WATER RESOURCES OF THE PARK CITY AREA, UTAH, WITH EMPHASIS ON GROUND WATER

U.S. Geological Survey

Open-File Report 85-638

PREPARED IN COOPERATION WITH THE
UTAH DEPARTMENT OF NATURAL RESOURCES

Dept.
Seal

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by Walter F. Holmes, Kendall R. Thompson, and Michael Enright

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CONVERSION FACTORS AND RELATED INFORMATION

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
acre	0.4047	square hectometer
	4,047	square meter
acre-foot (acre-ft)	0.001233	cubic hectometer
	1,233	cubic meter
cubic foot per day	0.02832	cubic meter per day
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per day	0.3048	meter per day
foot squared per day (ft^2/d)	0.0929	meter squared per day
gallon per minute (gal/min)	0.06308	liter per second
inch (in.)	25.40	millimeter
	2.54	centimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 milligrams per liter, the numerical value is about the same as for concentrations in parts per million.

Water temperature is given in degrees Celsius (° C), which can be converted to degrees Fahernheit (° F) by the following equation:

$$^{\circ}F = 1.8\ (^{\circ}C) + 32.$$

WATER RESOURCES OF PARK CITY AREA, UTAH, WITH EMPHASIS ON

GROUND WATER

by Walter F. Holmes, Kendall R. Thompson, and Michael Enright

ABSTRACT

The Park City area, about 140 square miles in northern Utah, contains the headwaters of East Canyon, Silver, and Drain Tunnel Creeks, and also includes a reach of the Provo River. Consolidated rocks of Pennsylvanian to Tertiary age crop out over most of the area except along the major stream channels where unconsolidated valley fill of Quaternary age is exposed at the surface.

The two major streams that originate within the study area are East Canyon and Silver Creeks. The estimated long-term average flow of East Canyon Creek near Park City is 55 cubic feet per second, and the estimated long-term average flow of Silver Creek near Wanship is 8.55 cubic feet per second. Some streamflow yields from individual basins are smaller than expected when compared to streamflow yields from 45 other sites in the mountains of northern Utah.

Ground water in the Park City area occurs in both unconsolidated valley fill and consolidated rocks. Recharge to the unconsolidated valley fill from precipitation, uncomsumed irrigation water, leakage from consolidated rocks, and seepage from streams is estimated to be 15,400 acre-feet per year. Recharge to the consolidated rocks from precipitation, stream infiltration and subsurface inflow is estimated to be 46,000 acre-feet per year.

Discharge from the unconsolidated valley fill by evapotranspiration, seepage to streams, and wells is estimated to be 15,500 acre-feet per year. Discharge from consolidated rocks from springs, drain tunnels, leakage to unconsolidated valley fill, and wells is estimated to be 46,000 acre-feet per year.

Water in the unconsolidated valley fill generally follows the slope and direction of the major streams. Water in the consolidated rocks generally moves from recharge areas at high altitudes toward discharge areas at lower altitudes, except in areas affected by drain tunnels where water moves toward and discharges to the tunnels and associated mine workings.

The quality of both surface and ground water in the Park City area generally is suitable for all uses, although some of the water had concentrations of dissolved solids, trace metals, chloride, or sulfate that exceeded recommended standards or limits. Several water sources had pH values that were less than or exceeded recommended limits.

The Twin Creek Limestone and Thaynes Formation have the best potential for yielding large quantities of water to individual wells. Increasing withdrawals from consolidated rocks may cause a decrease in the flow of springs and streams, water-level declines in wells, and downward movement of poor quality water to aquifers containing freshwater.

The construction of the proposed Jordanelle reservoir may cause an increase in the pumping necessary to dewater mines that are below the altitude of the reservoir. Data are not available to determine the magnitude of the increased pumpage required to dewater the mines.

INTRODUCTION

The Park City area is a rapidly growing residential and recreational area about 30 miles east of Salt Lake City (fig. 1). The area of study is about 140 square miles in which the principal industries are agriculture, skiing, and other recreational activities. The area once was a major lead- and silver-mining district, but no mines were active in 1984. A resumption in mining activity, however, could take place with an increase in the price of metals.

The population of the Park City area is expected to increase rapidly in the near future; and the provision of an adequate water supply for the growing population, while avoiding harmful affects of development, is a major concern for local municipalities, developers, and the Utah Division of Water Rights. In addition, agricultural interests in and below the area are concerned about the effects of increased ground-water withdrawals on streamflow, which is fully appropriated by downstream users. The area also contains the proposed site for the Jordanelle dam, a part of the Bonneville Unit of the Central Utah Project. The damsite is near an historic mining area; and mining companies are concerned that if mining is resumed, the reservoir may create some additional dewatering problems in the mines.

Purpose and Scope

In order to address the concerns listed above, the U.S. Geological Survey, in cooperation with the Utah Department of Natural Resources, Division of Water Rights, made a study of the water resources of the area from July 1982 to June 1985. This report describes the results of that study. It provides information on the availability of water for future needs and the potential hydrologic effects that might result from increased withdrawals of ground water. The report also addresses the possible hydrologic effects of the proposed Jordanelle reservoir on mining activities in the area.

Previous Investigations

Previous hydrologic studies in the area include a water-resources study by Baker (1970) and reconnaissances of the quality of surface water by Mundorff (1974) and Thompson (1983). Other available data include streamflow records collected by the U.S. Geological Survey, Weber River Commissioner, Provo River Commissioner, U.S. Bureau of Reclamation, and consultants. Streamflow records have been published annually by the U.S. Geological Survey (1985) for Silver Creek near the northern boundary of the study area (1941-46), Threemile Creek, a tributary to East Canyon Creek (1963-74), and the Provo River near Hailstone (1949-present). Additional streamflow data are available from the Provo and Weber River Commissioners, and from the U.S. Bureau of Reclamation for the proposed Jordanelle dam site. Information for wells and springs was obtained from the files of the Utah Division of Water Rights and the U.S. Bureau of Reclamation. Information for municipal water use was obtained from the Park City Municipal Corp., Summit Park Water

Figure 1 this page

Distribution Co., Summit Park Water Co., and other small developments. Discharge data from mines and drain tunnels is available from mining company records.

Baker (1970) reported on ground-water levels, and additional levels are reported in drillers' logs on file with the Utah Division of Water Rights. Baker (1970) also presented data concerning ground-water storage in the unconsolidated valley fill, discharge of ground water by evapotranspiration, general direction of ground-water movement, hydraulic properties of the unconsolidated deposits, and the water quality and water levels for selected wells. Thompson (1983) reported on the quality of flow in Silver and East Canyon Creeks, and Mundorff (1974) described the quality of flow in Drain Tunnel Creek and the Provo River.

Well-, Spring-, Tunnel-, and Stream-Site Numbering Systems

The system of numbering wells, springs, and tunnels in Utah is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating the well, spring, or tunnel, 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, 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 inclosed in parentheses. The number after the parentheses indicates the section, and it is followed by three letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section--generally 10 acres[1]; the letters a, b, c, and d indicate, respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision.

A number after the letters is the serial number of a well or spring within the 10-acre tract; the letter "S" preceding the serial number denotes a spring, and the absence of an "S" and a serial number denotes a tunnel. Thus, (D- 1- 4)22cba- 1 designates the first well constructed or visited in the NE1/4 NW1/4 SW1/4 sec. 22, T.1S., R.4E.; (D- 1- 4)30bbb-S1 designates a spring in the NW1/4 NW1/4 NW1/4 sec. 30, T.1S., R.4E.; and (D- 2- 4) 8dbd designates a tunnel in the SE1/4 NW1/4 SE1/4 sec. 8, T.2S., R.4E. The numbering system is illustrated in figure 2.

Streamflow sites where data were collected are numbered in a sequential downstream order for this report. In addition, an 8-digit number has been assigned to gaging stations operated by the U.S. Geological Survey, and data from these stations and an explanation of the numbering system can be found in the annual water-resources-data reports for Utah (U.S. Geological Survey, 1985).

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[1]Although the basic land unit, the section, is theoretically 1 square mile, many sections are irregular. Such sections are subdivided into 10-acre 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 2 this page

Acknowledgments

Numerous individuals, companies, and governmental entities provided valuable data used in this report. The U.S. Bureau of Reclamation provided much data in the vicinity of the proposed Jordanelle dam site. The United Park City Mines Co. provided valuable information concerning the occurence of water in mines in the Park City Mining District. J. J. Johnson & Assoc. provided data and cooperated in a number of aquifer tests. The Park City Municipal Corp. provided water-use information and access to observation wells. Lois Arnow, Curator, Garrett Herbarium, University of Utah, identified the plants collected in the study area.

HYDROLOGIC ENVIRONMENT

Physiography

The Park City area lies within the Middle Rocky Mountains physiographic province (Fenneman, 1931). Altitudes range from about 5,880 feet at the southern border of the study area on the Provo River, to about 10,100 feet near the southwest corner at Scott Hill in the Wasatch Range.

The northern part of the study area consists of two valleys separated by a relatively low topographic divide, and the southern part of the area virtually consists of one valley, which includes the proposed site of the Jordanelle dam. The northern part of the area is drained by tributaries of the Weber River and the southern part by the Provo River. (See plate 1.)

Geology

Rocks in the Park City area range in age from Pennsylvanian to Holocene (pl. 1). In the northern, central, and southwestern parts of the area, the principal consolidated formations cropping out are sedimentary deposits, primarily sandstone, limestone, quartzite, and shale. In the southeastern part of the area, the principal consolidated formations cropping out are extursive volcanic deposits, primarily andesitic pyroclastics and some intrusive rocks. The principal unconsolidated deposits in the area are stream and glacial deposits.

The entire study area has been structurally deformed by folding and faulting. Much of the deformation is related to high-angle-thrust faults, although in the southeastern part of the area most of the deformation was probably was the result of intrusive volcanic rocks displacing sedimentary rocks. The structural deformation has resulted in a complex geologic framework. Most of the consolidated rocks are extensively fractured, and some of the fractures in limestone have been enlarged by solution. Although numerous localized fracture patterns can be identified on the surface and in underground mine workings, no regional fracture patterns are apparent.

Climate

The normal annual precipitation (1931-60) in the Park City area ranged from 16 inches at low altitudes to more than 40 inches in the Wasatch Range on the western border of the study area (U.S. Weather Bureau, 1963). Most of the precipitation falls during October-April. The normal annual precipitation (1931-60) in the Park City area is shown in figure 3; and the annual precipitation for 1900-83 at Heber, which is about 6 miles south of the southern boundary of the study area, is shown in figure 4. The 1982-83 average annual precipitation at Heber was 24.17 inches (National Oceanic and Atmospheric Administration, 1984) or 8.17 inches more than the 1900-83 average annual precipitation of 16.00 inches.

The Park City area has mild summers and cold winters when compared to other populated areas in Utah. Winter temperatures in the lower valleys in the area commonly are less than 0 ° Fahrenheit, and summer temperatures rarely exceed 90 ° Fahrenheit. The normal annual air temperature (1951-80) at Heber is 44.1 ° Fahernheit (National Oceanic and Atmospheric Administration, 1984). The annual evaporation from Wanship Reservoir, about 3 miles east of the northeast corner of the study area, is estimated to be 35 inches (Waddell and Fields, 1977, table 12).

Vegetation

The native plants in the Park City area generally can be divided into two communities: plants growing in low-altitude meadows and plants growing in mountainous areas. The dominant plants in the meadows consist of grasses (primarily *Phleum pratense, Poa pratensis, Hordeum brachyantherum, Bromus inermis*, and *Dactylis glomerata*), sedges (primarily *Carex nebrascensis*), and rushes (*Juncus* spp.). Other woody plants along stream courses include willow (*Salix* spp.), elderberry (*Sambucus* spp.), chokecherry (*Prunus virginiana*) and cottonwood (*Populus* spp.).

The dominant plants in the mountainous areas include sagebrush (*Artemisia* spp.), juniper (*Juniperus* spp.), and Gambel oak (*Quercus gambelii*) on the lower slopes, and quaking aspen (*Populus tremuloides*), Douglas fir (*Pseudotsuga menziesii*), and smooth maple (*Acer glabrum*), on the upper slopes. Some areas above 9,000 feet are sparsely vegetated.

Plants in the Park City area listed as phreatophytes by Robinson (1958, table 1) include *Juncus arcticus, Salix* spp., *Sambucus* spp., and *Populus* spp. Phreatophytes are plants that obtain their water supply from the zone of saturation, either directly from or through the capillary fringe.

WATER RESOURCES

Most of the water in the Park City area originates from precipitation directly on the area or inflow from the Provo River. Some subsurface inflow through consolidated rocks occurs along the southwestern border of the study area. Most of the precipitation that falls on the area is consumed by evapotranspiration or flows from the area in East Canyon and Silver Creeks and the Provo River.

Figure 3 this page

Figure 4 here

Surface Water

The streamflow in the Park City area either originates from the Wasatch Range on the western border or enters the area from the east in the Provo River at the southeastern border. Some of the streamflow is diverted near the mountain fronts and used for irrigation at lower altitudes, and some of the original stream channels have been altered during mining or construction.

Major Streams

The two major streams that originate within the Park City area, collect tributary discharge, and flow out of the area, are East Canyon and Silver Creeks. The Provo River flows into and across the southeastern corner of the study area, and collects tributary discharge from Drain Tunnel Creek, which also originates within the area. Several smaller tributaries contribute discharge to the Provo River in the southeastern part of the area.

East Canyon Creek.--East Canyon Creek originates in Thaynes Canyon on the eastern side of the Wasatch Range near the southwest corner of the study area. The creek flows northwest and leaves the area near its northwest corner after draining an area of about 70 square miles. The location of continuous-recording gaging stations, partial-record stations, and miscellaneous stations where data were collected are shown on pl. 2.

Gaging station 10133900, East Canyon Creek near Park City, was constructed and operated from July 1982 through September 1984 as part of this study. The average flow for the 1983-84 water years (October 1982 through September 1984) was about 86 cubic feet per second (U.S. Geological Survey, 1984 and 1985).

Gaging station 10133700, Threemile Creek near Park City, was reactivated and operated during the 1983-84 water years as part of this study. The average discharge for the 2 years of record was 3.7 cubic feet per second (U.S. Geological Survey, 1984 and 1985).

Seven partial-record stations were constructed on tributaries to East Canyon Creek as part of this study and discharge measurements were made at approximately monthly intervals. The measurements of discharge at the seven stations (sites 1, 3 and 4, 5, 8, 22, 27, and 28) are shown in table 1.

A hydrograph-matching procedure (Cruff, 1975, p. 4) was used to estimate the annual mean flow at the partial-record stations. The measurements at a partial-record station were plotted on a daily hydrograph sheet which then was overlain on the daily hydrographs of nearby gaging stations. A daily hydrograph for the partial-record station then was constructed using the hydrographs of the nearby gaging stations as a guide to estimate daily flows between measurements at the partial-record station. The estimated daily flows then were summed to obtain monthly mean flows, and the monthly mean flows were summed to obtain the annual mean flow.

The 2 years of discharge records collected at the two gaging stations and the seven partial-record stations were adjusted for long-term average flow using the 13 water years of discharge record (1964-74, 1983-84) available for gaging station 10133700 on Threemile Creek. The 1983-84 average discharge of Threemile Creek of 3.7 cubic feet per second was 1.56 times the 13-year average of 2.37 cubic feet per second. Thus, the 1983-84 average discharges at the gaging stations and partial-record stations were multiplied by a factor of 0.64 (reciprocal of 1.56) to obtain the estimated long-term average flow. The estimated long-term average flow of East Canyon Creek at gaging station 10133900 is 55 cubic feet per second. The estimated average flow for the 1983-84 water years and the estimated long-term average flow at seven partial-record stations are shown in table 2.

<u>Silver Creek</u>.--Silver Creek heads in the southern part of the study area, flows north, and leaves the area near the northeast corner. The creek drains an area of about 26 square miles.

Streamflow-gaging station 10130000, Silver Creek near Wanship, was constructed and operated during the 1983-84 water years at about the same location as a previous gage operated during the 1941-46 water years. The average discharge during the 1983-84 water years was 13.2 cubic feet per second. The 2-year record was combined with the 1941-46 record to estimate a long-term average flow of 8.55 cubic feet per second.

In the upstream part of the Silver Creek drainage south of Park City, several perennial and intermittent streams--including Ontario and Empire Canyons and Deer Valley--have a total estimated average annual flow of 0.8 cubic foot per second (James Midgett, Park City Municipal Corp., oral commun., 1984).

Provo River.--The Provo River heads in the Uinta Mountains east of the study area, flows into the area at the southeastern corner, and leaves the area at the southern boundary. The river drains about 40 square miles of the study area. The proposed station of the Jordanelle dam is on the Provo River downstream from the junction with Drain Tunnel Creek, the only major tributary to the Provo River within the area.

Streamflow-gaging station 10155000, Provo River near Hailstone, has been operated in the study area by the U.S. Geological Survey since 1949. The average flow for 31 water years (1954-84) was 285 cubic feet per second.

A gaging station on Drain Tunnel Creek, a tributary to the Provo River, has been operated by the U.S. Bureau of Reclamation since 1978. The average flow for 5 water years (1979-83) was 17.5 cubic feet per second.

Discharge from Individual Basins

The annual streamflow from individual basins within the study area is dependent on basin size, precipitation, vegetation, air temperature, exposure, geology (which is related to infiltration), and other factors. K. L. Lindskov and B. E. Thomas (U.S. Geological Survey, written commun., 1984) developed an equation to calculate annual flow based on drainage area and precipitation. The equation was used to compare flow estimated from measurements at streamflow stations and sites and in the study area which had similar characteristics, with the exception of geology, with 45 other streamflow stations and sites in drainage basins in the mountains of northern Utah. The equation had a standard error of estimate of 28 percent. The estimated annual flow at selected streamflow stations and sites in the study area compared with the annual flow calculated from the equation is shown in figure 5.

Most of the annual flows estimated from measurements compare favorably with those calculated using the equation. Some of the estimated flows however, are considerably smaller than the calculated flows. The most likely explanation for the largest differences is that the geology varies between basins, thus, the infiltration characteristics of the individual basins differ. In basins where fractured rock underlies the stream channels, or where underlying drain tunnels and mines have lowered water levels in the fractured rock below the stream channel, some of the streamflow infiltrates into the ground-water reservoirs. Infiltration of surface water into ground-water reservoirs is discussed in greater detail in the section of this report entitled, "Water in Consolidated Rocks."

Figure 5 this page

Ground Water

Ground water in the study area occurs in unconsolidated valley fill and in consolidated rocks. The unconsolidated valley fill covers about one-third of the study area (pl. 1), and it is confined mainly to the lower parts of the area. The consolidated rocks underlie most of the high mountain areas bounding the valleys. Records of selected wells are given in table 3, drillers' logs of selected wells are given in table 4, water levels in selected observation wells are given in table 5, results of aquifer tests are given in table 6, and records of selected springs and tunnels are given in table 7.

Water in Unconsolidated Valley Fill

Major deposits of water-bearing unconsolidated valley fill (those deposits that have a large areal extent and an estimated thickness of greater than 50 feet) occupy about 5,000 acres in Parleys Park and the Silver Creek drainage, about 2,200 acres in the Drain Tunnel Creek drainage, and about 1,000 acres along the flood plain of the Provo River. Minor deposits (those deposits that have a small areal extent and an estimated thickness of less than 50 feet) occur along East Canyon Creek downstream from Parleys Park and along major tributaries such as Red Pine and White Pine Canyons. Because of the few data available for the minor deposits and their slight effect on the overall hydrologic system, only the major deposits will be addressed in this report.

The unconsolidated valley fill primarily is of alluvial or glacial origin, and it consists of clay, silt, sand, gravel, cobbles, and boulders. The deposits generally are poorly sorted, although some local deposits are well sorted. The alluvium primarily is in the low areas, along stream channels, whereas the glacial deposits are in the high parts of the Wasatch Range along the western side of the study area.

The unconsolidated valley fill ranges in thickness from a few feet near the mountain fronts to about 450 feet in the southern part of the area in the Drain Tunnel Creek drainage. The average thickness of the fill in Parleys Park is about 200 feet, in Silver Creek drainage about 100 feet, in Drain Tunnel Creek drainage about 250 feet, and along the Provo River about 60 feet. The thickness of the fill in the northern part of the area is difficult to determine because its description in drillers' logs is similar to that of semiconsolidated to consolidated volcanic and conglomeratic rocks.

Recharge.--Recharge to the unconsolidated valley fill from precipitation, unconsumed irrigation water, leakage from consolidated rocks, and seepage from streams is estimated to be 15,400 acre-feet per year. Recharge from subsurface inflow from outside the study area along the Provo River probably is small; and for the purposes of this report, it is assumed to equal the subsurface outflow along the Provo River, East Canyon, and Silver Creeks. A summary of the estimated recharge to the unconsolidated valley fill is presented in table 8.

Precipitation and unconsumed irrigation water.--Recharge to the unconsolidated valley fill from precipitation and unconsumed irrigation water occurs primarily on irrigated croplands and pasture along and adjacent to the major stream channels. The irrigated lands in the East Canyon and Silver Creek drainages and along the Provo River approximately cover the entire surface outcrop of the major deposits of unconsolidated valley fill. In the Drain Tunnel Creek drainage, about one-third of the major deposits of unconsolidated valley fill are covered by irrigated lands.

Haws and others (1970, tables 26 and 36, area no. 6) estimated the precipitation on about 5,100 acres of irrigated cropland and wetlands in East Canyon and Silver Creek drainages to be about 10,400 acre-feet per year, and they further estimated the diversions from streams to the cropland to be about 19,300 acre-feet per year. The consumptive use on the cropland is estimated to be about 11,300 acre-feet per year and the return flow about 13,200 acre-feet per year. Based on these estimates, and assuming no change in storage in the unconsolidated valley fill, the recharge to the fill in East Canyon and Silver Creek drainages from precipitation and unconsumed irrigation water is about 5,200 acre-feet per year, or about 1 acre-foot per acre per year.

The recharge from precipitation and unconsumed irrigation water on about 700 acres of irrigated cropland and wetlands in Drain Tunnel Creek drainage and 1,000 acres on the flood plain of the Provo River (estimated from aerial photographs), assuming the same recharge rate of 1 acre-foot per acre per year, is about 1,700 acre-feet per year. In addition, about 1,500 acres of unconsolidated valley fill in Drain Tunnel Creek drainage, was not classified as irrigated cropland or wetland but does receive some recharge from precipitation. That recharge was calculated as follows: Precipitation represents about 35 percent of the total supply of water to irrigated croplands and wetlands in East Canyon and Silver Creek drainages. The average annual consumptive-use requirements must be exceeded before excess water from precipitation is available for recharge; thus, the value of 35 percent probably is too large for the 1,500 acres of nonirrigated land in Drain Tunnel Creek drainage. Assuming a value of 20 percent (0.2 acre-foot per acre per year) it is estimated that recharge from precipitation on the 1,500 acres of nonirrigated land is about 300 acre-feet per year. Thus, the total estimated recharge to the unconsolidated valley fill from precipitation and unconsumed irrigation water in the study area is 7,200 acre-feet per year.

Leakage from consolidated rocks.--Recharge to the unconsolidated valley fill from leakage from contiguous and underlying consolidated rocks in Parleys Park and Silver and Drain Tunnel Creek drainages primarily estimated from seepage studies conducted during the late summer and fall of 1983, is 6,400 acre-feet per year. Seepage studies on the Provo River were not attempted because high-flow conditions resulting from greater-than-normal precipitation during this study made it virtually impossible to identify any gains or losses. The measurements stations and gaging stations are shown on pl. 2, and measurements from seepage studies are shown in table 1.

The seepage studies were conducted during the late summer and fall when recharge to the unconsolidated valley fill from unconsumed irrigation water, precipitation, discharge from wells, and evapotranspiration was minimal. Measurements were corrected for tributary inflow and inflow from springs discharging from consolidated rocks directly to streams. Using the corrected measurements for streamflow and assuming no changes in storage in the unconsolidated valley fill, the following conclusions are: Increases in streamflow represent recharge to the fill from consolidated rocks and discharge from the fill to streams, and decreases in streamflow represent recharge to the fill from seepage from streams and discharge from the fill to consolidated rocks.

Tributary inflow into Parleys Park was measured where stream channels cross Utah Highway 224 between Kimball Junction and Quarry Mountain (pl. 2, stations 2-5, 9, and 11-13), and stream outflow was measured where streams cross Interstate Highway 80 (pl. 2, stations 7, 10, and 14) and where flow from the northern part of Parleys Park enters East Canyon Creek (pl. 2, site 6). The area between the inflow and outflow-measurement stations represents the one major deposit of unconsolidated valley fill in the East Canyon Creek drainage. The consolidated rock underlying most of the unconsolidated valley fill in Parleys Park is the Nugget Sandstone. The average gain in streamflow, measured during three seepage runs, was 1.67 cubic feet per second (11 percent of the average inflow), or about 1,200 acre-feet per year.

Silver Creek obtains its base flow from springs in the Park Meadows area southeast of Quarry Mountain. On November 3, 1983, the streamflow from the Park Meadows area, measured at site 32 (pl. 2), was 5.96 cubic feet per second (table 1). An estimated 1.2 cubic feet per second was flow from Dority Spring, (D- 2- 4)4dca-S1, which is the only major spring identified that discharges water to Silver Creek directly from consolidated rocks. After subtracting the flow of Dority Spring, the gain in streamflow from the unconsolidated valley fill was 4.76 cubic feet per second. An additional gain in streamflow from the fill of 3.03 cubic feet per second was measured in the downstream part of Silver Creek between stations 32 and 35 (pl. 2), for a total gain in streamflow from the fill of 7.79 cubic feet per second or about 5,600 acre-feet per year. The consolidated rocks that underly the unconsolidated valley fill near Silver Creek are the Thaynes and Ankareh Formations, Woodside Shale, and the Park City Formation, in the Park Meadows area; and primarily Tertiary volcanic rocks in the downstream part of Silver Creek.

Seepage studies on Drain Tunnel Creek conducted during September and October 1983 show an average gain of 2.1 cubic feet per second, or 1,500 acre-feet per year, from unconsolidated valley fill upstream from station 55. The gain was computed by subtracting the flow of the Ontario No. 2 Drain Tunnel (station 40) from the flow at station 55. The gain of 2.1 cubic feet per second is assumed to be leakage from consolidated rocks to the unconsolidated valley fill. The consolidated rocks underlying the unconsolidated valley fill near this reach of Drain Tunnel Creek primarily are Tertiary volcanic rocks.

In summary, streams flowing across major deposits of unconsolidated valley fill in Parleys Park and in the drainage basins of Silver and Drain Tunnel Creeks during the late summer and fall of 1983 showed gains equivalent to about 8,300 acre-feet per year. The gains in streamflow are assumed to represent recharge to the fill from leakage from consolidated rocks.

The estimated leakage from consolidated rocks to the unconsolidated valley fill in Parleys Park and in the drainage basins of Silver and Drain Tunnel Creeks during the summer and fall of 1983 probably is somewhat larger than might be expected during periods of normal precipitation. Discharge records for the Spiro Tunnel, supplied by the Park City Mines Co., were used to correct the estimated leakage from consolidated rocks to the unconsolidated valley fill in order to obtain a long-term estimate. The estimated long-term average discharge of the Spiro Tunnel, when not affected by dewatering operations in workings below the tunnel (1950-84), is about 8.0 cubic feet per second. The estimated average discharge from the tunnel during 1983 was 10.4 cubic feet per second. Thus, the 8,300 acre-feet per year of estimated recharge to the unconsolidated valley fill from leakage from consolidated rocks measured during seepage studies in 1983 was multiplied by 0.77 (8.0 divided by 10.4) to estimate a long-term annual recharge from leakage from consolidated rocks of 6,400 acre-feet per year. The correction factor of 0.77 is similar to the correction factor of 0.64 that was used to adjust short-term streamflow records to obtain long-term average flows, as described above in the section on East Canyon Creek.

Seepage from streams.--Seepage studies on Drain Tunnel Creek show an average loss of about 2.45 cubic feet per second, or 1,800 acre-feet per year, between stations 55 and 56 (table 1). Seepage studies on East Canyon and Silver Creeks did not show any areas of significant losses. Seepage studies on the Provo River were not attempted because high-flow conditions resulting from greater than normal precipitation made it virtually impossible to identify any gains or losses.

<u>Movement</u>.--Water in the unconsolidated valley fill moves with the same general slope and direction as does water in the major streams, such as East Canyon, Silver, and Drain Tunnel Creeks. In upland bench areas, where recharge is from precipitation and unconsummed irrigation water, the general direction of ground-water movement is toward the major streams. This is evident in Parleys Park (fig. 6), the only area with sufficient water-level measurements for which a potentiometric-surface map could be prepared.

<u>Discharge</u>.--Discharge from the unconsolidated valley fill in the study area by evapotranspiration, seepage to streams, and wells is estimated to be 15,500 acre-feet per year. Subsurface outflow where the Provo River and East Canyon and Silver Creeks leaves the study area probably is small; and for the purposes of this report, it is assumed to be equal to subsurface inflow where the Provo River enters the area. A summary of the estimated discharge from the unconsolidated valley fill is presented in table 9.

Evapotranspiration.--Discharge from the unconsolidated valley fill by evapotranspiration is estimated to be 2,600 acre-feet per year. The estimate is based on about 500 acres of phreatophytes on the flood plains of East Canyon and Silver Creeks (Haws and others, 1970, table 26), which consume about 1,300 acre-feet per year (Haws and others, 1970, table 36). Assuming the same consumptive use rate (about 2.6 acre-feet per acre per year) on about 500 acres of phreatophytes in Drain Tunnel Creek drainage and on the flood plain of the Provo River (area estimated from aerial photographs), the estimated consumptive use by phreatophytes in Drain Tunnel Creek drainage and the Provo River drainage also is 1,300 acre-feet per year.

Figure 6 this page

Seepage to streams.--Discharge from the unconsolidated valley fill by seepage to streams is estimated to be 12,800 acre-feet per year. The estimate is based on the assumption that gains in streamflow measured during seepage studies are not only a reflection of recharge to the fill from leakage from consolidated rocks but also can be used to estimate discharge from the unconsolidated valley fill from seepage to streams. The estimate assumes that discharge by evapotranspiration and wells is small, and there are no changes in storage in the unconsolidated valley fill. Therefore, the estimated long-term discharge from the unconsolidated valley fill by seepage to streams as estimated from seepage studies conducted in the late summer and fall of 1983 on East Canyon and Silver Creeks and adjusted for greater-than-normal precipitation during this study is 6,400 acre-feet per year as previously described. In addition, Haws and others (1970, table 36) report that about 3,900 acre-feet per year (recharge from precipitation and unconsumed irrigation water minus wetland consumptive use) discharges from the fill to streams in the East Canyon and Silver Creek drainages between March and June. Their estimate assumed no change in ground-water storage.

