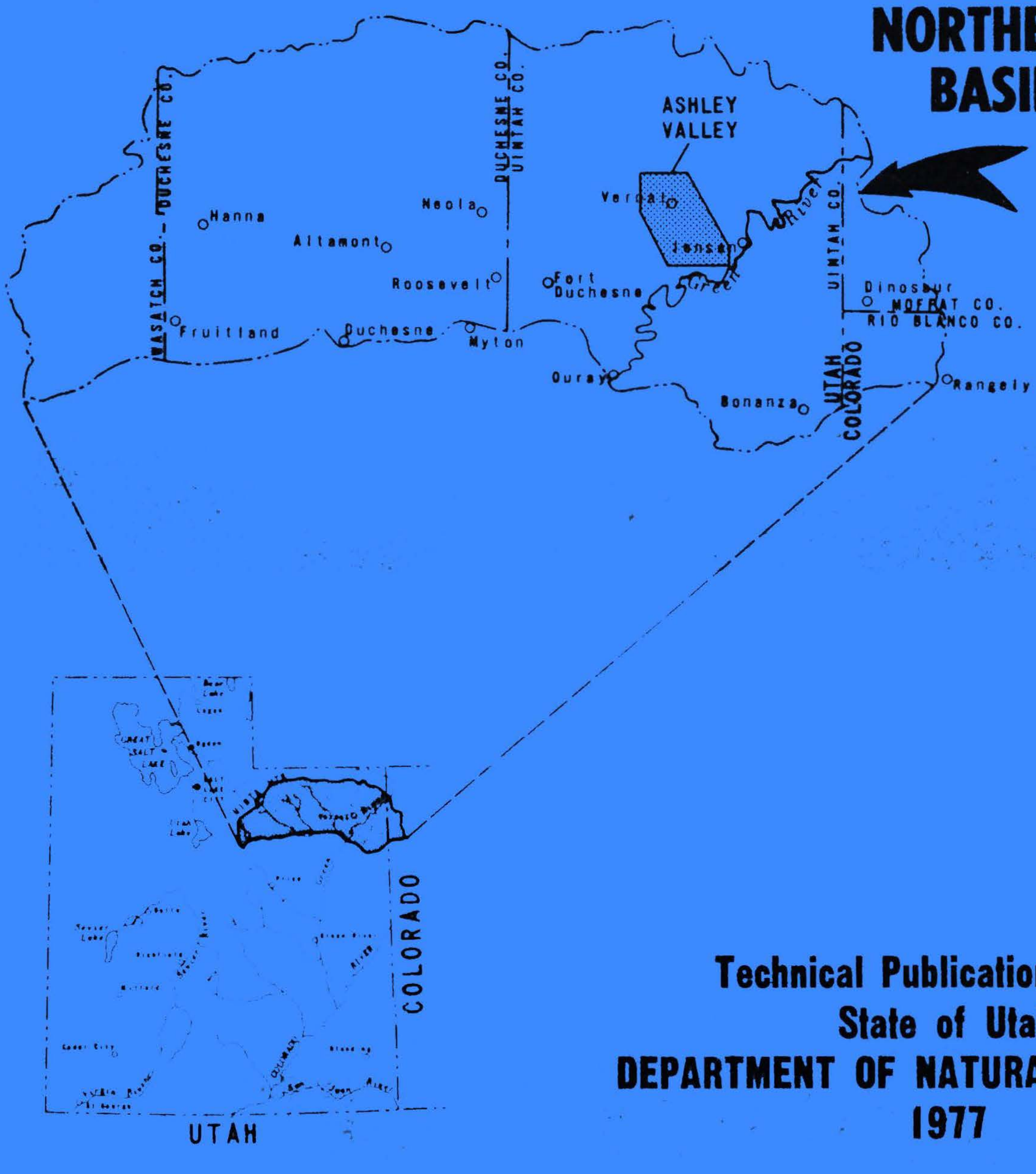
HYDROLOGIC EVALUATION OF ASHLEY VALLEY, NORTHERN UINTA BASIN AREA, UTAH



Technical Publication No. 54

State of Utah

DEPARTMENT OF NATURAL RESOURCES

1977

CALVIN L. RAMPTON
Governor

This report was prepared as a part of the Statewide cooperative water-resource investigation program administered jointly by the Utah Department of Natural Resources, Division of Water Rights and the United States Geological Survey. The program is conducted to meet the water administration and water-resource data needs of the State, as well as the water information needs of many units of government and the general public.

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by

James W. Hood
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ILLUSTRATIONS

[Plate is in pocket]

ENGLISH-TO-METRIC CONVERSION FACTORS

Most numbers are given in this report in English units followed by metric units. The conversion factors used are shown to four significant figures. In the text, however, the metric equivalents are shown only to the number of significant figures consistent with the accuracy of the number in English units.

English Units (Multiply)	Abbreviation	(by)	Metric Units (to obtain)	Abbreviation
Acres		0.4047	Square hectometres	hm^2
Acre-feet	acre-ft	.001233	Cubic hectometres	hm^3
Cubic feet per second	ft^3/s	.02832	Cubic metres per second	m^3/s
Feet	ft	.3048	Metres	m
feet per mile	ft/mi	.1894	Metres per kilometre	m/km
Inches	in	25.40	Millimetres	mm
Miles	mi	1.609	Kilometres	km
Square feet	ft^2	.09290	Square metres	m^2
Square miles	mi^2	2.590	Square kilometres	km^2

Chemical concentration and water temperature are given only in metric units. Chemical concentration is given in milligrams per litre (mg/l). For concentrations less than 7,000 mg/l, the numerical value is about the same as for concentrations in the English unit, parts per million.

Chemical concentration in terms of ionic interacting values is given in milliequivalents per litre (meq/l). Meq/l is numerically equal to the English unit, equivalents per million.

Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation: $°F = 1.8(°C) + 32$.

HYDROLOGIC EVALUATION OF ASHLEY VALLEY,

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ABSTRACT

The water resources of the northern Uinta Basin, Utah and Colorado, were studied during 1971-74. Ashley Valley was evaluated in slightly greater detail than the general area, in order to assess the general relation of ground- and surface-water supplies.

