Availability of Ground Water in the Bear River Valley Wyoming

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1539-V

Prepared in cooperation with the Wyoming Natural Resource Board and the State Engineer of Wyoming

Availability of Ground Water in the Bear River Valley Wyoming

By CHARLES J. ROBINOVE *and* DELMAR W. BERRY

With a section on CHEMICAL QUALITY OF THE WATER

By JOHN G. CONNOR

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1539-V

Prepared in cooperation with the Wyoming Natural Resource Board and the State Engineer of Wyoming

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1963

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C.

CONTENTS

ILLUSTRATIONS

[All plates in pocket]

TABLES

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

AVAILABILITY OF GROUND WATER IN THE BEAR RIVER VALLEY, WYOMING

By Charles J. Robinove and Delmar W. Berry

ABSTRACT

The Bear River valley is in southwestern Wyoming on the east side of the Great Salt Lake basin. The river flows in a valley underlain by unconsolidated Quaternary alluvium flanked by consolidated bedrock formations ranging in age from Pennsylvanian to early Tertiary. The pre-Laramide rocks generally are steeply dipping and the post-Laramide rocks are horizontal or gently dipping.

The valley fill is the largest potential source of ground water in the area. Its thickness exceeds 185 feet in places, and the material generally is coarse and permeable. The water table is close to the land surface. Wells producing as much as 1,100 gallons per minute have been constructed, and larger yields are possible. Most of the waters sampled for chemical analysis are chemically suitable for irrigation but are hard.

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESTIGATION

A program of ground-water investigations in Wyoming was begun in November 1940 by the U.S. Geological Survey, in cooperation with the State of Wyoming. As part of this program a study of the ground-water resources of the part of the Bear River valley that is in Wyoming was begun in August 1955 in cooperation with the Wyoming Natural Resource Board and the Wyoming State Engineer. The primary purpose of the study was to determine the availability of ground water for irrigation and industrial use. Consequently, fieldwork was concentrated on the unconsolidated Quaternary sediments that afford the best possibility of yielding large supplies of water, and little information was collected on the consolidated bedrock formations.

The fieldwork and collection of data for the report were done by the authors under the direct supervision of H. M. Babcock and E. D. Gordon, successive district supervisors of the Ground Water Branch for Wyoming.

Studies of the quality of water were made under the general supervision of J. G. Connor, district chemist of the Quality of Water Branch for Utah.

LOCATION AND EXTENT OF THE AREA

The Bear River valley is in the southwestern part of Wyoming, east of the Great Salt Lake basin. The Bear River rises on the north flank of the Uinta Mountains in Utah and flows generally northward through Uinta County and part of Lincoln County, Wyo. About 4 miles north of Cokeville, in Lincoln County, the river swings northwest and enters Idaho. It flows north and near Soda Springs, Idaho, turns sharply southwest, reenters Utah about 45 miles farther south, and discharges into Great Salt Lake. The river, whose course is more than 300 miles long, crosses State borders five times and discharges into Great Salt Lake at a point only about 90 miles northwest of its headwaters. Plate 1 shows the Bear River valley in Wyoming. Figure 1 shows the drainage basin of the Bear River and figure 2 shows the location of the area of this investigation and other investigations in Wyoming. This report covers only the part of the Bear River valley that is in Wyoming.

For the purpose of this report, the part of the Bear River valley between the south border of Wyoming and The Narrows, about 15 miles north of Evanston (pl. 1), is referred to as "southern Bear River valley," and the area between the river's reentrance into Wyoming and Border, Wyo., where the river enters Idaho, is referred to as "northern Bear River valley."

PREVIOUS INVESTIGATIONS

Several investigations of the geology and ground-water resources of the general area made previously have been concerned primarily with the geology and only to a limited extent with the water resources. However, the results of these studies have been very useful in the preparation of this report, and the geology of the area shown on plate 1 was adapted largely from reports of previous workers, as indicated on the map.

Veatch (1907) described the geology of part of the Bear River valley in Wyoming and included some data on ground water; the geologic map of southern Bear River valley is adapted from his report.

Gale and Richards (1910) described the geology of part of the Bear River valley south of Cokeville in a report on phosphate deposits in southeastern Idaho and adjacent areas. Geologic mapping of the Montpelier quadrangle in Idaho and Wyoming by Mansfield (1927) included part of the Bear River valley north of Cokeville. The

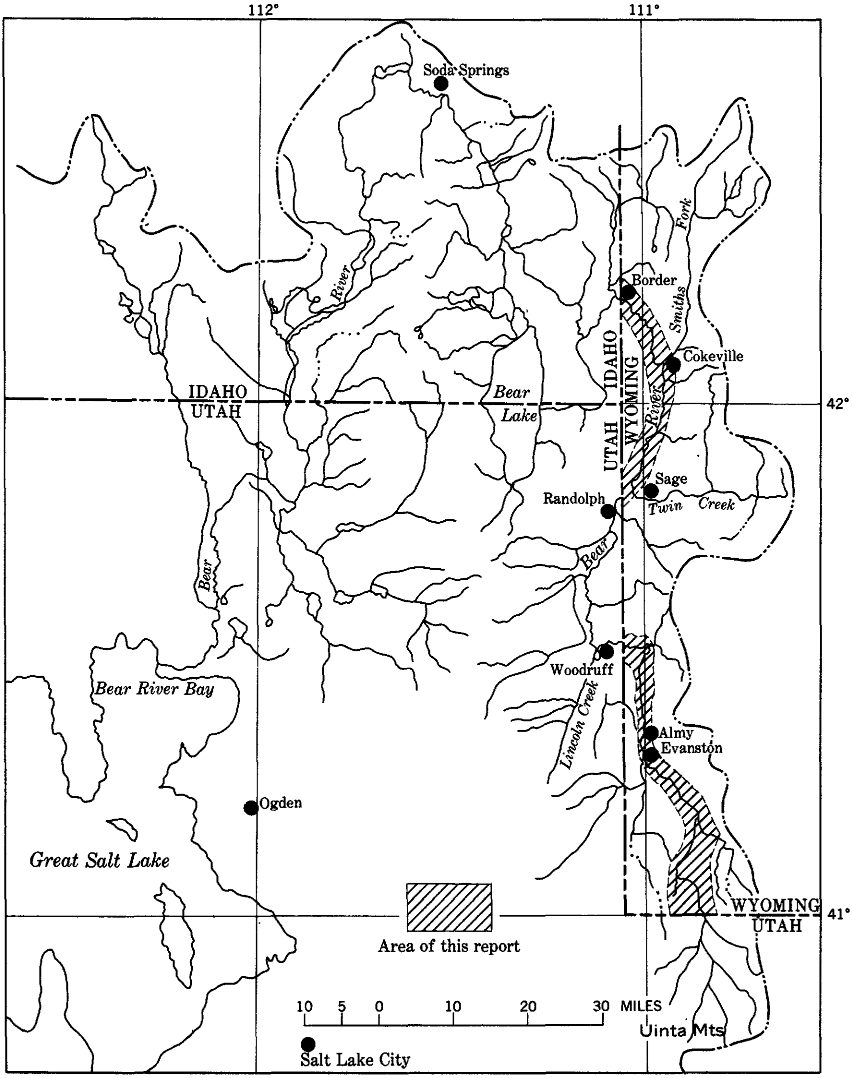

FIGURE 1.—Map of the northeastern part of the Great Salt Lake basin showing the Bear River drainage system and the area covered in this report.

geology of the Randolph quadrangle in Utah and Wyoming was mapped by Richardson (1941). The Wyoming Geological Association guidebook of southwestern Wyoming (1950) contains several papers, road logs, and maps on the geology of the Bear River valley and adjacent areas. The geology (pl. 1) of the northern Bear River valley is adapted from an unpublished map by W. W. Rubey, of the U.S. Geological Survey, who is mapping part of the northern Bear River valley and adjacent areas in the Wyoming overthrust belt.

Surface-water resources of the Bear River valley have been described in the annual reports on Bear River hydrometric data covering the years 1944–54 by the U.S. Geological Survey. Berry (1955) described the ground-water resources of the Bear River valley in the vicinity of Cokeville. Data from some of these studies have been used freely in this report.

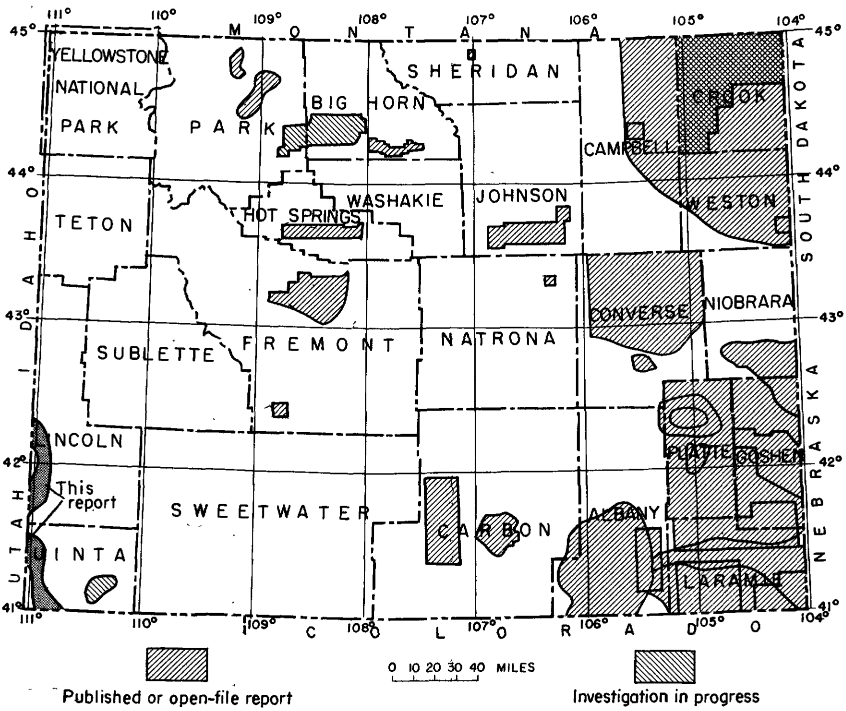

FIGURE 2.—Map of Wyoming showing area described in this report and other areas for which ground-water reports have been released or are in preparation.

ACKNOWLEDGMENTS

The writers acknowledge the assistance of all those who aided in the collection of information for this report. Well drillers in the area supplied records and logs of wells, and the residents of the area supplied information about the wells and gave permission to measure the depths of wells and depths to water. Information on public water supplies was given by the officials of Evanston and Cokeville. Mr. Earl Lloyd, the Wyoming State Engineer, gave helpful assistance and permitted access to State records of wells. Mr. W. W. Rubey, of the U.S. Geological Survey, permitted the authors to include a generalized version of his previously unpublished geologic map of the northern

Bear River valley in this report (pl. 1), and also gave technical assistance in the field.

METHODS OF INVESTIGATION

Seventy-three wells and springs in the Bear River valley were inventoried in the investigation. The wells were inspected and well drillers and the owners or tenants of property on which the wells or springs are situated were interviewed for information on the wells and the water-bearing formations. The depth to water was measured in most of the wells, and measurements of discharge and drawdown were made, as feasible, of large-capacity wells. Eleven wells tapping the unconsolidated Quaternary deposits were selected for periodic measurements to observe the fluctuations of the water level. Measurements of depths to water made in these wells at irregular intervals between July 1955 and September 1958 are listed in table 2.

Water samples collected from 16 wells and 1 spring were anaylzed by the U.S. Geological Survey Laboratory at Salt Lake City, Utah, to determine the chemical quality of the ground water. Samples of water collected from the Bear River in April, June, and September 1956, and samples from its major tributaries collected in April 1956, were analyzed to determine the chemical quality of the surface water and its relation to the chemical quality of the ground water.

WELL-NUMBERING SYSTEM

The wells are numbered according to the Federal system of land subdivisions. The well number shows the location of the well by township, range, section, and position within the section as shown on figure 3. The first numeral of a well number indicates the township, the second the range, and the third the section in which the well is located. In the Bear River valley in Wyoming all townships are north of the base line and all ranges are west of the sixth principal meridian. The first letter following the section number denotes the quater section, the second letter the quarter-quarter section, and the third letter, if used, the quarter-quarter-quarter section (10-acre tract). The subdivisions of the sections are lettered a, b, c, and d counterclockwise, beginning in the northeast quarter. Where more than one well is in a 10-acre tract, consecutive numbers, beginning with 1, are added to the well number. Thus, well 13–121–26 bca is in the NE¼SW¼ NW¼ sec. 26, T. 13 N., R. 121 W.

The numbering system is used also to designate places where surface-water samples were taken for analysis.

