UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GROUND-WATER CONDITIONS IN THE EASTERN PART OF MICHAUD FLATS, FORT HALL INDIAN RESERVATION, IDAHO

By Nathan D. Jacobson

Open-File Report 82-570

Prepared in cooperation with the
Shoshone-Bannock Tribes, Fort Hall Indian Reservation

Boise, Idaho
June 1982

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

For the convenience of those who prefer SI (International System of Units) rather than the inch-pound system, conversion factors for terms used in this report are listed below. Constituent concentrations are given in mg/L (milligrams per liter) or µg/L (micrograms per liter), which are equal to parts per million or parts per billion, respectively. Specific conductance is expressed as µmho/cm (micromhos per centimeter at 25 degrees Celsius). Conversion of °C (degrees Celsius) to °F (degrees Fahrenheit) is based on the equation, °F=(°C)(1.8)+32. Water temperatures are reported to the nearest 0.5 degree.

Multiply inch-pound unit	By	To obtain SI unit
acre	4047	square meter
acre-foot (acre-ft)	1233	cubic meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
inch (in.)	25.40	millimeter
foot (ft)	0.3048	meter
foot squared per day (ft^2/d)	0.0929	meter squared per day
gallon per minute (gal/min)	0.06309	liter per second
micromho per centimeter (µmho/cm)	1.000	microsiemens per centimeter
mile (mi)	1.609	kilometer
million gallons per day (Mgal/d)	0.04381	cubic meter per second
square mile (mi^2)	2.590	square kilometer

GROUND-WATER CONDITIONS IN THE EASTERN PART OF MICHAUD FLATS, FORT HALL INDIAN RESERVATION, IDAHO

By
Nathan D. Jacobson

ABSTRACT

The Michaud Flats study area occupies about 20 square miles on the Snake River Plain in southeastern Idaho. Ground-water resources underlying the Flats are substantial and are extensively developed for irrigation and industrial uses. Ground water occurs under both confined and unconfined conditions. The more productive wells are completed in the pediment gravel and the basalt flows of the Big Hole Basalt and Starlight Formation and the sand and gravel of the Sunbeam Formation; the wells are artesian and heads are below land surface. A few shallow domestic wells are completed in the water-table aquifer in the Michaud Gravel.

Historically, high levels of arsenic and other minor elements were observed in water sampled from several wells completed in the shallow aquifer. In most wells and springs sampled during this study, levels of arsenic and other minor elements were within limits recommended by the U.S. Environmental Protection Agency. Heavy metal concentrations were highest in one well completed in the shallow aquifer, and the concentration of arsenic exceeded the recommended limits. There is some evidence that arsenic, as well as several other minor elements, may occur in above-normal levels naturally in local ground waters.

Ground water used for irrigation generally has a low sodium-adsorption ratio and can be used on almost all soils with little danger of developing harmful levels of exchangeable sodium. All the irrigation waters sampled have a medium to high salinity hazard, and caution should be used when applying these waters on poorly drained soils.

INTRODUCTION

This report describes the first of a two-phase study that is being made by the U.S. Geological Survey, in cooperation with the Shoshone-Bannock Tribes of the Fort Hall Indian Reservation. The study was initiated because the ground water, at least in one well in the Michaud Flats area, has been degraded in quality to the point that it is unusable. Tribal water managers are greatly interested in determining the cause and extent of the degradation.

The first phase of study is to describe current geohydrologic and water-quality conditions in the vicinity of a large industrial complex that processes phosphate ores in the eastern Michaud Flats area on and near the Fort Hall Reservation.

The second phase is to evaluate alternative management strategies for controlling or eliminating ground-water contamination in the aquifers that underlie the Flats.

Michaud Flats includes more than 50 mi^2 on the Snake River Plain in eastern Power and northwestern Bannock Counties, Idaho (fig. 1). The Flats are bounded on the north by American Falls Reservoir, on the east by the Portneuf River, on the west by Rock Creek, and on the south by foothills of the Deep Creek Mountains and Bannock Range.

Land-surface altitudes in the area range from more than 4,650 ft NGVD (National Geodetic Vertical Datum of 1929) on the foothills west of Pocatello to less than 4,355 ft NGVD on the Fort Hall Bottoms on the flood plain of the Portneuf and Snake Rivers. All streams that drain the bordering mountains are intermittent and flow northward to the Snake River.

Relatively level farmland characterizes the area. Irrigation water is supplied from wells and canal systems of the Michaud Project and from privately owned wells. Ground-water resources underlying the Flats are substantial and are extensively developed for irrigation and industrial uses.

Descriptions of geohydrology and water quality in this report focus on a 20-mi^2 area, within which is located the industrial complex. The complex comprises two firms. One is a plant that produces dry and liquid fertilizers from phosphate ore and manufactures gypsum and phosphoric acid. The other includes a plant that produces elemental phosphorus.

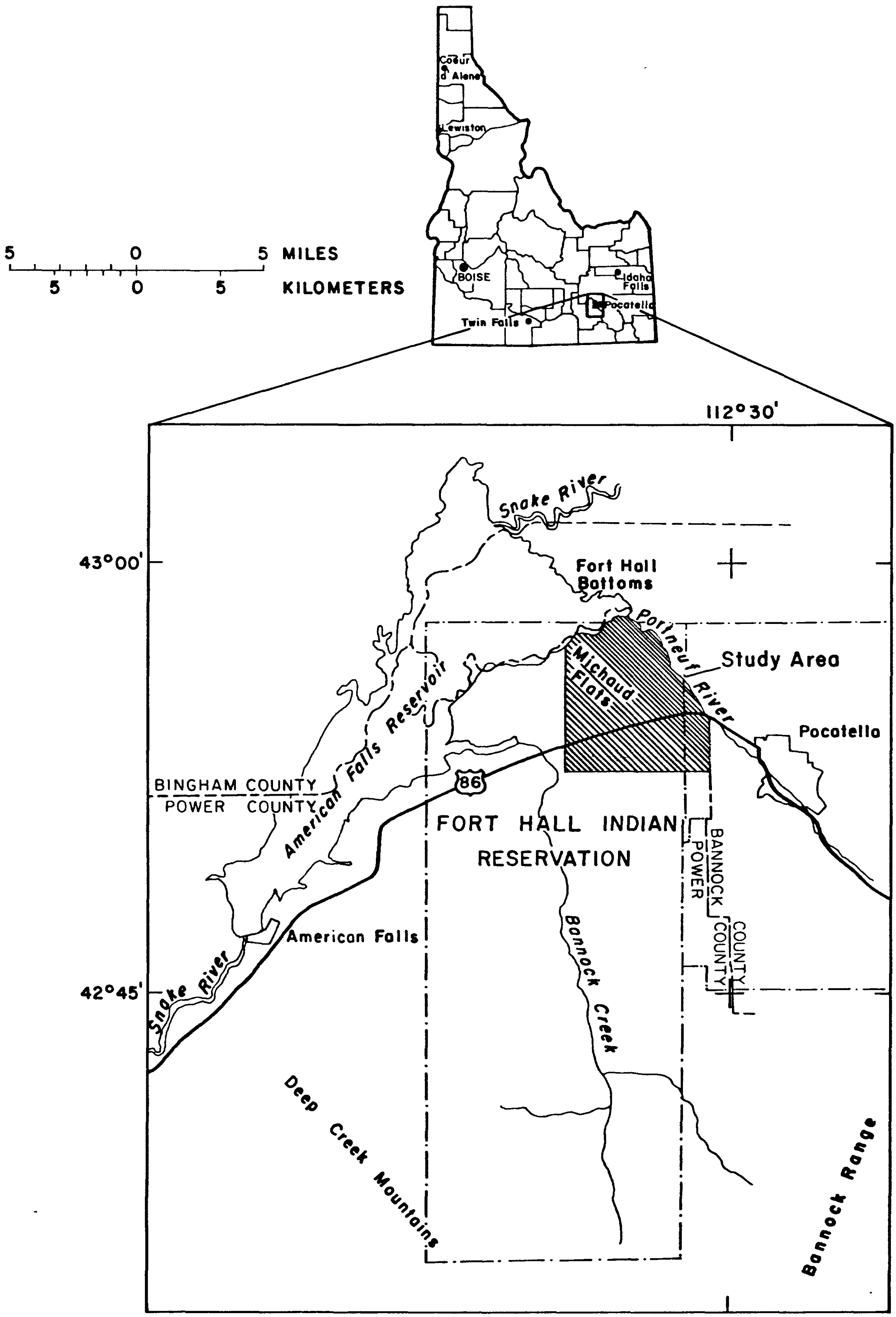


Figure 1.-- Index map of Idaho showing location of study area.

Together, these firms are the single largest users of ground water in the area. In their processing activities, the plants necessarily create large volumes of industrial wastes, which must be disposed.

The fertilizer plant has 213 acres of retention ponds and sludge areas at eight sites. All of the ponds are lined. An impoundment pond receives about 1 Mgal/d of treated waste water, which is distributed as irrigation water to local farmers. The phosphorus plant maintains 22 acres of holding and evaporation ponds. Only two of its ponds (about 10 acres) are unlined. Its other ponds are lined with clay or plastic. About 1.5 Mgal/d of treated water is returned, under permit, to the Portneuf River.

Objectives and Approach

Specific objectives of this phase of the study are to: (1) Describe the geologic framework as related to the ground-water system, (2) describe the classification of soil units, (3) define the occurrence and movement of ground water in the area to arrive at a better understanding of the degree and extent of existing or potential pollution, and (4) periodically sample and analyze water from selected wells and springs in Michaud Flats.

The approach to the study includes: (1) Describing the geologic units and constructing a fence diagram showing the extent of the aquifers and their confining layers, (2) describing the soil units and their engineering properties, (3) constructing a contour map of the potentiometric surface of the aquifer and a hydrograph depicting fluctuation of the water table, and (4) obtaining samples from selected wells and springs for chemical and isotopic analyses.

Acknowledgments

The author expresses gratitude to the Shoshone-Bannock Tribes and Mr. Dwight Tanner, water-quality specialist for the Tribes, for their cooperation in conducting this study. Thanks are also due Mr. John Cochrane and Mr. Paul Evans, J. R. Simplot Company; Mr. C. D. Holmes, FMC Corporation; Mr. John Postlewait, City of Pocatello; Mr. Bob Rowland, Rowlands Dairy; Ms. Flora Goldstein, Idaho State University; employees of the Fort Hall-Michaud Irrigation Project; and the many residents and farmers of Michaud Flats, who supplied information on their wells and allowed access to their property.

Well- and Spring-Numbering System

The numbering system used by the Geological Survey in Idaho indicates the location of wells or springs 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 ¼ section (160-acre tract), the ¼-¼ section (40-acre tract), the ¼-¼-¼ section (10-acre tract), and the serial number of the well within the tract, respectively. Quarter sections are lettered A, B, C, and D in counterclockwise order from the northeast quarter of each section (fig. 2). Within the quarter sections, 40-acre and 10-acre tracts are lettered in the same manner. Well 6S-33E-12DAD1 is in the SE¼NE¼SE¼ sec. 12, T. 6 S., R. 33 E., and is the first well inventoried in that tract. Springs are designated by the letter "S" following the last numeral; for example, 6S-34E-7ACA1S.