Discharge from the valley fill in Drain Tunnel Creek and the Provo River drainages between March and June was determined to be 700 acre-feet per year by applying the same assumptions and values used by Haws and others in East Canyon and Silver Creek drainages (recharge from precipitation and unconsumed irrigation water minus wetland consumptive use). In addition, a large marshy area south and west of Hailstone discharges water to the Provo River. Data collected in the area (Reed Mower, consulting engineer, oral commun., March 1985) indicate that the source of most of the water probably is from subsurface inflow through unconsolidated deposits in the Drain Tunnel Creek drainage. Therefore, the streamflow loss of 1,800 acre-feet per year in the Drain Tunnel Creek drainage, as described in the section Water in unconsolidated fill, Recharge, is assumed to be discharged to the Provo River in this area.

Wells.--Discharge from the unconsolidated valley fill from wells in the Park City area is small. Most of the wells are in Parleys Park and are used primarily for domestic purposes or stock watering. Probably fewer than 100 active wells discharge from the unconsolidated valley fill. Assuming an average use of 1 acre-foot per year from domestic and stock wells (Bill Smart, Utah Division of Water Rights, oral commun., April 1984), the annual discharge from the unconsolidated valley fill from wells is about 100 acre-feet per year, some of which may return to the unconsolidated valley fill.

<u>Storage</u>.--The quantity of recoverable water in storage in the major deposits of unconsolidated valley fill in the study area is about 190,000 acre-feet. The estimate is based on an area of 3,500 acres in Parleys Park, 1,500 acres in Silver Creek drainage, 2,200 acres in Drain Tunnel Creek drainage, and 1,000 acres along the Provo River; a saturated thickness of 180 feet in Parleys Park, 220 feet in Drain Tunnel Creek drainage, 80 feet in Silver Creek drainage, and 50 feet along the Provo River; and an estimated specific yield of 0.15 (Baker, 1970, p. 44). To recover all this water, the aquifer would have to be completely dewatered, which is not practical.

Water-level fluctuations.--Water-level fluctuations in the unconsolidated valley fill in the study area result from seasonal changes in recharge and discharge. The degree of fluctuation generally is related to the distance from sources of recharge and discharge and to the rates of recharge and discharge. Hydrographs of four representative wells completed in the unconsolidated valley fill are shown in figure 7, and water-level measurements are listed in table 5.

The water level in well (D- 1- 4)29ccc-1, in Parleys Park, ranged from 1.3 feet below land surface in May 1983 to 23.3 feet below land surface in March 1984 (fig. 7). The rapid water-level rise during March and April 1984 corresponds to the spring thaw, when infiltration from the melting snowpack was maximum. The water level in well (D- 1- 4)29dcc-2 shows the same general trend (fig. 7), except that the lowest water levels are during the summer when pumping for outdoor use probably is at a maximum.

The water level in well (D- 2 -4)25abc-1, in Drain Tunnel Creek drainage, ranged from 21.1 feet below land surface in March 1983 to about 102 feet below land surface in January 1983 (fig. 7). Water levels in the well rose 57 between March 10 and March 15, 1983. An even larger rise in water levels occurred in the spring of 1984, but data are not available to establish the exact time and magnitude of that rise. The water level in well (D- 2-5)31aac-1 reached high and low points at about the same time as in well (D- 2-4)25abc-1 (fig. 7), but it did not show the rapid rise in water level that was observed in the latter well during March 1983. Well (D- 2- 5)31aac-1 is near McHenry Creek, and the water level in the well probably is controlled by the altitude of the creek surface.

Hydraulic properties.--Hydraulic properties of the unconsolidated valley fill were estimated from specific capacities obtained from drillers' logs, results of field permeability tests conducted by the U.S. Bureau of Reclamation, descriptions of materials reported in drillers' logs, and aquifer tests. The specific capacity of 12 wells completed in the unconsolidated valley fill in Parleys Park, obtained from drillers' logs, ranges from about 0.2 to 3.5 gallons per minute per foot of drawdown. The transmissivity, based on specific capacity (Walton, 1970, p. 314) and assuming well loss is negligible, ranges from about 13 to 350 feet squared per day; and the hydraulic conductivity, based on the perforated interval, ranges from about 0.1 to 18 feet per day, with an average of about 7 feet per day.

The specific capacity of well (D- 2- 4) 4dcc-1 in the Silver Creek drainage was about 9 gallons per minute per foot of drawdown. This equates to a transmissivity of about 1,500 feet squared per day and a hydraulic conductivity of about 60 feet per day. Data for specific capacity were not available for other wells in the Silver Creek drainage or for wells in Drain Tunnel Creek drainage or the unconsolidated deposits along the Provo River.

Field-permeability tests were conducted by the U.S. Bureau of Reclamation in the unconsolidated valley fill in Drain Tunnel Creek drainage and along the flood plain of the Provo River. The mean horizontal hydraulic conductivity of the unconsolidated valley fill in Drain Tunnel Creek drainage was about 0.2 foot per day, and the mean vertical hydraulic conductivity was about 0.02 foot per day (UINTEX Corp., 1984, p. 13). The mean horizontal hydraulic conductivity of the unconsolidated valley fill along the Provo River

Figure 7 this page

was about 42 feet per day, and the mean vertical hydraulic conductivity was about 28 feet per day. An aquifer test at well (D-1-4)31aac-1 conducted in the unconsolidated valley fill in Parleys Park yielded a transmissivity of 20 feet squared per day (table 6).

The average specific yield of the unconsolidated valley fill in the study area, based on descriptions of materials reported in drillers' logs, is estimated to be about 0.15 (Johnson, 1967, table 29). In parts of Drain Tunnel Creek drainage, the water in the fill is under artesian conditions, but data were not available to determine the storage coefficient

Water in Consolidated Rocks

Consolidated rocks crop out or are buried by less than 50 feet of unconsolidated valley fill throughout almost all the high parts of the study area and in a large percentage of the low areas (pl. 1). The consolidated rocks are the most important source of water in the area because of their large areal extent, the large volume of water that they contain in storage, and their ability to yield large quantities of water to springs and wells. The consolidated rocks also supply the base flow of streams originating in the high-altitude areas surrounding the mountain valleys.

The consolidated rocks consist of sedimentary and extrusive and intrusive igneous deposits. The sedimentary rocks primarily are sandstone, limestone, quartzite, and shale, and the igneous rocks primarily are breccia, tuff, and flows. Some intrusive stocks are present in the southern part of the study area in Drain Tunnel Creek drainage. Most of the consolidated rocks are greatly fractured, and the movement of water primarily is along fractures, or in the case of limestone, along fractures that have been enlarged by solution.

The thickness of individual consolidated-rock formations may vary from less than 100 feet for some of the extrusive igneous rock units to more than 2,000 feet for sedimentary formations such as the Twin Creeks Limestone (Baker, 1970, table 1). The intrusive igneous rocks in the southern part of the area are present at the surface; but they have been encountered in mine workings at depths of 3,000 feet, and they probably extend to much greater depths.

<u>Recharge</u>.--Recharge to the consolidated rocks in the study area is from precipitation, stream infiltration, and subsurface inflow from adjoining areas. It is estimated to average about 46,000 acre-feet per year (table 10).

Precipitation and stream infiltration.--Recharge to consolidated rocks from precipitation and stream infiltration primarily occurs in the high-altitude areas bordering the western and southwestern part of the study area. The normal annual precipitation (1931-60) exceeds 40 inches in parts of the high bordering areas, and most of the precipitation falls as snow during winter and spring. Recharge from the melting snowpack infiltrates the consolidated rocks in the spring when temperatures are sufficiently high to thaw the soil crust and soil moisture reaches saturation.

Seepage studies and streamflow records collected during this study did not detect any significant streamflow losses to consolidated rocks in the lower altitudes, but losses probably occur in the high-altitude areas surrounding the major valleys. Such losses can be inferred when the streamflow from a basin is significantly smaller than the streamflow estimated from equations based on drainage area and precipitation. (See the section "Discharge from individual basins" and fig. 5). Areas of probable recharge include Red and White Pine Canyons, Thaynes Canyon, and the upper part of Silver Creek drainage (including Ontario Canyon, Empire Canyon, and Deer Valley).

The major consolidated-rock units cropping out in Red and White Pine Canyons are the Twin Creek Limestone, Nugget Sandstone, and the Ankareh and Thaynes Formations. In most of the area, these formations are covered by a thin veneer of unconsolidated valley fill, primarily glacial deposits, which facilitates streamflow losses to the consolidated rocks. The Twin Creek Limestone and the Thaynes Formation discharge large quantities of water to springs, and they probably are the principal formations being recharged in Red and White Pine Canyons.

The major consolidated rock unit cropping out in Thaynes Canyon is the Thaynes Formation, which consists of sandstone, siltstone, and limestone. The formation apparently is extremely permeable, based on the large yields of springs that discharge from the formation throughout the study area (table 7). Some water from the Thaynes Formation also discharges to the Spiro Tunnel (pl. 2), but evidence submitted in a court case (Silver King Consolidated Mining Co. v. Sutton, 39 P.2d 682, SUP. CT. UT. 1934) involving the owners of the tunnel and numerous parties with water rights to springs in the area indicated that the primary source of discharging water from the Spiro Tunnel is the Weber Quartzite. The development of the tunnel apparently had little effect on the movement of water through the consolidated rocks overlying the Weber Quartzite. In the vicinity of the tunnel, the Woodside Shale and Park City Formation are relatively impermeable, and they probably inhibit the downward migration of water from the overlying Thaynes Formation to the underlying Weber Quartzite.

The major consolidated-rock unit cropping out in the upper part of Silver Creek drainage is the Weber Quartzite. Mining operations that began in 1870 have significantly affected the movement of water through consolidated rocks in most of the upper part of Silver Creek drainage. Water initially was encountered near the surface in consolidated rocks, and Boutwell (1912, p. 101) reported a great flow of water at depths less than 100 feet from early mining operations. The construction of drain tunnels and dewatering of the rocks by pumping water into the drain tunnels from deeper workings has lowered water levels by thousands of feet. It is estimated that by 1984 there were more than 1,000 miles of tunnels, shafts, and other workings within the mining district near Park City, including parts of Drain Tunnel Creek drainage and East Canyon Creek drainage (UINTEX Corp., 1984, p. 6).

The effects of mining operations on the recharge to the consolidated rocks (primarily the Weber Quartzite) in the upper part of the Silver Creek drainage is not well understood. It is probable that declining water levels in the consolidated rocks have induced additional infiltration of streamflow, but historic records are not available to substantiate this contention. In addition, some water moving through consolidated rocks in the upper part of Silver Creek drainage now discharges to the Ontario No. 2 Tunnel and flows under the topographic divide into the Drain Tunnel Creek drainage.

An estimate of the quantity of recharge to consolidated rocks from precipitation and stream infiltration can be made if the other component of recharge is known, the total discharge is known, and the ground-water system is assumed to be in steady-state equilibrium with no change in storage. The subsurface inflow from adjoining areas is estimated to be 15,000 acre-feet per year (table 10), and the total discharge from consolidated rocks is estimated to be about 46,000 acre-feet per year (table 11). Thus, the estimated recharge to consolidated rocks from precipitation and stream infiltration is about 31,000 acre-feet per year.

Subsurface inflow from adjoining areas.--Recharge to consolidated rocks from subsurface inflow from adjoining areas occurs primarily along the southwestern border of the study area. Consolidated rocks crop out from the study-area boundary to about 2 miles southwest of the study area in Salt Lake County in the headwater areas of Lambs, Mill Creek, and Big Cottonwood Canyons. These formation dip toward the east and crop out in the Park City area. A court case involving the owners of the Spiro Tunnel and the Salt Lake City Corp. (1969 Civil no. 148376) determined that some of the water discharging from the Spiro Tunnel originated in the headwaters area of Big Cottonwood Creek. Most of the discharge to the Sprio Tunnel is from fractured Weber Quartzite, but the Thaynes Formation also may transmit substantial quantities of water through subsurface inflow along the southwestern border of the study area. Small quantities of water also may be moving through the Park City and Ankareh Formations and the Woodside Shale.

The recharge from subsurface inflow from adjoining areas through consolidated rocks was estimated using the Darcy equation in the following form:

$$Q = TIL$$

where

Q = recharge, in cubic feet per day;
T = transmissivity, in feet squared per day;
I = hydraulic gradient; and
L = length of the contributing formation at the drainage divide bordering the adjoining area, in feet.

Data were not available near the southwestern border of the study area to compute the transmissivities or hydraulic gradients in the consolidated rock formations. Transmissivities of the Weber Quartzite and Thaynes Formation were estimated from aquifer tests conducted in other parts of the study area (table 6). The transmissivity of the Weber Quartzite is assumed to be about 1,000 feet squared per day, based on a test at the Ontario No. 2 Tunnel. The transmissivity of the Thaynes Formation is estimated to be about 7,400 feet squared per day, based on an aquifer test at well (D- 1- 3)13abb-1. That test was used because it represents a perforated interval of 85 feet as contrasted to the aquifer test at well (D-2-4)8aaa-1, where the perforated interval was 30 feet. The combined transmissivity of the Park City and Ankareh Formations and the Woodside Shale, probably is less than 500 feet squared per day. Therefore, the transmissivity of the consolidated rocks contributing to subsurface inflow is estimated to be about 9,000 feet squared per day.

The hydraulic gradient in the consolidated rocks (primarily the Weber Quartzite) near the southwestern border of the study area has been altered by the construction of the Spiro and Ontario No. 2 Tunnels. The hydraulic gradient in the consolidated rocks in the area affected by the tunnels is assumed to be approximately equal to the slope of the tunnels, which is reported to be about 0.5 percent or 0.005 (Joe McPhie, Park City Mines Co., oral commun., 1984). That hydraulic gradient is assumed to be representative of the gradient throughout the length of the outcrop, which is about 7.5 miles. Thus, the subsurface inflow from consolidated rocks is estimated to be 1.8 million cubic feet per day or about 15,000 acre-feet per year.

Movement.--Water moving through consolidated rocks in the study area generally moves from recharge areas at high altitudes toward discharge areas at lower altitudes. The movement of water primarily is along faults or fractures as evidenced by reports from the construction of the Ontario No. 2 Tunnel (Boutwell, 1912, p. 25). The construction of drain tunnels has changed the direction of ground-water movement in widespread areas adjacent to the tunnels. Water in consolidated rocks in these areas now moves toward and discharges to the drain tunnels and associated mine workings.

Data are insufficient to construct a potentiometric contour map showing the altitude of the water surface in consolidated rocks. In addition, the direction of ground-water movement cannot be extrapolated from a contour map of the land surface because the direction of movement in fractured rocks is not necessarily perpendicular to the land-surface contours. The direction of ground water movement also may differ from one consolidated-rock formation to another.

Discharge.--Discharge from consolidated rocks in the study area is from springs, drain tunnels, leakage to unconsolidated valley fill, and wells. The discharge is estimated to average about 46,000 acre-feet per year (table 11).

Springs.--Discharge from consolidated rocks by springs in the lower parts of the study area (at or below the mouths of major canyons) is estimated to be about 13,000 acre-feet per year. Records of selected springs used for this estimate are shown in table 7. Most springs only were measured once during the study, therefore, the total estimate of discharge is only approximate. No attempt was made to adjust the discharge to a more normal period of precipitation. The largest springs in the area discharge from the Thaynes Formation and the Twin Creek Limestone, which indicates that the permeability of those formations may be large.

Discharge by springs from consolidated rocks in the higher parts of the study area is estimated to be 6,000 acre-feet per year. Springs discharging from consolidated rocks in the higher areas provide the base flow of perennial streams entering the valleys. The discharge of the springs in these areas was estimated by assuming that streamflow measured primarily during winter months (some small tributaries were not measured during winter months) at the mouths of the major tributaries is representative of discharge from consolidated rocks by springs in the higher areas. The estimate was not adjusted to represent a more normal period of precipitation.

Numerous small springs discharge primarily from the Nugget Sandstone in the lower parts of the study area. The springs were not measured during this study, but their discharge is relatively small, about 1,000 acre-feet per year. Thus, the total discharge from consolidated rocks to springs is estimated to be about 20,000 acre-feet per year.

Drain tunnels.--Long-term (1900-84) discharge from consolidated rocks by drain tunnels is about 19,700 acre-feet per year. Most of the discharge is from the Ontario No. 2 and Spiro Tunnels, but some water discharges from the Judge/Anchor and Alliance Tunnels. Records of selected tunnels are in table 7, hydrographs showing estimated long-term discharge of the Ontario No. 2 and Spiro Tunnels are in figure 8, and seasonal fluctuations in the discharge of the Spiro Tunnel from 1982-84 are shown in figure 9.

The discharge from the Ontario No. 2 and Spiro Tunnels has been affected at various times by dewatering operations at levels both below and at the approximate levels of the drain tunnels. The history of dewatering operations in the Ontario No. 2 Tunnel is complex, and the details are beyond the scope of this report. Pumping at various locations (often at the same time) and at varying rates occurred between about 1916 and the present (1984). The only time when there was no pumping was between April 1982 and January 1984. In addition to the installation of pumps, branch drainage tunnels and other mining operations were connected with the main tunnel at various times and places. Pumping into the Spiro Tunnel was during 1929-49 (Ed Higbee, Salt Lake City Corp., written commun., 1984). Since 1949, the discharge of the Spiro Tunnel has not been affected by pumping inside the tunnel.

The discharge of the drain tunnels shown in figure 8 is not directly related to precipitation (fig. 4), probably because of the variable discharge rates from the dewatering operations. The decrease in discharge of the Ontario No. 2 Tunnel between 1930 and 1950 may be related to increased pumping in the vicinity of the Spiro Tunnel and decreased pumping into the Ontario No. 2 Tunnel. The drain tunnels, or their related workings, may be connected by fractures. The rapid rise each spring in the hydrograph of the discharge from the Spiro Tunnel (fig. 9) suggests a rapid movement of water from recharge areas to the drain tunnel.

Leakage to unconsolidated valley fill.--Discharge from consolidated rocks by leakage to unconsolidated valley fill is estimated to be 6,400 acre-feet per year. The estimate is based on the results of seepage studies that were conducted during the summer and fall of 1983, and which were corrected to represent long-term precipitaion patterns, as described in the section, "Water in Unconsolidated Valley Fill." The long-term average annual discharge from Spiro Tunnel (1950-84) was compared with the 1983-average discharge to calculate a ratio between the two values. The ratio was used with the estimated 1983 discharge from consolidated rocks to the unconsolidated valley fill to compute a long-term average. The method assumes that the discharge to the unconsolidated valley fill from consolidated rocks varies in the same way that the discharge from consolidated rocks into the Spiro Tunnel varies.

Figures 8 and 9 near here

Wells.--Discharge from consolidated rocks by wells during 1983 were estimated to have been 300 acre-feet. Most of the withdrawals were from the Thaynes Formation. The largest number of wells completed in consolidated rocks are completed in the Nugget Sandstone, but most of these wells are of small diameter, have small yields, and are used primarily for domestic and stock-watering purposes. Almost all the wells are in the Parleys Park area.

Storage.--Data are not available to estimate the volume of ground water in storage in consolidated rocks in the study area with any degree of certainty. Most of the consolidated rocks have little if any primary porosity, and most water is stored in fractures and solution cavities. The thickness of the consolidated-rock formations is unknown and difficult to determine with the available data. Therefore, no attempt was made to estimate the volume of water in storage in the consolidated rocks.

Water-level fluctuations.--Water-level fluctuations in consolidated rocks in the study area result from seasonal changes in recharge and discharge. In addition, changes in the rates of discharge due to mining and dewatering operations since the early 1870's have caused large fluctuations in water levels in mine workings and adjacent consolidated rocks. Hydrographs of five representative wells completed in consolidated rocks are shown in figures 10 and 11, and water-level measurements are listed in table 5.

Water levels in wells (D- 1- 4)19bbc-1, (D- 1- 4)32daa-1, and (D- 2- 4) 8aaa-1 in the East Canyon Creek drainage and (D- 2- 5)31aac-2 in Drain Tunnel Creek drainage reached their highest levels between April and June and generally reached their lowest levels during the winter (fig. 10). The highest water levels occur during periods of maximum recharge, whereas the lowest water levels occur during periods of minimum recharge. The withdrawal of 300 acre-feet per year from wells completed in consolidated rocks throughout the study area is not large enough to cause water levels to decline significantly over large areas.

The water level in well (D- 2- 5)19dcb-2 in Drain Tunnel Creek drainage seems to respond to dewatering operations in the Ontario No. 6 shaft (Reed Clawson, United Park City Mines Co., oral commun., December 1984), which is about 14,000 feet inside the Ontario No. 2 Tunnel (fig. 11). Dewatering operations at an altitude of about 5,400 feet in the Ontario No. 6 shaft were suspended in April 1982; and in January 1983, the water level in the shaft reached an altitude of about 6,320 feet and water began to discharge into the Ontario No. 2 Tunnel. Water levels in well (D- 2- 5)19dcb-2 rose from 205.5 feet below land surface on January 24, 1983, to 112.1 feet below land surface on October 17, 1983 (fig. 11). In January 1984, dewatering operations were restarted in the Ontario No. 6 shaft, and by June 28, 1984, the water level in the well had declined to 120.25 feet. Additional measurements (table 5) show continued declines. On December 12, 1984, the water level in the shaft was at an altitude of about 6,080 feet. Water levels in other wells in the area of the shaft did not show large fluctuations in response to the dewatering operations. The most probable explanation is that well (D- 2- 5)19dcb-2 is connected through fractures to the Ontario No. 6 shaft, whereas other observation wells in the area are not.

Figure 10 near here

Figure 11 near here (half page)

Hydraulic properties.--Hydraulic properties of the consolidated rocks in the study area were estimated from field-permeability tests conducted by the U.S. Bureau of Reclamation and aquifer tests conducted by the Bureau of Reclamation and the U.S. Geological Survey. The results of aquifer tests are shown in table 6.

The transmissivity of the consolidated rocks based on aquifer tests (table 6) ranged from 3 feet squared per day in well (D- 1- 4)36aac-2 to 7,400 feet squared per day in well (D- 1- 3)13abb-1. The largest transmissivity was in the Thaynes Formation and the smallest was in extrusive igneous rocks. The magnitude of the transmissivities probably is related to the number of fractures or solution openings because most of the rocks have little primary permeability. The complex system of faults and fractures in the consolidated rocks indicate that the test results probably apply only to the area near the wells that were tested.

Vertical movement of water through consolidated rocks probably is more prevalent than horizontal movement. Many of the faults and fractures are nearly vertical, and the vertical permeabilities probably are larger than the horizontal permeabilities. Also, in some cases, gouge associated with faults may impede the horizontal movement of water. Boutwell (1912, p. 25) stated that during the construction of the Ontario No. 2 Tunnel, "...frequently 40 or 50 carloads of loose ground would escape through a crevice only as large as a man's hand, and startling accounts of the size and power of water flows which were tapped are related".

The storage coefficient of most of the consolidated rocks could not be determined from the available data. Flowing wells are evidence of artesian conditions in the Nugget Sandstone in the Parleys Park area and in consolidated rocks in Drain Tunnel Creek drainage. The artesian conditions probably are the result of overlying unconsolidated valley fill or overlying consolidated rock of lesser permeability than the formations yielding water to the wells. Artesian conditions probably can be expected in other consolidated rocks at lower altitudes, whereas water-table conditions can be expected at higher altitudes. Mining-company records indicate the amount of pumping necessary to dewater mining zones, but data are not available to estimate the extent of the rock mass that is dewatered during the operations.

Water Quality

The quality of a particular water can be complex because hundreds of constituents from natural occurring or manmade sources may be suspended or dissolved in the water. It is expensive and time consuming to try to determine all the possible constituents in a water (such as naturally occurring elements, organic substances, nutrients, radioactive substances, suspended sediment, and gasses) or all the physical properties of a water (such as pH, specific conductance, and temperature) in order to establish the absolute quality of that water.

For the investigation in the Park City area, 29 dissolved constituents or physical properities of water were determined. These include the common anions and cations, selected trace metals, nutrients, and physical properties. Analytical values determined in water analyses were compared with standards or limits set by the Utah Division of Environmental Health, Bureau of Public Water Supplies (1984) or the U.S. Enviromental Protection Agency (1977), and selected standards and recommended limits for 13 constituents or physical properties of water are shown in table 12. The primary standards of the State were established for the protection of human health, and the secondary standards were established to provide guidance in evaluating the esthetic qualities of drinking water. Primary standards must be met by all public drinking-water systems, and secondary standards are recommended limits which should be met in order to avoid consumer complaint (Utah Division of Environmental Health, Bureau of Public Water Supplies, 1984, p. 3-1).

The standards and recommended limits are for total constituents, whereas the analyses used in this report are for dissolved constituents. The analyses used in this report can be compared to the standards, but the magnitude and frequency of exceedence of these standards will be underestimated. This is especially true for iron. It should be noted also that the standard is for nitrate (as nitrogen) but the analyses used in this report show nitrate plus nitrite (as nitrogen). A comparison is useful, however, because the water samples generally contain little nitrite. In addition, values of alkalinity in tables 12-15 are approximately equivalent to bicarbonate when the pH is between 7.0 and 8.0.

Water types have been characterized in this report using a system developed by Davis and DeWiest (1966, p. 119). Major ions present in proportions less than 20 percent of the total milliequivalents per liter of cations or anions are not used to name the water type. If any ion represents more than 60 percent of the total milliequivalents per liter of either cations or anions, that ion is used alone to represent the dominate type. In mixed water-types, ions present in greater than 20 percent but less than 60 percent of the cations or anions are listed in order of their abundance. For example, water at well (D- 1- 3)13adc-1 on August 8, 1983, contained cations equal to 62 percent calcium, 28 percent magnesium, 9 percent sodium, and less than 1 percent potassium; and anions equal to 50 percent bicarbonate, 40 percent chloride, 8 percent sulfate, and 2 percent other anions. This water was of the calcium bicarbonate chloride type.

The hardness of water conventionally is expressed in all water analyses made in the United States in terms of equivalent quantity of calcium carbonate ($CaCO_3$). Some such convention is needed for hardness because it is a property imparted by several different cations, which may be present in varying proportions. The actual presence of the indicated number of milligrams per liter of $CaCO_3$ itself, however, certainly should not be assumed (Hem, 1970, p. 84).

In practical water analysis, the hardness is computed by multiplying the sum of milliequivalents per liter of calcium and magnesium by 50.05. The hardness value resulting generally is entitled "hardness as CaCO3" or "total hardness". If the hardness exceeds the alkalinity (in milligrams per liter of $CaCO_3$ or other equivalent units), the excess is termed "noncarbonate hardness" (Hem, 1970, p. 224-225).

The classification for hardness commonly used by the U.S. Geological Survey (Hem, 1970, p. 225) is shown below:

Hardness range (milligrams per liter as calcium carbonate)	Description
0-60	Soft
61-120	Moderately hard
121-180	Hard
More than 180	Very hard

Surface-Water Quality

Water samples were collected at 26 surface-water sites in the study area from 1971-83. Samples were collected in East Canyon Creek drainage, in Silver Creek drainage, and in the Drain Tunnel Creek and Provo River drainages (table 13).

East Canyon Creek Drainage.--Samples collected at 16 surface-water sites in East Canyon Creek drainage show two general types of water. Water in the major tributaries generally is of a calcium bicarbonate type, and water in the main stem of East Canyon Creek is of a calcium sulfate, calcium sulfate bicarbonate or calcium bicarbonate sulfate type. The primary reason for the larger concentrations of sulfate in the main stem of East Canyon Creek is the discharge from the Spiro Tunnel, (D- 2- 4)8dba, which contains a large concentration of sulfate (table 14).

Several samples collected in East Canyon Creek drainage had concentrations of dissolved solids, sulfate, or manganese that exceeded State secondary drinking-water standards (table 13, sites 2, 6-8, 21, and 29). A sample collected at site 6 had a cadmium concentration of 3 micrograms per liter which exceeds the recommended limit for freshwater aquatic life. A sample collected at site 21 had a pH of 8.7, which exceeds the State secondary drinking-water standard. The hardness of water samples collected in East Canyon Creek drainage ranged from soft to very hard, with a median value of very hard.

Silver Creek Drainage.--Water collected at four surface-water sites in Silver Creek drainage is of a calcium sulfate bicarbonate or calcium bicarbonate sulfate type. During low flow, the water generally is of the calcium sulfate bicarbonate type; and during high flow, it is of a calcium bicarbonate sulfate type.

Several samples collected in Silver Creek drainage had concentrations of dissolved solids or manganese that exceeded State secondary drinking water standards (table 13, sites 31, 33, and 36). A sample collected at site 36 had a cadmium concentration of 7 micrograms per liter, which exceeded the recommended limit for some freshwater aquatic life, and a pH of 8.6, which exceeded the State secondary drinking-water standard. The samples collected in Silver Creek drainage were hard.

Drain Tunnel Creek and Provo River Drainages.--Water samples collected at six surface water sites in Drain Tunnel Creek and the Provo River drainage are of several different water types. Samples from the Provo River generally are of a calcium bicarbonate type and from Drain Tunnel Creek are of a calcium sulfate bicarbonate type. Samples from McHenry Creek, a tributary to Drain Tunnel Creek, are of a calcium sulfate type. Mundorff (1974, p. 28) associated the large sulfate concentrations in McHenry Creek with areas of Triassic sedimentary rocks of the Ankareh and Thaynes Formations, and the Woodside Shale, and with the mining of sulfide ores in the drainage area of McHenry Canyon.

Several samples collected in Drain Tunnel Creek drainage had concentrations of dissolved solids, sulfate, or manganese that exceeded State primary or secondary drinking-water standards (table 13, sites 56 and 57). Samples collected in Drain Tunnel Creek and the Provo River drainage ranged from soft to very hard, with a median value of very hard.

Ground-Water Quality

Ground-water quality will be discussed as it pertains to the geologic formations from which the water is discharging. The location of the sampling sites is shown on pl. 2, and the water-quality data are shown in table 14. The data in table 15, which is a statistical summary of water-quality, can be used to compare the water quality in the unconsolidated valley fill, drain tunnels, and different bedrock formations.

Unconsolidated valley fill.--Water samples were collected from 12 wells and 6 springs discharging from unconsolidated valley fill. The water generally was of a mixed type, and water types differed considerably from site to site. The predominate cations were calcium and magnesium and the predominate anions were bicarbonate, chloride, and sulfate. Hardness ranged from moderately hard to very hard, with a median value of very hard.