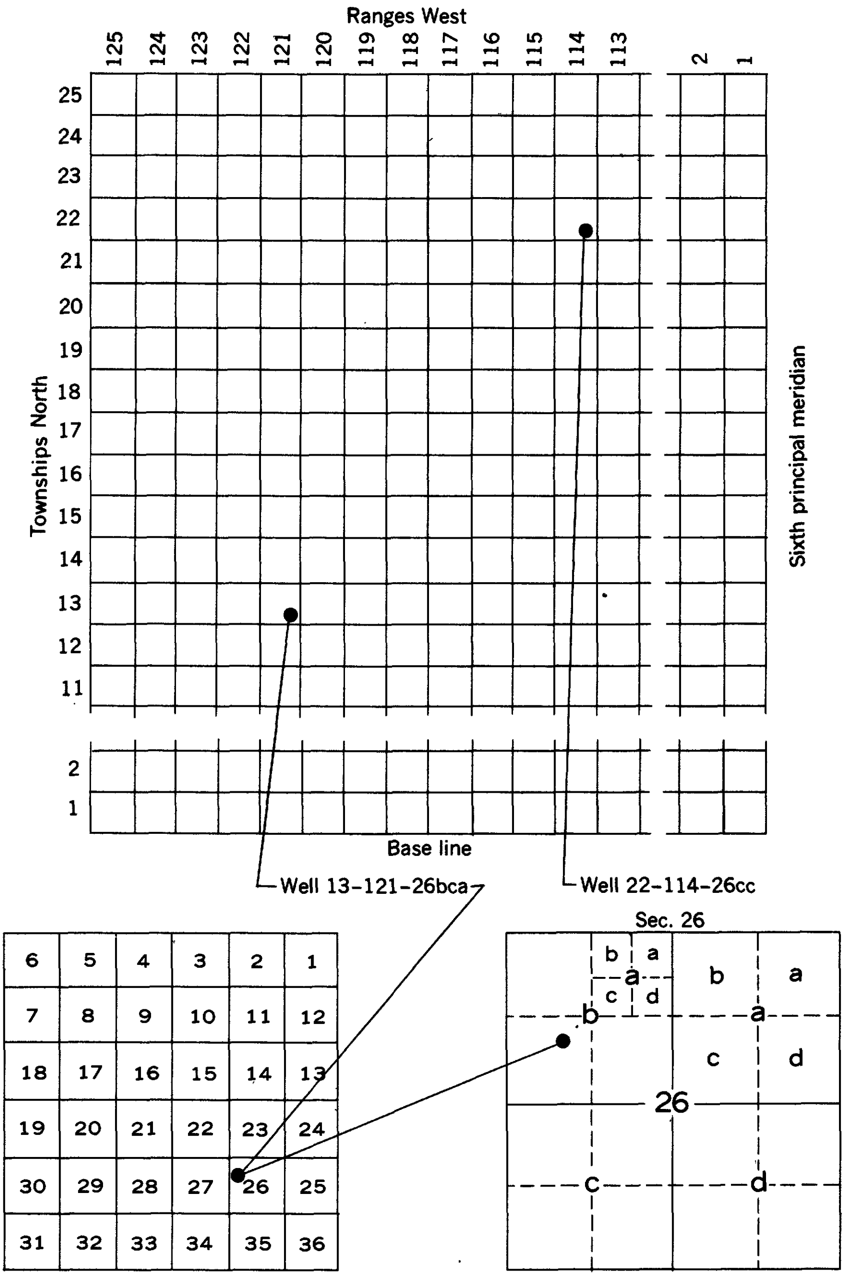

Figure 3.—Sketch showing well-numbering system.

GEOGRAPHY

TOPOGRAPHY AND DRAINAGE

The Bear River originates in the Uinta Mountains in Utah and flows northward into Wyoming. The longitudinal profile of the river is steep near its headwaters but flattens greatly within a short distance. The gradient of the river from the south border of Wyoming to Almy, 3 miles north of Evanston, a distance of 40 river miles, averages 30 feet per mile, but from Almy to the east border of Utah, a distance of 28 river miles, the gradient averages 8.5 feet per mile. In the northern Bear River valley, the gradient averages only 2.1 feet per mile in a distance of 40 river miles. The uplands to the east of the Bear River valley constitute the divide between the drainage basin of Great Salt Lake and the Green River. The uplands to the west are the divide between the circuitous drainage of the Bear River and the direct drainage to Great Salt Lake.

The Bear River valley reaches its maximum width of about 3 miles a few miles north of the south border of Wyoming. (See pl. 1.) The valley narrows to less than a quarter of a mile at Myers Narrows, about 9 miles south of Evanston, and to less than 100 yards at The Narrows, north of Evanston. The northern Bear River valley is generally 1 to 2 miles wide except at The Narrows, north of Cokeville, where it is less than a quarter of a mile wide.

CLIMATE

The climate of the Bear River valley area is semiarid and is characterized by extremes of temperature. Records of the U.S. Weather Bureau for Evanston in the southern Bear River valley show that the mean annual temperature for the period 1931–55 was 39.5° F; the range in mean monthly temperatures for the same period was from 17.1° F in January to 62.5° F in July. The mean annual precipitation was 12.69 inches for the period 1899–1955. The mean growing season (period between killing frosts) for the period 1898–1950 was 88 days.

Mean monthly temperatures at Border, 13 miles north of Cokeville, in the northern Bear River valley, range from 11.4° F in January to 62.9° F in July and the mean annual temperature was 38.2° F for the period 1931–52. The mean annual precipitation for the period of record (1902–55) was 13.12 inches. The mean growing season averaged 70 days in the period of 1902–50. Figure 4 shows the annual and monthly precipitation at Border and Evanston.

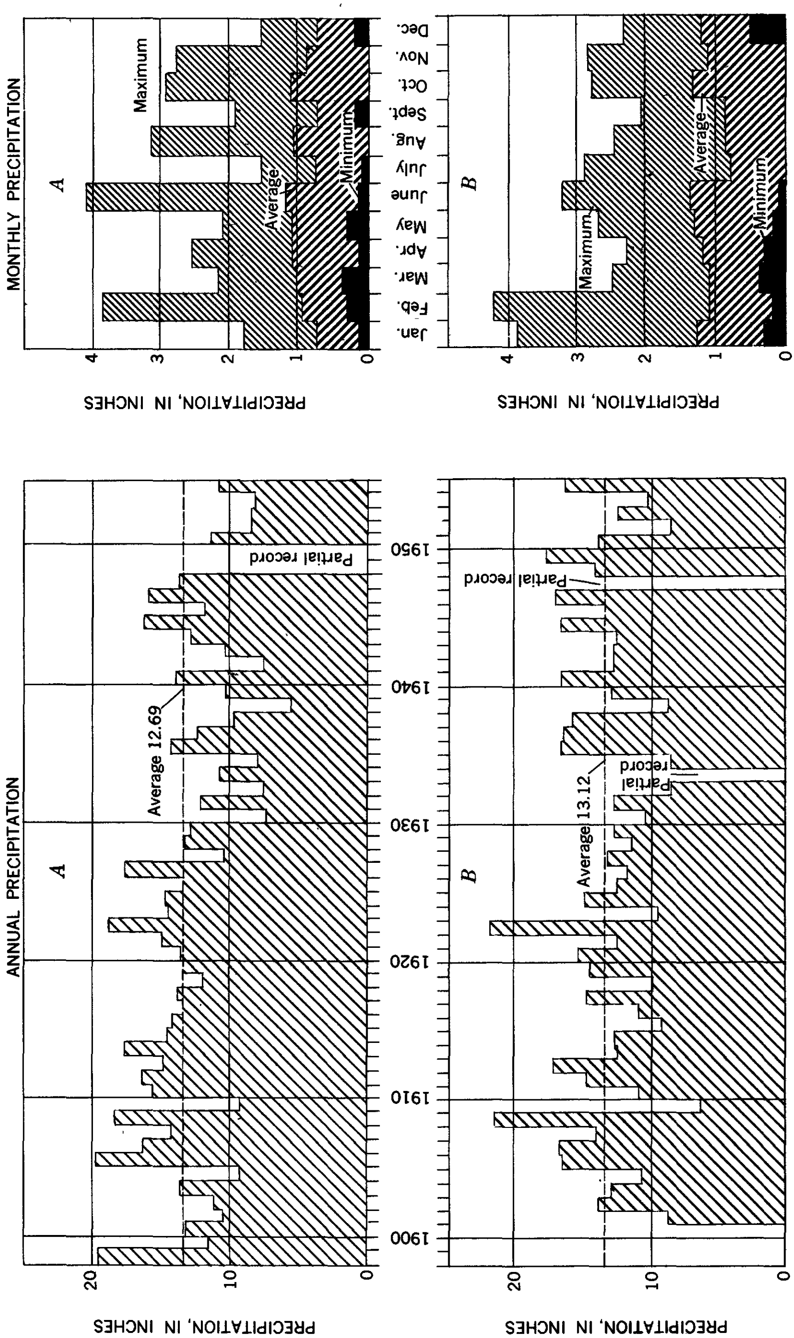

FIGURE 4.—Precipitation records at (A) Evanston and (B) Border, Wyo. (Records from U.S. Weather Bureau)

AGRICULTURAL, INDUSTRIAL, AND CULTURAL DEVELOPMENT

Agriculture is the most important industry in the Bear River valley. The major crops are alfalfa and native grass, which are cut for hay and used as livestock feed. Water for irrigation is principally water diverted from the Bear River and its tributaries. Veatch (1907, pl. 2) shows that a large part of the present irrigated land in the valley was also irrigated in 1906. There are no irrigation wells in the southern Bear River valley, but there is one in the Yellow Creek valley southwest of Evanston, and several irrigation wells have been drilled in the northern Bear River valley.

The city of Evanston, population 3,863 in 1950, is the trading center for the southern Bear River valley. It was founded near the coal mines which supplied coal for the Union Pacific Railroad after the Civil War. A branch of the Union Pacific Railroad and U.S. Highway 30 South pass through Evanston and cross the southern Bear River valley.

Cokeville, population 440 in 1950, is the trading center for the agricultural area of the northern Bear River valley. A branch of the Union Pacific Railroad and U.S. Highway 30 North enter the northern Bear River valley west of Sage, pass through Cokeville, and leave Wyoming at Border.

The chief mineral commodity produced in the area is phosphate, which is mined in the Beckwith Hills west of Sage.

GEOLOGIC SETTING

The topography of southwestern Wyoming west of the floor of the Green River basin is characterized by northward-trending mountain ranges, ridges, and valleys that are an expression of the geologic structure. Underlying the area are complexly folded and eastward-thrust rocks of Paleozoic, Mesozoic, and early Tertiary age overlain by only slightly deformed later Tertiary and Quaternary sediments. The north-south belt of mountains and overthrust faults is known as the "overthrust belt of western Wyoming and adjacent States." The Laramide orogeny that produced the folding and faulting began during Cretaceous time and may have lasted into Eocene time. The arching of the Unita Mountains to the south and the deformation of the rocks composing the Wasatch Mountains to the west are also results of this orogeny.

The valley of the Bear River follows approximately the north-south trend of the structures and its width is closely related to the lithology of the rocks in which its original bedrock-floored valley was cut; several narrow places in the valley are bordered by rocks that are more re-

TABLE 1.—*Stratigraphic units and their water-bearing properties*

System	Series	Unit	Thickness (feet)	Physical character and distribution	Water-bearing properties
Quaternary	Recent	Slope wash and rock debris	0–?	Locally derived rock fragments mantling slopes.	May be capable of yielding small amounts of water sufficient for domestic and stock supply.
		Eolian deposits	0–10±	Wind-blown sand and silt mantling small areas.	Ground-water possibilities not known, but deposits are probably too thin and fine grained to yield usable amounts of water.
		Alluvial fans	0–150+	Gravel, sand, and silt derived from small tributary drainage basins. Well developed on west side of Bear River valley near Cokeville.	Large yields obtainable where a considerable thickness of saturated material is present Locally may supply sufficient water for limited irrigation.
	?	Alluvium (flood-plain and channel deposits)	0–185+	Gravel, sand, and silt underlying stream valleys.	Yields as much as 1,100 gpm to individual wells and is capable of even greater yields; most productive aquifer in area.
	Pleistocene	Terrace deposits, terrace gravels, and older alluvium	0–50+	Gravel, sand, and silt in places along sides of Bear River valley and Hilliard Flat.	Yields small quantities to wells. Probably capable of moderate yields where a considerable thickness of saturated material is present. Locally may supply sufficient water for small industries.
Quaternary(?) or Tertiary(?)	Pleistocene(?) or Oligocene(?)	Gravel	0–50+	Gravel mantling slopes in northern part of area.	Ground-water possibilities not known

Tertiary	Eocene	Knight formation	Wasatch formation in northern part of area.		500–5,000	Sandstone, shale, and claystone. Extensive in npland areas.	Yields small quantities for domestic and stock use. Probably conld yield moderate quantities in some areas.
		Fowkes formation			0–2,500	Shale of volcanic origin, sandstone, claystone, and limestone. Exposed in upland areas.	
	Paleocene	Almy formation			2,100–3,200	Claystone, sandstone, and comglomerate	
		Evanston formation		Unit names not applicable in northern part of area	1,500+	Clay, shale, sandstone, and coal	
Cretaceous		Hilliard shale			2,940–6,800	Shale, and sandstone. Underlies gravel mantle at Hilliard Flat.	
		Frontier formation (Oyster Ridge sandstone member in middle)			2,000+	Shale and sandstone	
		Aspen shale	Bechler conglomerate, Ephraim conglomerate, and Draney limestone and units A through E in northern part of area		325–2,000	Shale and bentonite	
		Bear River formation			500–5,000	Sandstone, shale, limestone, and coal. Crops out on ridge between Bear River valley and Hilliard Flat.	
		Gannett group			360–2,400	Limestone, shale, conglomerate, and sandstone.	