GEOLOGIC UNITS AND THEIR WATER-BEARING CHARACTERISTICS

For the purposes of this study, the rocks in the area are grouped into units of Tertiary and Quaternary age. Table 1 gives a generalized description of the geologic units and their water-bearing characteristics. Figure 3 is a fence diagram drawn using drillers' logs of wells and depicts the general geohydrologic conditions in Michaud Flats. The American Falls Lake Beds appear to be continuous and overlie the Sunbeam Formation, with the exception of well 6S-33E-14DCD1. Data are insufficient to determine if the absence of the American Falls Lake Beds in the log for well 6S-33E-14DCD1 indicates the presence of a fault along the southern part of the area or if it is due to the lack of a detailed driller's log from the well. Additional subsurface data are needed to determine whether the Lake Beds are actually absent in the stratigraphic section in this part of the area.

SOIL UNITS AND THEIR ENGINEERING PROPERTIES

Soils in the vicinity of Michaud Flats were mapped by McDole (1977). For the purposes of this study, some soil series are combined and are shown in figure 4. Soils in the study area are either one of two general types; those that are well drained and those that are poorly drained. The well-drained soils occupy the alluvial fans and terraces and are of loam and silt-loam. The poorly drained soils are on the low terraces and along stream bottoms. They are silt-

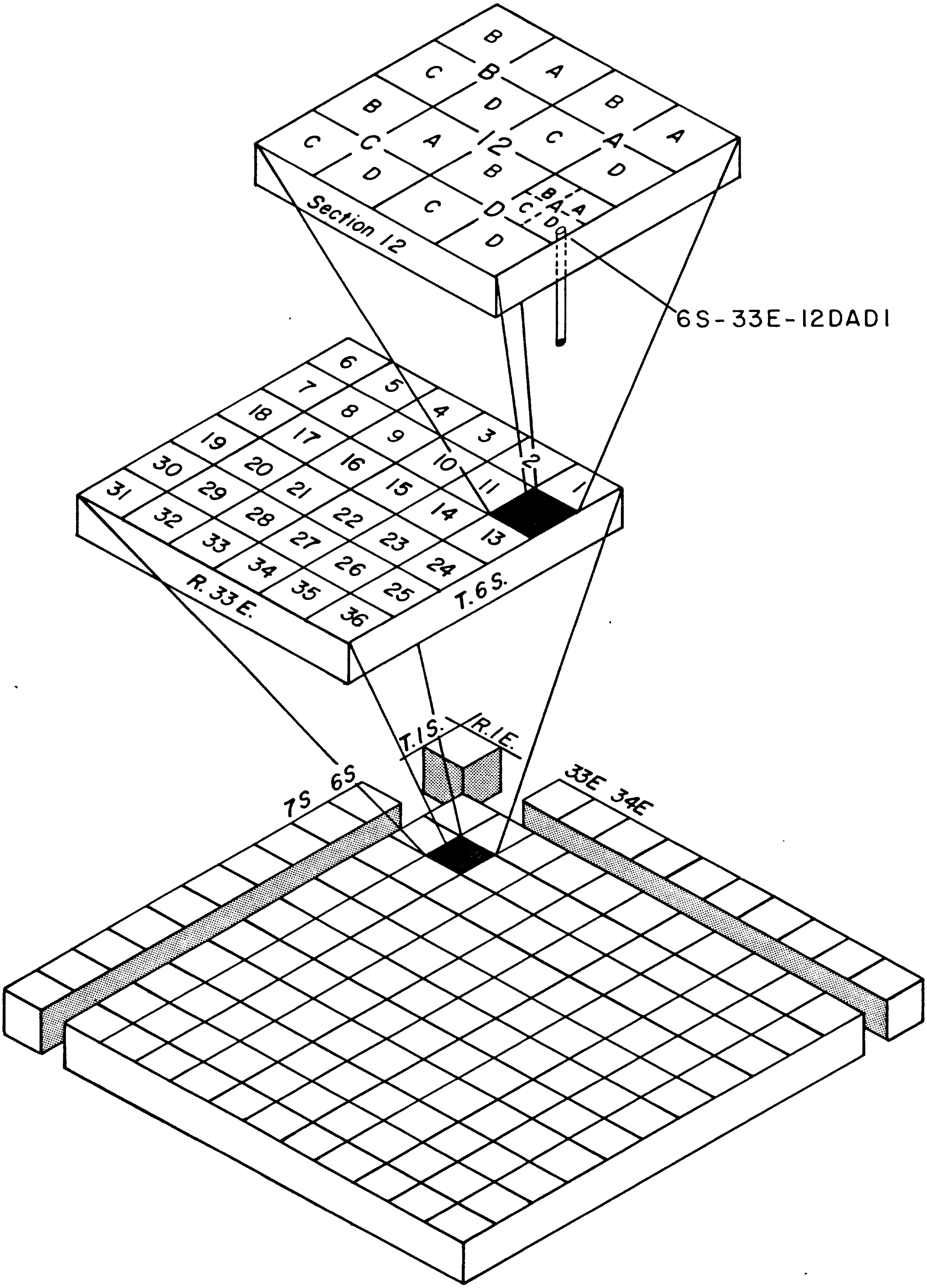


Figure 2.--Well- and spring-numbering system.

Table 1.--Description of geologic units and their water-bearing characteristics

Period	Epoch	Geologic unit	Description	Water-bearing characteristics
Quaternary	Holocene	Alluvium	Surficial deposits of clay, silt, sand, and gravel. Includes some terrace gravels and windblown deposits (loess).	Generally thin and above the zone of saturation. Not important as an aquifer.
	Pleistocene	Michaud Gravel	Flood-plain deposits of sand and gravel, may include some large boulders. Unit is 50 to 80 ft thick.	Locally, contains water under water-table conditions.
		American Falls Lake Beds	Fine-grained deposits consisting mainly of clay and small amounts of sand, sandy silt, and, locally, fine sand. Unit has an average thickness of 80 ft.	Not important as an aquifer; however, is the confining bed for underlying aquifers.
		Sunbeam Formation	Chiefly alluvial and colluvial deposits of silt and interstratified sand and gravel. Most of unit is unbedded to poorly bedded silt containing some fine sand. Sand and gravel occur as lenses. Unit is locally at least 100 ft thick.	Hydraulic conductivity highly variable; generally contains water under confined conditions. Well yields range from a few gallons per minute from clayey beds to several hundred gallons per minute from sand and gravel.
		Big Hole Basalt	Dense blue-gray to blue-black basalt. Locally, basalt may be as much as 170 ft thick.	Hydraulic conductivity is generally high; well yields range from about 500 to 2,000 gal/min. Unit is an important aquifer.
		Pediment gravel	Pediment gravels consisting mainly of quartzite derived from nearby mountains. Near mountain fronts, deposits are a rubble composed mostly of large, angular boulders several feet in diameter. Size and angularity decrease away from mountains. Locally, unit is more than 125 ft thick.	Hydraulic conductivity is generally high; well yields range from about 500 to 2,000 gal/min. Gravels are an important aquifer.
Tertiary	Miocene	Starlight Formation	Mainly bedded rhyolite tuff; locally, contains basaltic lava flows. Maximum thickness is unknown; however, unit is more than 800 ft thick, locally.	Hydraulic conductivity is variable; generally, well yields range from 500 to 2,000 gal/min. Locally, unit is an important aquifer.

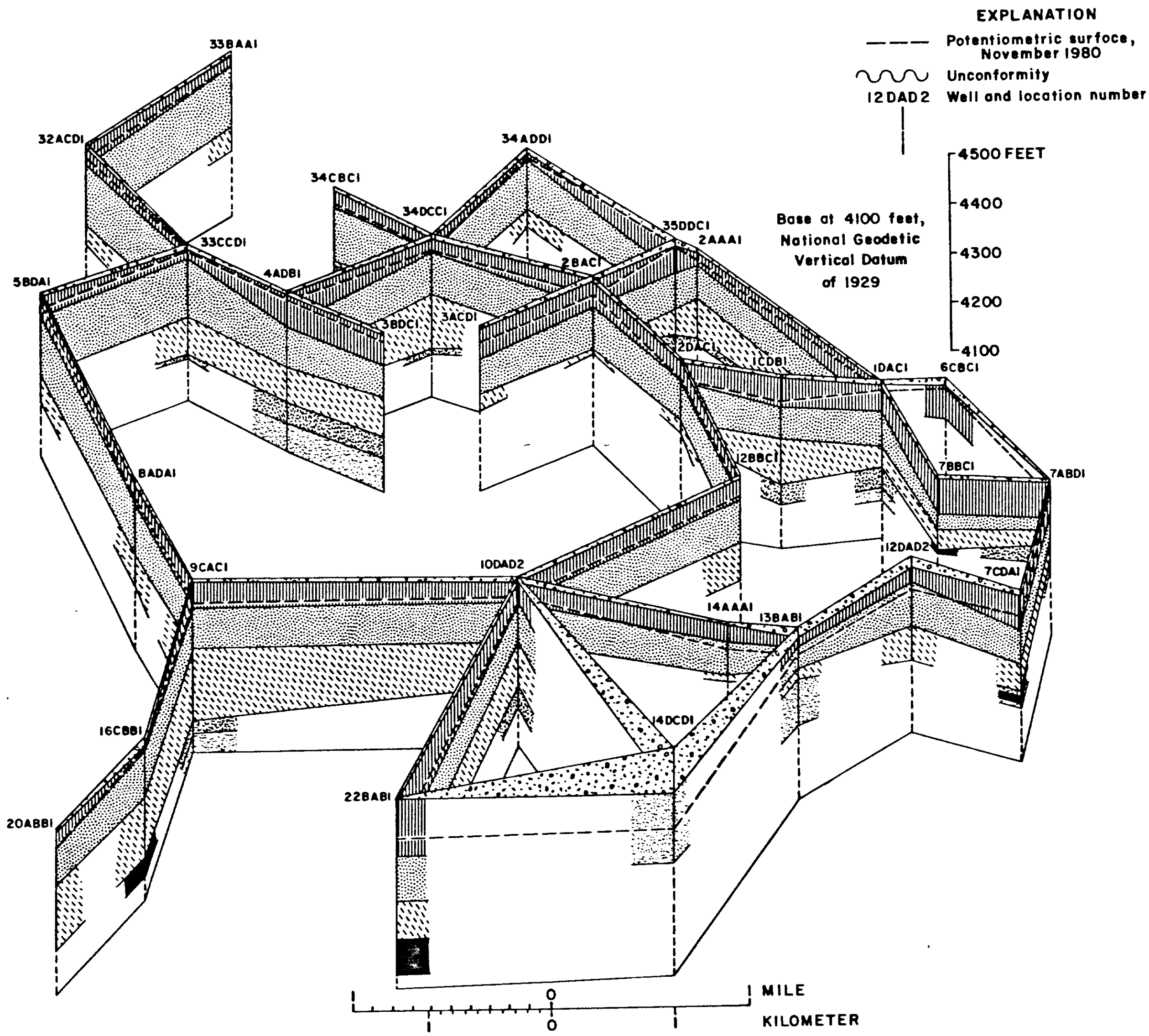
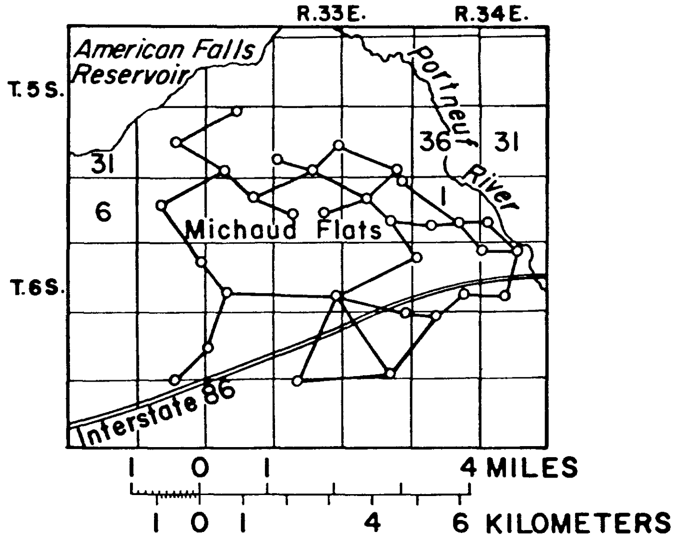


Figure 3.--Geohydrologic

LOCATION OF FENCE DIAGRAM



CORRELATION OF GEOLOGIC UNITS

PERIOD	EPOCH	GEOLOGIC UNITS
QUATERNARY	HOLOCENE	ALLUVIUM
QUATERNARY	LATE PLEISTOCENE	MICHAUD GRAVEL
		AMERICAN FALLS LAKE BEDS
		SUNBEAM FORMATION
		BIG HOLE BASALT
		PEDIMENT GRAVEL
TERTIARY	MIOCENE	STARLIGHT FORMATION

conditions.