Several water samples exceeded standards or recommended limits for certain constituents. These constituents are listed below:

Cadmium--The cadmium concentration of 14 micrograms per liter for spring (D-2-4)24adb-S1 exceeded the State primary drinking-water standard and the Environmental Protection Agency's recommended limit for less sensitive aquatic life.

Chloride--The chloride concentration for well (D-1-4)8ada-1 of 550 milligrams per liter was more than twice the State secondary drinking-water standard.

Iron--The iron concentration for well (D-1-4)8ada-1 of 1,100 micrograms per liter and for well (D-1-4)16acd-4 of 330 micrograms per liter exceeded the State secondary drinking-water standard. The iron concentration for well (D-1-4)8ada-1 also exceeded the Environmental Protection Agency's recommended limit for aquatic life.

Manganese--Manganese exceeded the State secondary drinking-water standard at two wells and three springs. The manganese concentration of 1,600 micrograms per liter at spring (D-2-4)2aac-S1 was 32 times greater than the State standard, and the concentration of 540 micrograms per liter at spring (D-1-4)35cad-S1 was more than 10 times greater than the standard. The other manganese concentrations that exceeded the State standard were 120 micrograms per liter at well (D-1-4)8ada-1, 74 micrograms per liter at well (D-1-4)16acd-4, and 56 micrograms per liter at spring (D-2-5)17bca-S1.

Sulfate--Sulfate concentrations of 770 milligrams at spring (D-2-4)2aac-S1 and 350 milligrams at spring (D-2-4)24adb-S1 exceeded the State secondary drinking-water standard.

Dissolved solids--Dissolved solids exceeded the State secondary drinking-water standard at five wells and three springs. Concentrations that exceeded the standard ranged from 505 milligrams per liter at well (D-1-3)24aaa-1 to 1,380 milligrams per liter at spring (D-2-4)2aac-S1.

The water from some wells and springs exceeded standards for more than one constituent. These were well (D- 1- 4) 8ada-1, for chloride, iron, manganese, and dissolved solids; well (D- 1- 4)16acd-4, for iron and manganese; spring (D- 2- 4)24adb-S1, for cadmium, sulfate, and dissolved solids; and spring (D- 2- 4) 2aac-S1, for manganese, sulfate, and dissolved solids.

Several samples collected in Drain Tunnel Creek drainage had concentrations of dissolved solids, sulfate, or manganese that exceeded State primary or secondary drinking-water standards (table 13, sites 56 and 57). Samples collected in Drain Tunnell Creek and the Provo River drainage ranged from soft to very hard, wiwth a median value of very hard.

Drain Tunnels.--Mines in the Park City area typically intersect several water-bearing formations, and water that is discharged from drain tunnels commonly is a mixture of water from several formations. Mining activities also may affect the water quality of the discharge from the tunnels. Water was sampled from four drain tunnels, and all the water was a calcium sulfate type and very hard. The water samples from the drain tunnels that exceeded standards or recommended limits for certain constituents are listed below:

Iron--An iron concentration of 2,000 micrograms per liter at drain tunnel (D-2- 4)24aca exceeded the State secondary drinking-water standard and the Environmental Protection Agency's recommended limit for freshwater aquatic life.

Manganese--Manganese concentrations at drain tunnel (D- 2- 4)24aca were 36 times greater than the State secondary drinking-water standard, and at drain tunnel (D- 2- 4)24caa they were 9 times greater.

Sulfate--Sulfate concentrations at all four drain tunnels exceeded the State secondary drinking-water standard.

Dissolved solids--Dissolved-solids concentrations at all four drain tunnels exceeded the State secondary drinking-water standard.

Zinc--The zinc concentration at drain tunnel (D- 2- 4)24aca of 6,800 micrograms per liter exceeded the State secondary drinking-water standard.

Weber Quartzite.--Water samples were collected from a well and a spring discharging from the Weber Quartzite. The water was a calcium bicarbonate type and moderately hard. At well (D- 2- 4)36aaa-1, the manganese concentration was 130 micrograms per liter, which is more than twice the State secondary drinking-water standard; and at spring (D- 2- 4)22abc-S1 the manganese concentration of 370 micrograms per liter was more than seven times greater than the State standard.

Woodside Shale.--A water sample was collected from one spring discharging from the Woodside Shale. The water was a calcium bicarbonate type and was very hard. No constituents exceeded the standards or recommended limits.

Thaynes Formation.--Water samples were collected from two wells and seven springs discharging from the Thaynes Formation. The water generally was a calcium bicarbonate or calcium magnesium bicarbonate type. Sulfate also was a major ion at several of the springs. Hardness ranged from hard to very hard, with a median value of hard.

A water sample from spring (D- 1- 3)14bca-S1 had a nitrate concentration of 26 milligrams per liter, which is more than double the State primary drinking-water standard.

Ankareh Formation.--Water samples were collected from two wells completed in the Ankareh Formation. The water was a calcium bicarbonate or calcium magnesium bicarbonate type and was very hard.

The iron concentration at well (D- 1- 4)35dbb-1 of 940 micrograms per liter was more than 3 times the State secondary drinking-water standard. The manganese concentration of 86 micrograms per liter in the same well exceeded the State secondary drinking-water standard.

Nugget Sandstone.--Water samples were collected from five wells and five springs discharging from the Nugget Sandstone. The water generally was a calcium bicarbonate or calcium magnesium bicarbonate type. Sodium and sulfate also were major ions in water from some springs. Hardness ranged from moderalely hard to very hard, with a median value of very hard.

The iron concentration at well (D- 1- 4)30bbd-1 of 440 micrograms per liter exceeded the State secondary drinking-water standard. The pH at spring (D- 1- 4)30bbc-S1 was 6.3 and the pH at well (D- 1- 4)32daa-1 was 6.4. Both of these values for pH were less than the range of pH recommended by the State secondary drinking-water standard and less than the Environmental Protection Agency's recommended range for freshwater-aquatic life.

Twin Creek Limestone.--Water samples were collected from one spring and one well discharging from the Twin Creek Limestone. The water from well (D-1- 4)17bbb-1 was a calcium magnesium bicarbonate type and was very hard. The water from spring (D- 1- 3)36aad-S1 was a calcium bicarbonate type and was hard. No constituents from the well or the spring exceeded the standards and recommended limits.

Pruess Sandstone.--One water sample was collected from a well completed in the Pruess Sandstone. Water from this well was a calcium magnesium sodium bicarbonate type and was very hard. No constituents exceeded the standards and recommended limits.

Frontier Formation.--Water from three springs discharging from the Frontier Formation was a calcium bicarbonate type. The water was very hard at springs (A- 1- 3)28ddd-S1, (A- 1- 3)34cbd-S1, and (A- 1- 3)35bbb-S1. No constituents at any of the three springs exceeded the standards and recommended limits.

Igneous rocks.--Water samples were collected from four wells and seven springs discharging from extrusive igneous rocks. Water types generally were mixed, ranging from a calcium bicarbonate or calcium magnesium bicarbonate type to calcium sulfate or calcium magnesium sulfate type. Hardness ranged from hard to very hard, with a median value of very hard.

Water samples from three springs exceeded standards or recommended limits for certain constituents. At spring (D- 2- 5)21ccd-S1, the concentration of manganese was almost three times larger than the State secondary drinking-water standard and concentrations of sulfate and dissolved solids were about double the secondary standards. At spring (D- 2- 5)29cad-S1, the concentrations of sulfate and dissolved solids were about double the State secondary drinking-water standards. At spring (D- 1- 4) 8bbd-S1, the manganese concentration was three times greater than the State secondary drinking-water standard.

FUTURE DEVELOPMENT OF WATER RESOURCES

Demands for water in the study area will increase if the present rate of growth continues. The surface water in the area is fully appropriated, and although surface-water rights can be transferred, additional water supplies probably will come from increased ground-water withdrawals. The unconsolidated valley fill probably will continue to be an important supply of water for domestic and stock wells. Large withdrawals from the unconsolidated valley fill probably are not possible, however, because of its small areal extent and relatively low permeability. The consolidated rocks offer the best potential source for development of additional water supplies.

Increased Withdrawals of Water from Consolidated Rocks

The consolidated rocks with the greatest potential for yielding large quantities of water to individual wells are the Thaynes Formation and the Twin Creek Limestone. The Weber Quartzite yields large quantities of water to drain tunnels, but data are insufficient to determine its potential for large sustained yields to individual wells in areas some distance from the tunnels. The Nugget Sandstone yields small quantities of water to domestic and stock wells, but aquifer tests conducted during this study do not indicate a potential for large sustained yields. Data for other consolidated rocks in the area are insufficient to determine their potential for possible large ground-water withdrawals, but all the formations may yield substantial quantities of water where their permeability has been increased by faulting or fracturing.

The Thaynes Formation probably offers the greatest potential for developing water supplies in the Park City area. The formation crops out or is at relatively shallow depths close to the major population centers near Park City. The formation can yield large quantities of water to individual wells as evidenced by a production test at well (D- 2- 4) 8aaa-1 where a pumping rate of 1,050 gallons per minute was maintained for 72 hours with a drawdown of about 20 feet (Fred Duberow, J. J. Johnson & Associates, written commun., 1983).

The Twin Creek Limestone also may be capable of producing large quantities of water to individual wells in the Park City area. Well (D- 1-4)19BBC-1, which was drilled near Kimball Junction and completed in the Twin Creek Limestone, produced 520 gallons per minute after 12 hours of pumping with a drawdown of about 35 feet, as reported by the driller.

Potential Effects of Increased Withdrawal of Ground Water From Consolidated Rocks

The potential effects of increasing water withdrawals from consolidated rocks are decreases in the discharge of springs and streams, water-level declines in wells, and downward movement of poor quality water to freshwater aquifers.

Decreased Discharge of Springs and Streams

Increased water withdrawals from consolidated rocks may cause a decrease in the discharge of springs and streams. Tests at two wells near Park City showed effects of ground-water withdrawals on the discharge of Dority Spring, (D- 2- 4) 4dca-Sl, and the flow of Silver Creek (Keith Higginson, Higginson-Barnett, Consultants, written commun., 1983). Well (D- 2- 4) 8aaa-l, in East Canyon drainage, was pumped for 72 hours at a rate of 1,050 gallons per minute. A decrease in the discharge of Dority Spring, in Silver Creek drainage, was observed within 2 hours after the pump was started. The discharge of the spring gradually decreased from about 1 cubic foot per second, and it ceased to flow after 12 hours of pumping. The spring and the well discharge from the Thaynes Formation.

Similar results were observed when well (D- 2- 4) 9aac-l was pumped for 72 hours at a rate between 90 and 200 gallons per minute, but the observed decreases in the discharge at Dority Spring were much smaller. The well is completed in the Woodside Shale which may be fractured in the area of the test, thus providing direct hydraulic connection to the overlying Thaynes Formation.

It is possible that similar conditions apply to other consolidated formations in the Park City area, and large withdrawals from wells will result in similar decreases in the discharge of springs and streams that are hydraulically connected either directly to the formations or indirectly through other formations. A decrease in spring discharge from consolidated rocks or in streamflow where streams are in direct contact with consolidated rocks primarily will be related to the quantity of water being pumped and the hydraulic characteristics of the consolidated rocks. Decreases in streamflow and discharge from springs in unconsolidated valley fill will be related to the quantity of water pumped, the hydraulic characteristics of the consolidated rocks, and the thickness and hydraulic characteristics of the fill.

The unconsolidated valley fill in the Park City area generally has small permeability and a relatively large storage capacity. Thus, the effects of water withdrawals from consolidated rocks on springs discharging from or streams crossing the unconsolidated valley fill may not be easily detected. The unconsolidated valley fill may act as a buffer, releasing water from storage to the consolidated rocks when water levels in the rocks decline below water levels in the fill. If water levels in the consolidated rocks decline but remain higher than water levels in the unconsolidated valley fill, the upward movement of water from the rocks to the overlying fill will decrease.

Water-Level Declines in Wells

Water-level declines in wells can be anticipated if withdrawal of water from consolidated rocks increases substantially. The largest water-level declines will occur in the consolidated rocks near the points of withdrawal. Smaller water-level declines will occur in underlying or overlying formations or at greater distances from the points of withdrawal. Because of the complex geologic framework in the area and the existence of miles of mine tunnels and drifts, the magnitude of water-level decline is difficult to predict other than at locations where wells have been tested.

The test at well (D- 2- 4) 8aaa-1 described in the previous section caused water-level declines of as much as 1 foot in well (D- 2- 4) 4dcc-1 (Keith Higginson, Higginson-Barnett, Consultants, written commun., 1983), about 3,000 feet east of well (D- 2- 4) 8aaa-1. Well (D- 2- 4) 4dcc-1 is a dug well, about 33 feet deep, completed in unconsolidated valley fill. A gage on the pond sustained by Dority Spring, which discharges from the Thaynes Formation, showed a decline of about 1 foot in the first 12 hours of the test at well (D- 2- 4) 8aaa-1 before the pond became dry (Keith Higginson, Higginson-Barnett, Consultants, written commun., 1983). Based on this observation and the observed recovery in the pond after pumping ceased, it is estimated that after 72 hours of pumping the water-level decline in the aquifer at the site of the spring (about 4,000 feet east of the pumped well) was between 2 and 3 feet.

Downward Movement of Poor Quality Water to Aquifers Containing Freshwater

Downward movement of poor quality water from the unconsolidated valley fill to consolidated rocks that contain freshwater may occur if withdrawals from the consolidated rocks increase significantly. In most of the study area, water levels in the consolidated rocks generally are higher than water levels in the overlying unconsolidated valley fill. The movement of water in the unconsolidated valley fill generally follows the slope and direction of the major streams except at upland-bench areas where the movement is toward streams, as previously described. If water levels in the consolidated rocks were to decline below water levels in the unconsolidated valley fill, some water that normally discharges to streams could move downward to the underlying consolidated rocks; and eventually that water could move toward areas of large ground-water withdrawals from consolidated rocks.

The downward movement of water from the unconsolidated valley fill to the consolidated rocks will not pose a significant problem if the quality of the water is good, as it is much of the study area. Possible problem areas, however, are in northern Parleys Park, Park Meadows, Richardsons Flat, and near Keetley Station. Large water-level declines in the consolidated rocks near these areas may cause the downward movement of poor quality water into aquifers containing freshwater. In addition, some streams in the area contain concentrations of dissolved ions and solids that exceed standards or recommended limits. This also could cause water quality problems if large water-level declines in consolidated rocks cause the downward movement of water from these streams.

Potential Effects of the Proposed Jordanelle Dam and Reservoir on the Ground-Water System

The potential effects of the proposed Jordanelle dam and reservoir on dewatering operations in the adjacent mining areas is difficult to address with the available data. The U.S. Bureau of Reclamation has drilled numerous test and observation wells in the vicinity of the proposed dam and reservoir in an attempt to understand the geologic conditions controlling ground-water movement. Several aquifer tests have been conducted to evaluate hydraulic properties of the consolidated rocks that separate the dam and reservoir site from the mine shafts and tunnels. A report prepared by UINTEX Corp. (1984) for the U.S. Bureau of Reclamation summarizes much of the data and contains some conclusions based on simulations using a ground-water model developed by Prickett and Lonnquist (1971).

The site of the proposed Jordanelle dam on the Provo River is just upstream from the town of Jordanelle (pl. 2). The maximum altitude of the proposed reservoir is about 6,170 feet, and the reservoir will cover a large part of Drain Tunnel Creek drainage and several miles of the flood plain of the Provo River upstream from the dam. The relationship of the proposed reservoir to the Mayflower Tunnel and Shaft, the Ontario No. 2 Tunnel and the Ontario No. 6 Shaft is shown in figure 12.

The Mayflower Shaft is the deepest mine in the study area, with an altitude at its lowest levels of about 4,200 feet. The mine has not been operated since 1971, and the water level in the shaft on April 25, 1979, was at an altitude of about 6,303 feet (Leon Hansen, L. A. Hansen Assoc., oral commun., Dec., 1984). The Ontario No. 6 shaft has been worked to an altitude of about 5,400 feet and on December 12, 1984, the water level in the shaft was at an altitude of about 6,080 feet and dewatering operations were in progress.

The rocks separating the reservoir site from the mine tunnels and shafts are primarily unconsolidated valley fill underlain by extrusive igneous rocks. On the eastern side of the north arm of the proposed reservoir (Drain Tunnel Creek drainage) and along the Provo River flood plain, some extrusive igneous rocks and several small outcrops of the Thaynes Formation will be in direct contact with the water in the reservoir. The consolidated rocks in the vicinity of the reservoir site are fractured and displaced by a number of faults trending generally eastward (pl. 1). The faults cannot be traced under the unconsolidated valley fill in Drain Tunnel Creek drainage, and the magnitude and trend of faulting has been a controverisal subject.

The water levels in bedrock (extrusive igneous rocks) during 1982, as measured in well (D- 2- 5)19dcb-2, were about the same as the water levels in unconsolidated valley fill, as measured in well (D- 2- 5)19dcb-1 (fig. 11). By October 17, 1983, the water level in the bedrock had risen almost 100 feet. The rise in water level seems to correspond to the cessation of pumping in the Ontario No. 6 Shaft in April 1982. By October 11, 1984, the water level in the bedrock well had declined about 10 feet, but it was about 80 feet higher than the water level in the unconsolidated valley fill, indicating an upward gradient. The water-level decline seems to be related to pumping in the Ontario No. 6 Shaft, which resumed in January, 1984.

Other observation wells in the reservoir area do not show water-level fluctuations that might be related to pumping in the Ontario No. 6 Shaft. This indicates that the movement of water is primarily through fractured rocks. Water-level fluctuations in wells that do not intercept fractures connecting the mining zone to the well may not be related to dewatering operations in the mines.

UINTEX Corp. (1984, p. 17) reports good hydraulic connection between unconsolidated valley fill and underlying bedrock aquifers in the proposed reservoir area. Water levels probably decline in the unconsolidated valley fill in parts of Drain Tunnel Creek drainage when water levels in fractured consolidated rocks decline below water levels in the fill because of dewatering operations in the mines.

Figure 12 this page

The main effects of the proposed reservoir on dewatering operations in the mines at an altitude below the reservoir would be an increase in the hydraulic gradient between the reservoir and the mine shafts and an increase of recharge to the unconsolidated valley fill when water levels decline in the consolidated rocks beneath and adjacent to the reservoir. The reservoir probably will have little or no effect on the ground-water flow to the drain tunnels when dewatering operations are not being conducted below the level of the drain tunnels.

The result of the increase of hydraulic gradient and increase of recharge to the unconsolidated valley fill may be to increase the pumping necessary to dewater mines that are at an altitude below the reservoir. The magnitude of the increase in pumping will be dependent on the number of fractures connecting the reservoir site to the mines and the permeability of the fractured rocks. The magnitude of increase in pumping cannot be estimated because data are not available to identify the number of fractures or the permeabilities of the fractured rocks.

FUTURE STUDIES

Future studies of ground-water flow through fractured rock in the Park City area would help to resolve problems associated with the complex hydrologic conditions that exist in the area. Such studies need to include: (1) Detailed mapping of fracture systems in underground workings and on surface outcrops, to identify the principal directions of ground-water movement; (2) a large number of exploratory drill holes, to help determine the extent and magnitude of fracturing in the consolidated rocks in areas where they are overlain by unconsolidated valley fill; (3) a large number of aquifer tests, to define the hydraulic properties of aquifers in complex areas of faulting and fracturing; (4) a data-collection program that would include water-level measurements and the collection and analysis of water samples from selected wells, to monitor the possible downward migration of poor-quality water to freshwater aquifers.

Future studies also would benefit from the continued operation of gaging stations on East Canyon, Silver, and Drain Tunnel Creeks. Large withdrawals of ground water may decrease streamflow, which would be reflected in records collected at the gaging stations. Seepage studies in Drain Tunnel Creek would help to determine the effects of mine dewatering on streamflow if these studies are made when dewatering operations in the mines change so that the relationship between streamflow and mine dewatering can be determined.

SUMMARY

The Park City area is a rapidly growing residential and recreational area in northern Utah. The population of the area is expected to increase rapidly in the near future; the provision of providing an adequate water supply, while avoiding harmfull affects of development, is a major concern. In addition, the area contains the proposed site of the Jordanelle dam and reservoir, a part of the Central Utah Project. The damsite is near an historic mining area, and mining companies are concerned that the proposed reservoir may create additional dewatering problems in the mines.

The surface water in the Park City area originates primarily in the Wasatch Range on the western border, or flows into the area from the east in the Provo River at the southeastern border. The two major streams that originate within the study area are East Canyon and Silver Creeks. The estimated long-term average flow of East Canyon Creek near Park City is 55 cubic feet per second, and the estimated long-term average flow of Silver Creek near Wanship is 8.55 cubic feet per second. Streamflow yields from some tributary basins are smaller than expected, based on analyses of 45 streamflow stations and sites in the mountains of northern Utah. This suggests that in those tributary basins, recharge may be greater than in the control basins.

Ground water in the Park City area occurs in unconsolidated valley fill and consolidated rocks. Recharge to the unconsolidated valley fill from precipitation, unconsumed irrigation water, leakage from consolidated rocks, and seepage from streams is estimated to be 15,400 acre-feet per year. Water moving in the unconsolidated valley fill generally follows the slope and direction of the major streams. Discharge from the unconsolidated valley fill by evapotranspiration, seepage to streams, and wells is estimated to be 15,500 acre-feet per year. The estimated quantity of recoverable ground water in

storage in the unconsolidated valley fill is 190,000 acre-feet. The average hydraulic conductivity of the unconsolidated valley fill is about 7 feet per day, and the average specific yield is about 0.15.

Recharge to the consolidated rocks in the Park City area is from precipitation, stream infiltration, and subsurface inflow from adjoining areas. The recharge is estimated to average about 46,000 acre-feet per year. Water moving in consolidated rocks generally moves from recharge areas at high altitudes toward discharge areas at the lower altitudes. Water in consolidated rocks near drain tunnels moves toward and discharges to the drain tunnels and associated mine workings. Discharge from the consolidated rocks from springs, drain tunnels, leakage to unconsolidated valley fill, and wells is estimated to average about 46,000 acre-feet per year. The transmissivity of consolidated rocks based on aquifer tests ranged from 3 to 7,400 feet squared per day.

Water quality in the Park City area generally is suitable for all uses. Several ground-water sources, however, had concentrations of some constituents that exceeded State or Federal standards or recommended limits for drinking water or sensitive aquatic life. These constituents included cadmium, chloride, iron, manganese, sulfate, dissolved solids, nitrate, and zinc. Several water samples collected from surface-water sources had concentrations exceeding recommended limits or standards for dissolved solids, manganese, cadmium, and sulfate. Several ground-water and surface-water sources had pH values that were less than or exceeded recommended limits.

The consolidated rocks with the greatest potential for yielding large quantities of ground water to wells in the Park City area are the Thaynes Formation and the Twin Creek Limestone. Increasing withdrawals from consolidated rocks may cause a decrease in the flow of springs and streams, water-level declines in wells, and downward movement of poor quality water to aquifers containing freshwater.

The potential effects of the proposed Jordanelle dam and reservoir on the ground-water system and dewatering operations in mines at an altitude below the reservoir are an increase in the hydraulic gradient between the reservoir and the mine shafts and an increase of recharge to the unconsolidated valley fill when mining operations are at an altitude below the reservoir. Data are not available to determine the magnitude of the increase of pumping required to dewater the mines.

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Table 1.--Measurements of discharge, temperature, and specific conductance at surface-water stations or sites

Site No.: Refers to number assigned to stations or Sites on plate 2.
Discharge: ft^3/s, cubic feet per second; e, estimated; r, reported.
Temperature: ^{o} C, degrees Celsius.
Specific conductance: µS/cm, microsiemens per centimeter at 25 ^{o}C.

Site No.	Station or site name	Date of measurement	Discharge (ft^3/s)	Temperature (^{o}C)	Specific conductance (µS/cm)
1	Thaynes Canyon Creek at Snow Summit Ranch near Park City	07-27-82	0.12	-	-
		09-09-82	dry	-	-
		04-21-83	dry	-	-
		06-02-83	7.32	-	-
		07-06-83	.48	-	-
		08-22-83	.14	-	-
		09-08-83	.15	-	-
		10-19-83	.12	-	-
		12-27-83	dry	-	-
		01-31-84	dry	-	-
		03-23-84	.05e	-	-
		05-11-84	.79	-	-
		07-26-84	.15	13.5	360
		08-27-84	.17	-	-
2	McLeod Creek at Utah Highway 224, near Park City	08-03-79	7	13.5	720
		02-26-80	9	4.5	800
		04-03-80	7.5	5.0	820
		05-14-80	25	10.0	560
		08-13-80	11.9	17.0	750
		10-12-83	13.8	10.0	790
		10-21-83	13.8	9.5	820
		10-27-83	11.7	9.0	820
3	White Pine Creek at Utah Highway 224 near Park City	11-12-82	0.81	4.0	300
		01-13-83	.59	1.0	285
		03-28-83	.54	-	290
		05-17-83	2.70	4.0	220
		06-01-83	44.5	-	150
		07-08-83	12.8	10.5	260
		08-05-83	.34	14.5	300
		09-08-83	.06	13.0	325
		10-12-83	1.22	6.0	350
		10-21-83	.98	5.0	325
		10-27-83	.97	2.5	315
		11-29-83	.80	2.0	290
		01-05-84	.47	-	-

Table 1.--Measurements of discharge, temperature, and specific conductance at surface-water stations or sites--Continued

Site No.	Station or site name	Date of measurement	Discharge (ft^3/s)	Temperature (°C)	Specific conductance (μS/cm)
3	White Pine Creek at Utah Highway 224, near Park City--Continued	02-21-84	0.47	3.0	300
		03-23-84	.47	2.0	290
		04-30-84	1.73	6.0	225
		05-25-84	31.2	6.0	195
		07-26-84	1.36	14.0	300
4	White Pine diversions at Utah Highway 224, near Park City	11-12-82	0.30	-	-
		01-13-83	.09	-	-
		03-28-83	.18	-	-
		05-17-83	.96	-	-
		06-01-83	14.3	-	-
		07-08-83	.5e	-	-
		08-05-83	.23	16.5	310
		10-12-83	.14	-	-
		10-21-83	.14e	-	-
		10-27-83	.16	-	-
		02-21-84	.15e	-	-
		03-23-84	.16	-	-
		04-30-84	.49	-	-
		05-25-84	17.4	-	-
		07-26-84	1.4e	-	-
5	Red Pine Creek at Utah Highway 224, near Park City	03-23-83	dry	-	-
		05-17-83	0.48	7.5	180
		06-02-83	36.9	5.0	100
		07-06-83	9.66	12.0	150
		08-05-83	dry	-	-
		04-30-84	dry	-	-
		05-15-84	35.8	4.5	95
		07-03-84	7.72	9.5	150
		08-03-84	dry	-	-
6	Unnamed creek from Parleys Park near mouth at westbound rest stop on Interstate Highway 80, near Park City	08-03-79	0.25	16.0	1,130
		05-14-80	9.80	8.0	360
		08-13-80	.1	21.0	920
		04-19-83	48.0	-	300
		10-27-83	.35	5.5	1,380
		11-04-83	.37	5.0	1,400

Table 1.--Measurements of discharge, temperature, and specific conductance at surface-water stations or sites--Continued

Site No.	Station or site name	Date of measurement	Discharge (ft^3/s)	Temperature (°C)	Specific conductance (µS/cm)
7	McLeod Creek at Interstate Highway 80, near Park City	08-03-79	6.0	12.5	700
		02-26-80	19	0.0	740
		04-03-80	16	.5	750
		05-14-80	42	7.0	530
		08-13-80	8.1	23.0	670
		10-27-83	13.8	8.0	750
		11-04-83	11.0	5.0	740
8	Willow Draw Creek above Utah Highway 224, near Park City	11-24-82	0.99	0.5	370
		01-19-83	.59	2.0	355
		03-29-83	1.06	4.5	260
		05-17-83	4.24	-	-
		06-03-83	21.9	8.0	260
		07-06-83	2.69	11.5	355
		08-05-83	.80	14.0	420
		10-12-83	.63	-	520
		10-27-83	.52	4.5	430
		12-27-83	.64	2.5	410
		01-31-84	.53	1.5	400
		02-29-84	.63	3.0	410
		03-23-84	1.15	4.0	-
		04-30-84	4.18	6.5	390
		05-15-84	24.2	5.0	210
		06-27-84	4.31	13.5	310
		08-03-84	1.07	18.0	405
		08-28-84	.94	16.0	420
9	Willow Creek at Utah Highway 224, near Park City	10-12-83	0.53	-	-
		10-21-83	.62	6.0	425
		10-27-83	.58	2.5	420
10	Willow Creek at Interstate Highway 80, near Park City	08-03-79	1.5	12.5	680
		05-14-80	1.0	8.0	660
		10-12-83	.36	8.5	660
		10-21-83	.31	6.5	590
		10-27-83	.30	8.0	600
		11-04-83	.20	8.0	585
11	Unnamed creek at Utah Highway 224, near Snyderville	10-12-83	0.44	-	365
		10-21-83	.38	7.0	375
		10-27-83	.47	5.5	360

Table 1.--Measurements of discharge, temperature, and specific conductance at surface-water stations or sites--Continued

Site No.	Station or site name	Date of measurement	Discharge (ft³/s)	Temperature (°C)	Specific conductance (µS/cm)
12	Unnamed creek below Silver Springs at Utah Highway 224, near Snyderville	10-12-83	1.07	6.0	360
		10-21-83	.97	6.0	360
		10-27-83	.92	4.5	350
13	Unnamed ditch draining seepage area, 0.5 mile south of Kimball Junction	10-12-83	0.14	7.0	900
		10-21-83	.18	7.0	820
		10-27-83	.19	6.0	790
14	Unnamed ditch draining Parleys Park at Interstate Highway 80, 0.4 mile east of Kimball Junction	08-03-79	2.0	11.5	590
		05-14-80	26	8.0	350
		10-12-83	3.88	7.0	510
		10-21-83	3.42	5.5	490
		10-27-83	3.50	6.5	470
15	East Canyon Creek at Kimball Junction, near Park City	08-03-79	6.0	16.5	680
		05-14-80	85	6.0	470
16	East Canyon Creek above Threemile Creek, near Park City	10-27-83	18.5	5.0	730
		11-04-83	15.1	8.0	710
17	Threemile Creek near Park City (U.S. Geological Survey gaging station 10133700)	08-05-82	2.94	10.0	520
		10-05-82	1.45	6.0	570
		12-16-82	1.13	4.0	560
		01-21-83	.88	-	-
		03-20-83	1.39	-	-
		05-03-83	6.31	7.0	570
		06-01-83	24.7	7.0	400
		07-05-83	7.22	12.0	510
		08-05-83	3.81	10.5	560
		09-21-83	2.33	8.0	-
		10-20-83	1.45	5.0	565
		10-27-83	1.73	-	-
		12-06-83	1.23	3.0	560
		01-10-84	1.08	-	530
		02-15-84	.98	-	-
		03-20-84	1.10	-	550
		04-13-84	1.39	2.0	550
		05-04-84	6.18	5.0	460

