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A SURVEY OF THE GROUND WATER OF THE STATE OF IDAHO

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FOREWORD

The growth and development of Idaho has been and will continue to be closely related to the existence of sufficient water supplies. As ground water is an extremely important source in some areas of the state from which water for communities, farms and industries is secured, it is felt that this pamphlet by Mr. Philip T. Kinnison, titled "A Survey of the Ground Water of the State of Idaho" is a valuable and significant contribution.

The Idaho Bureau of Mines and Geology is pleased to sponsor this project and to make Mr. Kinnison's findings available.

J. D. Forrester, Director
Idaho Bureau of Mines
and Geology

A SURVEY OF THE GROUND WATER OF THE STATE OF IDAHO

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PURPOSE AND SCOPE

Water is an important commodity in Idaho, with much of the population in areas of relatively low rainfall and much of the agriculture depending upon irrigation. Two million acres of the state were under irrigation in 1944 (43, p. 62) and the area has greatly increased since that time. In addition to irrigation, there is extensive demand for municipal and domestic water and a growing demand for water for industry. Most of the demand is being met by use of surface waters, but demand for ground water for each of these purposes is increasing.

Some area studies have been made, but no general survey of ground water occurrences of the state and no analysis of the potential use and the problems which this use will raise. Some of these problems are already being faced in valleys in South Idaho, where pumpage is approaching intake and new wells are being drilled to increase production further.

This report surveys ground water occurrence in Idaho as an initial step in bringing together the available information and filling in information on areas which have not been studied. It also analyzes the future ground water needs and problems that will arise as use increases, aiming at the best use ultimately of the available ground water resources.

Because of municipal and irrigation development, subsurface information is plentiful for some areas. Much of this detailed information was summarized. But subsurface information is almost completely lacking in other areas and broad inferences about occurrence of ground water had to be made. It is hoped the report will attract attention to this little-studied branch of geology and serve as an outline of ground water information until more detailed studies are available.

PROCEDURE

Compilation of this report began with a questionnaire canvass of all incorporated municipalities, and most of them were later visited to inspect well logs and well sites and obtain all possible ground-water information. The municipal water-supply map, Figure 7, is one of the results of this study. Information on quality of water is mainly derived from a 1952 report of the Idaho State Department of Health. Geologic information was taken from libraries of the University of Idaho and the Idaho Bureau of Mines and Geology. Well records of drillers and various government agencies were collected, interpreted, and where possible correlated.

One of the main tasks was to correlate and evaluate ground water information not previously assembled, and field trips assisted in this evaluation.

ACKNOWLEDGMENTS

The writer is grateful to members of the Idaho Well Drillers Association for making available valuable geologic logs; to city clerks and engineers throughout the state for supplying detailed information; to the Ground Water Branch of the United States Geological Survey for detailed records of wells; and to the Idaho Bureau of Mines and Geology for financial assistance.

PREVIOUS STUDIES

Ground-water studies that have been made were prompted by the use or potential use of ground water for municipal supply or irrigation. Geologic publications' discussion of ground water are usually brief and general.

The ground-water resources of the Snake River Plain in southeastern Idaho have been investigated by the U. S. Geological Survey in cooperation with the Idaho Bureau of Mines and Geology and the Idaho Department of Reclamation. Water-Supply Paper 774 (39), the product of these studies, is the most useful publication available on the ground water of the state.

The Ground-Water Branch of the U. S. Geological Survey has published several reports concerning ground-water in Idaho. Most of these studies have been made in cooperation with the U. S. Bureau of Reclamation and the Idaho State Bureau of Reclamation. These reports cover very small areas and contain little interpretive data.

The Idaho Bureau of Mines and Geology has published a number of ground-water reports, in some cases with the cooperation of the U. S. Geological Survey. These studies were made at the request of municipalities, organizations, or institutions in Idaho, and are of small areal extent.

The titles of the principal ground-water reports dealing with Idaho are included in the list of references.

DESCRIPTION OF THE AREA

Location

The State of Idaho is bounded on the north by Canada at 49 degrees north latitude, on the south by Utah and Nevada at 42 degrees north latitude, on the west by Oregon and Washington at approximately 117 degrees longitude, and on the east by Montana and Wyoming at longitudes varying from 116 to 110 degrees. Its area is approximately 84,000 square miles.

Topography

Much of Idaho has a rugged surface, but there are considerable areas of nearly level or rolling land between the mountains. Elevations range from 783 feet near Lewiston to 12,665 feet at the top of Borah Peak, in eastern Custer County. The Snake River Plain forms a large, comparatively flat surface in South Idaho.

Climate

The entire state lies within the zone of prevailing westerly winds and is greatly affected by the moderating influence of the Pacific Ocean, so that the climate is milder than the latitude and altitude would indicate. The annual average precipitation in Idaho ranges from less than 10 inches on the Snake River Plain to more than 40 inches in the Bitterroot Mountains along part of Idaho's northeastern border (45, p. 839). For the state as a whole, January is the wettest month. There is an irregular monthly decrease until July and August, which are the driest months. Thirty-three per cent of the annual precipitation occurs during the winter months, December-February; 27 per cent in March-May; 15 per cent in June-August and 25 per cent in the fall, September-November. The average annual snowfall ranges from 16 inches at Lewiston,in Nez Perce County, to 230 inches at Roland, eastern Shoshone County. The last killing frost, or freezing temperature in spring usually occurs in May over much of the Snake River Valley and in Lemhi County, northern and eastern Custer County, and much of the Panhandle of Idaho; however, along the Idaho-Wyoming border, locally in the Panhandle, and over portions of the interior, the average date is in June. The first killing frost in the fall usually occurs during August along parts of the Idaho-Wyoming border, locally in the interior, and in northern Adams County, while in the Boise River Valley and parts of the western and southern Panhandle it is usually deferred until October. Over much of the remainder of the state the first killing frost is usually recorded sometime in September (45, p. 840).

General Geology

The two major rock types occurring in Idaho are granitic rocks associated with the Idaho batholith in the central part of the state, and extrusive rocks of the Snake and Columbia River flows. Large portions of the Panhandle are underlain by metamorphosed sediments of the Belt series. North-south or northwest-southeast trending mountain ranges composed mainly of Paleozoic sediments occur to the north and south of the Snake River Plain in southeastern Idaho. Acidic volcanic rocks are found in smaller amounts at several locations in the state.

GROUND-WATER ENVIRONMENTS

About 90 per cent of the ground water produced in the United States comes from unconsolidated rocks, chiefly sand and gravel (44, p. 10). Other principal aquifers or water-bearing beds for the country as a whole are (44, p. 11-13):

1. Limestone and other soluble rocks
2. Basalt and other volcanic rocks
3. Sandstone and conglomerate
4. Crystalline and metamorphic rocks
5. Porous but poorly permeable materials

The main physiographic environments from which water is recovered in the United States are watercourses, abandoned or buried valleys, plains, and intermontane valleys (44, p. 10). In Idaho the principal aquifers are:

1. Sand and gravel
2. Basalt
3. Sand and gravel intercalated with basalt

These aquifers occur in a variety of environments. Figures 1 through 4, which illustrate these environments, are highly generalized and simplified, and show types of environment rather than specific occurrences.

Figure 6, which illustrates the major water sources in Idaho, gives some indication of the distribution of the various environments. On the map it was not possible to separate the basalt environment from the sand and gravel intercalated with basalt environment.

VALLEY-FILL SAND AND GRAVEL ENVIRONMENT

Most of the water pumped from wells in Idaho comes from sand and gravel deposits in valley-fill. Most of the sediments are alluvial fan deposits but flood-plain deposits are also found. In some valleys fine lacustrine sediments are present and act as confining beds (Figure 2). Glacial deposits of sand and gravel also occur as valley-fill material (Figure 3). The amount of water present and available is controlled by the size, sorting, shape, and roundness of the sediments and the size and efficiency of the intake area.

BASALT ENVIRONMENT

In general, the basalt flows are very permeable because of jointing, fracturing, weathering of exposed surfaces, and openings caused by the expansion of gases when cooling (Figure 1). The amount of water present

GENERALIZED GROUND-WATER ENVIRONMENTS

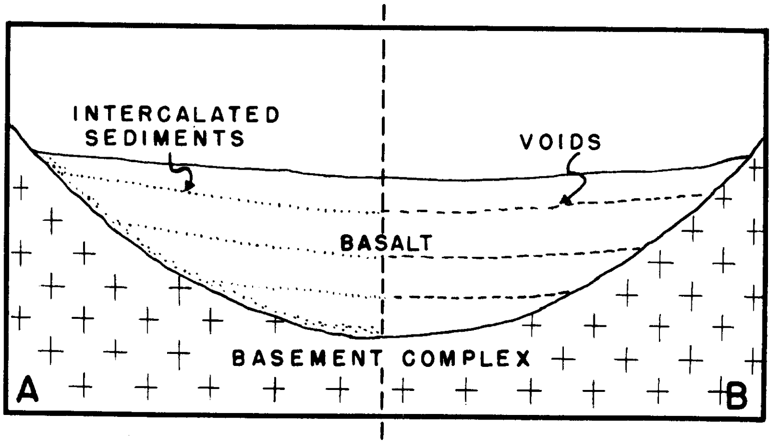

FIGURE 1 BASALT ENVIRONMENT

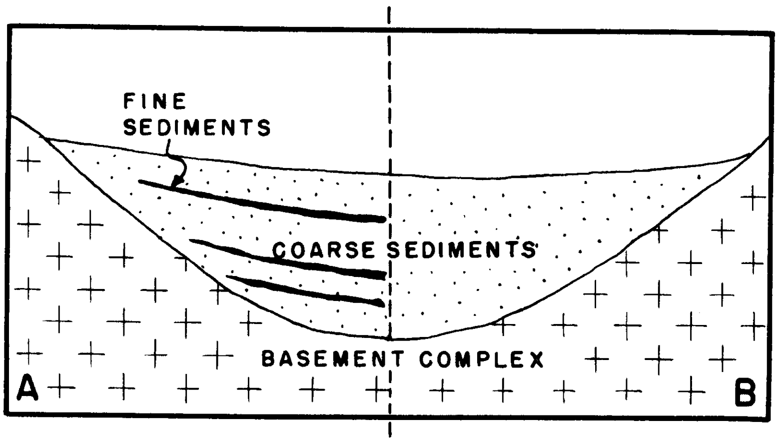

FIGURE 2 VALLEY FILL ENVIRONMENT

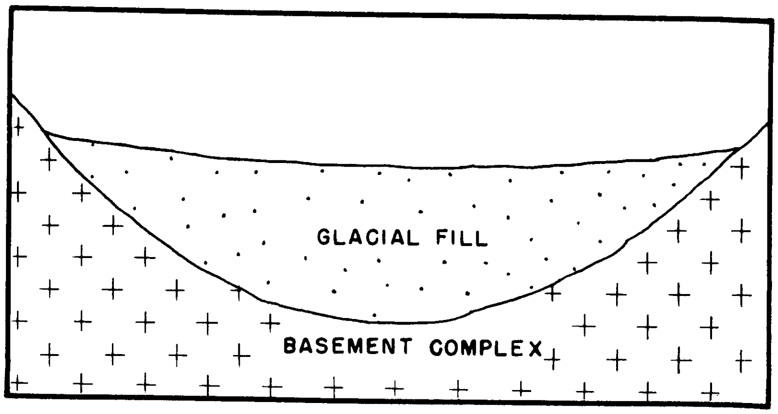

FIGURE 3 GLACIAL FILL ENVIRONMENT

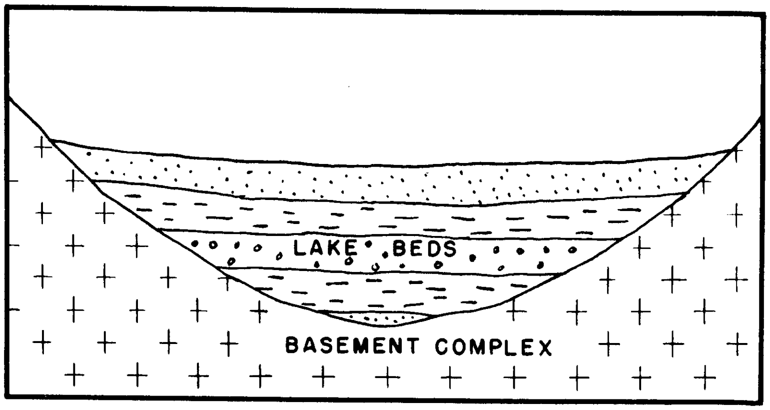

FIGURE 4 LACUSTRINE ENVIRONMENT

and the amount available depends mainly on the porosity and permeability of the basalt, and the size and efficiency of intake area.