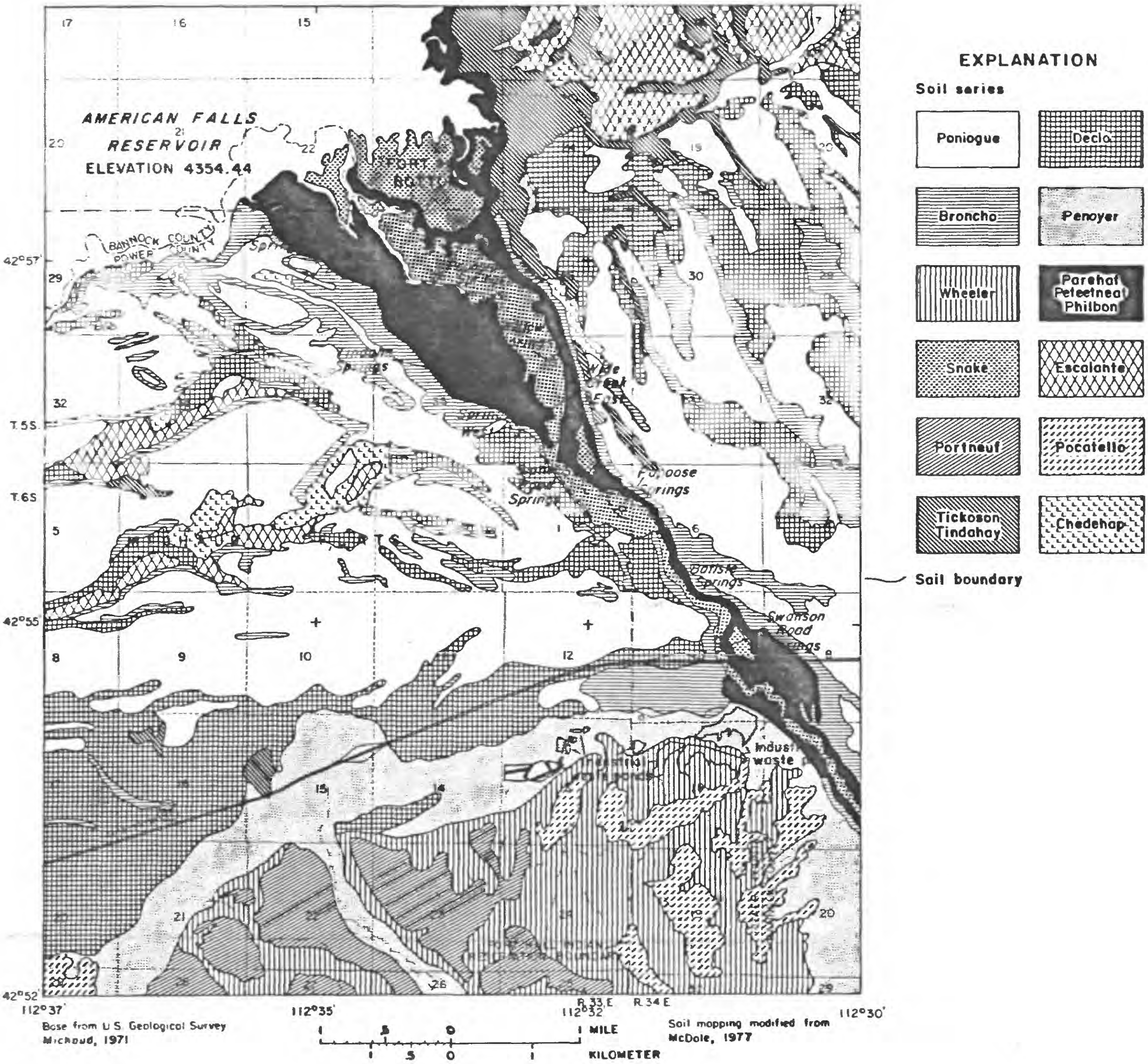


Figure 4.--Soil series.

loam, limy, and alkaline. Generally, hydraulic conductivity is moderate and the available water capacity is high. Other physical properties of the major soil series are shown in table 2, and their generalized features and limitations for agricultural and engineering uses are shown in table 3.

HYDROLOGIC FRAMEWORK

Ground water occurs in virtually every geologic unit in the study area. Water is contained in voids, fractures, joints, and interflow zones in basalt and in interstitial spaces in sand and gravel. The more productive aquifers are the pediment gravel, the basalts of the Big Hole Basalt and Starlight Formation, and the sand and gravel of the Sunbeam Formation.

Ground water occurs under both water-table (unconfined system) and artesian (confined system) conditions. Shallow domestic wells on Michaud Flats generally are completed in the Michaud Gravel and tap water under unconfined conditions. The deep irrigation wells penetrate the confining layers of the American Falls Lake Beds and tap water under artesian conditions. Water levels in wells completed in the different aquifers seem to have similar heads. If the water-table head is greater than the artesian head, water could possibly move downward to the artesian system. Any head difference that might occur between the shallow and deep aquifer systems was not determined because shallow and deep wells completed close together were not available to make comparative measurements.

Several additional wells completed in the unconfined aquifer would allow measurements of head differences between the two systems. These measurements are needed to determine direction of vertical water movement which could occur through the confining beds. Additional wells also would allow better definition of the nature and extent of possible contamination in the unconfined aquifer.

The ground-water system is recharged by infiltration of water from intermittent streams that drain the mountains south of the area, and to a lesser degree, by precipitation, both within the area and on rock outcrops of the Starlight Formation in the foothills south of the Flats. Some recharge occurs as underflow from the Portneuf River above the gage at Topaz, which was reported by Stearns, Crandall, and Steward (1938, p. 139) to be about 50,000 acre-ft/yr. Some recharge also occurs, at least in the shallow aquifer, as percolation of applied irrigation water and leakage from canals. The Michaud Irrigation Project

Table 2.--Major soils series and their physical properties

(Depth to bedrock for all soil series is greater than 5 ft; >, greater than)
[Modified from McDole, 1977]

Soil series	Seasonal high-water table below land surface (ft NGVD)	U.S. Department of Agriculture texture	Liquid limit (percent)	Hydraulic conductivity (in./hr)	Available water capacity of soil (in./in.)	pH	Salinity	Shrink-swell potential	Potential frost action
Broncho--------	>5	Gravelly loam	-----	0.6-2.0	0.14-0.16	7.9-8.4	None	Low	Low.
		Very gravelly coarse sand	-----	>20	.03- .05	8.5-9.0	-do-	-do-	
Chedehap-------	>5	Sandy loam	-----	2.0-6.0	.11- .13	7.4-8.4	-do-	-do-	Moderate.
		Coarse, sandy loam, loamy coarse sand, and sand	-----	6.0-2.0	.08- .10	7.4-8.4	-do-	-do-	
Declo----------	>5	Loam and silt loam	25-35	.6-2.0	.18- .20	7.4-8.4	-do-	-do-	Do.
		Loamy coarse sand and coarse sand	-----	6.0-2.0	.05- .07	7.9-8.4	Low	-do-	
Escalante------	>5	Sandy loam and fine, sandy loam	-----	.6-2.0	.13- .15	7.4-7.8	None	-do-	Do.
Paniogue-------	>5	Loam and silt loam	10-20	.6-2.0	.18- .20	7.4-9.6	-do-	-do-	Low.
		Coarse sand and gravelly coarse sand	-----	>20	.04- .06	8.5-9.0	Low	-do-	
Parehat--------	2-4	Silt loam	20-35	.6-2.0	.18- .20	7.9-9.0	None	-do-	High.
Penoyer--------	>5	Silt loam	20-30	.2- .6	.19- .21	7.9-8.4	-do-	-do-	Moderate.
Peteetneet-----	0	Peat and muck	-----	.6-2.0	.25- .30	6.6-7.3	-do-	-do-	High.
		Light, silty clay loam	35-45	.6-2.0	.18- .20	6.6-8.4	-do-	High	
Philbon--------	0	Peat	-----	.6-2.0	.40- .50	6.6-7.3	-do-	Low	High.
		Mucky silt loam	40-50	.6-2.0	.25- .35	6.6-8.4	-do-	-do-	
Pocatello------	>5	Silt loam	25-35	.6-2.0	.19- .21	7.9-9.6	-do-	-do-	Moderate.
Portneuf-------	>5	Silt loam	20-30	.6-2.0	.19- .21	6.6-9.0	([1])	-do-	Do.
Snake----------	1½-4	Heavy silt loam and silty clay loam	35-50	.06- .2	.19- .21	7.9-9.0	-do-	Moderate	High.
Tickason-------	>5	Stratified loam, silt loam, sandy loam	20-30	.6-2.0	.18- .20	6.6-8.4	-do-	Low	Low.
		Loamy sand	-----	6.0-2.0	.07- .09	7.9-8.4	-do-	-do-	Do.
Tindahay-------	>5	Loamy coarse sand and sandy loam	-----	2.0-6.0	.06- .08	6.6-7.3	-do-	-do-	Do.
		Coarse sand and sand	-----	6.0-2.0	.04- .06	7.4-7.8	-do-	-do-	
Wheeler--------	>5	Silt loam	20-30	.6-2.0	.19- .21	7.4-8.4	-do-	-do-	Moderate.

[1] None to a depth of 24 in., moderate below 24 in.

