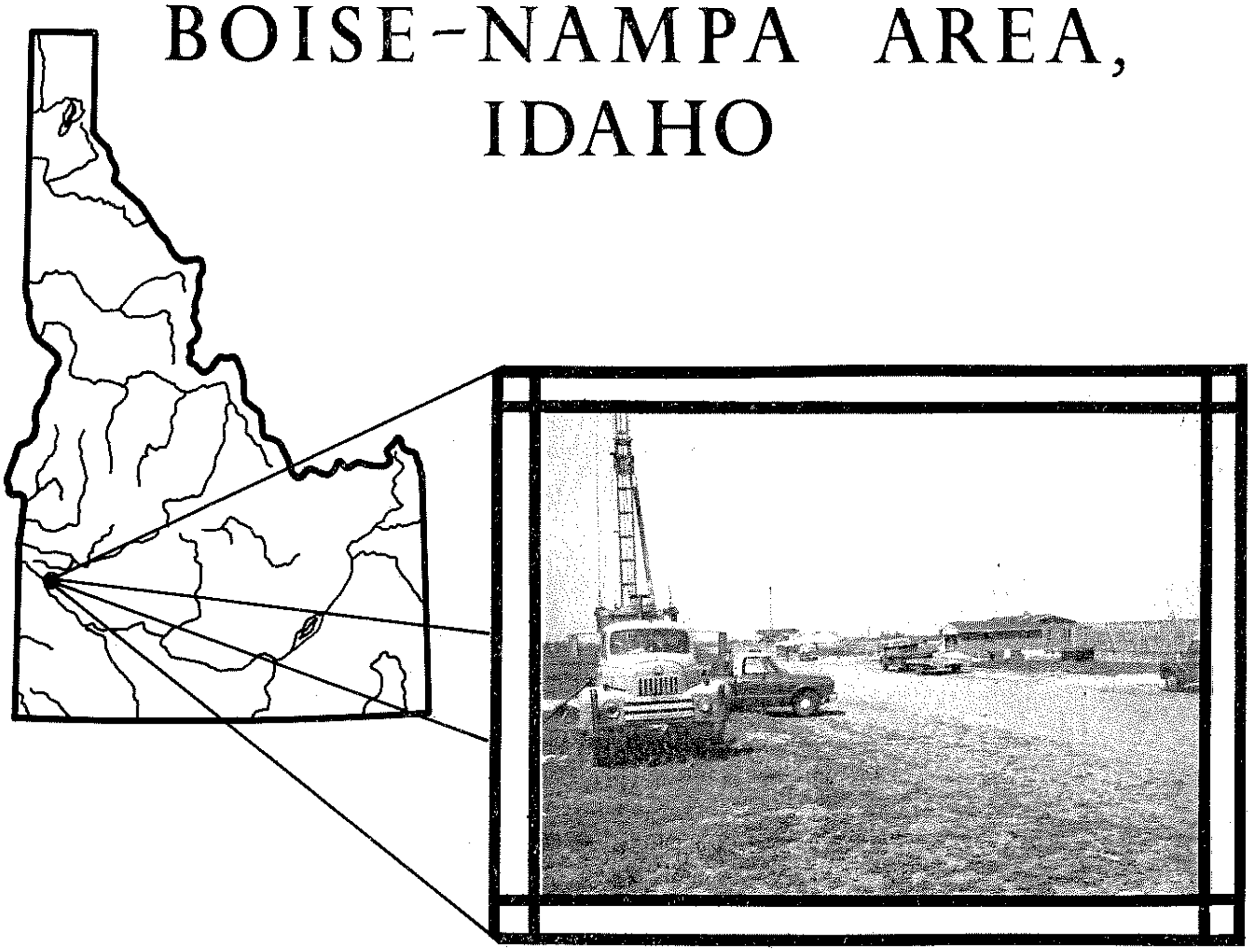
SOME EFFECTS OF LAND USE CHANGES ON THE SHALLOW GROUND WATER SYSTEM IN THE BOISE-NAMPA AREA, IDAHO



IDAHO DEPARTMENT OF WATER ADMINISTRATION

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SOME EFFECTS OF LAND-USE CHANGES ON THE SHALLOW GROUND-WATER SYSTEM IN THE BOISE-NAMPA AREA, IDAHO

by

N. P. Dion

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SOME EFFECTS OF LAND–USE CHANGES ON THE SHALLOW GROUND-WATER SYSTEM IN THE BOISE-NAMPA AREA, IDAHO

by

N. P. Dion

ABSTRACT

The rapidly-growing population of the Boise-Nampa area has necessitated that increasing amounts of cropland irrigated by surface water in Boise Valley be taken out of production to make room for new urban development. To determine the effects of this urbanization and of other changes on the underlying shallow ground-water resources, comparisons were made between (1) land- and water-use conditions as they existed in 1953 and in 1970 and (2) hydrologic conditions in the shallow aquifers as they existed at these same times.

Some of the changes noted over the 1953-70 period include increases in: (1) total population, 97,800 to 134,000; (2) total irrigated acreage, 144,000 to 164,000; (3) acreage irrigated with ground water, 7,100 to 31,000; (4) population served by municipal water systems, 72,500 to 95,800; and (5) population served by municipal sewer systems, 44,100 to 87,400. A decrease (137,000 to 133,000) was observed in the acreage irrigated with surface water.

Land- and water-use changes between 1953 and 1970 had the effect of increasing both withdrawals from and recharge to the shallow aquifers. Withdrawals increased by 3,600 acre-feet and recharge increased by 53,000 acre-feet, resulting in a net increase in recharge of 49,400 acre-feet. In spite of the added recharge to the shallow aquifers, hydrographs indicate that no significant change in the amount of water stored in these aquifers occurred. This is largely because of the efficiency with which ground water is removed from the shallow aquifers by the extensive network of natural and manmade drains in the area.

A comparison of water-quality data for 1953 and 1970 suggests that the quality of water in the shallow aquifers either did not change or the changes were too small or too localized to be detected. Despite the abundance of septic tanks in the study area, tests of water samples from shallow wells in highly urbanized areas for the presence of fecal coliform bacteria were negative. Tests of water samples from wells in agricultural environments for the presence of pesticides also were negative.

INTRODUCTION

Background

A significant part of the land and water resources of Boise Valley in southwestern Idaho, formerly used for agricultural purposes, is now used to accommodate urban expansion. This change, which has resulted from the rapidly-increasing population of the area, has had an effect on the ground-water resources of the valley.

The economy of Boise Valley is, and has been since the turn of the century, based largely on irrigated agriculture. Water for irrigation of crops in the valley was first diverted on a large scale from the Boise River in 1906, shortly after passage of the Federal Reclamation Act of 1902. Since 1906, three major dams and reservoirs – Lucky Peak, Arrowrock, and Anderson Ranch – have been constructed on the headwaters of the Boise River. These structures help regulate streamflow and thereby provide irrigators with a more dependable supply of water.

The irrigated area is served by a maze of canals, which supply water to fields, and by numerous drainage channels, which help to keep the water table at a reasonable depth below land surface.

Application of surface water to farmlands over a long period has raised ground-water levels in the shallow aquifers several tens of feet and has significantly increased the amount of ground water held in storage. Records indicate that water levels began a dramatic rise about 1912 and continued to rise until the 1930's, at which time water levels more or less stabilized. As a result of the application of surface water, seasonal ground-water level fluctuations of 6 to 8 feet are now considered normal in the irrigated parts of Boise Valley.

The rapid growth of population in the Boise-Nampa area has necessitated that increasing amounts of irrigated cropland in Boise Valley be taken out of production to make room for new homes. The population of Ada County, for example, increased 59 percent during 1950-70 in contrast to only a 21 percent increase in the State. This rapid rate of growth has resulted in the development of suburban complexes, or subdivisions, on the margins of the larger cities. Many of the homes in these complexes rely on wells that pump water from, and on septic tanks that dispose of wastes to, the shallow aquifers.

It was expected that water-use patterns would change in response to shifts in land-use patterns. Also, it was suspected that less cropland was being irrigated with surface water, but it was not known if more or less water was being recharged to the shallow aquifers.

Reports from several newly-urbanized areas throughout the United States indicate that outflow from septic tanks has, on occasion, contaminated ground-water supplies (Perlmutter and others, 1964; Chemerys, 1967). The possibility existed, therefore, that similar conditions could produce similar effects in the Boise-Nampa area.

A primary function of the U.S. Geological Survey in Idaho is to study and report on the water resources of the State in cooperation with various governmental agencies. The Idaho Department of Water Administration has a need for acquiring knowledge of Idaho's water resources as a part of its designated responsibilities. Both the U.S. Geological Survey and the Idaho Department of Water Administration recognized for several years that additional information was needed so that the effects of the changing land- and water-use patterns on the ground-water resources of the Boise-Nampa area could be evaluated. For these reasons, the study summarized in this report was initiated in 1969 by the Geological Survey in cooperation with the Idaho Department of Water Administration.

Objectives of Report

The purposes of this report on the Boise-Nampa area are to: (1) present an updated description of the development of ground water in the study area; (2) describe the occurrence and distribution of the aquifer units; (3) describe the hydrology of the shallow aquifers; (4) describe the effects, if any, of land-use changes occurring during 1953-70 on the shallow aquifer regimen; and (5) present a base of hydrologic information to which future data can be compared.

Although both deep and shallow aquifers exist in the Boise-Nampa area, this report deals almost exclusively with the effects of land- and water-use changes on the hydrology of the shallow aquifers. The deep aquifer is mentioned only when the discussion is pertinent to the hydrology of the shallow aquifers.

Location and General Features

The area studied is in the Columbia Plateau and Northern Rocky Mountain physiographic provinces (Fenneman, 1931). It occupies about 640 square miles of northern Ada and eastern Canyon counties (fig. 1) and includes three principal physical subdivisions: the eastern half of Boise Valley, the northwestern end of the Mountain Home Plateau, and a mountainous subdivision referred to informally as the Boise front (fig. 7).

The part of Boise Valley that lies within the area studied is below an altitude of about 2,800 feet and includes a broad, alluvial valley floor and several step-like terraces, or benches. The regional slope of the valley floor is to the northwest at about 14 feet per mile. The altitude of the valley floor at the western edge of the project area is locally below 2,400 feet. Several river terraces occur on both the north and south sides of Boise River, but they are better developed and more continuous on the south side.

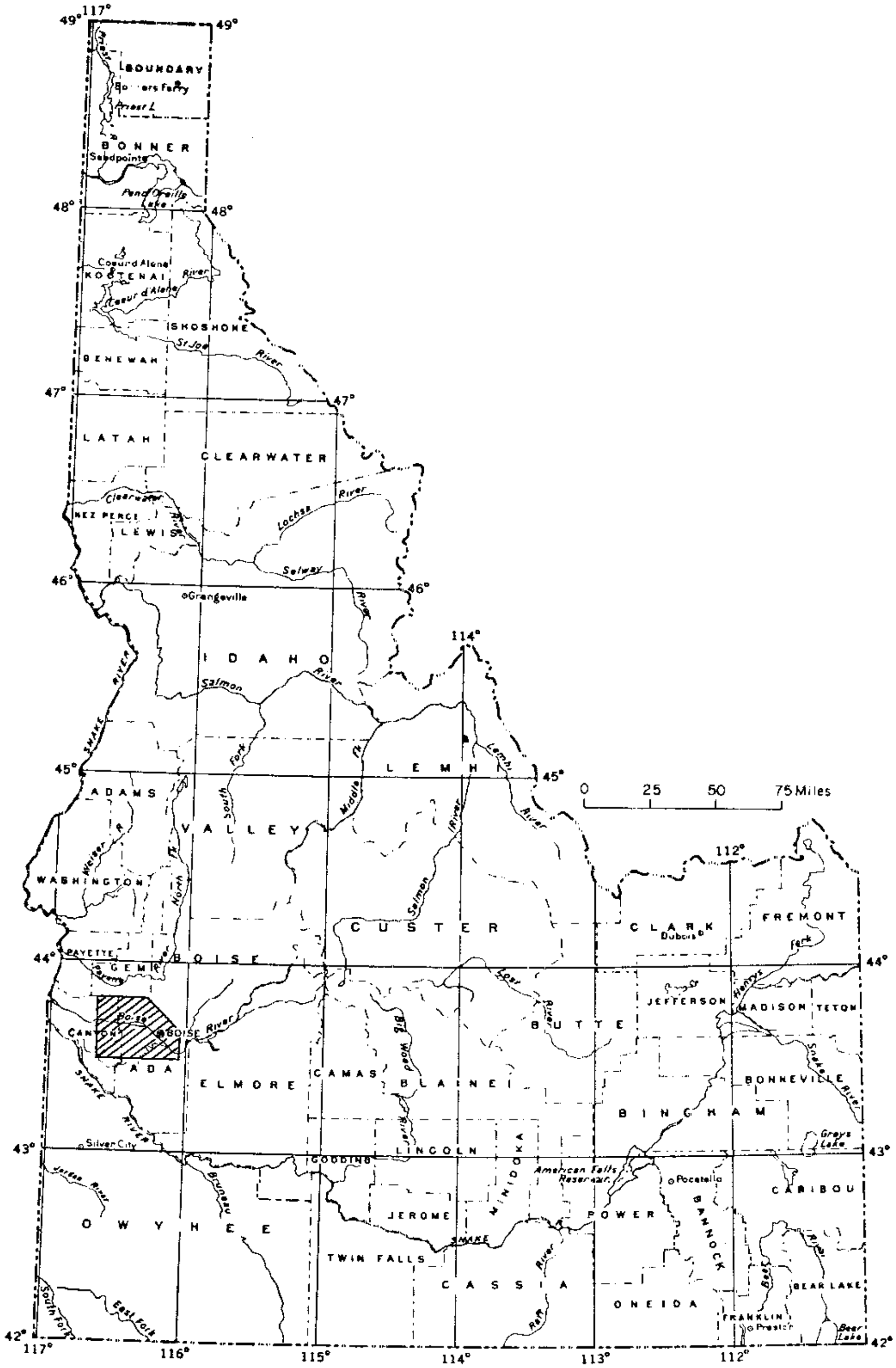

FIGURE 1. Map of Idaho showing area covered by this report.

The southeastern corner of the study area is occupied by the northwestern end of the Mountain Home Plateau. The Plateau slopes westward and northwestward from an altitude of about 4,000 feet to about 2,800 feet, and is generally a rolling, upland plain. A large part of the Plateau is underlain by basalt and the topography is rough and broken where the basalt is exposed.

The Boise front, as used in this report, includes a group of rounded hills and mountains that lie north and northeast of Boise Valley. Altitudes range from about 2,800 feet at the base to almost 6,000 feet on some peaks along the northeastern boundary of the project area. Altitudes and relief within the Boise front decrease to the west and northwest.

The study area is drained principally by the Boise River and its tributaries, and to a lesser extent by canals and drains. Tributary streams, especially in their upper reaches, are dry during much of the year. Streams flowing off the Boise front generally flow southwesterly; south of Boise River, the streams have a northwesterly trend.

Reservoirs in the area include Lucky Peak, Blacks Creek, Hubbard, and Lake Lowell. Principal cities and towns are Boise, Meridian, Eagle, Star, and Kuna in Ada County, and Nampa and Middleton in Canyon County.

The aquifers underlying this area can be categorized as either deep or shallow. The only deep aquifer of concern is the Glenns Ferry Formation of the Idaho Group. The shallow aquifers in the project area are the older terrace gravels, basalts of the Snake River Group, the younger terrace gravels, and Quaternary alluvium. (See figs. 10, 11, and 12.) The hydrology of the aquifers is described more fully in the section entitled "Ground-Water Hydrology" (p. 23).

Previous Investigations

Geologic and hydrologic studies of the Boise Valley have been made by several investigators. West (1955) investigated drainage problems on the Whitney terrace south of Boise and concluded that the problems were due in part to rapid urbanization of the area. One of his suggested solutions was the installation of a municipal sewer system; this has since been done. The most comprehensive investigation of aquifer characteristics in Boise Valley was by Nace, West, and Mower (1957) who evaluated the feasibility of the ground-water features of a large-scale irrigation plan. Field work for their study was completed in 1953 and, though their report area was limited to only the part of Boise Valley south of Boise River, the data collected provide a basis for comparing ground-water conditions in 1953 with those in 1970. A report by Savage (1958) contains the most recent description available of the geology of Ada and Canyon counties. Lewis (1959) studied the quality of potential irrigation waters from streams, springs, and wells in Boise Valley. He concluded that half the well water tested was satisfactory for irrigation use and that the other half could be made satisfactory by dilution with existing surface-water supplies. In addition, Lewis found no clearly-defined pattern of water quality by area. An investigation of the source, occurrence, and quality of ground water in the Boise area was made by Toron (1964). Toron described three "hydrostratigraphic units," each with unique hydrologic characteristics. A report by Mohammad (1970) described the geology and hydrology of the Boise front and that part of Ada County lying north of the Boise River.