Table 1.--Measurements of discharge, temperature, and specific conductance at surface-water stations or sites--Continued

Site No.	Station or site name	Date of measurement	Discharge (ft^3/s)	Temperature (°C)	Specific conductance (µS/cm)
17	Threemile Creek near Park City (U.S. Geological Survey gaging station 10133700)--Continued	06-27-84	8.55	12.0	-
		08-03-84	3.73	10.0	530
		09-18-84	2.01	9.0	520
18	Diversion on Threemile Creek at reservoir, near Park City	10-20-83	0.07e	-	-
		10-27-83	.15e	-	-
19	Threemile Creek at Interstate Highway 80, near Park City	10-20-83	1.86	-	560
		10-27-83	1.92	4.0	580
20	Twomile Creek at Interstate Highway 80, near Park City	10-27-83	0.73	5.0	540
		11-04-83	.49	7.0	540
21	East Canyon Creek above Toll Creek, near Park City	08-03-79	8.0	13.0	660
		10-26-79	16	10.0	700
		02-26-80	20	0.5	750
		04-03-80	21	.5	750
		05-14-80	88	5.0	475
		08-13-80	13.3	24.0	620
		10-27-83	22.6	7.0	650
		11-04-83	19.5	5.0	600
22	Toll Creek near Park City	07-15-82	1.33	18.0	-
		08-02-82	0.87	-	-
		09-09-82	.46	15.0	850
		11-30-82	1.31	4.0	-
		01-12-83	1.23	-	1050
		02-22-83	1.30	2.0	1200
		03-21-83	19.0	4.5	640
		06-03-83	27.8	9.0	475
		07-05-83	4.61	11.5	680
		08-05-83	1.85	12.5	760
		09-08-83	1.51	-	780
		10-19-83	1.15	4.0	910
		10-27-83	1.01	5.0	825
		11-29-83	1.22	-	-
		01-04-84	1.08	2.0	1100

Table 1.--Measurements of discharge, temperature, and specific conductance at surface-water stations or sites--Continued

Site No.	Station or site name	Date of measurement	Discharge (ft^3/s)	Temperature (^oC)	Specific conductance ($\mu S/cm$)
22	Toll Creek near Park City--Continued	02-23-84	1.23	1.0	1130
		03-23-84	2.19	2.0	1140
		04-30-84	11.4	6.0	720
		05-15-84	57.5	8.0	400
		06-27-84	6.10	10.5	640
		07-25-84	2.37	-	720
		08-28-84	1.12	13.0	780
		09-20-84	.84	11.0	820
23	Toll Creek at Interstate Highway 80, near Park City	08-03-79	1.0	12.5	850
		05-14-80	14	4.5	575
24	Toll Creek at mouth, near Park City	10-19-83	1.37	4.5	900
		10-27-83	1.13	3.0	780
		11-04-83	1.16	-	-
25	East Canyon Creek below sewage-treatment plant, near Park City	10-11-83	29.1	12.0	700
		10-27-83	24.4	6.5	700
		11-04-83	20.2	6.0	640
26	Mill Hollow Creek at mouth, near Park City	10-27-83	0.03	-	-
		11-11-83	.01	-	-
27	Porcupine Creek at mouth, near Park City	07-21-82	0.16	-	-
		10-10-82	.10	-	710
		01-12-83	.05	0.5	650
		03-30-83	1.16	-	-
		05-04-83	7.93	11.0	390
		06-06-83	4.85	10.0	510
		07-05-83	1.02	15.5	740
		08-04-83	.30	17.0	730
		09-09-83	.21	14.0	700
		10-11-83	.12	9.0	720
		10-27-83	.22	4.0	700
		11-04-83	.13	-	-
		01-04-84	.12	8.0	700
		02-21-84	.12	3.0	730
		03-23-84	.40	2.0	640
		04-30-84	3.05	5.0	630
		05-11-84	16.0	10.0	380
		06-27-84	1.38	14.5	740

Table 1.--Measurements of discharge, temperature, and specific conductance at surface-water stations or sites--Continued

Site No.	Station or site name	Date of measurement	Discharge (ft^3/s)	Temperature (°C)	Specific conductance (µS/cm)
27	Porcupine Creek at mouth, near Park City--Continued	07-25-84	0.50	17.5	1,050
		08-27-84	.27	17.0	770
		09-20-84	.09	13.0	770
28	Big Bear Hollow Creek at mouth, near Park City	07-14-82	0.71	-	-
		08-05-82	.47	17.0	510
		10-22-82	.49	7.0	550
		01-05-83	.28	-	-
		03-17-83	1.68	-	-
		05-10-83	14.1	-	-
		05-24-83	25.9	10.0	320
		06-30-83	3.22	13.0	495
		08-04-83	1.27	16.0	540
		09-09-83	.52	14.0	530
		10-11-83	.62	10.5	540
		10-27-83	.56	2.5	510
		11-04-83	.60e	-	-
		01-04-84	.70	2.5	550
		02-21-84	.31	1.0	520
		03-21-84	.55	4.0	510
		04-30-84	5.16	4.0	415
		05-14-84	50.4	6.0	235
		06-27-84	3.63	13.0	490
		07-25-84	1.58	14.5	530
		08-27-84	.93	17.5	510
		09-20-84	.62	11.5	510
29	East Canyon Creek near Park City (U.S. Geological Survey gaging station 10133900)	04-29-82	253	6.5	355
		06-28-82	78.6	-	-
		08-03-82	34.7	21.5	620
		08-24-82	20.7	18.0	510
		10-01-82	73.4	7.0	680
		01-05-83	30.4	-	-
		03-17-83	101	-	-
		04-19-83	138	10.0	485
		05-24-83	265	-	460
		05-26-83	322	-	-
		05-31-83	437	-	400
		06-21-83	209	-	410
		08-04-83	46.1	17.0	620
		09-09-83	32.0	14.0	630

Table 1.--Measurements of discharge, temperature, and specific conductance at surface-water stations or sites--Continued

Site No.	Station or site name	Date of measurement	Discharge (ft^3/s)	Temperature (°C)	Specific conductance (µS/cm)
29	East Canyon Creek near Park City (U.S. Geological Survey gaging station 10133900)--Continued	10-11-83	34.2	12.0	700
		10-27-83	25.3	2.5	670
		11-04-83	20.5	7.5	600
		12-28-83	29.3	5.0	820
		01-30-84	17.6	0.0	800
		02-29-84	19.2	.5	860
		03-21-84	53.4	3.0	770
		04-16-84	427	-	-
		04-23-84	216	6.0	640
		05-16-84	420	-	350
		06-25-84	131	17.0	-
		07-03-84	82.1	-	-
		07-25-84	52.8	14.5	610
		08-23-84	42.4	16.5	620
		09-17-84	26.0	17.0	670
30	Silver Creek above Dority Spring, near Park City	08-03-79	dry	-	-
		05-14-80	3.0	11.5	495
31	Pace-Homer Ditch at mouth, near Park City (discharge after 05-14-80 reported in Weber River Distribution System annual reports, 1982-83)	08-03-79	3.0	12.5	720
		05-14-80	5.5	11.0	740
		06-25-82	5.34r	-	-
		07-01-82	5.12r	-	-
		07-08-82	4.18r	-	-
		07-16-82	4.30r	-	-
		07-24-82	5.77r	-	-
		07-31-82	5.99r	-	-
		08-09-82	5.66r	-	-
		08-17-82	4.60r	-	-
		08-25-82	3.62r	-	-
		09-01-82	3.62r	-	-
		09-09-82	3.17r	-	-
		09-16-82	4.30r	-	-
		09-23-82	2.48r	-	-
		09-30-82	9.27r	-	-
		10-12-82	5.66r	-	-
		10-28-82	5.44r	-	-
		11-05-82	4.01r	-	-
		11-13-82	3.62r	-	-
		11-28-82	3.26r	-	-
		06-04-83	5.6r	-	-

Table 1.--Measurements of discharge, temperature, and specific conductance at surface-water stations or sites--Continued

Site No.	Station or site name	Date of measurement	Discharge (ft^3/s)	Temperature (^oC)	Specific conductance ($\mu S/cm$)
31	Pace-Homer Ditch at mouth, near Park City--Continued (discharge reported in Weber River Distribution System annual reports, 1982-83)	06-16-83	2.8r	-	-
		06-17-83	3.7r	-	-
		06-20-83	3.6r	-	-
		06-23-83	3.8r	-	-
		06-24-83	3.6r	-	-
		06-29-83	3.1r	-	-
		06-30-83	3.0r	-	-
		07-04-83	3.1r	-	-
		07-08-83	5.0r	-	-
		07-09-83	4.6r	-	-
		07-13-83	5.0r	-	-
		07-14-83	5.0r	-	-
		07-16-83	6.3r	-	-
		07-20-83	4.7r	-	-
		07-22-83	5.9r	-	-
		07-28-83	7.5r	-	-
		07-31-83	7.8r	-	-
		08-03-83	7.5r	-	-
		08-04-83	9.0r	-	-
		08-07-83	7.3r	-	-
		08-10-83	6.8r	-	-
		08-12-83	6.8r	-	-
		08-15-83	6.8r	-	-
		08-18-83	6.8r	-	-
		08-21-83	6.7r	-	-
		08-25-83	6.4r	-	-
		08-26-83	6.7r	-	-
		08-30-83	6.7r	-	-
		08-31-83	7.0r	-	-
		09-03-83	6.7r	-	-
		09-06-83	4.6r	-	-
		09-08-83	6.7r	-	-
		09-10-83	5.0r	-	-
		09-14-83	5.7r	-	-
		09-19-83	6.1r	-	-
		09-24-83	6.6r	-	-
		09-27-83	5.8r	-	-
		09-28-83	6.1r	-	-
		09-31-83	5.9r	-	-

Table 1.--Measurements of discharge, temperature, and specific conductance at surface-water stations or sites--Continued

Site No.	Station or site name	Date of measurement	Discharge (ft^3/s)	Temperature (^oC)	Specific conductance (µS/cm)
32	Silver Creek above Keetley Junction, near Park City	11-03-83	5.96	8.5	760
33	Silver Creek at Keetley Junction, near Park City	08-03-79	0.5	18.5	840
		02-27-80	3	3.0	810
		04-03-80	2	3.5	860
		05-14-80	10	11.0	800
		08-13-80	1	20.0	880
34	Silver Creek below Keetley Junction, near Park City	11-03-83	7.62	8.5	810
35	Silver Creek at Interstate Highway 80, near near Park City	11-03-83	8.99	8.5	750
36	Silver Creek near Wanship (U.S. Geological Survey gaging station 10130000)	09-08-82	1.04	17.5	800
		10-01-82	29.8	-	980
		11-22-82	8.16	1.0	1140
		12-12-82	5.15	2.0	1040
		01-21-83	4.95	1.0	1020
		02-22-83	6.90	0.0	1010
		03-09-83	18.7	1.5	-
		03-09-83	21.2	-	-
		03-28-83	14.4	2.5	1040
		04-19-83	61.8	-	-
		05-02-83	41	9.0	720
		05-26-83	19.9	15.0	850
		06-30-83	14.1	18.0	820
		08-04-83	6.26	21.0	940
		09-14-83	5.73	14.0	880
		10-14-83	14.0	8.0	910
		11-03-83	8.50	8.0	860
		12-23-83	7.32	-	1100
		01-12-84	5.50	1.0	900
		02-23-84	6.84	.5	-
		03-23-84	15.3	4.0	1050
		04-12-84	25.4	2.5	1080
		04-16-84	87.1	13.0	640

Table 1.--Measurements of discharge, temperature, and specific conductance at surface-water stations or sites--Continued

Site No.	Station or site name	Date of measurement	Discharge (ft^3/s)	Temperature (°C)	Specific conductance (µS/cm)
36	Silver Creek near Wanship (U.S. Geological Survey gaging station 10130000)--Continued	05-25-84	23.1	10.0	610
		06-25-84	6.28	19.5	790
		07-26-84	5.94	20.0	850
		08-27-84	6.64	14.5	910
37	Weber-Provo Canal near Woodland	05-26-71	545	7.0	155
		06-14-71	73	10.0	175
		08-26-71	2.5	11.5	315
		06-01-72	120	10.5	115
		08-08-72	2	22.5	245
38	Provo River below Weber-Provo Canal, near Francis	06-14-71	1,200	10.0	105
		08-26-71	110	12.0	190
39	Provo River near Hailstone	03-29-71	179	3.0	190
		04-22-71	650	5.0	185
		05-21-71	916	7.0	150
		05-26-71	1,930	9.0	105
		06-14-71	1,250	8.0	98
		12-28-71	85	0.0	260
		02-10-72	106	0.0	255
		04-11-72	543	6.5	180
		04-26-72	590	4.0	200
		05-05-72	968	7.0	155
		06-01-72	1,950	7.5	70
		06-02-72	1,600	8.0	78
		07-06-72	300	14.0	155
		08-09-72	54	17.0	205
		09-12-72	57	10.0	250
		09-14-72	55	10.0	255
40	Drain Tunnel Creek at Keetley Station, near Park City	09-12-83	21.3	-	-
		10-14-83	21.4	-	-
41	Upper canal from Drain Tunnel Creek below Sage Hen Hollow	09-12-83	0.13	14.5	560
		10-14-83	.12	-	-

Table 1.--Measurements of discharge, temperature, and specific conductance at surface-water stations or sites--Continued

Site No.	Station or site name	Date of measurement	Discharge (ft^3/s)	Temperature (°C)	Specific conductance (µS/cm)
42	Unnamed tributary to upper canal, 0.5 mile north of Sage Hen Hollow	09-12-83	0.04	13.0	550
		10-14-83	dry	-	-
43	Upper canal from Drain Tunnel Creek at reservoir, near mouth of Todd Hollow	09-12-83	0.20	10.5	570
		10-14-83	.17	-	-
44	Canal from Ross Creek below confluence with Todd Hollow	09-12-83	0.82	14.5	640
		10-14-83	.94	-	-
45	Seepage area to Ross Creek below reservoir	09-12-83	0.09	14.5	550
		10-14-83	.04	-	-
46	Lower canal from Drain Tunnel Creek at road to Keetley Station	09-12-83	0.20	10.5	970
		10-14-83	.11	-	-
47	Lower canal from Drain Tunnel Creek at mouth	10-14-83	0.57	-	-
48	Ross Creek below confluence with lower canal from Drain Tunnel Creek	09-12-83	0.36	13.0	490
		10-14-83	.98	-	-
49	Ross Creek at road to Keetley Station	09-12-83	2.25	11.0	560
		10-14-83	3.63	-	-
50	Unnamed tributary to Ross Creek, 100 feet downstream from site 49	10-14-83	0.25	-	-
51	Canal from Ross Creek at road to Keetley Station	09-12-83	0.22e	-	-
		10-14-83	.25	-	-
52	Drain Tunnel Creek above confluence with Ross Creek	09-12-83	20.2	11.0	830
		10-14-83	19.5	-	-

Table 1.--Measurements of discharge, temperature, and specific conductance at surface-water stations or sites--Continued

Site No.	Station or site name	Date of measurement	Dis-charge (ft^3/s)	Temper-ature (°C)	Spe-cific con-duct-ance (µS/cm)
53	Diversion from Drain Tunnel Creek, 600 feet below site 52	09-12-83	3.19	12.0	850
		10-14-83	0	-	-
54	Drain Tunnel Creek at road crossing, 0.7 mile south of Keetley	09-12-83	17.0	11.5	630
		10-14-83	22.7	-	-
55	Drain Tunnel Creek, 0.45 mile north of Hailstone	09-12-83	22.8	12.5	650
		10-14-83	24.1	-	-
56	Drain Tunnel Creek at Hailstone	04-26-72	15	6.5	590
		06-01-72	12	10.5	690
		07-20-72	20	14.0	690
		09-14-72	13	8.0	680
		09-12-83	21.0r	13.5	650
		10-14-83	21.0r	-	-
57	McHenry Creek at Hailstone	04-26-72	4	8.0	1,340
		06-01-72	4	20.0	1,590
		07-20-72	3	21.0	1,830
		09-14-72	3.5	15.0	1,780
58	Provo River at U.S. Highway 40, near Hailstone	08-26-71	15	13.5	320
		03-02-72	100	4.0	370
		04-26-72	600	5.0	230
		09-14-72	70	10.5	445

Table 2.--Estimated annual average discharge for the 1983-84 water years and estimated long-term average discharge at seven partial-record stations.

Site No: Refers to number assigned to stations on plate 2.
Discharge: ft^3/s, cubic feet per second.

Site No. (pl. 2)	Station name	Estimated annual average discharge (ft^3/s) 1983	1984	Estimated long-term average discharge (ft^3/s)
1	Thaynes Canyon Creek at Snow Summit Ranch, near Park City	0.39	0.19	0.19
3, 4	White Pine Creek at Utah Highway 224, near Park City	4.87	5.34	3.27
5	Red Pine Creek at Utah Highway 224, near Park City	2.64	3.02	1.81
8	Willow Draw Creek above Utah Highway 224, near Park City	2.68	2.65	1.71
22	Toll Creek near Park City	5.49	5.11	3.39
27	Porcupine Creek at mouth, near Park City	1.23	1.55	.89
28	Big Bear Hollow Creek at mouth, near Park City	4.09	3.48	2.42

Table 3.—Records of selected wells

Location: See well-, spring-, tunnel-, and stream-numbering system.
Owner or user: Last known owner or user.
Casing Finish: O, open end; P, perforated, upper and lower limits of perforation given in feet below land surface; S, screen, length of screen given in feet.
Altitude of land surface: National Geodetic Vertical Datum of 1929; altitudes interpolated from topographic maps.
Use of water in 1983: D, domestic; I, industrial; O, observation; P, public supply; U, unused.
Water-bearing formation: Qa, Alluvial deposits; Tv, Igneous rocks; Jp, Preuss Sandstone; Jtc, Twin Creek Limestone; JTRn, Nugget Sandstone; TRa, Ankareh Formation; TRt, Thaynes Formation; TRw, Woodside Shale; Ppc, Park City Formation; Pw, Weber Quartzite; Prv, Round Valley Limestone.
Water level: r, reported.
Other data available: C, chemical analysis in table 14; L, drillers' log in table 4; W, water-level measurements in table 5.

Location	Owner or user	Year constructed	Depth of well (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Casing: Finish	Altitude of land surface (feet)	Use of water in 1983	Water-bearing formation	Water level: Above(+) or below(-) land surface (feet)	Water level: Date measured	Other data available
(D-1-3) 3ddb-1	J. Knight	1968	200	8,6	200	P125-200	6,520	U	Jp	-3.45	06-15-84	W
9caa-1	S.Soter	1973	610	24,18,6	610	P233-574	7,100	P	—	-70r	11-21-73	-
9cdd-1	do.	1963	407	16	30	O	7,080	P	—	-87	06-25-84	-
10aab-1	Hillco Corp.	1981	603	8	603	P431-603	6,640	P	Jp	-86.86	06-15-84	C,L
11cad-1	Gorgoza Pines Ranch Inc.	1979	500	7	20	O	6,600	O	—	-50.51	06-15-84	W
11dbc-1	do.	1979	306	16,12	306	P131-301	6,520	D	TRt	-27.23	06-14-84	W
12bcc-1	O. Rasmassen	1973	110	6,4	110	O	6,300	D	Qa	-20.46 -20.89	09-30-83 11-01-83	-
12cbd-1	J. Kilby	1966	189	12,8	189	P174-189	6,290	D	TRa	-30r	12-10-66	C
13abb-1	Utah State Road Com	1974	197	12,8,6	197	P112-197	6,340	P	TRt	-13.5	08-09-83	C,L
13adc-1	R. McComb	1965	250	6	250	P200-250	6,330	D	Qa	-36.39	06-21-83	C
15aaa-1	Gorgoza Pines Ranch Inc.	1979	710	12	404	O	6,800	O	JTRn	-33.5	06-23-83	-
16cac-1	Summit Park Corp.	1971	600	10,8	600	P148-548	7,660	P	—	-124r	09-30-71	-
24aaa-1	Chevron Pipeline Co	1973	154	12,8,6	154	P104-154	6,480	U	Qa	-	-	C
24dda-1	P. Buehner	1981	540	8,6	-	-	6,500	U	JTRn	-19.15	06-20-84	W
25ddc-1	Silver Springs Development Inc.	1979	340	12,8	320	S30-320	6,750	U	Jtc	-6.38	06-14-84	W
36cac-1	Park West	1979	388	10	35	O	6,920	U	—	-15.22	06-20-84	W
(D-1-4) 3dcb-1	-	-	-	8,12	-	-	6,860	D	—	-315.0	08-26-83	-
4acd-1	-	-	-	6	-	-	6,720	U	—	-184.24	06-12-84	-
4caa-1	-	-	-	6	-	-	6,620	U	—	-27.37	06-11-84	W
4ccd-1	B. Olsen	1967	258	10,6,4	247	P52-245	6,570	D	Qa	-10.41	06-11-84	W
4dbc-1	R. Burns	1967	205	10,6	200	P120-195	6,620	D	Qa	-55.55 -61.95 -51.86	06-16-83 10-03-83 06-11-84	-
9aba-1	A. Johnson	1978	315	6	315	P190-315	6,560	U	—	-14.62	06-12-84	-
9bab-1	J. Conway	1976	160	6	160	P150-160	6,530	D	Qa	-17.82	06-16-83	-
9bbb-1	A. Potter	1978	268	8	242	-	6,540	D	Qa	-72.38	06-11-84	C
9caa-1	G. Goddard	1976	135	6	130	P120-130	6,460	D	Qa	+3.64	06-11-84	C
10bad-1	M. VanDenakker	1974	300	8,6	260	P250-260	6,740	D	Qa	-207.02	06-12-84	-
10bbb-1	A. Johnson	1978	251	6	250	P124-125	6,640	D	Qa	-127.30	06-12-84	-
10bcc-1	F. Larsen	-	225	8,6	-	-	6,600	D	Qa	-95.48 -95.53	08-18-83 06-12-84	C
15bab-1	J. Bacon	1976	130	6	-	-	6,510	D	—	-68.02	06-11-84	-
16aad-1	Silver Creek Co.	1964	668	10,8	668	P100-668	6,440	D	Qa	-44.17	06-16-83	C,L
16abd-1	S. Pace	1973	92	6	90	O	6,460	D	Qa	-0.14	06-11-84	-
16aca-1	V. Bair	1974	174	6,4	174	P144-174	6,430	D	Qa	-9.81	06-11-84	-
16acb-1	D. Alvey	1978	120	6	110	P102-110	6,420	D	Qa	-	-	C
16bab-2	Z. Johnson	1982	170	6	-	-	6,380	D	—	+17.3	06-22-84	-
16dca-1	Utah State Road Com	1955	202	6	202	O	6,470	D	Tv	-127r	12-19-55	C
17bbb-1	G. T. Flinders	1950	127	6	127	O	6,620	U	Jtc	-12r	09-07-50	C
18ccc-2	W. Wirthlin	1980	242	10,8,6	240	P136-239	6,410	U	JTRn	-72.79	06-20-84	W
18cda-1	L. Swanner	1971	180	10,8	86	O	6,320	P	JTRn	-13.28	06-19-84	-
18ddc-1	Spring Creek Inv. C	1971	150	10,8	150	P72-134	6,350	U	Jtc	-17.04	06-19-84	-
19aba-1	L. Swanner	1971	235	10,8	196	P112-128	6,320	U	Qa	-0.72	06-19-84	-
19bab-1	Standard Oil of Cal	1972	146	10,8	146	P130-135	6,425	D	Qa	-71.94	07-28-83	C
19bba-1	American Oil Co.	1970	141	8,6	141	P117-120	6,430	D	Qa	-89.65	07-28-83	-
19bbc-1	Hi-Ute Enterprises	1974	183	12,10,8	183	P135-180	6,480	U	Jtc	-55.94	06-15-84	L,W
19bbc-2	Summit County	-	-	-	-	-	6,490	D	Qa	-38.36 -39.31	06-10-83 06-15-84	-
19bca-1	Utah State Road Com	1947	48	4	48	O	6,430	D	Qa	-14.5r	06-23-47	C
19cac-1	J. Jarman	-	400	16,10	300	P100-300	6,420	U	JTRn	+3.5	11-15-83	C
20aaa-1	Utah State Road Com	1969	300	12,8,7	300	P185-300	6,380	P	Qa	-14r	09-19-69	-
20bcb-1	Flinders Mutual Water Co.	1980	146	10,8	146	P105-146	6,350	U	Qa	-8.77	06-20-84	W
20dab-1	G. Flinders	1980	295	10,8,6	295	P170-290	6,410	U	—	-67.30	06-19-84	-
21cad-1	Flinders Mutual Water Co.	1980	410	10,8	240	P140-240	6,480	U	Qa	-14.82	06-19-84	-
21cdd-1	G. Flinders	1978	450	10,6	410	P105-136 P303-410	6,546	U	Tv	-10.78	06-13-84	W
22cba-1	Silver Summit Development Co.	1978	520	16,12,10	520	P50-338	6,520	U	Qa	-5.60	06-13-84	W
22cdd-1	do.	1978	370	10	280	P120-280	6,590	U	Jtc	-61.88	06-13-84	W
28bac-1	G. Flinders	1979	446	10,8	446	P100-446	6,640	U	Jtc	-57.07	06-19-84	-
29acd-2	C. Long	1977	120	6	113	P81-111	6,417	D	Qa	-7.44	06-20-84	-
29bdc-1	McLachlan	1979	110	8	110	O	6,430	D	Qa	-6.89	06-20-84	-
29ccc-1	D. Osguthorpe	1947	194	4	32	O	6,490	U	Qa	-6.48	06-20-84	W
29dcc-1	T. Miller	1980	148	6	148	P140-148	6,450	D	Qa	-20.76 -18.27	04-27-83 06-09-83	C
29dcc-2	R. Sieverts	1976	152	6	152	O	6,445	D	Qa	-17.04	06-20-84	W
30bbd-1	L. Hixson	1940	75	4	75	O	6,460	D	JTRn	-5.31	06-14-84	C,W
30cad-1	Silver Springs Development Co.	1979	500	14,10	365	P200-285	6,470	D	JTRn	+38.5 +38.5	08-03-83 06-22-84	C
31aac-1	AWS Associates	1983	460	20,16	387	P115-323	6,520	U	Qa	-30.52	06-20-84	C,L,W
31aac-2	F. Kilgore	-	-	6	-	-	6,555	-	—	-29.75	06-10-83	-
31bdb-2	J. Bloom	1979	300	8	300	P100-300	6,650	D	Qa	-15.88	06-20-84	W
32daa-1	A. Thomson	1979	135	6,5	135	P65-135	6,420	D	JTRn	+1.34	06-20-84	W
33bbd-1	L. Strong	1973	147	6	-	-	6,440	U	JTRn	-1.47	06-20-84	W
33cac-1	-	-	125	6	125	P75-125	6,460	-	—	-0.77 -3.03	04-27-83 06-20-84	-
35dbb-1	Geneva Rock Product Co.	1981	451	12,10,8	451	-	6,600	I	TRa	-37.90 -46.06	06-21-83 06-13-84	C
36aac-3	Bertagnole	1984	805	6	20	-	6,680	D	Tv	-24.95	07-16-84	

Table 3.--Records of selected wells.--Continued

Location	Owner or user	Year constructed	Depth of well (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Casing: Finish	Altitude of land surface (feet)	Use of water in 1983	Water-bearing formation	Water level: Above(+) or below(-) land surface (feet)	Water level: Date measured	Other data available
(D- 2- 4) 4dcc-1	K. Cartier	-	33	24	-	-	6,751	D	Qa	-22.67	03-15-83	C
8aaa-1	Park City	1979	320	14,10	130	P100-130	6,750	P	TRt	-28.66	06-20-84	L,W
9aac-1	do.	1948	446	16,12,10,6	446	P300-446	6,760	P	TRw	-0.08	06-22-84	L,N
13ddb-1	U.S. Bureau of Reclamation	1982	63	0.75	60	P20-60	6,300	O	Qa	-1.56	06-21-84	W
13ddb-2	do.	1982	555	0.50	555	P355-555	6,300	O	Tv	-20.32	06-21-84	W
13ddb-3	do.	1982	623	1	623	P583-623	6,300	O	Tv	-20.64	06-21-84	L,W
24daa-1	do.	1979	370	3	250	O	6,277	O	Tv	-103.43	06-21-84	W
24ddd-1	do.	1982	249	0.75	249	P25-249	6,388	P	Qa	-191.76	06-28-84	-
24ddd-2	do.	1982	400	1	400	P255-400	6,388	O	Tv	-205.87	06-28-84	-
25aab-1	do.	1982	217	0.75	217	P20-217	6,410	O	Qa	-79.81	06-28-84	-
25aab-2	do.	1982	322	1	322	P285-322	6,410	O	TRt	-126.24	06-28-84	-
25abc-1	do.	1982	134	0.75	134	P100-134	6,545	O	Qa	-43.30r	06-13-83	W
25abc-2	do.	1982	353	1	350	P240-350	6,545	O	IPw	99.36	06-21-84	-
25bac-1	do.	1982	51	0.75	51	O	6,596	O	Qa	-40.95	06-21-84	-
25bac-2	do.	1982	451	1	400	P62-400	6,596	O	IPw, IPrv	-163.90	06-21-84	-
36aaa-1	do.	1983	500	18,8	415	S295-415	6,734	O	IPw	-252.7r	06-13-84	C
(D- 2- 5) 6cdb-1	San Francisco Chemical	1965	265	4	250	P90-250	6,620	D	Tv	-94r	11-20-65	C
19bac-1	U.S. Bureau of Reclamation	1981	255	0.50	255	O	6,105	O	Qa	+31.2r	07-09-82	-
19bac-2	do.	1981	539	2	430	O	6,105	O	Tv	+22R	07-09-82	-
19dcb-1	do.	1982	478	0.75	478	P460-478	6,234	O	Tv	-192.3	06-28-84	W
19dcb-2	do.	1982	600	1	600	P517-600	6,234	O	Qa	-120.25	06-28-84	L,W
29bda-1	do.	1982	150	0.75	150	P0-150	6,054	O	Qa	-5.99	06-21-84	-
29bda-2	do.	1982	192	1	191	P155-191	6,054	O	Ppc	-6.95	06-21-84	-
30cbc-1	do.	1972	369	3,2	357	S352-357	6,470	O	IPw, Tv	-92.60	06-21-84	L
31aac-1	do.	1981	100	0.75	100	P15-100	5,966	O	Qa	-10.90	06-20-84	W
31aac-2	do.	1981	383	2	279	P160-279	5,966	O	Tv	-24.85	06-20-84	W
31ada-1	H. Morris	1956	34	6	-	-	5,840	D	Qa	-8r	10- -56	C
31bab-1	U.S. Bureau of Reclamation	1983	110	1	110	P60-110	6,210	O	Qa	-59.77	06-28-84	-
31bba-1	do.	1983	322	-	-	-	6,307	O	Tv	-	-	C
31bba-2	do.	1983	67	1	67	P15-65	6,304	O	Qa	-31.29	06-28-84	-
31bba-3	do.	1983	323	1	322	P140-320	6,304	O	Tv	-12.59	06-28-84	-
31bbb-1	do.	1983	84	1	84	P24-84	6,651	O	Qa	-65.3r	09-28-83	-
31bbb-2	do.	1983	344	1	344	P145-344	6,651	O	IPw	-189.0r	09-28-83	-
31bbb-3	do.	1983	75	1	75	P25-75	6,446	O	Qa	-19.1r	06-10-83	-
31bbb-4	do.	1983	133	1	133	P107-133	6,446	O	Ppc	-16.8r	06-10-83	-
31bbb-5	do.	1983	334	1	334	P251-332	6,446	O	IPw	-2.6r	06-10-83	-
31bbc-1	do.	1982	354	1	354	P0-354	6,452	O	Ppc, IPw	-3.34	06-28-84	-
31cda-1	do.	1982	43	1	43	P23-43	5,889	O	Qa, Tv	-0.98	06-28-84	-
31cdb-1	do.	1983	20	1	20	P10-20	5,887	O	Qa	-8.45	06-28-84	-
31cdb-2	do.	1983	492	1	492	P92-492	5,887	O	Tv	-9.14	06-28-84	-
31cdd-1	do.	1983	37	1	37	P20-37	5,889	O	Qa, Tv	-1.71	06-28-84	-
31cdd-2	do.	1983	69	1	69	P40-69	5,889	O	Qa, Tv	-2.68	06-28-84	-
31cdd-3	do.	1983	30	1	30	P20-30	5,885	O	Qa, Tv	+0.37	06-28-84	-
32bbc-2	L.D.S. Church	1950	150	7	-	O	5,950	O	Tv	12r	03- -50	C
(D- 3- 5) 6bab-2	H. Jensen	1958	53	6	-	O	5,860	O	TRt	9r	12- -58	C

Table 4.--Drillers' lithologic logs of selected wells

Well number: See well-, spring-, tunnel-, and stream-site numbering system.
Thickness: ft, feet.
Depth: Depth to bottom of strata in feet below land surface.