TABLE 1.—*Stratigraphic units and their water-bearing properties*—Continued

System	Series	Unit	Thickness (feet)	Physical character and distribution	Water-bearing properties
Jurassic		Stump sandstone and Preuss sandstone	≦1,900	Sandstone and some sandy siltstone	The ground-water possibilities of the consolidated bedrock formations were not investigated in detail. However, formations composed principally of relatively permeable materials, such as sandstone, conglomerate, and, possibly, fractured and fissured limestone, may be expected to yield small to moderate quantities of water in areas where they dip gently and are not complexly folded or faulted. Formations composed principally of siltstone, shale, and bentonite, will yield only meager amounts of water to wells.
		Twin Creek limestone	≦3,000	Limestone. Exposed in the Narrows north of Cokeville.	
		Nugget sandstone	[1] 1,500	Sandstone. Exposed near Cokeville	
Triassic		Ankareh red beds	450–1,400	Limestone and sandstone	
		Thaynes limestone	0–1,190	Limestone, sandstone, and shale	
		Woodside red beds	500–1,000	Shale and sandstone	
		Dinwoody formation	0–750	Sandstone and siltstone	
Permian		Phosphoria formation: Rex chert member	250–350	Phosphatic shale and cherty limestone. Exposed in Beckwith Hills and east of Cokeville.	
		Phosphoria formation: Meade Peak phosphatic shale member			
Permian and Pennsylvanian		Wells formation	[2] 2,400	Sandstone and limestone. Exposed east of Cokeville.	

[1] In southern area of outcrop.
[2] In Bear Lake area, Idaho.

sistant to erosion than the rocks bordering the wide stretches of the valley.

The topography of the uplands bordering the valley is of two types and is intimately related to the structure and degree of deformation of the underlying rocks. Beds that are folded and faulted and dip steeply have been eroded into ridges and valleys that generally follow the north-south trend of the structures. Sediments deposited after the main part of the Laramide orogeny are not deformed or were only slightly deformed by orogenic movement and form plateaus, tablelands, and benches. Therefore, the surface topography gives a clue to the age of the underlying rocks.

The geomorphic processes active in the formation of the present landscape have been described by Bradley (1936) for the north flank of the Uinta Mountains and the adjacent northern lowlands in the area east of the divide between the Bear River and Green River Basins. The physical and water-bearing characteristics of the sedimentary rocks in the Bear River valley are summarized in table 1; the units that are important aquifers are discussed in greater detail in the section on stratigraphic units and their water-bearing properties (p. V18).

OCCURRENCE OF GROUND WATER

Ground water is water beneath the land surface in the zone of saturation. It is derived chiefly from precipitation. A large part of the precipitation is carried away by streams as surface runoff; some evaporates from the surface, and the remainder is absorbed by the soil and the underlying material. Some of the water that enters the ground is lost by evaporation and transpiration and some moves downward until it reaches the water table, the top of the zone of saturation, where is becomes ground water. At the water table, the pressure is atmospheric and below it the water is under hydrostatic pressure.

POROSITY AND PERMEABILITY

The alluvial materials underlying the Bear River valley are composed mainly of weakly cemented clay, silt, sand, and gravel. The bedrock formations are composed mainly of claystone, shale, siltstone, sandstone, conglomerate, limestone, and local coal beds which are more consolidated than the alluvial materials.

All these sediments contain interstices or voids between the individual grains, and the volume of the voids depends upon the size, shape, sorting, arrangement, and degree of cementation of the particles composing the sediments. The ratio of the volume of the voids to the total volume of the rock material, expressed as a percentage, is called the

656184 O—63——3

porosity. When the voids are filled with water the rock is said to be saturated; thus the porosity indicates the amount of water the material will hold. Well-consolidated rocks generally have lower porosity than unconsolidated or poorly consolidated rocks, and fine-grained materials commonly have higher porosity than coarse-grained materials.

The ability of a rock unit to transmit water, and thus to yield water to wells, is called its permeability. The number, size, and degree of interconnection of the voids governs the permeability. A rock unit capable of yielding water to wells or springs is known as an aquifer. Clay and other fine-grained materials, having small interstices, although commonly of high porosity, transmit water slowly, but coarse sand or gravel, having large interstices, transmits water more rapidly.

WATER-TABLE AND ARTESIAN CONDITIONS

The water table is not a flat or level surface but slopes in general agreement with the slope of the land surface and reflects the topography of the land surface in a subdued manner. That is, the water table generally is higher under high surface areas than under low surface areas but the relief of the water table is less than that of the land surface. The water table rises and falls in response to the amount of water entering or leaving the ground-water reservoirs. The distance between the water table and the bottom of the water-bearing rocks is known as the saturated thickness and varies with the rise and fall of the water table. When the water table rises, the saturated thickness and, consequently, the amount of water in storage in the aquifer increases; when the water table declines, the reverse is true. The water level in wells that tap a water-table aquifer stands at the level of the water table in the aquifer. For this reason, records of the fluctuations of water level in wells for long periods of time are valuable in ascertaining the changes in the amount of ground water in storage. Ground water in the valley fill and other unconsolidated alluvial deposits in the Bear River valley occurs under water-table conditions.

Artesian conditions occur where an aquifer is overlain by a relatively impermeable bed which confines water in the aquifer under hydrostatic pressure. The water level in wells tapping an artesian aquifer is higher than the top of the aquifer; if the pressure is great enough to raise the water above the land surface at the well site the well will flow. A potentiometric surface of an aquifer is an imaginary surface that coincides with the head of water in the aquifer and is analogous to the water table. Ground water in the consolidated bedrock formations of the Bear River valley generally occurs under artesian conditions except in the recharge (outcrop) areas.

RECHARGE AND DISCHARGE

Aquifers under water-table conditions in the Bear River valley are recharged by direct penetration of local rainfall and snowmelt, seepage from streams, and seepage from irrigation canals and irrigated fields. Artesian aquifers in the Bear River valley are recharged by underflow from adjacent areas, by infiltration of precipitation on outcrop areas, by influent seepage from streams crossing the outcrops, and by leakage of water through confining beds.

Ground water is discharged from the zone of saturation by both natural and artificial means. Means of natural discharge include underflow to adjacent areas, evaporation at the land surface, transpiration, and discharge through seeps and springs. Evaporation and transpiration by plants (evapotranspiration) are particularly effective in areas where the water table is near the land surface, mainly during the season when plants are growing actively. Artificial discharge of ground water is through flowing or pumped wells.

If extensive development of ground water for irrigation is undertaken in the Bear River valley in the future, a considerable change in the position of the water table might take place. Additional discharge of ground water by wells would constitute a new discharge superimposed on the existing balanced system of natural recharge and discharge. Before a new equilibrium condition would be established, water levels must decline sufficiently throughout the aquifer to increase the natural recharge or decrease the natural discharge, or both, by the discharge from the wells. In the alluvium, water levels would decline in the vicinity of the pumping wells during the irrigation season but could be expected to recover during the nonpumping season when the ground-water reservoir is replenished by seepage from precipitation and streamflow and by underflow from adjacent areas.

As soon as a pump begins to withdraw water from a well under water-table conditions, the water table in the vicinity of the well is lowered, a hydraulic gradient toward the well is established, and ground water flows toward the well. The water table assumes the form of an inverted cone, with the pumped well at the apex of the cone. The cone of depression spreads laterally as materials farther from the well are dewatered. When pumping begins, the water table in the vicinity of the well lowers rapidly at first, then gradually slows as the cone of depression spreads laterally. The rate of spread depends upon the thickness and permeability of the aquifer and the discharge of the well.

When the pump is shut off, the water continues to flow in the direction of the hydraulic gradient and fills the voids that were dewatered by pumping. Initially, water flows toward the well at a relatively

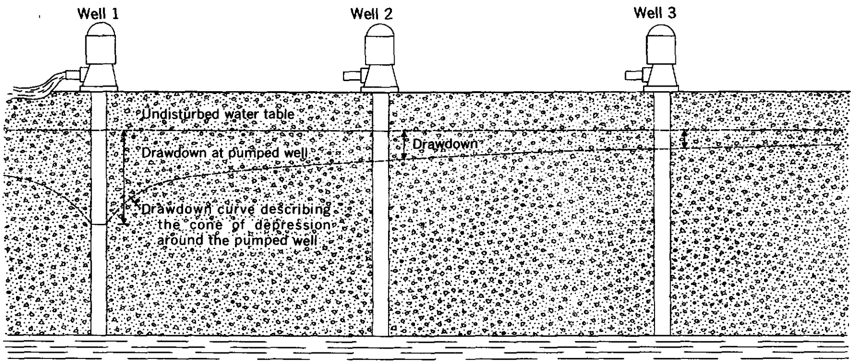

FIGURE 5.—Diagrammatic section of the water table near a well that is being pumped.

rapid rate, but as the voids become filled and the gradient decreases, the rate of flow decreases, and flow toward the well ceases when the cone of depression is filled.

Figure 5 illustrates the cone of depression caused by a pumping well and the drawdown caused in nearby unpumped wells. If wells are closely spaced, mutual interference may lower water levels greatly in nearby wells. If several closely spaced wells are pumped at the same time the mutual interference may greatly increase pumping lifts.

The ratio of the discharge, in gpm (gallons per minute), to the drawdown, in feet, is called the specific capacity, and is a guide to the productivity of the well. For example, a well producing 1,000 gpm at 50 feet of drawdown has a specific capacity of 20; a well producing 2,000 gpm at 50 feet of drawdown has a specific capacity of 40. Specific capacities of wells in the alluvial fill of the Bear River valley range from 17 to 56.

FLUCTUATIONS OF WATER LEVEL

Ten wells tapping the unconsolidated Quaternary sediments and one well penetrating both terrace deposits and bedrock were selected for observation of the water levels. Measurements of the depths to water, made periodically between July 1955 and September 1958, are presented in table 2. The maximum change in water level for the observation period was 10.2 feet in well 16–121–11ac, which penetrates both terrace deposits and bedrock. The maximum change in wells that tap the alluvium was 9.0 feet in well 23–119–32bd and the least was 1.2 feet in well 23–119–7acc. The fluctuations represent a seasonal change. The highest water levels occur during the growing season when irrigation water replenishes the aquifer. The lowest water levels occur during the winter when water is discharged from the aquifer.

TABLE 2.—*Depths to water below the land surface, in feet, in observation wells in the Bear River valley*

[Aquifer: Qal, alluvium; Qaf, alluvial fan deposits; Qs, slope wash; Qt, terrace deposits; Tw, Wasatch formation, or rocks of equivalent age]

Well	Aquifer	July and Aug. 1955	Nov. 24, 1955	Feb. 7, 1956	Apr. 19, 1956	June 16, 1956	Sept. 4, 1956	Oct. 30, 1956	Apr. 28, 1957	Oct. 11, 1957	Apr. 12, 1958	Sept. 29, 1958
13-120-23aa	Qal	2.57	0.87	1.87	1.50							
15-120-8dd	Qal	3.78	2.03	------	------	1.71	4.59	2.18	------	------	------	------
16-121-11ac	Qt, Tw	22.45	23.39	26.55	23.05	16.39	24.18	26.53	22.06	22.90	21.78	24.34
24ad	Qal	8.32	7.14	7.00	7.00	5.53	7.37	7.90	6.26	7.38	8.05	7.83
36cd	Qal	3.13	2.40	------	1.20	------	------	------	------	------	------	------
22-120-10dc	Qs	13.20	13.33	------	------	11.79	12.90	13.28	11.88	12.12	11.56	13.45
23-119-6ad	Qaf, Qal	11.83	16.11	------	------	11.15	14.70	11.34	11.20	13.64	------	------
9bc	Qal	8.10	8.28	9.33	------	7.83	4.68	6.90	8.17	------	------	------
18bb	Qaf, Qal	44.92	44.61	44.59	------	------	44.68	44.25	46.17	44.19	------	44.42
32bd	Qal	19.70	26.40	------	------	22.78	20.21	28.69	------	------	------	------
7acc	Qal	------	------	------	------	------	6.70	6.55	6.46	7.66	------	6.75

STRATIGRAPHIC UNITS AND THEIR WATER-BEARING PROPERTIES

PRE-TERTIARY ROCKS

The rocks in and along the Bear River valley fall into two general groups: the consolidated bedrock formations, consisting of rocks generally of pre-Tertiary and Tertiary age, and the unconsolidated valley fill and associated deposits of Quaternary age. The consolidated rock is only a minor producer of water in the area; the unconsolidated valley fill contains the most productive aquifers.

The Paleozoic rocks exposed in the Bear River valley are the Wells and Phosphoria formations comprising limestone, sandstone, quartzite, and shale. These formations may be expected to yield small to moderate amounts of water to wells. The only information available on the water-bearing character of these rocks is from Sucker Spring in sec. 26, T. 22 N., R. 120 W. (Harris and Jibson, 1954). The spring issues from a fissure in Paleozoic rocks and discharges into the Bear River. Its flow on June 23, 1954, was reported to be 1.1 cfs (cubic feet per second). However, the flow of the spring varies widely from time to time, as reported field estimates of the flow made from June 10 to August 24, 1954, ranged from nil to 2.0 cfs.

The Mesozoic rocks comprise shale, sandstone, and limestone. The more permeable rocks, such as sandstone and limestone, may be expected to yield small to moderate quantities of water. The fine-grained rocks, such as the Hilliard shale, generally cannot be expected to yield sufficient water to wells even for domestic use.