Climate

A National Weather Service weather station has been in continuous operation at or near its present location (sec. 28, T. 3 N., R. 2 E.) near the Boise Municipal Airport since 1939. Weather at the station (altitude 2,838 feet) is representative of weather on the irrigated lowlands throughout the project area.

Boise Valley has a dry, temperate climate that is characterized by cool, wet winters and warm, dry summers. Large diurnal temperature fluctuations are normal and the arrival of the warm season is relatively fast. Hot periods during the summer rarely last longer than a few days, but cold spells in winter may last a week or more. A part of the winter precipitation is in the form of snow, but the snow cover is characteristically thin and melts rapidly. Compared with conditions nationwide, the average relative humidity at Boise is low (58 percent) and the percentage of maximum possible sunshine is high (67 percent).

The mean annual temperature at Boise is 10.6^{o} C (Celsius). January has the lowest (-1.6^{o} C), and July the highest (24.0^{o} C) mean monthly temperature (fig. 2). The average date of the last freeze in the spring is May 6; that of the first freeze in the fall is October 12. This results in an average freeze-free growing season of 159 days (Stevlingson and Everson, 1968).

The mean annual precipitation at Boise is 11.42 inches. August has the lowest (0.16 inch) and February the highest (1.33 inch) mean monthly precipitation. The amount of precipitation during the average freeze-free growing season is only about 2.9 inches, or 25 percent of the annual total.

Winds of destructive force are rare in Boise Valley. Southeasterly winds predominate and average 9 miles per hour.

Nace, West, and Mower (1957, p. 30) estimated the average yearly rate of evaporation from Lake Lowell at 33 inches. This estimate was based on adjusted records for Class A land pans of the National Weather Service.

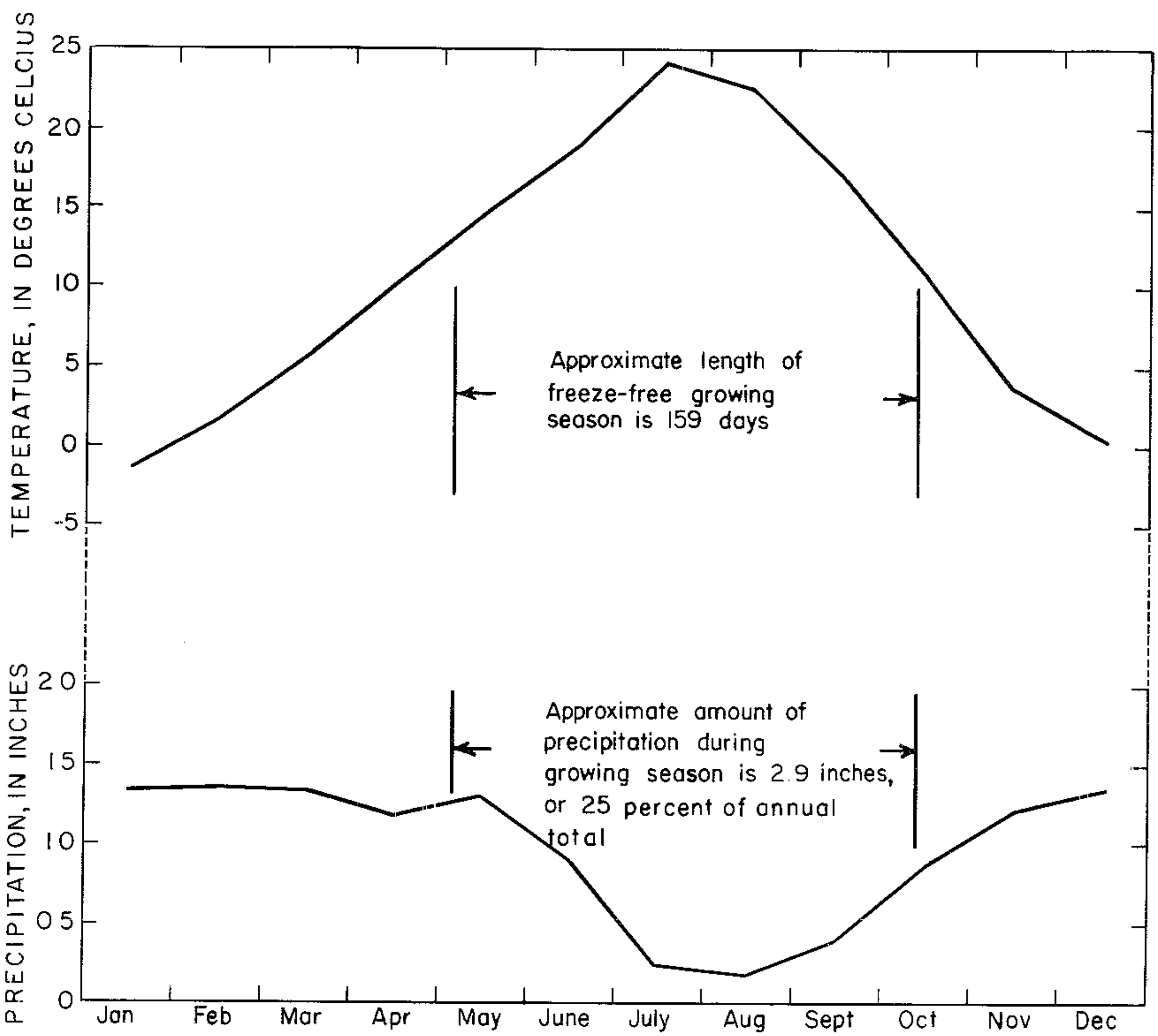

FIGURE 2. Average monthly temperature and precipitation at Boise Municipal Airport. (Based on data from National Weather Service for 1939-60.)

Well-Numbering System

The well-numbering system used by the U.S. Geological Survey in Idaho indicates the location of wells within the official rectangular subdivision of the public lands, with reference to the Boise base line and meridian. The first two segments of the number designate the township and range. The third segment gives the section number, followed by three letters and a numeral, which indicate the quarter section, the 40-acre tract, the 10-acre tract, and the serial number of the well within the tract, respectively. Quarter sections are lettered a, b, c, and d in counter-clockwise order from the northeast quarter of each section (fig. 3). Within the quarter sections, 40-acre and 10-acre tracts are lettered in the same manner. Well 3N-2E-8adc1 is in the SW¼SE¼NE¼ sec. 8, T. 3 N., R. 2 E., and was the first well inventoried in that tract.

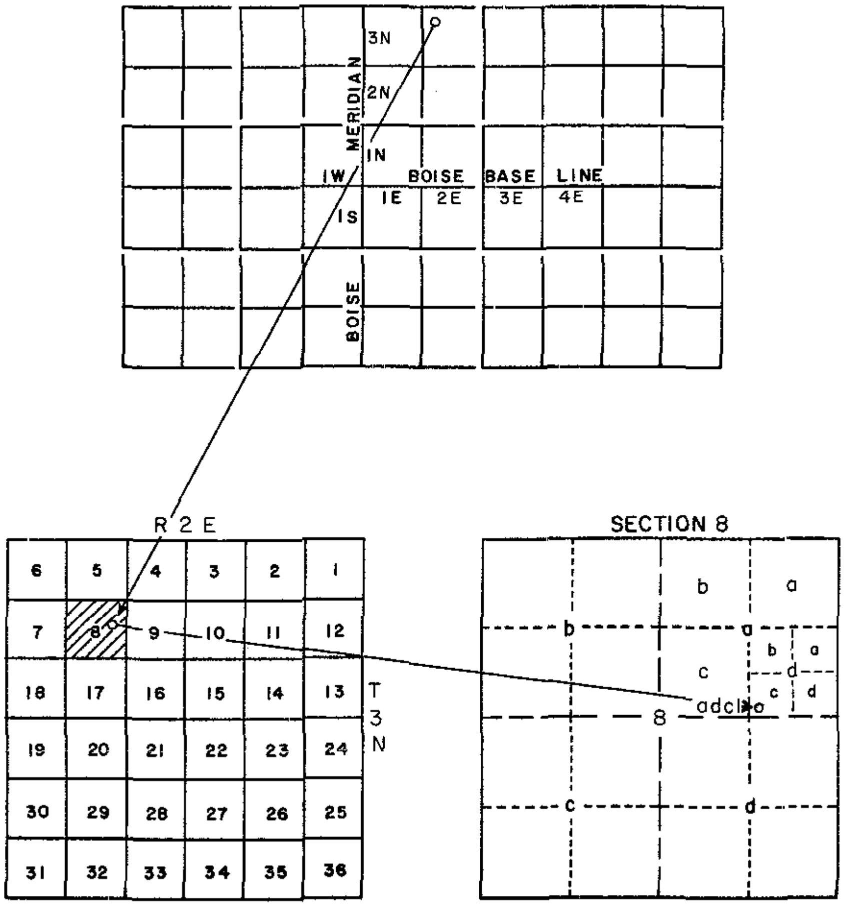

FIGURE 3. Diagram showing the well-numbering system. (Using well 3N-2E-8adc1.)

Use of Metric Units

In this report, the units that indicate concentrations of water-quality parameters determined by chemical analyses and the temperatures of air and water are metric units. This change from reporting in "English units" has been made as a part of a gradual change to the metric system that is underway within the scientific community and is intended to promote greater uniformity in reporting of data. Chemical data for concentrations are reported in mg/l (milligrams per liter) rather than in ppm (parts per million), the units used in earlier reports of the U.S. Geological Survey. However, numerical values for the chemical concentrations given in this report would be essentially the same whether reported in terms mg/l or ppm.

Table 1 will help to clarify the relation between degrees Fahrenheit and degrees Celsius.

Table 1

Temperature-Conversion Table

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-8.0	17.6	6.0	42.8	16	60.8	26	78.8	45	113
-6.0	21.2	7.0	44.6	17	62.6	27	80.6	50	122
-4.0	24.8	8.0	46.4	18	64.4	28	82.4	55	131
-2.0	28.4	9.0	48.2	19	66.2	29	84.2	60	140
0	32.0	10	50.0	20	68.0	30	86.0	65	149
1.0	33.8	11	51.8	21	69.8	32	89.6	70	158
2.0	35.6	12	53.6	22	71.6	34	93.2	75	167
3.0	37.4	13	55.4	23	73.4	36	96.8	80	176
4.0	39.2	14	57.2	24	75.2	38	100	85	185
5.0	41.0	15	59.0	25	77.0	40	104	90	194

°C = Degrees Celsius = 0.56 (°F - 32)

°F = Degrees Fahrenheit = 1.80 (°C) + 32.

Acknowledgments

The author expresses his gratitude to Messrs. Royse Van Curen of the Boise Project Board of Control, Art Norland of the Pioneer Irrigation District, Ed Schmidt of the Nampa-Meridian Irrigation District, and D. L. Mussleman, Watermaster of Water District 63 for sharing their knowledge of hydrologic conditions in the project area; and to the residents of the Boise-Nampa area for their cooperation in furnishing information about their wells and for allowing access to their property.

Of particular value was the assistance rendered by Omar M. J. Mohammad of the University of Idaho and recently of Amman, Jordan. His help in the collection of field data and the chemical analysis of water samples proved invaluable in the timely completion of the project.

LAND– AND WATER–USE PATTERNS

To evaluate the effects of land-use changes on the underlying ground water, comparisons were made between (1) land- and water-use conditions as they existed in 1953 and in 1970 and (2) hydrologic conditions in the shallow aquifers, as they existed at these same times. The year 1953 was chosen as a basis for comparison because of the existence of hydrologic information for that year in a report by Nace, West, and Mower (1957). Data relating to population, land use, and water use for the two dates (1953 and 1970) were collected from various private, municipal, county, State, and Federal sources.

This section of the report describes and compares land- and water-use patterns for 1953 and 1970. Other sections of this report describe and compare hydrologic conditions for the same dates and attempt to determine the causes of any significant changes found.

Conditions in 1953

Population

The total population within the project area in 1953 is estimated to have been about 97,800, of which about 65 percent was urban and about 35 percent was rural (fig. 4). This estimate is based on population trends for Ada and Canyon counties (fig. 5) and on the assumption that the project area contained 98 percent of the population of Ada County and 40 percent of the population of Canyon County. The urban population resided primarily in the cities of Boise, Nampa, and Meridian. The total number of dwelling units in the project area is estimated to have been about 31,700 (fig. 6).

Land Use

An examination of aerial photographs taken of the project area in 1953 shows that use of the land was as follows: about 2 percent solely residential, 2 percent residential and commercial, 50 percent farming and residential, and 46 percent grazing on nonirrigated land or unused (fig. 7). Most of the irrigated farmland was on the terraces and flood plain of the Boise River. The major crops grown included alfalfa, irrigated pasture, small grains, vegetables, sugar beets, and potatoes. Of the 144,000 agricultural acres irrigated, only about 7,100 acres, or 5 percent of the total, was irrigated by ground water (fig. 8). The amount of irrigated acreage within the boundaries of the project area is based on estimates by the U.S. Soil Conservation Service, the Ada and Canyon County Agent's offices, the Census of Agriculture, the Idaho Tax Commission, and the examination of aerial photographs.

Water Use

The principal uses of water in the study area in 1953, in order of quantities used, were for irrigation, domestic and stock (including municipal supplies), and industrial purposes.

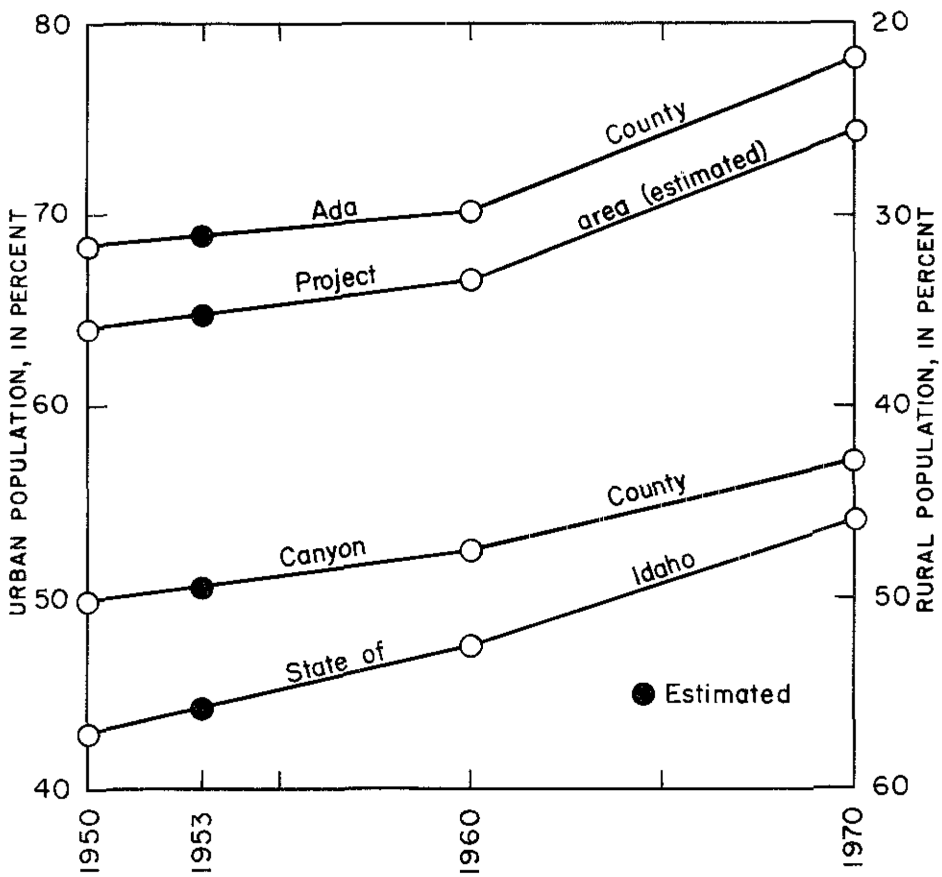

FIGURE 4. Urban and rural population in the State of Idaho, Ada and Canyon Counties, and the project area. (Based on data from the U. S. Bureau of Census.)