	Thickness (ft)	Depth (ft)
(D- 1- 3)10aab-1. Log by J.G. Lee Drilling Co.		
Boulders and shale	79	79
Conglomerate	91	170
Limestone	25	195
Shale	16	211
Limestone	35	246
Limestone, shale streaks	146	392
Conglomerate	44	436
Shale	5	441
Shale, red and gravel	43	484
Shale, gray and gravel	119	603
Shale, gray	17	620
Limestone; water	217	837
(D-1 -3)13abb-1. Log by Peterson Brothers Drilling Co.		
Soil, hard	8	8
Clay, sand, and gravel, loose	19	27
Sand and gravel, brown	25	52
Gravel, brown and red	40	92
Clay, hard, dark brown	9	101
Clay, gravel, and boulders, very hard	12	113
Limestone	84	197
(D- 1- 4)16aad-1. Log by J.S. Lee and Sons.		
Soil	3	3
Clay, brown	9	12
Sand, fine	1	13
Clay, gray	37	50
Clay, sandy, brown, and gravel	112	162
Clay, sticky, red	29	191
Clay and gravel	19	210
Clay, sticky, red	10	220
Clay and sand, red	30	250
Clay, sticky, brown	15	265
Clay and gravel	15	280
Clay, red and brown	10	290

	Thickness (ft)	Depth (ft)
(D- 1- 4)16aad-1. Log by J.S. Lee and Sons.		
Clay and gravel	10	300
Clay, sticky, red	8	308
Gravel and boulders	3	311
Clay, sticky, red	9	320
Clay and gravel, brown	14	334
(D- 1- 4)16aad-1. Log by J.S. Lee and Sons--Continued		
Gravel, some clay	6	340
Clay, sticky, brown	8	348
Gravel and rock, hard	7	355
Clay and gravel, sticky, brown	13	368
Clay, red	22	390
Clay, brown	10	400
Conglomerate	40	440
Clay, sticky, brown	10	450
Conglomerate	14	464
Clay and conglomerate, sandy	204	668
(D- 1 -4)19bbc-1. Log by D. Petersen.		
Soil	3	3
Clay, cobbles, and boulders	7	10
Clay, brown, cobbles and boulders	3	13
Clay, brown, and boulders	38	51
Clay, cobbles and boulders	16	67
Rock, solid (some water at 103 feet)	36	103
Limestone, hard	80	183

(D- 1- 4)31aac-1. Log by Webber Drilling, Inc.

	Thickness (ft)	Depth (ft)
Soil	2	2
Clay and gravel, redish, water	90	92
Clay and gravel, gray	2	94
Clay and gravel, red	46	140
Clay and gravel, brown	82	222
Gravel	7	229
Clay and gravel	113	342
Clay, sticky	3	345
Clay and gravel	38	383
Sandstone, broken	77	460

(D- 2- 4) 8aaa-1. Log by Daves Drilling

	Thickness (ft)	Depth (ft)
Clay	10	10
Sand and gravel	30	40
Clay	10	50
Sand and gravel	10	60
Clay	10	70
Sand and gravel	10	80
Cobbles	10	90
Shale, reddish	40	130
Shale, reddish, mixed with limestone, gray	50	180
Limestone, gray, mixed with shale, reddish	40	220
Limestone, gray	80	300
Unknown	20	320

(D- 2- 4) 9aac-1. Log by Larry W. Dalton.

	Thickness (ft)	Depth (ft)
Sand and gravel	5	5
Sand	4	9
Clay and gravel	57	66
Gravel, loose, some water	4	70
Clay and gravel	95	165
Clay, fine gravel, and quartzite	10	175
Clay	25	200
Clay and gravel	10	210
Gravel, loose, some water	5	215
Clay and quartzite	45	260
Shale, red	35	295
Shale, red, some water	20	315
Shale, red, quartzite and gravel	45	360

(D- 2- 4) 9aac-1. Log by Larry W. Dalton.

	Thickness (ft)	Depth (ft)
Lime, hard, quartzite and shale	5	365
Shale, red, quartzite	60	425
Shale, red, sulfur odor	7	432
Shale, red, quartzite, gravel	13	445
Bedrock, very hard	1	446

(D- 2- 4)13ddb-3. Log by S. Petersen U.S. Bureau of Reclamation.

	Thickness (ft)	Depth (ft)
Alluvium	10	10
Tuff, lapilli, greenish gray	28	38
Breccia, lapilli	31	69
Tuff, lapilli, gray to reddish-gray	11	80
Tuff-breccia, greenish-gray	22	102
Tuff, lapilli,varigated gray	30	132
Tuff-breccia, reddish gray to gray	8	140
Tuff-lapilli, gray to grayish tan	21	161
Tuff-breccia, redish-gray	44	205
Tuff, greenish-gray	7	212
Tuff, lapilli, gray to greenish gray	58	270
Tuff, breccia, greenish-gray to gray	91	361
Tuff, lapili, reddish gray to medium gray	28	389
Tuff-breccia, medium greenish gray	74	463
Andesite flow, breccia, medium to dark gray	53	516
Tuff, lapilli, greenish gray	40	556
Andesite flow, mottled gray and greenish gray	33	589
Tuff, lapilli, greenish gray	24	613
Andesite flow, medium to dark gray	10	623

Table 4.--Drillers' lithologic logs of selected wells.--Continued

	Thick-ness (ft)	Depth (ft)
(D- 2- 5)19dcb-2. Log by G. Eatman, U.S. Bureau of Reclamation		
Clay, sandy, dark brown	2	2
Sand, brown	2	4
Clay, sandy, brown	37	41
Sand, silty, brown	19	60
Clay, sandy, grayish brown	41	101
Gravel, brown	9	110
Sand, silty	10	120
Gravel, brown to gray	8	128
Clay, lean, gray to light gray	4	132
dark gray	2	134
Gravel, brown	16	150
Sand, clayey, brown	40	190
Gravel, gray	10	200
Sand, silty, brown	20	220
Clay, sandy, brown	20	240
Sand, clayey, brown	30	270
Gravel, gray to brown	40	310
Sand, clayey, brown	10	320
Sand, silty, brownish gray	1	321
Gravel, brown to gray	9	330
Sand, clayey, grayish brown	40	370
Gravel, brown to gray	10	380
Sand, silty, brown	30	410
Sand, light brown	10	420
Gravel, brown to gray	11	431
Sand, clayey, brown	9	440
Gravel, gray to brown	12	452
Clay, sandy, brown	4	456
Gravel, brown to gray	14	470
Sand, silty, light brown	6	476
Gravel with cobbles	12	488
Andesite flow, gray	112	600

	Thick-ness (ft)	Depth (ft)
(D- 2- 5)30cbc-1. Log by D. Weskamp, U.S. Bureau of Reclamation.		
Clay, sandy, dark brown	35	35
Sand, silty, tan	5	40
Quartzite, yellow	65	105
Porphyry, granodiorite, cream colored	35	140
Quartzite, hard, reddish-brown	78	218
Porphyry, granodiorite, light gray to cream colored	47	265
Quartzite, light gray to dark reddish-brown	104	369

Table 5.— Water levels in selected observation wells

Well number: See well-, spring-, tunnel-, and stream-site numbering system.
Altitude of land surface: See table 3.
Water levels: In feet above (+) or below (-) land surface; r, reported by U.S. Bureau of Reclamation.

(D- 1- 3) 3ddb-1							
Sept 30, 1983	-8.33	Jan 20, 1984	-7.52	Mar 28, 1984	-6.87	May 24, 1984	-3.08
Nov 1, 1983	-8.17	Feb 27, 1984	-8.00	Apr 26, 1984	+1.63	June 15, 1984	-3.45
(D- 1- 3)11cad-1							
June 23, 1983	-54.79	Aug 26, 1983	-72.57	Nov 1, 1983	-75.34	May 24, 1984	-49.21
July 27, 1983	-67.62	Sept 29, 1983	-76.12	Apr 24, 1984	-48.07	June 15, 1984	-50.51
(D- 1- 3)11dbc-1							
June 23, 1983	-28.98	Aug 26, 1983	-37.20	Nov 1, 1983	-35.24	May 24, 1984	-26.92
June 27, 1983	-32.26	Sept 29, 1983	-34.62	Apr 24, 1984	-29.75	June 14, 1984	-27.23
(D- 1- 3)24dda-1							
Aug 12, 1983	-21.06	Nov 14, 1983	-22.96	Mar 28, 1984	-20.00	June 20, 1984	-19.15
Sept 29, 1983	-22.00	Jan 18, 1984	-21.25	Apr 24, 1984	-18.75		
(D- 1- 3)25ddc-1							
June 28, 1983	-9.04	Nov 2, 1983	-10.65	June 14, 1984	-6.38		
Sept 29, 1983	-10.21	Jan 31, 1984	-9.84				
(D- 1- 3)36cac-1							
July 26, 1983	-26.46	Sept 29, 1983	-24.01	June 20, 1984	-15.22		
Aug 26, 1983	-19.66	Nov 2, 1983	-21.21				
(D- 1- 4) 4caa-1							
Aug 26, 1983	-41.09	Nov 1, 1983	-44.75				
Oct 3, 1983	-43.84	June 11, 1984	-27.37				
(D- 1- 4) 4ccd-1							
Sept 29, 1983	-16.95	Jan 12, 1984	-13.58	Mar 27, 1984	-10.98	May 24, 1984	-10.45
Nov 1, 1983	-16.72	Feb 24, 1984	-13.40	Apr 24, 1984	-10.07	June 11, 1984	-10.41
(D- 1- 4)18ccc-2							
June 21, 1983	-75.23	Sept 30, 1983	-81.75	Jan 18, 1984	-83.24	Apr 24, 1984	-72.72
July 27, 1983	-78.59	Nov 18, 1983	-83.07	Feb 24, 1984	-83.38	May 24, 1984	-71.36
Aug 26, 1983	-80.29	Dec 21, 1983	-83.12	Mar 27, 1984	-80.14	June 20, 1984	-72.79
(D- 1- 4)19bbc-1							
June 28, 1983	-56.48	Sept 30, 1983	-63.90	Jan 18, 1984	-64.40	Apr 24, 1984	-55.57
July 27, 1983	-60.55	Nov 1, 1983	-64.30	Feb 24, 1984	-64.54	May 24, 1984	-54.99
Aug 26, 1983	-62.82	Nov 18, 1983	-64.44	Mar 27, 1984	-63.96	June 15, 1984	-55.94
(D- 1- 4)20bcb-1							
June 10, 1983	-8.75	Sept 29, 1983	-8.90	Jan 20, 1984	-8.84	May 24, 1984	-9.23
July 27, 1983	-8.30	Nov 1, 1983	-8.59	Mar 27, 1984	-7.79	June 20, 1984	-8.77
Aug 26, 1983	-8.40	Dec 21, 1983	-8.54	Apr 24, 1984	-7.34		
(D- 1- 4)21cdd-1							
June 21, 1983	-14.24	Sept 29, 1983	-25.10	Mar 28, 1984	-32.14	June 13, 1984	-10.78
July 27, 1983	-19.18	Nov 1, 1983	-27.22	Apr 24, 1984	-14.58		
Aug 26, 1983	-22.63	Jan 12, 1984	-30.26	May 24, 1984	-8.51		
(D- 1- 4)22cba-1							
Jan 18, 1984	-7.81	Mar 28, 1984	-8.12	May 24, 1984	-4.18		
Feb 24, 1984	-8.01	Apr 24, 1984	-4.05	June 13, 1984	-5.60		
(D- 1- 4)22cdd-1							
June 28, 1983	-68.06	Sept 29, 1983	-74.70	Feb 24, 1984	-78.62	May 24, 1984	-60.20
July 27, 1983	-70.67	Nov 1, 1983	-76.13	Mar 28, 1984	-77.75	June 13, 1984	-61.88
Aug 26, 1983	-72.83	Jan 18, 1984	-77.90	Apr 24, 1984	-61.66		
(D- 1- 4)29ccc-1							
Apr 26, 1983	-9.72	May 10, 1983	-8.00	Aug 26, 1983	-14.22	Feb 24, 1984	-22.20
Apr 28, 1983	-9.49	May 13, 1983	-7.68	Sept 29, 1983	-19.78	Mar 27, 1984	-23.31
May 3, 1983	-8.85	May 27, 1983	-1.30	Nov 2, 1983	-18.58	Apr 26, 1984	-8.36
May 5, 1983	-8.62	June 9, 1983	-3.62	Dec 21, 1983	-22.37	May 25, 1984	-7.00
May 9, 1983	-8.12	July 27, 1983	-8.14	Jan 20, 1984	-19.91	June 20, 1984	-6.48

(D- 1- 4)29dcc-2

Apr 26, 1983	-18.21	July 27, 1983	-24.46	Dec 21, 1983	-21.16	Apr 26, 1984	-17.22
Apr 28, 1983	-18.00	Aug 26, 1983	-19.95	Jan 20, 1984	-20.15	May 25, 1984	-16.31
May 9, 1983	-16.48	Sept 29, 1983	-21.48	Feb 27, 1984	-21.53	June 20, 1984	-17.04
June 9, 1983	-22.51	Nov 2, 1983	-21.68	Mar 28, 1984	-20.84		

(D- 1- 4)30bbd-1

Nov 14, 1983	-8.49	Feb 27, 1984	-6.71	Apr 25, 1984	-2.64		
Jan 16, 1984	-6.87	Mar 27, 1984	-5.26	June 14, 1984	-5.31		

(D- 1- 4)31aac-1

May 27, 1983	-26.99	Sept 29, 1983	-36.36	Jan 20, 1984	-37.88	Apr 26, 1984	-33.07
July 27, 1983	-31.39	Nov 2, 1983	-37.14	Feb 24, 1984	-37.57	May 25, 1984	-31.45
Aug 26, 1983	-36.12	Dec 21, 1983	-37.67	Mar 27, 1984	-37.82	June 20, 1984	-30.52

(D- 1- 4)31bdb-2

Apr 28, 1983	-15.47	Nov 2, 1983	-21.90	Apr 26, 1984	-12.43		
July 27, 1983	-19.22	Dec 21, 1983	-21.02	June 20, 1984	-15.88		

(D- 1- 4)32daa-1

Apr 27, 1983	+2.10	Aug 26, 1983	-0.25	Jan 18, 1984	+0.63	Apr 24, 1984	+2.57
May 5, 1983	+2.10	Oct 3, 1983	-0.91	Feb 27, 1984	-0.40	May 25, 1984	+1.65
June 9, 1983	+1.49	Nov 2, 1983	-1.23	Mar 27, 1984	+2.01	June 20, 1984	+1.34

(D- 1- 4)33bbd-1

Apr 27, 1983	+0.02	Nov 2, 1983	-2.08	Mar 27, 1984	+2.45	June 20, 1984	-1.47
May 5, 1983	+0.09	Jan 18, 1984	-1.48	Apr 24, 1984	+3.07		
Sept 29, 1983	-2.00	Feb 27, 1984	-1.56	May 25, 1984	-0.97		

(D- 2- 4) 8aaa-1

July 26, 1983	-29.23	Dec 21, 1983	-31.03	Mar 28, 1984	-31.08	June 20, 1984	-28.66
Sept 30, 1983	-29.52	Jan 20, 1984	-31.71	Apr 26, 1984	-30.35		
Nov 2, 1983	-29.67	Feb 27, 1984	-31.88	May 25, 1984	-30.62		

(D- 2- 4) 9aac-1

July 26, 1983	-8.30	Dec 21, 1983	-17.23	Mar 28, 1984	-1.80	June 22, 1984	+0.08
Sept 30, 1983	-10.16	Jan 20, 1984	-16.86	Apr 26, 1984	+5.75		
Nov 2, 1983	-13.54	Feb 27, 1984	-15.03	May 25, 1984	+0.82		

(D- 2- 4)13ddb-1

Aug 12, 1982	-5.75r	Nov 15, 1982	-7.35r	June 21, 1984	-1.56		
Oct 7, 1982	-6.25r	Dec 17, 1982	-8.05r				

(D- 2- 4)13ddb-2

Aug 12, 1982	-15.5r	Nov 15, 1982	-15.75r	June 21, 1984	-20.32		
Oct 7, 1982	-15.45r	Dec 17, 1982	-16.05r				

(D- 2- 4)13ddb-3

Aug 12, 1982	-26.6r	Nov 15, 1982	-27.15r	June 21, 1984	-20.64		
Oct 7, 1982	-28.35r	Dec 17, 1982	-27.75r				

(D- 2- 4)24daa-1

Mar 12, 1979	-105.0r	July 14, 1980	-105.5r	Dec 15, 1980	-105.3r	Apr 29, 1982	-104.4r
May 1, 1979	-104.5r	July 28, 1980	-105.6r	Jan 20, 1981	-105.4r	June 10, 1982	-104.35r
May 18, 1979	-105.2r	Aug 15, 1980	-126.4r	Feb 23, 1981	-105.3r	July 9, 1982	-104.55r
June 21, 1979	-108.4r	Aug 28, 1980	-105.6r	Feb 25, 1981	-105.3r	Aug 12, 1982	-104.95r
July 31, 1979	-105.7r	Sept 15, 1980	-105.4r	Apr 20, 1981	-105.2r	Nov 15, 1982	-103.45r
Sept 11, 1979	-105.8r	Oct 6, 1980	-105.4r	July 14, 1981	-105.6r	June 21, 1984	-103.43
June 13, 1980	-105.0r	Oct 22, 1980	-105.4r	Aug 25, 1981	-105.7r		
June 30, 1980	-105.3r	Nov 17, 1980	-105.5r	Oct 20, 1981	-105.3r		

(D- 2- 4)25abc-1

July 8, 1982	-96.7r	Dec 13, 1982	-99.7r	Apr 11, 1983	-67.9r	Nov 28, 1983	-92.9r
Aug 12, 1982	-96.9r	Dec 21, 1982	-99.9r	May 13, 1983	-43.3r	Dec 5, 1983	-92.9r
Sept 21, 1982	-99.4r	Jan 6, 1983	-101.7r	June 13, 1983	-43.3r	Jan 9, 1984	-96.5r
Oct 1, 1982	-94.6r	Jan 11, 1983	-101.95r	July 13, 1983	-74.5r	Jan 16, 1984	-96.8r
Oct 7, 1982	-99.0r	Jan 24, 1983	-101.5r	Aug 17, 1983	-80.0r	Jan 23, 1984	-97.3r
Oct 14, 1982	-99.6r	Feb 4, 1983	-101.3r	Sept 15, 1983	-82.6r	Jan 29, 1984	-97.4r
Oct 26, 1982	-99.7r	Feb 17, 1983	-100.45r	Oct 13, 1983	-84.5r	May 15, 1984	-24.8r
Nov 5, 1982	-100.5r	Feb 25, 1983	-100.05r	Oct 17, 1983	-85.0r	May 30, 1984	-74.3r
Nov 9, 1982	-99.0r	Mar 10, 1983	-80.05r	Oct 24, 1983	-85.6r	June 13, 1984	-76.0r
Nov 15, 1982	-100.1r	Mar 15, 1983	-23.1r	Nov 7, 1983	-85.6r	July 10, 1984	-80.1r
Nov 22, 1982	-99.3r	Mar 22, 1983	-23.2r	Nov 14, 1983	-88.3r		
Dec 8, 1982	-99.95r	Mar 29, 1983	-21.1r	Nov 21, 1983	-91.5r		

(D- 2- 5)19dcb-1

June 11, 1982	-211.2r	Oct 7, 1982	-203.2r	May 24, 1983	-169.5r	June 28, 1984	-192.3
July 8, 1982	-210.1r	Nov 12, 1982	-206.8r	June 8, 1983	-160.5r	Oct 11, 1984	-201.2r
Aug 14, 1982	-208.3r	Jan 24, 1983	-208.2r	Oct 17, 1983	-74.0r	Jan 23, 1985	-201r

(D- 2- 5)19dcb-2

Apr 29, 1982	-214.3r	Oct 7, 1982	-204.8r	June 8, 1983	-172.8r	Jan 3, 1985	-127.3r
June 11, 1982	-210.9r	Nov 12, 1982	-204.9r	Oct 17, 1983	-112.1r	Jan 23, 1985	-127.5r
July 8, 1982	-210.6r	Jan 24, 1983	-205.5r	June 28, 1984	-120.25	Feb 7, 1985	-127.9r
Aug 14, 1982	-210.5r	May 24, 1983	-172.1r	Oct 11, 1984	-122.8r	Apr 9, 1985	-128.8r

(D- 2- 5)31aac-1

Jan 27, 1981	-3.5r	Nov 11, 1982	-11.5r	Apr 26, 1983	-6.8r	Sept 26, 1983	-12.1r
Feb 23, 1981	-12.7r	Nov 16, 1982	-11.3r	May 4, 1983	-8.6r	Oct 3, 1983	-11.9r
Feb 27, 1981	-13.6r	Nov 22, 1982	-10.6r	May 9, 1984	-5.9r	Oct 11, 1983	-11.8r
Mar 5, 1981	-14.1r	Nov 29, 1982	-11.45r	May 16, 1983	-9.0r	Oct 17, 1983	-12.0r
Mar 9, 1981	-14.2r	Dec 8, 1982	-11.6r	May 23, 1983	-9.4r	Oct 24, 1983	-11.6r
Mar 16, 1981	-14.3r	Dec 13, 1982	-11.6r	May 31, 1983	-9.6r	Nov 7, 1983	-12.0r
Mar 23, 1981	-14.3r	Dec 21, 1982	-11.45r	June 6, 1983	-10.1r	Nov 14, 1983	-11.7r
Mar 25, 1981	-14.1r	Jan 6, 1983	-12.55r	June 13, 1983	-10.1r	Nov 21, 1983	-11.6r
July 14, 1981	-15.9r	Jan 11, 1983	-12.6r	June 27, 1983	-10.8r	Dec 5, 1983	-11.1r
Aug 25, 1981	-16.3r	Jan 18, 1983	-12.7r	July 5, 1983	-11.1r	Jan 2, 1984	-10.7r
Oct 26, 1981	-15.7r	Jan 25, 1983	-13.05r	July 11, 1983	-11.4r	Jan 9, 1984	-12.6r
Apr 29, 1982	-12.0r	Feb 3, 1983	-12.95r	July 18, 1983	-11.6r	Jan 16, 1984	-12.6r
June 10, 1982	-13.5r	Feb 8, 1983	-13.1r	July 25, 1983	-11.4r	Jan 23, 1984	-12.6r
July 8, 1982	-14.4r	Feb 17, 1983	-11.85r	Aug 1, 1983	-11.5r	Jan 29, 1984	-12.7r
Aug 13, 1982	-14.4r	Feb 25, 1983	-10.3r	Aug 8, 1983	-11.7r	May 15, 1984	-10.6r
Sept 21, 1982	-13.6r	Mar 10, 1983	-9.0r	Aug 15, 1983	-11.7r	May 30, 1984	-10.2r
Oct 1, 1982	-11.6r	Mar 15, 1983	-8.7r	Aug 22, 1983	-11.6r	June 13, 1984	-10.4r
Oct 6, 1982	-12.0r	Mar 22, 1983	-9.4r	Aug 29, 1983	-12.0r	June 20, 1984	-10.90
Oct 12, 1982	-12.0r	Mar 29, 1983	-9.25r	Sept 6, 1983	-11.85r	June 27, 1984	-10.9r
Oct 25, 1982	-12.6r	Apr 7, 1983	-9.2r	Sept 12, 1983	-12.0r	July 10, 1984	-11.2r
Nov 4, 1982	-12.5r	Apr 21, 1983	-9.4r	Sept 19, 1983	-13.1r		

(D- 2- 5)31aac-2

Jan 27, 1981	-24.5r	Nov 9, 1982	-27.8r	Apr 26, 1983	-22.7r	Sept 26, 1983	-26.0r
Feb 23, 1981	-25.9r	Nov 16, 1982	-28.1r	May 4, 1983	-23.2r	Oct 3, 1983	-26.2r
Feb 27, 1981	-25.7r	Nov 22, 1982	-27.8r	May 9, 1983	-21.7r	Oct 11, 1983	-26.6r
Mar 5, 1981	-25.2r	Nov 29, 1982	-26.7r	May 16, 1983	-21.9r	Oct 17, 1983	-27.1r
Mar 9, 1981	-24.9r	Dec 8, 1982	-27.0r	May 23, 1983	-22.3r	Oct 24, 1983	-27.7r
Mar 16, 1981	-25.2r	Dec 13, 1982	-27.01r	May 31, 1983	-21.5r	Nov 7, 1983	-27.8r
Mar 23, 1981	-25.5r	Dec 21, 1982	-27.15r	June 6, 1983	-21.0r	Nov 14, 1983	-27.7r
Mar 25, 1981	-25.2r	Jan 6, 1983	-28.3r	June 13, 1983	-21.0r	Nov 21, 1983	-27.5r
July 14, 1981	-25.3r	Jan 11, 1983	-28.3r	June 27, 1983	-23.4r	Dec 5, 1983	-26.8r
Aug 25, 1981	-27.3r	Jan 18, 1983	-28.1r	July 5, 1983	-23.8r	Jan 2, 1984	-26.5r
Oct 26, 1981	-28.9r	Jan 25, 1983	-28.2r	July 11, 1983	-24.5r	Jan 9, 1984	-28.3r
Apr 29, 1982	-23.1r	Feb 3, 1983	-28.25r	July 18, 1983	-25.1r	Jan 16, 1984	-28.3r
June 10, 1982	-23.6r	Feb 8, 1983	-28.25r	July 25, 1983	-25.2r	Jan 23, 1984	-28.6r
July 8, 1982	-24.7r	Feb 17, 1983	-27.15r	Aug 1, 1983	-25.6r	Jan 29, 1984	-28.9r
Aug 13, 1982	-26.7r	Feb 25, 1983	-26.6r	Aug 8, 1983	-26.0r	May 15, 1984	-26.8r
Sept 21, 1982	-26.8r	Mar 10, 1983	-24.4r	Aug 15, 1983	-26.0r	May 30, 1984	-24.3r
Oct 1, 1982	-25.2r	Mar 15, 1983	-23.2r	Aug 22, 1983	-25.6r	June 13, 1984	-24.9r
Oct 6, 1982	-25.4r	Mar 22, 1983	-22.55r	Aug 29, 1983	-26.4r	June 20, 1984	-24.85
Oct 12, 1982	-26.1r	Mar 29, 1983	-22.75r	Sept 6, 1983	-26.2r	June 27, 1984	-24.9r
Oct 25, 1982	-27.5r	Apr 7, 1983	-22.5r	Sept 12, 1983	-25.8r	July 10, 1984	-25.4r
Nov 11, 1982	-28.5r	Apr 21, 1983	-22.8r	Sept 19, 1983	-26.0r		

Table 6.--Results of aquifer tests

Well number: See well-, spring-, tunnel-, and stream-site numbering system.

Pumped well	Observation well	Primary geologic unit tested	Transmissivity (feet squared per day)	Storage coefficient	Method of analysis or reference
(D- 1- 3)13abb-1	(D- 1- 3)13abb-1	Thaynes Formation	7,400	-	Straight-line method (Lohman, 1972, p. 23)
(D- 1- 4)19cac-1	(D- 1- 4)19cac-1	Nugget Sandstone	200	-	do.
30cad-1	30cad-1	do.	300	-	do.
31aac-1	31aac-1	Unconsolidated valley fill	20	-	do.
36aac-3	36aac-3	Extrusive igneous rocks	3	-	do.
(D- 2- 4) 8aaa-1	(D- 2- 4) 8aaa-1	Thaynes Formation	2,400	-	do.
9aac-1	9aac-1	Woodside Shale	140	-	do.
24aca[1]	24aca	Weber Quartzite	1,060	-	Theis nonleaky-type curve (analysis by UINTEX, Corp. 1984)
24aca[2]	24aca	do.	910	-	do.
24aca[3]	24aca	Doughnut and Humbug Formations, and Deseret Limestone of Mississippian age	130	0.013	do.
24aca[4]	24aca	Fault (Silver fissure)	780	0.013	United Park City Mine Co. (analysis by Williams Brothers Engineering Co.)
36aaa-1	(D- 2- 5)31bbb-2	Weber Quartzite	360	0.007	Theis nonleaky-type curve (analysis by UINTEX, Corp. 1984)
(D- 2- 5)31bba-1	31bba-3	Extrusive igneous Rocks	73	0.0004	do.