Table 3.--Features and limitations of soils for agricultural and engineering uses
[Modified from McDole, 1977]

Soil series	Degree and kind of limitation for--					Soil features affecting--				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings without basements	Sanitary landfill (trench type)	Pond Reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions
Broncho	Slight where slope is less than 8 percent: moderate where 8 to 15 percent; severe where more than 15 percent.	Severe: very rapidly permeable in substratum: coarse fragments; slope of more than 7 percent.	Severe: gravelly and cobbly below a depth of 10 to 20 inches; slope where slope is more than 8 percent.	Slight where slope is less than 8 percent; moderate where 8 to 15 percent; severe where more than 15 percent.	Severe: very rapid permeability in substratum: slope, where slope is more than 25 percent.	Moderately permeable to a depth of 10 to 20 inches; very rapid permeability below a depth of 10 to 20 inches; slopes of 2 to 40 percent.	High compacted permeability.	Favorable where slope is less than 4 percent; erodes where slope is more than 4 percent.	Droughty; slopes of more than 4 percent erode.	Droughty; slopes of more than 4 percent erode easily.
Chedehap	Severe: slope hazard.	Severe: moderately rapid permeability; slope, where slope is more than 7 percent.	Slight where slope is less than 8 percent; moderate where 8 to 15 percent; severe where more than 15 percent.	Moderate: frost action; slope, where slope is 8 to 15 percent. Severe where slope is more than 15 percent.	Moderate: frost action; slope, where slope is more than 15 percent.	Moderately rapid permeability; slopes of 0 to 20 percent.	Medium shear strength; piping hazard.	Favorable where slope is less than 2 percent; erosion hazard where slope is more than 2 percent.	Droughty; erosion hazard where slope is more than 2 percent; salt and alkali spots.	Droughty; erodes easily; slope of less than 2 percent; salt and alkali spots.
Declo	Slight where slope is less than 8 percent; moderate where more than 8 percent.	Moderate: moderate permeability: slope, where slope is 2 to 7 percent. Severe where slope is more than 7 percent.	Slight where slope is less than 8 percent; moderate where more than 8 percent.	Moderate: low strength and frost action; slope, where slope is 8 to 15 percent.	Slight-------	Moderately permeable: slopes of 0 to 15 percent.	Medium to low shear strength: piping hazard.	Favorable where slope is less than 2 percent; erosion hazard on steeper slopes.	Favorable where slope is less than 2 percent; erosion hazard on steeper slopes; salt and alkali spots.	Erodes easily where sloping; salt and alkali spots.
Escalante	Slight------	Moderate: moderate permeability; slope, where slope is 2 to 7 percent. Severe where slope is more than 7 percent.	Slight------	Moderate: frost action.	Slight-------	Moderately permeable: slopes of 0 to 8 percent.	Medium shear strength; medium to high piping hazard.	Favorable where slope is less than 2 percent; erosion hazard where slope is more than 4 percent.	Soil blowing hazard; water erosion hazard where slope is more than 2 percent; salt and alkali.	Low precipitation; sloping areas erode easily; salt and alkali.

Table 3.--Features and limitations of soils for agricultural and engineering uses--Continued

Soil series	Degree and kind of limitation for--					Soil features affecting--				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings without basements	Sanitary landfill (trench type)	Pond Reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions
Paniogue	Severe where slope is 0 to 8 percent; moderate where 8 to 12 percent; salt and alkali spots.	Severe; very rapid permeability; slope is more than 7 percent.	Severe: underlying gravel and sand.	Slight where slope is less than 8 percent; moderate where more than 8 percent.	Severe: very rapid permeability.	Moderately permeable soil underlain by sand and gravel; slopes of 0 to 12 percent.	Medium to low strength in upper layers; low to high compacted permeability in lower layers; piping hazard.	Favorable where slope is less than 2 percent; erodibility where slope is more than 2 percent.	Droughty; erodibility where slope is more than 2 percent; salt and alkali spots.	Low precipitation; droughty; erodes easily.
Parehat	Severe: high water table.	Severe: high water table.	Severe: wet.	Moderate: wet.	Severe: wet.	High water table at a depth of 24 to 48 inches.	High piping hazard; medium to low shear strength; hard to pack.	Poor outlets.	Wet; salt and alkali spots.	Wet.
Penoyer	Severe: moderately slow permeability.	Moderate: difficult to compact.	Slight-----	Moderate: low strength.	Slight-----	Slopes of 0 to 4 percent.	Medium to low shear strength; piping hazard; hard to pack.	Favorable where alope is less than 2 percent.	Moderately slow permeability; erodibility where slope is more than 2 percent; salt and alkali spots.	Favorable.
Peteetneet	Severe: high water table.	Severe: high organic-matter content.	Severe: wet.	Severe: wet low strength.	Severe: wet; seepage.	Excess humus; water table at or near surface	Not suitable.	Poor outlets.	Wet.	Wet.
Philbon	Severe: high water table.	Severe: high organic-matter content.	Severe: wet.	Severe: wet low strength.	Severe: wet; seepage.	Excess humus; water table at or near surface.	Not suitable.	Poor outlets.	Wet.	Wet.
Pocatello	Slight where slope is 0 to 8 percent; moderate where 8 to 15 percent; severe where more than 15 percent.	Moderate: moderately permeable; slope, where slope is 2 to 7 percent. Severe where slope is more than 7 percent.	Slight where slope is less than 15 percent; moderate where 15 to 25 percent; severe where more than 25 percent.	Moderate: low strength: slope where slope is 8 to 15 percent. Severe where slope is more than 15 percent.	Slight where slope is less than 15 percent; moderate where 15 to 25 percent; severe where more than 25 percent.	Moderately permeable; slopes of 0 to 30 percent.	High piping hazard; medium to low shear strength; hard to pack.	Favorable where slope is less than 2 percent; erodibility where slope is more than 2 percent.	Favorable where slope is leas than 2 percent; complex slopes are steeper and erode easily.	Short complex slopes; erodes easily.

Table 3.--Features and limitations of soils for agricultural and engineering uses--Continued

Soil series	Degree and kind of limitation for--					Soil features affecting--				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings without basements	Sanitary landfill (trench type)	Pond Reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions
Portneuf	Moderate: moderate permeability; slope, where slope is more than 8 percent.	Moderate: moderate permeability; slope, where slope is 2 to 7 percent. Severe where slope is more than 7 percent.	Slight where slope is less than 8 percent; moderate where 8 to 12 percent.	Moderate: low strength; slope, where slope is more than 8 percent.	Slight------	Moderately permeable; slopes of 0 to 12 percent.	High piping hazard; medium to low shear strength; hard to pack.	Favorable where slope is less than 2 percent; complex slopes; erodes easily.	Favorable where slope is less than 2 percent; complex slopes; erodes easily.	Short complex slopes; erodes easily.
Snake	Severe: high water table.	Severe: high water table.	Severe: wet	Moderate: high water table.	Moderate: wet.	High water table at a depth of 30 to 48 inches.	Medium to low shear strength; hard to pack.	Poor outlets; slowly permeable.	Wet.	Not needed.
Tickason	Slight where slope is 0 to 8 percent; moderate where 8 to 12 percent.	Moderate: moderately permeable; slope, where slope is 2 to 7 percent. Severe where slope is more than 7 percent.	Slight where slope is 0 to 8 percent; moderate where 8 to 12 percent.	Moderate: low strength; slope, where slope is more than 8 to 12 percent.	Slight-----	Moderately permeable; slopes of 0 to 12 percent.	Medium to low shear strength; medium compressibility.	Not needed.	Favorable where slope is less than 2 percent; erodes easily where more than 2 percent.	Low precipitation; erodes easily; slopes of less than 2 percent.
Tindahay	Slight where slope is 0 to 8 percent; moderate where 8 to 15 percent; severe where more than 15 percent.	Severe: moderately rapid permeability; slope, where slope is more than 7 percent.	Severe: cut banks unstable, slope, where slope is more than 15 percent.	Slight where slope is less than 8 percent; moderate where 8 to 15 percent; severe where more than 15 percent.	Moderate: too sandy; slope, where slope is more than 15 percent.	Moderately rapidly permeable; slopes of 0 to 20 percent.	Medium to high piping hazard; medium shear strength; high compacted permeability.	Favorable where slope is less than 2 percent; erodes easily on steeper soils.	Droughty: very high soil blowing hazard.	Droughty: very high soil blowing hazard.
Wheeler	Moderate where slope is 8 to 15 percent; severe where more than 15 percent.	Severe: slope is more than 7 percent.	Moderate where slope is 8 to 15 percent; severe where more than 15 percent.	Moderate: low strength; slope, where slope is less than 15 percent. Severe where slope is more than 15 percent.	Slight where slope is less than 15 percent; moderate where 15 to 25 percent; severe where more than 25 percent.	Moderately permeable; slopes of 8 75 percent.	High piping hazard: medium to low shear strength; hard to pack.	Complex slopes; erodes easily.	Complex slopes; erodes easily.	Short complex slopes; erodes easily.

canal (fig. 5) traverses the study area to distribute water from the Portneuf River to the south and west of Michaud Flats. Average flow in the canal during the irrigation season is 150 ft^3/s. Estimated loss to ground water from the canal is about one-third of its flow, or about 50 ft^3/s (A. Oliver, U.S. Bureau of Indian Affairs, oral commun., 1981).

The general direction of ground-water movement in the artesian system can be inferred from the potentiometric-surface map (fig. 5). Movement is down the hydraulic gradient and roughly perpendicular to the contours, from areas of high head to areas of low head. Direction of movement is to the north and northwest, and in the vicinity of the Portneuf River, to the northeast. The position of the potentiometric surface in spring 1981 is shown in figure 5. Not enough is known about gradients in the water-table aquifer, if a continuous one exists, to determine the direction of ground-water movement. Depth-to-water data in wells are shown in table 4. Over most of Michaud Flats, the potentiometric surface has a flat gradient. Hydraulic gradients range from 1.0 to 5.0 ft/mi. A cone of depression due to pumpage is apparent near the southeastern part of the study area in the vicinity of the industrial plants, where ground water moves toward the pumping wells.

Ground-water discharge from Michaud Flats occurs as spring flow, underflow west out of the area and north to the American Falls Reservoir, seepage into the Portneuf River, and pumpage from wells. Spring discharges are shown in table 5. Goldstein (1981) estimated the total ground-water discharge from Michaud Flats to be 180,000 acre-ft/yr.