In Ashley Valley, the principal source of both irrigation supply and ground-water recharge is the flow from Ashley Creek canyon. Ground-water recharge to the valley fill, however, is mainly from canal and field losses along the west side of the valley. The permeability of the fill in most places is high, and water-level records indicate rapid changes in storage in response to the annual applications of irrigation water.

Prior to the distribution of water from Steinaker Reservoir, the short runoff season led to a brief, intense irrigation period that was followed by a long period of post-irrigation drainage. After the reservoir began operation, smaller applications of water were made during a longer season, and ground-water levels rose in parts of the valley, mainly the lower areas. Despite local water-level rises, no perennially gaining reaches of the canals were observed.

The amount of ground water available from storage in Ashley Valley is estimated to be 50,000-75,000 acre-feet (62-92 cubic hectometres), or enough water to supply irrigation in the valley for a maximum of 2 years. The ground-water storage varies annually about 10 percent and has not changed significantly. Ground water is discharged from Ashley Valley both by seepage back to Ashley Creek and by evapotranspiration.

Evapotranspiration of surface and ground water has increased by an estimated 20 percent above the 48,000 acre-feet (59 cubic hectometres) determined for pre-reservoir conditions. As a result, the water that flows from Ashley Valley has been degraded in chemical quality.

The water from Ashley Creek canyon is fresh. Mixing of snowmelt and base flow in Steinaker Reservoir yields a water of more uniform quality; but despite some concentration by evaporation from the reservoir, the outflow from the reservoir is fresh. Ground water in most of the valley is fresh, but the water increases in dissolved-solids concentration toward the south and east as a result of both evapotranspiration and solution of minerals from the valley fill and soils.

INTRODUCTION

This report was prepared as a part of a general appraisal of the water resources of the northern Uinta Basin area, Utah and Colorado, which was made by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights. Fieldwork was carried out during the period July 1971 to June 1974.

Ashley Valley is one of two areas that were evaluated in slightly greater detail than the remainder of the northern Uinta Basin area (fig. 1), owing to specified needs of the Utah State Engineer. The purpose of this report is to evaluate the general relation of ground- and surface-water supplies in Ashley Valley and the effect of the operation of Steinaker Reservoir on those supplies.

Data used in support of the evaluations and conclusions made in this report have been or will be released separately in the following reports: Hood (1976), Hood, Mundorff, and Price (1976), and Thomas and Wilson (1952).

Data-site numbering systems

Well- and spring-numbering system

The system of numbering wells and springs in Utah is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating the well or spring, describes its position in the land net. By the land-survey system, the State is divided into four quadrants by the Salt Lake base line and meridian, and these quadrants are designated by the uppercase letters A, B, C, and D, indicating the northeast, northwest, southwest, and southeast quadrants, respectively. Numbers designating the township and range (in that order) follow the quadrant letter, and all three are enclosed in parentheses. The number after the parentheses indicates the section, and is followed by three letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section--generally 10 acres (4 hm^2);[1] the letters a, b, c, and d indicate, respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision. The number after the letters is the serial number of the well or spring within the 10-acre (4-hm^2) tract; the letter "S" preceding the serial number denotes a spring. If a well or spring cannot be located within a 10-acre (4-hm^2) tract, one or two location letters are used and the serial number is omitted. Thus, (D-4-21)2bad-1 designates the first well constructed or

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[1] Although the basic land unit, the section, is theoretically 1 mi^2 (2.6 km^2), many sections are irregular. Such sections are subdivided into 10-acre (4-hm^2) tracts, generally beginning at the southeast corner, and the surplus or shortage is taken up in the tracts along the north and west sides of the section.

