STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

Technical Publication No. 107

HYDROLOGY AND POTENTIAL FOR GROUND-WATER DEVELOPMENT IN SOUTHEASTERN TOOELE VALLEY AND ADJACENT AREAS IN THE OQUIRRH MOUNTAINS, TOOELE COUNTY, UTAH

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Prepared by the
United States Geological Survey
in cooperation with
Tooele City and
Tooele County
1994

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CONVERSION FACTORS, VERTICAL DATUM, ABBREVIATED WATER-QUALITY UNITS, AND GEOGRAPHIC NAME INFORMATION

Multiply	By	To obtain
acre	0.4047	square hectometer
	4,047	square meter
acre-foot	0.001233	cubic hectometer
	1,233	cubic meter
cubic foot per second	0.02832	cubic meter per second
foot	0.3048	meter
foot per day	0.3048	meter per day
foot squared per day[1]	0.0929	meter squared per day
gallon	3.785	liter
gallon per minute	0.06308	liter per second
	0.00006308	cubic meter per second
inch	2.54	centimeter
mile	1.609	kilometer
square mile	2.59	square kilometer

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

$$°F = 1.8\ (°C) + 32.$$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Chemical concentration and water temperature are reported only in metric units. Chemical concentration is reported in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the 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. Specific conductance is reported in microsiemens per centimeter (µS/cm) at 25 degrees Celsius.

Geographic names and locations that are not completely capitalized indicate that no formal name exists for the feature. For example, the water that flows through Settlement Canyon does not have a formal name and is therefore referred to as Settlement Canyon creek.

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[1]This unit is used to express transmissivity, the capacity of an aquifer to transmit water. Conceptually, transmissivity is cubic foot (of water) per day per square foot (of aquifer cross-section) times foot (of aquifer thickness) $[(\text{foot}^3/\text{day})/\text{foot}^2]$foot. In this report, the unit is reduced to its simplest form.

HYDROLOGY AND POTENTIAL FOR GROUND-WATER DEVELOPMENT IN SOUTHEASTERN TOOELE VALLEY AND ADJACENT AREAS IN THE OQUIRRH MOUNTAINS, TOOELE COUNTY, UTAH

By Bernard J. Stolp

ABSTRACT

Communities in southeastern Tooele Valley, Utah, are growing, and future demand for water is expected to increase. To prepare for this demand, local surface- and ground-water resources were evaluated.

Average streamflow in Settlement, Middle, and Soldier Canyons is about 6,000, 2,100, and 3,900 acre-feet per year, respectively. The combined average perennial streamflow of Pine, Pole, Swensons, Leavetts, and Pass Canyons is about 700 acre-feet per year.

Average ground-water recharge to basin-fill deposits in southeastern Tooele Valley is about 44,000 acre-feet per year. Discharge approximately equals recharge. Specific capacity of wells in the basin fill ranges from less than 1 to 180 gallons per minute per foot of drawdown, and dissolved-solids concentration ranges from 363 to 1,550 milligrams per liter.

Stream-channel deposits are recharged mainly by streamflow losses and subsurface inflow. Average discharge from stream-channel deposits in Settlement and Middle Canyons is about 2,100 and 3,400 acre-feet per year, respectively. Specific capacity of wells in the stream-channel deposits ranges from less than 1 to 45 gallons per minute per foot of drawdown, and dissolved-solids concentration ranges from 320 to 350 milligrams per liter.

Average ground-water recharge to consolidated rock is about 42,000 acre-feet per year. Discharge, mainly by subsurface outflow to southeastern Tooele Valley, approximately equals recharge. Locations of springs in consolidated rock are not correlated with known topographic or geologic features. Specific capacity of wells in the consolidated rock ranges from less than 1 to 97 gallons per minute per foot of drawdown, and dissolved-solids concentration ranges from 220 to 1,400 milligrams per liter.

Areas southwest of Tooele City and near Lincoln are considered to have potential for additional ground-water withdrawal.

