Ground Water in the Upper Star Valley Wyoming

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1809-C

Prepared on behalf of the U.S. Bureau of Reclamation

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By EUGENE H. WALKER

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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CONTENTS

ILLUSTRATIONS

TABLES

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

GROUND WATER IN THE UPPER STAR VALLEY, WYOMING

By Eugene H. Walker

ABSTRACT

The upper Star Valley covers about 55 square miles of lowland in the westernmost part of Wyoming. The altitude of the floor of the valley is 6,000–6,700 feet. The climate is cool; the growing season, short. Annual precipitation averages about 18 inches, and total precipitation in July and August averages 2.2 inches. Additional supplies of water are needed for irrigation of pasture and hay.

The principal water-bearing formation is a thick body of gravel of Pleistocene age. Consolidated to semiconsolidated sedimentary formations of Paleozoic to Tertiary age form the surrounding mountains and underlie the gravel. These bedrock formations yield small amounts of water to wells on the margins of the valley.

Most of the recharge to the gravel aquifer is received at the heads of alluvial fans by infiltration from tributaries that drain the surrounding mountains. Snow upon the valley floor provides a significant amount of recharge. Water moves toward the Salt River, which flows northward through the valley and which has large gains due to ground-water inflow.

On the east side of the valley, the water table is 100–200 feet below land surface at a distance of half a mile from the mountain front. On the west side of the valley, the depth to water is rarely more than 30 feet. Depth to water decreases toward the center of the valley.

The gravel aquifer can provide sufficient water for supplemental irrigation. Irrigation supplies of several hundreds of gallons per minute have been developed at two localities on the west side of the valley. Two pumping tests showed values for transmissibility of 82,500 and 370,000 gallons per day per foot in the vicinity of a well on the east side of the valley and a well on the west side, respectively.

The ground water is of good quality for irrigation usage through most of the valley. Hardness of the water exceeds 200 parts per million, however, and this characteristic makes the water somewhat undesirable for domestic and industrial use. Water beneath the northwestern part of the valley has relatively high content of sodium and chloride.

INTRODUCTION

This report presents information on the ground-water resources of the upper Star Valley in Lincoln County in southwestern Wyoming (fig. 1). It is based on a study made in cooperation with the U.S. Bureau of Reclamation and is one of a series designed to provide an inventory of the water resources of the State that will facilitate full use

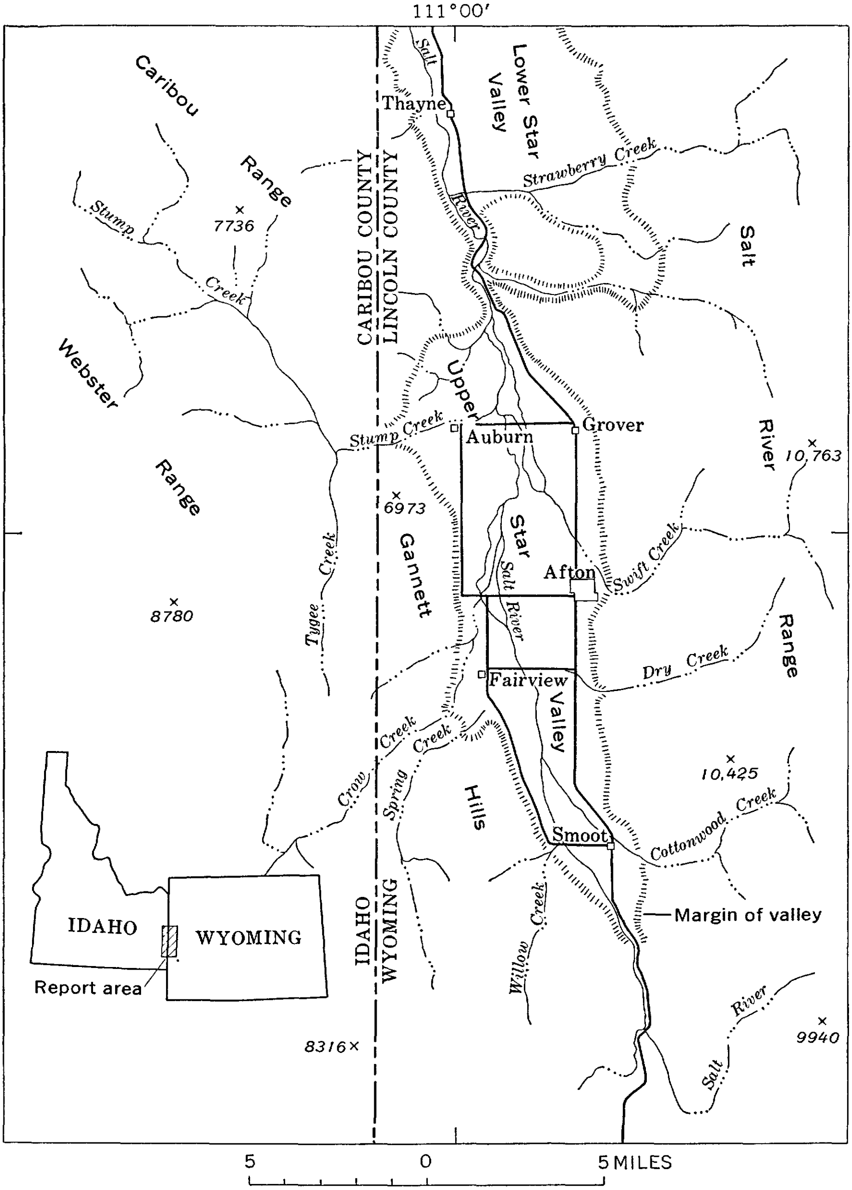

FIGURE 1.—Location of the upper Star Valley, Wyo., and major physical features.

of these resources without overdeveloping them and causing local shortages. Land in the upper Star Valley is devoted to dairy and stock farming, but productivity is often limited by inadequate supplies of surface water for supplemental irrigation. This report shows that sufficient ground water for supplemental irrigation can be developed through a large part of the upper Star Valley.

The geology of the area and the location of wells inventoried during the investigation are shown on plate 1. Records of wells and geologic logs were obtained from well owners and drillers. Information on the hydrologic properties of the water-bearing formation was derived from pumping tests on two wells. Water samples were collected from representative wells for analysis to show the chemical quality of the ground waters. The samples were analyzed by the Regional Laboratory of the Bureau of Reclamation at Boise, Idaho.

The well-numbering system used in this report indicates the location of wells within the official rectangular subdivisions of the public lands. The first two segments of a number designate the township and range. The third segment gives the section number and is followed by two letters and a numeral, which indicate the quarter section, the 40-acre tract, and the serial number of the well within the tract. 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 tracts are lettered in the same manner. Thus well 31N–119W–1dd1 is in the SE¼ SE¼ sec. 1, T. 31 N., R. 119 W. and is the first well visited in that tract.

GEOGRAPHIC FEATURES

The upper Star Valley is the southern part of a long trench between mountain ranges that trend slightly west of north. On the east the valley is bounded by the Salt River Range, which rises abruptly along a straight fault scarp to altitudes a little more than 10,000 feet above sea level. On the west side of the valley, gentle slopes rise to the rolling uplands of the Gannett Hills, at altitudes of 7,000–8,000 feet.

The valley is a little less than 20 miles long and is about 55 square miles in area. It widens northward from its south end and is about 5 miles wide near the Narrows, which is a constriction at the north end between low hills that separate the upper Star Valley from the lower Star Valley to the north. The floor of the valley declines from an altitude of about 6,700 feet at the south end of the valley to about 6,000 feet at the Narrows.

Most of the valley floor consists of gentle slopes on the alluvial fans built from the flanking mountains. The fans on the east side of the valley, built by streams from the high and steep Salt River Range, are steeper at their heads and more extensive than those on the west side of the valley. In the southern half of the valley, the alluvial fans from the east and west are separated only by a narrow strip of bottom land occupied by the Salt River. The bottom land is almost 2 miles wide in the northern part of the valley.