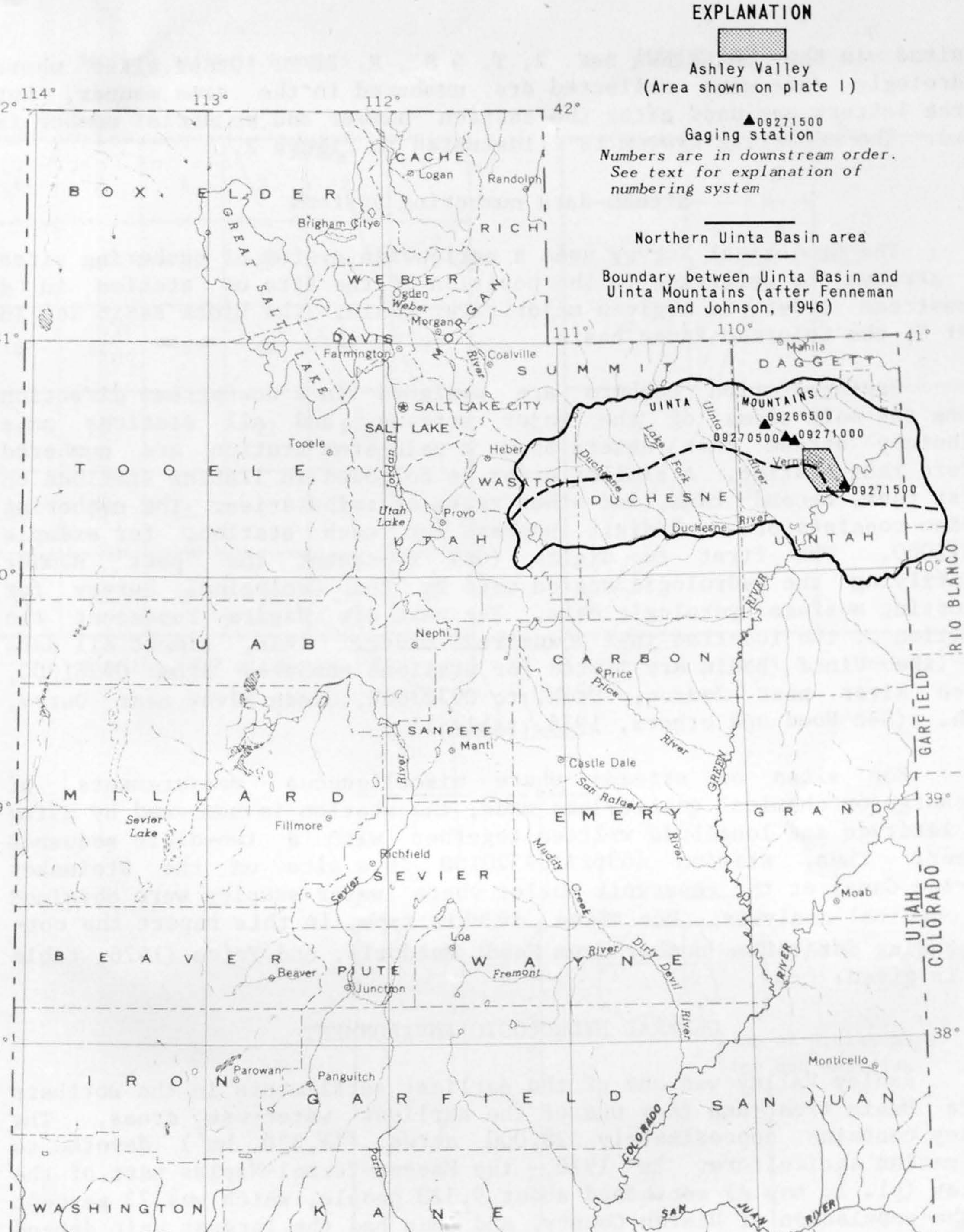

Figure 1.—Location and extent of the northern Uinta Basin area and location of Ashley Valley.

visited in the SE¼NE¼NW¼ sec. 2, T. 4 S., R. 21 E. Other sites where hydrologic data were collected are numbered in the same manner, but three letters are used after the section number and no serial number is used. The numbering system is illustrated in figure 2.

Stream-data numbering systems

The Geological Survey uses a nationwide system of numbering sites on streams by referring to the position of the site or station in a downstream order in a given major river basin. The Uinta Basin is in Part 9, the Colorado River basin.

Gaging-station numbers are assigned in a downstream direction along the main stems of the major streams, and all stations on a tributary stream that enters above a main-stem station are numbered before that station. A similar order is followed in listing stations on first rank, second rank, and other ranks of tributaries. The numbering system consists of an 8-digit number for each station, for example 09271000. The first two digits (09) represent the "part" number identifying the hydrologic region used by the Geological Survey for reporting surface hydrologic data. The next six digits represent the position of the location in a downstream order. Thus, almost all data for the Uinta Basin are listed for stations numbered from 09261000, Green River near Jensen, Utah, to 09307000, Green River near Ouray, Utah. (See Hood and others, 1976, table 11.)

For sites on streams where miscellaneous measurements of discharge or chemical quality are made, the station is numbered by using its latitude and longitude written together with a two-digit sequence number. Thus, station 403021109320100 is a site on the Steinaker Service Canal at the reservoir outlet where water samples were obtained for chemical analysis. For sites of this type, in this report the corresponding data-site number from Hood, Mundorff, and Price (1976, table 15) is given.

GENERAL HYDROLOGIC ENVIRONMENT

Ashley Valley was one of the earliest settlements in the northern Uinta Basin area, and thus one of the earliest water-use areas. The valley contains approximately 28,000 acres (11,330 hm^2) devoted to irrigation agriculture. In 1970, the Maeser-Vernal-Naples part of the valley (pl. 1, map A) contained about 9,320 people, which was 73 percent of the population of Uintah County, and thus had the largest unit demand for domestic water supply in the northern Uinta Basin area.

The principal source of water for the valley is streamflow from the Ashley Creek drainage basin, which includes a small transbasin diversion. A piped supply from springs in Ashley Creek canyon is the major source of municipal, suburban, and rural domestic water. From pioneer times until about 1963, surface-water storage in the drainage basin was small. As a result, the irrigators used the stream water when it was available. The spring snowmelt freshets generally lasted only a