INTRODUCTION

Communities in southeastern Tooele Valley, Utah, are growing, and future demand for water is expected to increase. To prepare for this demand, the U.S. Geological Survey studied the surface- and ground-water resources of southeastern Tooele Valley and the adjacent Oquirrh Mountains (fig. 1) during 1988-90 in cooperation with Tooele City and Tooele County.

Purpose and Scope

This report provides information needed to determine the ability of local Tooele area water resources to meet future water demands. Information presented in this report includes (1) estimates

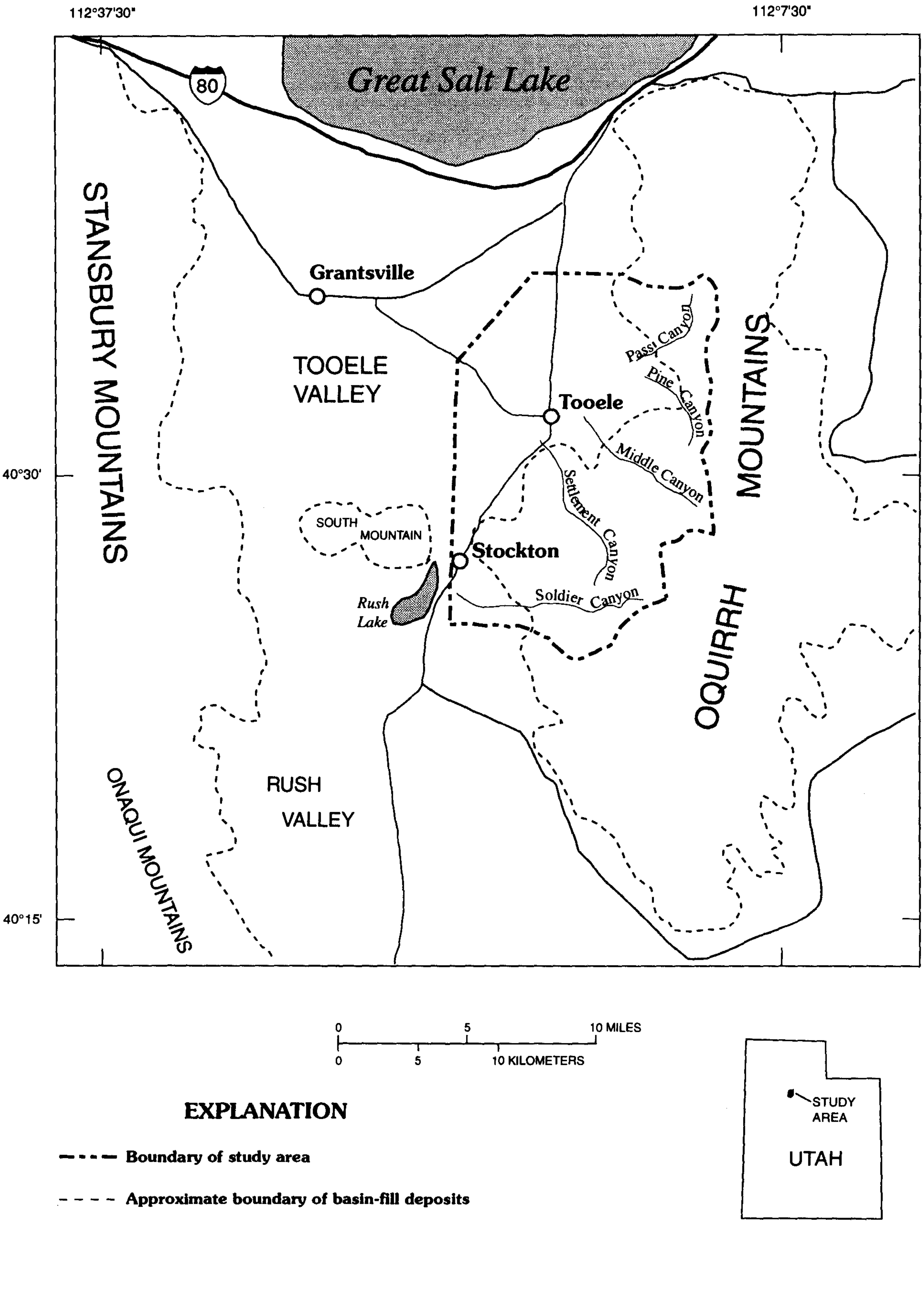


Figure 1. Location of study area.

