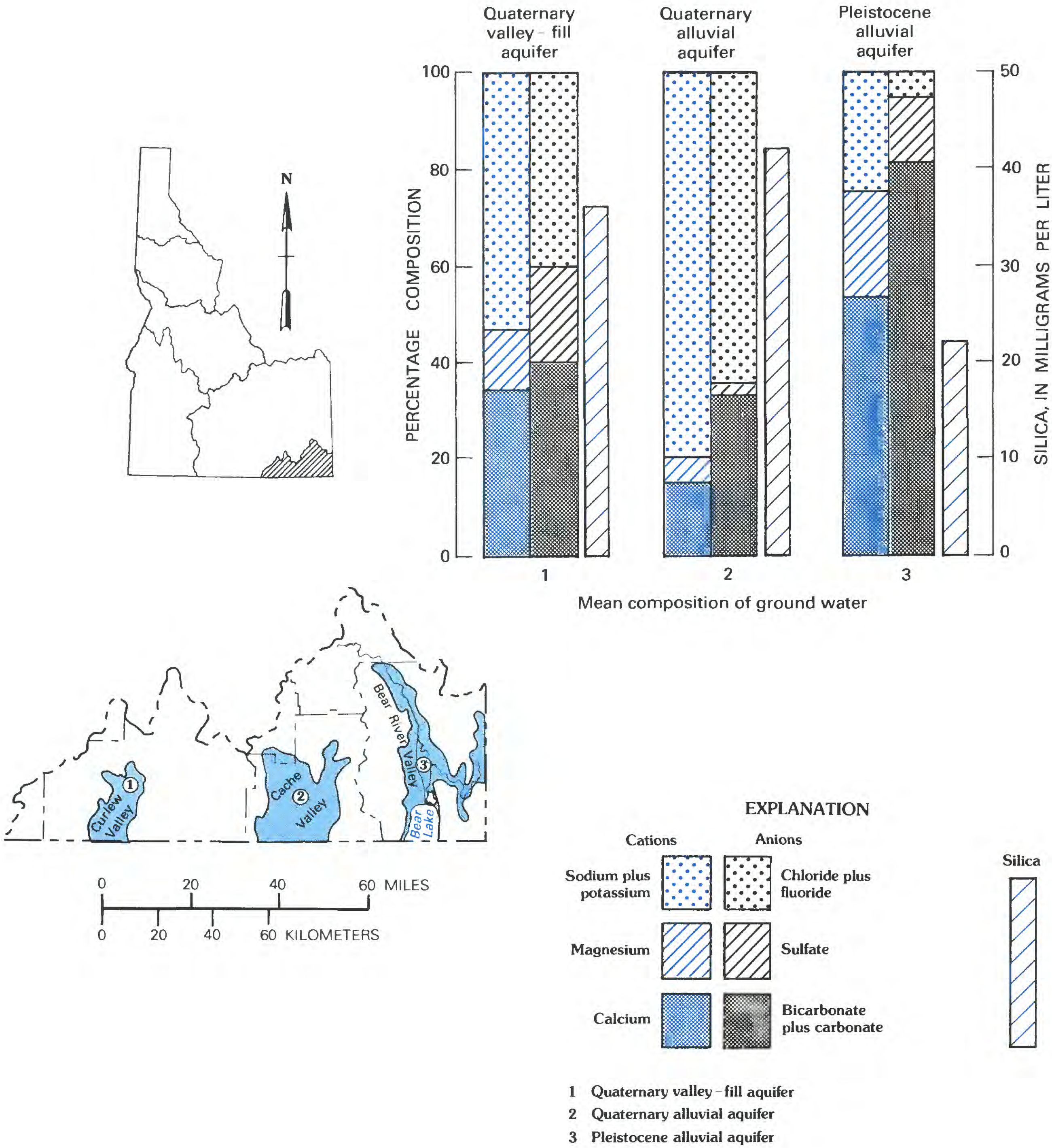


Figure 12.1. Chemical characteristics of water in major aquifers, Bear River basin, Idaho.

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. On the basis of available data, the quality of water is within the 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.

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

Figure 12.2 shows statistical summaries of water quality indicators in the three aquifers. 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 has.