A seepage study made in fall 1980 on the Portneuf River below the gage at Pocatello showed a gain of about 560 ft^3/s along the reach. This figure includes about 290 ft^3/s of spring discharge measured in November 1980 (table 5). At the time of the seepage study, the discharge recorded at the nearest gaging station, Portneuf River at Pocatello (13075500) about 7 mi upstream, was 273 ft^3/s. At the beginning of the seepage study reach, discharge was about 260 ft^3/s, and essentially no water is gained or lost in the first 7 mi below the gage. Some of the gain is ground-water discharge from east of the Portneuf River. Ground water from Michaud Flats is probably about half of the measured gain minus spring discharge, or about 140 ft^3/s. Assuming that ground-water discharge is relatively constant year round, on the basis of the seepage measurements, about 427 (290+137) ft^3/s, or 309,000 acre-ft/yr of ground water is discharged from Michaud Flats. Also assuming that annual ground-water pumping is relatively constant,

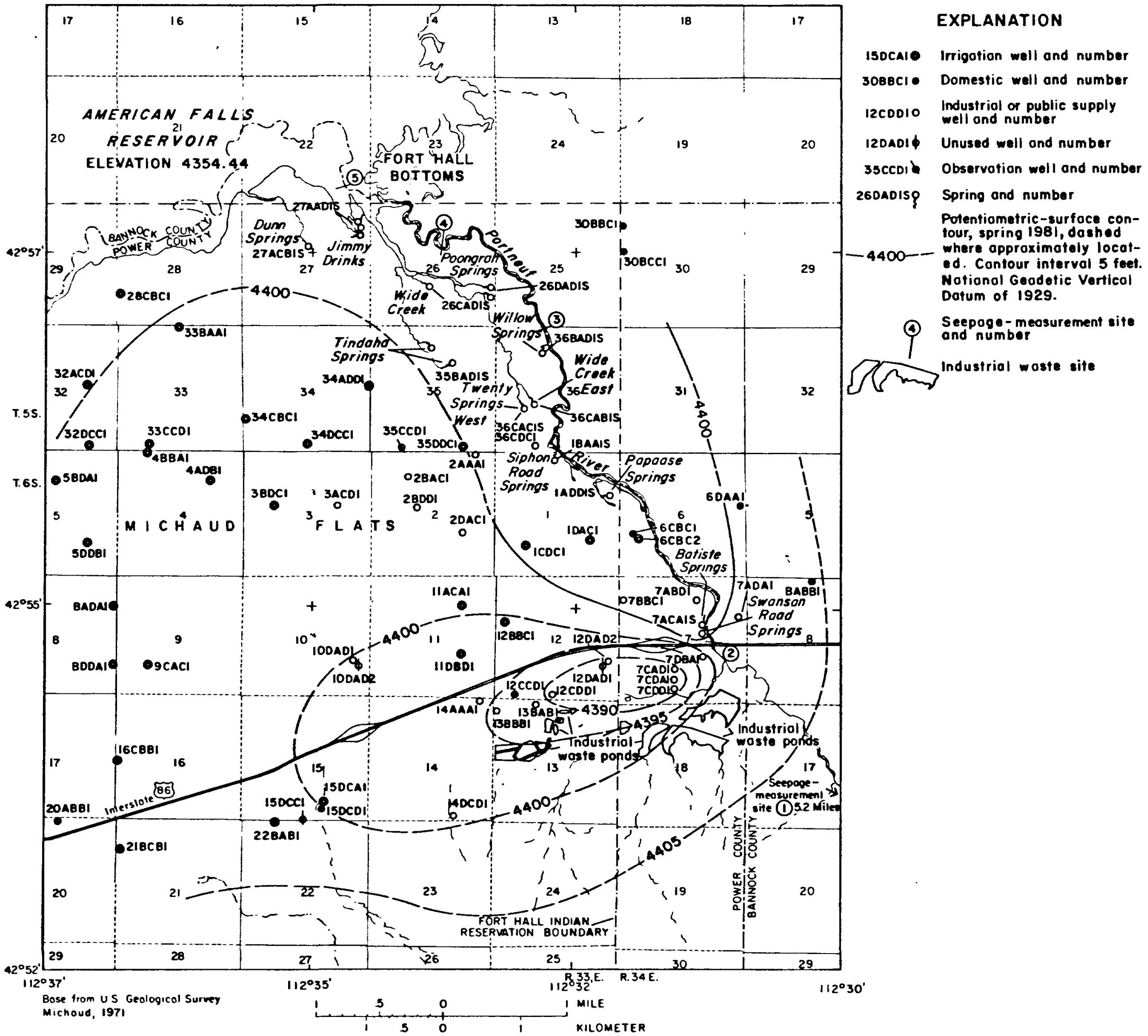


Figure 5.--Potentiometric surface of the artesian aquifer, March 1981, and well and spring locations.

Table 4.--Data from wells

Well No.	Well depth (ft)	Diameter (in.)	Perforated interval (ft)	Altitude[1] (ft)	Depth to water below land surface (ft)	Date measured
5S-33E-28CBC1	210	18	160-205	4,431	34.43	4-12-78
					34.09	3-18-80
					35.29	11-05-80
					35.57	3-17-81
32ACD1	200	18	168-195	4,428	28.15	11- 3-80
					29.98	3-17-81
32DDC1	300	16	150-170	4,413	10.53	11- 3-80
					11.10	3-17-81
33BAA1	200	16	72-192	4,429	28.03	11- 5-80
					28.30	3-17-81
33CCD1	224	16	192-222	4,414	11.49	11- 3-80
					11.94	3-17-81
34ADD1	155	16	130-154	4,414	12.77	4-26-59
					13.26	11- 3-80
					13.90	3-17-81
34CBC1	123	6	-------	4,437	30.90	8-29-52
					33.66	4-26-59
					35.62	3-17-80
					34.88	11- 4-80
					35.39	3-17-81
34DCC1	231	16	185-220	4,430	28.16	11- 3-80
					29.74	3-17-81
35DDC1	260	16	197-260	4,414	12.10	11- 3-80
					13.26	3-17-81
36CDC1	---	6	-------	4,411	22.49	12-12-80
					22.89	3-16-81
5S-34E-30BBC1	87	6	80- 87	4,448	48.73	11- 6-80
					46.62	3-19-81
30BCC1	78	6	77- 78	4,450	48.63	11- 5-80
30CCD1	185	6	-------	4,451	52.99	11- 5-80
					54.03	3-19-81
6S-33E- 1CDB1	265	16	68-145	4,453	-----	4-26-59
					53.29	11- 4-80
					53.80	1-12-81
					53.64	3-17-81
1DAC1	240	18	166-240	4,424	25.36	11- 4-80
					28.10	3-17-81

Table 4.--Data from wells--Continued

Well No.	Well depth (ft)	Diameter (in.)	Perforated interval (ft)	Altitude[1] (ft)	Depth to water below land surface (ft)	Date measured
6S-33E- 2AAA1	180	6	156-180	4,420	19.67	8-31-76
					19.97	11- 4-80
2BAC1	152	8	-------	4,440	39.08	11- 4-80
					39.69	3-16-81
2BDD1	150	6	-------	4,442	41.29	11-14-80
					41.82	3-16-81
2DAC1	152	8	-------	4,446	45.89	11- 4-80
					46.47	3-16-81
3ACD1	171	18	150-170	4,432	30.72	11- 5-80
					31.30	3-17-81
3BDC1	287	18	50- 65	4,424	23.32	11- 5-80
					23.59	3-17-81
4ADB1	340	20	225-340	4,421	18.76	11- 5-80
					19.26	3-17-81
4BBA1	223	16	188-218	4,416	13.64	3-18-80
					13.08	11- 3-80
					13.45	3-17-81
5BDA1	220	18	180-220	4,432	29.16	11- 5-80
					29.30	3-17-81
5DDB1	---	--	-------	4,417	15.50	11- 5-80
					15.80	3-17-81
8ADA1	221	16	170-200	4,444	41.55	11- 5-80
					43.26	3-17-81
8DDA1	212	16	175-205	4,446	43.72	11- 5-80
					44.30	3-17-81
9CAC1	370	20	287-370	4,450	49.85	8-31-76
					48.74	11- 5-80
					49.19	3-17-81
10DAD1	214	12	160-209	4,439	35.63	11- 6-80
					36.19	3-18-81
10DAD2	265	20	221-265	4,444	43.15	11- 6-80
					43.70	3-18-81
11ACA1	309	16	210-220	4,442	41.29	8-28-52
					41.75	1-12-81
					41.80	3-18-81

Table 4.--Data from wells--Continued

Well No.	Well depth (ft)	Diameter (in.)	Perforated interval (ft)	Altitude[1] (ft)	Depth to water below land surface (ft)	Date measured
6S-33E-11DBD1	130	16	-------	4,452	52.12	8-28-52
					50.30	4-27-59
					51.68	3-18-80
					51.58	11-14-80
					51.97	3-18-81
12BBC1	213	20	175-210	4,442	42.57	1-12-81
					42.77	3-18-81
12CCD1	103	22	-------	4,453	52.50	8-28-52
					55.50	1- 9-81
12CDD1	196	16	-------	4,464	68.00	9-13-51
12DAD1	113	8	81-103	4,455	65.41	8-18-52
12DAD2	212	8	170-200	4,456	65.86	11- 6-80
					66.11	3-19-81
13BAB1	200	16	-------	4,461	61.00	8-18-52
					63.76	1-12-81
13BBB1	210	16	-------	4,451	51.00	8-18-32
14AAA1	120	6	119-120	4,448	52.16	11- 6-80
					52.78	3-18-81
14DCD1	234	12	95-234	4,562	162.00	11- 6-80
					162.26	3-19-81
15DCA1	205	16	-------	4,486	85.74	4-25-59
					85.82	11- 7-80
					86.20	3-19-81
15DCC1	160	18	-------	4,499	94.94	8-28-52
					97.30	4-25-59
					97.37	11- 7-80
					97.78	3-19-81
15DCD1	---	--	-------	4,501	-----	--------
16CBB1	284	20	253-278	4,431	29.06	11- 6-80
					29.50	3-17-81
20ABB1	250	6	249-250	4,437	38.72	11- 6-80
					39.03	3-17-81
21BCB1	227	20	175-223	4,436	39.06	4-25-59
					34.74	11- 7-80
					35.15	3-19-81
22BAB1	360	20	115-120	4,488	82.89	11- 7-80
					83.36	3-19-81

Table 4.--Data from wells--Continued

Well No.	Well depth (ft)	Diameter (in.)	Perforated interval (ft)	Altitude[1] (ft)	Depth to water below land surface (ft)	Date measured
6S-34E- 6CBC1	80	6	79- 80	4,409	14.88	11- 4-80
					15.68	3-17-81
6CBD1	65	6	56- 65	4,400	3.88	11- 4-80
6CBD2	98	8	88- 91	4,404	12.78	11- 4-80
					13.54	3-17-81
6DAA1	85	6	-------	4,467	64.64	11- 5-80
					67.74	3-19-81
7ADA1	146	12	132-146	4,436	22.29	11- 7-80
7ABD1	174	12	132-174	4,422	26.44	11- 4-80
					27.12	3-17-81
7BBC1	151	10	115-145	4,428	30.55	5- 8-81
7CAD1	300	20	90-185	4,448	67.00	8- 3-64
7CDA1	229	20	68-215	4,446	57.00	12- 1-54
					76.40	8-14-58
					66.20	3-19-80
7CDD1	275	20	94-216	4,447	70.00	8- 3-64
					62.87	12- 9-80
					62.38	3-18-81
8ABB1	---	8	-------	4,459	55.54	11- 5-80
					42.77	3-18-81

[1]National Geodetic Vertical Datum of 1929.