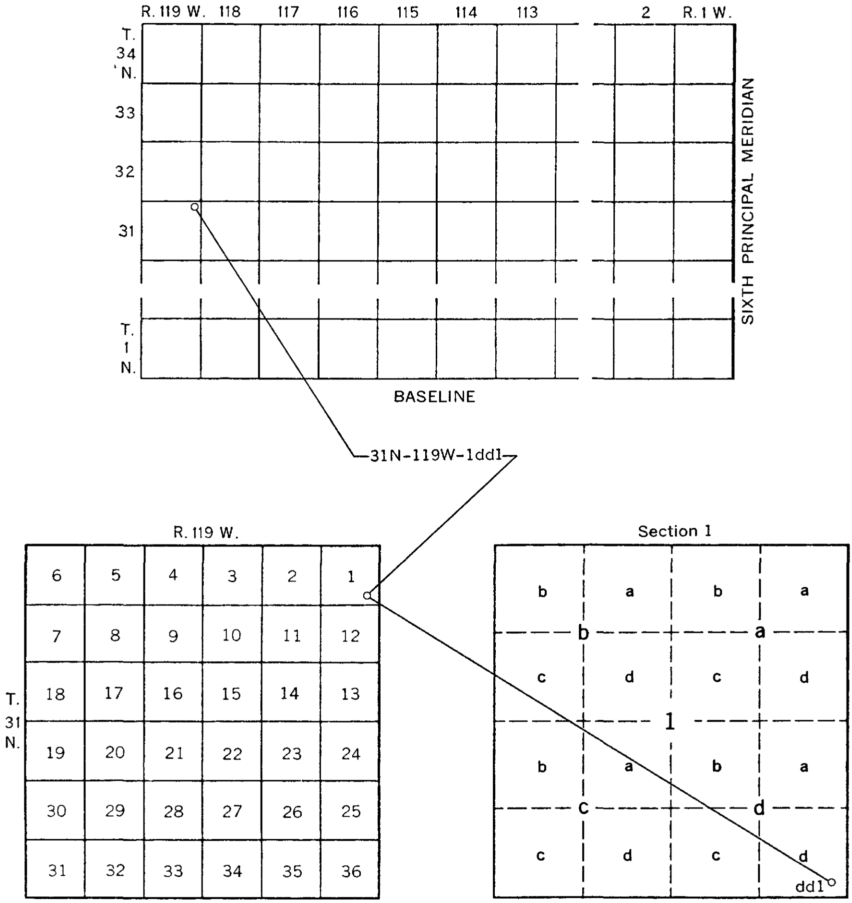

FIGURE 2.—Well-numbering system.

The course of the Salt River lies west of the center of the valley, because it has been crowded over by the larger alluvial fans built out from the foot of the Salt River Range. The river assumes a meandering pattern in the wider bottom land in the northern part of the valley. Principal tributaries from the east are Cottonwood and Swift Creeks; from the west, Crow and Stump Creeks.

The climate of the valley is cool and dry. Average monthly temperatures range from about 13° F in January to a maximum of about 60° F in July (table 1). Annual precipitation at the U.S. Weather Bureau station in Afton has averaged 18.19 inches for the period 1915–60. Much of the precipitation falls as snow, and heavy snow cover lies on the valley floor during winter months. Precipitation is fairly well distributed throughout the year but is least in

TABLE 1.—*Average monthly temperature and precipitation at Afton, Wyo.*

[From records of U.S. Weather Bur.]

	Temperature [1] (° F)	Precipitation [2] (in.)		Temperature [1] (° F)	Precipitation [2] (in.)
January	13. 1	1. 52	July	60. 4	1. 10
February	17. 6	1. 44	August	58. 7	1. 10
March	24. 6	1. 61	September	51. 3	1. 21
April	37. 0	1. 49	October	42. 1	1. 61
May	47. 3	1. 85	November	27. 5	1. 50
June	53. 0	2. 14	December	17. 0	1. 62
			Avg annual	37. 5	18. 19

[1] Avg, 1920–60.
[2] Avg, 1915–60.

summer months. Precipitation in July and August has averaged 2.20 inches.

Soils formed on young alluvial fans and are generally gravelly and immature. They show certain differences corresponding to the main topographic divisions of east side alluvial fans, west side alluvial fans, and bottom land.

Most of the soils on the east side alluvial fans have an upper horizon a few inches thick of silty loam and a little gravel. The proportion of gravel increases rapidly with depth, and the cobbly gravel of the fans is found at depths of 2–4 feet below the surface. The silt in the upper horizon is wind-blown loess and is thin on the fans because they are geologically very young. These soils retain little moisture and are very permeable; farmers state that canal and field losses of irrigation water are very high.

Soils of the west side alluvial fans are mainly silty loams free of gravel to depths of 3–4 feet. Stratified sand and silt or gravels having a varying degree of coarseness occur at depth. These soils are the best in the valley, for they retain moisture, yet are well drained.

Silty or clayey loams prevail through the bottom land. Sand and gravel normally are found at depths of 3–4 feet. These soils are water retentive. Some of the clayey loams are very heavy textured. Drainage is poor because of high water level and high clay content of the soils.

The largest town in the valley is Afton, which had a population of about 1,350 in 1960. The other named settlements—Fairview, Auburn, Smoot, and Grover—are much smaller.

Settlement of the valley began in the 1880's, and except for areas of willow thicket along the wetter bottom land, the entire valley floor has long been cleared for crops or pasture. Most of the farms are small. Study in 1947 showed that the most common size of farm was about 60 acres (U.S. Bur. Reclamation, 1949, p. 6). The prin-

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cipal activity is the production of milk, which is processed into cheese at a factory in Thayne, about 14 miles north of Afton, at the head of the lower Star Valley. Beef cattle and sheep are raised in the valley, especially on farms with large acreages of bottom-land pasture.

About three-quarters of the cropped acreage supports hay, principally alfalfa. Normally, two cuttings are made. The yield of the second cutting depends on the length of the growing season and the amount of moisture and irrigation water available that year. Alfalfa is not successful in the bottom land where the water table is within 3 feet of the surface, and such areas are used for meadow hay and pasture.

GEOLOGIC FEATURES

The two main elements of the geology are the older and generally consolidated rocks that form the foothills and mountains, and the unconsolidated materials, mainly gravel of Pleistocene age, that occupy the lowlands. The gravel of Pleistocene age is the principal water-bearing formation of the area. The bedrock formations are significant because they bound the gravel aquifer and also because they yield some water, at places salty, that moves into the gravel of the valley.

CONSOLIDATED FORMATIONS OF PRE-PLEISTOCENE AGE

Consolidated sedimentary rocks of Paleozoic age form the higher parts of the Salt River Range. They exert some control over the pattern of runoff from the high mountains but otherwise have no hydrologic importance. They probably lie at considerable depth beneath most of the valley. The low butte in the northern part of the valley, in sec. 25, T. 33 N., R. 119 W., however, is formed by a block of limestone that is probably of Paleozoic age.

Sedimentary strata of Mesozoic age occur along the front of the Salt River Range and form the Gannett Hills on the west side of the valley. A good description of the formations is given by Mansfield (1927), who mapped the region west of the valley up to a line 2 miles east of the Wyoming-Idaho boundary. The Mesozoic formations consist of shales, thin-bedded limestones, sandstones, and a thick conglomerate.

The sedimentary formations of Mesozoic and Paleozoic age were folded and thrust faulted in Late Cretaceous time, and the structural features produced trend slightly west of north and determine the pattern of ranges and valleys.

The Preuss Sandstone of Late Jurassic age contains beds of rock salt, and water moving through the formation gives rise to a number of salty springs in valleys in the Gannett Hills west of the upper Star Valley. The Preuss Sandstone crops out as a belt in the Gannett Hills and is well exposed where the valleys of Spring and Crow Creeks cut across it. An oil-test well drilled in 1922 about 4 miles southwest of Auburn, along Tygee Creek (fig. 1), a north-flowing tributary of Stump Creek, penetrated 96 feet of salt in six beds that ranged in thickness from 6 to 29 feet (Mansfield, 1927, p. 340). About 7 miles up Crow Creek on the east side of the creek valley a deposit of rock salt has been found at a depth of only a few feet.

The region was uplifted and eroded during the Tertiary Period, and thick deposits accumulated in lowlands. The Salt Lake Formation, which consists mostly of coarse conglomerate and some beds of semiconsolidated sand, silt, and marl, occurs in the foothills around the upper Star Valley. It underlies the hills and low uplands at the north end of the valley, east of the Salt River (pl. 1). It also forms a narrow and discontinuous belt in the foothills on the west side of the valley, where it lies on the eroded surface of the formations of Mesozoic age and is in turn overlapped by alluvial fans of Pleistocene age.

ALLUVIUM OF PLEISTOCENE AGE

The alluvium of Pleistocene age consists of sand and gravel deposited as alluvial fans and in stream channels and some thin beds of silt and clay. These materials accumulated in a lowland bounded on the west by gently inclined eroded slopes and on the east by the fault scarp along the front of the Salt River Range. Movement along the fault has occurred during the accumulation of the alluvium, as shown by a fault scarp in the alluvium at places along the mountain foot. The mass of alluvium is probably shaped like a wedge, thickest near the base of the Salt River Range and thinning to a feather edge against the western hills.

An early stage of building of alluvial fans is shown by the belt of eroded fans along the west side of the valley. A small patch of these early fans occurs along the east side of the valley north of Grover. The several isolated benches above the general level of the valley floor south and southwest of Smoot also are remnants of the early fan surface. A mantle of loess as much as 3 feet thick has accumulated on the flatter parts of this old fan surface since the gravel was deposited.

Most of the valley floor is formed by a younger generation of alluvial fans. These probably date from the last period of glaciation in the mountains with the attendant heavy stream runoff.