STATISTICAL SUMMARY

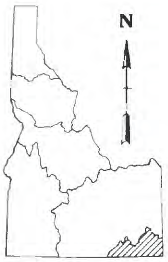
Pleistocene alluvial aquifer

Constituent	Number of analyses	Minimum	Maximum	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	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	Minimum	Maximum	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	.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	Minimum	Maximum	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

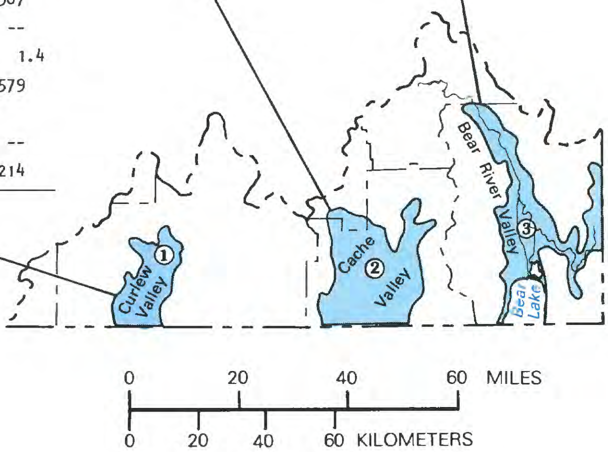


Figure 12.2. Statistical summaries of selected indicators for water quality in Quaternary valley-fill, Quaternary alluvial, and Pleistocene alluvial aquifers, Bear River basin, Idaho.

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 subject to degradation largely stemming from man's activities. The generalized location and extent of the more notable of these problem 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, sewage-system leakage, sewage 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 the INEL, in the Upper Snake River basin. A brief description of the special problem areas in each of the major drainage basins follows.

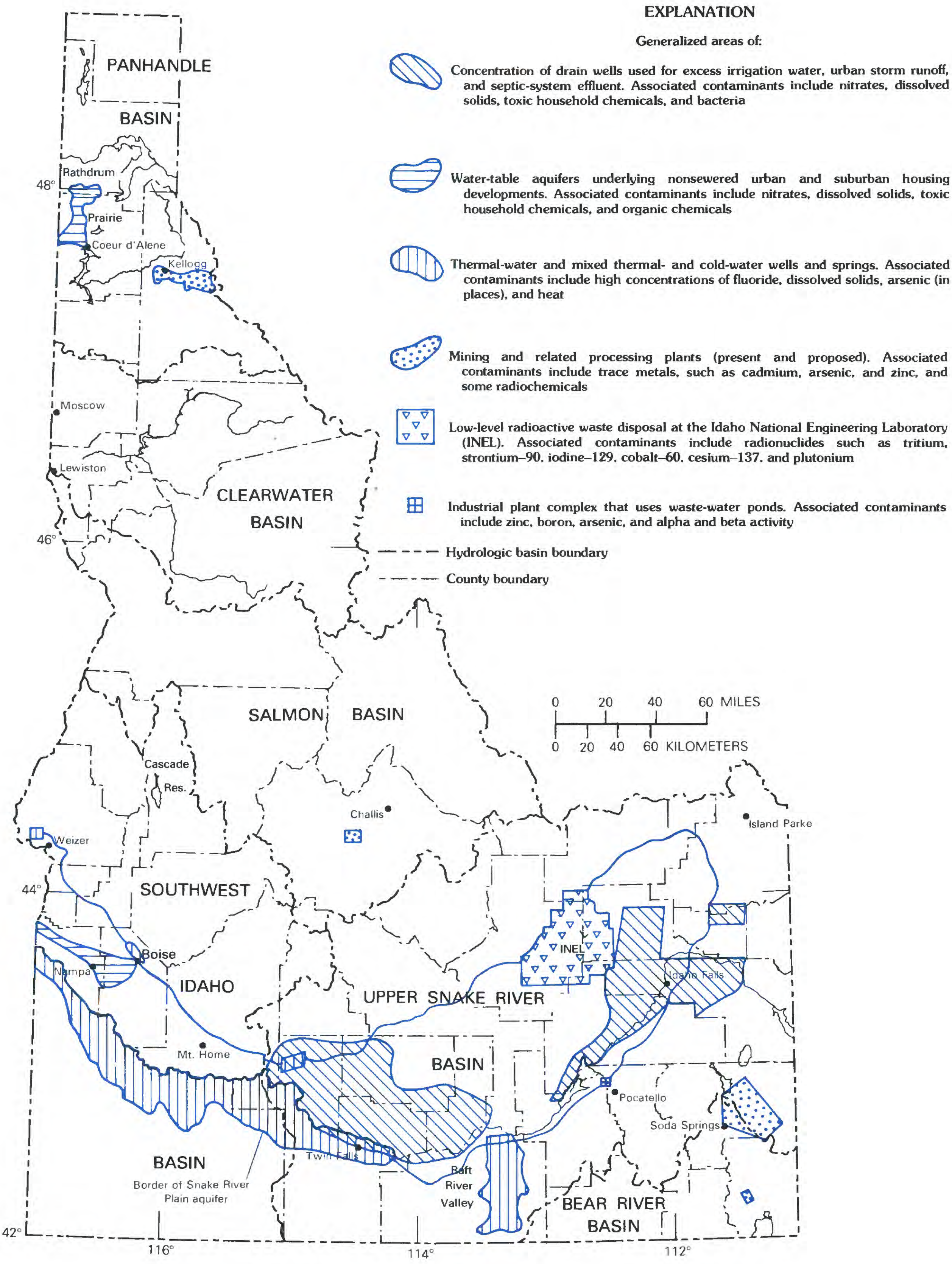
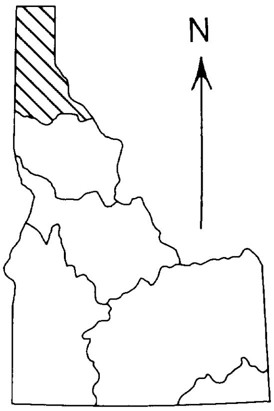