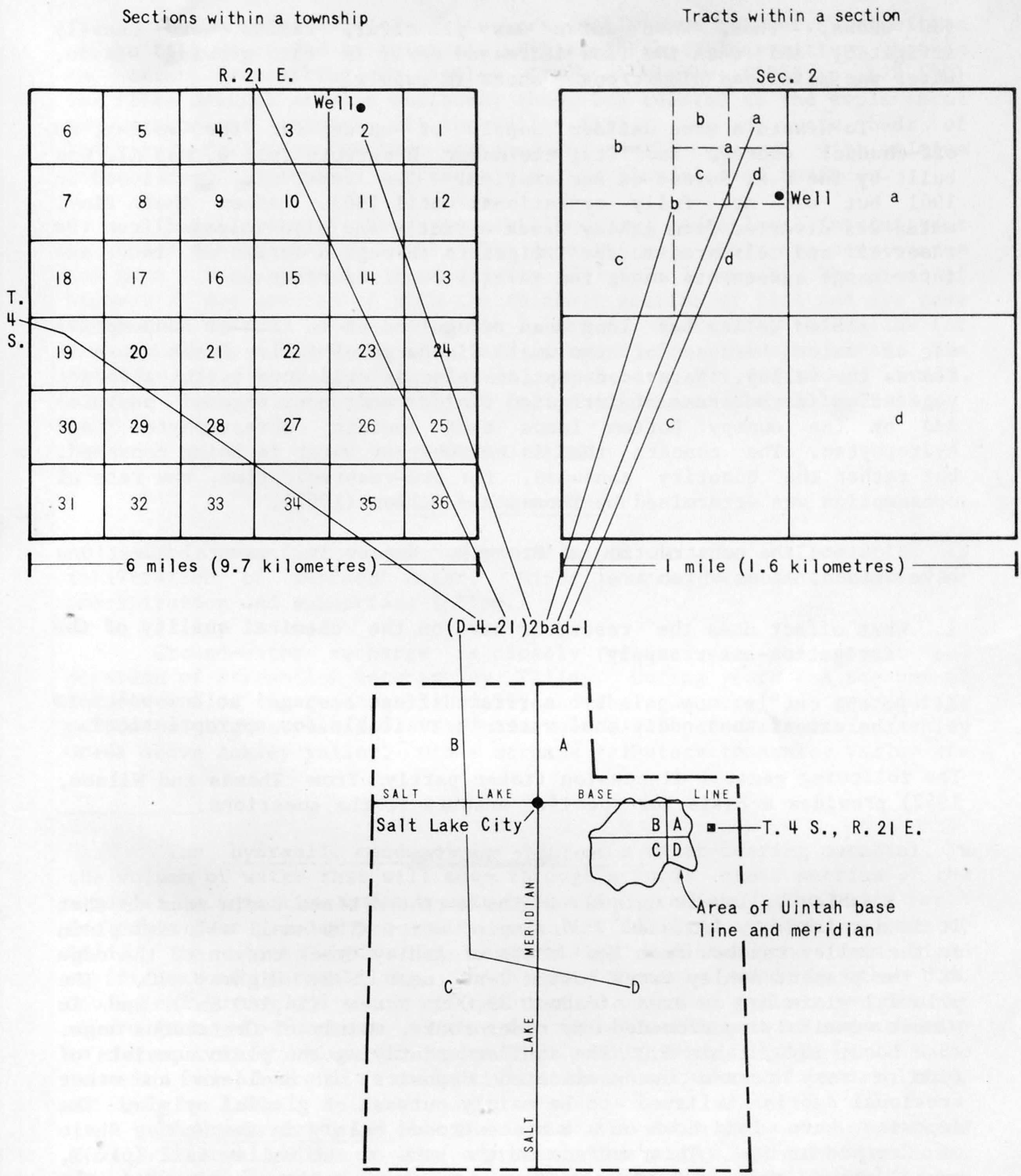

Figure 2.—Well- and spring-numbering system used in Utah.

few weeks. Thus, when water was plentiful, fields were heavily irrigated, and when the flow decreased early in the growing season, water was sometimes disastrously short in supply.

To assure a more uniform supply of water for the valley, an off-channel storage facility, Steinaker Reservoir (pl. 1, map A), was built by the U.S. Bureau of Reclamation. The reservoir was closed in 1961 but was not fully operational until 1963. After that time, water was diverted from Ashley Creek directly and also released from the reservoir and delivered to the irrigators through a series of intricate interchange agreements among the several canal operators.

Ashley Valley has long been recognized as an area of consumptive use of water because of the small discharge of Ashley Creek where it leaves the valley. Water consumption also is evidenced by the abundant vegetation in the areas of irrigated fields and nonirrigated pastures and by the swampy bottom lands that contain phreatophytes and hydrophytes. The concern then is not whether water is being consumed, but rather the quantity consumed. For pre-reservoir time, the rate of consumption was determined by Thomas and Wilson (1952).

Since the construction of Steinaker Reservoir, several questions have arisen, among which are:

1. What effect does the reservoir have on the chemical quality of the irrigation-water supply?

2. Do the canals now gain by natural diffuse seepage at any point to the extent that additional water is available for appropriation?

The following general discussion (taken partly from Thomas and Wilson, 1952) provides a basis for specific answers to the questions.

Geologic setting

Ashley Valley is unique in the northern Uinta Basin area in that it is a relatively isolated hydrologic unit. The small alluvial plain in the valley reaches from the mouth of Ashley Creek canyon to the edge of the present Ashley Creek bottom land near U.S. Highway 40. The alluvial plain has an area of about 35,000 acres (14,160 hm^2) and is almost entirely surrounded by older rocks, mainly of Cretaceous age. (See Hood, 1976, table 1.) The aquifer underlying the plain consists of fine to very coarse unconsolidated deposits of boulders and other erosional debris believed to be mainly outwash of glacial origin. The deposits were laid down on a surface eroded mainly in the Mancos Shale of Cretaceous age. This surface at the base of the valley fill (pl. 1, map A) shows that the main source of the eroding water and the subsequent unconsolidated deposits was Ashley Creek above Ashley Valley. The creek channel trends southeastward across the valley, but the buried channel is south of the modern channel of Ashley Creek.

The unconsolidated deposits originally were thicker. Deposition of the fill proceeded at intervals with concurrent, intermittent erosion and later downcutting by Ashley Creek. Kinney (1955, p. 128-130) describes several erosion surfaces; these are related to the emplacement and subsequent erosion of the valley fill. One or more beds of "hardpan"--fill that has been enriched and partly cemented with calcium carbonate--also probably represent old interfluvial land surfaces.

These layers of low permeability may cause local intermittent perched zones of shallow water. The deposits as a whole are very coarse and have a high hydraulic conductivity (*K*)[1] (pl. 1, map B). The areas of highest *K* are associated with the thickest section of fill and are near the buried channel shown on plate 1, map A. Therefore, the values for transmissivity (*T*)[2] of the fill are largest for the same areas. The point values for *K* and *T* on plate 1, map B, are for individual wells, some of which do not penetrate the full thickness of the valley fill.

GROUND WATER

Source and movement

The principal source of ground water in the valley fill is infiltration of surface water. Minor sources are infiltration of precipitation and subsurface inflow.

Ground-water recharge is closely related to the amount and duration of streamflow into Ashley Valley. During years and seasons of low streamflow the recharge is small, and the converse is true during periods of high streamflow. The main source of streamflow is Ashley Creek above Ashley Valley. Other streams tributary to Ashley Valley are

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[1]The hydraulic conductivity (*K*) of a water-bearing material is the volume of water that will move through a unit cross section of the material in unit time under a unit hydraulic gradient. The units for *K* are cubic feet per day per square foot [$(ft^3/d)/ft^2$], which reduces to ft/d. The term hydraulic conductivity replaces the term field coefficient of permeability, which was formerly used by the U.S. Geological Survey and which was reported in units of gallons per day per square foot. To convert a value for field coefficient of permeability to the equivalent value of hydraulic conductivity, divide by 7.48; to convert from hydraulic conductivity to coefficient of permeability, multiply by 7.48.

[2]Transmissivity (*T*) is the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient. The units for *T* are cubic feet per day per foot [$(ft^3/d)/ft$], which reduces to ft^2/d. The term transmissivity replaces the term coefficient of transmissibility, which was formerly used by the U.S. Geological Survey and which was reported in units of gallons per day per foot. To convert a value for coefficient of transmissibility to the equivalent value of transmissivity, divide by 7.48; to convert from transmissivity to coefficient of transmissibility, multiply by 7.48.

intermittent and contribute only small quantities of water to the system. Prior to the development of the canal system in Ashley Valley, recharge occurred mainly along the channel of Ashley Creek where the creek enters the valley.