The youngest gravel deposits occur along the channels that are trenched a short distance below the surface of the younger alluvial fans. Present stream profiles are somewhat flatter than the profiles of the fans; thus there is some trenching at the heads of fans but little or none at the lower ends. Similarly, the Salt River is somewhat trenched through the southern part of the valley but meanders in flat meadows in the northern part, where the fans merge without topographic break into the bottom land.

The gravel forms one large body, though it was not deposited in one episode. The character of the gravel differs from place to place; this variation reflects differences in environment of deposition. Fan material contains alternating layers of fairly clean gravel and gravel with high proportions of silt and clay. Gravel deposited by the Salt River, exposed in cut banks in the southern part of the valley, is clean cobble gravel with little silt or clay. The general character of the material is shown by the well logs of figure 3.

GROUND WATER

SOURCE AND MOVEMENT

Ground water in the valley is derived from (1) water that percolates from streams near the heads of alluvial fans around the margins of the valley, (2) percolation of irrigation diversions on the alluvial fans, and (3) precipitation upon the valley floor. The ground water discharges into the Salt River and thus causes the river to gain a large amount of flow in passing through the valley.

Recharge occurs mainly in the spring season of snowmelt and high runoff rates. The graph of water-level fluctuation in well 31N–119W–1dd1 (fig. 4), though based on only a few measurements, shows the cyclic pattern of recharge. In 1962 the water level in the well was lowest in March or early April and rose about 60 feet by late June. In most years the annual fluctuation in this well might be somewhat less, however, because water levels were lower than average in the winter of 1961–62 as a result of a dry summer in 1961. This well is near an irrigation canal, which probably provides local recharge, and the seasonal changes in water level in wells remote from canals probably are considerably smaller. The pattern of high water level in late spring or early summer and low water level in late winter is reported in various other wells, though not substantiated by measurements.

Flow in tributary streams crosses the alluvial fans and joins the Salt River only during spring runoff. As the streams currently are fully diverted for irrigation, probably a larger proportion of the flow of tributary streams enters the ground now than did under original conditions. Streams from the high Salt River Range yield more runoff per square mile of drainage area than do those from the lower mountains to the west of the valley because of the greater snowfall in the Salt River Range.

Water that enters the fans moves downgradient and is discharged through springs and seeps into the Salt River. During the irrigation season, the flow of the Salt River at the Narrows is more than 400 cfs

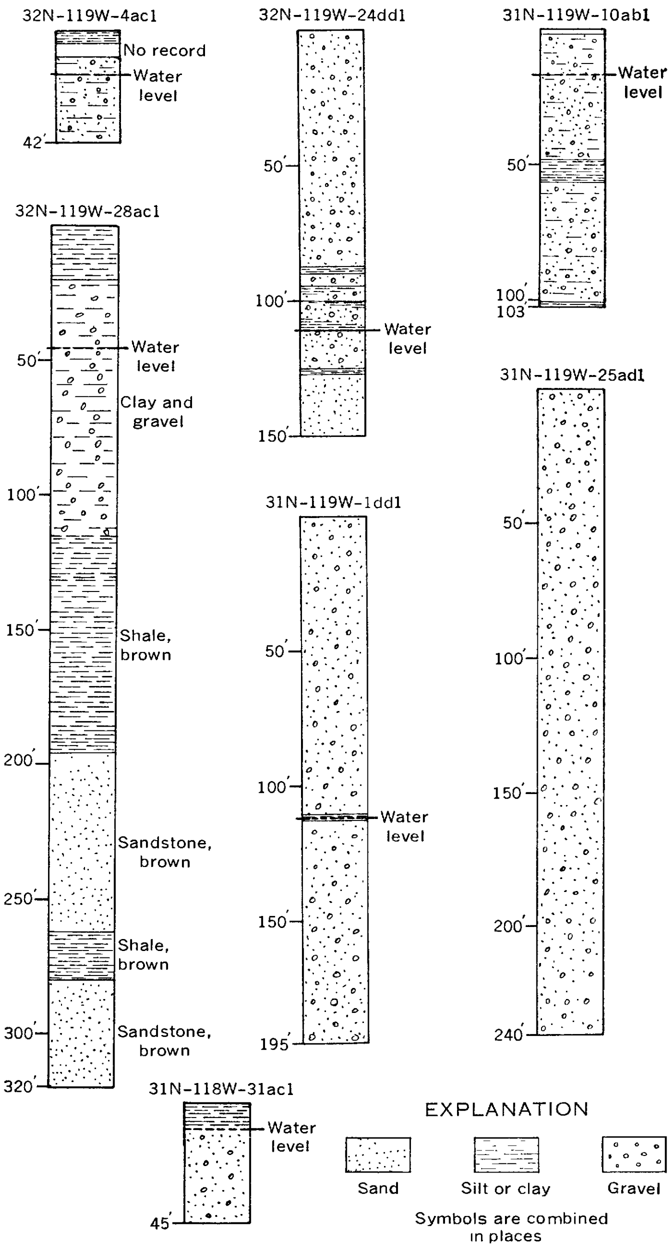

FIGURE 3.—Geologic logs of representative wells in the upper Star Valley, Wyo.

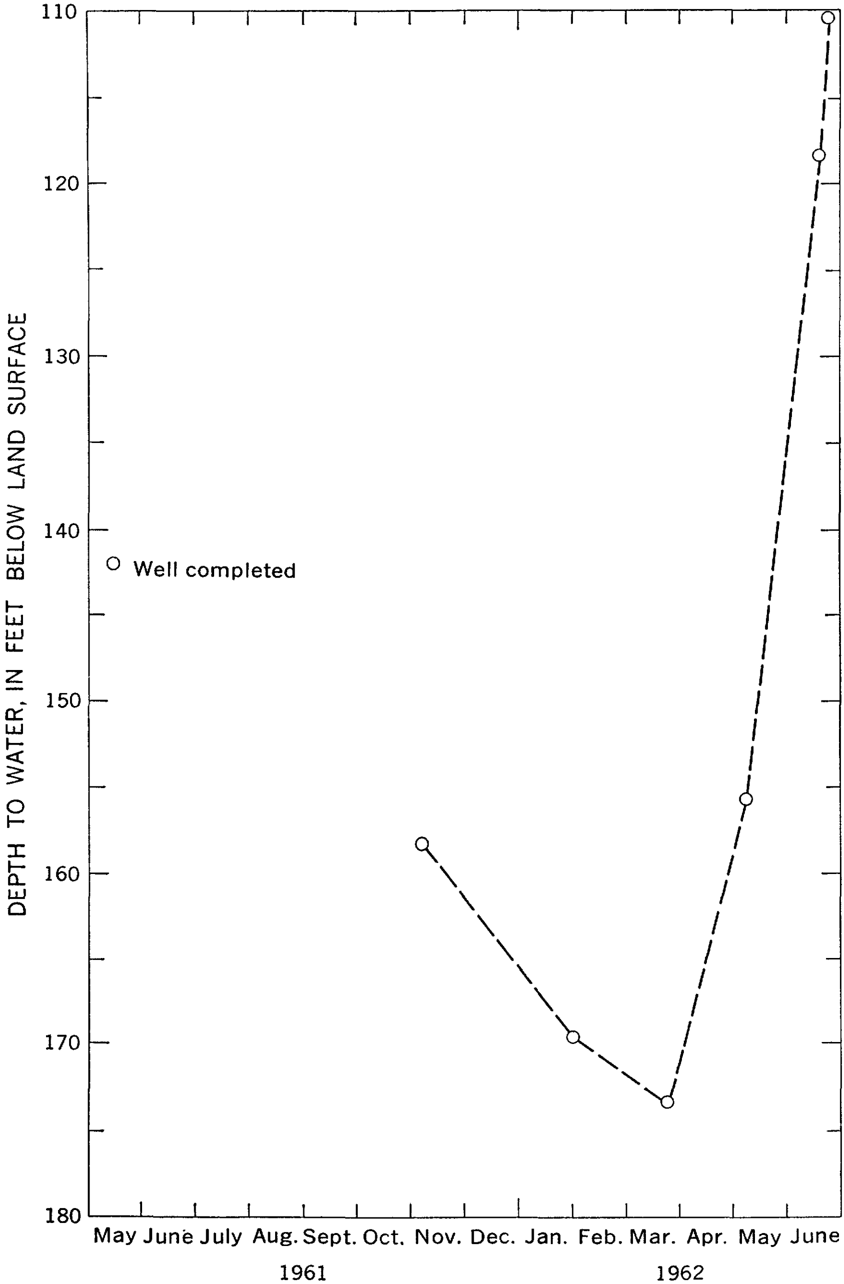

FIGURE 4.—Changes in water level in well 31N–119W–1dd1, in 1961–62.

(cubic feet per second) (U.S. Bur. Reclamation, 1949, p. 32), which is about 10 times the inflow at the south end of the valley. Most of the accessions to flow occur in the northern bottom land, for the Narrows forms a barrier to underground flow.