Agricultural land was irrigated chiefly with canal water diverted from surface streams and, to a lesser extent, with ground water pumped from wells. The volume of water needed to sustain the crops grown on this land is dependent on the consumptive use of the crop being grown. Sutter and Corey (1970), using a modified Blaney-Criddle method, determined that the average consumptive use of water by the most widely grown crops in the project area is about 2.2 acre-feet per acre in a climate similar to that found in the project area. The amount of precipitation during the average growing season is 0.24 acre-feet per acre; therefore, the "consumptive irrigation requirement" (the consumptive use minus the contribution from rainfall) for the majority of crops grown in the project area is assumed to be 2.0 acre-feet per acre. The quantity of water applied to the crops, however, is usually much greater than the consumptive irrigation requirement because of inefficiencies and other needs within the irrigation system. It is assumed for purposes of this report that: (1) all surface water is applied to the fields by gravity; (2) in the gravity system only 60 percent

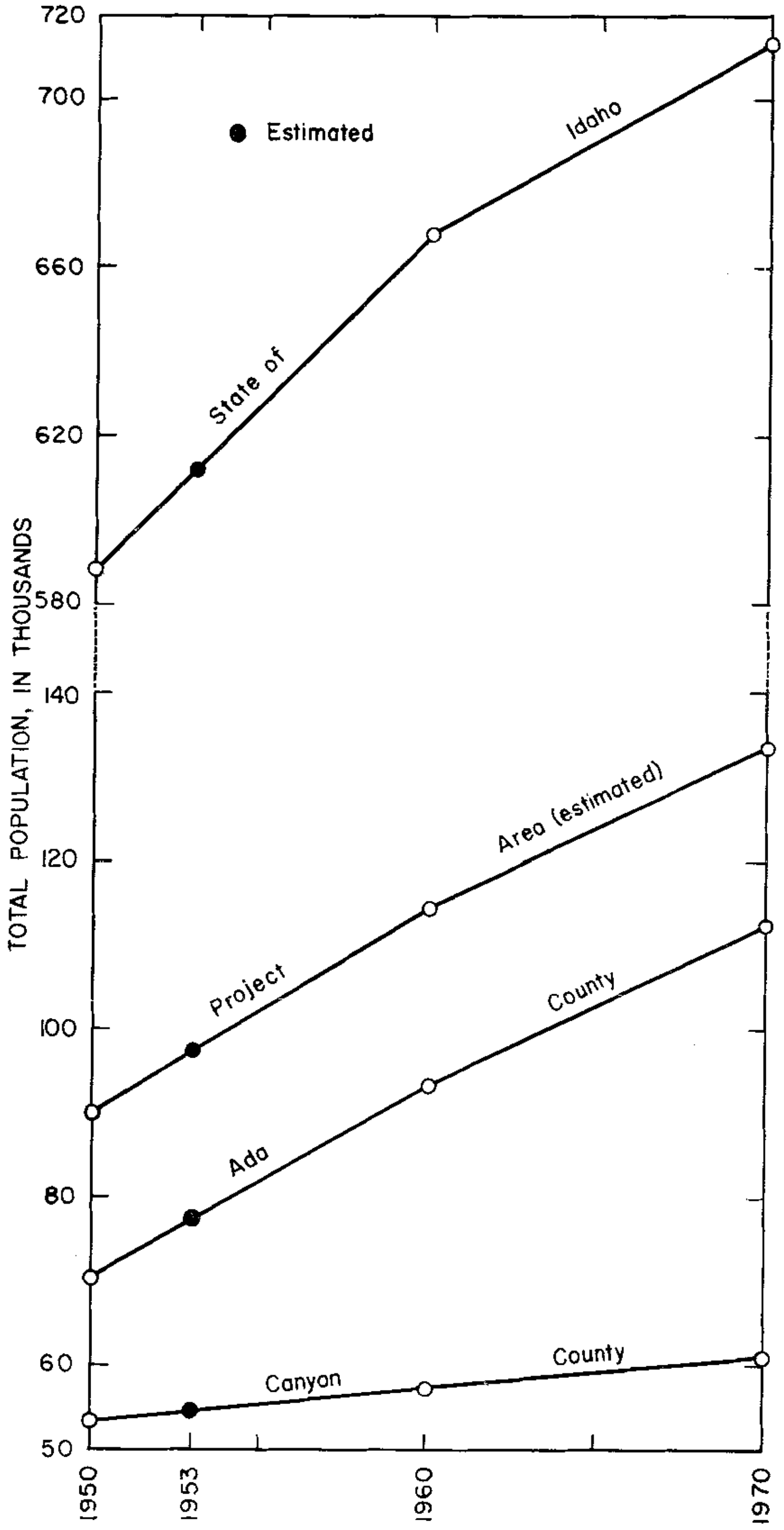

FIGURE 5. Population trends in the State of Idaho, Ada and Canyon Counties, and the project area. (Based on data from the U. S. Bureau of Census.)

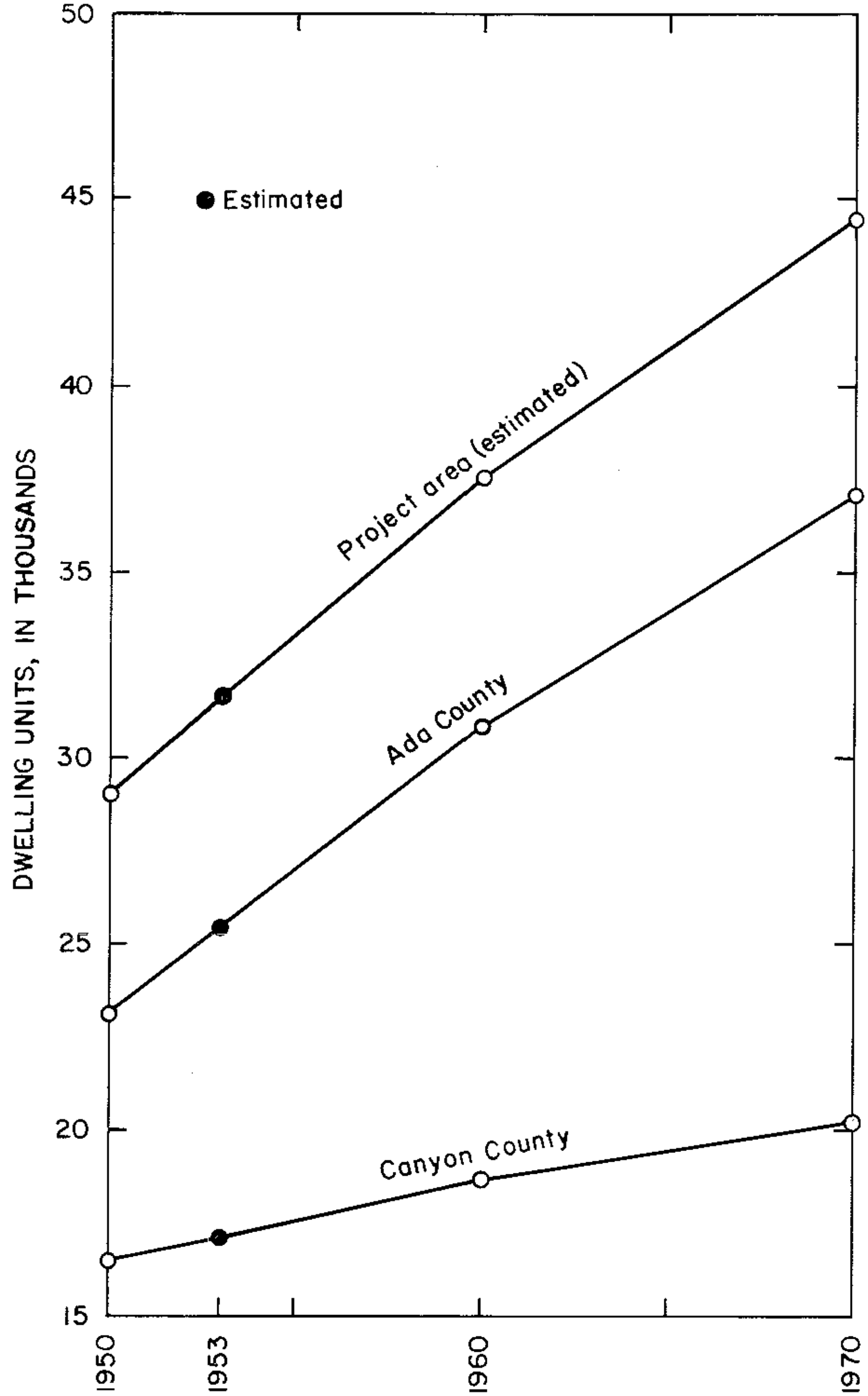

FIGURE 6. Total dwelling units in Ada and Canyon Counties, and the project area. (Based on data from the U. S. Bureau of Census.)

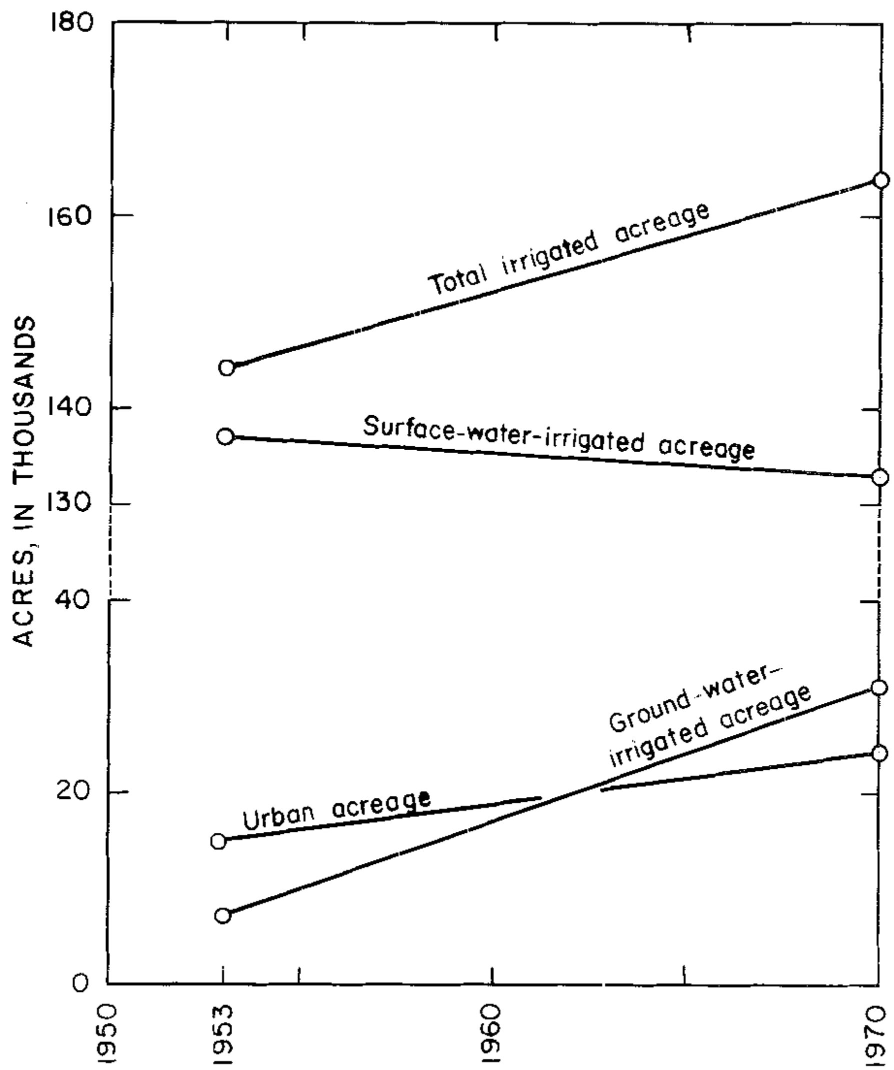

FIGURE 8. Irrigated and urban acreage in the project area. (Based on estimates from various sources.)

(3.1 acre-feet per acre in 1953) of the water diverted from streams actually reaches the fields and is applied to crops; (3) the evaporation losses in the canals are less than 1 percent and are negligible; (4) the 40 percent lost in conveyance recharges the aquifers; (5) all ground water is applied to the fields by sprinklers with no conveyance loss; and (6) in the sprinkler systems, 3.0 acre-feet per acre is pumped and applied to the crops.

Surface water was delivered to the fields in the study area by 11 large canals (fig. 7) and several smaller ones that diverted water from the Boise River and tributary streams. The New York Canal, by far the largest, delivered more than 60 percent of all surface water used for irrigation in the area. In 1953, the 11 major canals diverted a weighted average of 5.2

acre-feet per acre (Karn, 1953) to the estimated 137,000 acres that were irrigated by surface water. The amount lost in conveyance plus the amount applied in excess of the consumptive irrigation requirement totaled 3.2 acre-feet per acre, or 438,000 acre-feet. This quantity of water, therefore, seeped into the ground and served to recharge the underlying ground-water aquifers. The 7,100 acres that were irrigated by ground water at the rate of 3.0 acre-feet per acre consumed only 2.0 acre-feet per acre. Therefore, the aquifers were recharged from this source at a rate of 1.0 acre-feet per acre, or a volume of 7,100 acre-feet. Thus, the total amount of water recharged into the aquifers by both gravity and sprinkler irrigation systems in 1953 was about 445,000 acre-feet.

Although well data show that virtually all the irrigation water pumped from wells is from the deep aquifer, there is no way, from data available, to determine in what proportions the deep and shallow aquifers were recharged. In addition, the shallow aquifers are absent from a small part of the irrigated area. Nevertheless, for purposes of this report, it is assumed that all irrigation recharge was initially to the shallow aquifers. On this basis, the net hydrologic effects of irrigation in 1953 were to remove 21,000 acre-feet of water from the deep aquifer and to recharge the shallow aquifers by 445,000 acre-feet (table 2).

Domestic- and stock-water supplies in rural areas were pumped from individually-owned wells finished primarily in the shallow aquifers. Municipal water systems in the urban areas depended primarily on wells tapping the deep aquifer. Disposal of domestic sewage in rural areas was by septic tanks which return water to the shallow aquifers. In some urban areas, domestic sewage was collected in a municipal system and given at least primary treatment before being discharged either directly or indirectly to the Boise River.

The areas served by municipal water and sewer systems in 1953 are outlined in figure 7. Persons living outside the boundaries shown relied on individually-owned wells and septic tanks. About 72,500 people, or 74 percent of the total population, were served by municipal water systems, while only 44,100 people, or 45 percent of the total population, were served by municipal sewer systems. In this situation, municipal water that was withdrawn from the deep aquifer was supplied to 28,400 people who disposed of their waste water to septic tanks. This waste water served to recharge the shallow aquifers. Two effects of domestic- and stock-water usage in 1953 were the removal of 20,300 acre-feet of water from the deep aquifer and the recharging of 6,100 acre-feet to the shallow aquifers (table 2). In computing the data for domestic- and stock-water usage shown in table 2, it was assumed that: (1) the use of water for domestic and stock purposes combined was 250 gallons per day per person (Wells and others, 1969, p. 64, 65, and 106); (2) 25 percent of the water used was consumed and no longer available for reuse; (3) each municipal water or sewer connection served an average of 3.1 persons; (4) in areas served by septic tanks, all the water not consumed was recharged to the shallow aquifers; and (5) in areas served by municipal sewage systems, 20 percent of the water not consumed was recharged to the shallow aquifers.

Table 2

Summary of Use and Disposition of Water in the Boise-Nampa Area

		Year	Irrigation Use (acre-feet)	Domestic and Stock Use (acre-feet)	Industrial Use[1] (acre-feet)	Totals (acre-feet)
Diverted from Surface Streams		1953	712,000	0	0	712,000
		1970	732,000	0	0	732,000
Ground-water Pumpage	Deep Aquifer	1953	21,000	20,300	13,800	55,100
		1970	93,000	26,800	15,100	135,000
	Shallow Aquifers	1953	0	7,100	0	7,100
		1970	0	10,700	0	10,700
Consumed[2]		1953	288,000	6,800	3,300	298,000
		1970	328,000	9,400	2,800	340,000
Transferred from Project Area by Sewers, etc [2]		1953	0	7,400	10,500	17,900
		1970	0	14,600	12,300	26,900
Gross Recharge to Shallow Aquifers		1953	445,000	13,200	0	458,000
		1970	497,000	13,500	0	511,000
Net Recharge to (+) or Withdrawal from (-)	Deep Aquifer	1953	-21,000	-20,300	-13,800	-55,100
		1970	-93,000	-26,800	-15,100	-135,000
	Shallow Aquifers	1953	+445,000	+6,100	0	+451,000
		1970	+497,000	+2,800	0	+500,000

[1]Based on estimates by plant operators

[2]Unavailable for recharge

The largest industrial uses of water in 1953 were for food processing, ice production, and fish rearing. The locations of these industrial water users are shown in figure 7. Industrial water was pumped chiefly from the deep aquifer in 1953. The volumes not consumed were wasted either to surface streams or to municipal sewer systems, and, therefore, did not recharge the aquifers. An inventory of industrial pumpage made for this study indicates that 13,800 acre-feet of water was removed from the deep aquifer in 1953 (table 2).

The combined hydrologic effects of using water for irrigation, domestic and stock, and industrial purposes in 1953 were to remove about 55,100 acre-feet of water from the deep aquifer and to recharge the shallow aquifers with about 451,000 acre-feet (table 2).