Seepage from Ashley Creek was no longer a major source of recharge in 1948-51 when observed by Thomas and Wilson (1952, p. 6), and during 1971-74 the creek channel north of Vernal was observed to be dry during most of each summer. During 1971-74 most, if not all, flow from snowmelt and much of the base flow of Ashley Creek was diverted into canals and into Steinaker Reservoir. Recharge to the valley fill was derived mainly from infiltration of surface water from the canals and seepage from the fields where that water was applied along the western and central parts of the valley.

Recharge to the valley fill from precipitation is sporadic and infrequent, depending upon intensity of precipitation and rate of melting and thickness of snow cover. Instances of precipitation recharging the valley fill include exceptionally heavy thunderstorms, such as two in October 1949, which produced 3.29 in (84 mm) of rainfall and resulted in a water-level rise of 0.42 ft (0.13 m) (Thomas and Wilson, 1952, p. 7).

Recharge from subsurface flow beneath Ashley Creek where it enters the valley is relatively constant but small. Thomas and Wilson (1952, p. 1) estimated the underflow to be 2-3 ft^3/s (0.06-0.08 m^3/s) or about 1 percent of the streamflow in Ashley Creek. This estimate compares favorably with the underflow of approximately 0.5 ft^3/s (0.01 m^3/s) reported by Maxwell, Bridges, Barker, and Moore (1971, p. 24) for Dry Fork of Ashley Creek, about 3.8 mi (6.1 km) upstream from Ashley Valley.

Subsurface inflow also may come from the consolidated rocks that abut the valley fill. Little, if any, water rises through the underlying Mancos Shale, but some inflow may come from the nearby Glen Canyon Sandstone of Jurassic age and the Dakota Sandstone and Mesaverde Group of Cretaceous age. The quantity of inflow from the consolidated rocks is not known, but it is estimated to be less than that from underflow beneath Ashley Creek.

In 1948, the water-table slope in most of Ashley Valley was 60-70 ft/mi (11-13 m/km) and was almost directly eastward from the high western part of the alluvial plain along the foot of Asphalt Ridge toward the Ashley Creek bottoms east of Vernal. (See pl. 1, map C.) On plate 1, map C, water-level changes are shown for the only five wells that could be compared for the period March 1948-March 1974. The changes are not sufficiently large to appreciably change the positions of the 1948 water-level contours, which have a 50-ft (15.2-m) interval; thus, it is inferred that the gross direction of movement in 1974 was the same as in 1948.

Storage

Saturated valley fill (pl. 1, map B) underlies about 25,000 acres (10,120 hm^2) of the alluvial plain in Ashley Valley. The remainder of the 35,000 acres (14,160 hm^2) of the alluvial plain is an erosion surface on Mesozoic rocks, which has a thin cover of soil and alluvium generally less than 10 ft (3.0 m) thick. This discontinuous veneer is not considered to be an effective part of the ground-water reservoir. An additional 1,900 acres (770 hm^2) of saturated valley fill underlies the flood plain of Ashley Creek northwest of U.S. Highway 40 and below the edge of the alluvial plain.

The volume of saturated valley fill in Ashley Valley is about 500,000 acre-ft (620 hm^3). The estimated specific yield (*Sy*)[1] is in the range of 0.10 to 0.15. Thus, the volume of recoverable water in storage amounts to 50,000-75,000 acre-ft (62-92 hm^3), or enough water to supply the irrigation needs for a maximum of 2 years under current (1974) irrigation practices.

The calculated volume in storage is a net long-term average. The volume in storage varies seasonally by approximately 10 percent. Prior to the construction of Steinaker Reservoir, the change in storage from a dry year to a wet one was relatively large. Reservoir operation has reduced the long-term fluctuation in storage to some extent, as shown by reduction in long-term fluctuations in ground-water levels.

Fluctuations of water levels

The principal cause of water-level fluctuations in Ashley Valley is the change in rate of seepage of surface water from canals and irrigated fields. Thomas and Wilson (1952, p. 7) cite fluctuations as great as 12 ft (3.7 m) annually in one well and 5-10 ft (1.5-3.0 m) in three wells near canals. They also state that fluctuations in the irrigated areas were rapid during and after individual irrigation applications. Each year, as the supply of surface water increases in response to snowmelt, water levels rise to a seasonal high; subsequently, with diminishing surface-water input, the water levels

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[1]The specific yield (*Sy*) of an aquifer is the ratio of the volume of water that the saturated rock will yield by gravity to its own volume. The definition implies that gravity drainage is complete, although this rarely occurs in the northern Uinta Basin area. *Sy* is a dimensionless number related to the storage coefficient (*S*). Typical values for *Sy* range from 0.10 to 0.30.

The storage coefficient (*S*) of an aquifer is the volume of water it releases from or takes into storage per unit surface area of the aquifer per unit change in head. *S* is a dimensionless number. Under confined conditions, *S* is typically small, generally between 0.00001 and 0.001. Under unconfined conditions, *S* is much larger, typically from 0.05 to 0.30.

decline. (See fig. 3 and Thomas and Wilson, 1952, fig. 3.) Other factors affect water levels only slightly. Precipitation may cause water levels to rise after heavy rainstorms and, to a small extent, during snowmelt (Thomas and Wilson, 1952, p. 7 and 9). Evapotranspiration causes noticeable decline of water levels in some areas where the water table is shallow. After the growing season, however, water levels rise gradually for several months (Thomas and Wilson, 1952, p. 7).

Long-term fluctuations of water levels prior to the construction of Steinaker Reservoir primarily reflected annual variations in the quantity of surface supplies. The reservoir operation has prolonged the availability of water for irrigation supply, however, and the post-irrigation period of declining ground-water levels are shorter than before reservoir completion. As a result, annual high water levels tend to be higher than they were prior to reservoir completion. In the western and southern parts of the major recharge area of the valley, the spread between annual high and low water levels is greater than prior to reservoir completion. (See hydrograph for well (D-5-21)2dcb-1 in fig. 3.) In the low areas on the eastern side of the valley, however, input from the west is more continuous and water levels have remained high throughout the year. (See hydrographs for wells (D-5-22)6abb-1 and (D-4-22)32dcd-1 in fig. 3.) Water levels also have remained high throughout the year in perched zones.

As a result of water-level rises, drains were installed in some areas. The hydrograph for well (D-4-21)21dcd-1 (fig. 3) shows the rise of water levels after Steinaker Dam was closed in 1961, followed by a decline of water levels after a drain was installed about 1970.