The thickness, physical character, and water-bearing properties of the sedimentary rocks in the Bear River valley are summarized in table 1.

Owing to the folding and faulting that has deformed the Paleozoic and Mesozoic rocks, the beds in many areas are discontinuous, dip steeply, and have small outcrop areas. Permeable beds that dip steeply or do not have great areal extent may yield small quantities of water, but the supply is dependent upon local conditions of recharge and may be quite variable. In areas where the permeable beds dip gently and their continuity is not interrupted by faulting, they may yield small to moderate quantities of water to wells. In some areas, depths to water-bearing formations may be so great as to make drilling uneconomical.

TERTIARY ROCKS

Tertiary rocks are exposed extensively in the uplands along the Bear River valley. They include part of the Evanston formation and the Almy, Fowkes, and Knight formations in the southern Bear River valley. In the northern Bear River valley the Tertiary rocks are assigned to the Wasatch formation. The Tertiary and older formations were not studied in detail during the investigation, but information from a few wells indicates that small to moderate yields are available from the permeable beds. Small springs commonly issue from these beds where they have been dissected by streams. The springs generally are small swampy depressions on hillsides and provide only small supplies sufficient for livestock.

QUATERNARY SEDIMENTS

Unconsolidated sediments of Quaternary age are represented in the Bear River valley by terrace deposits, stream-channel and flood-plain deposits, alluvial fans, slope wash, and eolian deposits. These sediments are the "valley fill." Figure 6 is a generalized cross section of

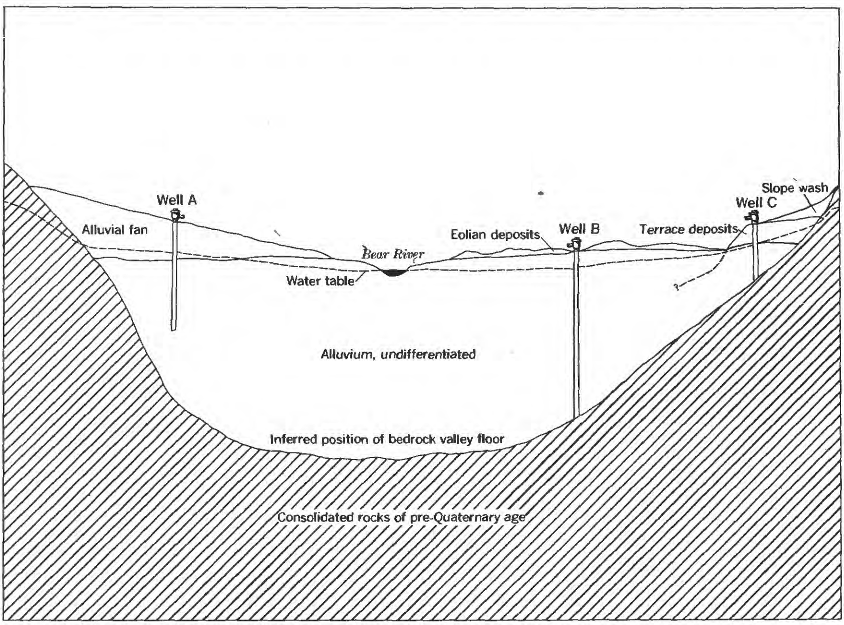

FIGURE 6.—Diagrammatic cross section of the Bear River valley showing the general relations of the Quaternary deposits.

the valley showing the relation of the Quaternary deposits and the bedrock-valley walls. The bedrock valley was carved in the consolidated rocks by the Bear River as it flowed from the north flank of the Uinta Mountains. Subsequently, during Quaternary time, the valley was filled with sediments deposited by the overloaded river and its tributaries. The terrace deposits along the sides of the valley are the oldest exposed components of the valley fill and are remnants of former valley floors which survived erosion during downcutting stages of the stream. Stream-channel and flood-plain deposits underlie the existing valley floor and are the result of the most recent depositional phase of the Bear River and its tributaries. Alluvial fans, which in places overlie and form gentle slopes upward and outward from the valley floor, were deposited by tributary streams flowing down the sides of the Bear River valley. Slope wash and eolian deposits are recent accumulations of weathered rock fragments. Slope wash forms a thin mantle of debris over the bedrock walls of the valley from which it is derived. Eolian deposits, which overlie the valley floor in places, are wind-accumulated material obtained principally from stream-laid sediments.

The valley fill is composed of rock fragments ranging in size from silt to large cobbles. The degree of sorting may be expected to differ greatly from place to place, often within short distances. In some places, coarse and fine materials may be interbedded; in others they may be intermixed. Figure 7 shows an exposure of terrace gravel

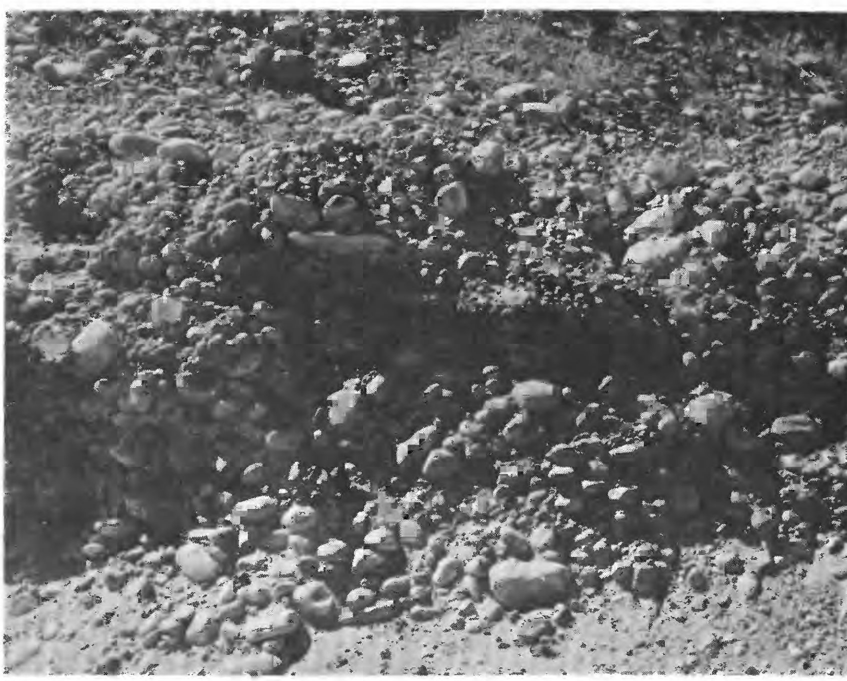

FIGURE 7.—Terrace gravel in roadcut on the west side of the Bear River valley about 6 miles south of Evanston. It is typical of the alluvial material in the Bear River valley. (Photograph by C. J. Robinove.)

that may be considered typical of the less well sorted materials. The valley fill is the largest potential source of ground water in the area. It ranges in thickness from a narrow wedge along the margins of the valley to more than 185 feet; the material commonly is coarse and permeable and, except in the terrace and alluvial-fan deposits, the water table generally is close to the land surface. The yield from wells drilled in the alluvium of the Bear River valley will depend on the extent and thickness of the saturated material penetrated, the grain size and degree of sorting, and the availability of recharge. Because of the variations in the factors controlling permeability, yields from wells may be expected to differ greatly from place to place.

Well A in figure 6 is a typical well on an alluvial fan and penetrates part of the valley fill. The water table is near the level of the valley floor, and the well obtains most of its water from the underlying alluvial sediments. If this well penetrated the total thickness of the valley fill, it undoubtedly would produce a larger quantity of water and have a larger specific capacity. Well B is on thin eolian deposits overlying the valley fill. The water table is much nearer the surface than in well A, and the well penetrates the total thickness of the valley fill. This well would have the largest specific capacity of the three wells shown. Well C is on a terrace and its location with respect to thickness of alluvium is similar to that of well A. Although it penetrates the total thickness of the valley fill, it would not produce as much water as well A or well B because the saturated section of the alluvium is much thinner at well C.

Slope wash is composed of debris locally derived from weathering of rocks exposed on the valley sides; its character depends upon the rock type from which it was derived. Eolian deposits consist of wind-blown silt and sand that mantle alluvium and bedrock in the northern section of the valley. The slope wash and eolian deposits generally lie above the water table and thus are not aquifers. Slope wash, however, may act as a confining bed for artesian water in the Yellow Creek valley. The eolian deposits are not a source of ground water in the area because they are topographically high and lie above the water table but they may serve as catchment areas for precipitation.

GROUND-WATER CONDITIONS

The order of discussion of the ground-water resources of the alluvial material underlying the Bear River valley is from south to north and is divided into six sections for convenient reference.

SOUTHERN BEAR RIVER VALLEY

BEAR RIVER VALLEY WEST AND SOUTH OF HILLIARD FLAT

There are few wells in the southern Bear River valley west of Hilliard Flat; therefore, little information is available as to the thickness and type of material underlying the valley. The geologic history sheds some light on the thickness of alluvium to be expected in the valley. Veatch (1907, p. 100) regarded the present course of Mill Creek, along the east side of the valley, as the original course of the Bear River and the present course of the Bear River, along the western edge of the valley, as a recently established course. This, together with the fact that low, rounded hills of the Knight formation protrude as islands above the alluvium between the Bear River and Mill Creek, indicates that possibly the thickest deposits of alluvium underlie the east side of the present wide valley. The greatest thickness of the alluvium penetrated by wells in Tps. 12 and 13 N., Rs. 119 and 120 W., is 25 feet at well 12–119–6add$_2$ about three-quarters of a mile east of Mill Creek. The alluvium probably is thicker than 25 feet, as bedrock was not reported to have been reached in this well. Well 12–120–12dda is reported to bottom in bedrock at a depth of 18 feet, but the well is very close to an outcrop of the Knight formation. Well 13–120–35ad was reported to have penetrated 17 feet of coarse alluvium before entering bedrock. Drillers report that most of the material found in drilling wells is gravel, but it probably is gravel mixed with clay and silt in varying proportions.

HILLIARD FLAT

Hilliard Flat is the southwestern continuation of Mammoth Hollow, a long, narrow, topographically low area lying east of the map area and extending southward and southwestward from about the latitude of Border, Wyo., to about the latitude of Evanston, Wyo. Its subdued topography is due to the fact that its floor is composed of the Hilliard shale, which is easily weathered and eroded. In Hilliard Flat, however, the shale is mantled by unconsolidated alluvial materials, about 30 feet thick (Veatch, 1907, p. 100), whose top now lies about 50 feet above the present floor of the Bear River valley. These unconsolidated materials were considered by Veatch, (1907) to be derived from the erosion of the north flank of the Uinta Mountains to the south and to have been deposited by the Bear River as it flowed over Hilliard Flat before occupying its present valley. Logs of wells indicate that the material is mostly unconsolidated gravel, but a layer of cemented gravel (locally called hardpan) has been reported to occur at a depth of about 7 feet. Wells that penetrate the hardpan, which acts as a confining bed, have been reported to flow for a short time.

Hilliard Flat is drained by Sulphur Creek, which flows along the east and north sides of the Flat and enters the Bear River valley through a gap cut in bedrock at the north end of Hilliard Flat.

BEAR RIVER VALLEY BETWEEN HILLIARD FLAT AND EVANSTON

Residents of the area between the north end of Hilliard Flat and Evanston are served by the Evanston municipal water supply; accordingly, few wells have been drilled, and no information is available on the thickness of the alluvium except in the immediate vicinity of Evanston.

The city of Evanston has three public-supply wells that produce water from alluvium to supplement the supply obtained from the Bear River. The deepest well, 185 feet deep, is on the bank of the Bear River, west of the center of the valley. The driller's log of the well shows a total of only 5 feet of clay, the rest of the material being reported as sand and gravel. The well did not reach bedrock; therefore, the alluvium is more than 185 feet thick at this site. Owing to construction difficulties, the well casing was perforated only from 55 feet to 75 feet, a zone which, according to the driller's log, is composed of 16 feet of gravel, 3 feet of sand, and 1 foot of clay. A specific-capacity test made on this well in 1950 indicated a drawdown of 26.5 feet while the well was discharging 730 gpm, or a specific capacity of 27.5 gpm per foot of drawdown. The water level was 8.48 feet below the land surface before pumping began and the pumping lift was 35 feet. If the casing had been perforated throughout the total depth of the well and the water level had been drawn down farther, it is probable that more than 2,000 gpm would have been obtained. The second city well, 65 feet deep, nearer the west side of the valley, has a specific capacity of 23 gpm per foot of drawdown. The third city well, on the south side of the city, is at the edge of the alluvium. It is 80 feet deep, but no log or construction record is available. The discharge is reported to be 425 gpm, but the drawdown is not known.

Terrace deposits are well exposed along the west borders of the valley southeast of Evanston. No wells are known to produce water from these deposits and no information is available on its water-bearing properties. Figure 7 shows the character of the gravel.

YELLOW CREEK VALLEY

Yellow Creek, which heads southwest of Evanston, flows into the Bear River north of Evanston. Well 15–120–31db, in the Yellow Creek valley, is 100 feet deep, and the owner reports that it penetrates

50 feet of clay overlying 50 feet of gravel. Much of the clay is slope wash and the gravel possibly is buried alluvium of Yellow Creek. The slope wash acts as a confining bed for artesian water in the alluvium. The well flows at a rate of 60 gpm and is pumped for irrigation at a rate of 320 gpm. The drawdown could not be measured.