Table 5.--Data from springs
[--, no data available]

Spring No.	Spring name	Altitude (ft)	Date measured	Discharge (ft^3/s)
5S-33E-26CAD1S	Wide Creek	4,359	5-22-80	49.5
			7-21-80	46.5
			9-17-80	45.6
			11-13-80	54.6
5S-33E-26DAD1S	Poongrah	4,359	11-11-80	24.3
5S-33E-27AAD1S	Jimmy Drinks	4,356	3-27-80	104
			5-22-80	103
			7-21-80	119
			9-17-80	120
			11-13-80	149
			1-13-81	122
5S-33E-27ACB1S	Dunn	4,362	11-11-80	.25
5S-33E-35BAD1S	Tindaha	4,364	11-11-80	.57
5S-33E-36BAD1S	Willow	-----	11-11-80	.36
5S-33E-35CAB1S	Wide Creek East	4,368	11-11-80	.56
5S-33E-36CAC1S	Twenty Springs West	4,358	11-11-80	3.75
6S-33E- 1ADD1S	Papoose	4,370	11-11-80	30.4
6S-33E- 1BAA1S	Siphon Road	4,380	11-13-80	------
6S-34E- 7ACA1S	Batiste	4,390	3-27-80	20.7
			11-11-80	27.8

on the basis of a withdrawal for irrigation of 44,700 acre-ft/yr (Balmer and Noble, 1979) and a withdrawal of 7,200 acre-ft/yr for industrial use, total pumpage from Michaud Flats is 51,900 acre-ft/yr. Using the above estimates, ground-water discharge from pumpage and seepage loss to the Portneuf River is about 361,000 acre-ft/yr. Natural ground-water discharge and pumpage probably will vary from year to year, but the above figures should be in the correct order of magnitude on an average annual basis.

Hydraulic characteristics of the artesian aquifer were determined from an aquifer test by Goldstein (1981). The test was conducted using well 6S-33E-4BBA1 as the production well and well 5S-33E-34ADD1 as the observation well. These are irrigation wells completed in the artesian aquifer. The pump test lasted 3½ hours, pumping 988 gal/min. At the end of the test, the water level had been drawn down 1.44 ft in the observation well. Goldstein (1981) reported a transmissivity between 228,000 and 281,000 ft^2/d and a storage coefficient of about 0.002.

A hydrograph of U.S. Geological Survey observation well 5S-33E-35CCD1, completed in the unconfined system (fig. 6), indicates that, over the last 25 years, the water level at this location has declined slightly. Historic measurements of the potentiometric surface are not available for most wells completed in the confined aquifers.

Potentiometric heads in seven wells completed in the confined aquifer were measured in the 1950's and again in 1981. Water levels in wells 6S-33E-11ACA1, 6S-33E-11DBD1, and 6S-33E-15DCA1 were unchanged or nearly so, whereas declines of about 2 to 5 ft are apparent in water levels in wells 5S-34E-34ADD1, 5S-34E-34CBC1, 6S-33E-15DCC1, and 6S-33E-21BCB1.

GROUND-WATER QUALITY

High levels of arsenic were first detected in well 6S-33E-12DAD1 in October 1972 (Balmer and Noble, 1979). Subsequently, from October 1972 to October 1973, the Idaho Department of Health and Welfare conducted a study of arsenic concentrations in wells 6S-33E-12DAD1, 6S-33E-12CCD1, and several wells owned by the fertilizer and phosphate plants. Arsenic concentrations in all the wells exceeded the recommended limit (U.S. Environmental Protection Agency, 1977) of 50 µg/L several times during the study. Well 6S-33E-12DAD1 ultimately was condemned by the State in 1976.

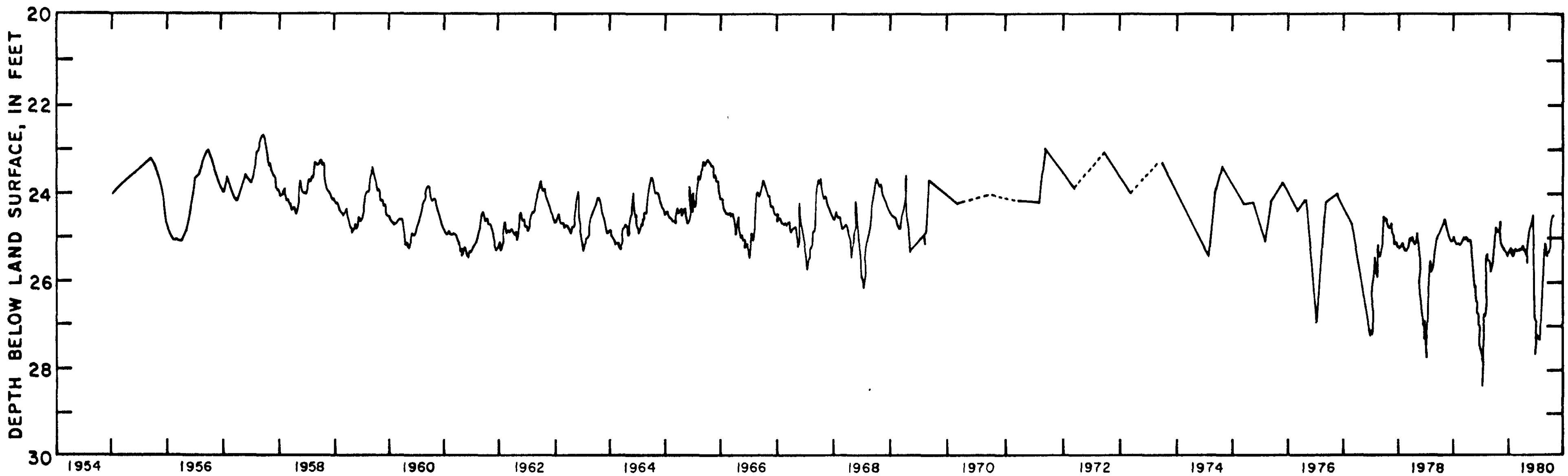


Figure 6.--Hydrograph for well 5S-33E-35CCD1.

Goldstein (1981) continued monitoring minor elements and radionuclides in wells 6S-33E-12DAD1, 6S-33E-12CCD1, 6S-33E-2DAC1, and in Batiste, Willow, Swanson Road, and Papoose Springs (table 5) from November 1977 to November 1978. Wells for the phosphate and fertilizer plants were not included in Goldstein's study. Goldstein (1981) reported concentrations of arsenic ranging from 10 to 30 μg/L and cadmium ranging from 1 to 3 μg/L in Batiste, Willow, and Swanson Road Springs and in wells 6S-33E-12DAD1 and 6S-33E-12CCD1.

Water samples were collected for chemical analyses from 4 retention ponds, 20 wells, and 5 springs. Samples were obtained from both the water-table system and the artesian system. The results of the analyses are shown in table 6.

Recommended upper limits of arsenic concentrations in drinking water were exceeded in water from well 6S-33E-12DAD1, which had a concentration of 62 μg/L. Analyses from well 6S-33E-14DCD1, the only well upgradient of 6S-33E-12DAD1, are being used as indicators of background water quality. The arsenic concentration in well 6S-33E-14DCD1, however, was 17 μg/L, which seems high. It was exceeded only by that in well 6S-33E-12DAD1. This seems to indicate that arsenic may occur naturally in relatively high levels in local ground waters. Evidence supplied by only one well is not sufficient to prove this occurrence, so additional chemical analyses of ground water upgradient from potential sources of contamination are needed.

Selenium concentrations obtained during the initial sampling round from well 6S-33E-12CCD1 and Twenty Springs West were 4 μg/L. The concentrations are more than or equal to selenium concentrations in the industrial retention ponds, with thé exception of the fertilizer decant pond. If the ponds were a source of selenium, they would have higher concentrations than the wells because of the diluting nature of ground water and the areal dispersion of any potential contaminant. Also, if the pond water were the source of the selenium, higher concentrations would be in the wells located between the fertilizer decant pond and Twenty Springs West.

Nutrients of most interest to irrigators and farmers are orthophosphate (PO_4), ammonia (NH_4), and nitrogen (NO_2+NO_3). Concentrations of orthophosphate ranged from less than 0.01 to 71 mg/L in the wells and less than 0.01 to 0.06 mg/L in the springs. Ammonia concentrations ranged from less than 0.01 to 1.3 mg/L in the wells and averaged

Table 6.--Chemical analyses of water from selected ponds, wells, and springs

Specific conductance: (UMHOS) - micromhos per centimeter at 25°C

Temperature: (DEG C) - degrees Celsius

Bicarbonate and Carbonate: FET-FLD - end-point titration method; field determination

Other Notations:
- UG/L - micrograms per liter
- PCI/L - picocuries per liter
- PER MIL - parts per thousand
- < - less than
- -- - no data available

SAMPLE SITE NAME OR NUMBER	REFERENCE NO. (SEE FIG. 7)	DATE OF SAMPLE	TIME	SPECIFIC CONDUCTANCE (UMHOS)	PH (UNITS)	TEMPERATURE (DEG C)
FERTILIZER PLANT EQUALIZATION POND	1	80-12-08	1500	1939	8.5	10.5
FERTILIZER PLANT DECANT POND	2	80-12-09	1035	15696	1.7	5.0
06S 34E 07CDA1	3	80-12-08	0930	1156	7.2	12.0
06S 34E 07CAD1	4	80-12-09	0844	597	7.6	13.5
06S 33E 12CDD1	5	80-12-09	1300	970	7.0	14.5
06S 33E 13BBB1	6	80-12-09	1335	519	7.5	14.0
PHOSPHATE PLANT SLURRY POND NO. 5	7	80-12-09	1600	5234	6.4	1.0
PHOSPHATE PLANT EVAPORATION POND	8	80-12-09	1700	2233	5.9	12.5
05S 33E 36CDC1	9	80-12-12	0930	459	7.9	7.5
05S 34E 30BCC1	10	80-12-18	0940	958	7.8	11.0
06S 33E 01CDB1	11	81-01-12	1455	414	7.8	11.5
06S 33E 02DAC1	12	80-12-17	1100	420	8.1	11.5
06S 33E 10DAD2	13	80-12-11	0910	437	7.9	11.0
06S 33E 12CCD1	14	80-12-10	1630	1764	7.3	8.5
06S 33E 12DAD1	15	80-12-09	1420	1608	7.3	18.0
06S 33E 12DAD2	16	80-12-09	1500	454	7.7	12.5
06S 33E 14AAA1	17	80-12-11	1000	437	7.8	12.5
06S 33E 14DCD1	18	80-12-11	1040	455	7.8	15.5
06S 33E 15DCD1	19	80-12-11	0815	1105	7.4	6.5
06S 34E 06CBC1	20	80-12-11	1600	518	7.7	10.0
06S 34E 05DAA1	21	80-12-12	1045	678	7.7	10.0
06S 34E 07ABD1	22	80-12-11	1500	630	7.6	12.5
06S 34E 07ADA1	23	80-12-11	1400	747	7.7	13.0
06S 34E 07BBC1	24	80-12-11	1200	449	7.9	10.5
BATISTE SPRINGS	25	80-12-11	1530	657	7.6	13.5
SIPHON ROAD SPRINGS	26	80-12-18	1045	465	7.8	11.0
TWENTY SPRINGS WEST	27	80-12-17	1430	1099	7.6	10.5
TINDAHA SPRINGS	28	80-12-17	1315	467	7.9	11.0
JIMMY DRINKS SPRINGS	29	80-12-17	1215	472	8.0	11.0

Table 6.--Chemical analyses of water from selected ponds, wells, and springs--Continued