Discharge

Ground water is discharged from the valley fill in Ashley Valley by a few wells, springs and seepage areas, a few drains, seepage back to Ashley Creek, and evapotranspiration. All the discharge except seepage back to Ashley Creek and evapotranspiration is small in volume.

Ashley Valley contained relatively few wells, almost all of which were of low yield and were used for domestic and stock supply and the irrigation of small garden tracts. By 1948, most of these wells were not in use owing to the availability of piped water of a better chemical quality (Thomas and Wilson, 1952, p. vi-vii). By 1971, only 5 of the 29 wells recorded by Thomas and Wilson (1952, fig. 2) still existed, and none of these were in use. By 1974, owing to the cost of piped water and the rapid population growth, the use of wells was expanding, but the withdrawal of ground water was estimated to be only about 1 percent of the total amount of water moving through the hydrologic system in the valley.

Individual springs in the valley mainly are small, but there are many acres of seepage area, particularly along the edges of terraces and bottoms of gullies tributary to Ashley Creek. Water from these sources is either consumed by evapotranspiration or discharged to Ashley Creek.

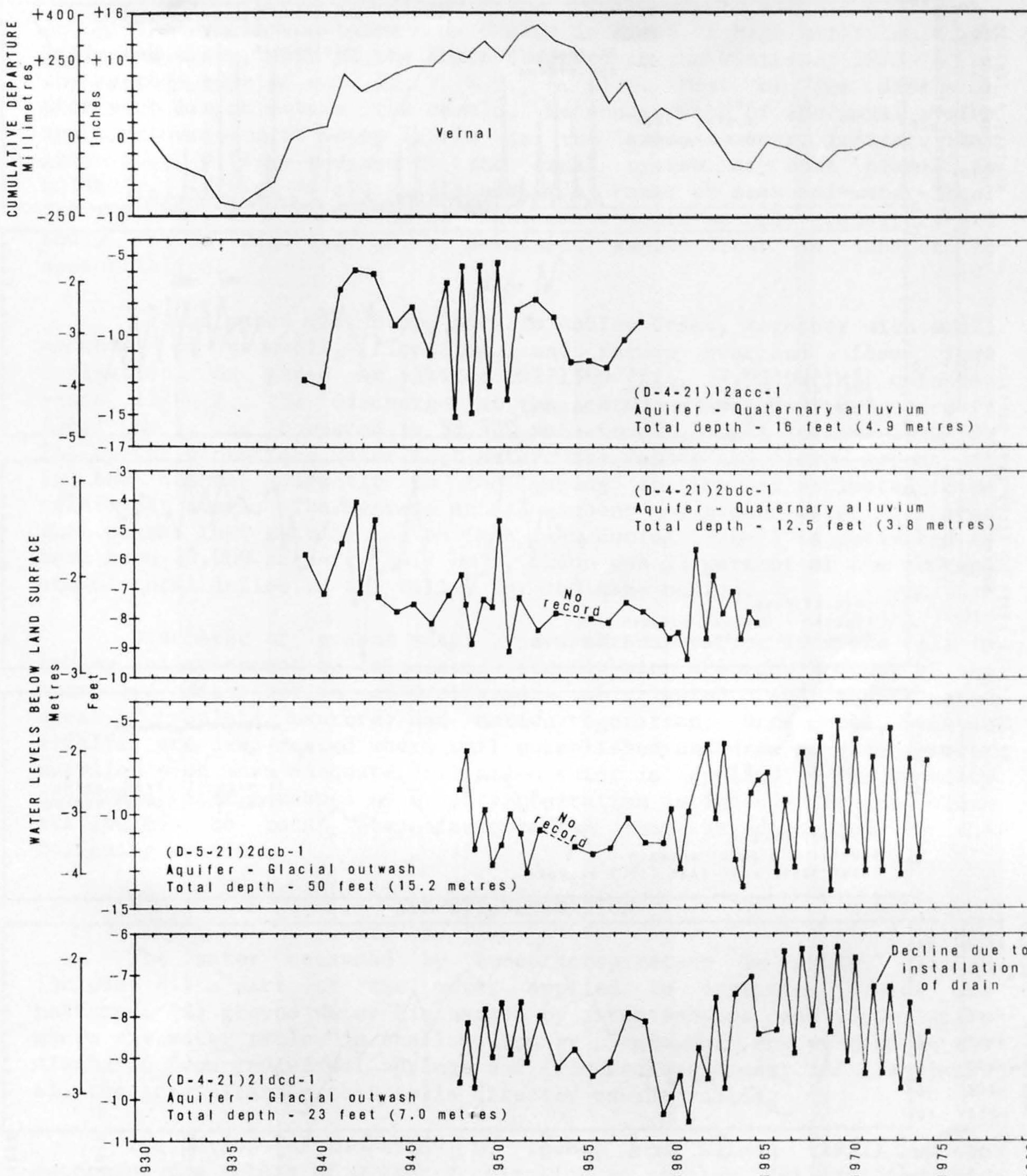

Figure 3.— Water levels in selected observation wells, cumulative departure from the 1931-73 average annual precipitation at Vernal and Jensen, and monthly discharge of Ashley Creek at station 09271500.