SAND AND GRAVEL INTERCALATED WITH BASALT ENVIRONMENT

Sediments intercalated with basalt flows contain appreciable amounts of water. The sediments may be deposited as alluvial fans, flood plains, lacustrine deposits, or a combination of these. The thickness and extent of the sedimentary inter-layers depends on the amount of material available for deposition and the period of time between outpourings of basalt (Figure 1). The amount of water present and available in the sediments is dependent on the size, sorting, shape, and roundness of the sediments and the size and efficiency of the intake area.

LACUSTRINE SAND AND GRAVEL ENVIRONMENT

Sediments deposited in lacustrine environments are not widespread in Idaho but they contain large quantities of water. The sand and gravel deposits occur as part of a sequence of deposition that also, in many cases, contains clay, silt, and shale (Figure 4). The finer sized sediments act as confining beds for the sands and gravel and may contribute to artesian pressure. The amount of water present and the amount available is dependent on factors similar to those in other sand and gravel environments.

GROUND-WATER REGIONS OF IDAHO

INTRODUCTION

Ground-water geologists of the U. S. Geological Survey have divided the country into ten major divisions chiefly on the basis of the type of aquifers that are the dominant sources of ground-water (44, p. 15). Idaho includes parts of three of these divisions, the Western Mountain Ranges, The Columbia Lava Plateau, and the Arid Basins. This very general division fits into the pattern set up by the physiography units of Idaho as subdivided by Anderson (4, p. 201), Fennemen (10, Plate 1) and others (Figure 5).

The Western Mountain Ranges division includes the Northern Rocky Mountain and Middle Rocky Mountain sections and the Rathdrum Prairie sub-section. The Columbia Lava Plateau division includes the Palouse, Craig Mountain, Seven Devils, Snake River Plain and Owyhee sections. The third division, Arid Basins, includes that part of the state assigned to the Basin and Range section.

It is on the basis of these physiographic subdivisions that the ground water of Idaho will be considered.

NORTHERN ROCKY MOUNTAIN SECTION

Physiography

This section is the largest of Idaho's physical subdivisions. It lies north of the Snake River Plain and east of the Columbia River Plateau. All of the area is mountainous with summit elevations of 5,000 to 8,000 feet. Occasional valleys cut from 2,000 feet to 5,000 feet below the mountain crests. There are many deep river canyons such as that of the Salmon River, which is fully a mile deep.

Geology

The Idaho batholith, composed of acidic rocks of varying composition, is the major feature of this section. The batholith is about 200 miles long and 100 miles wide. For the most part it has no dominant structural trends and the present top of the batholith is a high, sloping plateau. Because of its uniform resistance and lack of structural trends, excellent examples of dendritic drainage develop on its surface. Metamorphic rocks such as quartzites, slates, and argillites of the pre-Cambrian Belt series occur in the area north of the batholith. Folding and faulting have led to the development of complex structural features. The folding has been on a broad scale and relatively gentle. The faulting, although complex, is restricted to several fracture zones and does not usually lead to the development of large topographic features.

The southeast part of the section contains igneous, metamorphic, and sedimentary rocks. Granitic rocks associated with the Idaho batholith occur as "offshoots" of the batholith or as stocks. Extrusive rocks are represented in the Challis volcanics, and in other acidic rocks associated with the Snake River basalts. Metamorphosed sediments of the Belt series outcrop extensively in this area, and they make up the northern half of the Lemhi Range. Along the southwest margin of the section are the Lost River, Lemhi, and Beaverhead Ranges. These three sub-parallel ranges are composed mostly of sedimentary rocks of Paleozoic age and trend generally northwest-southeast.

There are many relatively flat, alluvium-covered valleys in the section. They are filled mainly by alluvial fan material but flood plain deposits are also present. Because most of the population is concentrated in these valleys, which contain the only arable land in the section, the ground-water geology of the valleys is important.

Occurrence of Ground Water

Water-Bearing Properties

The major rocks of the Northern Rocky Mountain section are metamorphic rocks of the Belt series, acidic rocks of the Idaho batholith, and Paleozoic sediments. All are relatively "tight" rocks and do not possess the qualities necessary for aquifers. This study has not revealed any producing wells in this section tapping aquifers in the above mentioned rocks.

Most of the ground water developed in the section is in the valleys. Although the size, shape, and geographical position of the valleys varies greatly, their ground-water geology is similar. In all the valleys, the aquifers are beds of sand or gravel. Clay or shale deposits usually act as confining beds (Figure 2). Flowing wells are numerous only in Camas Creek Valley in Camas County, but most of the other valleys contain wells in which considerable artesian pressure is encountered.

Correlation of Aquifers

Correlation of the gravel and sand aquifers is difficult because alluvial material is not evenly bedded. It has been deposited in the form of lenses and sheets of varying thickness and areal extent by braided streams.

In 1924 Piper (30, p. 15) made a detailed ground-water study of Camas Creek Valley and concluded that two artesian aquifers were present somewhere between 200 and 300 feet below the surface.

Intake Areas

The major intake areas for ground water are along the margins of the valleys where alluvial fan material abuts against the rocks of the mountain ranges. Run-off from these mountains, in the form of springs or seeps, may enter the alluvial fan material close to the flanks, or streams may flow for a distance on the surface of the fan and then lose part or all of their water by percolation into the porous material. Precipitation falling on the valley surfaces and infiltration from streams flowing in the valleys also replenishes the ground water.

Ground-Water Uses and Problems

Most of the municipalities located in the valleys of this section obtain their water supplies from streams, lakes, or springs. The use of ground water is restricted to small domestic supplies and irrigation.

Irrigation with ground water is extensive only in Camas Creek Valley, where more than half of the wells are flowing.

There is a potential danger of pumping the ground-water supply in excess of intake in the valleys which open onto the Snake River Plain from the north, but to the present supplies have been adequate.

RATHDRUM PRAIRIE SUB-SECTION

Physiography

The topography and ground-water geology of Rathdrum Prairie is sufficiently different from that of the rest of the Northern Rocky Mountain section to warrant special attention.

This area is bounded on the east by the Coeur d'Alene Mountains and on the north, west, and south by portions of the Selkirk Range. The Prairie extends into Washington to the vicinity of Spokane.

Rathdrum Prairie is considered to be part of the Purcell Trench which extends northward approximately 200 miles north of the International Boundary, and is thought to be caused mainly by erosion controlled by fault zones (5, p. 3).

Near the south boundary of Bonner County, Rathdrum Prairie is joined by the Hoodoo and Cocalalla Valleys. At this point the floor of Rathdrum Prairie is about 13 miles across. At Rathdrum it is about 8 miles wide and at the Washington-Idaho boundary is only about 4 miles wide. The floor of the trench slopes from northeast to southwest, from an elevation of 2400 feet at Athol to 2100 feet at the Washington line. A few low morainal hillocks are scattered over the Prairie and one islandlike mountain, Lone Mountain, rises about 800 feet above the surface southeast of Spirit Lake.

Geology

The rocks bordering Rathdrum Prairie are mainly of two types: (1) metamorphic rocks such as quartzites, slates, argillites, and associated rocks of the Belt series, and (2) acidic rocks of varying compositions associated with the Idaho batholith. The structural features of the rocks are extremely complex and are the result of folding and faulting on a large scale (1, p. 27).

The glacial materials underlying Rathdrum Prairie were deposited by two ice advances. The older glacial deposits outcrop either as remnant islands on the floor of the Prairie or as terraces along its sides, which dam tributary streams to form lakes. The later deposits of probable Wisconsin age form the outwash plain which is called Rathdrum Prairie and also the moraine at the south end of Pend Oreille Lake.

A large part of the glacial outwash is composed of cobbles and pebbles. Part of the glacial material appears to be unstratified and has the characteristics of till rather than outwash. The relatively rapid movement of ground water below the water table has sorted the material and greatly increased the porosity and permeability. Boulders up to three feet in diameter have been found in the material at various depths. Layers of clay, hardpan, and cemented material have also been encountered in a few wells but are of minor extent.

Occurrence of Ground Water

Water-Bearing Properties

The granitic and metamorphic rocks outcropping on either side of Rathdrum Prairie are relatively "tight" or impermeable rocks. The floor is thought to be composed of the same type of rocks as those outcropping on the sides and can also be considered relatively impermeable. As previously mentioned, the glacial material below the water table is highly porous and permeable. A few of the wells on the Prairie have been hand dug and cribbed, and contain ladders down to the water surface. In such wells the water actually can be seen to flow. In other wells it is possible to hear the movement of the water.

As determined by well logs, the depth to bedrock is about 500 feet near Athol and about 200 feet near the Washington-Idaho boundary. The depth to water decreases to the south and west from a depth of about 354 feet near Athol to 120 feet at the Washington-Idaho boundary to 50 feet near Spokane. Well data indicate that the water table is fairly uniform. The only perched water is found near Athol and is of minor extent.

Correlation of Aquifers

The material partially filling the Purcell Trench and making up Rathdrum Prairie is all glacial till or outwash and porous and permeable (Figure 3). Thus the entire filling acts as an aquifer. Actually, the saturated area beneath the water level is the aquifer in this area. Because there are many wells on the Prairie the surface of this saturated zone can easily be determined and the depth to water readily predicted. Depths to the saturated zone or aquifer have already been mentioned.

Intake Areas

The major intake areas for the aquifer underlying Rathdrum Prairie are the moraines blocking perennial lakes gordering the outwash plain. These lakes include Liberty and Newman Lakes in Washington and Coeur d'Alene, Pend Oreille, Spirit, and other lakes in Idaho. Only the largest two, Pend Oreille and Coeur d'Alene, have outlet streams. The others drain into the aquifer through the porous material blocking them. Although Pend Oreille Lake has an outlet stream it is believed to contribute the largest amount of water to the aquifers.