Under a project being studied by the U.S. Bureau of Reclamation, water stored in a reservoir in the valley of Crow Creek would be made available for irrigation in the summer months of low streamflow. Such regulation would diminish the rapid rises of ground-water level in spring in the vicinity of Fairview, which are produced by recharge from the uncontrolled runoff of Crow Creek, but would not alter ground-water levels very much in the lower, northern part of the valley. Ground-water level in the northern part of the valley is controlled mainly by the channel at the Narrows. The gravel under the heavy soils in the northern part of the valley permits free movement of water. Rise of ground-water level increases the discharge through seeps, and the increase in discharge tends to limit the rise in ground-water level.

OCCURRENCE

The main body of water in the gravel occurs under water-table conditions. However, bodies of perched water are common beneath the higher parts of the alluvial fans. At a few places, water is confined under artesian conditions. Artesian pressure is especially high during the seasons of high water levels.

Sheets of perched water are common in the alluvial fans on the east side of the valley. Water percolating from the streams near the mountain front becomes perched on clayey beds or sheets of cemented gravel that have low permeability. Such bodies of perched water have supplied water to a number of domestic wells on the east side of the valley, where depth and cost often have prohibited drilling to the water table. The perched water generally is not a reliable source of supply, and several wells have had to be deepened because the perched supplies proved insufficient. Well 31N–119W–25ad1, about 1½ miles north of Smoot, was deepened twice, to a final depth of 240 feet. That well penetrated two zones of perched water above the main water table. Because of the depth to the main water table, a majority of the rural households on the east side of the valley now obtain water from cooperatively owned pipelines that head in valleys in the mountain front.

Perched water also occurs in the alluvial fans on the west side of the valley. Here, however, the main water table is at such shallow depth that there is little economic reason to stop a well in the slightly shallower, less reliable water-bearing zones.

The water table descends beneath the alluvial fans and rises to the surface at the Salt River and in the sloughs of the bottom land.

Along the east side of the valley, the water table lies more than 100 feet below land surface in the vicinity of Afton and apparently lies more than 200 feet below the surface in the vicinity of well 31N–119W–25ad1, which is about 1½ miles north of Smoot and 1 mile west of the mountain front.

Along the west side of the valley, the water level generally is much closer to the surface; well owners report that water stands at or very near the surface in spring and rarely more than 20–30 feet below surface in winter.

The water table is at shallow depth in the lower parts of the valley, and some wells in the bottom land are pits only a few feet deep.

At places on the west side of the valley, water is under sufficient head during the spring to be confined in the gravel beneath the thick clayey soil or clayey beds at shallow depth. During a pumping test on well 31N–119W–10ab1, near Fairview, June 22, 1962, the water in the aquifer was under artesian pressure. The water level in the well was about 4.5 feet below the surface. Farther north along the west side of the valley, the water level during the spring stands almost at the surface in shallow excavations such as well 32N–119W–34ab1, which cuts through the soil into the underlying fan gravels. Later in the year, the water level declines so that the water at shallow depth is no longer under pressure in the west side zone, but water at depth in the gravel beneath clayey layers may still be under artesian pressure.

Wells that penetrate the tilted strata of pre-Pleistocene age in the foothills may yield water under pressure. Well 31N–119W–15cc1, on the edge of the valley of Spring Creek, obtains a small flow from a bed of sandstone beneath clay at a depth of 75 feet. The owner reports that pressure is sufficient to lift the water about 20 feet above land surface.

YIELD OF WELLS

Wells drilled in the gravel of the valley yield ample water supplies for domestic and stock needs, and a few wells are capable of yielding several hundred gallons per minute.

Well 31N–119W–10ab1, just east of Fairview, was drilled specifically for irrigation and is 103 feet deep. The well has been pumped at about 400 gpm (gallons per minute) to irrigate about 45 acres of alfalfa with a sprinkler system. Well 32N–119W–34ab1 is a pit dug with a backhoe to a depth of about 19 feet. It is on the gently sloping fan surface about 2 miles north of Fairview and 1 mile from the west margin of the valley and penetrates several layers of gravel beneath about 2 feet of clayey soil. It was pumped in the summer of 1961 to irrigate a field of alfalfa. The pumping rate is unknown but probably was several hundred gallons per minute.

Well 31N–119W–1dd1, 2 miles south of Afton, was drilled to a depth of 201 feet in alluvial-fan gravel to obtain irrigation water. A completion test by the driller in May 1961 showed that the well would yield several hundred gallons per minute, but the drawdown added to the original depth of the water (142 ft in May 1961) led the owner to decide that the well would not be an economic source of water.

HYDROLOGIC CHARACTERISTICS OF THE AQUIFER

Two pumping tests in June 1962 provided information on the hydrologic character of the alluvium. The wells tested were 31N–119W–1dd1 and 31N–119W–10ab1. The data are not necessarily representative of the entire area, and tentative conclusions from them should be used with caution.

Well 31N–119W–1dd1 was drilled to a depth of 201 feet, but measurement at the time of the pumping test showed that it was filled to a depth of 195 feet. The drilled diameter was 18 inches; 16-inch casing was set, and gravel was poured in the space between the casing and the well bore. The casing was slotted from a depth of 80 feet to the bottom of the hole. The data obtained during the test are given in table 2 and plotted in figures 5 and 6.

Pumping was started at a rate of 250 gpm. At this rate a drawdown of 3.65 feet resulted after 16 minutes of pumping (fig. 5); then the drawdown slowly increased until at the end of 120 minutes it was about 4.6 feet. At 123 minutes the pumping rate was increased to

TABLE 2.—*Data from pumping test on well 31N–119W–1dd1, June 21, 1962*

[Drawdown measurements during first part of test used to compute coefficient of transmissibility]

Hour (a.m.)	Time after pump started (min)	Depth to water below datum (ft)	Correction for static water-level trend (ft)	Drawdown (ft)	Corrected drawdown (ft)	Discharge (gpm)
8:07	Pumping began	113.30				
8:11	4	113.82		0.52	0.52	
8:15	8	114.70		1.40	1.40	225
8:20	13	116.95	+0.01	3.65	3.66	230
8:23	16	117.10	+.01	3.80	3.81	255
8:27	20	117.24	+.02	3.94	3.96	250
8:30	23	117.50	+.02	4.20	4.22	260
8:35	28	116.97	+.02	3.67	3.69	240
8:42	35	117.30	+.03	4.00	4.03	250
8:45	38	117.34	+.04	4.04	4.08	255
8:55	48	117.60	+.05	4.30	4.35	250
9:15	68	117.17	+.06	3.87	3.93	245
9:30	83	117.45	+.08	4.15	4.23	255
9:45	98	117.60	+.09	4.30	4.39	260
9:55	108	117.85	+.10	4.55	4.65	280
10:10	123	117.80	+.10	4.50	4.60	
10:11	Increased pumping rate					390

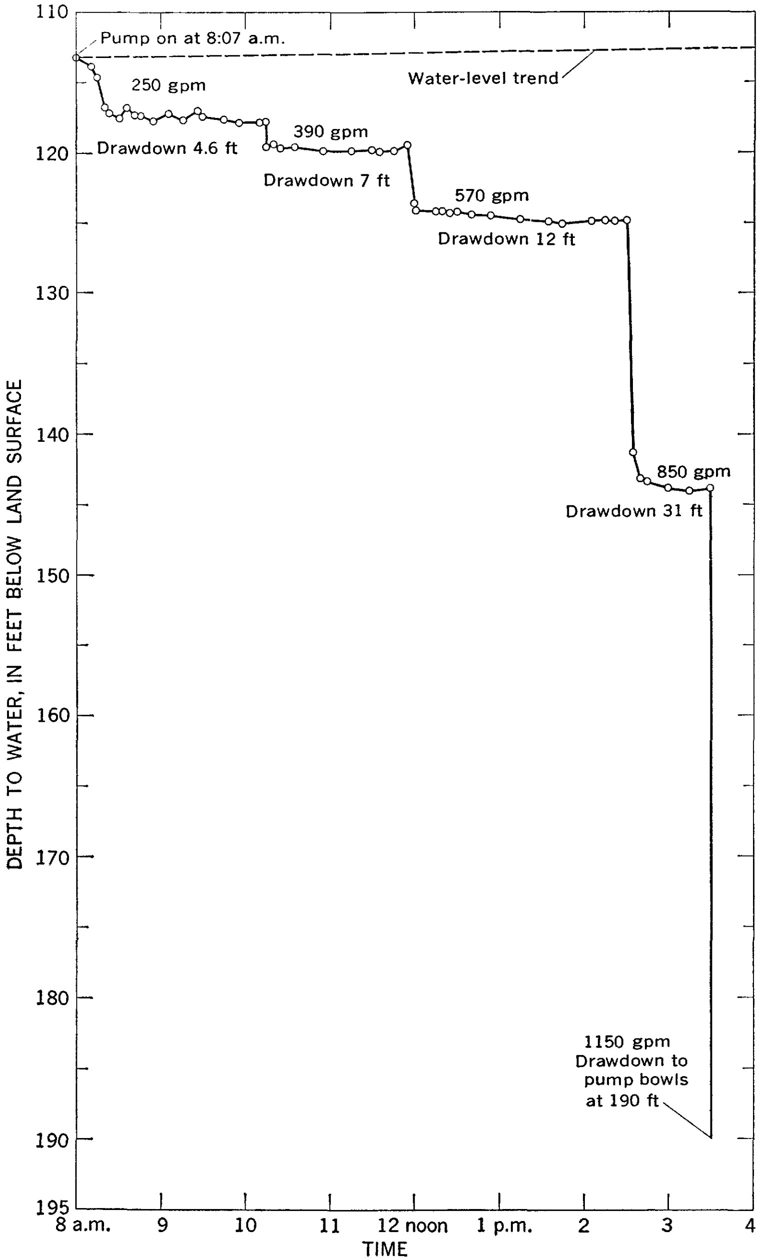

FIGURE 5.—Drawdown of water level in well 31N–119W–1dd1 (depth, 195 ft) when pumped at different rates, June 21, 1962.