DATE OF SAMPLE	HARD- NESS (MG/L AS CACO3)	HARD- NESS, NONCAR- BONATE (MG/L CACO3)	CALCIUM DIS- SOLVED (MG/L AS CA)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG)	SODIUM, DIS- SOLVED (MG/L AS NA)	SODIUM AD- SORP- TION RATIO	PERCENT SODIUM	POTAS- SIUM, DIS- SOLVED (MG/L AS K)	BICAR- BONATE FET-FLD (MG/L AS HCO3)	CAR- BONATE FET-FLD (MG/L AS CO3)	ALKA- LINITY FIELD (MG/L AS CACO3)	SULFATE DIS- SOLVED (MG/L AS SO4)
80-12-08	350	330	94	27	210	4.9	56	12	120	14	122	630
80-12-09	3800	3800	1200	200	820	5.8	30	250	--	--	0	5000
80-12-08	400	120	110	31	69	1.5	27	8.3	340	0	279	200
80-12-09	220	40	56	18	45	1.3	30	6.8	220	0	180	79
80-12-09	350	150	90	31	62	1.4	27	11	240	0	197	120
80-12-09	200	36	53	16	34	1.1	26	6.3	200	0	164	50
80-12-09	64	0	14	12	250	12	24	1300	450	0	369	850
80-12-09	130	32	30	13	140	5.4	30	460	120	0	98	340
80-12-12	190	10	52	15	15	.6	17	3.4	220	0	180	38
80-12-18	280	0	66	28	89	2.3	40	6.7	370	0	303	90
81-01-12	180	32	47	16	20	.6	19	3.5	180	0	148	48
80-12-17	170	31	44	15	21	.7	21	3.8	170	0	139	46
80-12-11	180	32	46	15	20	.7	19	3.6	180	0	148	47
80-12-10	550	320	140	51	140	2.6	35	1.4	290	0	238	150
80-12-09	320	0	64	39	130	3.2	36	140	470	0	385	150
80-12-09	180	32	47	15	29	.9	25	5.4	180	0	148	48
80-12-11	170	39	44	14	21	.7	21	.0	160	0	131	41
80-12-11	170	6	42	15	25	.8	23	8.6	200	0	164	20
80-12-11	490	170	130	39	40	.8	15	3.2	390	0	320	58
80-12-11	230	25	57	21	27	.8	20	4.4	250	0	205	36
80-12-12	280	0	58	32	43	1.1	25	7.5	360	0	295	49
80-12-11	250	0	62	22	49	1.4	30	5.7	350	0	287	46
80-12-11	270	0	65	25	57	1.5	31	7.2	370	0	303	49
80-12-11	210	30	54	17	20	.6	17	3.7	220	0	180	38
80-12-11	270	0	66	25	50	1.3	28	5.7	330	0	271	42
80-12-18	190	18	51	15	16	.6	17	3.4	210	0	172	36
80-12-17	350	170	84	35	86	2.0	34	4.9	250	0	180	160
80-12-17	180	16	49	15	20	.6	19	3.6	200	0	164	42
80-12-17	190	26	49	16	19	.6	18	3.5	200	0	154	42

Table 6.--Chemical analyses of water from selected ponds, wells, and springs--Continued

DATE OF SAMPLE	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)	NITROGEN DISSOLVED (MG/L AS N)	NITROGEN, ORGANIC DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA DISSOLVED (MG/L AS NH4)	NITROGEN, AMMONIA + ORGANIC DIS. (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	PHOSPHATE, ORTHO, DISSOLVED (MG/L AS PO4)
80-12-08	100	2.3	51	1220	1200	63	10	39.0	50	49	14	29
80-12-09	70	--	1.4	15200	7750	34	.00	35.0	45	34	.00	29
80-12-08	47	.7	36	591	705	1.6	.37	.020	.03	.39	1.2	28
80-12-09	33	.9	30	373	390	1.4	.38	.030	.04	.41	.97	.89
80-12-09	120	--	43	604	501	2.3	1.2	.050	.06	1.2	1.1	.49
80-12-09	36	.8	38	330	397	1.6	.61	.020	.03	.63	.92	58
80-12-09	190	--	1.0	4360	2950	26	8.0	19.0	24	27	.73	29
80-12-09	110	--	2.3	281	1230	33	9.0	23.0	30	32	.77	29
80-12-12	15	.7	25	273	281	1.7	.57	.040	.05	.61	1.1	.00
80-12-18	69	.4	36	570	575	2.8	1.1	.040	.05	1.1	1.7	.03
81-01-12	10	.8	26	273	263	1.5	.64	.080	.10	.72	.73	.03
80-12-17	22	.7	20	259	266	1.3	.52	.050	.06	.57	.68	.03
80-12-11	20	.6	27	262	271	1.1	.35	.000	.00	.35	.72	.00
80-12-10	320	.8	40	1060	1090	5.7	.58	.030	.04	.61	5.1	71
80-12-09	180	--	70	1020	1020	3.7	.40	1.30	1.7	1.7	2.0	.49
80-12-09	29	1.1	32	279	298	1.1	.40	.000	.00	.40	.67	.18
80-12-11	20	.6	38	256	260	.73	.28	.000	.00	.28	.45	.00
80-12-11	32	.4	59	296	305	1.5	.57	.000	.00	.57	.93	.03
80-12-11	100	1.6	31	639	644	12	.93	.030	.04	.96	11	.12
80-12-11	23	.4	30	333	330	2.8	.90	.060	.08	.96	1.8	.03
80-12-12	20	.3	31	421	428	3.0	.80	.050	.06	.85	2.1	.09
80-12-11	24	.3	36	419	426	2.7	.88	.040	.05	.92	1.8	.03
80-12-11	28	.2	34	461	462	4.0	.78	.070	.09	.85	3.1	.06
80-12-11	17	1.2	27	276	291	1.4	.26	.000	.00	.25	1.1	.00
80-12-11	24	.3	35	406	420	2.7	.62	.050	.08	.68	2.0	.06
80-12-18	19	.7	25	290	277	1.9	.63	.060	.08	.69	1.2	.00
80-12-17	130	.8	30	--	644	1.8	.55	.060	.08	.51	1.2	.03
80-12-17	16	.6	27	280	278	1.5	.44	.070	.09	.51	.98	.00
80-12-17	20	.7	26	285	279	1.7	.60	.050	.06	.65	1.0	.03

Table 6.--Chemical analyses of water from selected ponds, wells, and springs--Continued

DATE OF SAMPLE	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, ORTHO, DIS-SOLVED (MG/L AS P)	ARSENIC DIS-SOLVED (UG/L AS AS)	BORON, DIS-SOLVED (UG/L AS B)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, DIS-SOLVED (UG/L AS PB)	MERCURY DIS-SOLVED (UG/L AS HG)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	ZINC, DIS-SOLVED (UG/L AS ZN)
80-12-08	4.00	9.50	7	170	2	1800	260	<10	.1	<10	2	900
80-12-09	800	9.50	160	1300	14000	9100	63000	300	.0	280	180	26000
80-12-08	5.10	9.10	5	120	<1	10	<10	<10	.1	<10	2	<3
80-12-09	5.80	.290	6	80	<1	0	<10	<10	.0	<10	1	<3
80-12-09	40.0	.160	16	280	<1	0	60	<10	.1	15	2	<3
80-12-09	.590	19.0	7	110	<1	10	10	<10	.0	<10	1	<3
80-12-09	670	9.50	120	3400	200	250	780	200	.5	23	2	47000
80-12-09	320	9.50	22	1400	100	70	580	100	.0	12	2	9200
80-12-12	.020	.000	1	50	<1	0	10	34	.0	<10	0	290
80-12-18	.020	.010	2	140	1	10	50	1	.0	<10	1	160
81-01-12	.040	.010	2	60	<1	0	30	1	.0	<10	0	20
80-12-17	.020	.010	2	60	<1	0	20	48	.0	<10	0	60
80-12-11	.040	.000	2	50	<1	0	<10	<10	.0	<10	0	<3
80-12-10	1.40	23.0	7	160	<1	0	20	<10	.3	<10	4	310
80-12-09	130	.160	40	960	<1	0	40	<10	.4	51	1	<3
80-12-09	.370	.060	3	40	<1	0	30	<10	.0	10	0	<3
80-12-11	.040	.000	3	40	<1	0	10	<10	.2	<10	0	270
80-12-11	.060	.010	17	40	<1	0	<10	<10	.0	14	1	400
80-12-11	.130	.040	1	50	<1	0	<10	<10	.0	<10	2	90
80-12-11	.020	.010	1	50	<1	0	20	48	.0	<10	0	80
80-12-12	.040	.030	2	90	<1	0	<10	1	.0	<10	1	130
80-12-11	.030	.010	2	90	<1	0	<10	1	.0	<10	1	<3
80-12-11	.040	.020	3	120	1	0	<10	0	.0	<10	1	<3
80-12-11	.010	.000	2	30	<1	10	10	<10	.0	<10	0	60
80-12-11	.030	.020	3	90	<0	10	<10	1	.0	<10	1	<3
80-12-18	.020	.000	2	60	<1	0	<10	48	.0	<10	0	<3
80-12-17	.020	.010	2	120	1	0	10	45	.0	12	4	<3
80-12-17	.000	.000	2	60	1	0	<10	59	.0	<10	0	3
80-12-17	.020	.010	2	60	<1	0	<10	40	.0	<10	0	<3

DATE OF SAMPLE	TRITIUM TOTAL (PCI/L)	H-2/ H-1/ STABLE ISOTOPE RATIO PER MIL	O-18/ O-16 STABLE ISOTOPE RATIO PER MIL
80-12-08	<20	-117.0	-16.4
80-12-09	<20	-127.0	-16.0
80-12-08	<20	-137.0	-18.0
80-12-09	<20	-135.0	-15.2
80-12-09	25	-134.0	-17.6
80-12-09	<20	-138.0	-16.2
80-12-09	37	-102.0	-12.8
80-12-09	<20	-125.0	-15.9
80-12-12	--	--	--
80-12-15	--	--	--
81-01-12	--	--	--
80-12-17	--	--	--
80-12-11	<20	-139.0	-18.2
80-12-10	34	-132.0	-17.4
80-12-09	37	-134.0	-17.6
80-12-09	<20	-137.0	-18.3
80-12-11	<20	-138.0	-18.1
80-12-11	<20	-103.0	-18.0
80-12-11	110	-130.0	-17.1
80-12-11	--	--	--
80-12-12	--	--	--
80-12-11	--	--	--
80-12-11	320	-125.0	--
80-12-11	76	-131.0	-17.5
80-12-11	270	-127.0	-16.4
80-12-18	130	-131.0	-17.2
80-12-17	110	-131.0	-17.1
80-12-17	27	-135.0	-17.6
80-12-17	46	-136.0	--

about 0.08 mg/L in the springs. Nitrogen concentrations ranged from 0.45 to 11.0 mg/L in the wells and averaged 1.1 mg/L in the springs.

Concentrations of lead were high in the springs, and averaged about 48 μg/L. Concentrations of lead were highest in wells 6S-34E-6CBC1, 6S-33E-2DCA1, and 5S-33E-36CDC1 and range from 34 to 48 μg/L.

Water samples (table 6) from selected wells and springs were collected for analysis of tritium (^3H). Tritium content can be used as a means of determining how long a particular water may have been in storage in an aquifer, out of contact with tritium in the atmosphere. Tritium values obtained indicate a lengthy aquifer residence time, except for wells 6S-33E-14DCD1, 6S-33E-15DCD1, and 6S-34E-7ADA1, which may be influenced by mixing with younger waters, high in tritium, that infiltrate from Portneuf River, Michaud Creek, or Bannock Creek. High tritium content in Siphon Road Springs and Twenty Springs West indicates a short residence time in the spring system or mixing with younger recharge waters. Tindaha and Jimmy Drinks Springs probably discharge water from the deeper, confined system, which receives little, if any, recharge from younger waters.