BEAR RIVER VALLEY FROM EVANSTON TO THE UTAH STATE LINE

For a distance of about 16 miles from a point north of Evanston to Narrows Hill, the Bear River valley maintains a fairly uniform width of about 1 mile, except for a constriction about half a mile wide about 11 miles north of Evanston. Only shallow stock and domestic wells have been constructed in this section of the valley. It is probable that the alluvium is about the same thickness as near Evanston. Well 16–121–11ada is a 28-foot domestic well drilled in the valley fill. The well, which was equipped with a small turbine pump, was pumped at a rate of 11 gpm for 1 hour at the end of which time the water level had lowered 1.55 feet, indicating a specific capacity of about 7 gpm per foot of drawdown. The water level before pumping was 2.67 feet below the land surface. This specific capacity, however, is not representative of the aquifer as a whole because the well penetrates only the top 28 feet of the aquifer. Wells penetrating a thicker saturated section of the valley fill will yield larger quantities of water and have larger specific capacities.

About 16 miles north of Evanston, in sec. 32, T. 18 N., R. 120 W., the Bear River bends sharply northeast, then swings north and passes west through The Narrows, around Narrows Hill. Beyond, it again enters a broad valley and flows west into Utah. Veatch (1907, p. 100) interpreted the geologic events in this section of the valley as follows: The Bear River originally flowed west of Narrows Hill, Salt Creek flowed southwest through the upper part of The Narrows, and Alkali Creek flowed west through the lower part of The Narrows. The Bear River filled its channel with sediments faster than Salt Creek and Alkali Creek and was deflected up the valley of Salt Creek, where it cut through a low divide and flowed westward down the valley of Alkali Creek on the north side of Narrows Hill.

There is no direct information available regarding the thickness of the alluvium in the former or present channels, but probably the alluvial material in the former channel is comparable in thickness to the valley fill underlying the main valley farther south, and the present narrow channel contains only a small thickness of alluvium.

NORTHERN BEAR RIVER VALLEY

The Bear River reenters Wyoming west of Sage and flows to the Idaho State line in a valley averaging 2 miles in width. About 2 miles north of Cokeville the valley narrows to one-fourth of a mile for a distance of about one-half mile. The west side of the valley from a point 11 miles south of Cokeville to Cokeville is flanked by coalescing alluvial fans; the largest and best developed fan extends for about 2 miles along the valley borders.

No wells are known to penetrate the full thickness of the valley fill, but several irrigation wells have been drilled into the valley fill, and logs of these wells provide some information on the type of material encountered. Well 23–120–18bb, on an alluvial fan, penetrated 142 meet of unconsolidated sediments in the fan and the underlying valley fill. It produces 400 gpm with a drawdown of 21 feet at a specific capacity of 19 gpm per foot of drawdown. The static water level in this well, which is on the fan and about 45 feet above the level of the valley floor, is approximately 44 feet below the land surface and is therefore approximately at the level of the valley floor. The water in the alluvial-fan deposits is derived from precipitation on the small drainage basin of the stream that formed the alluvial fan. The stream is influent; that is, it loses water into the materials composing the fan and thus recharges the ground-water reservoir.

Well 23–119–29cd is 150 feet deep but did not penetrate the full thickness of the valley fill. It produces 1,120 gpm with 20 feet of drawdown at a specific capacity of 56 gpm per foot of drawdown.

Well 23–119–7acc is near the toe of an alluvial fan. It penetrated 117 feet of alluvial material but did not reach bedrock. The well produces 500 gpm with a drawdown of 29 feet at a specific capacity of 17.2 gpm per foot of drawdown.

Well 24–119–5cc, in the town of Cokeville near the center of the valley, penetrated 154 feet of valley fill. The drawdown was 20 feet while the well was pumping 1,120 gpm. The discharge and drawdown is the same as for well 23–119–29cd, 10 miles south, suggesting that the hydrologic properties of the valley fill are fairly constant through this section of the valley. From the available data, it is evident that large quantities of ground water can be obtained from the Quaternary sediments of the Bear River valley.

AVAILABILITY OF GROUND WATER

Ground water in quantities adequate for domestic and livestock use can be obtained from permeable beds in some of the bedrock formations underlying the Bear River valley and adjacent uplands. Ground water in quantities sufficient for irrigation and large-scale municipal or industrial use can be obtained from the unconsolidated Quaternary sediments underlying the Bear River valley. Properly constructed wells penetrating the greatest thickness of the valley fill could be expected to produce more than 2,000 gpm. It is not possible to determine the volume of ground water in storage in the unconsolidated sediments of the Bear River valley, because the maximum thickness of the sediments is unknown. Data from the Evanston public-supply wells in the southern Bear River valley and irrigation wells in the northern Bear River valley indicate that the maximum thickness is greater than 185 feet. The alluvium consists largely of coarse gravel, and the water table is near the surface; therefore, it is reasonable to assume that a large amount of water is in storage.

The mantle of terrace deposits on Hilliard Flat probably is not thick enough to contain large quantities of water and thus probably would not furnish large sustained yields to wells. The alluvium of the Yellow Creek valley is capable of yielding moderate amounts of water.

In order to locate the thickest and most permeable water-bearing materials in areas underlain by Quaternary sediments, it is advisable to drill test holes before drilling a more expensive large-diameter well. Generally, one or more buried channels that mark the position of the thickest and most permeable water-bearing materials lie beneath the valley fill. The buried channels generally may have a much different course than the present meandering stream. The position of the buried channels is not indicated by the position of the present channel, and their width and extent can be determined most easily by test drilling. Although irrigation wells of sizeable yield have been developed that do not penetrate the full thickness of the valley fill, the greatest yields and largest specific capacities may be expected where the full section is penetrated.

If extensive test drilling is planned, the buried channels may be found with a minimum of test drilling by locating the test holes along lines across the flood plain at approximate right angles to the trend of the valley. Widely spaced test holes along these lines might then be supplemented by additional test holes drilled between those of the initial survey that penetrate the thickest and most permeable water-bearing materials.

CHEMICAL QUALITY OF THE WATER

By John G. Connor

Samples were collected from 16 ground-water and 9 surface-water sources during the period April 13–19, 1956, to obtain information on water quality in the Bear River valley, Wyoming. (See fig. 8.) Two additional ground-water samples were collected, one in July 1956, and one in March 1958, and eight additional stream samples were collected in June and September 1956 at four points on the Bear River

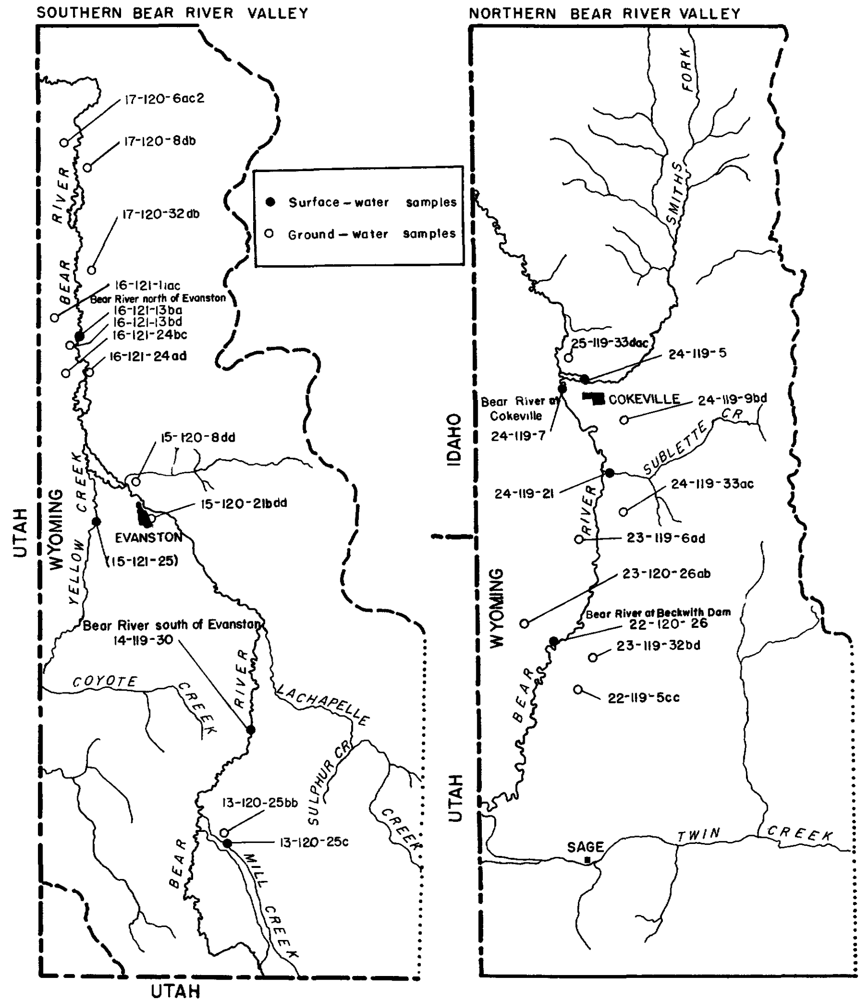

FIGURE 8.—Map showing ground- and surface-water sampling points in the Bear River valley, Wyoming.

that had been sampled in April. The additional stream samples were collected to ascertain whether there were marked differences in chemical quality between high and low flows.

The results of chemical analyses of ground-water samples are shown in table 3, and of surface-water samples in table 4.

TABLE 3.—*Chemical analyses of ground water in the Bear River valley, Wyoming*

[Analytical results in parts per million, except as indicated]

Well	Depth (feet)	Geologic source	Date of collection	Temperature (° F)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Dissolved solids (sum)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C)	pH
Southern part, Bear River valley																				
13-120-25bb	152	Tertiary deposits	4-18-56	52	0.01	84	24	7.7	-----	358	24	10	0.7	-----	326	308	14	5	579	7.4
15-120- 8dd	30.2	Alluvium	4-19-56	52	.01	74	30	59	-----	389	70	42	.0	-----	467	310	0	29	788	8.1
21bdd	65	do	7- 3-56	46	-----	82	20	41	1.3	383	24	20	9.8	0.2	[1] 399	288	0	24	672	7.3
16-121-11ac	33.9	Terrace deposits and Tertiary deposits.	4-17-56	45	.01	49	42	53	-----	255	52	90	30	-----	422	298	89	28	799	7.7
13bd	15	Alluvium	4-19-56	50	.00	44	43	74	-----	368	72	42	35	-----	491	290	0	36	811	8.2
24ad	9.6	do	4-18-56	46	.01	147	148	243	-----	476	700	290	7.1	-----	1,770	976	586	35	2,610	7.4
24bc	13.0	do	4-18-56	45	.01	57	21	26	-----	274	28	31	2.2	-----	300	227	2	20	546	7.5
17-120- 6ac2	100		4-19-56	50	.06	53	27	494	-----	186	192	710	1.4	-----	1,570	243	90	82	2,820	7.6
8db	25.7	do	4-19-56	44	.07	46	47	96	-----	422	48	104	19	-----	568	309	0	40	1,060	7.5
19db	80.0	Teritary deposits	3- 7-58	52	-----	50	86	33	-----	468	97	55	.9	-----	558	476	92	13	994	7.9
32db	31.7	Alluvium and Teritary deposits.	4-19-56	44	.04	71	39	77	-----	347	52	128	.7	-----	539	336	51	33	1,010	7.4
Northern part, Bear River valley																				
22-119- 5cc	28	Alluvium	4-16-56	38	0.01	84	32	51	-----	292	100	69	30	-----	510	344	105	25	864	7.7
23-119- 6ad	17.6	Alluvium and alluvial fan deposits.	4-16-56	42	.01	67	14	20	-----	233	29	30	9.5	-----	285	224	33	16	503	7.5
32bd	35.4	Alluvium	4-16-56	52	.01	62	26	9.6	-----	246	64	10	4.7	-----	297	263	61	7	516	7.5
23-120-26ab	Spring	Nugget sandstone	4-16-56	43	.00	77	40	148	-----	366	328	50	1.1	-----	824	357	57	47	1,270	7.6
24-119- 9bd	75	Terrace deposits	4-16-56	46	.00	64	40	29	-----	328	63	33	14	-----	405	325	56	16	697	8.1
33ac	27.8	Slope wash	4-16-56	42	.00	60	43	72	-----	379	131	25	3.0	-----	521	327	16	32	855	7.7
25-119-33dac	30	Alluvium	4-16-56	40	.01	81	13	7.0	-----	249	52	10	5.0	-----	290	255	51	6	501	7.5

[1] Contains 12 ppm of SiO_2. SiO_2 not determined for other samples.