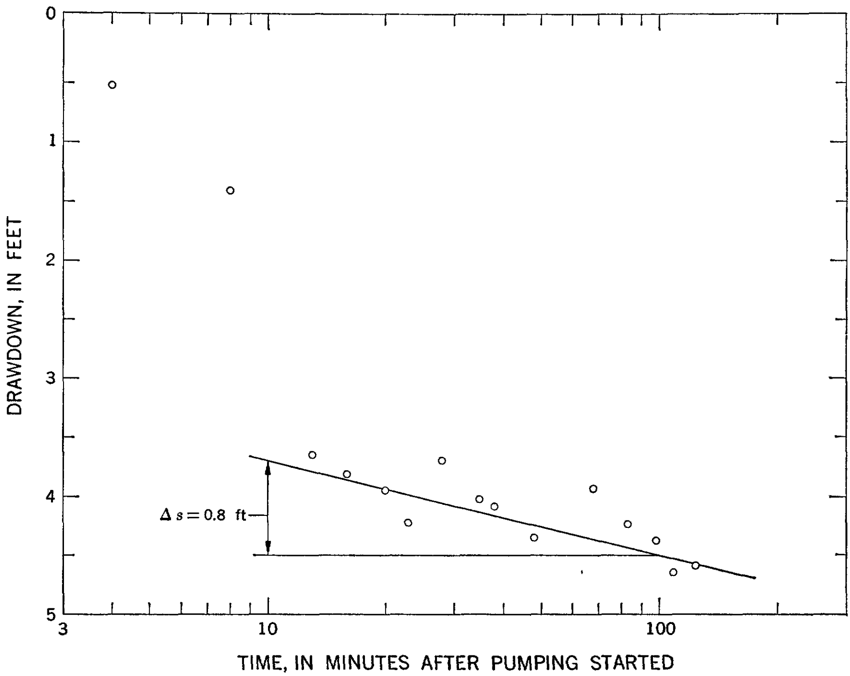

FIGURE 6.—Time-drawdown plot of water level in well 31N–119W–1dd1 during first part of pumping test, June 21, 1962. $T=\frac{264Q}{\Delta s}=\frac{264\times 250}{0.8}=82{,}500$ gpd per ft where

T=transmissibility, in gallons per day per foot
Q=pumping rate, in gallons per minute
Δs=drawdown, in feet, over one log cycle of time.

390 gpm, later to 570 gpm, then to 850 gpm, and finally to 1,150 gpm. The final rate of 1,150 gpm quickly drew the water level in the well down to the pump intake, which was set at 190 feet below the surface.

The several pumping rates, corresponding drawdowns, and values of specific capacity (yield, in gallons per minute per foot of drawdown) were as follows:

Pumping rate (gpm)	Drawdown (feet below static water level)	Specific capacity (gpm per ft of drawdown)	Relative efficiency (percent)
250	4.6	54.2	--------
390	7	55.7	100
570	12	47.5	85
850	31	27.4	49

The well showed slightly higher specific capacity at 390 gpm than at 250 gpm; presumably this was due to some development in the well, which had not been pumped for more than a year. At increased rates of pumping the specific capacity declined, as was to be expected, owing to dewatering of the aquifer around the well and to the increasing well loss caused by turbulence in and close to the well at higher entrance velocities. If it is assumed, for purposes of comparison, that there is little or no well loss at the pumping rate of 390 gpm and the well has an efficiency of 100 percent, then the efficiency of the well is only 85 percent at a pumping rate of 570 gpm and 49 percent at a pumping rate of 850 gpm. The well-loss constant could not be computed because of the development that occurred during the pumping and changed the characteristics of the layer immediately surrounding the slotted casing.

Drawdown was plotted against time on semilogarithmic paper (fig. 6) for the first part of the test to determine the coefficient of transmissibility [1] by the method that Jacob described (1950). After 10 minutes of pumping, the drawdown points roughly define a straight line, which slopes about 0.8 foot of drawdown per log cycle. The calculated coefficient of transmissibility is 82,500 gpd per ft (gallons per day per foot). The gradient of the water table in this area is much more than 1 foot per mile, and consequently the flow per linear mile is far more than 82,500 gpd.

The scatter of the plotted points probably reflects three things: (1) Small errors in measuring a water level more than 100 feet below land surface, (2) surges of the water level in response to minor changes in pumping rate, and (3) changes in barometric pressure due to the thunderstorms that occurred during the test. However, the transmissibility estimated from specific capacity [2] is 72,500 gpd per ft, and this suggests that the value of 82,500 gpd per ft is approximately correct.

The water-bearing formation in the vicinity of Fairview, on the west side of the valley, was tested on June 22 by pumping well 31N–119W–10ab1 and measuring drawdown in a well 80 feet away (–10ab2). The pumped well is 103 feet deep and has 10-inch casing perforated for the lower 36 feet. The observation well is about 100 feet deep and is perforated in the lower 40 feet. The aquifer in this area consists of gravel and a few thin beds of clay. Data obtained during the test are given in table 3 and plotted in figures 7 and 8.

[1] The coefficient of transmissibility is defined as the quantity of water, in gallons per day, that will move through a strip of the aquifer 1 mile wide, under a gradient of 1 ft per mile.

[2] Theis, C. V., and others, 1954, Estimating transmissibility from specific capacity: U. S. Geol. Survey Ground-Water Note 26, 11 p.

TABLE 3.—*Data obtained by pumping well 31N–119W–10ab1 at a rate of 320 gpm on June 22, 1962*

Hour	Time after pump started or stopped (min)	Depth to water below datum (ft)	Correction for static water-level trend (ft)	Drawdown (ft)	Corrected drawdown (ft)
8:55 a.m.	Pump started	7.615	----------	----------	----------
8:56	1	7.985	+0.001	0.370	0.371
8:57	2	8.05	.002	.435	.437
8:59	4	8.115	.003	.500	.503
9:00	5	8.15	.004	.535	.539
9:01	6	8.17	.005	.555	.560
9:02	7	8.175	.005	.560	.565
9:03	8	8.175	.006	.560	.566
9:05	10	8.17	.007	.555	.562
9:07	12	8.155	.009	.540	.549
9:12	17	8.16	.012	.545	.557
9:15	20	8.155	.015	.540	.555
9:20	25	8.17	.019	.555	.574
9:30	35	8.18	.026	.565	.591
9:35	40	8.17	.030	.555	.585
9:45	50	8.17	.037	.555	.592
9:55	60	8.165	.045	.550	.595
10:05	70	8.17	.052	.555	.607
10:15	80	8.17	.060	.555	.615
11:05	130	8.155	.097	.540	.637
11:30	155	8.14	.116	.525	.641
12:00 m.	185	8.13	.139	.515	.654
12:30 p.m.	215	8.10	.161	.485	.646
1:40	285	8.055	.214	.440	.654
2:00	305	8.05	.229	.435	.664
2:30	335	8.035	.251	.420	.671
2:35	Pump off	----------	----------	----------	Residual drawdown
2:36	1	7.73	.256	----------	.371
2:44	9	7.455	.262	----------	.102
2:53	18	7.39	.268	----------	.043
3:00	25	7.365	.274	----------	.024
3:20	45	7.335	.289	----------	.009
3:30	55	7.385	Disturbance in water level occurred.		
4:00	85	7.375			
4:30	115	7.36			
7:25	----------	7.35			

Pumping at a rate of 320 gpm produced drawdown in the observation well of 0.54 foot in the first 5 minutes. The rate of drawdown decreased thereafter. The water level began to rise slowly in the observation well after about 130 minutes of pumping, because the rate of drawdown had by then become slower than the natural rise in static water level that was occurring because of spring runoff. The drawdown corrected for the rising trend is shown by the lower curve of figure 7. After 355 minutes the pump was turned off, and the water level recovered through a smooth curve for 45 minutes; then some disturbance of unknown origin caused a downward break in the recovery curve.