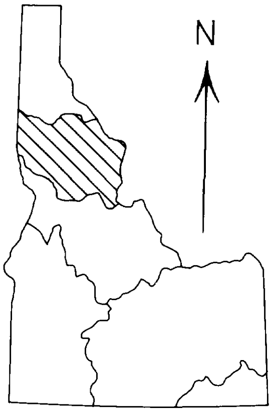
Figure 13.0. Generalized areas where potential exists for degradation of ground-water quality.



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 quartertly basis (S. Tanner, oral commun., 1982). Constituent determinations include nitrate, chloride, pH, specific conductance, and volatile organic materials. These data are stored in the EPA's STORET system.

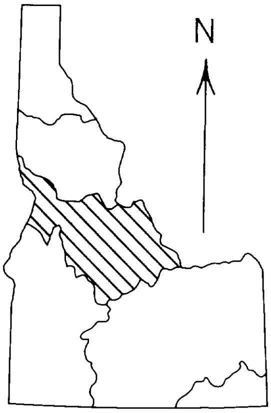
Another concern is elevated trace metals concentrations in ground water in the Coeur d'Alene mining district near Kellogg. Some of these concentrations may be naturally occurring; however, leachates from mining and smelting operations in the mining district also may be contributors (Parliman and others,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



Clearwater basin

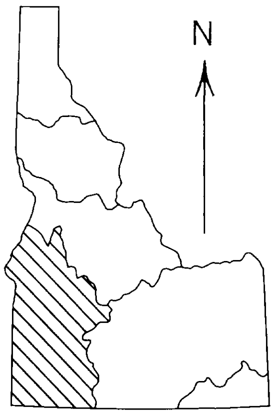
In the Clearwater basin, highly mineralized ground water is locally a problem to water users, particularly in the Moscow basin. Dissolved iron, manganese or sulfate, and dissolved-solids concentrations may exceed drinking water limits (fig. 8.2), and dissolved cadium, lead, or mercury concentrations are high in isolated areas.

Highly mineralized water is due to variability of aquifer mineral composition rather than land- or water-use influences. Ground-water sampling and monitoring efforts are generally limited to the Moscow, Lewiston, or small mining-impacted areas. Thermal-water springs in the Idaho batholith contain somewhat high fluoride concentrations, but these concentrations are not known to have affected water quality in the cold-water system.



Salmon basin

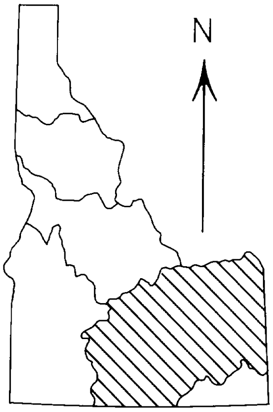
Similarly, in the Salmon basin, ground-water problems are not severe. Mining operations, particularly a rather large operation recently started southwest of Challis (fig. 13.0), might impact water quality in the valley-fill aquifers. However, water-quality monitoring is not yet sufficient to document 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 on p. 47. Land use in this area is changing rapidly 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 is the influx of thermal waters, high in fluoride and other undesirable constituents, into the cold-water aquifers. Part of this influx is naturally occurring; that is, 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 permits mixing of the two waters and can result in degradation of quality in the cold-water aquifers.