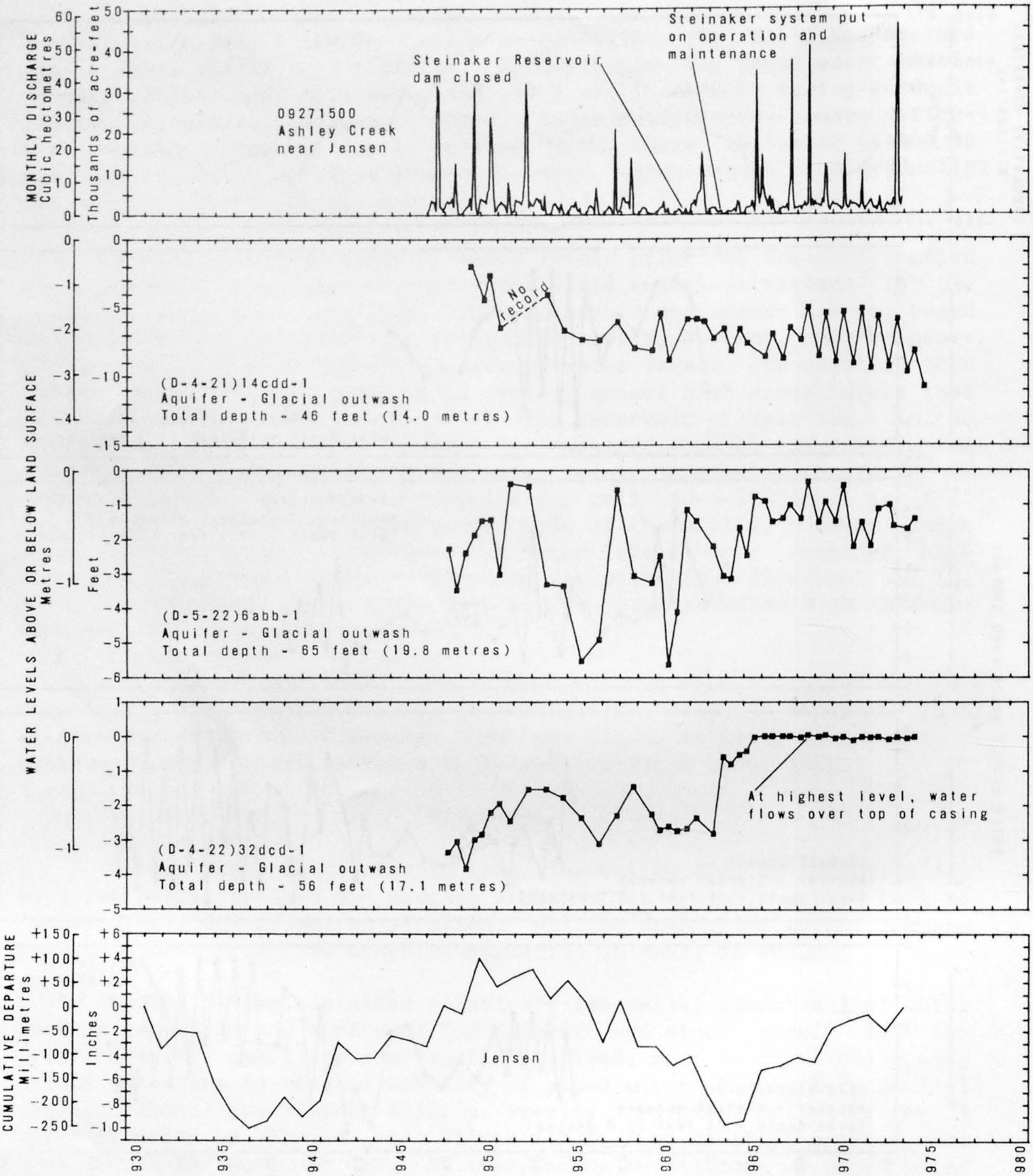

Figure 3.— Continued.

The valley contains some drains in areas of high water table in irrigated areas, such as the drain observed in the winter of 1973-74 at the eastern edge of sec. 21, T. 4 S., R. 21 E. Most of the discharge from such drains enters the canals. Reconnaissance of the canal system and consideration of water levels in the area, however, indicate that gain from diffuse seepage to the canal system at most places is unlikely. In view of the relatively wide range of seasonal water-level fluctuations, such discharge as might occur would be only transitory and could not be regarded as a permanent supply that is subject to appropriation.

Ground water that seeps back to Ashley Creek, together with small amounts of snowmelt, floodflow, and return overland flow from irrigation, is gaged at station 09271500 (fig. 3). During calendar years 1970-72, the discharge at the station averaged 29,800 acre-ft (36.7 hm^3), as compared to 58,500 acre-ft (72.1 hm^3) during 1948-50. The amount of surface water that enters the valley and flows across it in the channel directly to the gaging station is estimated to be relatively small. The average annual amount of ground-water discharge that passed the station as surface flow during 1970-72 is estimated to have been 20,000 acre-ft (24.7 hm^3), which was 22 percent of the average annual total inflow to the valley for the same period.

Discharge of ground water by evapotranspiration from the fill in Ashley Valley cannot be calculated directly with accuracy because of the intricate distribution of irrigated, subirrigated, and nonirrigated areas of cropland, pasture, and native vegetation. Some crops, such as alfalfa, are deep-rooted where well established and draw on ground-water supplies even when adequate irrigation water is applied. The quantity of ground water consumed by evapotranspiration is included in the volume attributed to total evapotranspiration that is discussed in the following section.

EVAPOTRANSPIRATION

The water consumed by evapotranspiration in Ashley Valley includes (1) a part of the water applied to irrigated fields and pastures; (2) ground water discharged by phreatophytes and from soils where the water table is shallow, and by plants that are watered by the discharge from individual springs and from seepage areas; and (3) almost all the precipitation that falls directly on the valley.

The purpose of the study by Thomas and Wilson (1952) was to determine the volume of evapotranspiration in Ashley Valley; for this report, a parallel computation was made for the same area. The computations are reasonably comparable because the average precipitation was the same during both periods, and both periods followed nearly a decade of generally above-average precipitation (fig. 3).

Thomas and Wilson (1952, p. 6-11) studied the changes in ground-water storage, as indicated by changes in water levels in wells, in order to include such storage changes in the budget used for determining total evapotranspiration. It is inferred from their discussion that changes in storage tend to average out over several seasons. Long-term water levels during both periods of computation, 1948-51 and 1970-72, were reasonably stable (fig. 3); therefore, storage changes were not taken into account for either period.

The computation of annual average evapotranspiration in Ashley Valley for 1949-50 (after Thomas and Wilson, 1952, p. 13) and 1970-72 are given below.

Period of computation	May 1, 1949- Jan. 31, 1951	Calendar years 1970-72
Inflow[1]	+119,700	+90,640
Outflow[2]	−71,750	−33,260
Subtotal (rounded)	48,000	57,000
Precipitation[3]	+24,000	+24,000
Total evapotranspiration	72,000	81,000

[1]Includes (1) flow at station 092710000 and the canal flow and underflow that bypassed the station in 1948-51 and (2) the combined flow at stations 09270500 and 09266500 (fig. 1) and the underflow that entered the valley in 1970-72. Both figures include flow diverted into the Ashley Valley culinary-water pipeline.

[2]Figures for both periods include flow in canals that bypass station 09271500.