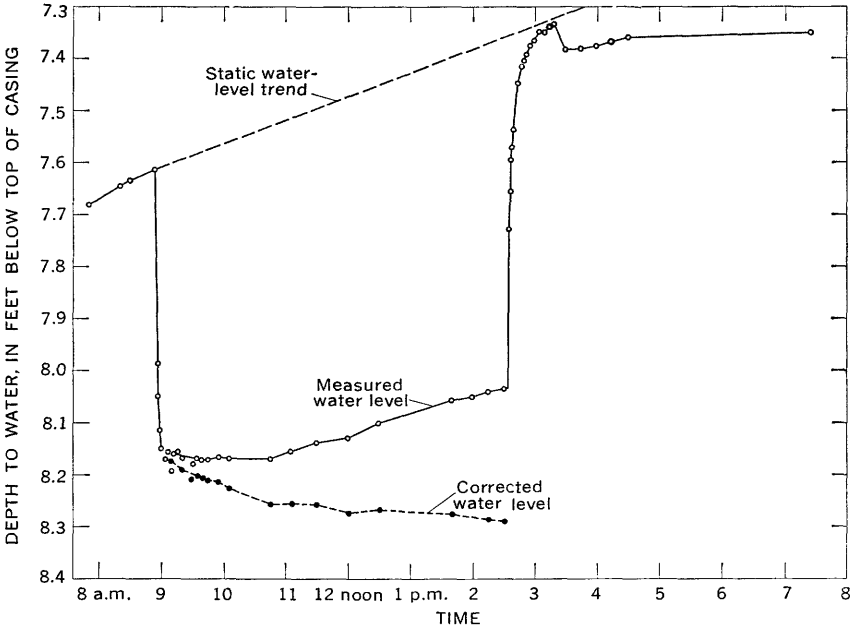

FIGURE 7.—Drawdown of water level in observation well 31N–119W–10ab2, during pumping of well 31N–119W–10ab1, June 22, 1962. Pumping rate 320 gpm. Distance from pumped well, 80 feet.

The plot of corrected drawdown against time on semilogarithmic graph paper (fig. 8) shows straight-line relations for about the first 7 minutes after pumping. Thereafter the rate of decline of water level decreased, and the plotted points trace a straight line of lower slope.

The straight line traced by points from 1 to 7 minutes slopes 0.23 foot per log cycle. This value substituted in the equation given by Jacob (1950) gives a coefficient of transmissibility of 370,000 gpd per ft. The storage coefficient is computed to be 0.0003.

The above values are preferable to values computed from the slope of a straight line drawn through points of drawdown after 10 minutes. Computation shows that after about 1 minute of pumping, points of drawdown could be expected to plot on a straight line. Also, the coefficient of storage computed from the later points is unreasonably low (0.000007), and the coefficient of transmissibility (1,060,000) is somewhat higher than would be expected for the type and thickness of gravel in this valley.

The change in slope of the curve after about 8 minutes of pumping may show that the cone of drawdown had spread at that time to reach some source of recharge, which caused a lower rate of drawdown. It

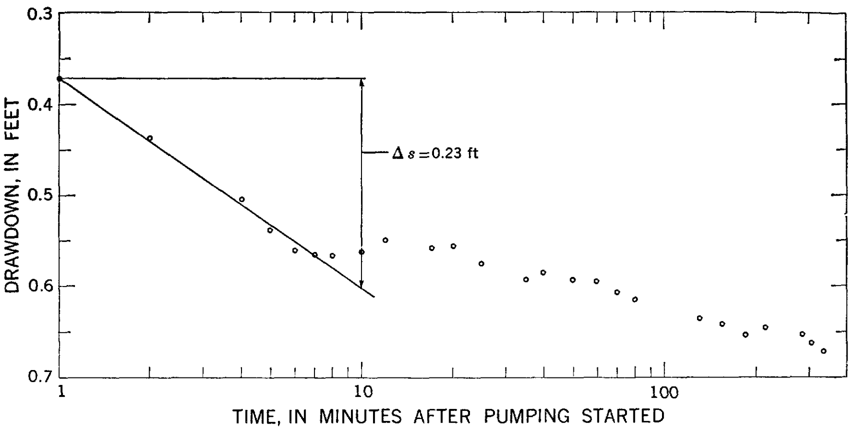

FIGURE 8.—Time-drawdown plot of water level in observation well 31N–119W–10ab2, during pumping of well 31N–119W–10ab1, June 22, 1962.

$$T=\frac{264Q}{\Delta s}=\frac{264\times 320}{0.23}=370{,}000 \text{ gpd per ft}$$

$$S=\frac{0.3Tt_0}{r^2}=\frac{0.3\times 370{,}000\times 0.000017}{80^2}=0.0003$$

where

T=transmissibility, in gallons per day per foot
Q=pumping rate, in gallons per minute
Δs=drawdown, in feet over one log cycle of time
S=storage coefficient
t_0=time in days at intersection of zero drawdown axis
r=distance, in feet, to pumped well (80 ft).

is also possible that the cone of drawdown had spread into more permeable material.

The two pumping tests show that the gravel at both sites has a moderately high transmissibility. The value of 370,000 gpd per ft for gravel on the west side is more than four times the value of 82,500 gpd per ft for that on the east side. The differences may reflect local conditions around the two wells. However, two tests are insufficient to permit a general conclusion regarding relative permeabilities of gravels on the east and west sides of the valley.

The two tests and the experience with a well and a pit used for irrigation on the west side of the valley show that the gravel will yield sufficient water for irrigation, at least in some places. The pumping lift required will probably not be more than a few tens of feet at most places on the west side of the valley. However, the lift probably will be more than 150 feet through broad parts of the east side of the valley.

In the project under study by the U.S. Bureau of Reclamation, water from a reservoir in the valley of Crow Creek would be distributed to the east side of the upper Star Valley by a canal crossing the valley about 1½ miles south of Fairview. Supplies of water for land south of the canal would have to come from ground water. Available evidence indicates that the gravel aquifer underlies the southern part of the valley and will yield as much there as it does in the areas tested to the north. Coarse gravel is exposed in banks along the Salt River in the area of T. 31 N., R. 119 W. The well 31N–119W–25ad1 on the east side of the valley, 1½ miles north of Smoot, reportedly penetrates gravel to a depth of 240 feet, or considerably below the level of the Salt River. Recharge occurs by infiltration from streams and from irrigation diversions on the alluvial fans. Depth to water will range from a few feet in bottomlands along the Salt River to possibly as much as 200 feet beneath the higher parts of the alluvial fans on the east side of the valley.

All evidence leads to the conclusion that the aquifer can yield large amounts of water. To the extent that pumped water is consumed by crop plants and evaporated, the flow of the Salt River will be decreased. However, large volumes of water now flow from the valley unused. Pumping will of course lower water levels measurably in pumped areas. In areas on the east side of the valley the aquifer fills to overflowing in spring; lowering of water levels by pumping in such areas will cause more of the spring runoff to enter the ground and less to run off in surface drainageways. Pumping of ground water on the alluvial fans, where supplementary water is needed most, probably will not lower water levels significantly in the bottom land, especially that in the northern part of the valley where ground-water levels are controlled by the barrier to ground-water flow at the Narrows.

CHEMICAL CHARACTER OF GROUND WATER

Chemical analyses of 12 samples of ground water from the upper Star Valley (table 4) were made to determine the suitability of the water for irrigation. The amounts of certain substances commonly present in water—notably silica, fluoride, and iron—were not determined. The sum of the determined constituents probably amounts to about 90 percent of the total dissolved solids in these waters.

The analyses of water are plotted in figure 9 to show graphically the character of the water. The relative proportions of the cations (calcium, magnesium, and sodium and potassium) and anions (bicarbonate, sulfate, and chloride and nitrate) can be read from the position of the points. Of the 12 analyses, 10 plot in about the same part of the diamond-shaped diagram; they are of water generally similar in character and represent the common water of the valley.

Reference to the lower diagrams shows that the common water is of the calcium-magnesium-bicarbonate type. Sodium content ranges from about 2 to 20 percent of the cations determined in analysis. Bicarbonate, the dominant anion, ranges from 65 to 95 percent of total anions; sulfate ranges from 4 percent to 35 percent, and only one of the samples shows more than 5 percent chloride.

The 10 samples of the common type of water show hardness ranging from 208 to 280 ppm (parts per million) and averaging 233 ppm; this water is considered very hard. Sum of determined constituents ranges from 223 to 363 ppm and averages 256 ppm.

The distribution of the points representing the common water shows certain differences between the water derived from the east and from the west sides of the valley. Points 2, 4, 5, 7, and 12, which form a cluster in figure 9, represent water from wells in the alluvial gravel on the east side of the valley. The others except point 8, represent water from wells on the west side of the valley. In general the water of the east side is distinguished from that of the west side by lower proportions of sodium and higher proportions of sulfate and by a slightly lower content of dissolved solids.