Cross-sectional studies of the amount of glacial material at the southern end of the lake, together with hydrographs showing a close correlation between the level of the lake and the depth to water on Rathdrum Prairie, indicate that Pend Oreille is a major contributor to ground water in the outwash plain (31, p. 5).

The sources of ground water in the area are, in order of importance:

1. Seepage from perennial lakes (mainly Pend Oreille)

2. Infiltration from mountains

3. Infiltration from rain and snow on the Prairie itself

4. Infiltration of water pumped from Hayden Lake or diverted from the Spokane River for irrigation.

Ground-Water Uses and Problems

All municipalities on Rathdrum Prairie other than Coeur d'Alene and Spirit Lake which use lake water, draw their water supplies from the Rathdrum Prairie aquifer. The development of ground water for irrigation purposes has been slow, probably for four reasons:

1. Depth to water

2. Difficulty of irrigation of porous soil

3. Availability of surface water

4. Difficulty of drilling wells using standard well-drilling techniques

In Washington, the ground water contained in the glacial outwash is used much more extensively. Spokane's municipal water supply comes from this source and irrigation with ground water is more extensively practiced.

There seems to be little chance of depleting the available supply, as indicated by several wells yielding more than 1500 gallons per minute with rarely over one foot of drawdown.

PALOUSE SECTION

Physiography

The Palouse section, which is a portion of the Columbia River Plateau, is bounded on the north and east by elevated areas of older rock, and to the south by the Clearwater and Potlatch river canyons.

To the west the section continues into Washington, where its boundaries have not yet been defined. The characteristic feature of the section is the Palouse Hills topography. The hills are usually elongate from southwest to northeast and are steepest on the northeast side. The topography of the surface soil is mature while the underlying lava is but youthfully dissected (4, p. 219). Another distinguishing feature of the Palouse section is that the underlying Columbia River lavas have a regional dip from northeast to southwest. The plateau surface has an elevation of 2,500-2,700 feet at the base of the Rocky Mountain section to the east and dips to about 500 feet near Walla Walla, Washington (4, p. 219). Very little warping occurs in the section.

Geology

Along the eastern boundary of the Palouse section, the lava flowed into old river valleys cut in granitic and metamorphic rocks, making an irregular border. Older rocks, mostly granodiorite (Idaho batholith), but some quartzite, schist, and gneiss (Belt series) probably underlie the later lava flows. These underlying rocks are relatively impermeable. It can be deduced from conditions as we know them today and from the logs of wells drilled that coarse sandy soil existed over the surface of the pre-basalt topography.

The periods between successive lava flows were long enough to allow soil to form and some vegetation to grow. By this intermittent process, the plateau was built up as a series of flows interbedded with layers of sandy or gravelly soils. Since its extrusion, the lava has been youthfully dissected in places and been covered by loess, which has been maturely eroded.

The thickness of the basalt is estimated to be about 800 feet at Moscow. Near Juliaetta, the Potlatch River has cut about 1700 feet below the surface without penetrating the bottom of the lava (42, p. 153). The thickness of individual flows varies from a few feet to hundreds of feet (42, p. 153).

Other than the low regional dip to the west, the lava has been very little disturbed.

Occurrence of Ground Water

Water-Bearing Properties

As previously mentioned, the older "basement" rocks are for the most part impervious. An exception to this might occur where a bedded metamorphosed sediment is dipping so water can move down the bedding or foliation planes. This situation occurs near St. Maries, Idaho, according to Kirkham (16, p. 8). It is very unlikely that any of the older rocks contain enough water to make well-drilling feasible and this study has revealed no wells in the area drawing water from the basement rocks.

The lava, which is the main water-bearing rock, shows great variation in such physical characteristics as vesicularity, porosity, fracturing,and jointing so that it is difficult to predict the permeability. The fact that a well at a certain location encounters a water-bearing zone does not necessarily mean that a well a few hundred feet away will intercept the same zone. This fact is borne out by the pattern of wells at the lumber mill at Potlatch, Idaho, where three wells, all within 300 feet of one another show very little correlation.

Aquifers are found both in the basalt and in the inter-layers of sediment between basalt flows (Figure 1). Vesicular and fracture zones and weathered tops of individual flows are probable aquifers. The interflow material may range in thickness from a few inches to several feet. Where this material is sandy or gravelly and occurs beneath the water table, it is usually a good aquifer. However, where the sediments are poorly sorted, as for example, close to the elevated areas of older rock, they have proved to be relatively "tight." At several places in the Palouse section, including Moscow, these interlayers are being tapped for large quantities of water.

Small supplies of water may be secured from shallow wells that tap water perched above the lava or about a layer of clay in the soil. The flow is never great, however, and often the water is not potable.

Correlation of Aquifers

Only in the Moscow and Potlatch areas is there enough information available to attempt a correlation of aquifers. The nature of the lava flows changes so rapidly that it would be necessary to possess numerous and detailed well logs before attempting a correlation over a large area. These are not available in the Palouse section.

The inter-layers of sandy and gravelly soil that were deposited between lava flows appear to be fairly persistent in the Moscow Basin. One of these inter-layers several feet in thickness has been tapped by several wells in the basin and is at an elevation of approximately 2325 feet or about 250 feet below the land surface. It has yielded a good supply to the City of Moscow and the University of Idaho. This aquifer probably continues westward to Pullman, Washington, for it was reported that after Pullman developed its large city well the water level at Moscow declined rapidly for a short time then became stable at a lower level (20, p. 6).

The logs of the Potlatch lumber mill wells at Potlatch indicate five separate flows of lava with thicknesses of 28-100 feet. A flow of water was reported between each of these flows. No inter-deposits of soil were mentioned.

Intake Areas

The most important intake areas are where the lavas and their inter-layers abut against the older elevated rocks with their cover of soil. Water percolates down through this mantle and feeds aquifers in the lava and in the inter-layers. It is possible that some water could percolate down from the surface of the basalt and eventually reach the static water level through cracks, fissures, or jointing, but the amount is relatively small.

Ground-Water Uses and Problems

Ground water is not extensively developed in the Palouse section because irrigation is practiced only on a minor scale. Most of the municipalities receive their public water supplies from wells, but the drain is small and does not constitute a problem except in areas of restricted intake such as the Moscow Basin.

Several flowing artesian wells were present in the Moscow Basin in 1895 (20, p. 6). At the present time artesian pressure does occur but no flowing wells exist. Two wells at Moscow illustrate the decrease of artesian pressure. The depth to water in a U. S. Geological Survey observation well at the Inland Motor Freight Company office in Moscow is slowly but steadily increasing (47, p. 34). From 1893 to 1922 the water level of the Moscow city well dropped about 44 feet (20, p. 6).

CRAIG MOUNTAIN SECTION

Physiography

On the south, the Craig Mountain section borders the Seven Devils section, the boundary passing along the north side of Grangeville Mountain. On the east the boundary is the contact of the basalt flows with the older rocks of the Clearwater Mountains. On the north the boundary is the monoclinal scarp of the Lewiston downwarp.

The central part of the section has been arched into a broad dome which rises about 5,000 feet above sea level and has been termed Craig Mountain. To the south of the uplift the plateau descends approximately 1,000 feet to the broad shallow warp of Camas Prairie. To the north of Craig Mountain the plateau surface descends 4,500 feet on the flank of the Lewiston downwarp to an elevation of about 500 feet.

Geology

The rocks exposed in this section are lava flows of the Columbia River Plateau except in deep river canyons where the lava has entirely eroded away or in a few areas of relatively high elevation that are thought to have been above the "lava seas." The lavas are underlain by older rocks of the Belt series and the Idaho batholith. The Belt series rocks outcrop in a few small areas in the section and are mainly quartzites and argillites. The Idaho batholith rocks vary from granite to quartz diorite in composition and are exposed in the eastern part of the section. The Seven Devils volcanics (Permo-Triassic) outcrop in several areas. They are made up mainly of andesite flows but are extensively cut by intrusive masses and dikes of diorite and gabbro (3, p. 14).

The Columbia River basalt is made up of several separate flows. At Orofino 17 different flows have been counted (3, p. 25). Between some of the flows there were time lapses, as indicated by weathered zones or deposition of sediments. The flows vary in thickness from a few feet to hundreds of feet and the total thickness varies from a few feet where it abuts against older rocks to an estimated thickness of more than 4,000 feet (3, p. 25).

The lava in the Craig Mountain section has a general dip to the west but due to severe warping this regional dip is not always apparent. The major expression of warping is the Lewiston downwarp or syncline. The surface flows have been downwarped to 700 feet above sea level at Lewiston while on the northern flank the beds were slightly raised to a present height of about 3,000 feet. The Craig Mountain anticline is a broad uplift between the Lewiston downwarp and Camas Prairie near Grangeville.

Occurrence of Ground Water

Water-Bearing Properties

The Belt series and Idaho batholith are considered to be relatively "tight" rocks. Water could move along bedding planes in the Belt series but it would be an insignificant amount.

In several stream bottoms, recent alluvium is of sufficient thickness to act as a good aquifer.

The Seven Devils volcanics, which are composed mostly of meta-andesite, could be water-bearing, but their extent in this section is also small.

The basalt of the Columbia River Plateau is the most important water-bearing formation in the section. Water can occur in several different ways in the basalt (Figure 1).

The lava formation is made up of several separate flows. Time elapsed between certain flows as is indicated by weathered basalt "tops" on some flows, and deposition of sediments between others. The presence of springs and water seeps issuing from these weathered "tops" in canyon walls indicates that they are potential aquifers. The sediments found between lava flows vary from "tight" formations of clay, silt, or shale, to permeable deposits of sand or gravel. The clay, silt, and shale deposits are important as confining beds. The sand and gravel beds have been tapped for large supplies of water in the Lewiston area. Vesicular zones in the lava itself commonly prove to be aquifers. Because of the tendency for gaseous materials to rise to the upper part of the separate flows, the tops of the flows are commonly more vesicular than the middle or lower portions. The lower portions may be slightly vesicular because of rapid cooling.

Correlation of Aquifers

With the exception of the Lewiston area, there is very little detailed sub-surface data available. Most of the wells are shallow and very old. Very few well logs were found, locally, aquifers can be traced in canyons cut by streams, by following lava beds or intercalated sediments from which springs or seeps issue.

In the Lewiston area where the downwarp is at a maximum, the basalt extends to great depths but farther eastward up the valley of the Clearwater and its tributaries, basalt in the valleys is thin or entirely eroded away. Thus the basalt layers which contain the best and sometimes the only aquifers in this area, are exposed in the canyon walls above the towns, which are located in the valleys. Because of leakage from the aquifers where they are exposed in the canyon walls, wells must be located back from the edge of the canyon to tap a good supply of water.

In some parts of the section the basalt does not contain porous weathered "tops," vesicular zones, or porous intercalated sediments. In the Cottonwood area for example, a well was drilled to a depth of about 1,200 feet without encountering more than a few gallons of water per minute.

About 10 miles south of Cottonwood near the Salmon River canyon, "the Point" in local terminology, a well was drilled approximately 800 feet into extremely vesicular and creviced basalt and encountered no water whatsoever. In this case, ground water is being drained through the creviced and vesicular layers into the Salmon River Canyon.

Although some of the wells are within a half mile of each other, the logs show a great disparity of sub-surface geology. Each shows intercalated layers of porous sediments which serve as aquifers but no correlation can be made between them.