The large volume of irrigation water that recharges the aquifers each year is the primary cause of chronic waterlogging problems throughout much of the project area, especially in the shallow aquifers that underlie the flood plain and lower terraces of the Boise River. In some areas, sufficient water is recharged to raise the water table above land surface. However, in these areas, the water table is effectively kept below the land surface by a complex system of manmade open drains and subsurface tile drains, by streams and canals that act as drains, and by dozens of large and small drainage wells that flow or are pumped throughout much of the 5- to 6-month irrigation season. The amount of water recharged to the shallow aquifers in 1953 (451,000 acre-feet) caused water levels in observation wells to rise 4 to 7 feet between the beginning and end of the 1953 irrigation season.

Conditions in 1970

Population

The total population within the project area in 1970 was about 134,000, of which 74 percent was urban and 26 percent was rural (fig. 4). This estimate is based on a census of population in April 1970 by the U.S. Bureau of the Census and on the assumption that the project area contained 98 percent of the population of Ada County and 40 percent of the population of Canyon County. The urban population resided primarily in the cities of Boise, Nampa, and Meridian. The total number of dwelling units in the project area was about 44,500 (fig. 6).

Land Use

Aerial photographs were taken of the project area in the summer of 1969 for the U.S. Department of Agriculture. It is assumed that land-use conditions then were much the same as they were in 1970. An examination of the photographs shows that use of the land was as follows: about 3 percent solely residential, 3 percent residential and commercial, 51 percent farming and residential, and 43 percent grazing on nonirrigated land or unused (fig. 9). Most of the irrigated farmland was on the terraces and flood plain of the Boise River. The major crops grown included alfalfa, irrigated pasture, small grains, vegetables, sugar beets, and potatoes. Of the 164,000 agricultural acres irrigated, 31,000 acres, or 19 percent of the total, was irrigated by ground water (fig. 8). The estimates of irrigated agricultural acreage within the boundaries of the project area are from the same sources described under "Conditions in 1953 - Land Use" on page 10.

Water Use

The principal uses of water in the study area in 1970, in order of quantities used, were for irrigation, domestic and stock (including municipal supplies), and industrial purposes.

The methods of irrigation and the consumptive irrigation requirement of crops were virtually the same as described under "Conditions in 1953 - Water Use" on page 10. The same assumptions concerning irrigation that were made for the 1953 conditions also applied in 1970.

In 1970, the 11 major canals serving the project area diverted a weighted average of 5.5 acre-feet per acre (Musselman, 1970) to the 133,000 acres that were irrigated by surface water. The amount lost in conveyance plus the amount applied in excess of the consumptive irrigation requirement totaled 3.5 acre-feet per acre, or about 466,000 acre-feet. This quantity of water, therefore, seeped into the ground and recharged the underlying aquifers. The 31,000 acres that were irrigated by ground water at the rate of 3.0 acre-feet per acre consumed only 2.0 acre-feet per acre. Therefore, the aquifers were recharged from this source at a rate of 1.0 acre-feet per acre, or 31,000 acre-feet. The total amount of water recharged into the aquifers by both gravity and sprinkler irrigation systems in 1970 was about 497,000 acre-feet. The net hydrologic effects of irrigation in 1970 were to remove about 93,000 acre-feet of water from the deep aquifer and to recharge the shallow aquifers by 497,000 acre-feet (table 2).

The areas that were served by municipal water and sewer systems in 1970 are outlined in figure 9. Approximately 95,800 people, or 72 percent of the total population, were served by municipal water systems, while 87,400 people, or 65 percent of the total population, were served by municipal sewer systems. In this situation, municipal water that was withdrawn from the deep aquifer was supplied to 8,400 people who disposed of their waste water to septic tanks. The waste water served to recharge the shallow aquifers. Two effects of domestic- and stock-water usage in 1970 were the removal of 26,800 acre-feet of water from the deep aquifer and the recharging of 2,800 acre-feet to the shallow aquifers (table 2). The same assumptions concerning domestic- and stock-water usage that were made for the 1953 conditions (p. 15) also applied in 1970.

The largest industrial uses of water in 1970, as in 1953, were for food processing, ice production, and fish rearing. The locations of these industrial water users are shown in figure 9. Industrial water was pumped chiefly from the deep aquifer and the volumes not consumed were wasted either to surface streams or to municipal sewer systems. The net effect of pumping water for industrial purposes in 1970 was to remove 15,100 acre-feet of water from the deep aquifer.

The combined hydrologic effects of using water for irrigation, domestic and stock, and industrial purposes in 1970 were to remove about 135,000 acre-feet of water from the deep aquifer and to recharge the shallow aquifers with about 500,000 acre-feet of water (table 2). As in 1953, most of the water recharged to the shallow aquifers was irrigation seepage. Because of continuous ground-water discharge, the amount of water recharged caused water levels in the shallow aquifers to rise only about 4 feet (p. 27) between the beginning and end of the 1970 irrigation season. This rise is comparable to that which occurred in 1953.

Changes (1953-70)

Population

The population within the project area increased by 35,700 people, or 36 percent of the 1953 population, between 1953 and 1970. The population of Idaho increased only 16 percent over the same period (fig. 5). The percentage of the population that resided in an urban environment had increased in the project area, in Ada and Canyon counties, and in the State as a whole. As figure 4 indicates, the urban population of the project area had increased from about 65 percent in 1953 to about 74 percent in 1970. The urban population of the State increased from 44 percent to 54 percent over the same period.

The number of dwelling units in the project area had increased by 12,800 units, or 40 percent, from 1953 to 1970 (fig. 6) as compared with an increase of 23 percent for the State over the same period.

Land Use

The total irrigated acreage in the project area increased during the period 1953-70, owing primarily to a substantial increase in the amount of land irrigated by ground water (fig. 8). Most of this land was on the northern and southern margins of the project area and previously was either dryfarmed, grazed or unused. In general, the methods of irrigation and the kinds of crops grown remained unchanged.

The amount of land irrigated by surface water showed a decline of about 4,000 acres during the 1953-70 period. This slight loss was due to agricultural land being taken out of production to provide room for the construction of private family dwellings. Most of the land so affected was between Boise and Meridian, but some development had occurred in the Nampa area. Urban acreage, herein defined as the land used for commercial and residential purposes only, increased by about 9,600 acres over the 17-year period (fig. 8)

Water Use

The volumes of water used for agricultural irrigation in the project area were so large that the relatively small water-use changes brought about by changing irrigation, domestic, and industrial conditions between 1953 and 1970 were completely overshadowed and became almost insignificant.

The net hydrologic effect of increasing the total amount of land irrigated during 1953-70 was to increase the net amount of ground water withdrawn from the deep aquifer by 72,000 acre-feet (93,000-21,000). This, in turn, increased the net amount of water being recharged into the shallow aquifers as a result of irrigation by 52,000 acre-feet (497,000-445,000).

As stated previously, the population in the project area increased by 35,700 people (36 percent) between 1953 and 1970. Of greater hydrologic significance, however, are the facts that the population served by municipal water systems increased by 23,300 (32 percent) and that the population served by municipal sewer systems increased by 43,300 (98 percent). The increased reliance on municipal water systems resulted in increasing ground-water withdrawals from the deep aquifer by 6,500 acre-feet (26,800-20,300); the effect of increased use of municipal sewer systems was to decrease the potential amount of recharge to the shallow aquifers. Both trends resulted in a net decrease in recharge to the shallow aquifers as a result of domestic and stock use of 3,300 acre-feet (6,100-2,800) between 1953 and 1970.

Industrial conditions in the project area changed very little between 1953 and 1970. One exception is that in 1970 a large part of the industrial waste water was piped to sewage plants instead of being dumped directly into drains or natural stream channels, as in 1953. A slight increase (1,300 acre-feet) in the amount of ground water pumped from the deep aquifer for industrial purposes between 1953 and 1970 reflects increased production by essentially the same industrial concerns that existed in 1953.

The combined hydrologic effects of the water-use changes that were brought about by changes in irrigation, domestic and stock, and industrial conditions were to increase withdrawals from the deep aquifer by 79,900 acre-feet (135,000-55,100) and to increase recharge to the shallow aquifers by 49,000 acre-feet (500,000-451,000).

No quantitative difference could be detected in the output of drainage wells between 1953 and 1970. The drainage problem on the Ellis farm described by Nace, West, and Mower (1957, p. 65-67) was alleviated considerably by the construction of two or three additional small-diameter drainage wells. Much of the land previously described as chronically waterlogged was dewatered and in full production. The drainage problem on Whitney terrace described by West (1955) was somewhat relieved by extending the sewer service to that area.

Future Trends

Total population in the project area will certainly increase, and undoubtedly at a faster rate than for the State as a whole. The trend toward a larger proportion of urban dwellers will probably continue, in line with nationwide trends.

As people move or are annexed into the cities, urban areas will grow in size and good agricultural land will be taken out of production. Even though the total amount of irrigated acreage is currently increasing, at some future time all potentially irrigable land will be in production. From that time on the project area will probably experience a reduction in the total irrigated acreage concomitant with a growth of the cities. Therefore, it seems that, over the long term, the study area as a whole is moving away from the present predominantly agricultural economy. The type of economy that will eventually emerge is not yet known. Industry currently plays a minor role in the economy of the project area, but the potential for a large-scale development of industry is present.

Most of the homes that were built recently outside the city limits rely on septic tanks and privately-owned shallow wells. As the cities expand and annex these homes, municipal water and sewer facilities will become available. If past trends are an indication of future trends, most homes will eventually be connected to municipal facilities. Septic tanks will be abandoned completely and shallow wells will be used only for lawn sprinkling. Coupled with the reduction in irrigated acreage, the actions described above will tend to greatly reduce the amount of recharge to the shallow aquifers. The drilling of more public-supply wells into the deep aquifer will tend to increase withdrawals from that zone. Should the source of municipal water shift to surface-water bodies, withdrawals from the deep aquifer would be lessened considerably.

Increased industrial water demands will be satisfied according to the type of industry involved. If industrial growth is concentrated primarily in the food-processing industry, water most likely will have to be pumped from the deep aquifer, which contains water of a slightly better chemical quality than do the shallow aquifers. For other industries where quality is not as critical, water supplies may be taken from the shallow, more productive, aquifers.

GEOLOGIC FRAMEWORK

The area described in this report has a complex geologic history of erosion, sedimentation, and intrusion. Consequently, an accurate determination of age relationships between lithologic units, especially the younger sands and gravels, is often difficult. The surface distribution of the rock units shown in figure 10 has been generalized from the work of Nace, West, and Mower (1957) and Savage (1958).

Rock units ranging in age from Cretaceous to Holocene underlie the report area. Some of the older units shown in figure 10 also occur at depth below surface outcrops of younger units.

The oldest rock unit exposed in the area is the Idaho batholith of Early and Late Cretaceous age. It is composed of gray quartz monzonite and granodiorite, with associated schists and gneisses. The unit crops out in northeastern Ada County where it was uplifted and faulted to form isolated, rocky crags at high altitudes. At lower altitudes, the rock weathers into rounded, convex slopes. Rocks of the Idaho batholith probably underlie the entire study area at depth and form a structural troughlike basin in which younger rocks were deposited.

Basalt of the Columbia River Group of Miocene and Pliocene age unconformably overlies parts of the Idaho batholith. Isolated remnants of this basalt that are exposed in the foothills north of Boise indicate that it has been extensively weathered and eroded. Local evidence also suggests that some folding and faulting of the formation has occurred.

Basalt of the Columbia River Group is overlain unconformably by the Glenns Ferry Formation. The Glenns Ferry Formation is considered to be of late Pliocene and early Pleistocene age and is composed of nonindurated, complexly intertonguing, continental deposits of clay, silt, sand, and fine gravel. It also contains some volcanic ash and local lava flows of olivine basalt. Total thickness of the formation in the Boise-Nampa area is about 2,000 feet. The formation is well exposed along the Boise front where the massive, light-colored beds commonly erode into badlands. As indicated by drillers' logs of wells, this formation underlies a large part of the project area at fairly shallow depths. There is abundant evidence of minor faulting and tilting within the formation (Savage, 1958, p. 26, 44). Immediately north of Boise, a northwest-trending fault-line scarp separates the floor of Boise Valley from the Boise front. Locally, the Glenns Ferry Formation is well cemented in areas where hot springs emerged along the fault zone.

Above the Glenns Ferry Formation, and separated from it by an unconformity, are the several rock units referred to as the "shallow" aquifers. The oldest of these is a thick sheet of unconsolidated silt, sand, and well-sorted gravel of Pleistocene age, herein referred to informally as the older terrace gravels. The gravels contain crystalline pebbles and cobbles of the Idaho batholith, but do not contain basalt debris from the Snake River Group. Exposures are characterized by cut-and-fill channels, inclined bedding, and cross bedding. Well-developed imbrication of the gravels suggests that they were deposited by torrential floods of meltwater coming from glaciated areas to the northeast (Savage, 1958, p. 26). The gravels were later eroded by floodwaters and prominent terraces were formed. Total thickness of the unit in the project area is about 150 feet.

Extensive flows of vesicular olivine basalt belonging to the Snake River Group crop out on the Mountain Home Plateau and south of Boise Valley. The age of these basalts ranges from Pleistocene to Holocene. In places, the basalts are intercalated with the upper part of older terrace gravels; elsewhere the basalts rest directly on the Glenns Ferry Formation. The sources of the basalt flows are mostly outside the project area. Maximum thickness of the flows in the project area is about 300 feet.

The lower river terraces north and south of the Boise River are underlain by unconsolidated clay, silt, and sand, and by well-sorted gravel that contains pebbles and cobbles of the Idaho batholith and of the Snake River Group. This rock unit is Pleistocene and Holocene in age and is herein referred to informally as the younger terrace gravel. This gravel was deposited on a former flood plain of the Boise River and consists primarily of reworked older terrace gravel. For this reason, the material composing the younger terrace gravel is somewhat finer grained than that in the older terrace gravel. Deposition of the younger terrace gravel seems to have been by streams flowing to the northwest (Savage, 1958, p. 27).

The youngest rock unit exposed in the study area is the unconsolidated alluvium of Holocene age. It is composed of silt, sand, and coarse, well-sorted gravel. The alluvium is present beneath the flood plains of the Boise River, where it directly overlies the Glenns Ferry Formation, and beneath some of the larger tributaries. Maximum thickness of the alluvium is about 50 feet.

GROUND–WATER HYDROLOGY

Deep Aquifer

The Glenns Ferry Formation of the Idaho Group is the only significant "deep" aquifer in the project area. The basalt of the Columbia River Group, exposed only in small, isolated patches in the foothills north of Boise (fig. 10), is not saturated. Joints and fractures in rocks of the Idaho batholith yield only small volumes of water to a few domestic wells.

Very little is known about the hydrology of the Glenns Ferry Formation south of Boise River. The hydrology of the formation north of Boise River is discussed by Mohammad (1970).

Shallow Aquifers

The shallow aquifers in the project area are the older terrace gravel, basalts of the Snake River Group, the younger terrace gravel, and Quaternary alluvium. Although each has individual hydraulic characteristics (Nace and others, 1957, p. 21-22), the aquifers act as a single hydrologic unit and for purposes of this report, they are treated as such. The areal distribution of the shallow aquifers is shown in figure 10.

Hydrogeologic sections (figs. 11 and 12) show that the materials composing the shallow aquifers lie on the eroded surface of the Glenns Ferry Formation and that the younger clastic materials lie at progressively lower altitudes. Ground water occurs under water-table conditions in all four units composing the shallow aquifers and, so far as known, its flow is unaffected by formation boundaries. Zones of perched ground water occur above the main water table near secs. 10, 19, and 32, T. 2 N., R. 1 E., but the zones are probably of limited extent.

Recharge to the shallow aquifers is mainly by leakage from irrigation canals and laterals, the downward percolation of applied irrigation water and precipitation, and by the downward percolation of domestic waste water from septic tanks. Other lesser amounts of recharge are probably supplied by the smaller streams, losses from the channel of the Boise River between Lucky Peak and Barber dams (Ralston and Chapman, 1970, p. 41-43), upward leakage of water from the underlying Glenns Ferry Formation, and by the natural influx of ground water from outside the project area. As stated previously, most of the water recharged to the shallow aquifers each year is a result of irrigation and usually occurs between the months of April and October.

The general direction of ground-water movement in the study area can be deduced from the water-level map (fig. 13). Movement of the water is downgradient at right angles to the contour lines. Throughout most of the area, ground water flows to the northwest at a gradient of about 19 feet per mile. However, in the southeastern part of the area, the ground water flows to the south at a gradient of about 16 feet per mile, strengthening the conclusion of Ralston and Chapman (1970) that water is leaking out of the channel of the Boise River between Lucky Peak and Barber dams. In detail, the shape of the water table and direction of ground-water movement undoubtedly are more complex than indicated in figure 13. The details, however, cannot be resolved from the available data. Moreover, some of the shallow wells in the study area tap local, weak artesian zones but do not flow at ground surface. Such wells are often hard to distinguish from nearby water-table wells strictly on the basis of water levels. It is likely that some of the wells alternate between water-table and artesian conditions as water levels change with time.