The common water represented by 10 samples is of good quality for irrigation, according to the classification for suitability for irrigation of the U.S. Salinity Laboratory Staff (1954), because it contains only moderate concentrations of dissolved solids and low proportions of sodium.

The water from a well in Auburn (point 3, well 32N–119W–4ab1) is chemically dissimilar to most ground water of the valley because of the relatively high proportions of sodium and chloride. Water from the hot spring (33N–119W–23ac1) at the north end of the valley is of the sodium-chloride type, and the sum of the determined constituents is 5,490 ppm. The sodium chloride in both of these waters is probably derived from the salt that is known to occur in the Preuss Sandstone. Because of high content of sodium the water from the hot spring is definitely unsuitable for irrigation, and water of the type from well 32N–119W–4ab1 should not be used on poorly drained soils; it is of marginal quality even on well-drained soils for crops intolerant of salt.

CONCLUSIONS

The Upper Star Valley is underlain by fairly coarse textured gravel that contains unconfined water. Only a few wells close to the west edge of the valley have penetrated gravel to bedrock, and gravel probably extends far below the water table through most of the valley. The gravel is recharged from water of tributary streams that per-

TABLE 4.—*Chemical analyses of representative samples of ground water from the upper Star Valley, Wyo.*

[Analyses by U.S. Bur. Reclamation. Chemical constituents in parts per million]

Well	No. on fig. 9	Depth (ft)	Date of collection (1962)	Aquifer	Temperature (°F)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate NO_3	Boron (B)	Dissolved solids sum of determined constituents (ppm)	Residual sodium carbonate (meq per l)	Sodium-adsorption ratio (SAR)	Hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	pH	Class [1]
33N-119W-23ac1	1	([2])	5/10	Limestone	140	404	78	1,440	156	892	0	1,086	1,885	0	2.90	5,490	−11.98	17.10	1,330	4,300	6.8	C4–S4
32N-119W-1dd1	2	92	5/11	Gravel	48	55	22	2.5	1.2	205	0	53	.0	13	.08	248	−1.17	.07	226	403	7.7	C2–S1
4ab1	3	80	5/11	do	49	72	28	110	5.9	234	0	58	197	2.5	.04	589	−2.06	2.79	295	992	7.9	C3–S1
23dd1	4	80	5/11	do	42	61	20	1.4	1.2	185	0	79	.4	1.9	.03	256	−1.69	.04	237	415	7.8	
24dd1	5	150	5/11	Sand	46	51	25	1.4	1.2	198	0	62	2.5	3.1	.01	243	−1.31	.04	228	420	7.8	
28ac1	6	320	5/11	Sandstone	55	47	23	10	3.1	262	0	8.2	7.8	0	.03	228	.07	.30	211	408	7.6	
31N-119W-1da1	7	148	5/11	Gravel	45	54	22	5.5	1.2	204	0	54	1.1	6.2	0	243	−1.13	.16	224	408	7.8	
1dd1	8	195	6/21	do	45	56	17	2.8	.8	187	0	48	1.4	5.6	0	223	−1.03	.08	208	377	7.7	C2–S1
2cc1	9	89	5/11	do	48	44	28	3.4	1.6	246	0	26	1.1	1.2	.01	228	−.44	.10	224	408	7.7	
10ab1	10	103	6/22	do	-----	79	17	7.4	1.6	279	0	33	2.8	11	.03	289	−.68	.20	267	500	7.4	
10bc1	11	50	5/11	do	47	54	36	30	3.9	314	0	48	34	1.9	.04	363	−.46	.79	280	619	7.5	
25ad1	12	240	5/11	do	48	59	17	1.4	1.2	185	0	62	.4	5.0	.03	237	−1.34	.04	220	393	7.7	

[1] According to classification for suitability for irrigation of U.S. Salinity Lab. Staff (1954).
[2] Spring.

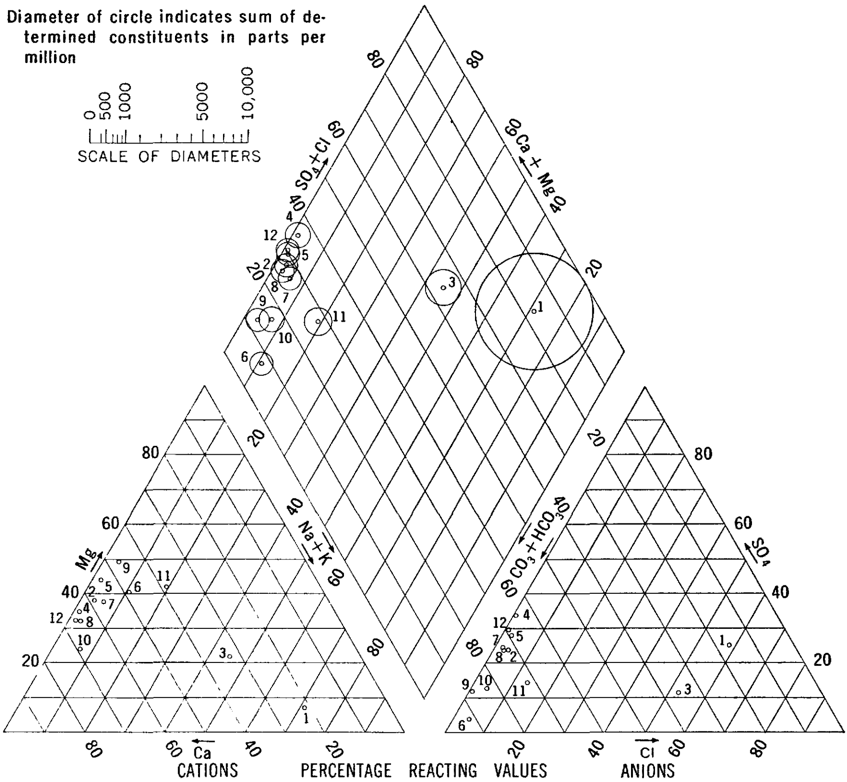

FIGURE 9.—Chemical character of typical ground waters of the upper Star Valley, Wyo.

colates into the alluvial fans at the valley margins, from irrigation diversions on the fans, and from melting snow on the valley floor.

Pumping tests on two wells, one on the east side and the other on the west side of the valley, gave values of transmissibility of 82,500 and 370,000 gpd per ft, respectively. These values indicate the minimum range that may be expected of the type of gravel observed in exposures.

The data from the pumping tests and successful attempts by two ranchers to obtain water indicate that wells in the gravel will produce sufficient water for irrigation, at least in some places. Development of ground water for irrigation is favored in the center and on the west side of the valley by relatively shallow depth to water. On the east side, however, the water level probably is more than 100 feet below the surface for at least 1 mile out from the mountain front.

The amount of water that can be pumped from the aquifer each season without causing progressive decline in ground-water level has not been estimated but undoubtedly is large. Pumping of ground water will lower water levels and reduce the amount of water that seeps into the Salt River and escapes from the upper Star Valley. The amount will be less than the amount pumped and will be close to that consumed by the crops and lost by evaporation incident to its delivery for irrigation.

More information on the hydrologic characteristics of the gravel aquifer and the amounts of water moving through it is needed for planning large-scale development of ground water in the upper Star Valley. Values for the coefficient of transmissibility can be obtained from controlled pumping of test or production wells at selected sites. The amount of water in movement and coefficient of transmissibility can be obtained by analysis of a flow net prepared from a contour map of the water table and measurement of gain in flow along the Salt River. Construction of a water-table map would require drilling many test wells, because, at present, water levels can be measured in only a few, widely separated wells.

RECORDS OF WELLS

The following table presents data on wells inventoried in the upper Star Valley in the course of this investigation. Not all the wells in the valley were visited, but effort was made to obtain good geographic distribution, and the inventoried wells probably show representative conditions.

The data were acquired mainly through interviews with well owners. Drillers' records were available for a few wells.

TABLE 5.—*Records of wells in the upper Star Valley, Wyo.*

Type: D, dug; Dr, drilled; Dv, driven.
Depth: In feet below land-surface datum, all depths are reported.
Character of aquifer: S, sand; G, gravel.
Water level: Depth in feet below land-surface datum. Measured depths to water are given to the nearest 0.1 ft. Reported depths to water given to the nearest foot.

Pump type: J, jet; P, piston; T, turbine; C, centrifugal; N, none.
Use: N, none; Irr, irrigation; Dom, domestic; St, stock; Ind, industrial; Obs, observation.