Intake Areas

The major intake area is the zone in which the lavas flow and their interlayers abut against the older rock masses on the north, east, and south. Water moves through the soil and disintegrated portions of the older rocks and thence into the aquifers of the lava formation. Water percolation from the surface of the basalt itself down to aquifers is possible via weathered tops, vesicular zones, joints, faults and the like but this source of intake is of minor importance.

Ground-Water Uses and Problems

Only in the Lewiston area of the Craig Mountain section is ground water extensively tapped. The static water level of most of the wells is about 25 feet below the surface of the ground. This fact indicates that there is considerable artesian pressure because when drilling, water is usually not encountered for 100 feet or more. One well in the vicinity, belonging to Snow Crop Frozen Foods, Inc., has a yield of more than 1,500 gallons per minute and is used entirely for industrial purposes. Lewiston's municipal water system obtains all of its supply from ground-water sources.

Ground water produced from recent alluvial material is being used in the Craig Mountain section for sprinkler irrigation supply. Because of possible contamination, this source of water has not been widely used for domestic supplies.

SEVEN DEVILS SECTION

Physiography

On the south the Seven Devils section is bordered by the Snake River Plain. On the east it is bordered by the granitic mass of the Idaho batholith, which is included in the Northern Rocky Mountain section. On the north, the north base of Grangeville Mountain is the boundary.

The Seven Devils section, which is part of the Columbia River Plateau, has been broken into a maze of faulted blocks, trending generally north-south, which have been raised differentially to fairly high levels (33, p. 27).

The section is cut by the canyons of the Snake and Salmon Rivers which are up to one mile in depth.

Geology

The geology of the Seven Devils section is extremely complex. Columbia River basalt flows are found over much of this section. The basalt is more intensively faulted in this area than elsewhere in the state. The basalt formation is made up of several different flows. In Rice Creek Canyon, Wagner (48, p. 7) counted 21 separate flows varying in thickness from 6 to 100 feet and having a total thickness of more than 2,200 feet. The separate flows vary in vesicularity and amount of weathering. Between some flows deposits of sand, silt, and clay are present.

The Seven Devils volcanics outcrop extensively in the section. They are Permo-Triassic in age and are composed mostly of flows of andesite but include a variety of other clastic and volcanic rocks. The thickness has been estimated by Cook (7, p. 3) to exceed 10,000 feet. Other rocks outcropping in the section are shales and limestones of Triassic age.

In the southern part of the section, deposits of alluvium and lake sediments (Idaho formation) are found.

The structure of the section is also complex. Generally, however, the surfaces seem to have been broken into north-south fault blocks, which have been uplifted and tilted. Between these blocks are trough valleys of which Long, Council, and Cambridge Valleys are examples (33, p. 27). The high central portion, or Seven Devils proper, is composed of volcanic tuffs and flows and was uplifted as narrow blocks which were eroded and sharpened by glaciation (33, p. 27).

Occurrence of Ground Water

Water-Bearing Properties

Because of inaccessibility and low population, little work has been done on the ground-water geology of this section.

The basalt flows probably would yield water because they are similar to the basalts to the north which usually contain aquifers. Wagner (48, p. 3) mentions that the basalt is broken and jointed and forms good underground reservoirs.

In the southern part of the section in the Weiser River Valley, the alluvium and deeper deposits of lake sediments supply moderate quantities of water. Much of the sediment in the valley is "tight" clayey material which acts as a restricting layer for aquifers of sand below. Flowing artesian wells have been reported at several locations in the valley.

Correlation of Aquifers

The almost complete absence of sub-surface geologic data makes a correlation of aquifers impossible in the Seven Devils section. In the canyons of the Snake and Salmon Rivers one could probably trace vesicular or weathered layers of basalt containing seeps or springs but since ground water is of little importance in this area, it has not been attempted.

Intake Areas

The most important intake areas in this section occur along fault and fracture zones. The intake of the basalt flows in this section is different from that in the sections to the north, because in this area the flows are usually a "capping" rock and thus do not abut against older rocks, whereas the flows to the north occur as valley fills.

Ground-Water Uses and Problems

The water levels in the wells in the Weiser River Valley are usually close to the surface and a few flowing wells have been reported. The aquifers are "clean" gravel or sand layers. Most of the wells in this valley are for domestic water supplies only, but a few produce enough water for limited irrigation.

It is unlikely that ground water will ever be in enough demand to create water-supply problems in this section.

SNAKE RIVER PLAIN SECTION

Physiography

The Snake River Plain section is the best delineated section of the state. It is a broad, shallow, partly-filled downwarp or depression which stretches across the state in a broad arc more than 400 miles long and from 50 to 120 miles wide. In this stretch there is a fall in elevation of about 4,000 feet from east to west. The section is characterized throughout by a comparatively flat expanse, somewhat dissected in the lower, western portion where lake beds comprise the surface material, but very little affected by erosion in the higher eastern part where the local relief is mainly restricted to low lava domes and cinder cones. River canyons cut deeply into the plain at some places but are not common.

Geology

The Snake River Plain is commonly regarded as a great structural depression or downwarp that has been filled mainly by Pliocene and Pleistocene basalts and more acidic extrusive volcanic rocks. In places the volcanic rocks are intermingled or intercalated with sediments. The term Snake River Downwarp was introduced by Kirkham (18, p. 457) in 1927 and has been generally accepted since then. The basalts which cover probably nine-tenths of the surface of the Plain are practically undisturbed by faulting or folding, although in all parts of the downwarp the lavas dip toward the axis or generally towards the Snake River.

Along the border of the Snake River Plain are large quantities of silicic volcanic rocks generally referred to as rhyolites although many of them are actually latites or quartz latites. The acidic volcanics dip beneath the basalt and so are probably present beneath a large part of the Plain. Evidence that the rhyolite underlies the basin filling of Snake River basalt can be found at many places where the Snake River has cut through the basalt, as at Shoshone or American Falls. Stearns (39, p. 34) states that the presence of acidic volcanics at any locality is evidence that the base of the basalt flows has been reached. The silicic volcanic rocks themselves rarely contain aquifers except where intercalated tuff or cinder beds are present (39, p. 34).

Beginning hear Heise, on the Snake River northeast of Idaho Falls, a large alluvial fan spreads north and west over the Plain for up to 20 miles and attains a thickness of several hundred feet. Smaller alluvial fans are present where streams tributary to the Snake River flow onto the Plain.

Lake deposits are present on top of or intercalated with the basalts at several locations in the Plain area (Figure 4). The Mud Lake beds northwest of Idaho Falls are among the largest of such deposits. Lake deposits are also present along the Snake River at American Falls, Hagerman, Glenns Ferry, and King Hill. Westward from the Boise area, the basalt flows gradually give way to lake deposits of the Idaho and Payette formations. In the Nampa-Caldwell area, basalt occurs only as stringers and very seldom contains aquifers.

The lake deposits belong to two formations separated by 600 or more feet of basalt (17, p. 20). The lower formation has been named the Payette formation and outcrops only as intermontane deposits on each side of the Plain. The more recent deposits, named the Idaho formation, overlie the basalt flows and outcrop over extensive areas. These basalt flows are older than the flows east of Boise and have been assigned to the Columbia River basalt.

The Snake River basalts vary greatly throughout the Plain in thickness, number of flows, porosity, permeability and other characteristics which are important in relation to ground-water geology.

Occurrence of Ground-Water

Water-Bearing Properties

In general, the basalts of the Snake River Plain are very permeable (39, p. 58) and their potency as aquifers is indicated by the springs issuing from them between King Hill and Twin Falls. Very few wells have been drilled into them that have not yielded adequate supplies of water if the local water table was penetrated. The openings in the basalts through which water can move have been listed in their approximate order of importance by Stearns (39, p. 58):

1. Large open spaces at the contact of one lava flow with another or of a lava flow with the underlying formation

2. Interstitial openings in cinders, aa, and subaqueous lava formed during deposition

3. Open spaces in joints formed by shrinkage of the basalt in cooling

4. Tunnels and caves produced by liquid lava flowing out from under a hardened crust

5. Vesicles and cavities due to the expansion of gases during the cooling of the lava

6. Tree molds resulting from lava surrounding a tree and solidifying before the tree has burned away

In the extreme northeast portion of the Snake River Plain, basalt flows are the only aquifers. The soil mantle is relatively thin as evidenced by wells near Ashton that were drilled less than 10 feet before encountering basalt. Depths to water in the area range from 20 to 50 feet.

The alluvial fan of the Snake River below Heise is composed of silt, sand, and gravel dropped by the river as it flows onto the Plain from the mountains. Aquifers are found both in the alluvial fan material and in the underlying basalt flows. Intercalated with the flows are cinder layers which may yield large supplies of water. At the mouth of the canyon near Heise the depth to water is about 100 feet but farther out on the fan the depth to water is 50 feet or less. At the mouth of the Henry's Fork southwest of Rexburg the water table intercepts the land surface and large quantities of ground water are discharged into the Snake River by springs and seeps.

The basalt flows underlying the Mud Lake region attain a thickness of about 1,000 feet, are extremely permeable, and constitute the chief aquifers of the area (38, p. 1). It is necessary to drill only a few feet into the basalts, if they are beneath the zone of saturation, to obtain an adequate supply of water for irrigation (38, p. 36). Depressions in these basalts, have been partially filled by lake beds which are usually more effective as confining beds than as sources of water (38, p. 37). They support perched water in the Mud Lake area and are instrumental in producing artesian conditions (38, p. 38). Wells in the immediate vicinity of the lake, where there is a perched water table usually encounter water levels more or less concordant with the lake but wells a few miles south of the lake where no lake deposits are encountered, have depths to water of 200 to 300 feet.

In the Idaho Falls area large water supplies are obtained from vesicular zones in basalt and cinder or scoria layers. The water table is relatively deep -- 170 feet in one of Idaho Falls' deep municipal wells, and more than 200 feet in several irrigation wells a few miles east of Idaho Falls.

Southwest of Idaho Falls in the area including Blackfoot and Aberdeen various thicknesses of lake deposits are encountered. The depth to water is usually less than 50 feet. Some aquifers are found in the lake beds but most of the wells tap aquifers in the basalt beneath.

In the Burley-Rupert area the surface of the ground is mantled with alluvial material. These sands and gravels store and transmit moderate to large quantities of water (26, p. 15). According to Nace (26, p. 15) wells 31 to 105 feet deep in the city of Burley yield 375 to 1,000 gallons per minute with a drawdown of from 3 to 19 feet. The source of this water is either alluvial material or associated lake beds. The Burley lake beds and associated deposits are important sources of water for deep wells on the Minidoka irrigation project near Rupert (26, p. 16). Logs of wells in the Burley-Rupert area indicate that these sediments have thicknesses of up to 170 feet. A perched water table in the Burley area is indicated by two general depths to water within a mile radius. The depths to water are in the range of either 4 to 15 feet or 190 to 200 feet.

North of Rupert in the North Side Pumping Division of the Minidoka irrigation project, the alluvial material and lake beds are either very thin or completely absent. Open spaces at or near the contacts of separate lava flows are among the most important aquifers in this area (26, p. 18).