The shape of the water table in 1953 was influenced strongly by seepage from the New York Canal (Nace and others, 1957, p. 47 and pl. 5). Seepage from the canal in 1970, however, is not as great as it was in 1953, nor does it play as significant a role. Seepage losses from the canal in 1953 are estimated at 18 percent (R. Van Curen, oral commun., 1970). Since 1953, much additional lining of the canal has been done to reduce seepage losses. As part of the present study, a test of seepage losses from the New York Canal was made in the spring of 1970 when flow was about 800 cfs (cubic feet per second). Losses over a 38-mile reach of canal amounted to 5.5 percent and were heaviest in the reach of the canal between sec. 30, T. 3 N., R. 2 E., and sec. 23, T. 2 N., R. 1 W. The configuration of the water-level contours in this area tends to substantiate the conclusion that this is a reach of rather large seepage losses.

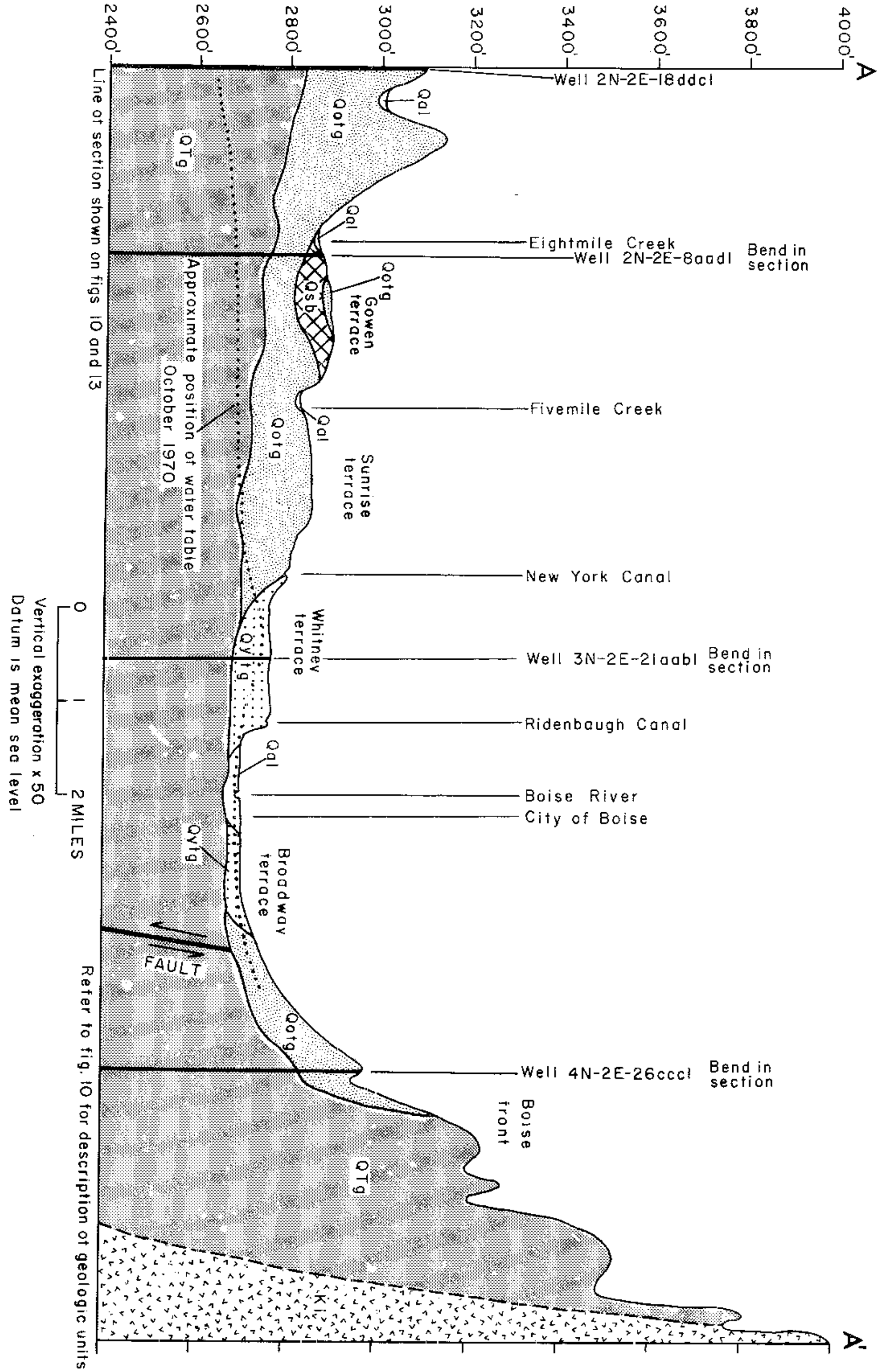

FIGURE 11. Generalized hydrogeologic section A-A'.

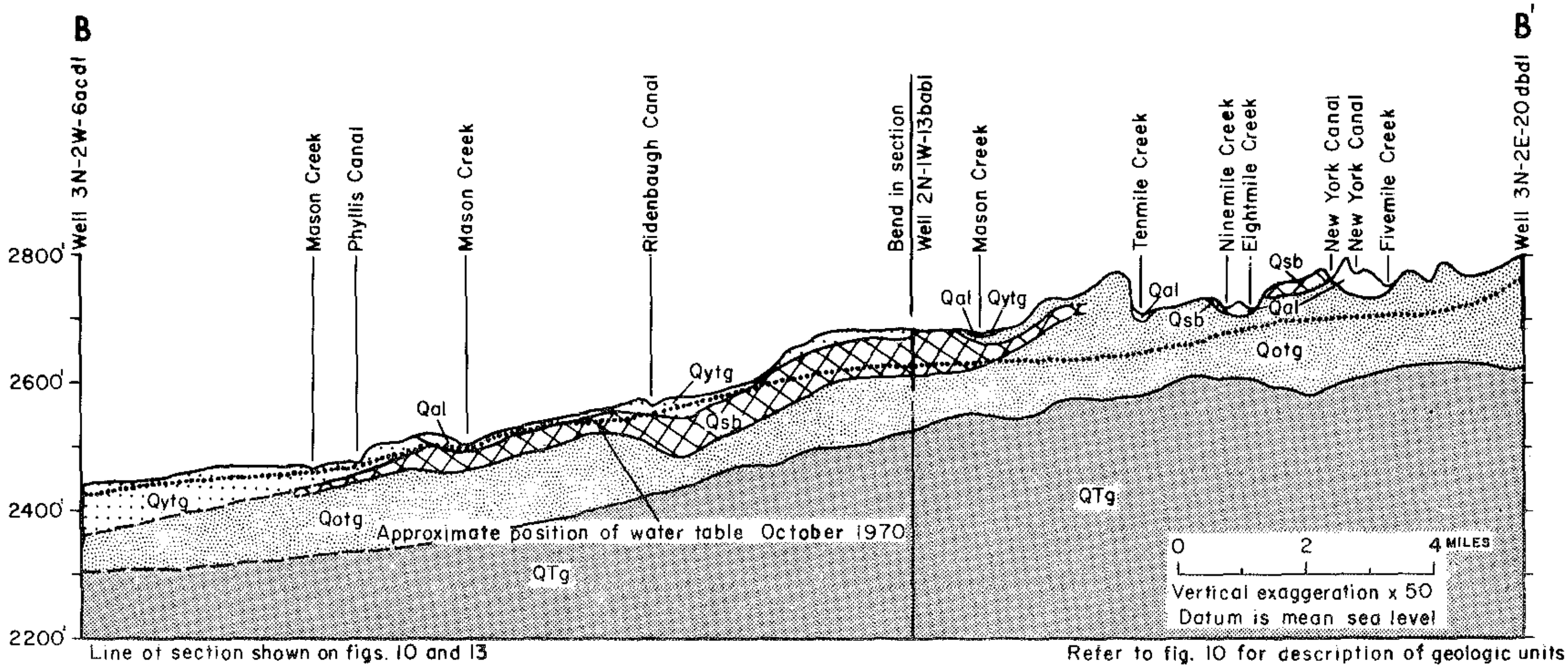

FIGURE 12. Generalized hydrogeologic section B-B'.

The prominent mound on the water table near secs. 20 and 21, T. 3 N., R. 2 E., is caused by canal seepage and probably, to a lesser degree, by the application of a large volume of water for irrigation. This mound underlies a golf course that is heavily irrigated with water taken from the New York Canal. Water levels in wells on and near the mound fluctuate as much as 30 feet between spring and fall.

The widespread application of irrigation water has altered the natural cycle of water-level fluctuations. Under natural conditions, highest water levels normally occur in late spring, immediately following the period of greatest natural recharge; and lowest water levels occur in the fall, following the dry season. In the irrigated areas, however, the annual water-level highs usually occur in early fall near the end of the irrigation season and annual lows usually occur in the spring, just prior to the beginning of the irrigation season. (See fig. 14.) One notable exception to this general pattern of water-level fluctuations occurs in areas immediately adjacent to Lake Lowell (fig. 13) where ground-water levels are influenced strongly by the stage of the lake. The lake is usually filled at the very beginning of the irrigation season with water diverted from the Boise River, thereby raising the stage of the lake. As the irrigation season progresses, water stored in the lake is withdrawn, thereby lowering the stage of the lake. Water levels in wells adjacent to the lake fluctuate accordingly; annual highs occur in the spring and annual lows in the fall.

As part of this investigation, water levels in about 200 wells open to the shallow aquifers were measured just prior to the beginning of the irrigation season (early March 1970) and again just before the end of the irrigation season (early October 1970). Even though several wells showed declines over this 7-month period, the overwhelming trend was upward. The average net change in water levels for all wells measured was a rise of 4.3 feet.

The Geological Survey has monitored water levels in several shallow observation wells throughout the study area since the early 1950's. The hydrographs of these wells, two of which are shown in figure 14, show no definite long-term trend in water levels for the period of record.

Ground water is discharged from the shallow aquifers by several natural and artificial means. Natural discharge is by flow to surface streams, in particular Boise River, Tenmile Creek, and Indian Creek, by evapotranspiration in areas where the water table is at or near land surface, and by a few springs. Artificial discharge is effected by manmade drains, by pumping for various beneficial water uses, and by flowing and pumped drainage wells.

A very general correlation was found between ground-water levels in the shallow aquifers and the amount of water being discharged by streams and drains. As mentioned previously, comparison of water levels measured in early March with those measured in early October showed a net rise of 4.3 feet, due mostly to the application of irrigation water. Over this same period, the measured discharges from five streams and drains located in the western part of the project area (fig. 13) more than doubled.

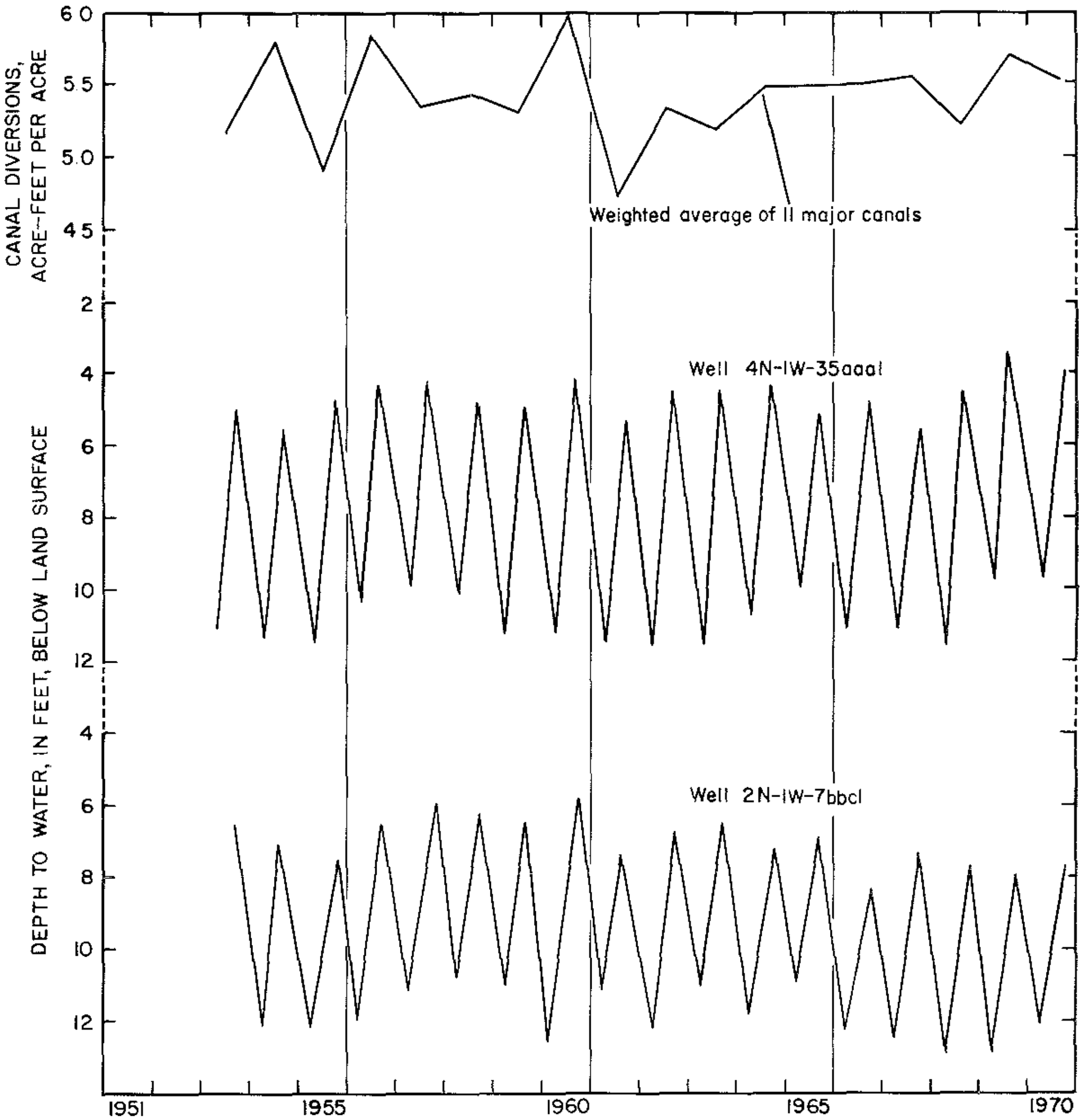

FIGURE 14. Hydrographs of surface-water diversion rates and of water levels in selected observation wells. (Location of wells shown on fig. 13.)

Yields from wells open to the shallow aquifers are generally higher than those from wells open to the deep aquifer. According to reports from well drillers, yields as large as 4,050 gpm (gallons per minute) and specific capacities as large as 185 gpm per foot of drawdown are obtainable from the shallow aquifers. Nace, West and Mower (1957, p. 55) reported that coefficient of transmissibility values of 130,000 to 1,700,000 gallons per day per foot and coefficient of storage values of 0.004 to 0.048 were determined from tests made in three wells in the shallow aquifers.

An unusual situation exists near the NE¼NW¼NW¼ sec. 11, T. 2 N., R. 2 W., where two 16-inch wells have been drilled for drainage purposes. These wells are 99 feet deep and tap a local artesian zone in basalt of the Snake River Group. The natural flow from each of the wells is reported to be in excess of 4,000 gpm, which is greater than most pumped wells in the project area.

EFFECTS OF LAND– AND WATER–USE CHANGES ON THE HYDROLOGY OF SHALLOW AQUIFERS

Changes in Recharge

The increase in recharge to the shallow aquifers in 1970 as compared to 1953 (table 2) resulted largely from the increase in irrigated acreage over the 17-year period and to the relative amounts of irrigation water diverted in the years used for comparison. However, a comparison of recharge in 1953 with recharge in 1970 is of limited benefit because diversion rates during the intervening years ranged from 4.7 to 6.0 acre-feet per acre (fig. 14) and averaged 5.4 acre-feet per acre. These large fluctuations tend to mask any small changes in recharge that might be expected between the years of comparison. A detailed year-by-year analysis of recharge from 1953 to 1970 is beyond the scope of this report.

There did not seem to be any long-term trend in the amount of water being diverted each year for irrigation during 1953-70. Diversion rates depended primarily on the amount of precipitation in the winter months prior to the irrigation season and, unless storage facilities change significantly, the rates will continue to average about 5.4 acre-feet per acre. Therefore, over the long term, the amounts of irrigation water recharged to the aquifers annually will be dependent on the amounts and proportions of agricultural acreage irrigated from surface-water and ground-water sources.