Well or spring	Owner	Year drilled	Type	Depth	Casing diameter (in)	Character of aquifer	Water level: Depth	Water level: Date	Pump: Type	Pump: Horsepower	Yield (gpm)	Use of water	Remarks
33N-119W-23ac1	Keith Hyde					Limestone.						Bathing	Sulfur Hot Spring. Temperature 140° F. Analysis.
24bc1	Clyde Bagley		Dr	50	6	G	15		J	½		Dom, St	
26ac1	Norman Johnson		D	4	36	G	2	(1)	J	½		Dom, St	
26ad1	Orson Johnson			(1)		G						N	Warms Spring, temperature 99° F.
35bb1	Clifford Burton	1944	Dr	38	6	G	12	1944	J	¾		Dom, St.	
33N-118W-31dc1	Serell Hurd	1940	Dv	14	1½	G	9	1940	J	¼		Dom	
32cc1	B. H. Anderson	1925	Dr	40	6	G	25		J	½		Dom	
32N-119W-1dd1	Ralph Herzog	1930	Dr	92	6	G	20	1930	T	½		Dom	Analysis.
4ab1	A. J. Anderson	1959	Dr	80	6	G	6–20		J	½		Dom, St.	Do.
4ac1	Gleno Draney	1961	Dr	42	8	G	16	1961	J	⅓		St	Log.
4db1	Jack West	1943	Dr	50	6	G			J	½		Dom, St.	
4dd1	John Smith	1958	D	14	1¼	G	6	1958	P	0		Dom	
13cd1	Wallace J. Gardner	1950	Dr	59	7	G	39	1950	J	½		Dom, St.	
13dc1	Paul Chase		D, Dr	62	6	G			J	½		Dom, St.	
14ca1	Winfield Burton	1942	Dv	27	6	G			J	½		Dom	
14cd1	Fielding Burton		Dr	33	6	G	6.41	May 10, 1962	N			N	
14cd2	do		D	4	36	G	2		J	½		Dom	
16da1	Lorin Leavitt		Dr	60	6	G	30		J	1		Dom, St.	
16db1	Ray Leavitt		Dr	87	6	S						Dom, St.	
21aa1	Dale Cazier	1948	Dr	80	6	G	12.65	May 10, 1962	N			N	
22bb1	do	1948	Dr	40	6	G	10		J	½		St	
23dd1	Ted Linford	1942	Dr	80	6	G	60	1942	T	½		Dom, St.	Analysis.
24dd1	Wyoming Dept. Highways.	1951	Dr	150	6	S	111	Dec. 1951			12	Ind	Log. Analysis.
25bb1	Cloyde Anglesey	1960	Dr	67	6	G	35	1960	J	½		Dom	
28ac1	Vernon Dabel	1953	Dr	320	6	Sandstone.	45	1953	T	½		Dom	Log. Analysis.
34ab1	Orla Miller	1961	D	19		G	10	1961	C			Irr	A pit, uncased.
32N-118W-19cb1	Karol Parsons	1945	Dr	135	8	G	115	1945	P	¾		Dom	

See footnote at end of table.

TABLE 5.—*Records of wells in the upper Star Valley, Wyo.*—Continued

Well or spring	Owner	Year drilled	Type	Depth	Casing diameter (in)	Character of aquifer	Water level		Pump		Yield (gpm)	Use of water	Remarks
							Depth	Date	Type	Horsepower			
31N-119W-1da1	Reed H. Gardner	1960	Dr	148	6	G	117	Jan 30, 1962	T	¾		Dom, St	Analysis.
1dd1	do	1961	Dr	195	16	G	157.4	Nov. 8, 1961	N			N	Pumping test. Log. Analysis.
2cc1	Hillstead & Allred	1950	Dr	89	6	G			T	1		Dom, St	Supplies 3 homes. Analysis.
3db1	Vearl Hoopes	1950	Dr	45	6	G			J	½		Dom, St	
3dc1	Eldon Allred	1910	Dr	65	6	G			J	½	7	St	
10ab1	Barney Flynn	1959	Dr	103	10	G	18	1959		20	400	Irr	Pumping test. Log. Analysis.
10ab2	do	1962	Dr	100	3	G	7.6	June 22, 1962				Obs	
10bc1	Julian Hoopes	1910	Dr	50	6	G	41.03	Nov. 9, 1961	P	¾		Dom, St	Analysis.
10db1	Lloyd Hoopes	1920	Dr	100	6	G	63.8	do	N			N	
11ba1	Jesse Hoopes	1939	Dr	120	8	G	75		T	¾		Dom, St	
12aa1	Claude Tippets	1961	Dr	124	6	G						Dom	
15cc1	Howard Nebeker	1949	Dr	75	6	Bedrock	Flows		P	½		Dom	Pressure lifts water 20 ft above land surface.
25ad1	William Stump	1954	Dr	240	6	G			T	½		Dom	Log. Analysis.
31N-118W-31ac1	E. G. Brown	1953	Dr	45	6	G	10	Aug. 1961	J	1		Dom	Log.

[1] Spring.

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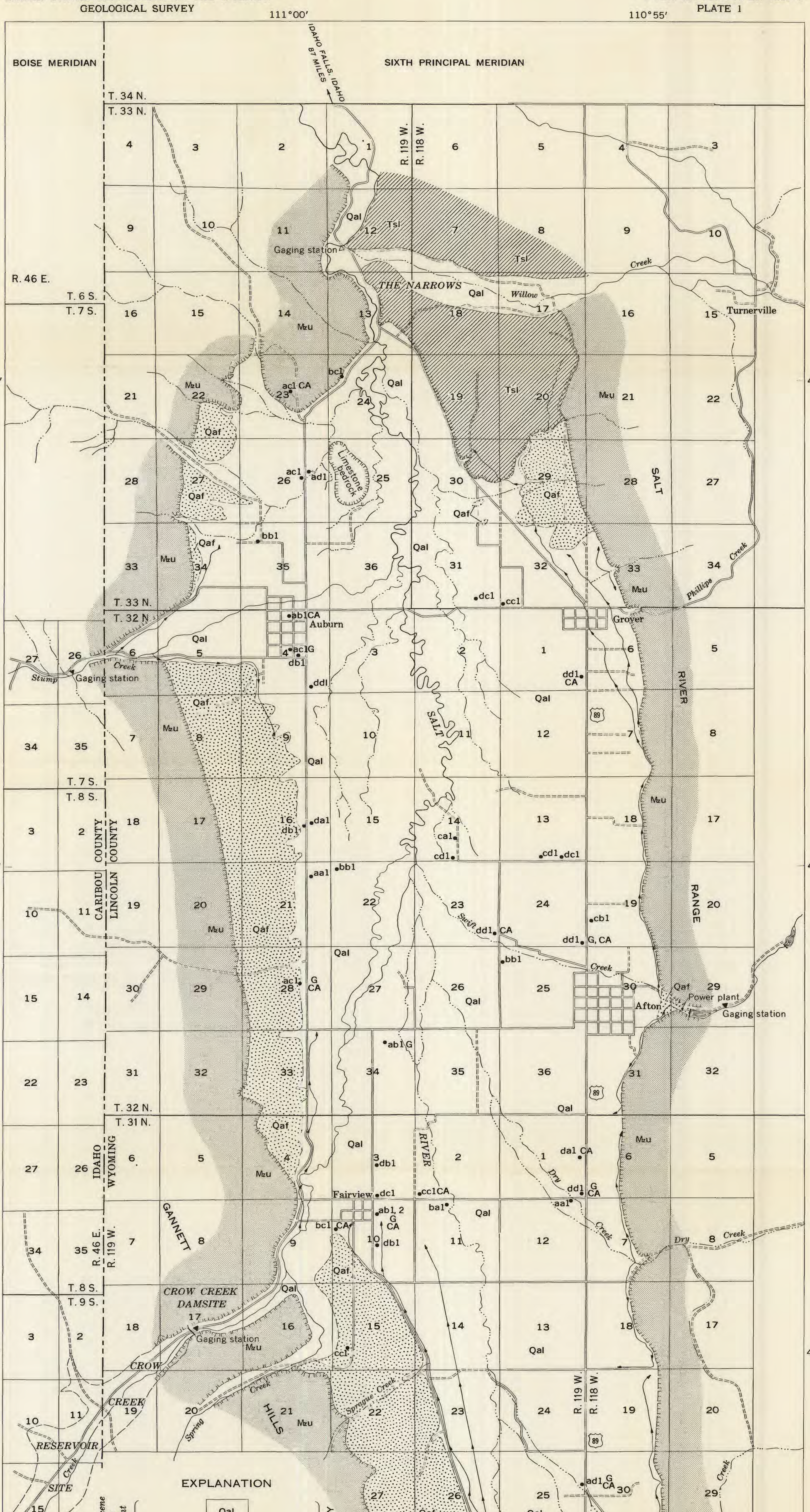

Base from U.S. Bur. Reclamation Map showing areal divisions and irrigation works for Star Valley Project under consideration

GENERALIZED GEOLOGIC MAP OF THE UPPER STAR VALLEY, WYOMING SHOWING LOCATION OF WELLS

TRUE NORTH — MAGNETIC NORTH — 17°
APPROXIMATE MEAN DECLINATION, 1965

1 ½ 0 1 2 3 MILES

1 .5 0 1 2 3 KILOMETERS

APPROXIMATE SCALE