Between Twin Falls and Burley in the Murtaugh-Rock Creek area, ground water is being used extensively for irrigation. The aquifers are usually in the basalt flows and are either vesicular zones or cinder or scoria beds. Intercalated deposits of gravel and sand also produce some water. The water table surrounding the reservoir is usually encountered in 50 feet or less of drilling. In the Rock Creek Basin the depth to water is also shallow. A few flowing wells occur south of Rock Creek. On either side of Murtaugh the depth to water increases sharply to 400 feet and more.

In the Twin Falls-Buhl-Filer area the usual aquifers are found in the basalt flows. Again some water is produced from intercalated deposits of sand and gravel. The average depth to water is between 50 and 150 feet in the Twin Falls area but the water depth of one of the Buhl city wells is 234 feet.

In the Gooding-Shoshone-Jerome-Wendell area the only sediments encountered in wells are thin layers of clay. There is seldom more than 20 feet of overburden before drilling into basalt. Cinder or scoria zones are numerous and either these or crevice or vesicular zones are the aquifers. The average depth to water is from 250 to 350 feet. The KLIX television station well east of Jerome draws water from a 643-foot depth.

Generally the depth to water decreases towards the Snake River. Near the edge of the Snake River canyon the water seems to be channeled into large crevices. This is indicated by the fact that there are some dry wells although most of the wells in the area have large capacities with practically no drawdown.

In the Mountain Home area the depth to water increases toward the Snake River. One of the Mountain Home municipal wells has a water depth of 180 feet while at the Mountain Home Air Force Base about 10 miles to the south, the depth to water is more than 300 feet. The aquifers in the area are vesicular or cinder zones in the basalt flows.

Sixteen wells supply Boise's city water system. Three of the walls are shallow "collecting" wells and the other 13 are deep. All of the deep wells draw their water from sand and gravel beds in lake deposits. The logs of the wells are variable but all contain shale, silt, sand, and gravel beds of varying thicknesses. The ground-water geology in the vicinities of Nampa and Caldwell is similar to that of the Boise area. The depth to water is dependent upon seasonal variations but generally is less than 25 feet.

There is a definite increase in the amount of shale deposits in the Wilder-Parma area west of Caldwell. The gravel and sand aquifers are usually thin but still supply large quantities of water.

Great thicknesses of clay are present between the sand and gravel aquifers in the Emmett Valley, and also in the New Plymouth area west of Emmett. Flowing wells are common in these regions. The depth to water in Emmett's municipal water wells varies from a few feet to about 12 feet.

Very little clay or shale is encountered by wells in the Payette area and therefore the ground water is under little or no artesian pressure. Water depths vary from a few feet to 50 feet.

In the Weiser area, shale is the predominant sediment. In the Weiser city well, which is used for emergency purposes only, no well-sorted gravel was encountered. In 1928, Kirkham (13, p. 2) reported several flowing wells northeast of Weiser. He also stated that an adequate and suitable supply of water should be found at a depth of 1,100 feet. A well was never drilled to that depth, however, and Weiser obtains its municipal water supply from the Snake River.

Correlation of Aquifers

From the preceding discussion of the water-bearing properties of the rocks of the Snake River Plain it is evident that ground-water characteristics vary greatly over the Plain. In several areas which use ground-water for irrigation purposes, the U. S. Geological Survey, Ground-Water Branch, has published detailed records, including logs of the wells. Even when logs of wells within a mile of each other are available, it is seldom that any correlation can be made.

Nace (26, p. 22) states in his report on the Minidoka Project near Rupert that there are several or many confined aquifers; these are probably discontinuous, lenticular, to some degree connected through imperfectly confining beds and variable in relative permeability and thickness. He also states that at present there is no hope of defining separate artesian aquifers or pressure surfaces.

Intake Areas

A large part of the ground water underlying the Snake River Plain is supplied by tributary valleys which contain water on the surface or underground or as is usually the case, both. The water table under much of the Plain lies more than 400 feet below the surface but in the valleys tributary to the Snake the depth to water usually is less than 50 feet. Where these streams debouch upon the Plain, there is usually a sudden increase in the depth to water. Stearns (39, p. 115) states that the ground water "cascades" at the mouths of the valleys are caused by the abrupt steepening of the impermeable rock floors that underlie the gravel upstream, and the occurrence of permeable basalt that interfingers with the alluvium near the mouths, thus offering a ready escepe for the underground water. It is a popular belief that some of the water from the Lost River and other rivers sinks into the Plain, and is discharged into the Snake River near Hagerman by springs. This has not been proved but is geologically possible.

Another major source of the ground water underlying the Plain is deep percolation losses from irrigated areas, storage reservoirs, and canals. In most of the areas where extensive irrigation is taking place a large proportion of the applied water is lost to the zone of saturation by deep percolation, thus raising the water table.

In some areas, the presence of impermeable basalt or sediments causes a perched water table. This situation is exemplified by the perched water table in the Mud Lake area northwest of Idaho Falls. Before irrigation began, Mud Lake was little more than its name implies. Now it is a perennial lake of large size.

In other areas, the infiltration of irrigation water has made necessary the construction of drains to prevent the accumulation of various harmful salts and the development of "wet spots" in low ground.

Stearns (39, p. 129) estimates that between 1906 and 1928 a probable 6,000,000 acre feet of water was lost by percolation to the ground water reservoir in an irrigation project south of Twin Falls. Stearns (39, p. 126) also estimated that one-third of the surface water applied for irrigation in the Minidoka Project is lost to the zone of saturation.

Losses from storage reservoirs probably result in a small increment to the zone of saturation but are relatively minor.

The infiltration of precipitation falling on the Plain is a source of ground water but is relatively unimportant as the average annual precipitation is only about 10 inches.

<u>Ground-Water Uses and Problems</u>

Ground water is more important to the Snake River Plain than to any other section of the State of Idaho. Most of the municipalities obtain their public supplies from ground water and since about three-fourths of the State's population lives on the Plain, this is an important item.

Although most irrigation water is at present obtained from surface sources, ground-water is becoming increasingly important for this purpose.

The Minidoka North Side Pumping Division north of Rupert when completed will consist of more than 66,000 acres of land irrigated by ground water (26, p. 1). At the present time, a large area east of Boise is being considered for irrigation with ground-water.

Ground-water has become a problem in certain parts of the section because its close proximity to the surface causes seepage areas and accumulation of harmful salts. This problem is particularly troublesome in the Payette River Valley where much land has been lost because of the accumulation of sodium salts caused by the lack of drainage.

Many industries use ground water extensively in the Plain area. The dairy, sugar beet, phorphorus, and fertilizer industries are among the heaviest consumers.

There are potential ground-water problems on the Plain. The most serious problems will occur in areas which have heavy ground-water development and restricted intake. Some of the tributary valleys of the Plain are faced with serious ground-water shortages if development continues.

The problem of surface water rights is an old one in the state and since surface flow can be measured and regulated, laws have been passed that adequately cope with this problem. Ground-water, however, is much less tangible. It is difficult to make laws which solve the problems of ground-water rights. The present ground-water laws in Idaho appear to be adequate to cope with any contention for ground-water rights that might arise but after these laws are more thoroughly tested, changes and additions will probably be made.

The present laws covering the use of ground-water were developed from ground-water legislation of other states. If a water-right conflict develops, the plaintiff informs the State Reclamation Engineer of his or her reasons for complaint. The State Reclamation Engineer, if he believes the complaint justified, will then appoint a board of three people to hear and decide the case. A disinterested landowner who resides in the same county as the plaintiff, a geologist or engineer, and a member of the State Reclamation Engineer's professional staff compose the appointed board.

The formation of a ground-water board was provided by one of the several 1953 amendments to the 1951 ground-water laws. The 1951 laws required all well drillers in the state to be licensed and to file records, including logs, with the State Reclamation Engineer. It wasn't until the 1953 amendments were passed, however, that the law was put into effect and forms for the well data distributed to the drillers. These logs are now being filed with the State Reclamation Engineer and will be of great value in assessing an area's ground-water potential and in settling ground-water rights conflicts.

OWYHEE SECTION

Physiography

The Owyhee section extends west to the Oregon boundary and south to the Nevada boundary. The northern boundary is the Snake River Plain and the section extends eastward to Goose Creek, south of Burley.

The section is a comparatively high, partly dissected, warped plateau of considerable relief. The lavas have been gently to moderately warped, somewhat faulted, and raised from 1,000 to 5,000 feet above the Snake River Plain. On the flanks of the Owyhee Mountains the lava has been eroded away, exposing the granite core of the mountains. The Owyhee section has been much more dissected than any part of the Snake River Plain.

Geology

Snake River basalts (Pliocene and Pleistocene) underlie a large part of this rugged and sparsely populated section. The flows are relatively thin as compared to the basalts of the same age in the Snake River Plain.

Columbia River basalts (Miocene?) are also present, occurring in the northwest part of the section. These older lavas occur as two major flows separated by several hundred feet of lake sediments of the Payette formation, and can be seen to dip under the more recent Snake River basalts in many areas.

Rhyolite flows of Upper Miocene or Lower Pliocene age also outcrop extensively in the section and are related to the Tertiary acidic flows that outcrop on either side of the Snake River Plain for most of its length.

Most of the lake sediments in this section have been mapped as Payette formation. In 1931, however, Kirkham (17, p. 193) revised the definitions of the Payette and Idaho formations so that most of the extensive outcrops of the lake sediments should now be mapped as Idaho formation.

There are several small exposures of granitic rocks in this area which for the most part are assigned to the Idaho batholith. The extrusive rocks in the section have been extensively warped and domed but faulting has been of minor importance.

Occurrence of Ground Water

Water-Bearing Properties

The only area in the Owyhee section in which ground-water is used to any extent is in the Bruneau Basin about 20 miles south of Mountain Home. Very little sub-surface data are available. The three most abundant types of outcrops, Snake River basalt, acidic volcanic rocks, and lake sediments are aquifers in other areas where they are tapped for large supplies of water, and are potentially aquifers in this section.

Thermal springs issue from sandy strata in exposed lake sediments on either side of the Bruneau River. Most of the wells located in the Basin are either flowing or have water levels close to the surface. Many wells in the area that were flowing when drilled have stopped flowing or have decreased greatly in flow since that time. Many of these old wells were not cased to the bottom so that caving is common. In others, the casing is badly corroded, causing leakage. The decrease in the capacity of the wells is probably due to the caving and corroding rather than to a decline of artesian pressure or lowered water table.

Lake deposits, mostly of Pliocene age, assigned to the Idaho formation and related volcanic tuffs contain most of the aquifers which release artesian flows. The deeper aquifers have been found to be under the greatest pressure, as was noted by Piper in 1922 (28, p. 46). The confining beds, according to Piper (28, p. 46) are usually basalt flows or shaley sand layers.

Correlation of Aquifers

The Bruneau Basin is the only area in the section where a correlation could be attempted. Piper (28, p. 46) mentions that several wells secured most of their flow from one or two layers of tuffs intercalated with basalt flows encountered at depths ranging from 1,300 to 1,750 feet in the Bruneau Valley. The Ground-Water Branch of the U. S. Geological Survey is at the present time (1954) conducting a survey of ground-water conditions in Bruneau Valley and the surrounding area. Their report may make possible more positive correlations.

Intake Areas

The intake areas for the aquifers present in the rocks of the section are many and varied. In the Bruneau Basin, Piper (28, p. 52) states that intake is at elevated outcrops remote from the Basin. The water descends along favorable channels to a considerable depth below the surface, and is charged into the aquifers by upward percolation along open fissures or joint planes. This theory is of course, highly theoretical. The forthcoming U. S. Geological Survey report may shed new light on the problem.