Changes in Ground-Water Levels and Movement

Water-level changes over a period of time can be detected either by comparing water-level maps for the area of concern or by comparing individual water-level measurements made in a single well at different times. Both methods were used as part of this study. A comparison of water-level maps drawn in 1953 (Nace and others, 1957, pl. 5) and in 1970 (fig. 13) suggests, at first, that ground-water conditions in the shallow aquifers have changed significantly. However, although differences do exist between the two maps, the differences most likely do not reflect hydrologic changes over the 17-year period, but rather differences in methods of data collection and interpretation. In both cases, the maps were based on the best data available. In 1970, however, many more wells were available for water-level measurements than in 1953, especially in the vicinity of T. 2 N., R. 1 E. where, in 1953, several shallow wells in a zone of perched water were interpreted as being in the main water body. In addition, whereas the map for 1953 is based on water-level data collected over a 4-month period, the water levels for the 1970 map were measured within a 4-day period. Thus, it was not considered feasible to use the two water-level maps as indicators of water-level changes.

As part of the present study, 42 wells that were measured for water levels in 1953 were revisited and remeasured in 1970. A comparison of the water-level measurements made in these wells (table 3) indicates an average decline in water level of 0.2 feet per well between 1953 and October 1970. The accuracy of this figure is in doubt, however, because year-to-year changes are greater than the 0.2 feet net change.

It is probably more reliable to refer to the hydrographs of shallow observation wells which, as pointed out on page 27 and figure 14, show that significant long-term changes in water levels had not occurred between 1953 and 1970. Failure to detect water-level changes is probably due to the fact that the water table is so near land surface in much of the area that rises large enough to be detected are prevented by an efficient network of drains and only declines could be detected if the recharge was reduced significantly.

Ground-water movement is controlled by the gradient of the water table It is, therefore, reasonable to conclude that, because water levels (and therefore gradients) had not changed significantly, the overall direction and amount of ground-water movement also had not changed.

Changes in Water Quality

The results of standard and partial chemical analyses of ground-water samples from 186 selected wells in the Boise-Nampa area are listed in tables 4 and 5 and summarized in table 6. The results of five standard analyses of water from wells sampled in 1970 are shown in figure 13 by means of patterns (Stiff, 1951). The patterns depict the concentrations of several ions and afford a ready method to compare the areal distribution of the different types of ground water.

Table 3

Comparison of 1953 and 1970 Water Levels in Selected Wells in the Boise-Nampa Area

Well No.	Altitude of Land Surface[1]	Depth to Water[2]	Date Measured	Depth to Water[2]	Date Measured	Net Rise (+) or Decline (-) in Water Level, 1953-70
4N-2W- 19ada1	2,421	12.5	9- 1-53	13.1	10-7-70	-0.6
26cad1	2,472	9.6	11-19-53	21.7	10-7-70	-12.1
27bba1	2,441	2.7	11- 6-53	11.0	10-7-70	-8.3
34cda1	2,467	9.8	11- 6-53	11.4	10-7-70	-1.6
35cdd1	2,479	10.4	11- 6-53	9.7	10-7-70	+.7
36cad1	2,491	8.0	11- 6-53	8.2	10-7-70	-.2
4N-1W- 30cda1	2,499	8.2	11-17-53	6.8	10-7-70	+1.4
31bdd1	2,499	7.9	11-16-53	8	10-7-70	+7.1
32aaa2	2,519	3.0	11-16-53	4.0	10-9-70	-1.0
34dad1	2,548	7.8	11-17-53	4.4	10-9-70	+3.4
4N-1E- 27add1	2,652	30.2	11-19-53	21.7	10-7-70	+8.5
29bbb1	2,600	25.1	11-17-53	27.5	10-7-70	-2.4
3N-2W- 1ddd1	2,500	7.7	10-20-53	7.8	10-7-70	-.1
3dda1	2,468	6.2	9-17-53	9.4	10-7-70	-3.2
4cbb1	2,454	10.5	10-12-53	13.5	10-7-70	-3.0
6acd1	2,441	7.3	9-16-53	17.9	10-7-70	-10.6
8ccd1	2,455	9.4	10-10-53	9.8	10-7-70	-.4
12bda1	2,492	6.2	11- 2-53	9.0	10-7-70	-2.8
20bdc1	2,470	9.2	11- 4-53	13.0	10-8-70	-3.8
25bbb1	2,511	10.9	10-27-53	10.1	10-9-70	+.8
30baa1	2,464	8.0	10-10-53	7.0	10-8-70	+1.0
32aba1	2,480	6.0	10-10-53	9.2	10-8-70	-3.2
3N-1W- 1ccd1	2,584	7.5	10-20-53	6.9	10-9-70	+.6
7bbc1	2,496	4.8	10-10-53	7.1	10-7-70	-2.3
14aaa1	2,590	5.8	9-19-53	6.4	10-9-70	-.6
23abb1	2,590	9.9	10-26-53	10.0	10-9-70	-0.1
29ddc1	2,576	27.7	10-27-53	27.8	10-8-70	-.1
3N-1E- 5aab2	2,616	6.3	9-24-53	4.8	10-7-70	+1.5
10baa1	2,650	5.0	9-18-53	6.0	10-7-70	-1.0
19cdd1	2,675	41.5	9-23-53	43.1	10-8-70	-1.6
20aba1	2,650	11.1	9-23-53	10.0	10-8-70	+1.1
36ada2	2,821	116.3	9-21-53	112.2	10-8-70	+4.1
3N-2E- 25bbb1	2,746	8.9	11- 9-53	4.2	10-7-70	+4.7
2N-2W- 1aaa1	2,542	16.1	11-19-53	15.0	10-8-70	+1.1
3ddc1	2,515	6.6	11-19-53	6.2	10-8-70	+.4
4ada1	2,519	14.4	11-19-53	12.5	10-8-70	+1.9
17cbc1	2,555	36.0	12- 1-53	34.0	10-8-70	+2.0
23cbb1	2,655	113.2	11-27-53	107.6	10-8-70	+5.6
2N-1W- 4dda1	2,614	34.3	10-12-53	33.4	10-8-70	+.9
6ddd1	2,574	22.9	7-14-53	21.5	10-8-70	+1.4
7bbc1	2,548	6.6	8-19-53	8.2	10-8-70	-1.6
23acc1	2,691	70.0	10- 8-53	66.2	10-8-70	+3:8

[1]In feet, above mean sea level.

[2]In feet, below land surface.

Table 4

Standard Chemical Analyses of Ground-Water from Selected Wells in the Boise-Nampa Area

(Chemical constituents in milligrams per liter.)

Analyses by U. S. Geological Survey

Well Number	Date of Collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Specific Conductance (micromhos at 25° C)	Percent Sodium	Sodium-Adsorption-Ratio (SAR)	pH
Comparison of 1970 and 1953 analyses																		
3N-2W-21bab1	8-13-70	46	0.37	61	16	58	5.5	275	80	21	0.5	11	438	218	652	36	1.6	7.9
	7-14-53	-	-	74	28	65	5.0	263	125	41	-	-	-	-	821	32	1.7	7.6
3N-1E-19cdd1	8-21-70	35	.37	93	18	96	4.0	255	230	47	.3	12	667	306	967	40	2.4	8.0
	7-13-53	-	-	74	16	46	4.0	153	148	41	-	-	-	-	679	28	1.3	7.4
3N-2E-25bbb1	8-13-70	19	.20	22	4.6	6.6	2.0	95	9.0	1.0	.3	6.5	117	74	173	16	.3	7.0
	11-10-53	22	-	25	8.6	-8.7-		118	12	3.0	-	4.0	142	98	208	16	.4	7.1
Additional 1970 analyses																		
4N-2W-12cbc1	8-13-70	25	0.76	17	2.5	8.4	1.0	83	2.0	0.5	0.3	0.4	98	53	138	25	0.5	7.1
4N-1E- 4bbc1	8-13-70	37	.42	43	7.2	50	3.2	267	15	2.0	.3	9.5	296	137	461	44	1.9	7.7

Table 5

Partial Chemical Analyses of Ground Water from Selected Wells in the Boise-Nampa Area

Analyses by U. S. Geological Survey

Well Number	Date of Collection	Temperature (° C)	Chloride (Cl) (mg/l)	Nitrate (NO_3) (mg/l)	Phosphate (PO_4) (mg/l)	Specific Conductance (micromhos at 25° C)	pH	Remarks[1]
Comparison of 1970 and 1953 analyses								
4N-2W- 26cad1	7-14-70	12.3	26	16	0.28	724	-	
	9-15-53	12.8	27	-	-	689	7.3	SAR = 1.39
27dcb1	7-14-70	12.6	15	13	0.59	649	-	
	8-17-53	12.8	25	-	-	776	7.5	SAR = 3.0
35cdd1	7- 8-70	13.3	34	14	-	740	-	
	9-15-53	-	31	-	-	638	7.3	SAR = 1.73
3N-2W- 3dda1	7- 8-70	12.6	21	32	-	836	-	
	9-15-53	12.8	28	-	-	890	7.5	SAR = 3.79
4cbb1	7- 8-70	13.0	9.0	20	-	613	-	
	8-17-53	13.3	12	-	-	804	7.9	SAR = 4.37
8ccd1	7- 8-70	15.5	16	5.9	-	472	-	
	7-13-53	-	22	-	-	471	7.9	SAR = 2.04
3N-1W- 7bbc1	6-30-70	13.6	24	12	-	747	-	
	11-11-53	13.9	41	9.3	-	815	7.4	SAR = 3.24
Additional 1970 analyses								
5N-1W- 33acd1	7-23-70	15.6	3.3	-	-	163	6.8	
34dba2	6-25-70	13.5	7.0	31	-	330	7.0	
35ccc1	6-25-70	14.6	6.0	22	-	370	-	
36abb1	6-25-70	14.8	8.0	5.3	-	414	7.6	
5N-1E- 31aca1	6-25-70	13.8	7.5	6.9	-	336	7.1	
32bdd1	6-25-70	-	8.5	8.7	-	571	7.3	
34dcd1	6-25-70	14.3	13	4.6	-	652	7.1	
4N-2W- 2ddd1	6-25-70	15.8	6.0	2.1	-	259	6.8	
3abc1	7-24-70	15.6	5.8	-	-	216	7.4	
5bad1	6-25-70	14.4	5.0	1.2	-	165	7.1	
8add1	6-25-70	13.7	3.0	1	-	127	7.5	
13bda1	6-25-70	13.0	5.5	.1	-	134	7.1	
19ada1	6-30-70	14.5	3.0	2.1	-	144	-	
21ddc1	6-30-70	13.4	38	7.7	-	775	-	
24ccc1	7-14-70	12.2	4.0	18	.73	543	-	

Table 5 (Cont'd.)

Partial Chemical Analyses of Ground Water from Selected Wells in the Boise-Nampa Area

Well Number	Date of Collection	Temperature (° C)	Chloride (Cl) (mg/l)	Nitrate (NO_3) (mg/l)	Phosphate (PO_4) (mg/l)	Specific Conductance (micromhos at 25° C)	pH	Remarks[1]
4N-2W- 27bba1	6-30-70	12.9	30	11	-	702	-	
29ccb1	6-30-70	13.9	4.0	1.4	-	150	-	
30ddd1	6-30-70	15.5	2.0	1.7	-	135	-	
31dda1	7-14-70	-	22	5.3	0.02	538	-	
33abc1	7-14-70	12.9	10	28	.58	734	-	
34cda1	7-14-70	12.5	15	26	.62	680	-	
36cad1	7- 8-70	12.0	10	22	-	694	-	
4N-1W- 2aab1	7-15-70	14.0	4.0	8.4	.29	547	7.4	
4dda1	6-25-70	16.7	18	9.7	-	422	7.2	
7bcc1	6-25-70	12.8	6.0	1.9	-	220	-	
8dcd1	7-31-70	12.8	4.0	1.7	0	223	-	C
11dcd1	7-14-70	13.0	5	.1	.07	124	-	
12ddb1	6-25-70	13.8	5.5	.2	-	185	7.0	
13ccd1	8- 3-70	12.3	16	9.4	.01	442	-	
15bbb1	7-14-70	13.2	1.0	.2	14	147	7.4	
22dbb1	7-14-70	13.8	25	9.5	.03	638	-	
30cda1	7- 8-70	11.8	2.0	13	-	294	-	
31bdd1	6-26-70	12.3	23	17	-	765	-	
32aaa2	6-26-70	13.2	48	9.2	-	934	-	
34dad1	7-14-70	13.0	14	14	.84	920	-	
4N-1E- 5bcc1	6-25-70	15.2	4.5	8.6	-	226	-	
6bbb1	7-15-70	14.2	2.0	8.2	.40	427	7.6	
8dcb1	7-31-70	13.9	5.0	8.6	.04	361	7.0	C
10bbc1	6-25-70	13.5	5.0	3.7	-	363	-	
10ddd1	7-15-70	15.9	1.0	1.8	.37	236	7.2	
13bdb1	6-26-70	14.2	4.0	3	-	104	-	
21ccc1	7-15-70	13.8	2.0	18	.27	540	-	
23adc1	7-15-70	-	0	.2	0	152	7.2	
24bca1	6-26-70	12.0	4.0	3	-	242	-	
26ddd1	6-26-70	-	18	7.9	-	620	-	
29bbb1	6-26-70	13.6	5.5	11	-	654	-	
31acd1	7-15-70	12.3	2.0	18	0.22	710	-	
32add1	7-15-70	12.4	2.0	15	.57	660	-	
33bbc1	6-26-70	12.2	5.0	36	-	736	-	
34aad1	7-15-70	12.6	2.0	8.8	.77	398	-	P
35dda1	7-31-70	13.5	7.0	-	1.8	590	-	C
36bbb1	7-30-70	13.7	3.0	9.2	.06	634	-	C

Table 5 (Cont'd.)

Partial Chemical Analyses of Ground Water from Selected Wells in the Boise-Nampa Area

Well Number	Date of Collection	Temperature (° C)	Chloride (Cl) (mg/l)	Nitrate (NO_3) (mg/l)	Phosphate (PO_4) (mg/l)	Specific Conductance (micromhos at 25° C)	pH	Remarks[1]
4N-2E - 28ccb1	7-16-70	14.8	6.5	23	98	493	-	
29acc1	8- 3-70	14.3	9.5	13	1.4	315	-	
30acb1	7-31-70	12.8	5.5	15	.06	289	7.0	C
32dbd1	7-30-70	13.2	4.0	11	0	252	7.0	C
33cad1	7-30-70	13.6	10	15	60	371	-	C
34bcc1	7-30-70	14.2	13	5.1	.14	484	6.8	C
3N-2W- 7cbc1	7-14-70	17.3	5.0	1.3	.06	232	-	
10acc1	6-30-70	13.4	10	29	-	585	-	P
11cdc1	6-30-70	14.1	16	14	.09	765	-	
12bda1	6-30-70	13.7	20	13	-	725	-	
13cbb1	6-30-70	14.2	13	10	-	834	-	
14ccd1	7- 8-70	13.6	8.0	16	-	684	-	
15dcd1	7- 8-70	14.2	14	12	-	701	-	
17ccb1	7-14-70	14.2	18	20	03	778	-	
18bac1	7- 8-70	15.3	31	10	-	638	-	
19aad1	7- 8-70	15.1	29	17	-	717	-	
22cca1	7-31-70	15.7	27	8.6	.01	930	-	C
23dba1	6-30-70	14.5	11	16	-	720	-	
24bad1	6-30-70	14.8	38	9.9	-	855	-	
25bbb1	6-30-70	15.1	29	38	-	541	-	
26baa1	7-31-70	14.8	17	19	.04	839	-	
29bcd1	6-30-70	15.6	28	13	-	741	-	
30baa1	7-14-70	15.7	5.0	1.8	.05	251	-	
3N-1E- 7cba1	7-31-70	13.4	22	13	0.01	882	-	C, P
8dcd1	7- 1-70	13.6	2.5	2.8	-	812	-	
9baa1	7-15-70	13.3	5.0	3.7	.34	598	-	
10baa1	7-31-70	11.8	5.5	8.3	47	495	-	
12ada1	7-30-70	13.3	12	14	.59	621	-	C
13ccc1	7- 1-70	13.7	14	4.4	-	816	-	
14cbc1	7-15-70	13.0	5.0	6.3	.10	762	-	
15aac1	7- 1-70	13.2	38	3.3	-	800	-	
16ddb1	7-31-70	13.6	1.0	1.4	.02	125	-	C
17dda1	7- 1-70	12.4	10	5.5	-	1,080	-	
18daa1	7-15-70	13.0	8.0	3.7	.18	780	-	
20aba1	7-15-70	13.4	3.0	7.1	.28	560	-	
21cdd1	7- 1-70	13.2	21	9.4	-	918	-	
22ccc1	7- 1-70	13.3	10	15	-	804	-	
23dab1	7-31-70	12.9	33	58	.13	676	-	C