[3]The values shown are calculations of average annual precipitation on the area for both periods of computation; their equivalence is coincidental.

The data tabulated above show that the average annual depletion of flow due to evapotranspiration was 40 percent in 1949-50 and 63 percent in 1970-72. The increase in evapotranspiration is attributed to the increase in the length of time that water is used for irrigation, the changes in irrigation practice resulting from a firmer irrigation supply, and the increased length of time and increased area in which shallow ground water is available for consumption. Such an increase in consumptive use would be expected to result in degradation of the water discharged from the valley.

CHEMICAL QUALITY OF WATER

The chemical quality of water in Ashley Creek and Steinaker Reservoir and of ground water in Ashley Valley are shown by diagrams on pl. 1, map D. The shape and color coding of the diagrams indicate relative concentrations of major dissolved constituents. The water samples represented by the diagrams were mainly fresh (less than 1,000 mg/l of dissolved solids), some were slightly saline (1,000-3,000 mg/l), and one was moderately saline (3,000-10,000 mg/l).

The chemical quality of surface water distributed for irrigation is indicated on plate 1, map D, by the diagrams that represent water from Ashley Creek and Steinaker Reservoir. Two diagrams are shown for water at station 09271000 near the point at which Ashley Creek enters the valley. One represents the period of base flow in early spring 1974, and the second represents the period of snowmelt later in the spring. The base flow contained about three times as much dissolved solids as the snowmelt. The water released from Steinaker Reservoir during the entire spring of 1974 was of a relatively uniform quality, similar to that observed in Ashley Creek during the period of base flow. (See site 174 in Hood and others, 1976, table 15.) The inflow to the reservoir, however, consists of about 80 percent snowmelt and 20 percent water similar in quality to the base flow of Ashley Creek. The average dissolved-solids concentration of outflow from Steinaker Reservoir is greater than that of inflow to the reservoir. The ratios of dissolved constituents do not change appreciably, however, thereby indicating that the increase in concentration is due to evaporation from the reservoir.

The chemical quality of ground water in Ashley Valley is indicated on plate 1, map D, by diagrams that represent water from 12 wells, 11 of which discharge water from the valley fill. The driller's log (Hood and others, 1976, table 6) for the 12th well, (D-4-21)29bbb-1, indicates the formation penetrated may be valley fill, but the well's position in the valley (pl. 1, map B) indicates that it probably is finished in rocks of Mesozoic age.

The chemical quality of ground water in the valley depends on the position of the well with respect to the recharge area, the depth to which the valley fill is penetrated, and the lithologic character of the aquifer. Thus, the lowest concentration of dissolved solids in ground water in the valley is found where the coarse-grained fill is near the source of recharge, as at well (D-4-21)9bcc-1. From the area of this well, the dissolved-solids concentration increases toward the south and east.

In the northern part of the valley, the water type changes from calcium bicarbonate to calcium magnesium bicarbonate as the water moves toward Ashley Creek. In this area, the deeper valley fill yields water with a lower dissolved-solids concentration. For example, compare the data for wells (D-4-21)11cbc-1 and (D-4-21)13bbb-1. For this reason, it is believed that most of the increase in dissolved solids occurs in the valley fill near the surface and represents mainly the effects of evapotranspiration and leaching of soils in irrigated fields.

Diagrams on plate 1, map D, for well water from the southern part of the valley show that magnesium and sulfate concentrations increase as the dissolved-solids concentration increases. The increase in sulfate, in particular, may be due to inflow of ground water from rocks of Mesozoic age, as represented by the diagram for well (D-4-21)29bbb-1; but it is more probable that most of the gain in sulfate is due to leaching of valley fill that contains debris from the Mesozoic rocks, as probably occurs at well (D-4-22)32dcd-1.

The flow in Ashley Creek at station 09271500 is the outflow from Ashley Valley. A base-flow sample obtained there during the early spring of 1974 had a dissolved-solids concentration more than seven times greater than the water released from Steinaker Reservoir during the same period (pl. 1, map D). Records of chemical analyses of water from station 09271500 (Hood and others, 1976, table 14) show that the chemical quality of the base flow (fall through early spring) has varied considerably both before and after closure of the reservoir. The dissolved-solids concentration of the base flow has been lowest, as might be expected, following wet years; and it was highest during the drought years of the 1950's. Base flow during 1974, however, represented conditions at the end of a decade of relatively wet years, and yet the dissolved-solids concentration was not much lower than it was during the drought years. This would imply that changes in irrigation practices owing to the availability of reservoir water have resulted in a degradation of the chemical quality of the water that leaves the valley.

CONCLUSIONS

The principal source of water for Ashley Valley is the flow in Ashley Creek above Ashley Valley. Most of the streamflow is diverted where the creek enters the valley, partly into distribution canals and partly into Steinaker Reservoir. Water obtained directly from the creek is fresh, but the dissolved-solids concentration varies seasonally. Water from Steinaker Reservoir is still fresh, although more concentrated than that from the creek, and there is less seasonal variation in concentration. Lesser sources of water for the valley are precipitation on the valley floor and underflow beneath Ashley Creek, which recharges the valley fill directly. Minor but unknown quantities of water probably are provided by intermittent streams tributary to the valley and by subsurface inflow from consolidated rocks.

The principal sources of recharge to the valley fill are infiltration from canals and seepage water from irrigated fields. The main area of recharge is in the western and central parts of the valley, and the ground water moves mainly toward the east.

The quantity of water available from storage is 50,000-75,000 acre-ft (62-92 hm^3), or enough water to supply irrigation in the valley for a maximum of 2 years. The volume in storage varies seasonally about 10 percent. Although recharge and discharge are variable, depending on the water available during an individual year, no significant long-term storage change has occurred.

A part of the ground water is discharged by evapotranspiration, and most of the remainder seeps back into Ashley Creek. In 1974, only small quantities of water were discharged from wells. Some ground water was discharged into canals by drains, but natural diffuse seepage into the canals was not observed. Such natural seepage as might occur would be only transitory.

The amount of water discharged from surface and ground sources by evapotranspiration appears to have increased about 20 percent since the construction of Steinaker Reservoir. The increase in total evapotranspiration, including water from precipitation, amounts to about 12 percent. As a result, the water that flows from the valley has been degraded in chemical quality.

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