Ground-Water Uses and Problems

As mentioned before, ground water is being used extensively only in the Bruneau Basin. Piper (28, p. 56) in 1923 stated that further development of ground water for irrigation purposes would be practical. Since that date development has been slow but several flowing wells have been drilled. One of the latest wells is reported to have an artesian flow of more than 5,000 gallons per minute.

Problems resulting from poor quality of water have been reported in the Owyhee section.

BASIN AND RANGE SECTION

Physiography

The Snake River Plain is the northern boundary of this section. On the west, the Goose Creek Valley separates this section from the Owyhee section, and on the east the boundary line is drawn from the vicinity of Blackfoot to Soda Springs to Preston. The Utah-Idaho interstate line is the southern boundary for the section in Idaho but Basin and Range topography actually extends far to the south.

The characteristic Basin and Range faulting is conspicuous in Idaho. Low angle thrust faults are also present in this area. Several examples of horsts and grabens occur in the section but the grabens are now covered by alluvium and flow rocks.

The mountain ranges in the section contain peaks up to 10,000 feet in elevation. The ruggedness of these ranges is emphasized by the comparatively flat valleys between them.

Geology

Sedimentary rocks of Paleozoic and Mesozoic age are the most extensive outcrops in the Basin and Range section. In the Albion Mountains, south of Albion, limestones and metamorphosed limestones, thought to be of pre-Cambrian age, outcrop extensively. Igneous intrusives of various types occur in the sediments but are usually of minor extent. Some 40 or 50 square miles of granites and granodiorites related to the Idaho batholith are exposed in the mountains south of Albion in central Cassia County (33, p. 39).

The Malta Range, west of Malta, is made up almost entirely of silicic volcanic rocks (quartz latite or latite) associated with the Snake River basalt. Silicic volcanics also outcrop near Oakley in the Upper Goose Creek Basin area, and in the southern portion of the Bannock Range, south of Lava Hot Springs.

The comparatively flat valleys between the mountain ranges are commonly underlain by alluvial deposits of sand, silt, and gravel or by conglomerates and associated sediments of the Salt Lake formation. In Oneida County, however, silty lake sediments of the Bonneville formation occur over extensive areas.

Occurrence of Ground Water

Water-Bearing Properties

The sedimentary mountain masses are composed for the most part of calcareous rocks, and are generally considered "tight" rocks except for water movement along fracture zones.

The comparatively flat valleys between the mountain masses, are extensively farmed and ground water is of great importance in all of them.

The Malad River Valley is underlain by alluvium, the Salt Lake formation, and lake sediments of the Bonneville formation (Figure 2). The main aquifers of the area are beds of sand and gravel that are overlain by confining beds of clay so that artesian pressure is common. It was estimated that in 1943 a total of 150 flowing wells existed in Malad Valley (21, p. 5).

In the Arbon and Rockland Valleys which enter the Snake River Plain from the south, near American Falls, ground water is important but is not used as extensively as elsewhere. There is little irrigation in these valleys and water is used mostly for domestic purposes. The aquifers again are beds of sand and gravel interlayered with clay and silt. This study has not revealed any flowing wells in the valleys, though there is some artesian pressure.

In the Raft River Valley, in the Malta area, ground water has been extensively tapped for irrigation. A report of the Ground-Water Branch of the U. S. Geological Survey in 1951 contains information on a total of 284 wells (8, p. 3). The entire valley is underlain by alluvial material except in the northern part of the valley, where Snake River basalt outcrops. As in the other valleys of the section, the aquifers are sand and gravel beds, commonly found under confining layers of clay. In the Malta area, the depth to water is between 8 and 20 feet. In the Raft River Valley south and southwest of Malta, flowing wells are a common occurrence.

Ground water in Goose Creek Valley near Oakley is also being extensively tapped for irrigation purposes. Many new wells are being drilled at the present time. Data on 579 wells in the Goose Creek Basin have been published by the Ground Water Branch of the U. S. Geological Survey (25, p. 5) but many of these wells are in the lower part of the basin near Burley, which is considered to be in the Snake River Plain section. In the Goose Creek Valley, vesicular zones in acidic volcanic rocks, and gravel and sand layers are the usual aquifers. Acidic volcanic rocks (quartz latite and latite) are encountered in wells in the Oakley vicinity at various depths and provide good flows of water. North of Oakley the alluvial cover thickens and a deep well approximately 5 miles north of Oakley encountered latite at a depth of 560 feet (25, p. 38).

Depth to water in the Goose Creek Valley varies greatly. Wells in the lower part of the valley have water levels close to the surface or in some cases are flowing, but outside of this area depths to water of 100 feet or even 300 feet are not uncommon. The area immediately south of Burley contains many flowing wells.

Correlation of Aquifers

Although all the valleys in this section contain wells on which logs were recorded at the time of drilling, only a few generalized conclusions can be made concerning the correlation of aquifers. Livingston and McDonald (21, p. 2), state in their paper on the Malad River Valley that beds of sand and gravel occur at several different depths and the depth to beds varies widely from place to place. This, for the most part, is true for the whole section.

Two generalizations can be made, however.

1. Close to the surface the gravel and sand beds are usually thicker than the clay layers. The deeper one drills, however, the thinner the gravel and sand layers become in relation to the clay.

2. The water encountered in the deeper layers of sand and gravel will usually rise higher in the well than the water encountered at shallow depths.

In the Goose Creek Valley, the volcanic flow rocks are not horizontal so aquifers are hard to correlate. A survey of well logs has shown that the first layer encountered is usually red in color, very porous and broken, and in many cases is an excellent aquifer. However, there have been instances when water encountered in the confined gravel beds above the latite drained through the drill hole into the latite thereby piercing the perched water table and greatly increasing the depth to water.

Intake Areas

If aquifers exist in the old sedimentary and intrusive igneous masses, their intake areas would probably be along fault or fracture zones on the surface.

Outcrops of the silicic extrusive serve as intake areas for aquifers in the latite itself, and in the gravel and sand of the valleys.

The most important intake areas for the valleys, as in other similar areas, is along the mountain fronts. Water enters the sand and gravel layers where they contact the mountain masses, from springs, seeps, or streams debouching onto the porous material.

Ground-Water Uses and Problems

Very few of the municipalities in the Basin and Range section use ground water as their source of water supply. Springs and surface water usually offer a more accessible and softer water supply.

All the valleys in this section use some well water for irrigation purposes. In 1943, it was estimated by Livingston and McDonald (21, p. 5) that more than 3,500 gallons per minute were being pumped in the Malad River Valley during the growing season of approximately 120 days. This amount has undoubtedly increased. As mentioned before, flowing wells are common in the Malad River Valley. Because many of these wells are old and were carelessly cased, some of the artesian pressure is being lost through breaks in the upper part of the wells. Livingston and McDonald (21, p. 8) found 34 flowing wells that were in an advanced state of corrosion and were in need of immediate repair.

The Raft River Valley yields a large amount of ground water, mostly for irrigation purposes. In a 1951 U. S. Geological Survey report (8, p. 133) it was estimated that an average of 976 acre-feet per year was being withdrawn from this valley.

The Goose Creek Valley also yields great quantities of ground water. A 1953 report of the U. S. Geological Survey (25, p. 7) estimates that 34,000 acre-feet were pumped during the year 1952. This amount includes water pumped in the Burley area which is considered in the Snake River Plain section.

As in most of the irrigated areas of the state, ground-water supplies have been sufficient to supply the demand to date. However, most of the new irrigation projects which are under development use ground water and the time is rapidly approaching when there will be serious problems because of over-pumping. The Basin and Range section will be one of the first in the state to have to face these problems.

MIDDLE ROCKY MOUNTAIN SECTION

Physiography

The Middle Rocky Mountain section is bounded on the north by the Snake River Plain and extends east and south to the Wyoming and Utah borders. On the west the goundary line is drawn from the vicinity of Blackfoot to Soda Springs to Preston.

The ranges and ridges of the section vary from 5 to 50 miles long and from 2 to 20 miles wide and rise from about 7,000 to nearly 10,000 feet above sea level. The valleys as a rule are narrower and shorter and vary in altitude from about 5,800 to nearly 7,500 feet.

The drainage of the southern part of this section flows through the Bear River to the Great Basin in Utah. The rest of the region is drained by branches of the Snake River.

Geology

The rocks of this section are largely sedimentary limestones, sandstones, and shales. Their thickness has been estimated to be as great as 46,000 feet (22, p. 48). The marine sediments are fossiliferous and some of the nonmarine sediments are slightly fossiliferous, and much detailed stratigraphic work has been done in this section. The beds have been warped, folded, and faulted to various degrees.

Rocks of Paleozoic and Mesozoic age make up the mountain ranges, with the Paleozoic rocks giving rise to higher and more rugged topography. Along the boundary of the Snake River Plain, the mountain ranges are embayed and interrupted by lava, which has buried the older strata.

The region is traversed by many folds and faults. The most noteworthy fault, the Bannock Overthrust, has been traced 150 miles (10, p. 171). Most of the faults have a northwest to southeast trend, but faults are found striking in all directions.

Between the mountain ranges are valleys underlain by alluvium, basalt flows, or the Salt Lake (Pliocene?) formation. The latter formation has been loosely used to designate a group of generally light-colored grayish or yellowish conglomerates with associated marly, gritty, or sandy beds (14, p. 29). These beds are of widespread occurrence and are generally found outcropping between recent alluvium or lava flows and the older sedimentary rocks.

Occurrence of Ground Water

Water-Bearing Properties

The warped, folded and faulted sedimentary mountain ranges are thought to contain aquifers of one type or another but very few water wells have been drilled into them. Springs and seeps issuing from sedimentary strata are common throughout the section.

Many of the valleys in the northern portion of this section are underlain by basalt associated with the widespread flows of the Snake River Plain. Intercalated beds of sediments are almost always present.

Extensive layers of volcanic cinders and pumice also were found. Where these porous volcanic deposits occur beneath the local ground-water table they are excellent aquifers and are capable of producing large amounts of water. Wells at Monsanto Chemical Company's Soda Springs plant tap cinder layers which produce up to 1,200 gallong per minute of water.

In the Grace-Bancroft area, west of Soda Springs, cinder beds are sometimes found, but more commonly the aquifers occur in narrow bands of porous intercalated sediments or in vesicular zones in the basalt itself. The amount of water produced is usually small and several wells have been drilled that encountered no beds capable of a reasonable flow of water.

In the southern portion of the section, the valleys are underlain mainly by alluvium and the Salt Lake formation. The alluvium is usually thin so most of the wells in this area are drilled in the stratified Salt Lake formation, which includes conglomerate, clay, sand, gravel, and shale beds. The water levels are often close to the surface but when a well is pumped the drawdown is extremely high. The reason for this is that the layers of sand and gravel, which are the only possible aquifers, are often comparatively "tight." Several attempts have been made to drill irrigation wells but very few have produced a sufficient flow.

<u>Correlation of Aquifers</u>

The faulted and fractured surfaces of the sedimentary mountain ranges serve as intake areas for the aquifers in the rocks which make up the mountains.