Table 5 (Cont'd)

Partial Chemical Analyses of Ground Water from Selected Wells in the Boise-Nampa Area

Well Number		Date of Collection	Temperature (° C)	Chloride (Cl) (mg/l)	Nitrate (NO_3) (Mg/l)	Phosphate (PO_4) (mg/l)	Specific Conductance (micromhos at 25° C)	pH	Remarks[1]
3N-1E-	25bbd1	7-15-70	13.2	63	22	0	1,210	-	
	26bad1	7- 1-70	13.2	42	20	-	540	-	
	27cdd1	7- 1-70	13.9	5.5	4.5	-	496	-	
	28aac1	7- 1-70	13.4	9.0	4.8	-	497	-	
	29cba1	7-15-70	13.5	15	9.3	-	626	-	
	30ddd1	7-15-70	13.1	23	19	-	818	-	
	31cdd1	7- 1-70	15.7	45	6.2	-	842	-	
	32dda1	7- 1-70	13.6	9.0	19	-	553	-	
	34aad1	7-15-70	13.3	4.0	4.2	-	424	-	
	34ccc1	7- 1-70	13.1	11	7.3	-	696	-	
3N-2E-	3cca1	7-30-70	16.8	8.0	16	.02	379	-	C
	3dda1	6-26-70	15.8	12	12	-	457	7.0	
	4aac1	7-30-70	14.3	8.0	18	.31	326	6.8	C
	5abb1	8- 3-70	12.6	6.0	.2	0	218	-	
	6aad1	7-30-70	13.6	9.0	15	.07	520	-	C
3N-2W-	32aba1	6-30-70	12.8	13	14	-	743	-	
	33cad1	7-31-70	13.4	8.0	15	0.01	667	-	
	34cda1	6-30-70	15.8	14	19	-	961	-	
	35cdd1	7-31-70	14.1	18	22	.01	740	-	
	36cdc1	6-30-70	14.8	45	14	-	1,010	-	
3N-1W-	2ddd1	7- 8-70	12.7	15	16	-	856	-	
	5baa1	7-14-70	13.2	57	13	.07	1,060	-	
	6ccc1	6-30-70	12.7	14	2.2	-	288	-	
	10bab1	8- 3-70	14.6	4.5	1.0	0	153	-	
	14aaa1	7-16-70	14.0	58	13	.10	837	-	
	14cbb1	7- 1-70	14.2	23	9.3	-	647	-	
	16ddd1	6-30-70	13.9	9.0	5.3	-	684	-	
	17daa1	7-16-70	-	5.0	5.3	.33	507	-	
	18dac1	6-30-70	14.3	22	7.1	-	732	-	
	19cbc1	8- 3-70	13.8	6.0	12	0	686	-	
	20bbb1	7-16-70	14.4	8.0	7.5	-	681	-	
	22cdd1	6-30-70	13.9	36	13	-	979	-	
	24abb1	7- 1-70	14.4	38	14	-	721	-	
	25dad1	7- 1-70	14.3	36	14	-	936	-	
	26aad1	7- 1-70	13.3	20	4.7	-	804	-	
	29ddc1	7- 8-70	13.8	12	21	-	848	-	
	30add1	6-30-70	14.2	8.3	14	-	740	-	

Table 5 (Cont'd.)

Partial Chemical Analyses of Ground Water from Selected Wells in the Boise-Nampa Area

Well Number	Date of Collection	Temperature (° C)	Chloride (Cl) (mg/l)	Nitrate (NO_3) (mg/l)	Phosphate (PO_4) (mg/l)	Specific Conductance (micromhos at 25° C)	pH	Remarks[1]
3N-1W- 31dda1	7-16-70	15.7	47	16	.15	979	-	
34acb1	7- 1-70	15.0	42	2.8	-	817	-	
35ccb1	7-16-70	15.4	42	1.6	.02	730	-	
36dba1	7-16-70	-	32	0	-	612	-	
3N-1E- 2aba1	7-30-70	11.4	14	16	.63	634	-	C
3bba1	6-26-70	13.2	8.0	10	-	663	-	
4bba1	7-15-70	12.3	4.0	13	.64	645	-	
6ddd1	7-31-70	12.6	14	15	0	769	-	C
3N-2E- 7aba1	7-30-70	-	3.0	4.5	0.26	394	-	
8adc1	7-30-70	16.0	19	7.0	0	595	-	C
11cbd1	7-29-70	14.4	4.0	7.0	0	304	-	C
14bac1	7-29-70	11.9	2.3	3.1	0	114	6.7	C
15bdb1	7-29-70	13.6	10	12	0	434	-	C
16dbb1	7-30-70	14.3	17	31	0	491	-	C
17caa1	7-29-70	14.2	11	15	.57	636	-	C
18bdc1	7-30-70	14.8	52	30	0	1,010	-	C, P
20dbd1	7-29-70	11.7	2.0	.8	0	130	-	C
23ada1	7-29-70	13.9	2.0	6.9	.01	135	-	C
27abd1	7-29-70	12.2	16	30	1.2	926	-	C
30cbc1	7- 1-70	12.3	16	5.9	-	455	-	
3N-3E- 30bcb1	7-29-70	15.2	4.0	2.1	.01	242	-	C
2N-2E- 2cac1	7-14-70	14.8	20	2.6	.09	793	-	
5aba1	6-30-70	16.7	46	9.0	-	616	-	
9bdd1	7- 6-70	14.4	26	17	-	929	-	
10caa1	7- 6-70	17.4	31	16	-	864	-	
11cba1	7-14-70	-	16	16	.07	756	-	
12aab1	7-14-70	13.4	11	18	.03	780	-	
14bbb1	7-14-70	15.5	20	16	.04	770	-	
17cbc1	7-14-70	13.3	15	27	-	687	-	
20cbb1	7-14-70	-	24	29	.11	1,030	-	
28ddd1	7- 6-70	17.6	42	8.9	-	971	-	
29bcc1	7- 8-70	18.2	28	.1	-	679	-	P
32cdb1	7- 8-70	16.4	13	3.7	-	309	-	
2N-1W- 1abd1	7- 2-70	15.1	22	15	-	702	-	
2bba1	7- 6-70	15.5	6.0	13	-	921	-	
4dda1	7- 6-70	14.9	50	16	-	1,010	-	P
5ddc1	8- 3-70	14.8	18	19	0	666	-	
6ddd1	7- 6-70	13.7	47	14	-	891	-	

Table 5 (Cont'd.)

Partial Chemical Analyses of Ground Water from Selected Wells in the Boise-Nampa Area

Well Number	Date of Collection	Temperature (° C)	Chloride (Cl) (mg/l)	Nitrate (NO_3) (mg/l)	Phosphate (PO_4) (mg/l)	Specific Conductance (micromhos at 25° C)	pH	Remarks[1]
2N-1W-11abd1	7- 6-70	15.3	56	17	-	1,090	-	
13bab1	8- 3-70	13.0	10	8.7	0	760	-	
15adc1	7- 2-70	14.3	6.0	20	-	796	-	
23acc1	7- 2-70	15.1	17	13	-	800	-	
33cca1	7- 2-70	16.3	11	2.3	-	299	-	
2N-1E- 3cdd1	7- 2-70	13.2	8.0	11	-	822	-	
7aab1	7- 2-70	14.2	26	9.8	-	942	-	
8acc1	7- 2-70	16.8	36	16	-	855	-	
9cad1	7- 2-70	17.5	41	12	-	670	-	
10ccd1	7- 2-70	15.1	10	5.5	-	525	-	
15cbc1	7- 2-70	14.5	28	13	-	812	-	
19dad1	7- 2-70	13.5	4.0	16	-	584	-	
28bbc1	7- 2-70	13.7	0	6.8	-	290	-	
33cac1	7- 2-70	15.3	11	14	-	656	-	

[1]SAR, sodium-adsorption-ratio; P, pesticide analysis, C, fecal coliform test

Table 6

Summary of Chemical Analyses for Wells Sampled in 1970

Parameter	Number of Samples	Range		Median
		Low	High	
Temperature (° C)	177	11.4	18.2	14.0
Specific conductance (micromhos at 25° C)	191	104	1,210	596
Chloride (mg/l)	191	0	63	16
Nitrate (mg/l)	188	0	58	12
Phosphate (mg/l)	80	0	1.8	.24

According to the results of samples collected and analyzed in 1970, ground water in the shallow aquifers of the Boise-Nampa area is of generally good quality and suitable for most purposes. Generally, the water is within the drinking-water standards established by the U.S. Public Health Service (1962) for the constituents analyzed, although the dissolved-solids content (as estimated from the specific conductance values) commonly exceeded the recommended maximum. In addition, the nitrate concentration of one sample (well 3N-1E-23dab1) exceeded the 45 mg/l limit suggested by the U.S. Public Health Service. Water that is quite hard occurs in several areas and domestic water softeners are used. Also, a small zone having water that is high in iron occurred near secs. 12 and 13, T. 4 N., R. 2 W. Gasoline has been reported in water from shallow wells near the SW¼ sec. 7, T. 3 N., R. 2 E., but water samples were not taken in this area as part of this study. Generally, there appears to be no definite areal pattern with regard to the distribution of dissolved minerals in the shallow ground waters of the study area.

Water samples from 29 shallow wells situated in highly-urbanized areas and from the New York Canal were collected in 1970 and the water tested for the presence of fecal coliform bacteria. The bacteria level in the New York Canal, the largest single source of recharge to the shallow aquifers, was very low (1 fecal coliform per 100 milliliters of sample), and despite the presence of many septic tanks in the areas sampled, all tests of the well-water samples were negative.

Pesticides are commonly applied directly to agricultural lands and could be leached into the shallow aquifers. Six wells located in agricultural environments were sampled in 1970 and the water tested for the presence of herbicides and insecticides. All six tests indicated that none were present. Although water from the New York Canal was not tested for pesticides as part of this study, samples were taken from the Boise River just above the diversion point for the canal by Bodhaine (1966) in the summer of 1965. Analyses of those samples for pesticides were negative.

The wells from which water was tested for the presence of fecal coliform bacteria and pesticides are indicated in table 5 under "Remarks" by the letter C (coliform) or P (pesticides).

Changes in water quality are best detected by comparing chemical analyses of water samples taken from the same well(s) at different times. As part of this study, three standard and seven partial analyses for wells sampled in 1953 were compared to analyses of samples taken from the same wells in 1970 (tables 4 and 5). In 1953, the specific conductance (an indicator of the amount of dissolved solids in water) of the 10 samples averaged 679 micromhos and chloride concentrations averaged 23 mg/l. In 1970, the specific conductance of water samples from the same 10 wells averaged 657 micromhos and chloride concentrations averaged 21 mg/l.

The preceding data should not be interpreted as indicating a significant change in the quality of the water for several reasons. First, the averages are based on a sampling of only 10 analyses; second, the changes are small enough to be due to error within the measuring instrument or laboratory technique; and third, the data in tables 4 and 5 indicate that both increases and decreases in concentration of dissolved solids were measured over the 17-year period. It is also impractical to try to predict what the change in water quality "should" have been, commensurate with the land- and water-use changes observed over the 1953-70 period. The increased application of irrigation water derived from ground-water sources (table 2) would tend to increase mineral concentrations in the water in the shallow aquifers. On the other hand, the reduced recharge of domestic- and stock-water wastes would tend to decrease those concentrations.

Based on the chemical data presented in tables 4 and 5 and on the above discussion, it seems likely that the quality of water in the shallow aquifers of the Boise-Nampa area either did not change between 1953 and 1970 or the changes were too small or too localized to be detected by the methods used in this study.

CONCLUSIONS

Increased recharge to the shallow aquifers in 1970 as compared to 1953 would be expected to produce correspondingly higher water levels. Failure of this study to detect water-level changes is probably due to several reasons: first, the changes that could be expected from the small increase in recharge would, in themselves, be quite small; second, the small increase in recharge was masked by large seasonal changes in recharge and by large year-to-year fluctuations in the surface-water diversion rate; and third, the water table is so near land surface in much of the area that a rise large enough to be detected is prevented by drains and only declines could be detected if the recharge was reduced significantly.

The quality of the water in the shallow aquifers either did not change between 1953 and 1970 or the changes were too small or too localized to be detected by the methods used in this study. In either case, the chemical data collected in 1953 were too few and too localized to provide an adequate base for comparison with data collected in 1970.

If the trends observed over the 1953-70 period continue, it is likely that ground-water withdrawals from the deep aquifer will continue to increase, placing greater emphasis on that aquifer (Glenns Ferry Formation) as a source of water. The increased recharge to the shallow aquifers observed over the 1953-70 period was due primarily to the application of irrigation water on a larger amount of agricultural land. Over the long term, however, the study area will experience a reduction in agricultural acreage as land is taken out of production to make room for new urban development. This will result in a long-term reduction in the amount of recharge to the shallow aquifers. As municipal sewer systems become available to the expanding urban areas, recharge to the shallow aquifers will be further reduced. The effects of these changes on the quality of water in the shallow aquifers cannot be predicted at this time.

RECOMMENDATIONS

The collection of data for this report was aimed solely at meeting the five objectives stated on page 3. Although the stated objectives are of relatively narrow scope, it became evident during the progress of the study that several facets of the hydrology in the Boise-Nampa area would need additional or continuing study.

The collection of water-level data through the use of selected observation wells should continue in the Boise-Nampa area at the present level of intensity. The wells in this area that had been measured periodically as a part of the statewide observation-well network and that have a relatively short length of record should be reevaluated and compared with wells that were inventoried and measured as part of this project. Many of the project wells are more accessible, in more desirable locations, and much easier to measure than some of the network wells used for observation purposes.

A ground-water sampling program should be initiated to monitor the quality of water in the shallow aquifers. Land- and water-use changes that will occur in the future will almost certainly have an impact on the water quality. Six wells in the project area should be sampled twice a year (spring and fall) and the waters analyzed for temperature and specific conductance, the concentrations of chloride, nitrate, and phosphate, and the presence of fecal coliform bacteria. Suggested observation wells include 4N-2W-12cbc1, 4N-2W-31dda1, 4N-1E-8dcb1, 3N-1W-14cbb1, 3N-1E-13ccc1, and 2N-2W-2cac1. The proposed program should be implemented as soon as possible before significant water-quality changes occur.

A detailed hydrologic study of the deep aquifer (Glenns Ferry Formation) should be made with emphasis on the part of the aquifer that lies beneath the lowlands of Boise Valley. Correlation of hydrologic and geologic data then could be made with the findings of Mohammad (1970) in his study of the Glenns Ferry Formation in the Boise front. As pointed out under "Conclusions," present trends suggest that increasing reliance is being placed on the deep aquifer as a source of water. Sufficient hydrologic information should be collected to aid in planning for the best management of the resource and to provide some understanding of the relation of the deep aquifer to the shallow aquifers.

A detailed study of seepage gains and losses should be made of the Boise River between Lucky Peak Dam and the Snake River. Seepage gains in the lower reaches of Boise River are known to be large, especially during the irrigation season. There is reason to believe that the upper reach of the river (between Lucky Peak and Barber dams) is losing water to the ground. A quantitative study of these gains and losses would help in assessing the role of the river in the hydrology of the valley.

At some point in the future, another comparison study should be made, using this report as a base, to assess the hydrologic impact of additional land- and water-use changes. The time to start the proposed study could be dictated by changes in water levels and (or) water quality observed in the monitoring networks.

SELECTED REFERENCES

Bodhaine, G. L., 1966, Pesticides in the Boise River basin: U. S. Geol. Survey open-file report, 23 p.

Boise Project Board of Control, 1953, Annual report of the Boise Project Board of Control: 132 p.

Chemerys, J. C., 1967, Effects of urban development on quality of ground water, Raleigh, North Carolina: U. S. Geol. Survey Prof. Paper 575-B, p. B212-B216.

Fenneman, N. M., 1931, Physiography of Western United States: New York, McGraw-Hill Book Co., 534 p.

Hem, J. D. 1970, Study and interpretation of the chemical characteristics of natural water, 2nd ed.: U. S. Geol. Survey Water-Supply Paper 1473, p. 180-187.

Idaho State Tax Commission, 1953, Annual report of the State Tax Commission of the State of Idaho: p. 13.

Karn, E. B., 1953, Water distribution of Boise River, District No. 12-A: Boise, Idaho, 15 p., 26 charts

Lewis, G. C., 1959, Water-quality study in the Boise Valley: Idaho Agr. Expt. Sta. Bull. 316, 27 p.

Lindgren, Waldemar, 1898, Description of the Boise Quadrangle, Idaho: U. S. Geol. Survey Geol. Atlas, Folio 45.

Lindgren, Waldemar, and Drake, N. G., 1904, Description of the Nampa Quadrangle, Idaho-Oregon: U. S. Geol. Survey Geol. Atlas, Folio 103.