TABLE 4.—*Chemical analyses of surface water in the Bear River valley, Wyoming*

[Analytical results in parts per million except as indicated]

Location	Discharge (cfs)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Dissolved solids (sum)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C)	pH
Southern part, Bear River valley																			
Mill Creek, east branch	20	4-18-56					4.4		202	18	5.0	0.4			174	8	5	334	7.9
Mill Creek, west branch (13-120-25bc)	20	4-18-56					4.3		245	16	4.5	.3			207	6	4	387	8.0
Bear River above Sulphur Creek, south of Evanston (14-119-30ab)	166	4-18-56	11	0.04	43	12	4.4	0.9	182	11	4.5	.4	0.3	178	157	8	6	307	7.9
Do	350	6-21-56	7.9		24	7.1	1.4		97	7.4	1.0	1.1		98	88	8	3	160	7.6
Do	8.2	9-4-56	9.8				3.4		179	14	2.0	.6			158	11	4	287	7.7
Yellow Creek near mouth, west of Evanston (15-121-25aa)	24	4-18-56					26		350	46	38	.6			335	48	14	696	8.0
Bear River 10 miles north of Evanston (16-121-13ba)	234	4-17-56					14		242	34	17	.6			227	29	12	467	8.0
Do	213	6-22-56	8.8		39	15	7.7		179	14	9.0	1.0		182	160	13	9	319	7.5
Do	.2	9-4-56	9.3				54		296	110	50	1.0			298	55	28	773	7.7
Northern part, Bear River valley																			
Bear River at Beckwith Dam (22-120-26ab)	324	4-13-56					39		313	67	45	0.8			302	45	22	706	7.9
Do	338	6-22-56	17		85	25	51		390	48	49	1.9		469	315	0	26	776	7.7
Do	18	9-4-56	16				61		347	121	70	1.2			368	83	26	915	7.8
Sublette Creek near mouth (24-119-21dc)		4-13-56					21		296	88	25	.3			323	80	12	662	8.0
Bear River at Cokeville, above Smiths Fork (24-119-7ad)	400	4-13-56	12	0.02	67	31	37	3.3	295	73	30	1.3	0.3	400	294	52	21	683	7.7
Do	425	6-22-56	15		55	37	49		327	61	46	1.9		426	290	22	27	717	7.7
Do	30	9-3-56	19				35		291	106	39	1.4			324	85	19	711	7.7
Smiths Fork at Cokeville (24-119-5ad)	20	4-13-56					8.8		216	47	9.5	2.6			215	38	8	431	7.6

QUALITY OF GROUND WATER

The samples collected represent water used mostly for domestic purposes and stock watering. Although no irrigation wells were sampled, water of similar quality is being used for irrigation.

The mineral content and chemical character of the ground water differ generally according to the depth of wells and source. The dissolved-solids content ranges from 290 to 1,770 ppm (parts per million). Excluding the spring sample (23–120–26ab) that contained 824 ppm, only 2 of the 16 ground-water samples contained more than 600 ppm of dissolved solids. All samples had a hardness greater than that usually recommended for satisfactory domestic use (less than 200 ppm as $CaCO_3$). Only three samples did not fall within the following recommended maximum limits of concentration of constituents in potable waters (U.S. Public Health Service, 1946).

Constituents	*Maximum concentrations (ppm)*
Iron and maganese (together)	0.3
Magnesium (Mg)	125
Chloride (Cl)	250
Fluoride (F)	1.5
Sulfate (SO_4)	250
Dissolved solids	[1] 500

[1] 1,000 ppm permitted if water of better quality is not available.

The general suitability of a water for irrigation is determined, in part, by two important chemical-quality factors; (1) the total concentration of salts in the water, and (2) the percent sodium, a ratio of sodium ions to the sum of the cations (calcium, magnesium, sodium, and potassium) expressed as a percentage. Thorne and Thorne (1951) have used a combination of these factors and salinity, expressed as specific conductance, and percent sodium to develop a diagram for the classification of irrigation waters. Their diagram indicates the salinity hazard and sodium hazard of a water and also includes the effects of soil texture and drainage in its interpretation. The ground waters sampled (table 3) would be classified for irrigation, according to Thorne and Thorne, as shown in figure 9. The interpretation of the diagram is quoted from Thorne and Thorne (1951) as follows:

Class	*Rating*
1	Water can be used safely on all soils.
2	Can be expected to cause salt problems where drainage is poor and leaching of residual salts from previous irrigation is not consistently practiced.
3	Water can be used on crops having medium to high salt tolerance, on soils of good permeability, and with irrigation practices which provide some leaching.

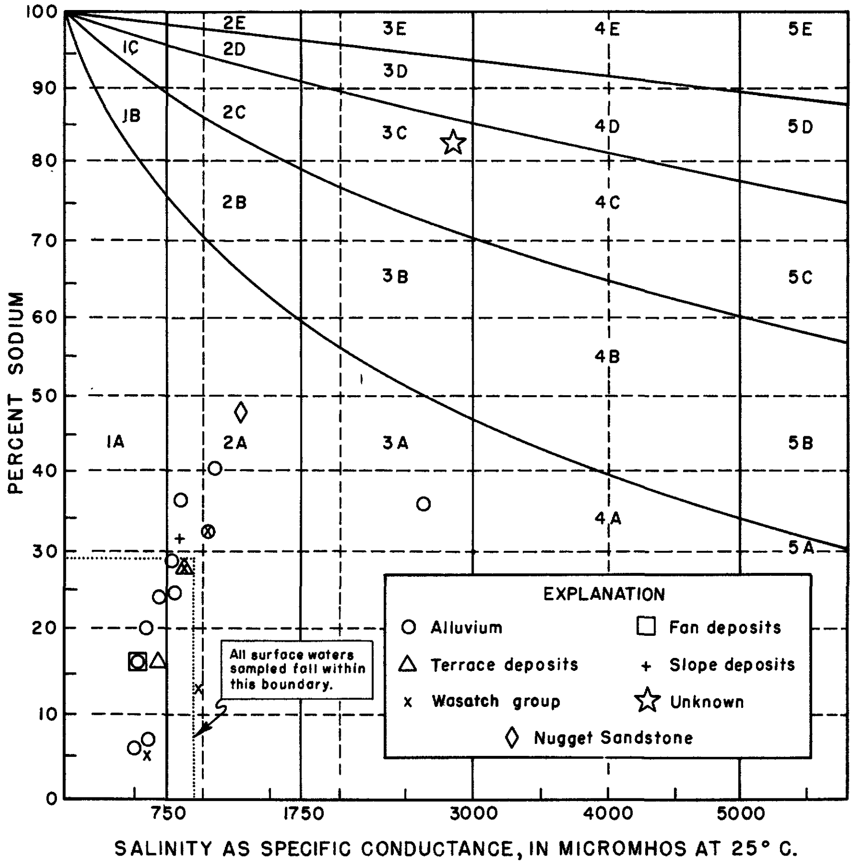

Figure 9.—Classification of Bear River valley ground and surface waters for irrigation use. (Base diagram from Thorne and Thorne, 1951.)

Class	*Rating*
4	Can only be used in successful farming with crops of high salt tolerance, on permeable and well-drained soils, and with carefully devised and conducted irrigation and soil management practices.
5	Waters are generally unsuitable and should be used for irrigation only under special situations.

Group	*Rating*
A	There should be no difficulty from sodium accumulation in soils.
B	With soils of fine texture that do not contain gypsum or lime, where drainage is poor, and where small quantities of water are applied with each irrigation, there may be some evidence of sodium accumulation but usually not enough to seriously injure soils or crops. Serious sodium accumulation may occur in waters high in carbonates or bicarbonates.

Group	*Rating*
C	Serious alkali formation should not occur on permeable soils from sands to silt loams in texture, unless poor drainage, residual carbonates in waters, or limited water use are problems. Fine textured soils must be managed with care to prevent trouble.
D	Some alkali formation should be expected in all soils irrigated with group D waters. Sandy or permeable soils high in gypsum might be irrigated with such waters without highly injurious sodium accumulations. Loams, soils, or soils finer in texture irrigated for some time with waters of class 3D or 4D and then irrigated with water of low salt content would probably puddle and require gypsum treatment for reclamation.
E	Generally unsatisfactory for irrigation purposes.

Waters of class 1C, 1D, and 1E can often be improved in quality by treating with gypsum to reduce the sodium percentage.

Only one sample (17–120–6ac$_2$) indicated a high sodium hazard. The remainder of the samples fall within group A, indicating that there should be no difficulty from sodium accumulation in soils. This is also one of the two samples that fall within class 3, relative to salinity hazard. The remainder of the water samples may be considered good to excellent for irrigation under normal drainage conditions and irrigation practices. Water from well 17–120–6ac$_2$ appears to be unsuitable for irrigation except under certain conditions, as described in the interpretation of figure 9.

WATER QUALITY IN RELATION TO SOURCE

Differences in mineral content of the ground water in various parts of the Bear River valley are indicated in table 3, which lists the well number, depth of well, geologic source, date sampled, temperature, and chemical analysis, in ppm, of each sample. For comparison of water-quality patterns and ratios of constituents, it is desirable to use the ionic concentrations rather than the concentrations by weight. The ionic concentration expresses the concentration of constituents in terms of a common denominator (combining weights) based on the chemical reacting values, and permits direct comparison of all ions. The analytical results are converted to the ionic concentrations in epm (equivalents per million) by dividing the concentration of each ion in ppm by the combining weight of that ion. The relationships given in table 5 and the bar diagrams in figure 10 are based on the equivalent (epm) values.

ALLUVIUM

Four samples from the alluvium in the southern Bear River valley near and north of Evanston, range in dissolved solids from 300 to 1,700 ppm. The constituent values in epm are shown graphically in figure 10. The shallowest well sampled, 16–121–24ad, is 9.6 feet deep and

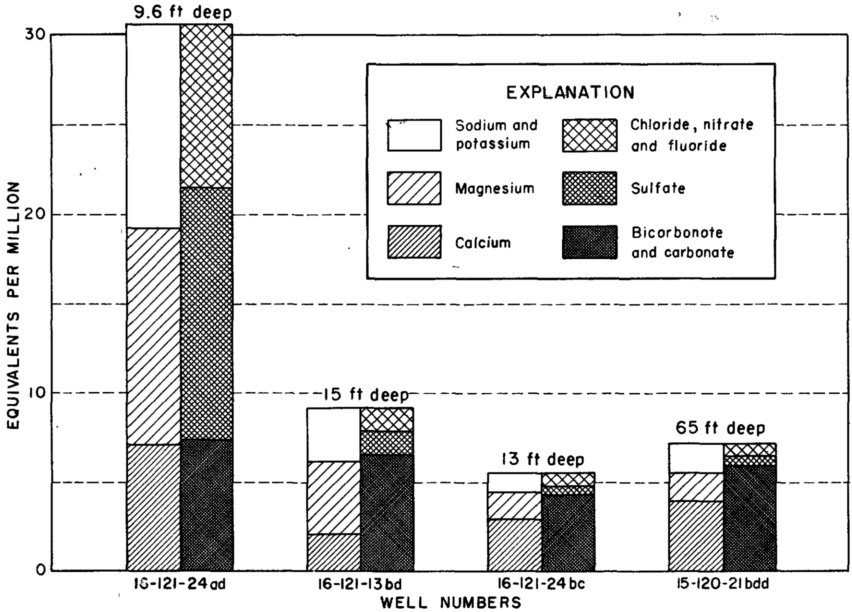

FIGURE 10.—Chemical character of ground waters from wells tapping alluvium near Evanston, Wyo.

yields a magnesium sulfate water having the highest concentration of dissolved solids, bicarbonate, and sulfate of all samples analyzed. The high salinity and the character of the water reflect possible recharge from water leaching surficial deposits near the river. The deepest of the four wells sampled, 15–120–21bdd, 65 feet deep, near Evanston, yields a calcium bicarbonate water which is chemically similar, in many respects, to water of the Bear River south of Evanston, the probable source of recharge (table 5).

The differences in source of recharge to the above wells that tap the alluvium are quite apparent when the analyses for wells 16–121–24ad, 9.6 feet deep, and 16–121–24bc, 13 feet deep, are compared. The former is on the east bank of the Bear River and the latter is three-quarters of a mile west of the Bear River near an outcrop of Tertiary rocks. Both wells are in the same section and have a difference in depth of only 3.4 feet, yet the water of well 16–121–24ad contains almost six times as much mineral matter as the water from well 16–121–24bc, and their chemical character is distinctly different.

All samples from the alluvium in the northern Bear River valley indicate a calcium bicarbonate type of water. Their range in total mineral content from 285 to 510 ppm of dissolved solids is not as pronounced as in the alluvium of the southern Bear River valley.