The aquifers in the unconsolidated sedimentary valley fill are charged by springs and seeps and small spring-fed streams. Very little of this surface water near or at the sides of the mountain ranges ever reaches the major rivers of the area. It sinks into the porous alluvial fans and percolates downward, feeding the aquifers under the valley surfaces.

Streams and rainfall probably contribute some water to aquifers but silting of the stream channels and the presence of impermeable clay or basalt layers make this source of minor importance.

<u>Intake Areas</u>

The faulted and fractured surfaces of the sedimentary mountain ranges serve as intake areas for the aquifers existing in these rocks themselves.

The aquifers in the unconsolidated sedimentary valley fill are charged by springs and seeps and small spring-fed streams. Very little of this surface water near or at the sides of the mountain ranges ever reaches the major rivers of the area. It sinks into the porous alluvial fans and percolates downward, feeding the aquifers under the valley surfaces.

Ground-Water Uses and Problems

The major source of municipal water supplies in the Middle Rocky Mountain section is springs. The largest city in the section, Montpelier, uses spring water exclusively in the winter because it is of higher quality than the well water. There are a few large irrigation wells in the section. However, several wells with diameters up to 20 inches did not encounter enough water to warrant a pumping test. Generally the problem appears to be fó find gravel or sand clean enough to transmit water freely. The aquifers that have been encountered in drilling are in pockets or lenses and not of a very great lateral extent.

Ground water is used for industrial purposes at Monsanto's Soda Springs chemical plant.

SUMMARY AND CONCLUSIONS

The state of Idaho is divided into ground-water regions on the basis of accepted physiographic units. Within these ground-water regions there are four principal environments in which ground-water is found. These are listed as:

1. Valley-fill sand and gravel environment
2. Basalt environment
3. Sand and gravel intercalated with basalt environment
4. Lacustrine sand and gravel environment

Among the chief objectives of any study of ground water must be the gathering of information on which to predict future needs and the way in which these needs can be met. The information presented in the section on the ground-water regions will serve here as the basis for general predictions concerning the future needs and supplies of ground water in Idaho. Some very general remarks on the likely areas to drill for ground water are included, but it must be emphasized that it is seldom possible to predict accurately where water will be found in an area without thorough study.

The Craig Mountain section is underlain by basalt, and ground water occurs both in the basalt and in intercalated sediments. In the Lewiston area where ground water is used for municipal and industrial supply the intercalated sediments produce the greatest quantity of water. There appears to be an ample supply of ground water for future development in the Lewiston area. In the southern part of the section, however, ground water is not available in large amounts. Very few or no intercalated sediments are encountered and the basalt approaches being a "tight" rock; limited irrigation with ground water has been proposed in the Grangeville-Cottonwood area. It is doubtful that enough ground water can be produced from the basalt for this purpose unless water under artesian pressure exists at depths not yet penetrated by the drill.

In the Northern Rocky Mountain section, the major supply of water is from surface sources, but ground water has been developed to varying degrees in many of the valleys. The ground water occurs chiefly in the valley-fill of intermontane valleys, with some water occurring in glacial or lacustrine deposits. Because of the large amount of surface water available and the small amount of arable land present in the Northern Rocky Mountain section, it is doubtful that ground water will be extensively developed except possibly in the valleys that border the Snake River Plain. The most productive wells are, in most cases, found in the central or lowest part of the valleys, as it is here that the ground water will accumulate and be under the greatest pressure.

The Rathdrum Prairie section is underlain by glacial deposits of high porosity and permeability. Ground water is becoming increasingly important for irrigation purposes but the amount available is in excess of any foreseeable developments. The water table varies in accordance with the water level of Pend Oreille Lake, indicating that the lake is the major contributor to ground water under the Prairie. Large amounts of water can be produced from the glacial material at most locations on the Prairie surface.

In the Palouse section, ground water occurs in the basalt and in intercalated sediments. Both environments supply ground water but the inter-layers are probably the most important. In much of the section, the basalt occurs as a fill in valleys cut in older, relatively impermeable rock. The most logical place to drill for water is in the central or lowest part of the basins or valleys because it is here that the water will accumulate and be under the greatest pressure. Also, the intercalated sediments are better sorted than those occurring close to the older rocks. Ground water is used for municipal and domestic supplies and a small amount is used for irrigation. Although ground water probably will not be extensively developed in the future, basins or valleys that have restricted intake areas can be over developed very easily and conservation of ground water or artificial recharge will be necessary.

In the Seven Devils section, little is known of the occurrence of ground water because of an almost complete lack of sub-surface data. Much of the area is underlain by basalt and because basalt in other sections contains aquifers it can be assumed that aquifers do exist. In the Weiser River Valley there has been some irrigation using ground water which occurs in valley-fill or lacustrine deposits but there is not enough arable land in this valley or in any other part of the section to promote ground-water development on a scale which would deplete the ground-water reservoirs.

In the Snake River section, ground water occurs in all four environments. In the Boise area and westward, lake deposits are the major aquifers.

Valley-fill deposits are important as aquifers in the marginal areas of the Plain. Basalt and intercalated sediments in the basalt are important aquifers in all parts of the Plain except west of Boise.

Ground water is present in larger quantities on the Snake River Plain than in any other area of Idaho. Large amounts are being used for irrigation and for municipal, domestic, and industrial supplies.

Because of the abundance of surface water, large irrigation developments using ground water have been initiated only recently. Proposed irrigation projects using ground water are now under consideration and will probably be started in the near future. The main potential ground-water problems are in or near the tributary valleys of the Plain that have restricted intake areas.

Bruneau Basin is the only area in the Owyhee section where ground water is being developed. In this Basin south of Mountain Home, the sand and gravel deposits of lacustrine and valley-fill environment contain large amounts of ground water. Irrigation of areas near Bruneau Basin has been proposed, however, and ground water may be used for this purpose. There has been a decrease in the artesian pressure in the Basin in recent years that may lead to ground-water problems but several new wells have been drilled into deeper strata that are producing very large artesian flows, indicating that further development is feasible.

In the Basin and Range section, ground water occurs in sand and gravel in the lacustrine and valley-fill environments. The lake deposits are probably more important as aquifers. Water is produced for irrigation purposes from these deposits in the major valleys of the area. The ground-water level is close to the surface in the valleys of the section but because most of the wells do not encounter well-sorted sands or gravels the drawdown is usually large. In most of the arable areas of the section new ground water wells are being drilled. Although no serious problems have arisen to the present time, the Basin and Range section will be one of the first areas to face ground-water problems.

Ground-water occurs in all types of environment in the Middle Rocky Mountain section. The lacustrine environment, however, probably contains the most water. Irrigation is not extensive in the section. Most of the municipalities use surface water for their supply. Several irrigation wells have been drilled but well-sorted sand and gravel was not encountered. It is doubtful that the parts of the section underlain by lacustrine deposits will be able to irrigate large areas with ground water. In the parts of the section underlain by basalt and intercalated sediments, extensive irrigation with ground water is feasible.

As the State of Idaho grows and develops the abundant ground-water resources will become increasingly important. There is already evidence of this in the currently planned development of ground water for irrigation, and for municipal and industrial supplies. As the demands on ground water grow there will be problems, for the water in any particular area is limited. However, Idaho is fortunate in having legislation in force to meet such problems before they become extreme, and to assure an orderly development of this valuable resource. It is not difficult to predict that as time progresses, more and more geologists and laymen will consider ground water as the most valuable mineral resource in the state.

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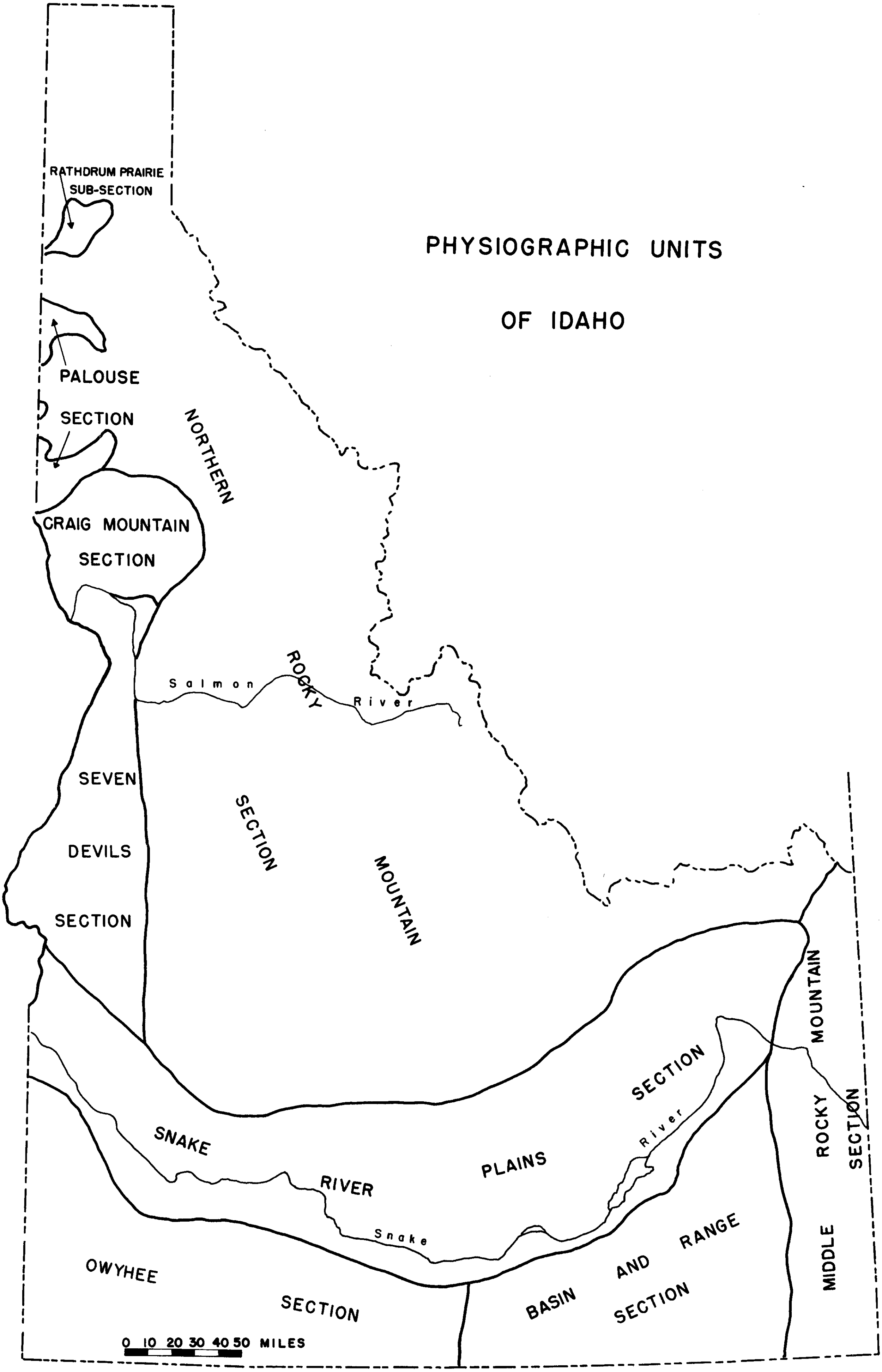
PHYSIOGRAPHIC UNITS
OF IDAHO
RATHDRUM PRAIRIE
SUB-SECTION
PALOUSE
SECTION
NORTHERN
CRAIG MOUNTAIN
SECTION
ROCKY
Salmon
River
SEVEN
DEVILS
SECTION
SECTION
MOUNTAIN
SNAKE
RIVER
PLAINS
SECTION
River
Snake
MOUNTAIN
ROCKY
SECTION
MIDDLE
OWYHEE
SECTION
BASIN
AND
RANGE
SECTION
0 10 20 30 40 50 MILES