[1]Test conducted inside Ontario No. 2 Tunnel; drawdown in West End Shaft, June-July 1949.
[2]Test conducted inside Ontario No. 2 Tunnel; water-level recovery in West End Shaft, April 1950-August 1951.
[3]Test conducted inside Ontario No. 2 Tunnel; water-level recovery in Ontario No. 3 Shaft after cessation of pumping in the Ontario No. 6 Shaft, April-November 1982.
[4]Test conducted inside Ontario No. 2 Tunnel; tested Silver Fissure for feasability of dewatering, December 1977-January 1978.

Table 7.—Records of selected springs and tunnels

Location: See well-, spring-, tunnel-, and stream-site numbering system.
Source of water: Geologic unit thought to be the primary source of the water—Qa, unconsolidated valley fill; Tv, intrusive and extrusive igneous rocks; Kf, Frontier Formation; Jtc, Twin Creek Limestone; JTRn, Nugget Sandstone; TRt, Thaynes Formation; TRw, Woodside Shale; IPw, Weber Quartzite.
Discharge: r, reported; e, estimated.
Specific conductance: r, reported
Temperature: r, reported
Other data available: C, chemical analyses (table 14).

Location	Name	Altitude of land surface (feet)	Source of water	Date	Discharge (gallons per minute)	Specific conductance (microsiemens per centimeter at 25 °Celsius)	Temperature (°Celsius)	Other data available
				SPRINGS				
(A- 1- 3) 28ddd-S1	—	6,640	Kf	08-30-83	2.5	570	11.5	C
34cbd-S1	—	6,560	Kf	08-29-83	2.3	740	10.0	C
35bbb-S1	—	6,400	Kf	08-29-83	3.2	780	18.0	C
(D- 1- 3) 14bcd-S1	Twomile Spring	6,840	TRt	05-28-63	—	350	—	—
				06-23-83	400	430	7.0	C
36aad-S1	Silver Springs	6,740	Jtc	06- -68	1,300e	—	11.0	—
				07-28-83	1,680	330	6.0	C
(D- 1- 4) 8bbd-S1	—	6,620	Tv	08-25-83	3.0	570	14.0	C
30bbb-S1	—	6,520	JTRn	08-22-83	14.0	500	10.0	C
30bbc-S1	—	6,460	JTRn	08-16-83	.5	185	9.5	C
30bca-S1	—	6,470	JTRn	11-16-83	18	—	—	—
31bcb-S1	—	6,680	JTRn	06-14-83	70e	375	7.0	C
33aab-S1	—	6,790	Qa	06- -68	50e	—	21.0	—
				08-23-83	44	610	15.0	C
33bbd-S1	—	6,440	JTRn	08-29-83	10	600	11.5	C
34dcd-S1	—	6,760	Tv	06- -68	350e	—	12.0	—
				08-23-83	45	550	18.0	C
35aca-S1	Homer Spring	6,600	Tv	09- -67	6e	—	13.0	—
				07-18-83	8.0	395	11.5	C
35cad-S1	—	6,610	Qa	08-14-83	13	1,160	15.0	C
(D- 2- 4) 2aac-S1	—	6,600	Qa	08-23-83	72	1,750	20.0	C
4dca-S1	Dority Spring	6,740	TRt	09-13-67	700e	690	8.0	C
				08-22-83	1,030	720	9.5	C
				11- 3-83	540e	—	—	—
5cdd-S1	Stahl Spring	6,820	TRt	09-01-83	10	420	9.0	C
8cab-S1	Sullivan Spring	6,990	TRt	09-09-82	1,100	370	6.0	C
				06-02-83	5,800	310	5.5	C
				08-22-83	1,300	315	5.5	C
8dab-S1	Theriot Spring	6,840	TRt	01-27-75	—	410	—	—
				08-20-81	—	300	—	—
				07-29-83	2,800	370	5.5	C
				10-27-83	840	—	—	—
9cbb-S1	—	6,805	Qa	06-19-63	—	280	—	C
22abc-S1	—	7,340	IPw	06- -68	100e	—	12.0	—
				08-22-83	45e	215	11.0	C
23cbc-S1	—	7,440	TRw	09-15-83	5	530	8.0	C
24adb-S1	—	6,200	Qa	09-15-83	90	970	11.0	C
(D- 2- 5) 5ccd-S1	—	6,550	Tv	09-13-67	200e	350	14.0	C
6cca-S1	—	6,630	Tv	08-31-83	3e	420	13.0	C
17bca-S1	—	6,200	Qa	09- -67	10e	—	11.0	—
				08-31-83	3e	380	14.5	C
17cda-S1	—	6,250	JTRn	09- -67	250e	—	12.0	—
				08-31-83	15	560	20.0	C
21ccd-S1	—	6,440	Tv	09-15-83	9	1,360	15.0	C
29cad-S1	—	6,040	Tv	09-13-67	4	1,250	14.0	C
				09-15-83	4	1,360	19.0	C
33ada-S1	Berg Spring	6,080	TRt	02-24-84	1,600	370	15.5	C
				TUNNELS				
(D- 2- 4) 8dba	Spiro Tunnel (at weir)	6,888	IPw	08-03-79	4,000	870	9.5	C
				05-14-80	4,100	830	9.0	C
				02-25-83	2,600	1,000	8.5	C
8dbd	Spiro Tunnel (west drift)	6,922	IPw	03-02-71	—	990r	—	—
				02-15-74	—	950r	—	—
				02-22-79	—	820r	—	—
				02-24-83	1,450	830	9.0	C
21cdc	Judge/Anchor Tunnel	7,640	IPw	03-08-74	—	410r	—	—
				05-11-81	—	320r	—	—
				11-17-81	—	335r	5.5r	—
				05-22-84	1,450r	—	—	—
21cdc	Alliance Tunnel	6,320	IPw	03-08-74	—	500r	—	—
				05-11-81	100e	520	—	—
24aca	Ontario No. 2 Tunnel	6,286	IPw	08-15-67	—	550	9.0	—
				02-15-83	5,400	910	10.0	C
24cad	McCune Tunnel	6,378	—	05-03-79	—	860r	10.5r	—
				09-09-83	22	790	10.5	C

Table 8.--Summary of estimated recharge to unconsolidated valley fill, in acre-feet per year

Precipitation and unconsumed irrigation water	
East Canyon and Silver Creek drainages	5,200
Drain Tunnel Creek and Provo River flood plain	2,000
Leakage from consolidated rocks	6,400
Seepage from streams	1,800
Total (rounded)	15,400

Table 9.--Summary of estimated discharge from unconsolidated valley fill, in acre-feet per year

Evapotranspiration	
East Canyon and Silver Creek drainages	1,300
Drain Tunnel Creek drainage and flood plain of Provo River	1,300
Seepage to streams	
East Canyon and Silver Creek drainages	10,300
Drain Tunnel Creek	2,500
Wells	100
Total (rounded)	15,500

Table 10.--Summary of estimated recharge to consolidated rocks, in acre-feet per year

Precipitation and stream infiltration	31,000
Subsurface inflow from adjoining areas	15,000
Total	46,000

Table 11.--Summary of estimated discharge from consolidated rocks, in acre-feet per year

Springs	
Lower areas	13,000
Higher areas	6,000
Small unmeasured springs	1,000
Drain tunnels	19,700
Leakage to unconsolidated valley fill	6,400
Wells	300
Total (rounded)	46,000

Table 12.--Selected standards and recommended limits for constituents and physical properties of water

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Constituent or physical property	State primary drinking-water standard[1]	State secondary drinking-water standard[1]	U.S. Environmental Protection Agency recommended limit[2]
Alkalinity	--	--	20 mg/L or more as calcium carbonate for freshwater-aquatic life
Total arsenic	50 µg/L	--	100 µg/L for irrigation of crops
Total boron	--	--	750 µg/L for long-term irrigation of sensitive crops
Total cadmium	10 µg/L	--	0.4-1.2 µg/L for cladocerns and salmonid fishes 4.0-1.2 µg/L for other less sensitive aquatic life. (smaller values are for water with harness of less than 75 mg/L and water with hardness of more than 75 mg/L)
Total chloride	--	250 mg/L	--
Total iron	--	300 µg/L	1,000 µg/L for freshwater-aquatic life
Total lead	50 µg/L	--	--
Total manganese	--	50 µg/L	--
Total nitrate as (N)	10 mg/L	--	--
pH	--	6.5-8.5	6.5-9.0 for freshwater-aquatic life

Table 12.--Selected standards and recommended limits for constituents and physical properties of water—Continued

Constituent or physical property	State primary drinking-water standard[1]	State secondary drinking-water standard[1]	U.S. Environmental Protection Agency recommended limit[2]
Total sulfate	1,000 mg/L	250 mg/L	—
Total dissolved solids	2,000 mg/L	500 mg/L	—
Total zinc	—	5 mg/L	—

[1]Utah Division of Environmental Health, Bureau of Public Water Supplies, 1984, State of Utah Public Drinking Water Regulations: Salt Lake City, 250 p.

[2]U.S. Environmental Protection Agency, 1977, Quality criteria for water, 1976: Washington, D.C., 256 p.

Table 13.--Chemical analyses of selected water samples from the drainage basins of

Site No.: Refers to number assigned to the surface-water sites on plate 2.
Streamflow, instantaneous: ft^3/s, cubic feet per second.
Temperature: DEG C, degrees Celsius
Specific Conductance: Microsiemens per centimeters at 25 ° Celsius.

SITE NO.	DATE	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE	PH (UNITS)	HARD-NESS (MG/L AS CACO3)	HARD-NESS, NONCAR-BONATE (MG/L CACO3)	ALKA-LINITY FIELD (MG/L AS CACO3)	ALKA-LINITY LAB (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)
							East Canyon Creek basin							
2	08-03-79	7.0	13.5	720	7.9	390	240	150	—	110	27	10	2.5	11
	02-26-80	9.0	4.5	800	8.3	470	320	150	—	130	35	13	2.2	18
	04-03-80	7.5	5.0	820	8.4	440	300	140	—	120	33	11	2.0	14
	05-14-80	25	10.0	560	8.1	290	150	140	—	82	21	7.5	1.4	11
	08-13-80	11.9	17.0	750	8.1	410	260	150	—	120	28	7.5	1.7	8.5
3	06-01-83	44.5	—	150	7.7	69	—	—	73	20	4.7	3.1	0.9	2.7
	08-05-83	0.34	14.5	300	7.4	140	—	—	150	42	9.4	3.9	1.4	2.5
4	08-05-83	0.23	16.5	310	7.7	150	—	—	150	44	9.7	3.9	0.7	2.9
5	06-02-83	36.9	5.0	100	7.7	48	—	—	49	14	3.2	2.7	0.8	1.9
6	08-03-79	0.25	16.0	1,130	7.9	430	230	200	—	110	37	74	3.6	240
	05-14-80	9.8	8.0	360	8.0	130	19	110	—	37	8.8	22	1.7	40
	08-13-80	0.1	21.0	920	8.3	360	210	150	—	98	29	38	3.5	200
7	08-03-79	6.0	12.5	700	8.2	360	170	190	—	100	26	11	1.2	18
	02-26-80	19	0.0	740	8.2	430	260	170	—	120	31	15	1.8	25
	04-03-80	16	0.5	750	8.2	390	230	160	—	110	29	12	1.7	19
	05-14-80	42	7.0	530	8.1	270	130	140	—	77	20	8.7	1.3	13
	08-13-80	8.1	23.0	670	8.5	350	180	170	—	97	25	10	1.2	15
8	06-03-83	21.9	8.0	260	7.9	130	10	—	120	37	9.3	4.5	1.3	3.4
	08-05-83	0.8	14.0	420	8.3	210	23	—	190	58	17	6.0	1.3	4.3
10	08-03-79	1.5	12.5	680	7.9	360	190	170	—	100	27	13	1.0	22
	05-14-80	1.0	8.0	660	7.9	320	190	130	—	87	24	18	1.3	34
14	08-03-79	2.0	11.5	590	8.2	310	110	200	—	86	22	14	3.6	23
	05-14-80	26	8.0	350	8.2	150	27	120	—	46	7.8	12	1.1	22
17	05-03-83	6.31	7.0	570	8.2	230	25	—	200	63	17	7.9	0.8	7.2
	06-01-83	24.7	7.0	400	7.9	230	12	—	220	68	15	6.8	1.0	6.4
	08-05-83	3.81	10.5	560	8.0	260	29	—	240	73	20	8.4	0.8	8.4
21	08-03-79	8.0	13.0	660	8.2	350	140	210	—	98	26	19	1.9	29
	10-26-79	16	10.0	700	8.5	350	180	170	—	100	25	16	2.5	26
	02-26-80	20	0.5	750	8.3	390	200	190	—	110	28	28	2.2	55
	04-03-80	21	0.5	750	8.2	350	170	180	—	100	25	22	2.0	47
	05-14-80	88	5.0	475	8.2	230	88	140	—	65	16	13	1.4	21
	08-13-80	13.3	24.0	620	8.7	300	130	170	—	84	23	13	1.5	21
22	09-09-82	0.46	15.0	850	8.0	350	150	—	200	110	18	32	1.5	91
	06-03-83	27.8	9.0	475	8.2	190	23	—	170	61	9.4	17	1.5	34
	08-05-83	1.85	12.5	760	7.3	310	80	—	230	97	17	26	1.3	60
23	08-03-79	1.0	12.5	850	8.2	370	160	210	—	110	22	24	1.7	110
	05-14-80	14	4.5	575	8.2	240	69	170	—	76	12	29	1.2	74
27	05-04-83	7.9	11.0	390	8.0	170	—	—	180	55	9.0	13	2.7	11
	08-04-83	0.3	17.0	730	8.3	300	6	—	300	93	17	26	3.5	40
28	05-24-83	25.9	10.0	320	7.8	140	2	—	140	50	4.4	5.6	1.9	5.7
	08-04-83	1.27	16.0	540	8.4	270	13	—	250	91	9.4	9.9	1.7	11
29	05-26-83	322	—	460	8.3	170	31	—	140	53	10	12	1.7	16
	08-04-83	46.1	17.0	620	8.1	290	89	—	200	84	20	15	1.6	21
							Silver Creek basin							
30	05-14-80	3.0	11.5	495	7.9	190	120	66	—	59	9.2	36	2.1	51
31	08-03-79	3.0	12.5	720	7.7	360	190	170	—	100	26	13	1.7	33
	05-14-80	5.5	11.0	740	7.8	390	220	170	—	110	29	18	1.6	52
33	08-03-79	0.5	18.5	840	7.7	450	200	250	—	130	31	17	0.9	36
	02-27-80	3.0	3.0	810	8.1	430	250	180	—	120	31	22	1.7	61
	04-03-80	2.0	3.5	860	8.0	420	250	170	—	120	29	23	2.4	63
	05-14-80	10	11.0	800	7.9	370	240	130	—	110	23	23	2.0	56
	08-13-80	1.0	20.0	880	7.8	460	230	230	—	130	32	17	0.4	47
36	09-08-82	1.04	17.5	800	8.6	320	120	—	200	90	24	2	4.1	62
	05-02-83	41	9.0	720	8.1	290	140	—	150	83	19	29	2.6	53
	08-04-83	6.26	21.0	940	8.5	430	200	—	220	120	31	30	4.2	58

SULFATE DIS-SOLVED (MG/L AS SO4)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	ARSENIC DIS-SOLVED (UG/L AS AS)	BORON, DIS-SOLVED (UG/L AS B)	CADMIUM DIS-SOLVED (UG/L AS CD)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	ZINC, DIS-SOLVED (UG/L AS ZN)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2)	PHOS-PHATE, ORTHO, DIS-SOLVED (MG/L AS PO4)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, ORTHO, DIS-SOLVED (MG/L AS P)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
							East Canyon Creek basin								
230	0.2	4.7	—	<10	—	—	—	—	—	3.6	1.1	—	0.37	1.2	486
300	0.2	14	—	<10	—	—	—	—	—	1.4	0.28	—	0.09	0.41	603
310	0.1	14	—	<10	—	—	—	—	—	1.1	0.18	—	0.06	0.32	588
140	0.1	13	—	<10	—	—	—	—	—	2.1	0.06	—	0.02	0.58	360
250	0.2	15	12	100	<1	10	<1	30	20	2.3	0.06	—	0.02	0.41	521
7.3	<0.1	6.9	1	10	<1	20	2	2	30	2.8	—	0.06	—	0.1	90
<5.0	<0.1	9.3	2	10	<1	10	<1	18	10	11	—	0.08	—	<0.1	162
5.5	<0.1	8.4	3	<10	<1	10	<1	23	10	5.9	—	0.03	—	<0.1	168
7.4	<0.1	6.6	2	10	<1	100	3	3	20	1.9	—	0.03	—	0.17	66
48	0.2	41	—	<10	—	—	—	—	—	4.9	0.03	—	0.01	0.02	674
12	0.2	19	—	<10	—	—	—	—	—	2.1	0.15	—	0.05	0.04	207
33	0.2	42	3	120	3	20	3	140	<10	1.4	—	—	0.00	0.26	534
180	0.1	16	—	<10	—	—	—	—	—	2.3	0.25	—	0.08	0.57	466
220	0.2	13	—	<10	—	—	—	—	—	2.1	0.25	—	0.08	0.56	528
240	0.1	13	—	<10	—	—	—	—	—	1.9	0.09	—	0.03	0.47	521
120	0.1	11	—	<10	—	—	—	—	—	2.1	0.06	—	0.02	0.68	335
170	0.2	15	—	100	—	—	—	—	—	1.0	0.03	—	0.01	0.55	435
11	<0.1	8.3	1	10	<1	<10	3	63	<10	2.9	—	0.07	—	0.82	148
40	0.1	9.2	1	20	<1	<3.00	<1	160	5.00	1.8	—	0.07	—	0.2	251
180	0.1	15	—	<10	—	—	—	—	—	4.1	0.12	—	0.04	1.1	460
160	0.1	12	—	<10	—	—	—	—	—	3.2	0.09	—	0.03	1.0	414
110	0.2	15	—	<10	—	—	—	—	—	2.4	0.31	—	0.10	0.18	394
24	0.1	9.1	—	<10	—	—	—	—	—	1.5	0.09	—	0.03	0.6	194
34	<0.1	10	1	<10	<1	60	1	6	10	2.4	—	0.05	—	0.22	261
23	0.1	9.5	1	20	<1	20	<1	4	7.00	5.3	—	0.07	—	0.1	262
36	0.1	9.9	2	20	<1	7.00	<1	12	6.00	4.5	—	0.05	—	<0.1	298
130	0.2	14	—	<10	—	—	—	—	—	2.5	0.12	—	0.04	0.09	444
190	0.1	11	—	<10	—	—	—	—	—	1.0	0.25	—	0.08	0.4	473
160	0.2	13	—	<10	—	—	—	—	—	1.8	0.21	—	0.07	0.53	511
160	0.1	13	—	<10	—	—	—	—	—	2.2	0.12	—	0.04	0.5	477
71	0.1	11	—	<10	—	—	—	—	—	1.7	0.09	—	0.03	0.6	283
130	0.2	13	—	110	—	—	—	—	—	0.6	0.09	—	0.03	0.02	388
73	0.1	13	1	140	<1	10	<1	35	20	3.9	—	0.04	—	<0.1	459
21	<0.1	11	1	<10	<1	40	1	19	<10	2.0	—	0.02	—	0.17	256
57	0.1	12	1	40	<1	20	<1	24	30	23	—	0.03	—	<0.1	410
68	0.2	13	—	<10	—	—	—	—	—	2.5	0.03	—	0.01	<0.1	475
23	0.1	9.8	—	<10	—	—	—	—	—	2.1	0.06	—	0.02	0.13	327
14	0.1	12	2	<10	<1	20	1	11	20	3.4	—	0.16	—	0.27	222
25	0.2	14	2	<10	<1	<10	4	4	10	2.8	—	0.14	—	<0.1	396
11	0.1	9.6	2	20	<1	30	1	17	20	4.3	—	0.13	—	0.14	173
15	0.2	12	2	30	<1	100	7	32	10	1.9	—	0.12	—	<0.1	302
35	0.1	11	3	30	<1	30	<1	30	10	1.4	—	0.09	—	0.31	225
96	0.2	11	4	30	<1	8.00	6	52	6.00	3.1	—	0.16	—	0.33	371
							Silver Creek basin								
120	0.2	11	—	<10	—	—	—	—	—	1.6	0.03	—	0.01	0.59	328
160	0.1	3.0	—	<10	—	—	—	—	—	6.6	0.12	—	0.04	1.5	439
180	0.2	14	—	<10	—	—	—	—	—	5.2	0.03	—	0.01	2.7	507
190	0.3	1.6	—	<10	—	—	—	—	—	9.6	0.52	—	0.17	0.01	557
190	0.2	13	—	<10	—	—	—	—	—	2.8	0.09	—	0.03	1.3	547
210	0.1	13	—	<10	—	—	—	—	—	3.3	0.06	—	0.02	1.6	562
200	0.2	13	—	<10	—	—	—	—	—	3.2	0.03	—	0.01	1.7	505
190	0.3	20	—	100	—	—	—	—	—	7.0	0.4	—	0.13	0.00	575
96	0.2	44	23	140	<1	<10	3	29	300	1	—	0.06	—	0.1	473
140	0.2	18	7	50	7	20	5	74	1200	2.2	—	0.03	—	<0.1	434
200	0.3	29	17	70	1	20	<1	120	220	1.3	—	0.08	—	<0.1	607

Table 13.—Chemical analyses of selected water samples from the drainage basins of

SITE NO.	DATE	STREAM-FLOW, INSTANTANEOUS (FT^3/S)	TEMPERATURE (DEG C)	SPECIFIC CONDUCTANCE	PH (UNITS)	HARDNESS (MG/L AS CACO3)	HARDNESS, NONCARBONATE (MG/L CACO3)	ALKALINITY FIELD (MG/L AS CACO3)	ALKALINITY LAB (MG/L AS CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	POTASSIUM, DISSOLVED (MG/L AS K)	CHLORIDE, DISSOLVED (MG/L AS CL)
						Drain Tunnel Creek and Provo River basins								
37	05-26-71	545	7.0	155	7.7	78	—	80	—	23	5.0	1.7	0.6	2.2
	08-26-71	2.5	11.5	315	7.4	150	—	160	—	43	11	5.6	2.0	6.6
	08-08-72	2.0	22.5	245	7.9	110	—	110	—	29	8.6	5.5	1.5	5.9
38	06-14-71	1,200	10.0	105	7.2	46	46	—	—	14	2.8	1.4	0.7	2.5
	08-26-71	110	12.0	190	7.6	92	—	94	—	27	6.0	2.5	1.3	2.1
39	03-29-71	179	3.0	190	7.9	62	62	—	—	25	—	—	—	—
	04-22-71	650	5.0	185	—	94	11	83	—	27	6.4	2.4	—	—
	05-21-71	916	7.0	150	8.1	76	—	80	—	23	4.5	2.1	—	—
	05-26-71	1,930	9.0	105	7.8	54	5	49	—	17	2.7	1.6	0.7	1.7
	06-14-71	1,250	8.0	98	7.4	46	46	—	—	14	2.6	1.4	0.7	2.1
	04-26-72	590	4.0	200	—	67	—	91	—	27	—	—	—	—
	06-01-72	1,950	7.5	70	8.0	33	33	—	—	9.6	2.1	1.4	0.5	1.8
	08-09-72	54	17.0	205	7.8	95	1	94	—	28	6.2	3.5	1.2	2.8
	09-12-72	57	10.0	250	7.8	120	12	110	—	35	8.4	4.2	1.3	4.0
	09-14-72	55	10.0	255	7.9	130	19	110	—	37	8.8	4.0	1.3	3.3
56	04-26-72	15	6.5	590	7.8	280	170	110	—	84	18	13	1.9	23
	06-01-72	12	10.5	690	7.7	330	330	—	—	96	21	14	2.3	21
	07-20-72	20	14.0	690	7.8	340	200	140	—	100	21	13	3.2	20
	09-14-72	13	8.0	680	8.1	330	200	130	—	99	20	13	2.6	18
57	04-26-72	4.0	8.0	1,340	7.5	770	720	48	—	260	29	32	5.1	15
	06-01-72	4.0	20.0	1,590	7.6	910	910	—	—	310	34	27	4.9	15
	07-20-72	3.0	21.0	1,830	7.1	1,100	1,100	51	—	380	41	31	6.2	17
	09-14-72	3.5	15.6	1,780	7.6	1,100	1,000	63	—	370	38	28	4.7	17
58	08-26-71	15	13.5	320	7.7	150	49	100	—	45	8.8	4.5	1.5	4.2
	03-02-72	100	4.0	370	8.4	180	72	110	—	53	12	5.6	1.6	8.2
	04-26-72	600	5.0	230	7.9	120	19	98	—	35	7.1	3.3	0.9	4.3
	09-14-72	70	10.5	445	8.0	220	110	110	—	65	13	7.4	1.7	7.4

SULFATE DIS-SOLVED (MG/L AS SO4)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	ARSENIC DIS-SOLVED (UG/L AS AS)	BORON, DIS-SOLVED (UG/L AS B)	CADMIUM DIS-SOLVED (UG/L AS CD)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	ZINC, DIS-SOLVED (UG/L AS ZN)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2)	PHOS-PHATE, ORTHO, DIS-SOLVED (MG/L AS PO4)	PHOS-PHORUS, DIS-SOLVED (UG/L AS P)	PHOS-PHORUS, ORTHO, DIS-SOLVED (MG/L AS P)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
							Drain Tunnel Creek and Provo River basins								
<.2	<.01	4.7	—	<10	—	—	—	—	—	3.1	0.03	—	0.01	0.26	85
6.5	—	—	—	—	—	—	—	—	—	12	—	—	—	—	168
10	—	18	—	—	—	—	—	—	—	2.6	—	—	—	—	142
5.3	—	—	—	—	—	—	—	—	—	—	—	—	—	0.22	27
8.0	0.5	13	—	<10	—	—	—	—	—	4.4	0.06	—	0.02	0.11	115
—	—	—	—	—	—	—	—	—	—	2.0	—	—	—	—	74
11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	96
5.8	—	—	—	—	—	—	—	—	—	1.2	—	—	—	—	83
6.8	0.2	6.1	—	<10	—	—	—	—	—	1.5	0.03	—	0.01	0.18	66
3.5	—	—	—	—	—	—	—	—	—	—	—	—	—	0.15	24
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	81
6.0	0.1	5.2	—	40	—	200	—	10	—	—	—	—	—	0.19	27
8.9	—	14	—	—	—	—	—	—	—	2.8	—	—	—	—	119
13	—	15	—	—	—	—	—	—	—	3.3	—	—	—	—	145
13	—	15	—	—	—	—	—	—	—	2.8	—	—	—	—	151
150	0.4	24	—	<10	—	220	—	190	—	3.5	0.06	—	0.02	0.07	384
190	0.4	22	—	60	—	80	—	130	—	—	—	—	—	0.14	367
190	0.4	25	—	<10	—	80	—	130	—	4.3	0.31	—	0.10	0.05	457
200	—	24	—	—	—	—	8	—	150	1.9	—	—	—	—	451
720	0.7	16	—	220	—	180	—	260	—	3.0	0.03	—	0.01	0.35	1,110
870	0.6	19	—	250	—	80	—	150	—	—	0.46	—	0.15	0.03	1,280
1,100	0.7	17	—	290	—	80	6	130	50	7.8	0.37	—	0.12	0.03	1,620
990	—	19	—	—	—	—	5	—	50	3.1	—	—	—	—	1,500
58	—	—	—	—	—	—	—	—	—	3.8	—	—	—	—	181
62	—	14	—	—	—	—	—	—	—	0.9	—	—	—	—	225
23	—	8.7	—	—	—	—	—	—	—	2.2	—	—	—	—	136
96	—	17	—	—	—	—	—	—	—	2.2	—	—	—	—	276

LOCATION: See explanation of well-, spring-, tunnel-, and stream-site numbering system.
DISCHARGE: GAL/MIN, gallons per minute; e, estimated.
SPECIFIC CONDUCTANCE: Microsiemens per centimeter at 25 °Celsius.
TEMPERATURE: DEG C, degrees Celsius.