Examination of the preliminary chemical data determined selection of wells and springs for a monitoring program. Four wells--6S-33E-1CDB1, 6S-33E-12CCD1, 6S-33E-12DAD1, and 6S-33E-14DCD1--and two springs, Batiste and Willow, will be sampled periodically for major ions, nutrients, trace metals, and gross alpha and gross beta activity. A second round of sampling was completed in June 1981 and a third will be initiated in the fall of 1981. Sampling sites were selected on the basis of previous high concentrations of potential contaminants and effectiveness in monitoring areal distribution of pollutants.

Figure 7 is a diagram for the classification of irrigation waters and a plot of the SAR (sodium-adsorption ratio) and specific conductance for waters in Michaud Flats. Experiments by the U.S. Salinity Laboratory Staff (1954) show that the SAR predicts reasonably well the degree to which irrigation water tends to enter into cation-exchange reactions in soil. High values for SAR imply a hazard of sodium replacing adsorbed calcium and magnesium, and this replacement is damaging to soil structure. With the exception of water in the plant ponds, all the water sampled has a low sodium range and can be used for irrigation on almost all soils with little danger of developing harmful levels of exchangeable sodium. High salinity in irrigation waters is indicated by high specific conduct-

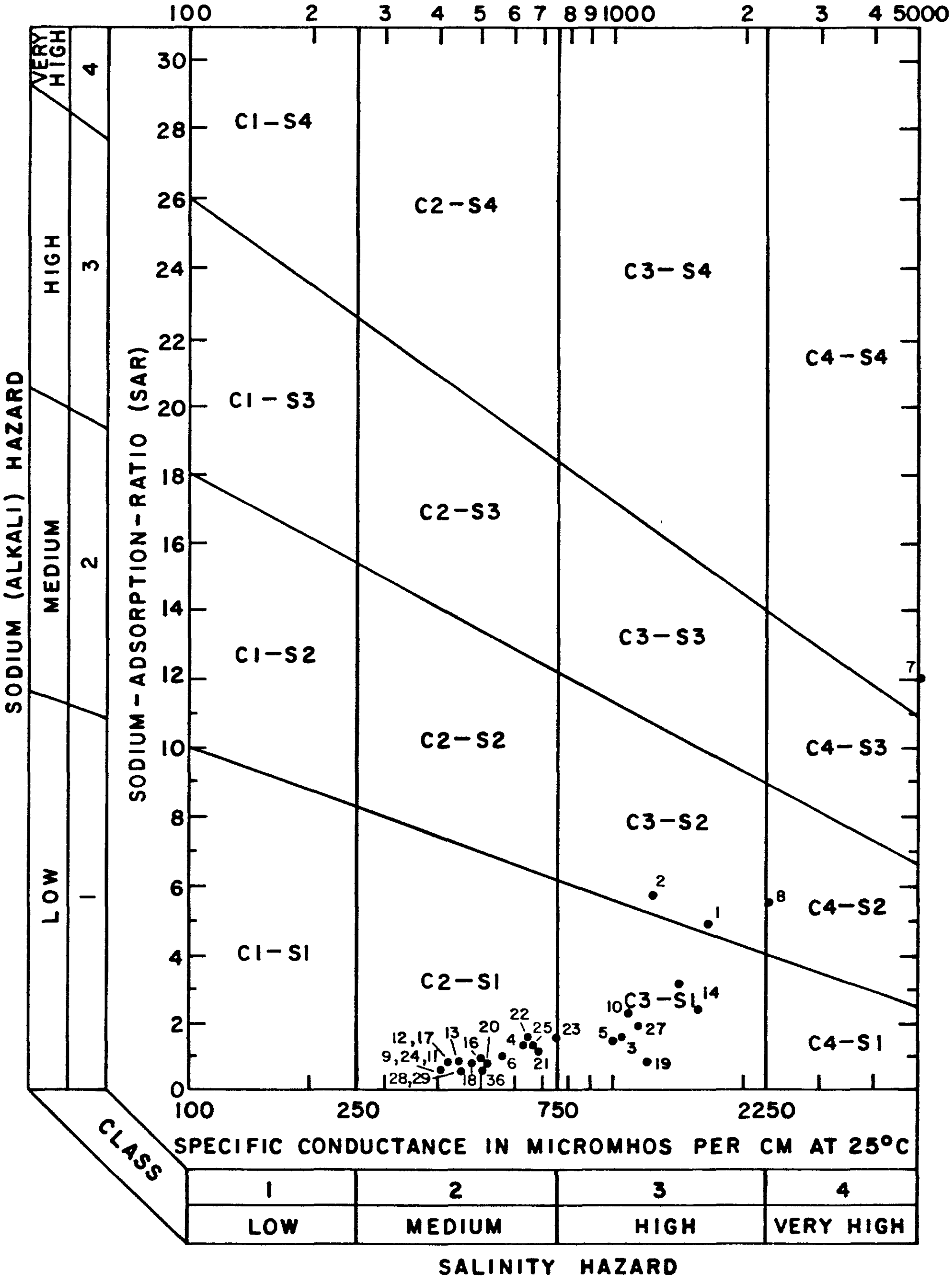


Figure 7.-- Classification of irrigation waters.
(Numbers are reference numbers, Table 6)
[From U.S. Salinity Laboratory Staff, 1954]

ance. Application of high salinity waters for irrigation can build an accumulation of salts in the soil and result in a failure of crops having a low salt tolerance. All the wells and springs have a medium- to high-salinity hazard, and caution should be exercised when using these waters on poorly drained soils.

SUMMARY

Michaud Flats occupies about 50 mi^2 on the eastern Snake River Plain in southeastern Idaho. Ground-water resources underlying the Flats are substantial and are extensively developed for irrigation and industrial uses.

Well-drained soils of loam and silt-loam occupy the alluvial fans and terraces. The basalt flows of the Big Hole Basalt and Starlight Formation and the sand and gravel of the Sunbeam Formation and pediment gravel are the most productive aquifers in the area.

Ground water occurs under both water-table and artesian conditions. It is recharged by infiltration from precipitation, leakage from intermittent streams, ground-water underflow from adjacent areas, and deep percolation of irrigation water, both from canal leakage and excess water applied to the fields.

The general direction of ground-water movement in the confined aquifer system is to the north and northwest. The potentiometric surface has a low gradient. A cone of depression caused by industrial well withdrawals exists in the vicinity of the fertilizer and phosphorus plants. Water-level data obtained from shallow wells completed in the unconfined aquifer system were not sufficient to draw a water-table map for the study area.

Seepage information obtained in the fall of 1980 on the Portneuf River shows the river to be a gaining reach through the study area.

Some degree of contamination is apparent in several wells completed in the water-table system. The deeper artesian system seems to be free of contamination; however, contamination potential exists. Wells that intercept both systems and are perforated in both could allow passage of potential pollutants to the artesian system from the water-table system. Contamination is also a possibility if the confining layer is not continuous and would allow leakage or percolation from overlying strata. Available data are not sufficient to determine sources of contamination, size of contaminant plume, and direction of movement.

SELECTED REFERENCES

Balmer, D. K., and Noble, J. B., 1979, Water resources of the Fort Hall Indian Reservation, final report: Tacoma, Wash., Robinson and Noble, Inc., 227 p.

Carr, W. J., and Trimble, D. E., 1963, Geology of the American Falls quadrangle, Idaho: U.S. Geological Survey Bulletin 1121-G, 44 p.

Crosthwaite, E. G., 1957, Ground-water possibilities south of the Snake River between Twin Falls and Pocatello, Idaho: U.S. Geological Survey Water-Supply Paper 1460-C, p. 99-145.

Davis, S. N., and DeWiest, R. J. M., 1966, Hydrogeology: New York, John Wiley and Sons, Inc., 463 p.

Goldstein, Flora, 1981, Hydrogeology and water quality of Michaud Flats, Idaho: Pocatello, Idaho State University, unpublished M.S. thesis, 80 p.

Hem, J. D., 1978, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 1473, 363 p.

Low, W. H., 1981, Radionuclide concentrations in streams in the upper Blackfoot River basin, southeastern Idaho: U.S. Geological Survey Water-Resources Investigations/ Open-File Report 81-142, 17 p.

Malde, H. E., 1968, The catastrophic late Pleistocene Bonneville flood in the Snake River Plain, Idaho: U.S. Geological Survey Professional Paper 596, 52 p.

Mansfield, G. R., 1920, Geography, geology, and mineral resources of the Fort Hall Indian Reservation, Idaho: U.S. Geological Survey Bulletin 713, 152 p.

McDole, R. E., 1977, Soil survey of Fort Hall area, in parts of Bannock, Bingham, Caribou, and Power Counties, Idaho: U.S. Department of Agriculture, 97 p.

Mundorff, M. J., 1967, Ground water in the vicinity of American Falls Reservoir, Idaho: U.S. Geological Survey Water-Supply Paper 1846, 58 p.

Mundorff, M. J., Crosthwaite, E. G., and Kilburn, Chabot, 1964, Ground water for irrigation in the Snake River basin in Idaho: U.S. Geological Survey Water-Supply Paper 1654, 224 p.

Norvitch, R. F., and Larson, A. L., 1970, A reconnaissance of the water resources in the Portneuf River basin, Idaho: Idaho Department of Reclamation, Water Information Bulletin no. 16, 58 p.

Russell, I. C., 1902, Geology and water resources of the Snake River Plains of Idaho: U.S. Geological Survey Bulletin 199, 192 p.

Seitz, H. R., and Norvitch, R. F., 1979, Ground-water quality in Bannock, Bear Lake, Caribou, and part of Power Counties, southeastern Idaho: U.S. Geological Survey Water-Resources Investigations/Open-File Report 79-14, 53 p.

Stearns, H. T., Crandall, Lynn, and Steward, W. G., 1938, Geology and ground water in the Michaud Flats Project, Power County, Idaho: U.S. Geological Survey Water-Supply Paper 774, 268 p.

Stewart, J. L., Nace, R. L., and Deutsch, Morris, 1951, Preliminary report on ground water in the Michaud Flats Project, Power County, Idaho: U.S. Geological Survey Open-File Report, 40 p.

Todd, E. W., editor, 1961, The adventures of Captain Bonneville, U.S.A., in the Rocky Mountains and the Far West, digested from his journal by Washington Irving, (2d ed.): Norman, Okla., University of Oklahoma Press, 424 p.

Trimble, D. E., 1976, Geology of Michaud and Pocatello quadrangles, Bannock and Power Counties, Idaho: U.S. Geological Survey Bulletin 1400, 88 p.

U.S. Environmental Protection Agency, 1977, Quality criteria for water: Washington, U.S. Government Printing Office, 256 p.

U.S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkali soils: U.S. Department of Agriculture, Agricultural Handbook no. 60, 160 p.

West, S. W., and Kilburn, Chabot, 1963, Ground water for irrigation in part of the Fort Hall Indian Reservation, Idaho: U.S. Geological Survey Water-Supply Paper 1576-D, 33 p.