FIGURE 5

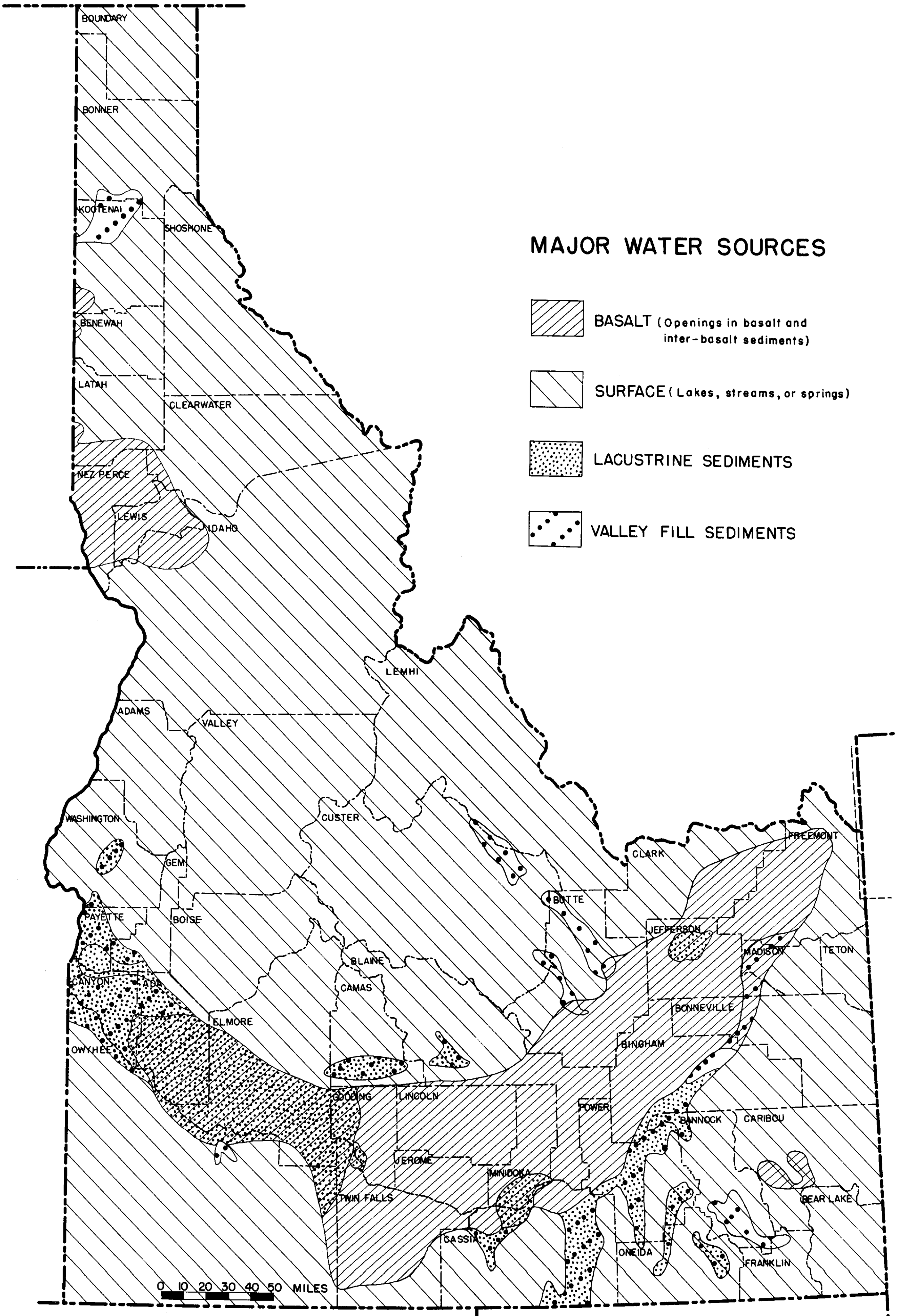
MAJOR WATER SOURCES
BASALT (Openings in basalt and inter-basalt sediments)
SURFACE (Lakes, streams, or springs)
LACUSTRINE SEDIMENTS
VALLEY FILL SEDIMENTS
BOUNDARY
BONNER
KOOTENAI
SHOSHONE
BENEWAH
LATAH
CLEARWATER
NEZ PERCE
LEWIS
IDAHO
LEMHI
ADAMS
VALLEY
WASHINGTON
CUSTER
GEM
CLARK
FREEMONT
BUTTE
PAYETTE
BOISE
JEFFERSON
MADISON
TETON
BLAINE
CANYON
ADA
CAMAS
BONNEVILLE
ELMORE
BINGHAM
OWYHEE
GOODING
LINCOLN
POWER
BANNOCK
CARIBOU
JEROME
MINIDOKA
TWIN FALLS
BEAR LAKE
CASSIA
ONEIDA
FRANKLIN
0 10 20 30 40 50 MILES

FIGURE 6

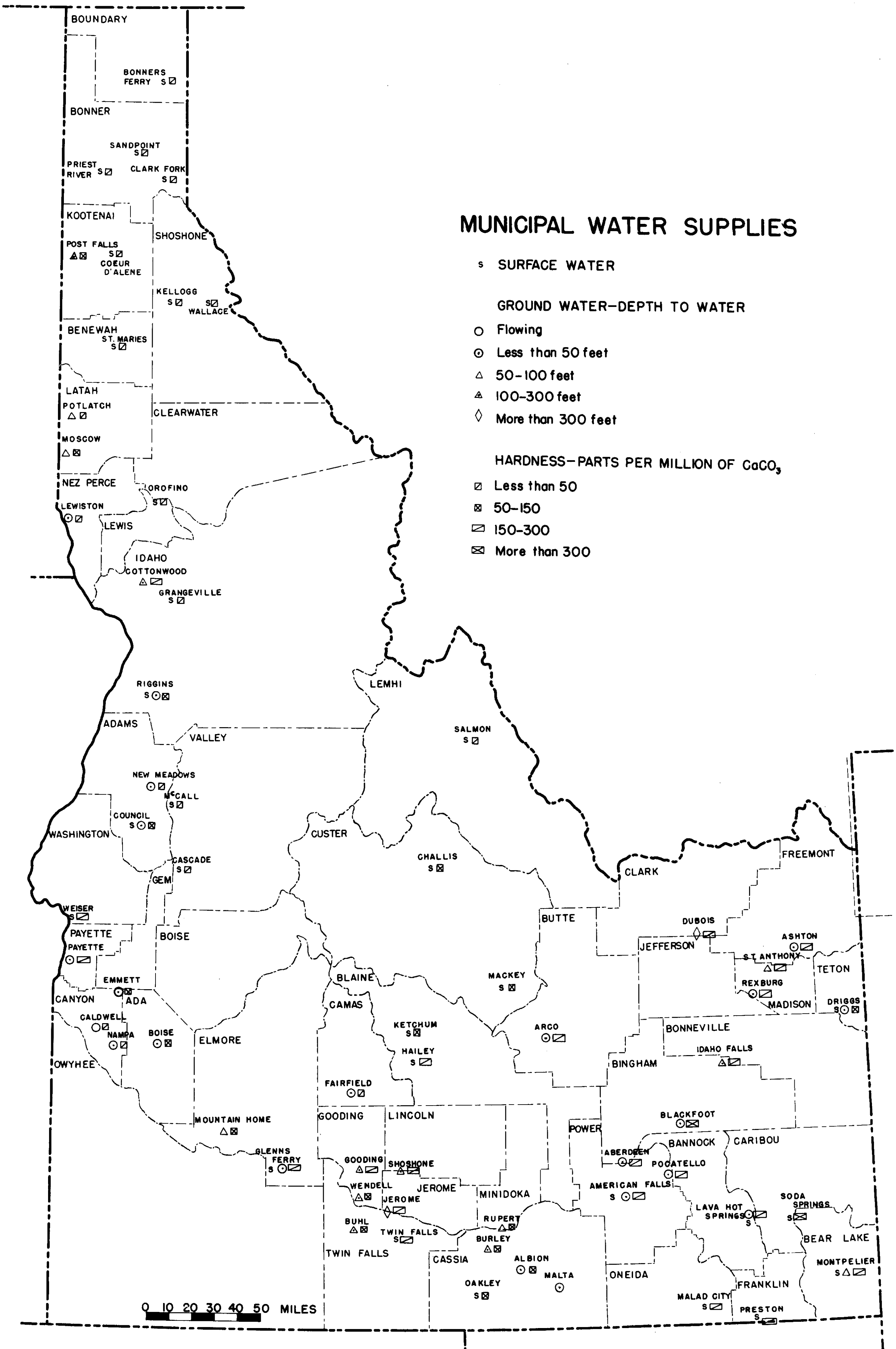
MUNICIPAL WATER SUPPLIES
s SURFACE WATER
GROUND WATER–DEPTH TO WATER
Flowing
Less than 50 feet
50-100 feet
100-300 feet
More than 300 feet
HARDNESS–PARTS PER MILLION OF CaCO3
Less than 50
50-150
150-300
More than 300
BOUNDARY
BONNERS FERRY
BONNER
SANDPOINT
PRIEST RIVER
CLARK FORK
KOOTENAI
SHOSHONE
POST FALLS
COEUR D'ALENE
KELLOGG
WALLACE
BENEWAH
ST. MARIES
LATAH
POTLATCH
CLEARWATER
MOSCOW
NEZ PERCE
OROFINO
LEWISTON
LEWIS
IDAHO
COTTONWOOD
GRANGEVILLE
RIGGINS
LEMHI
ADAMS
VALLEY
SALMON
NEW MEADOWS
McCALL
COUNCIL
WASHINGTON
CUSTER
CHALLIS
CASCADE
GEM
CLARK
FREEMONT
WEISER
PAYETTE
BOISE
BUTTE
DUBOIS
ASHTON
JEFFERSON
ST. ANTHONY
TETON
EMMETT
BLAINE
MACKEY
REXBURG
MADISON
DRIGGS
CANYON
ADA
CAMAS
CALDWELL
NAMPA
ELMORE
KETCHUM
ARCO
BONNEVILLE
HAILEY
IDAHO FALLS
OWYHEE
BINGHAM
FAIRFIELD
MOUNTAIN HOME
GOODING
LINCOLN
POWER
BLACKFOOT
GLENNS FERRY
SHOSHONE
ABERDEEN
BANNOCK
CARIBOU
POCATELLO
WENDELL
JEROME
MINIDOKA
AMERICAN FALLS
SODA SPRINGS
LAVA HOT SPRINGS
BUHL
RUPERT
TWIN FALLS
BURLEY
BEAR LAKE
CASSIA
ALBION
MONTPELIER
ONEIDA
MALTA
OAKLEY
FRANKLIN
MALAD CITY
PRESTON
0 10 20 30 40 50 MILES

FIGURE 7