LOCATION	DATE	DIS-CHARGE INSTAN-TANEOUS (GAL/MIN)	TEMPER-ATURE (DEG C)	SPE-CIFIC CON-DUCT-ANCE	PH (UNITS)	HARD-NESS (MG/L AS CACO3)	HARD-NESS, NONCAR-BONATE (MG/L CACO3)	ALKA-LINITY FIELD (MG/L AS CACO3)	ALKA-LINITY LAB (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)
						Unconsolidated valley fill								
(D- 1- 3)13adc- 1	08-12-83	—	9.0	960	7.4	440	190	—	250	120	33	20	0.8	140
24aaa- 1	07-28-83	40e	8.0	920	7.8	340	36	—	310	99	23	53	0.9	74
(D- 1- 4) 9bbb- 1	08-25-83	—	13.0	2,250	7.5	200	20	—	180	59	12	340	4.1	550
9caa- 1	08-23-83	2	11.0	550	7.6	230	15	—	220	66	17	24	2.5	44
10bcc- 1	08-18-83	—	13.0	450	7.7	180	6	—	170	52	12	19	3.4	36
16aad- 1	06-16-83	—	11.0	600	7.7	94	—	—	200	25	7.6	90	4.0	61
16acb- 1	08-23-83	—	9.5	500	7.9	190	—	—	200	52	14	36	2.6	39
19bab- 1	08-12-83	—	11.5	1,290	6.9	530	300	—	230	170	25	37	0.6	250
19bca- 1	05-24-63	—	—	520	7.8	260	39	220	—	84	12	17	0.8	30
29dcc- 1	08-16-83	—	13.0	650	7.1	320	170	—	150	90	23	8.2	1.1	12
33aab-S1	08-23-83	44	15.0	610	7.6	250	8	—	240	70	18	30	3.4	39
35cad-S1	08-14-83	13	15.0	1,160	8.0	510	200	—	310	140	38	56	1.1	160
(D- 2- 4) 2aac-S1	08-23-83	72	20.0	1,750	7.6	990	740	—	250	290	64	38	1.8	32
4dcc- 1	05-09-68	—	8.0	740	7.4	400	400	—	—	110	30	7.9	1.9	15
9cbb-S1	06-19-63	—	—	280	8.0	160	160	—	—	40	15	0.5	0.5	10
24adb-S1	09-15-83	90	11.0	970	7.2	520	360	—	170	160	30	12	1.9	16
(D- 2- 5)17bca-S1	08-31-83	3e	14.5	380	7.8	160	4	—	150	46	10	16	5.6	23
31ada- 1	05-17-67	—	8.5	950	7.6	450	450	—	—	140	25	20	3.1	84
						Igneous rocks								
(D- 1- 4) 8bbd-S1	08-25-83	3.0	14.0	570	7.7	220	15	—	200	68	11	24	4.0	51
16dca- 1	05-24-63	—	—	445	7.8	200	46	150	—	52	16	22	2.4	43
34dcd-S1	08-23-83	45	18.0	550	8.4	230	6	—	230	62	19	27	3.3	40
35aca-S1	07-18-83	8.8	11.5	395	7.6	150	26	—	120	44	9.9	17	3.1	36
(D- 2- 5) 5ccd-S1	09-13-67	200e	14.0	350	7.7	150	150	—	—	40	11	15	4.6	28
6cca-S1	08-31-83	3e	13.0	420	7.6	170	8	—	160	50	11	17	2.7	27
6cdb- 1	05-17-67	—	9.0	690	7.9	280	280	—	—	81	19	30	2.9	85
21ccd-S1	09-15-83	9	15.0	1,360	8.4	730	530	—	200	190	63	34	4.3	38
29cad-S1	09-13-67	4	14.0	1,250	7.7	680	680	—	—	190	50	33	0.7	32
	09-15-83	4	19.0	1,360	8.2	730	550	—	180	200	55	33	2.2	32
31bba- 1	10-25-83	100	16.0	420	8.3	190	14	—	170	57	11	12	1.3	16
32bbc- 2	06-08-50	—	—	—	—	420	420	—	—	130	24	12	—	60
						Frontier Formation								
(A- 1- 3)28ddd-S1	08-30-83	2.5	11.5	570	7.8	280	11	—	270	92	12	9.8	1.9	11
34cbd-S1	08-29-83	2.3	10.0	740	8.0	330	15	—	320	110	14	23	2.3	32
35bbb-S1	08-29-83	3.2	18.0	780	8.0	330	—	—	340	100	20	28	3.2	33
						Preuss Sandstone								
(D- 1- 3)10aab- 1	12-19-66	—	—	640	7.7	290	290	—	—	72	26	36	2.0	38
						Twin Creek Limestone								
(D- 1- 3)36aad-S1	07-28-83	1,680	6.0	330	7.6	160	—	—	170	50	8.8	4.7	0.8	3.8
(D- 1- 4)17bbb- 1	01-02-63	—	—	450	8.0	210	53	160	—	54	19	12	1.5	13
						Nugget Sandstone								
(D- 1- 4)19cac-1	11-17-83	55	10.5	460	7.5	250	33	—	220	80	13	9.7	1.3	22
30bbb-S1	08-22-83	14.0	10.0	500	7.5	240	22	—	220	73	15	11	1.5	14
30bbc-S1	08-16-83	.5	9.5	185	6.3	66	9	—	57	19	4.4	9.7	0.9	12
30bbd- 1	08-16-83	—	9.0	220	6.9	86	8	—	78	25	5.8	10	1.3	14
30cad- 1	08-03-83	110	11.0	500	7.2	220	13	—	210	63	16	15	1.4	17
31aac- 2	05-09-68	—	9.0	225	7.0	100	100	—	—	26	9.7	6.8	0.4	7.1
31bcb-S1	06-14-83	70e	7.0	375	6.7	170	10	—	160	58	6.0	8.7	1.1	16
32daa- 1	06-10-83	—	9.0	290	6.4	110	32	—	78	31	7.9	11	1.1	16
33bbd-S1	08-29-83	10	11.5	600	6.8	240	100	—	140	64	20	19	2.7	25
(D- 2- 5)17cda-S1	08-31-83	15	20.0	560	8.5	240	13	—	230	68	17	21	2.8	35
						Ankareh Formation								
(D- 1- 3)12cbd- 1	10-13-66	—	—	620	7.4	280	280	—	—	79	20	28	2.0	22
(D- 1- 4)35dbb- 1	08-22-83	—	10.5	500	8.0	210	21	—	190	50	21	18	7.2	20
						Thaynes Formation								
(D- 1- 3)13abb- 1	08-08-83	600	—	640	7.3	280	42	—	240	75	23	22	1.0	13
14bcd-S1	06-23-83	400	7.0	430	7.4	230	120	—	110	76	10	7.4	0.7	8.7
(D- 2- 4) 4dca-S1	09-13-67	700e	8.0	690	7.4	340	340	—	—	100	23	5.8	1.0	10
	08-22-83	1,030	9.5	720	7.4	340	16	—	190	93	27	11	1.5	24
5cdd-S1	09-01-83	10	9.0	420	7.9	190	81	—	110	50	16	6.2	0.8	3.8
8cab-S1	09-09-82	1,100	6.0	370	7.6	170	38	—	130	44	14	3.2	0.5	2.8
	06-02-83	5,800	5.5	310	7.2	160	10	—	150	47	9.9	3.0	0.6	2.5
	08-22-83	1,300	5.5	315	7.7	170	27	—	140	44	14	3.3	0.5	2.7
8dab-S1	07-29-83	2,800	5.5	370	7.8	180	14	—	160	52	11	3.6	0.9	3.0
(D- 2- 5)33ada-S1	02-24-84	1,600	15.5	370	7.7	170	2	—	170	42	17	5.3	1.3	5.9
(D- 3- 5) 6bab- 2	08-15-67	—	15.5	305	7.1	140	140	—	—	42	9.7	4.4	1.5	5.2
						Woodside Shale								
(D- 2- 4)23cbc-S1	09-15-83	5	8.0	530	8.1	260	23	—	240	77	16	9.5	1.4	10
						Weber Quartzite								
(D- 2- 4)22abc-S1	08-22-83	45e	11.0	215	7.4	90	12	—	78	26	6.0	5.9	1.4	6.5
36aaa- 1	01-09-84	27	15.0	260	6.9	120	21	—	100	39	6.3	7.3	1.1	11
						Drain tunnels								
(D- 2- 4) 8dba	08-03-79	4,000	9.5	870	7.9	530	390	140	—	150	37	5.9	2.2	4.4
	05-14-80	4,100	9.0	830	7.8	460	320	140	—	130	34	5.4	1.7	4.3
	02-25-83	2,600	8.5	1,000	8.4	580	440	—	140	170	38	6.3	1.9	4.1
(D- 2- 4) 8dbd	02-24-83	1,450	9.0	830	7.1	440	300	—	140	110	41	6.2	2.0	4.8
24aca	02-15-83	5,400	10.0	910	7.2	450	350	—	100	130	31	8.3	1.6	10
24cad	09-09-83	22	10.5	790	6.6	420	290	—	130	130	23	9.6	1.6	11

SULFATE DIS- SOLVED (MG/L AS SO4)	FLUO- RIDE, DIS- SOLVED (MG/L AS F)	SILICA, DIS- SOLVED (MG/L AS SIO2)	ARSENIC DIS- SOLVED (UG/L AS AS)	BORON, DIS- SOLVED (UG/L AS B)	CADMIUM DIS- SOLVED (UG/L AS CD)	IRON, DIS- SOLVED (UG/L AS FE)	LEAD, DIS- SOLVED (UG/L AS PB)	MANGA- NESE, DIS- SOLVED (UG/L AS MN)	ZINC, DIS- SOLVED (UG/L AS ZN)	CARBON DIOXIDE DIS- SOLVED (MG/L AS CO2)	PHOS- PHATE, ORTHO, DIS- SOLVED (MG/L AS PO4)	PHOS- PHORUS, DIS- SOLVED (MG/L AS P)	PHOS- PHORUS, ORTHO, DIS- SOLVED (MG/L AS P)	NITRO- GEN, NO2+NO3 DIS- SOLVED (MG/L AS N)	SOLIDS, SUM OF CONSTI- TUENTS, DIS- SOLVED (MG/L)
							Unconsolidated valley fill								
41	0.1	17	1	<20	<1	10	1	<1	60	19	—	0.04	—	2.9	521
48	0.2	23	1	110	<1	10	<1	4	300	9.4	—	<0.01	—	5.5	505
31	0.4	43	2	<20	<1	1,100	<1	120	70	11	—	<0.01	—	0.11	1,150
9.8	0.4	48	4	<20	<1	10	<1	2	20	11	—	0.04	—	u.63	344
9.2	0.3	53	1	<20	<1	10	1	10	210	6.7	—	0.04	—	0.66	289
13	0.5	49	8	<20	<1	<10	1	1	80	7.6	—	0.02	—	0.82	368
11	0.3	50	8	<20	<1	330	3	74	40	4.9	—	0.05	—	<0.1	326
43	0.2	24	1	<20	<1	10	<1	<1	40	55	—	0.02	—	4.9	686
25	0.1	9.0	—	110	—	—	<1	—	1,200	6.8	—	—	—	—	312
190	<0.1	12	<1	<20	<1	60	3	7	280	23	—	0.01	—	0.66	425
24	0.2	51	2	<20	<1	30	<1	32	<10	12	—	0.12	—	<0.1	380
72	0.3	41	1	<20	<1	<10	<1	540	<10	5.9	—	0.15	—	<0.1	693
770	0.4	31	7	100	—	20	1	1,600	110	12	—	0.03	—	<0.1	1,380
200	0.2	12	—	10	—	—	—	—	—	13	—	—	—	—	480
15	0.1	8..	—	120	—	—	—	—	—	2.5	—	—	—	—	170
350	0.4	19	9	<20	14	<10	33	16	<10	21	—	<0.01	—	0.21	690
11	0.2	61	2	<20	<1	30	<1	56	<10	4.7	—	0.04	—	0.21	264
220	0.9	20	—	—	—	—	—	—	—	7.2	—	—	—	—	602
							Igneous rocks								
14	0.2	51	3	<20	<1	70	1	150	10	7.7	—	0.05	—	0.13	343
15	0.2	32	-	130	—	—	<1	—	180	4.5	—	—	—	—	271
23	0.2	30	2	<20	<1	10	<1	5	10	1.7	—	0.19	—	<0.1	341
18	0.2	57	2	<20	<1	<10	6	2	10	6.1	—	0.11	—	0.41	260
8.8	0.2	52	—	<20	—	—	—	—	—	5.1	—	—	—	—	238
13	0.3	59	3	<20	<1	10	<1	8	20	7.9	—	0.03	—	<0.1	277
29	0.4	39	—	—	—	—	—	—	—	4.8	—	—	—	—	404
510	1.1	23	<1	<20	<1	<10	<1	140	10	1.5	—	<0.01	—	<0.1	983
510	0.7	33	—	<20	—	—	—	—	—	7.0	—	—	—	—	958
540	0.5	35	<1	<20	<1	<10	<1	2	10	2.2	—	<0.01	—	<0.1	1,010
18	0.1	21	<1	<20	<1	<10	3	33	10	1.7	—	0.03	—	<0.1	241
130	<0.1	22	—	—	—	—	—	—	—	—	—	—	—	—	484
							Frontier Formation								
18	0.2	12	2	<20	<1	10	<1	12	<10	8.2	—	0.15	—	<0.1	318
35	0.2	16	2	<20	<1	<10	1	23	<10	6.1	—	0.09	—	<0.1	423
24	0.3	17	3	<20	<1	<10	<1	12	<10	6.6	—	0.11	—	<0.1	432
							Preuss Sandstone								
65	0.8	19	-	130	—	—	<1	—	<10	10	—	—	—	—	417
							Twin Creek Limestone								
5.6	0.1	7.6	1	10	1	6	1	1	8	8.1	—	0.02	—	0.22	181
46	0.2	12	-	<20	—	—	<1	—	180	3.2	—	—	—	—	256
							Nugget Sandstone								
14	0.2	13	1	<20	<1	50	1	44	<10	13	—	0.01	—	0.1	285
30	<0.1	11	1	<20	<1	10	<1	6	<10	14	—	0.04	—	0.16	289
13	<0.1	12	1	10	<1	140	5	8	10	55	—	0.01	—	0.25	105
15	<0.1	13	<1	<20	<1	440	1	23	10	19	—	0.02	—	<0.1	131
34	0.1	12	<1	<20	<1	100	2	32	<10	26	—	0.05	—	0.26	285
4.5	0.1	17	—	<20	—	—	-	—	—	19	—	—	—	—	131
10	<0.1	11	4	<20	<1	60	1	5	20	62	—	0.03	—	0.26	207
31	<0.1	14	3	<20	<1	80	3	10	120	60	—	0.03	—	0.63	159
110	8.1	15	1	<20	<1	10	<1	3	<10	43	—	0.01	—	0.44	339
18	0.1	37	3	<20	<1	<10	<1	2	10	1.4	—	0.12	—	<0.1	335
							Ankareh Formation								
62	0.5	12	-	220	—	—	<1	—	20	19	—	—	—	—	373
36	0.2	52	2	<20	<1	940	<1	86	20	3.7	—	0.03	—	<0.1	319
							Thaynes Formation								
75	0.1	12	<1	<20	<1	50	<1	2	20	23	—	0.03	—	0.26	365
15	0.1	8.8	1	<20	<1	8	<1	1	<10	8.8	—	0.02	—	26	195
190	0.3	14	—	<20	—	—	—	—	—	13	—	—	—	—	447
150	0.1	14	2	<20	<1	<10	<1	<1	10	14	—	0.03	—	2.5	432
93	<0.1	12	4	<20	<1	<10	<1	2	<10	2.7	—	<0.01	—	0.28	248
25	<0.1	6.9	1	110	<1	<10	<1	<1	<10	6.3	—	0.04	—	0.31	175
11	<0.1	7.1	2	<10	<1	40	<1	3	30	18	—	0.02	—	0.17	170
22	<0.1	6.8	1	<10	<1	<10	<1	<1	<10	5.4	—	0.03	—	0.28	178
27	<0.1	200	2	<10	<1	<10	<1	<1	20	4.9	—	0.01	—	0.45	394
17	0.3	14	1	10	<1	<10	<1	<1	<10	6.7	—	0.02	—	0.27	207
44	—	14	—	—	—	—	—	—	—	15	—	—	—	—	180
							Woodside Shale								
37	<0.1	17	<1	<20	<1	<10	<1	2	<10	3.6	—	<0.01	—	<0.1	309
							Weber Quartzite								
17	<0.1	11	2	10.	—	170	1	370	10	6.0	—	0.03	—	1.4	121
13	0.1	23	1	10.	<1	<10	25	130	210	25	—	0.01	—	<0.1	162
							Drain tunnels								
400	0.2	6.5	—	<20	—	—	—	—	—	3.4	0.15	—	0.05	0.14	690
330	0.2	16	—	<20	—	—	—	—	—	4.3	0.03	—	0.01	0.19	606
440	0.2	17	12	<20	<1	<10	<1	32	120	1.1	—	0.01	—	0.12	762
310	0.2	16	33	<20	<1	50	<1	18	60	22	—	0.01	—	<0.1	574
360	0.4	18	5	<20	7	2,000	3	1,800	6,800	12	—	0.02	—	0.21	630
280	0.4	22	<1	<20	<1	70	<1	470	310	62	—	<0.01	—	<0.1	555

Statistics are: First line--number of samples
Second line--minimum value of constituent or physical property
Third line--maximum value of constituent or physical property
Fourth line--median value of constituent or physical property
Temperature: DEG C, degrees Celsius
Specific Conductance: Microsiemens per centimeter at 25 °Celsius.

TEMPERATURE (DEG C)	SPECIFIC CONDUCTANCE	PH (UNITS)	HARDNESS (MG/L AS CACO3)	HARDNESS NONCARBONATE (MG/L CACO3)	ALKALINITY (MG/L AS CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	POTASSIUM, DISSOLVED (MG/L AS K)	CHLORIDE, DISSOLVED (MG/L AS CL)	SULFATE DISSOLVED (MG/L AS SO4)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)
Statistics													
Unconsolidated valey fill													
16	18	18	18	16	15	18	18	18	18	18	18	18	18
8	280	6.9	94	4	150	25	7.6	0.5	0.5	10	9.2	<.1	8.5
20	2,250	8.0	990	740	310	290	64	340	5.6	550	770	0.5	61
11.2	695	7.6	290	180	220	87	20	22	1.9	39	36	0.25	24
Igneous rocks													
10	11	11	12	12	8	12	12	12	11	12	12	12	12
9.0	350	7.6	150	6	120	40	9.9	12	0.7	16	8.8	<.1	21
19.0	1,360	8.4	730	550	230	200	63	34	4.6	85	540	1.1	59
14.5	550	7.8	225	98	190	65	18	23	2.9	37	20	0.2	34
Frontier Formation													
3	3	3	3	2	3	3	3	3	3	3	3	3	3
10	570	7.8	280	11	270	92	12	9.8	1.9	11	18	0.2	12
18	780	8.0	330	15	340	110	20	28	3.2	33	35	0.3	17
11.5	740	8.0	330	13	320	100	14	23	2.3	32	24	0.2	16
Preuss Sandstone													
--	1	1	1	1	--	1	1	1	1	1	1	1	1
--	--	--	--	--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--	--	--	--	--
--	640	7.7	290	290	--	72	26	36	2.0	38	65	0.8	19
Twin Creek Limestone													
1	2	2	2	1	2	2	2	2	2	2	2	2	2
--	330	7.6	160	--	160	50	8.8	4.7	0.8	3.8	5.6	0.1	7.6
--	450	8.0	210	--	170	54	19	12	1.5	13	46	0.2	12
6.0	390	7.8	185	53	165	52	13.9	8.4	1.15	8.4	25.8	0.15	9.8
Nuggett Sandstone													
10	10	10	10	10	9	10	10	10	10	10	10	10	10
7	185	6.3	66	8	57	19	4.4	6.8	0.4	7.1	4.5	<0.1	11
20	600	8.5	250	100	230	80	20	21	2.8	35	110	0.2	17
9.8	418	6.95	195	17.5	160	60.5	11.4	10.5	1.3	16	16.5	<0.1	13
Ankareh Formation													
1	2	2	2	2	1	2	2	2	2	2	2	2	2
--	500	7.4	210	21	--	50	20	18	2.0	20	36	0.2	12
--	620	8.0	280	280	--	79	21	28	7.2	22	62	0.5	52
10.5	560	7.7	245	150	190	64	20.5	23	4.6	21	49	0.35	32
Thaynes Formation													
10	11	11	11	11	9	11	11	11	11	11	11	10	11
5.5	305	7.1	140	2	110	42	9.7	3.0	0.5	2.5	11	<0.1	6.8
15.5	720	7.9	340	340	240	100	27	22	1.5	24	190	0.3	200
7.5	370	7.4	180	42	150	50	14	5.3	0.9	5.2	27	0.1	12
Woodside Shale													
1	1	1	1	1	1	1	1	1	1	1	1	1	1
--	--	--	--	--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--	--	--	--	--
8.0	530	8.1	260	23	240	77	16	9.5	1.4	10	37	<0.1	17
Weber Quartzite													
2	2	2	2	2	2	2	2	2	2	2	2	2	2
11	215	6.9	90	12	78	26	6.0	5.9	1.1	6.5	13	<0.1	11
15	260	7.4	120	21	100	39	6.3	7.3	1.4	11	17	0.1	23
13	238	7.15	105	16.5	89	32.5	6.15	6.6	1.25	8.8	15	0.1	17
Drain tunnels													
6	6	6	6	6	6	6	6	6	6	6	6	6	6
8.5	790	6.6	420	290	100	110	23	5.4	1.6	4.1	280	0.2	6.5
10.5	1,000	8.4	580	440	140	170	41	9.6	2.2	11	440	0.4	22
9.25	850	7.5	455	335	140	130	35.5	6.25	1.8	4.6	345	0.2	16.5

analyses from aquifers and drain tunnels

ARSENIC DIS-SOLVED (UG/L AS AS)	BORON, DIS-SOLVED (UG/L AS B)	CADMIUM DIS-SOLVED (UG/L AS CD)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	ZINC, DIS-SOLVED (UG/L AS ZN)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2)	PHOS-PHATE, ORTHO, DIS-SOLVED (MG/L AS PO4)	PHOS-PHORUS DIS-SOLVED (MG/L AS P)	PHOS-PHORUS, ORTHO, DIS-SOLVED (MG/L AS P)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
					Statistics							
					Unconsolidated valley fill							
14	17	13	14	15	14	15	18	—	14	—	14	18
<1	<20	<1	<10	<1	<1	<10	2.5	—	<0.01	—	<0.1	170
9	120	14	1100	33	1600	1200	55	—	0.15	—	5.5	1,380
2	<20	<1	10	<1	13	60	10.2	—	0.04	—	.42	453
					Igneous rocks							
7	10	7	7	8	7	8	11	—	7	—	7	12
<1	<20	<1	<10	<1	2	10	1.5	—	<0.01	—	<0.1	238
3	130	<1	70	6	150	180	7.9	—	0.19	—	0.41	1,010
2	<20	<1	<10	<1	8	10	4.8	—	0.03	—	<0.1	342
					Frontier Formation							
3	3	3	3	3	3	3	3	—	3	—	3	3
2	<20	<1	<10	<1	12	<10	6.1	—	0.09	—	<0.1	318
3	<20	<1	10	1	23	<10	8.2	—	0.15	—	<0.1	432
2	<20	<1	<10	<1	12	<10	6.6	—	0.11	—	<0.1	423
					Preuss Sandstone							
—	1	—	—	1	—	1	1	—	—	—	—	1
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	130	—	—	<1	—	<10	10	—	—	—	—	417
					Twin Creek Limestone							
1	2	1	1	2	1	2	2	—	1	—	1	2
—	<10	—	—	<1	—	8.0	3.2	—	—	—	—	181
—	10	—	—	1	—	180	8.1	—	—	—	—	256
1	<10	1	6	<1	1	94	5.6	—	0.02	—	0.22	218
					Nuggett Sandstone							
9	10	9	9	9	9	9	10	—	9	—	9	10
<1	<20	<1	<10	<1	2	<10	1.4	—	0.01	—	<0.1	105
4	10	<1	440	5	44	120	62	—	0.12	—	0.63	339
1	<20	<1	60	1	8	10	22.5	—	0.03	—	0.25	246
					Ankareh Formation							
1	2	1	1	2	1	2	2	—	1	—	1	2
—	<20	—	—	<1	—	20	3.7	—	—	—	—	319
—	220	—	—	<1	—	20	19	—	—	—	—	373
2	120	<1	940	<1	86	20	11.3	—	0.03	—	<0.1	346
					Thaynes Formation							
9	10	9	9	9	9	9	11	—	9	—	9	11
<1	<10	<1	<10	<1	<1	<10	2.7	—	<0.01	—	0.17	170
4	110	<1	50	<1	3	30	23	—	0.04	—	26	447
1	<20	<1	<10	<1	<1	>10	8.8	—	0.02	—	0.28	207
					Woodside Formation							
1	1	1	1	1	1	1	1	—	1	—	1	1
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
<1	<20	<1	<10	<1	2	<10	3.6	—	<0.01	—	<0.1	309
					Weber Quartzite							
2	2	1	2	2	2	2	2	—	2	—	2	2
1	10	—	<10	1	130	10	6.0	—	0.01	—	<0.1	121
2	10	—	170	25	370	210	25	—	0.03	—	1.4	162
1.5	10	<1	85	13	250	110	15.5	—	0.02	—	0.7	142
					Drain tunnels							
4	6	4	4	4	4	4	6	2	4	2	6	6
<1	<20	<1	<10	<1	18	60	1.1	0.03	<0.01	0.01	<0.1	555
33	<20	7	2,000	3	1,800	6,800	62	0.15	0.02	0.05	0.19	762
8.5	<20	<1	60	<1	251	215	8.2	0.09	0.01	0.03	0.13	618

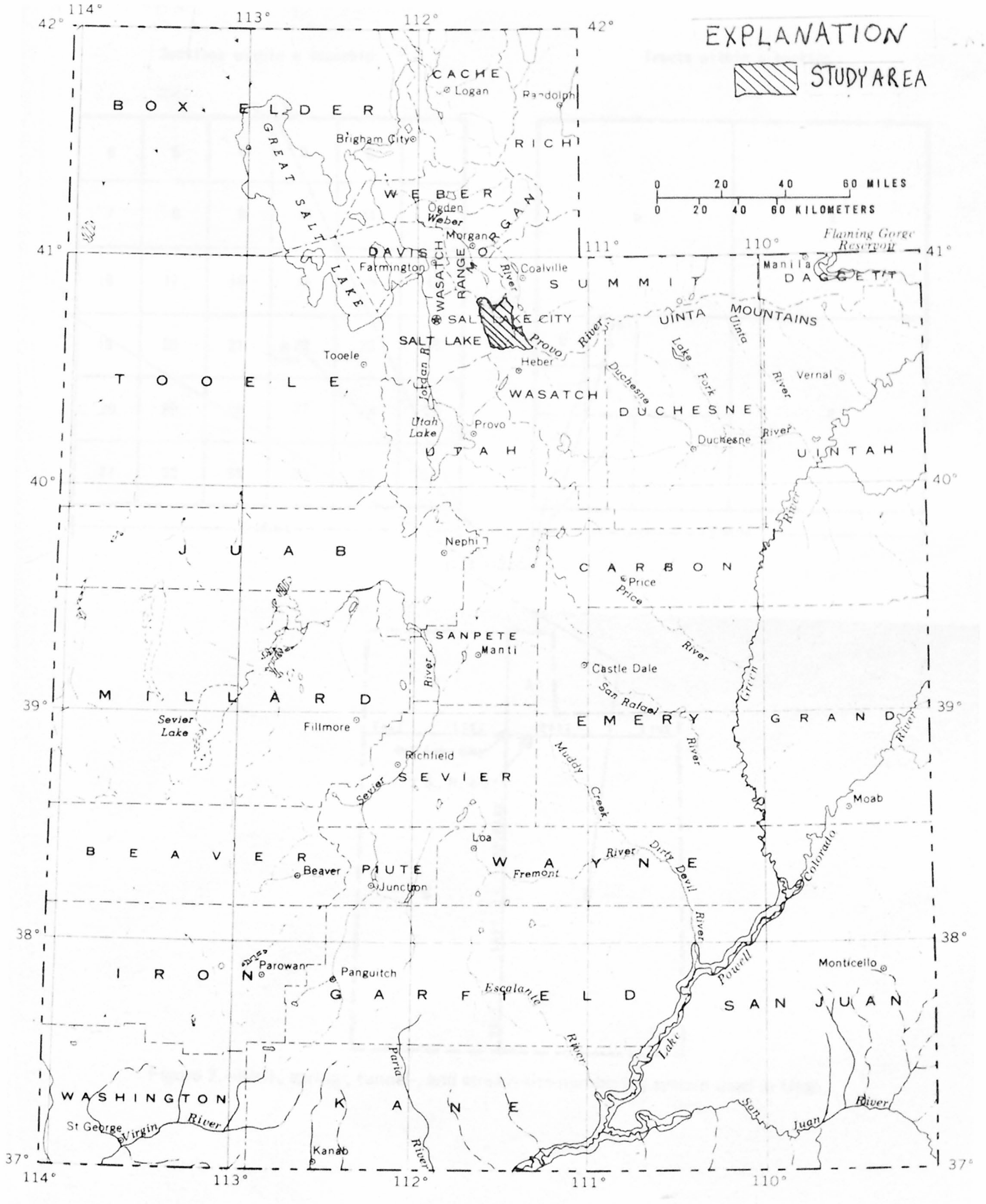

Figure 1. Location of the Park City area.

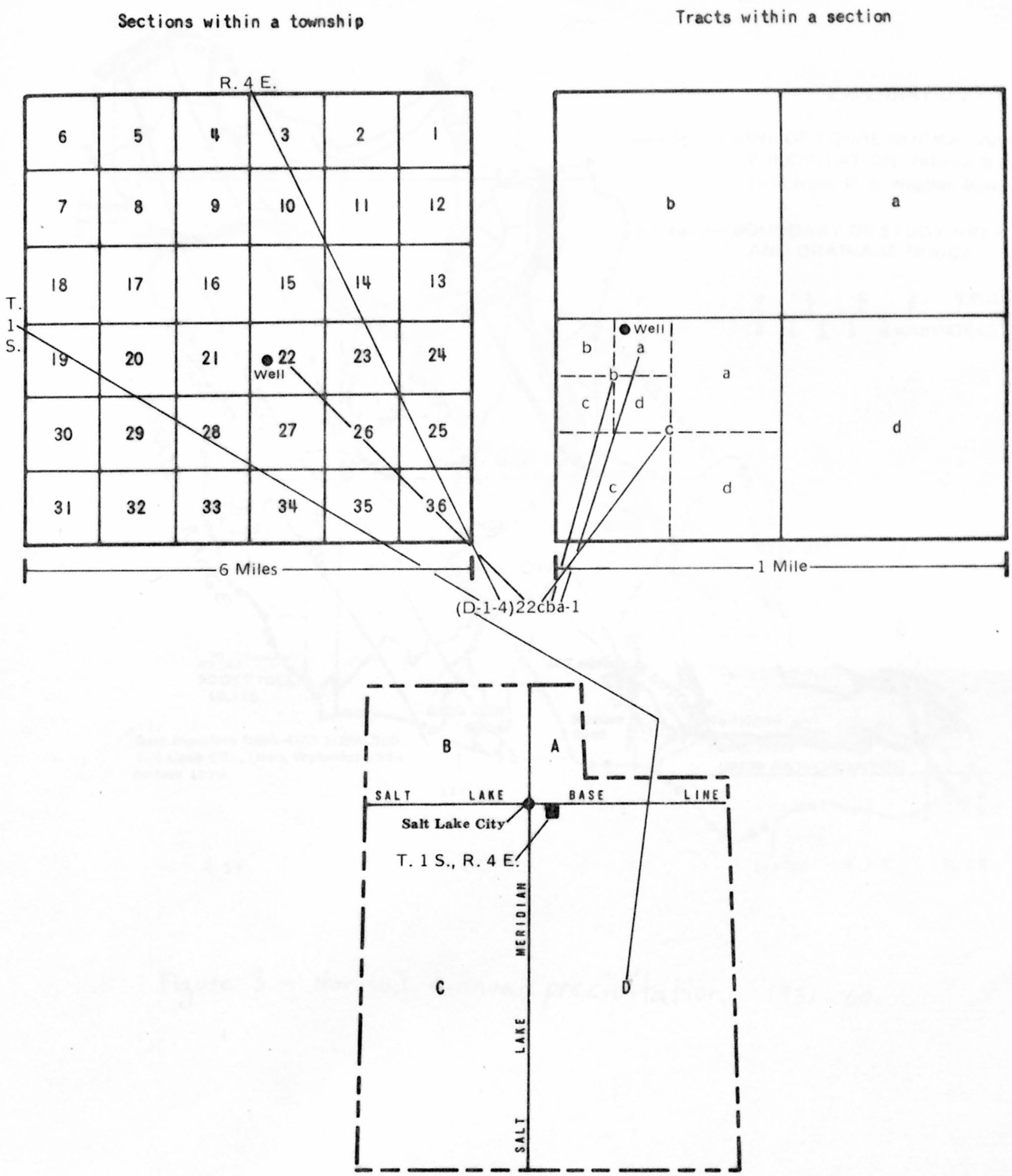

Figure 2.—Well-, spring-, tunnel-, and stream-site-numbering system used in Utah.