Upper Snake River basin

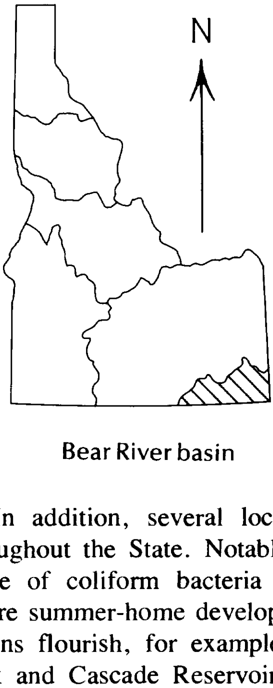
In the Upper Snake River basin, two major causes for concern involve widespread use of drain wells and disposal of low-level radioactive wastes at the INEL (fig. 13.0). Several thousand (exact number is not known) drain wells are used to dispose of excess irrigation water, urban storm runoff, and septic-system effluent from lands overlying the basalt of the eastern Snake River Plain aquifer. Contaminants introduced by some of the drain wells reportedly have 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. This inflow 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 since the early 1950's to trace the spread of contaminants at the INEL. 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 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 in this area, as in the Southwest Idaho basin, is the influx of thermal waters into cold-water aquifers and the resulting degradation of quality.

In the Raft River valley, the major problem is the lowering of water levels in the cold-water aquifers because of 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.

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 of mining on ground water 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 pronounced, but phosphate mining problems, similar to those in the Upper Snake River basin, may occur.

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 listed in a report by the Idaho Department of Health and Welfare (1980b) that 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, no monitoring of ground-water quality on an areal basis is 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.

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 resources in 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, including 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 also is generally good for most intended uses, including space heating, health spas, recreation, and irrigation. However, some thermal water mixes with the cold water. This mixing could become a major problem because the thermal water in some areas contains high concentrations of fluoride, arsenic, boron, and dissolved solids and could degrade the cold water and restrict its use for drinking.

In evaluating the ground-water-quality conditions in Idaho, a number of conclusions were derived as to the validity of the available data in making such evaluations. In sections 7.1–12.2 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 because 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 criteria are good for geochemical interpretations but are of little help in detecting pollution that results from land-surface-derived wastes. Contaminants that occur commonly in Idaho, but are generally absent in most 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, Idaho ground waters have not been analyzed for these constituents. 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 would 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 natural conditions, few data are available that represent natural conditions, particularly in the cold-water system. This lack of data exists 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. For most cold-water aquifers, any selected number of analyses taken in the past, or at present, represents some status of water-quality conditions for a particular time or period of time and not natural conditions. This hinders making a valid appraisal of man's effects on ground-water quality. Nothing practical can be done to rectify this data deficiency.

14.0 SUMMARY AND CONCLUSIONS

As to time span, 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 monitored (see fig. 10.4) in only a few places. This deficiency can be alleviated 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, data are insufficient for all aquifers except the Rathdrum Prairie aquifer. The data are insufficient 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 multiple collection results in difficulties when any one agency attempts to assimilate all data from all data bases for a single purpose. Each group of collectors uses its own sampling techniques, analytical methods, and quality-control procedures; this leads to incompatibility of data and precludes the use of all available data for certain interpretations and appraisals. Sampling techniques, analytical methods, and accuracy standards are continually improving. These changes 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, data-management systems differ. For example, data in two of the largest water-quality systems, STORET and WATSTORE, are difficult to merge. Programs used in one system will not work in the other without considerable adaptation. A more cumbersome problem is that data available from some sources are not stored in computers; this discourages any massive use of these data.

The above difficulties could be alleviated by standardization of all water-quality sampling and analysis techniques, use of similar quality-control standards, complete merger of data files among 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.

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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 inch-pound unit	By	To obtain SI (metric) unit
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)	1,233.0	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)

☆U.S. G.P.O. 1987-181-407:40106