TABLE 5.—*The relation of some chemical constituents of selected ground and surface waters in the Bear River valley, Wyoming*

[All values are expressed in or computed from equivalents per million]

Well	Geologic source	Percent of total cations			Percent of total anions			Total ions (epm)
		Ca	Mg	Na	HCO_3	SO_4	Cl-F-NO_3	
GROUND WATER								
Southern part								
13-120-25bb	Tertiary deposits	65	30	5	88	8	4	13.15
15-120- 8dd	Alluvium	42	29	29	71	16	13	17.75
21bdd	do	54	22	24	83	7	10	15.08
16-121-11ac	Terrace deposits and Tertiary deposits.	30	42	28	51	13	36	16.49
13bd	Alluvium	25	39	36	65	16	19	18.23
24ad	do	24	41	35	25	48	27	60.74
24bc	do	50	30	20	75	10	15	11.68
17-120- 6ac2		10	8	82	11	15	74	53.44
8db	Alluvium	22	38	40	62	9	29	21.51
19db	Tertiary deposits	23	64	13	68	18	14	22.35
32db	Alluvium and Tertiary deposits.	35	32	33	55	10	35	20.49
Northern part								
22-119- 5cc	Alluvium	46	29	25	52	22	26	18.34
23-119- 6ad	Alluvium and alluvial-fan deposits.	62	22	16	70	11	19	10.78
32bd	Alluvium	55	38	7	71	23	6	11.37
23-120-26ab	Nugget sandstone	29	24	47	42	48	10	27.83
24-119- 9bd	Terrace deposits	41	43	16	69	16	15	15.59
33ac	Slope wash	31	37	32	64	28	8	19.35
25-119-33dac	Alluvium	75	19	6	74	20	6	10.93

SURFACE WATER

Southern part

Location	Date	Ca	Mg	Na	HCO_3	SO_4	Cl-F-NO_3	Total ions (epm)
Mill Creek, east branch	4-18-56			5	86	10	4	7.50
Mill Creek, west branch	4-18-56			4	90	7	3	8.81
Bear River above Sulphur Creek south of Evanston	4-18-56	64	29	7	89	7	4	6.71
Do	6-21-56	65	32	3	89	9	2	3.61
Do	9- 4-56			4	89	9	2	6.60
Yellow Creek, near mouth, west of Evanston	4-18-56			14	74	12	14	15.61
Bear River, 10 miles north of Evanston	4-17-56			12	77	14	9	10.32
Do	6-22-56	56	35	9	84	8	8	7.03
Do	9- 4-56			31	56	28	16	17.33
Northern part								
Bear River, at Beckwith Dam	4-13-56			22	66	18	16	15.54
Do	6-22-56	50	24	26	73	11	16	17.32
Do	9- 4-56			26	56	25	19	20.21
Sublette Creek, near mouth	4-13-56			12	66	25	9	14.75
Bear River, at Cokeville, above Smiths Fork	4-13-56	44	34	22	64	20	12	15.16
Do	6-22-56	35	38	27	67	16	17	15.89
Do	9- 3-56			19	59	27	14	16.10
Smiths Fork, at Cokeville	4-13-56			8	74	20	6	9.51

Two samples from wells 23–119–32bd and 25–119–33dac, 12 miles apart, are comparatively low in sodium (Na) and chloride (Cl) and show evidence of influent seepage of water from Smiths Fork, which is also low in sodium and chloride. Well 23–119–32bd is near and just below the Covey Ditch Canal, which transports water from Smiths Fork southward, parallel to and just east of the Bear River. The other well is in the flood plain just north of the mouth of Smiths Fork and upgradient from the Bear River. The ratios of constituents of these samples are shown in table 5.

Generally, wells tapping the alluvium upgradient and away from return flow into the Bear River yield water of lower dissolved solids and lower sodium and choride content than those tapping the alluvium near the river's course.

TERRACE DEPOSITS

One sample from a well in the terrace deposits in the northern Bear River valley, 24–119–9bd, 75 feet deep, is a magnesium-calcium bicarbonate-type water that contains a moderate amount of sulfate (SO_4). Despite the fact that the wells are miles apart, this water differs only slightly in total mineral content from the water in well 16–121–11ac, 33.9 feet deep, which taps the terrace deposits and Tertiary deposits in the southern Bear River valley. However, the sample from the latter, shallower well contains considerably more chloride than the former.

SLOPE WASH

One sample from a 21.8-foot well that taps the slope wash in the northern Bear River valley, 24–119–33ac, indicates that water from this geologic source, in this area, may be moderately mineralized and of a magnesium-sodium bicarbonate type with a considerable amount of sulfate.

NUGGET SANDSTONE

A mixed-type water, predominantly sodium-calcium sulfate and bicarbonate, issues from the Nugget sandstone in a spring, 23–120–26ab, about 10 miles south of Cokeville. This is one of the three sampled waters that is not within recommended limits for potable waters.

PALEOCENE AND EOCENE ROCKS

Well 13–120–25bb, 152 feet deep, near the Mill Creek sampling point in southern Bear River valley, taps the Tertiary deposits and yields a calcium bicarbonate water low in sodium and chloride and almost identical to the water from Mill Creek and Bear River south of Evanston in its ratio of constituents (table 5). Well 17–120–19db, 80 feet deep, taps the Tertiary deposits in the north part of southern Bear River valley but yields a magnesium bicarbonate water containing a moderate amount of sulfate. Water from this source in this area should fall within the recommended permissible limits for potable waters (table, p. V30). The magnesium and sulfate may have some purgative effect when the water is used for drinking.

UNCERTAIN GEOLOGIC SOURCE

A 100-foot well, 17–120–60ac$_2$, near The Narrows at the north end of the southern Bear River valley, yields water containing the highest concentrations of sodium and chloride of all samples analyzed. The chemical character of this sample is quite dissimilar to all the other samples analyzed for this report. An analysis of a second sample from this well at a later date indicated that the original analysis was valid. The chemical quality of this water may be due to local conditions and not representative of a sizable part of the area.

The analysis of a single sample from any of the above geologic sources is insufficient to define the overall chemical character of the water to be yielded by those sources in this area, and gives only an approximate indication of what might be expected.

QUALITY OF SURFACE WATER

The Bear River drains an area underlain by Precambrian metamorphic rocks on the north slopes of the Uinta Mountains of northeastern Utah and flows through an area underlain by Tertiary formations almost to the Wyoming border, and thence through an area of Tertiary and Cretaceous rocks. The water from Mill Creek (13–120–25bc) and from the Bear River south of Evanston (14–119–30ab) is a calcium bicarbonate type. Seasonal fluctuations in the discharge of the Bear River south of Evanston are accompanied by changes in total mineral content of the water but do not appreciably affect the ratios of the constituents (table 5 and pl. 2). The effect of medium high flows during June was chiefly one of dilution.

Three samples were collected during various stages of flow on the main stem of the Bear River at each of the following locations: south of Evanston (14–119–30ab) and north of Evanston (16–121–13ba), in southern Bear River valley; at Beckwith Dam (22–120–26ab), a diversion dam; and at Cokeville, above Smiths Fork (24–119–7da), in the northern Bear River valley. Analyses of the above samples show progressive downstream increase in mineral content as far as Beckwith Dam and a decrease in mineral content between Beckwith Dam and Cokeville (table 4). Samples at Beckwith Dam and Cokeville above Smiths Fork were collected on the same days during receding stages of flow when there was an increase in discharge between the two points. The dilution in concentration and gain in discharge of the Bear River at Cokeville may be attributed to tributary inflow from Sublette Creek and possible seepage from the Covey and Mau Canals, which carry water from Smiths Fork.

The quality of the Bear River water north of Evanston is moderately influenced by tributary inflow from Yellow Creek. Samples collected on April 18 indicate that Yellow Creek (15–121–25aa) was then contributing one-seventh of the amount of flow, and water of more than twice the mineral content of Bear River south of Evanston (14–119–30ab). The water from Yellow Creek is a calcium bicarbonate type having moderate concentrations of sulfate and chloride.

The samples from Bear River at Beckwith Dam indicate a calcium bicarbonate type water containing considerable amounts of sodium, sulfate, and chloride. The total mineral content and ratio of constituents are expressed in table 5.

Discharge measurements are not available for Sublette Creek near its mouth (24–119–21), but estimates indicate that its contribution of a moderately mineralized calcium bicarbonate type water is comparatively small.

The analysis of a sample collected on April 13, 1956, indicates that Smiths Fork contributes a calcium bicarbonate type water of lower mineral content than water in the Bear River and tends to dilute the Bear River below Cokeville.

SUITABILITY OF SURFACE WATER FOR IRRIGATION

All the surface waters sampled are of good chemical quality for irrigation. Only 3 of the 17 samples failed to qualify for the best rating, 1A, by Thorne and Thorne's classification (fig. 9) and, of these, 2 were collected during the low-flow period in September (table 4). Because the ratings of the surface-water samples on the Thorne and Thorne diagram (fig. 9) would be very crowded in the lower left-hand corner, a dotted-line boundary, which would enclose all the points, has been drawn on the diagram.

RELATION OF CHEMICAL QUALITY TO STREAMFLOW

Seasonal fluctuations in flow and chemical quality of the Bear River north of Evanston (16–121–13ba) are represented graphically on the hydrograph shown in plate 2. This illustration points out the differences in mineral content that generally accompany changes in streamflow during the water year, October 1 to September 30. The spring rise of streams in this area usually occurs during March, April, or May, as water from melting snow swells the streamflow. Superimposed upon this seasonal pattern are the effects of local and general rainstorms and diversions for irrigation. Streamflow during the late summer, autumn, winter, and early spring season usually is maintained by ground water.

The mineral content of stream water is commonly greatest during low-flow periods because of ground-water contributions and the return flow from irrigation. The mineral content of ground water, as mentioned before, is generally higher than in natural streamflow, owing to the longer contact of ground water with subsurface formations and rocks. Minerals in return flow from irrigation are also generally more concentrated than in natural streamflow because this water has leached some of the minerals from irrigated soils.

During the spring rise of a stream the relatively pure snowmelt water dilutes the more concentrated ground-water inflow until the maximum stage of flow is reached. At this stage runoff from snowmelt constitutes the major part of the streamflow, and residual salts from the previous year's low-flow have been flushed out. During the receding stage, until it is affected by return flow, the water is generally less mineralized than during the rising stage of the stream.

Diversion for irrigation or lack of precipitation, or both, usually result in low streamflow toward the end of summer, and ground-water inflow and return flow again constitute the major part of the flow. The dissolved-solids content of a stream during this period, as would be expected, is generally large.

RECORDS OF WELLS AND SPRINGS

Table 6 presents tabulated descriptions of 73 water wells and springs in the Bear River valley, Lincoln and Uinta Counties, Wyo., obtained during this investigation. The location of the wells and springs is shown on plate 1.

TABLE 6.—*Records of wells and springs in the Bear River valley, Lincoln and Uinta Counties, Wyo.*

Well: See text (p. V5) for description of well-numbering system.
Type of supply: B, bored well; Dn, driven well; Dr, drilled well; Du, dug well; Sp, spring.
Depth of well: Measured depths are given in feet and tenths of feet below land-surface datum; reported depths are given in feet only below land-surface datum.
Type of casing: C, concrete, brick, or tile pipe; P, iron or steel pipe; R, rock; W, wood.
Character of material: Cl, clay; G, gravel; S, sand; Sl, silt; Ss, sandstone.
Geologic source: Jn, Nugget sandstone; Qaf, alluvial-fan deposits; Qal, alluvium (flood-plain and channel deposits); Qdl, rock debris; Qs, slopewash; Qlt and Qt, terrace deposits; Qtg, terrace gravels and older alluvium; Tw, Wasatch formation or rocks of equivalent age.
Method of lift and type of power: C, cylinder; Cf, centrifugal; F, flows; J, jet; N, none; T, turbine; E, electric motor; G, gasoline or diesel engine; H, hand operated; N, none; W, windmill.
Use of water: D, domestic; I, irrigation; In, industrial or railroad; N, none; O, observation; P, public; S, stock.
Altitude of land surface at well: Interpolated from topographic maps.
Depth to water: Measured depths to water level are given in feet, tenths, and hundredths; reported depths are given in feet only; F, flowing.
Remarks: Ca, sample collected for chemical analysis, results given in table 3; D, discharge in gallons per minute (M, measured); DD, drawdown, in feet, while discharging at preceding rate; L, log of well given in table 7; Th, time in hours for stated drawdown at stated discharge.

Well	Owner or tenant	Year drilled	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift and type of power	Use of water	Altitude of land surface at well above mean sea level (feet)	Depth to water level, below land surface (feet)	Date of measurement	Remarks
12–119– 4add	Howard Coleman	1940	Dr	44	6	P	Ss	Tw	J, E	D		12		
6add1	Ben R. Lowham		Du	18			G, S	Qal	J, E	D				
6add2	do		Dr	25	8	P	G, S	Qal	J, E	I				
6dbd1	Alex Lowham		Du	20			G, S	Qal		S				
6dbd2	do		Du	10			G	Qal	J, E	D				
18abd	Tom Saxton		Du	9	15		G	Qal	C, E	D		2.50	June 13, 1956	
12–120–12ba	Marvin Danielson		Du	20			G, S	Qal	C, H	D		14		
12dda	Joseph Danielson		Du	25	18		G, Ss	Qal, Tw	C, H	D	7,600	1.76	June 13, 1956	
13–119– 4dcb	Wm. Hutchinson		Du	16	72		G	Qlt	Cf, E	D				
9bdd	Louis Martin and son	1927	Du	15			G, S	Qlt	J, E	D				Water reported as hard, L.
9bdd2	do		Du	12	12	C	G, S	Qlt	J, E	D				
16dbb	Harvey Hutchinson	1954	Du	12	18		G	Qlt	C, N	D				
28cca	Theodore Robinson	1939	Du	18	12		Cl	Qlt	C, E	D				
34aba	Ernest Barker		Dr	365	6	P		Tw(?)	T, E	D		.00	July 6, 1956	Well has flowed.
34cbb1	William Cook	1935	Du	14	16		G, S	Qlt	J, E	D				Well flowed when dug.
34cbb2	do		Du	16	12		G	Qlt	C, H	S		1.00	July 6, 1956	Water reported as soft.
13–120–23aa	Meyers School		B(?)	4.3	8	P	G, S	Qal	N	O	7,305	2.57	Aug. 29, 1955	
25bb	Margaret Jamison		Dr	152	6	P	Ss	Tw	C, E	D,S	7,366	3.25	Apr. 18, 1956	Ca.
35ad	Ben Larson		Dr	39	6	P	G, Ss	Qal, Tw(?)			7,430	4.00	Apr. 25, 1956	L.