Malde, H. E., and Powers, H. A., 1962, Upper Cenozoic stratigraphy of western Snake River Plain, Idaho: Geol. Soc. America Bull., v. 73, no. 10, p. 1197-1220.

Mohammad, O. M. J., 1970, Hydrogeology of the Boise Ridge area: Univ. of Idaho (Moscow, Idaho), unpublished thesis (M.S.), 66 p.

Musselman, D. L., 1970, Water distribution of Boise River, District No. 63: Boise, Idaho, 13 p., 27 charts.

Nace, R. L., West, S. W., and Mower, R. W., 1957, Feasibility of ground-water features of the alternate plan for the Mountain Home Project, Idaho: U. S. Geol. Survey

Water-Supply Paper 1376, 121 p.

Perlmutter, N. M., Lieber, Maxim, and Frauenthal, H. L., 1964, Contamination of ground water by detergents in a suburban environment - South Farmingdale area, Long Island, New York: U. S. Geol. Survey Prof. Paper 501-C, p. C170-C175.

Ralston, D. R., and Chapman, S. L., 1970, Ground-water resource of southern Ada and western Elmore Counties, Idaho: Idaho Dept. Reclamation Water Inf. Bull. no. 15, 52 p.

Savage, C. N., 1958, Geology and mineral resources of Ada and Canyon Counties: Idaho Bur. Mines and Geology County Report no. 3, 94 p.

Savini, John, and Kammerer, J. C., 1961, Urban growth and the water regimen: U. S. Geol. Survey Water-Supply Paper 1591-A, 43 p.

Stevens, P. R., 1962, Effect of irrigation on ground water in southern Canyon County, Idaho: U. S. Geol. Survey Water-Supply Paper 1585, 71 p.

Stevlingson, J. D., and Everson, D. O., 1968, Spring and fall freezing temperatures in Idaho: Idaho Agr. Expt. Sta. Bull. 494, 19 p.

Stiff, H. A., Jr., 1951, The interpretation of chemical water analysis by means of patterns: Jour. Petroleum Technology Note 84

Sutter, R. J., and Corey, G. L., 1970, Consumptive irrigation requirements for crops in Idaho: Idaho Agr. Expt. Sta. Bull. 516, 97 p.

Toron, Praphat, 1964, Ground water in the Boise area, Idaho: Univ. of Idaho (Moscow, Idaho), unpublished thesis (M.S.), 48 p.

U. S. Bureau of Reclamation, 1966, Southwest Idaho water development project, Idaho: Regional Director's report, Boise, Idaho

U. S. Public Health Service, 1962, Drinking water standards, 1962, U. S. Public Health Service Pub. 956, 61 p.

Wells, G. R., Jeffery, G. C., and Peterson, R. T., 1969, Changes in employment, population, municipal and industrial water requirements, v. 1 of Idaho economic base study for water requirements: Idaho Water Resource Board Planning report no. 2, 131 p.

SELECTED REFERENCES (Cont'd.)

West, S. W., 1955, Ground-water and drainage problems in the Whitney Terrace area, Boise, Idaho: U. S. Geol. Survey open-file report, 25 p.

GLOSSARY

Acre-foot. The volume of liquid required to cover 1 acre to a depth of 1 foot (equal to 325,851 gallons).

Aquifer. A formation, group of formations, or part of a formation that contains sufficient permeable material to yield significant quantities of water to wells and springs.

Artesian well. One in which the water level stands above the top of the aquifer, whether or not the water flows at the land surface.

Coefficient of storage (storage coefficient). The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

Coefficient of transmissibility (transmissivity). The rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient.

Consumptive irrigation requirement. The consumptive use less the contribution by rainfall toward the production of irrigated crops.

Consumptive use. The quantity of water transpired and evaporated from a cropped area, or the normal loss of water from the soil by evaporation and plant transpiration.

Discharge. The processes by which water is removed from the zone of saturation. Also, the quantity of water that is removed from the zone of saturation.

Drawdown. The difference, at a given point, between the static water level and the pumping water level.

Evapotranspiration. Water consumed by evaporation from soil and water surfaces and by plant transpiration.

Freeze. The occurrence of a temperature of 0° C (32° F) or lower in a thermometer shelter approximately 5 feet above ground surface.

Hydrograph. A graph showing elevation of the water table with respect to time.

Perched water. Ground water separated from an underlying body of ground water by unsaturated rock.

Recharge. The processes by which water is added to the zone of saturation. Also, the quantity of water that is added to the zone of saturation.

GLOSSARY (Cont'd.)

Specific capacity. The yield of a well per unit of drawdown, usually expressed in gallons per minute per foot of drawdown.

Water table. The upper surface of a zone of saturation except where that surface is formed by an impermeable body.

Base modified from Idaho Department of Highways County maps.
Topography highly generalized from U.S. Geological Survey maps.

0 1 2 3 4 5 Miles
Contour intervals 100, 200, and 500 feet
Datum is mean sea level

EXPLANATION

Dominant Land Use

Commercial and residential

Residential

Farming and residential

Grazing and unused

Industrial Pumpage
(In acre-feet per year from the deep aquifer)

0-10

10-100

100-1000

1000-10,000

Area served by municipal-water system

Area served by municipal-sewer system

FIGURE 7.--Land-and water-use conditions in 1953, Boise-Nampa area.

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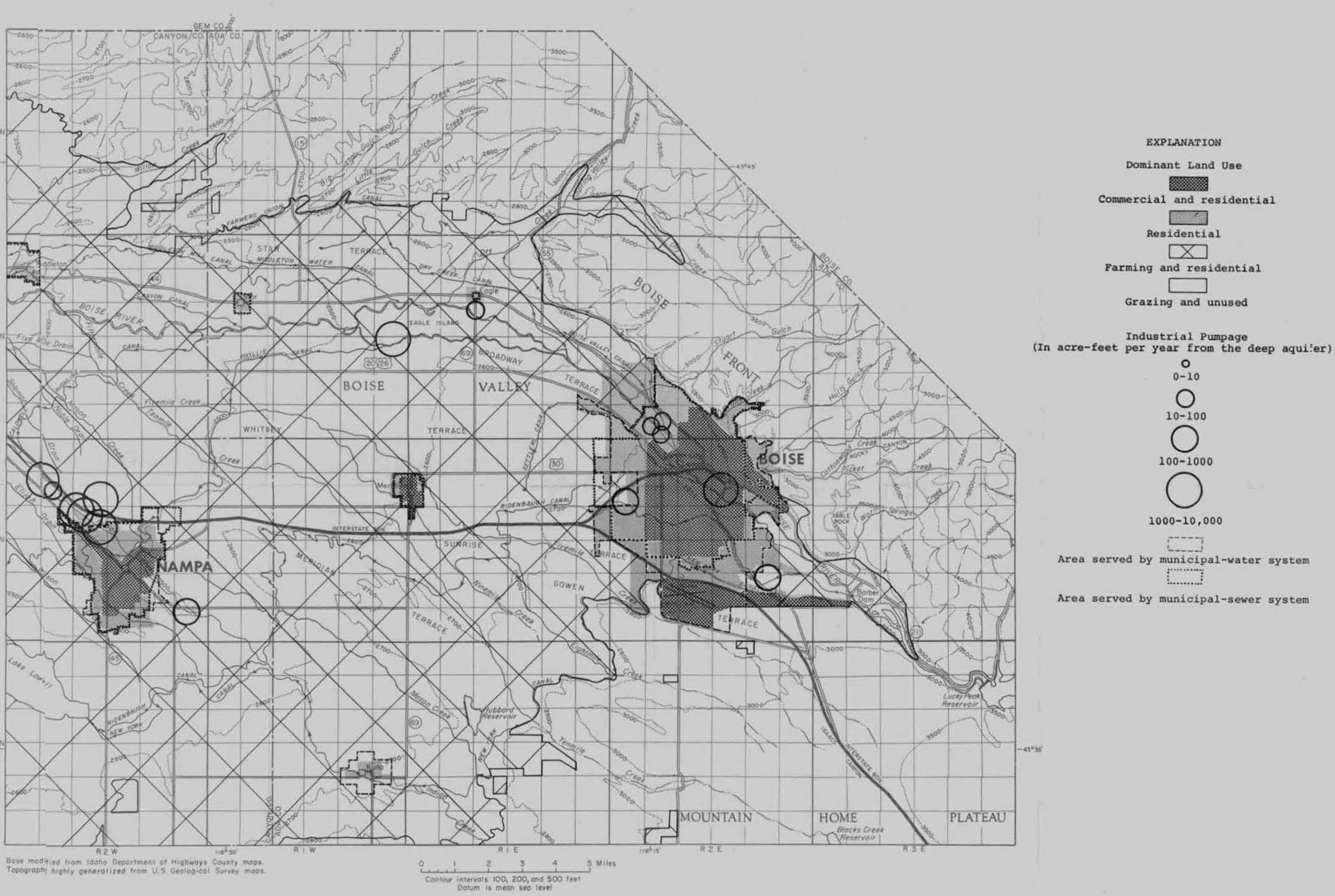

FIGURE 9.--Land-and water-use conditions in 1970, Boise-Nampa area.

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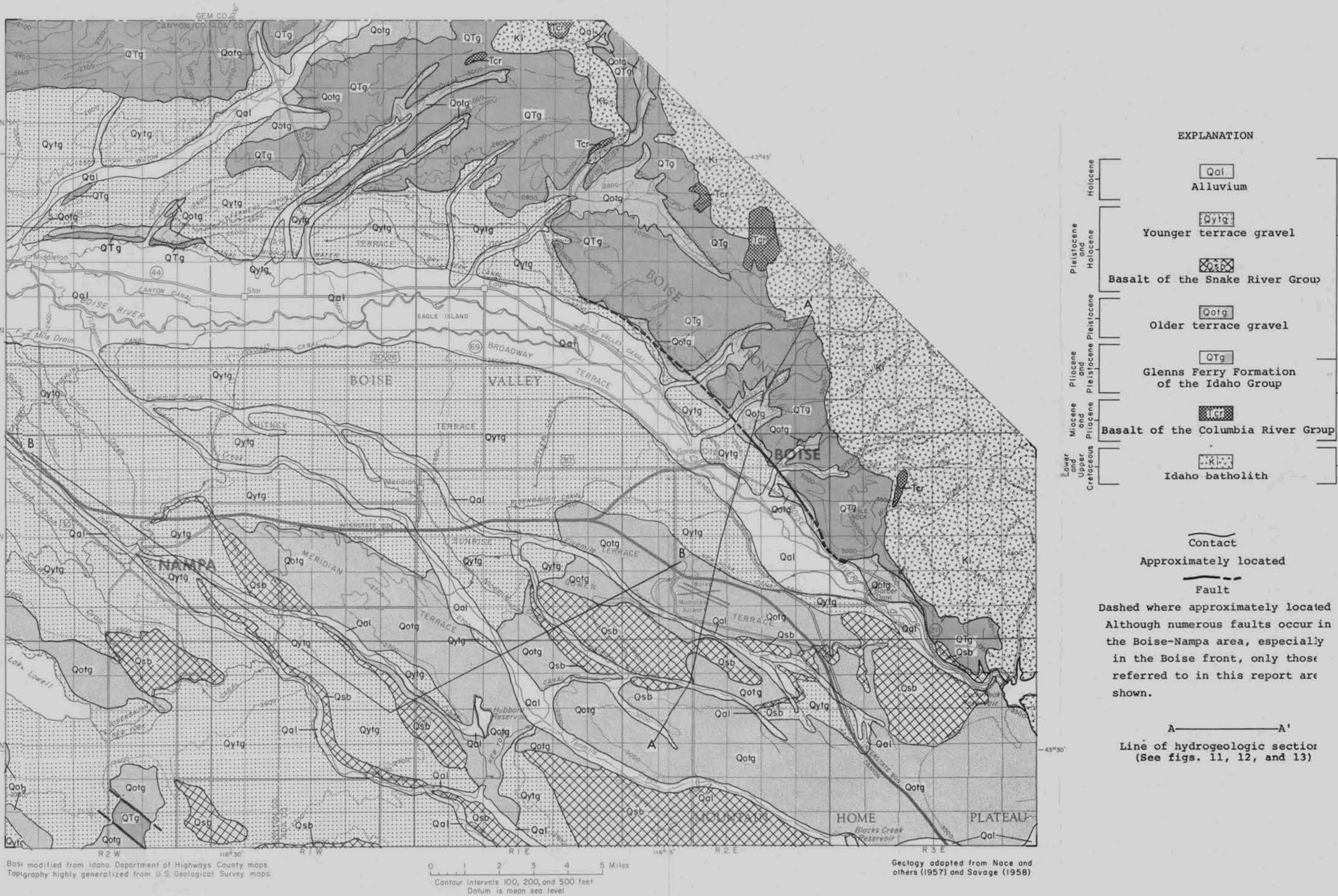

FIGURE 10.-- Generalized geologic map of the Boise-Nampa area.

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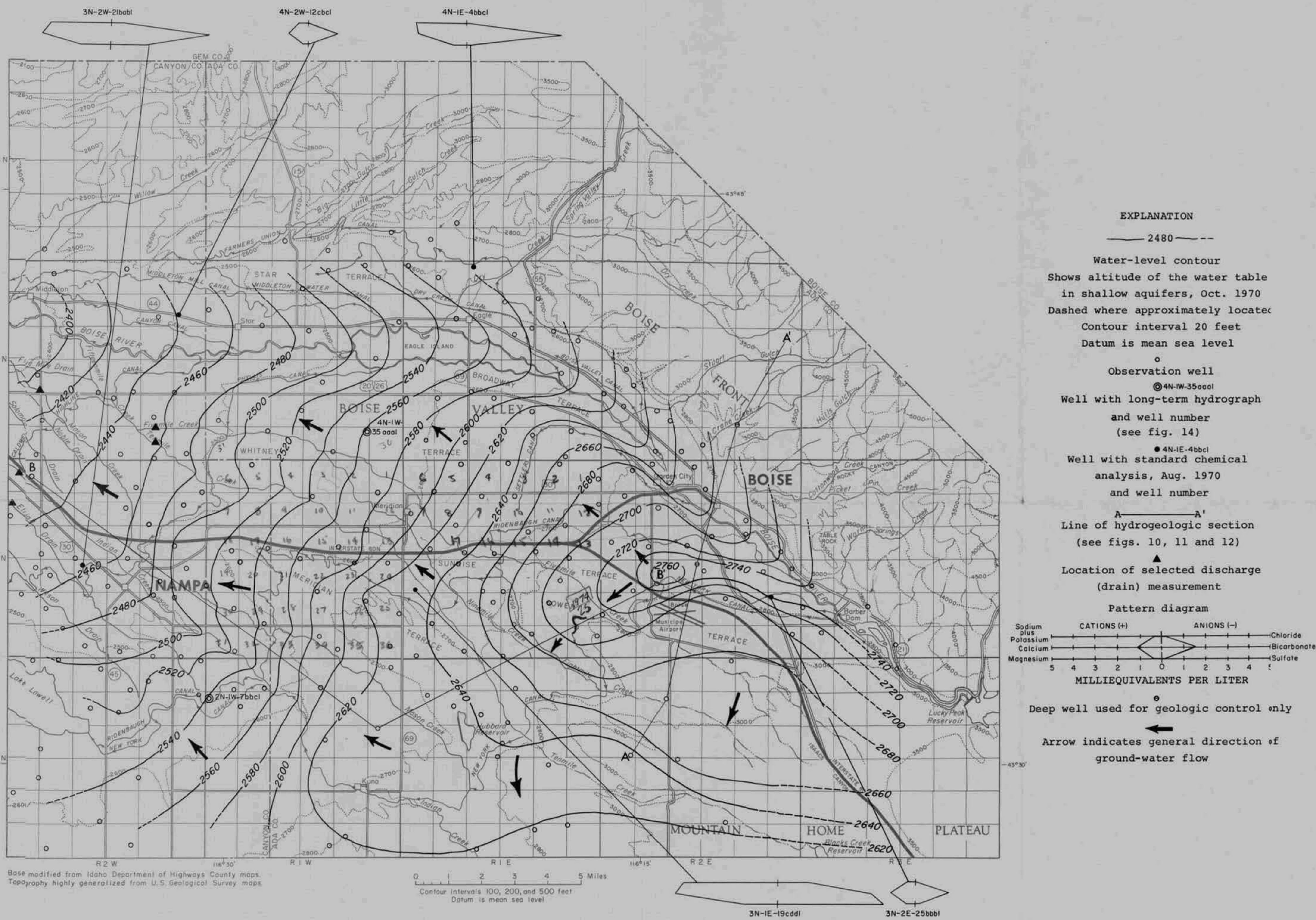

FIGURE 13.--Map of the Boise-Nampa area showing water-level contours, location of selected discharge measurements, chemical character of the ground water, and location of selected observation wells.