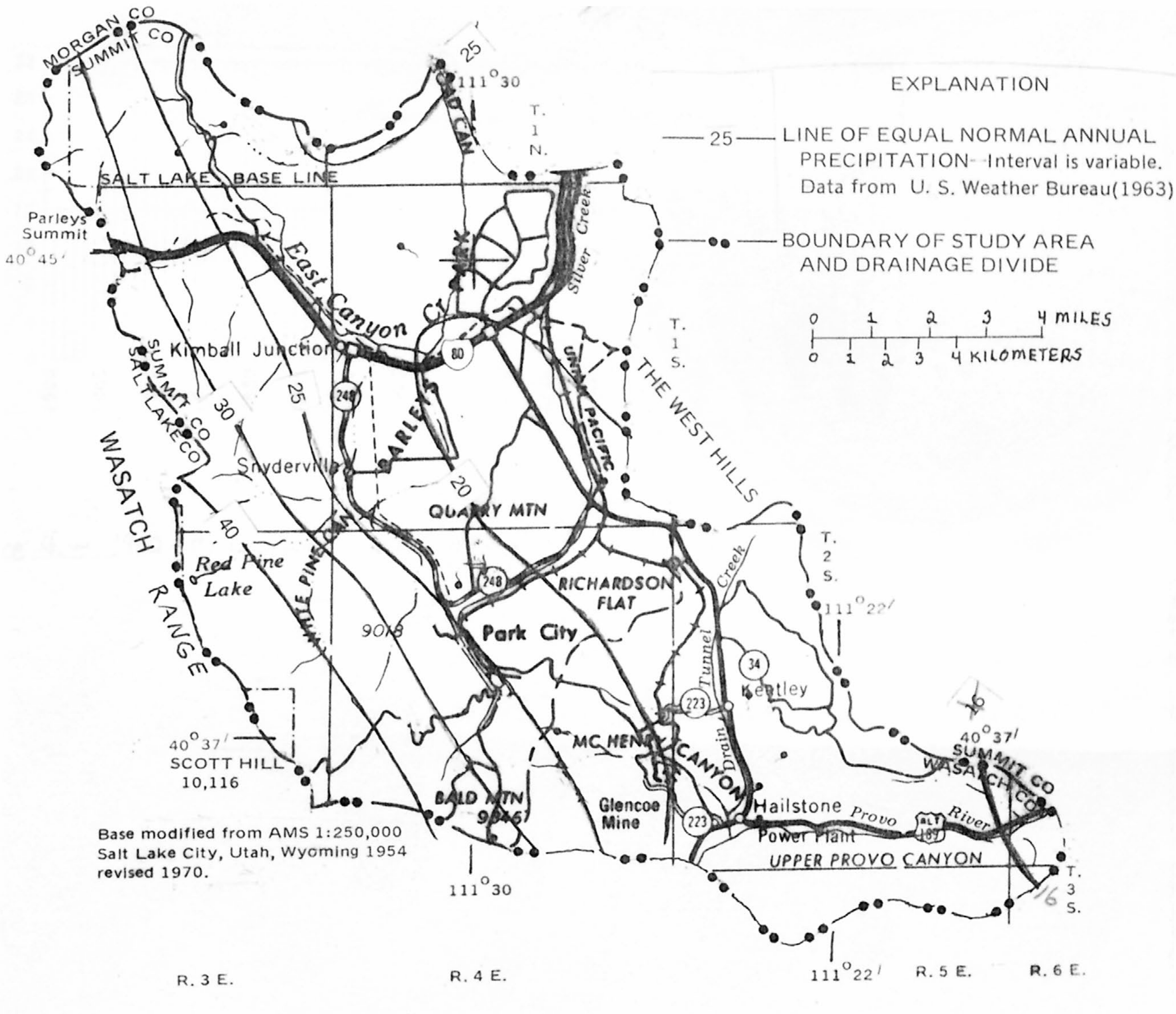

Figure 3.– Normal annual precipitation, 1931-60.

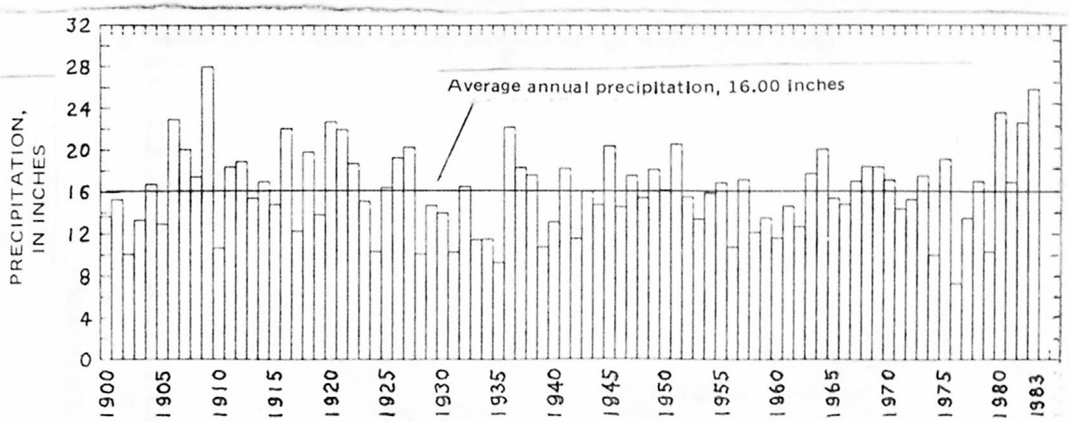

Figure 4.— 1900-83 average annual precipitation at Heber, Utah.

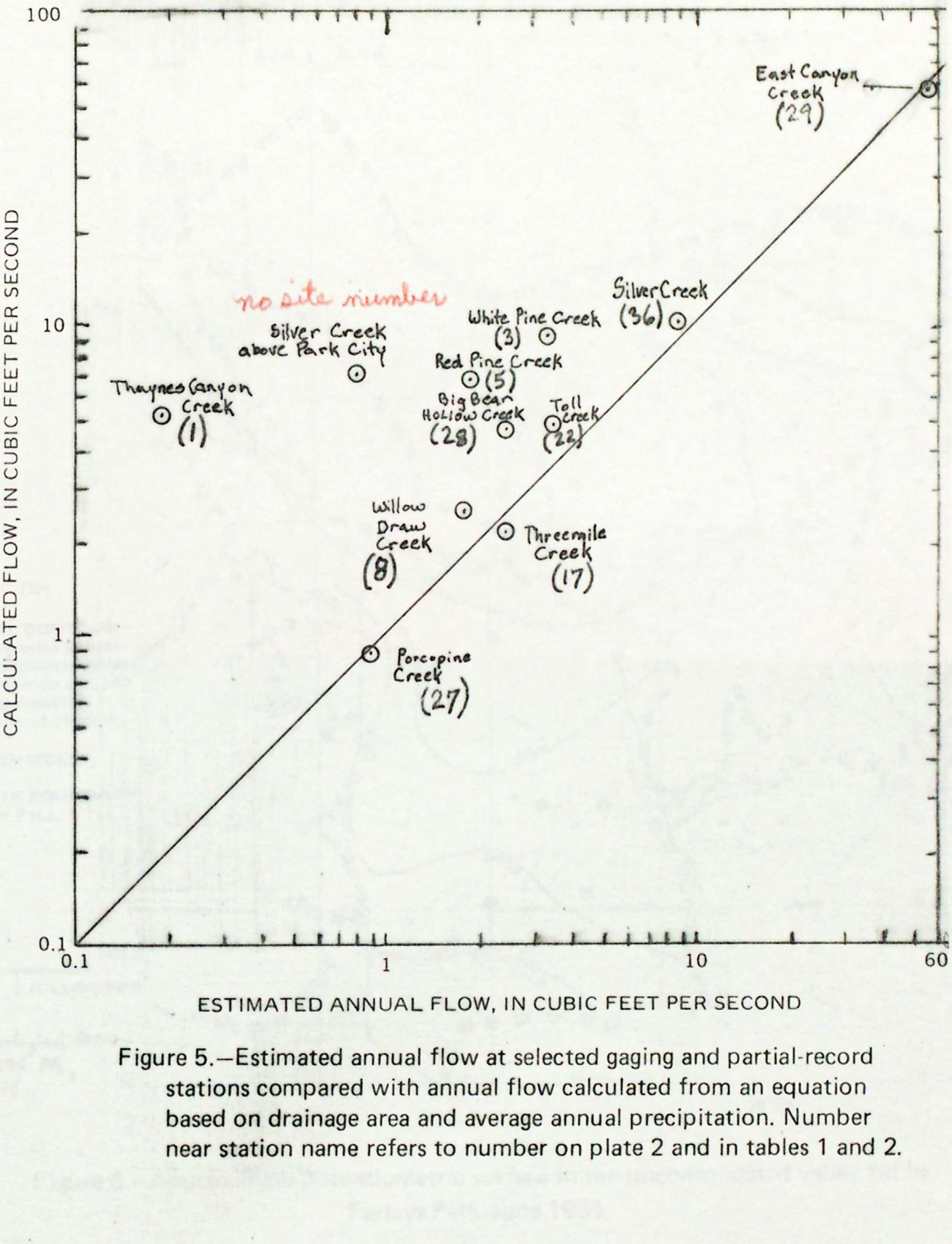

Figure 5.—Estimated annual flow at selected gaging and partial-record stations compared with annual flow calculated from an equation based on drainage area and average annual precipitation. Number near station name refers to number on plate 2 and in tables 1 and 2.

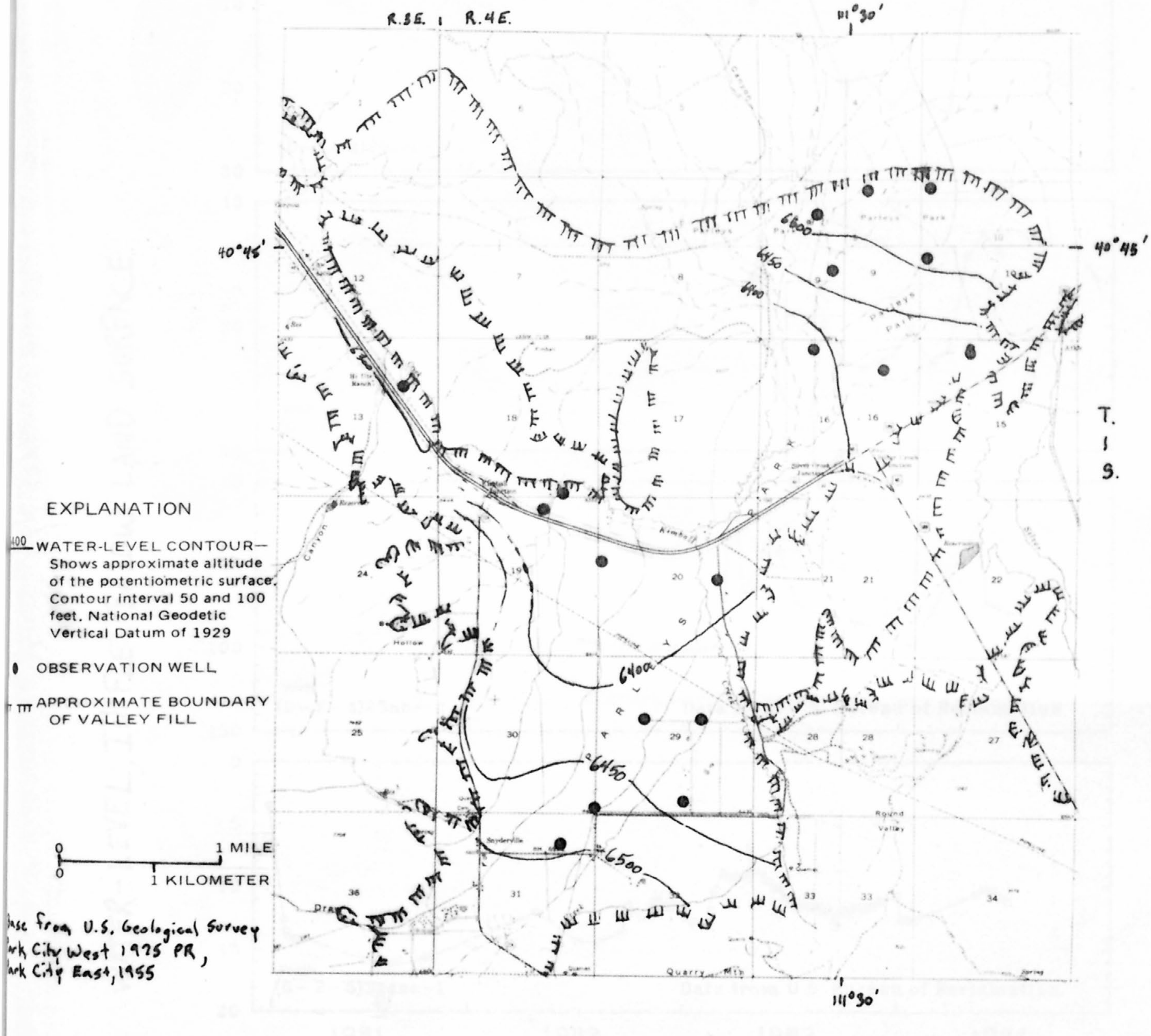

Figure 6.–Approximate potentiometric surface in the unconsolidated valley fill in Parleys Park June 1984.

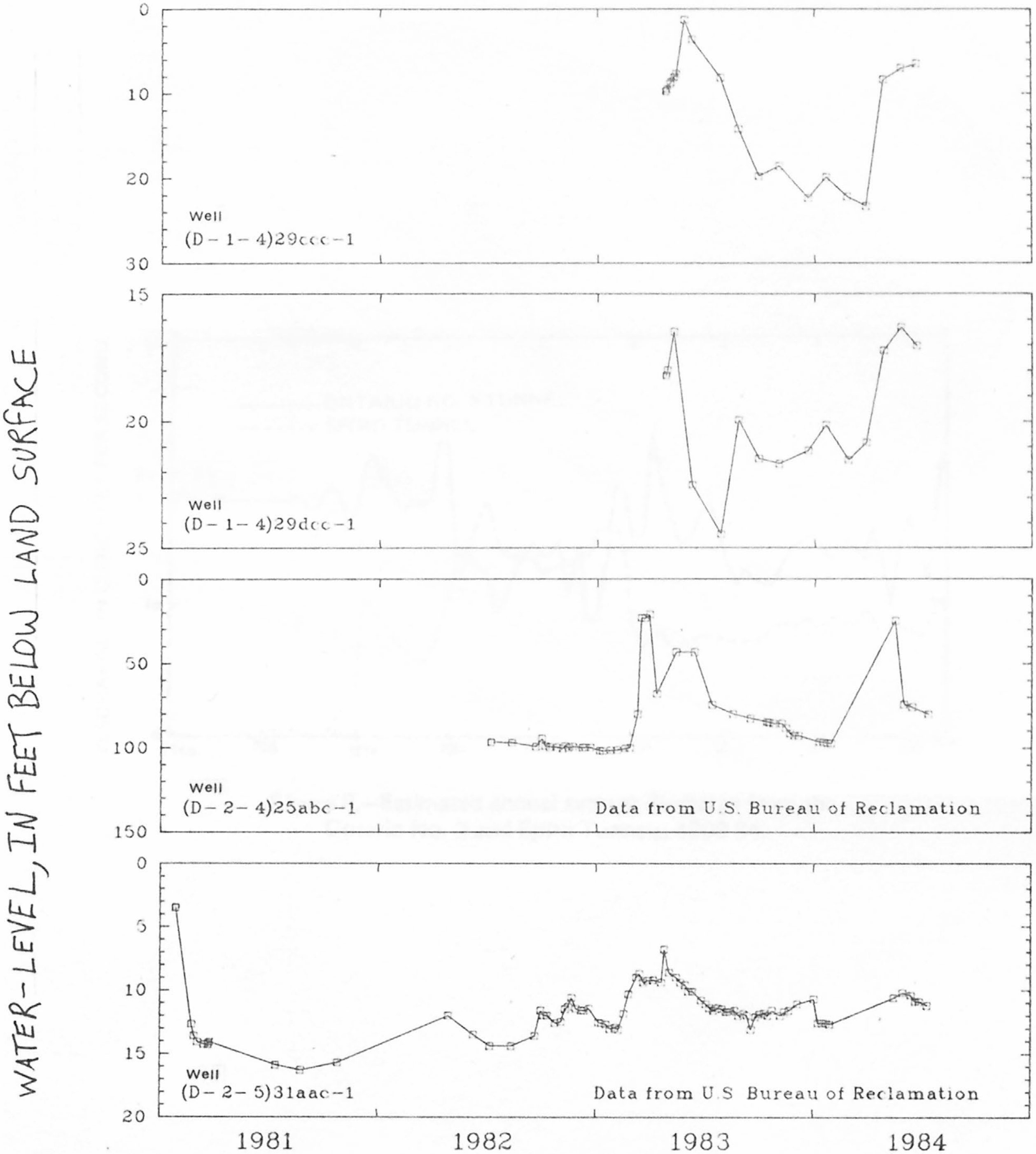

Figure 7.--Water-level fluctuations in four wells completed in the unconsolidated valley fill.

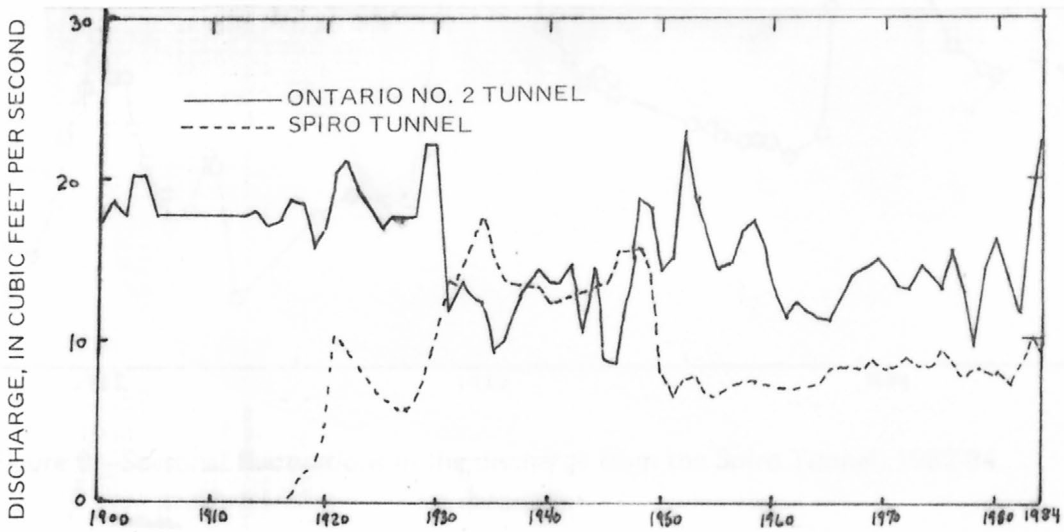

Figure 8.—Estimated annual average discharge from the Ontario No. 2 and Spiro Tunnels, 1900-84.

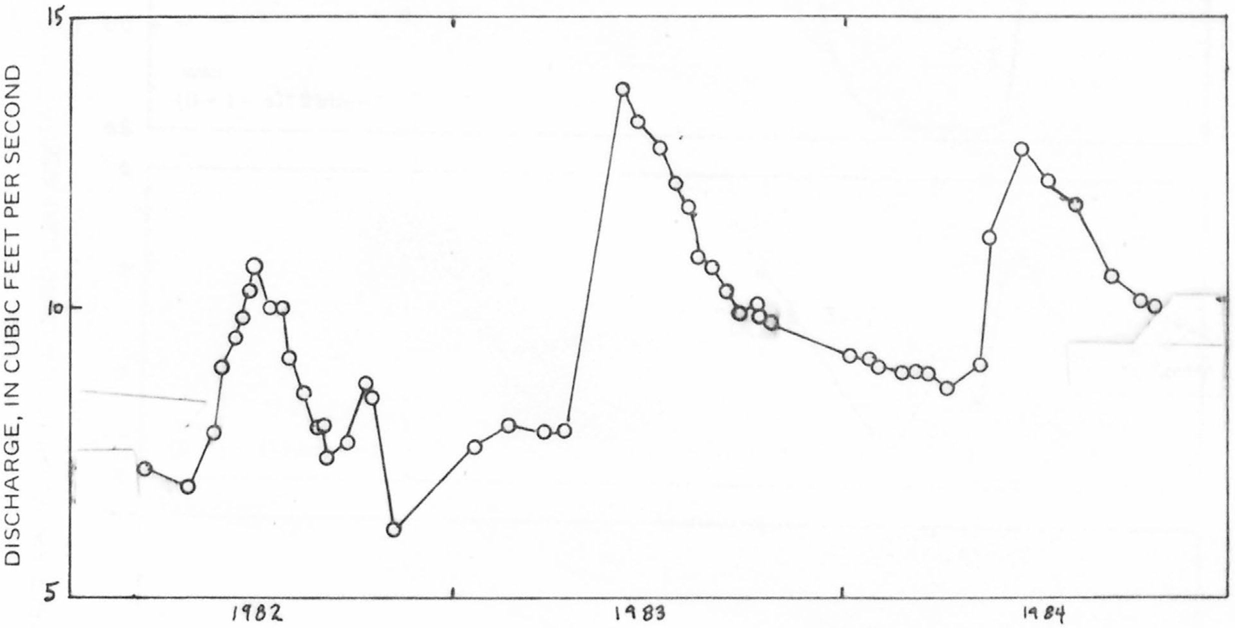

Figure 9.—Seasonal fluctuations in the discharge from the Spiro Tunnel, 1982-84.

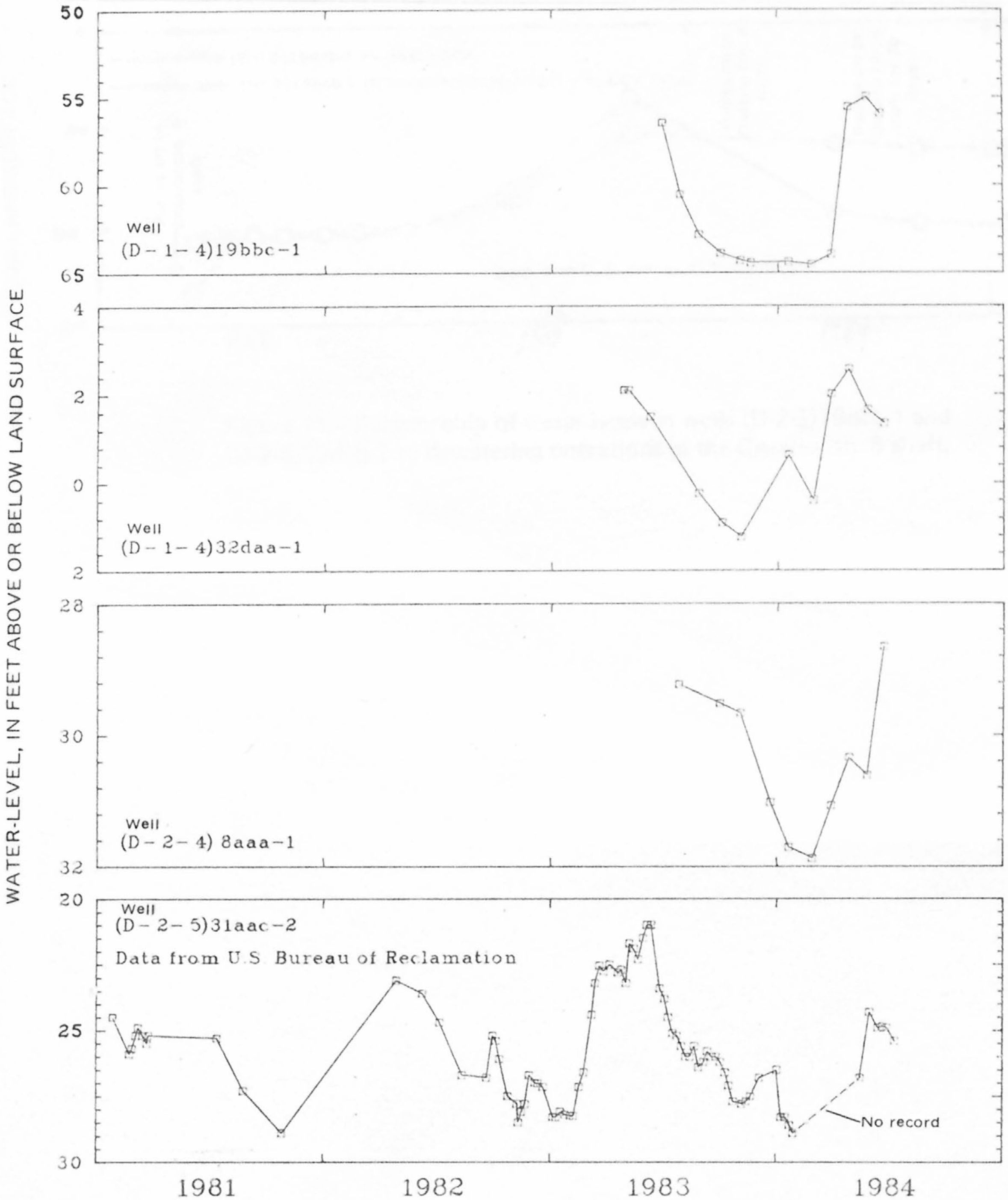

Figure 10.—Water-level fluctuations in four wells completed in the consolidated rocks.

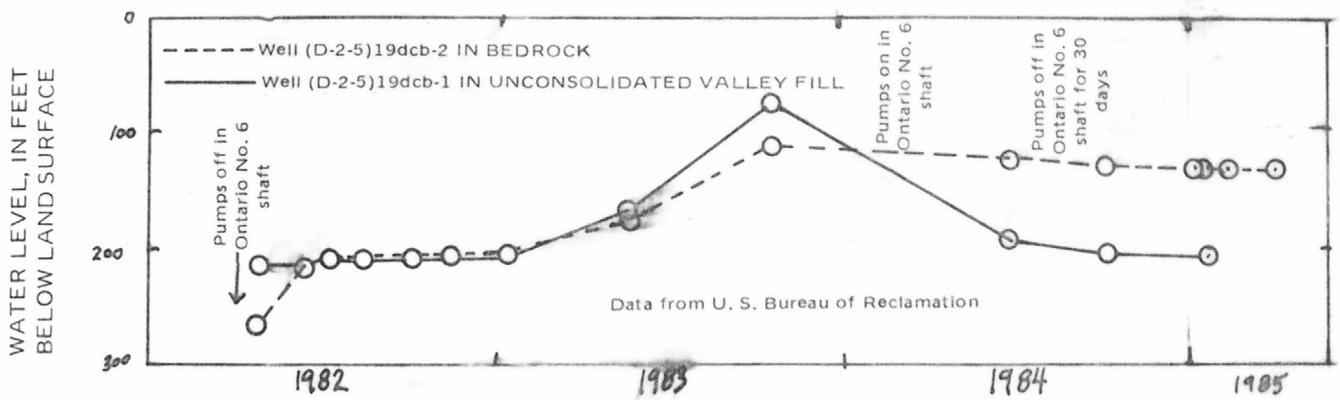

Figure 11.—Relationship of water levels in wells (D-2-5) 19dcb-1 and (D-2-5) 19dcb-2 to dewatering operations in the Ontario No. 6 shaft.

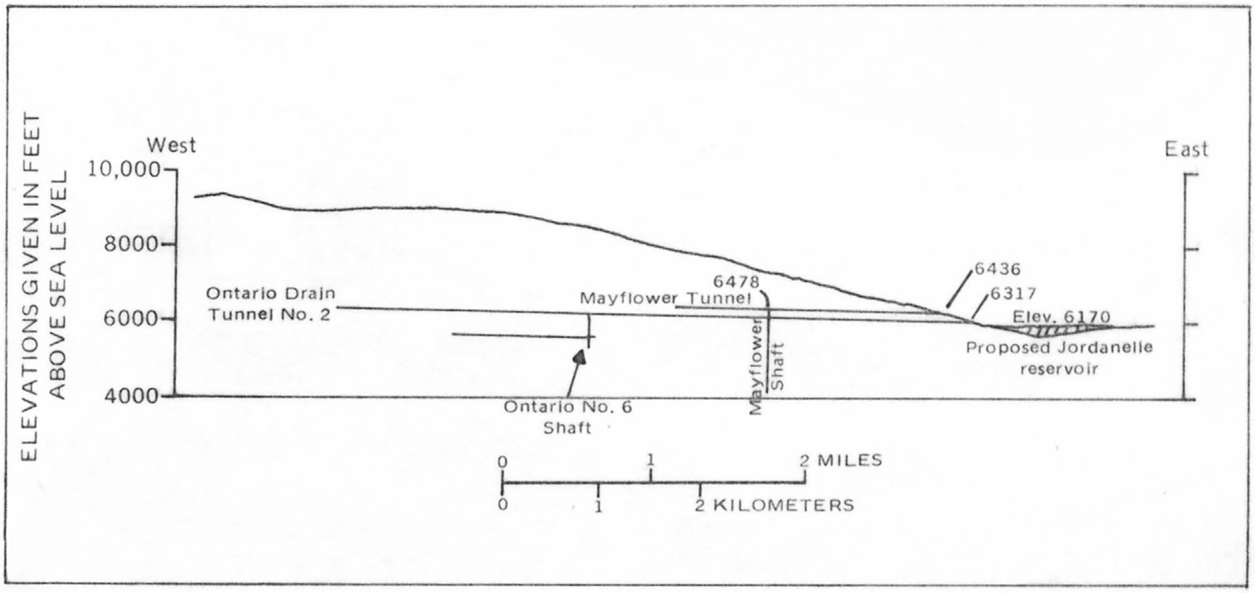

Figure 12.—Generalized section showing relationship of the proposed Jordanelle reservoir to the Mayflower Tunnel and shaft, the Ontario No. 2 Tunnel, and the Ontario No. 6 shaft. (Modified from UINTEX CORP., 1984, fig. 2).