TABLE 6.—*Records of wells and springs in the Bear River valley, Lincoln and Uinta Counties, Wyo.*—Continued

Well	Owner or tenant	Year drilled	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift and type of power	Use of water	Altitude of land surface at well above mean sea level (feet)	Depth to water level, below land surface (feet)	Date of measurement	Remarks
14-119-32dda	John J. Martin		Du	12	6	P	G	Qlt	T, E	D				
34cad	E. R. Cornelison		Sp				G	Qlt		D				Several small springs.
14-121-12aab1	Erschel Dean		Du	17	36	P	G	Qs	C, H	D	6,780	6.67	Aug. 5, 1956	L.
12aab2	do		Du	21			Ss, G	Qal, Tw	N	N				L.
15-120- 8bb	E. L. Dahlman		Dr	70		P	G, S	Qal	J, E	D	6,680			
8dd	George Schwitzer		Dr	30.2	6	P	G, S	Qal	C, E	D, O	6,710	3.78	Aug. 29, 1955	Ca.
21bba	City of Evanston		Dr	185	12	P	G, S	Qal	T, E	P	6,740	8.29	Oct. 28, 1950	Casing perforated 55–75 ft., D730M, DD26.5, L.
21bdd	do		Dr	65	16	P	G, S	Qal	T, E	P	6,755	7.17	do	Ca, D550M, DD24.
21cbd	do		Dr	80	16	P	G, S	Qal	T, G	P, I	6,768	10.83	do	D427M.
31db	Mrs. J. M. Peart	1954	Dr	100	12	P	G	Qal, Qs	T, G	I	6,780	F	July 3, 1956	Flows 60 gpm, pumps 320 gpm, L.
32cc	Fred Stahley		Dr	125	12	P	S		N	N		30	do	
16-120-30cd	D. McAllister		Du, Dn.		1¼	P	G, S	Qal	J, E	D		3	Apr. 25, 1956	
16-121-11ac	Elwin Sessions		Du	33.9	48	R	G, Ss	Qt(?), Tw	C, W	O	6,575	22.45	Aug. 30, 1955	Ca.
11ada	do		Dr	28	8	P	G, S, Ss	Qal	T, E	D	6,525	2.67	June 15, 1956	D11M, DD1.55, Th1, L.
13bd	John Pierce		Du	15			G, S	Qal	J, E		6,535	4	Apr. 19, 1956	Ca.
24ad	Salmela Bros		Du	9.6	20	P	G, S	Qal	C, H	S, O	6,560	8.32	Aug. 29, 1955	Ca.
24bc	Austin Moore		Du	13.0	24	R	G, S	Qal	N	N	6,562	9.06	Apr. 18, 1956	Ca.
25cc	May B. Key		Dr	58.0	6	P	G, S	Qal	C, H	D	6,595	15.94	Apr. 24, 1956	
36ad	J. H. Bowns		Du, Dn.	9.7	48	P	G, S	Qal			6,583	3.70	do	
36bb	Not known		Dr	12.9	1	P	G, S	Qal	N	N	6,620	5.45	Apr. 23, 1956	
36cd	do		Dr	4.9	½	P	G, S	Qal	N	O	6,618	3.13	Aug. 30, 1955	

17-120- 6ac1	William Heward		Du	23.3	28	C	G, S	Qs	C, H	N	6,470	13.72	Apr. 19, 1956	
6ac2	Mrs. Heward		Dr	100	6	P			J, E	D, S		15	do	Ca.
8db	Jack Simms		Du	25.7	36	P	G, S	Qal	C, H	N	6,445	22.02	do	Ca.
19db	Ralph Simms		Dr	80	6	P		Tw	J, E	D		30	Apr. 23, 1956	
32db	Sarah Harris		Dr	31.7		P		Qal, Tw(?)	C, H	S	6,550	26.40	Apr. 19, 1956	Ca.
22-119- 5cc	Claude Knouse		Du	28.0	48	R	G, S	Qal	N, H	D	6,211	20.83	July 19, 1955	Ca.
6cd	Not known		Du	5.0			G, S	Qal	N, H	S	6,193	3.20	do	
10dc	do		Du	18.3	26	P	G, S	Qs	N	O	6,209	13.20	Aug. 19, 1955	
23da	Arden Pope		Du, Dn.	14			G, S	Qal	C, H		6,200	10	July 18, 1955	
24cb	do		Dr	22		P	G, S	Qal		D	6,200	10	do	
25aa	John Dayton		Dr	19.4	6	P	G, S	Qal	Cf, G	S	6,225	6.70	do	
23-119- 6ad	Not known		Du	17.6	24	P	G, S	Qaf, Qal	N, H	S, O	6,185	11.83	July 15, 1955	Ca.
7acc	Claude Knouse	1954	Dr	117.3	12	P	G	Qaf, Qal	T, G	I	6,185	6.75	Aug. 19, 1955	D500M, DD29, L.
9ba	Dale Sparks		Dr	30	6	P	G, S	Qdl	J, E	D, S		8	Aug. 22, 1956	Bottom in bedrock.
9bc	Not known		Du	14.3	24	P	G, S	Qal	N	S, O	6,190	8.10	Aug. 24, 1955	
18bb	Doyle Knouse		Dr	142	12	P	G	Qal, Qaf	T, G	I, O		44.92	Aug. 19, 1955	D400M, DD21, L.
20dd	Orson Nate		Dr	54.8	5	P	G, S	Qdl	C, G	D, S	6,210	17.06	Aug. 24, 1955	
29cd	William Buckley		Dr	150	12	P	G, S	Qal	T, G	I	6,206	17.64	July 20, 1955	D1,125M, DD20, L.
29dc	Not known		Du	21.2			G	Qal	N	N	6,208	20.80	July 18, 1955	
32bd	Thornock Bros		Du	35.4	36	P	G, S	Qal	C, H	D, S, O	6,211	19.70	Aug. 25, 1955	Ca.
32da	William Buckley		Du	52.5	30	C	G, S	Qal	C, H	S	6,240	47.90	Sept. 20, 1955	
23-120-26ab	do		Sp					Jn		D, S				Ca.
24-119- 5cc	L. W. Roberts		Dr	154	18	P	G	Qal	T, E	I		20	Jan. 31, 1955	D1120M, DD20, Th4, L.
5ccd	Ira E. Perkins		Dr	79		P	G	Qal	T, E	I		8.3	Dec. 31, 1955	L.
9bd	Leo Somsen		Dr	75	8	P	G, S	Qtg	J, E	D, S		50	Apr. 16, 1956	Ca.
20bb	Mr. Thompson		Dr	90	6	P	G, S	Qaf, Qal		S		60	Feb. 11, 1955	
21ac	Bill Mack		Du	19.0	30	R	G, S	Qtg	N	N	6,195	10.53	Aug. 24, 1955	
28dc	Sam Bennion		Dr	78	4	P	G, S	Qal, Qtg		D, S		18	Aug. 22, 1955	
33ac	Stanley Nate		Du	27.8	60	W	G, S	Qdl	C, E	D, S	6,195	8.32	do	Ca.
25-119-21ad	J. Reed		B(?)	10.0			G, S	Qtg, Qal	C, H	S	6,135	6.69	Aug. 24, 1955	
27cb	do		Dr	100	5	P	G, S	Qal		D, S	6,165	19	do	
33dac	Reed Dayton		Dr	30	6	P	G, S	Qal	J, E	D, S	6,168	20	Apr. 16, 1956	Ca.
26-119-31cb	Anderson Bros		Dr	58.9	4	P	G, S	Qal	J, E	D		16.70	Aug. 31, 1955	

DRILLERS' LOGS OF WELLS

Listed on the following pages are the drillers' logs of 13 wells in the Bear River valley. The locations of these wells are shown on plate 1. The drillers' logs are written logs of wells that were obtained from drillers' records or from other sources, and their terminology is essentially unchanged; however, the geologic interpretations of the logs were made by the authors.

TABLE 7.—*Drillers' logs of wells*

12-119-4add. Howard Coleman.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil	5	5	Sandstone	5	40
Bentonite	30	35	Clay	4	44

13-119-9bdd1. Louis Martin and son.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	1.5	1.5	Terrace deposits—Cont.		
Terrace deposits:			Hardpan	0.5	6.5
Gravel	4.5	6	Sand and gravel	8.5	15

13-120-35ad. Ben Larson. Altitude, 7,430 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Tertiary deposits(?)—Cont.		
Cobbles	17	17	Clay, red	7	31
Tertiary deposits(?):			Sandstone	8	39
Clay, white	7	24			

14-121-12aab1. Erschel Dean. Altitude, 6,780 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Clay, sandy	15	15	Gravel	2	17

14-121-12aab1. Erschel Dean.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Gravel	19.5	19.5	Sandstone (hard sandstone at bottom)	1.5	21

15-120-21bba. City of Evanston. Altitude, 6,740 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Alluvium—Continued		
Gravel	18	18	Sand	5	77
Clay and sand	2	20	Gravel	6	83
Gravel	8	28	Clay	2	85
Clay	2	30	Gravel	10	95
Gravel	10	40	Sand	4	99
Sand	3	43	Gravel	15	114
Gravel	13	56	Sand	5	119
Clay	1	57	Gravel	11	130
Gravel	15	72	Sand and gravel	55	185

15-120-31db. Mrs. J. M. Peart. Altitude, 6,780 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Clay	50	50	Gravel	50	100

TABLE 7.—*Drillers' logs of wells*—Continued

16-121-11ada. Elwin Sessions. Altitude, 6,525 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Tertiary deposits:		
Sand and gravel	27	27	Sandstone, hard	1	28

23-119-7acc. Claude Knouse. Altitude, 6,185 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvial-fan deposits and alluvium:			Alluvial-fan deposits and alluvium—Continued		
Soil and gravel	10	10	Gravel	6	56
Clay and gravel	8	18	Clay	4	60
Clay	25	43	Gravel	9	69
Gravel	4	47	Clay	17	86
Clay	3	50	Gravel	31.3	117.3

23-119-18bb. Doyle Knouse.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvial-fan deposits and alluvium:			Alluvial-fan deposits and alluvium—Continued		
Soil and gravel	35	35	Clay	5	106
Clay	25	60	Gravel, clean	15	121
Gravel	4	64	Gravel, dirty	6	127
Gravel, dirty	37	101	Gravel, clean	15	142

23-119-29cd. William Buckley. Altitude, 6,206 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Alluvium—Continued		
Soil	3	3	Gravel	12	68
Clay and gravel	17	20	Clay	2	70
Gravel	1	21	Gravel	18	88
Gravel and clay	12	33	Clay	6	94
Clay	11	44	Gravel	28	122
Gravel	4	48	Clay	8	130
Gravel and clay	8	56	Gravel	20	150

24-119-5cc. L. W. Roberts

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Alluvium—Continued		
Soil	6	6	Gravel	11	137
Gravel and dirt	29	35	Clay	5	142
Gravel	88	123	Gravel	1	143
Clay	3	126	Clay	11	154

24-119-5ccd. Ira E. Perkins

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Alluvium—Continued		
Soil	6	6	Gravel	6	58
Gravel, dirty	22	28	Clay	5	63
Gravel	19	47	Gravel	16	79
Gravel, dirty	5	52			

LITERATURE CITED

Berry, D.W., 1955, Reconnaissance of the geology and ground-water resources of the Cokeville area, Lincoln County, Wyo.: U.S. Geol. Survey open-file rept., 11 p., 2 illustrations.

Bradley, W. H., 1936, Geomorphology of the north flank of the Uinta Mountains: U.S. Geol. Survey Prof. Paper 185–I.

Gale, H. S., and Richards, R. W., 1910, Preliminary report on the phosphate deposits in southeastern Idaho and adjacent parts of Wyoming and Utah: U.S. Geol. Survey Bull. 430–H.

Harris, A. B., and Jibson, W. N., 1954, Bear River hydrometric data tri-State investigations: U.S. Geol. Survey open-file rept.

Mansfield, G. R., 1927, Geography, geology, and mineral resources of part of southeastern Idaho: U.S. Geol. Survey Prof. Paper 152.

Meinzer, O. E., 1923, Outline of ground-water hydrology, with definitions: U.S. Geol. Survey Water-Supply Paper 494.

Richardson, G. B., 1941, Geology and mineral resources of the Randolph quadrangle, Utah-Wyoming: U.S. Geol. Survey Bull. 923.

Thorne, J. P., and Thorne, D. W., 1951, Irrigation waters of Utah, their quality and use: Utah Agr. Exp. Stat. Bull. 346, 64 p.

U.S. Geological Survey, 1944–54, Bear River hydrometric data, tri-State investigations: U.S. Geol. Survey open-file repts. (annual).

U.S. Public Health Service, 1946, Drinking water standards: Public Health Reports, v. 61, no. 11, p. 371–384.

Veatch, A. C., 1907, Geography and geology of a portion of southwestern Wyoming, with special reference to coal and oil: U.S. Geol. Survey Prof. Paper 56.

Wyoming Geological Association, 1950, Guide to southwest Wyoming, 5th Annual Field Conference, 1950: Casper, Wyo.

U.S. GOVERNMENT PRINTING OFFICE: 1963 O—656164