of streamflow in Settlement, Middle, and Soldier Canyons; (2) the occurrence, movement, yield to wells, and quality of ground water in the basin-fill deposits of southeastern Tooele Valley; (3) the occurrence, movement, yield to wells, and quality of ground water in the stream-channel deposits of Settlement and Middle Canyons; and (4) the yield to wells, location of springs, discharge of tunnels, and quality of ground water in the consolidated rock in the study area. General areas of potential ground-water development are identified on the basis of information derived from the study. Potential surface-water development was not evaluated.

Previous Studies

The first hydrologic reconnaissance of areas included in this study was by Carpenter (1913). Carpenter identified the following features of the hydrologic system of Tooele Valley:

1. Alternate layering of coarse- and fine-grained material in the basin-fill deposits and the presence of ground water under artesian conditions.

2. Identification of the valley fringes, where the basin-fill deposits are coarse grained, as major recharge areas for aquifers in the central parts of the valley.

A study by the U.S. Geological Survey in cooperation with the Utah Division of Water Rights (Thomas, 1946) quantified some of the earlier observations made by Carpenter. Descriptions of materials encountered during well drilling were used to identify and correlate water-bearing strata in the basin-fill deposits of Tooele Valley. A water-level-contour map for the northern part of Tooele Valley was compiled, and seasonal changes in water levels were correlated to ground-water withdrawals and precipitation. Streamflow for Settlement and Middle Canyons was estimated. Information on the occurrence, movement, and discharge, including discharge from several tunnels, of water in the consolidated rocks surrounding Tooele Valley was presented.

The hydrogeology of Middle Canyon was investigated by Gates (1963a). The study dealt specifically with water originating in the canyon and the method of water movement out of the canyon. In addition, the effects of mining in the Oquirrh Mountains on the hydrology of Middle Canyon were discussed.

A study by Gates (1965) reevaluated the ground-water resources of Tooele Valley and estimated a water budget for the principal artesian aquifer system. Aquifer tests were done to quantify the hydraulic properties of the basin-fill deposits, and water-quality data were collected and used to delineate areas of "poor quality" ground water.

In a hydrologic reconnaissance of Rush Valley, Hood and Waddell (1969) discussed a possible hydrologic connection between Rush and Tooele Valleys. Bingham Engineering (1979) used data from Rush and Tooele Valleys to develop a water plan for Tooele County.

An evaluation of ground-water conditions in Tooele Valley also was done by Razem and Steiger (1981). An updated water budget for the principal artesian aquifer system is presented based on longer term surface- and ground-water data, additional aquifer tests, and more detailed analysis of evapotranspiration. Concurrent with this study, test holes were drilled in Tooele Valley to obtain hydrologic and geologic information on the basin-fill deposits (Ryan and others, 1981). In addition, a two-dimensional ground-water-flow model (Razem and Bartholoma, 1980) was used to project future ground-water conditions on the basis of several water-management alternatives (Razem and Steiger, 1981).

A study by the U.S. Soil Conservation Service (1986) includes a water budget for Tooele and Rush Valleys. Average annual streamflow for Settlement, Middle, and Soldier Canyons was estimated.

Description of Study Area

The study area, shown in more detail on plate 1, encompasses an area of about 140 square miles. Altitudes range from more than 10,000 feet at the head of Settlement Canyon to about 4,400 feet near Erda. The numbering system for hydrologic-data sites is shown in figure 2. The physiography, geology, climate, and vegetation of the study area are described in the following paragraphs.

Physiography and Geology

Tooele Valley and adjacent areas in the Oquirrh Mountains lie in the Basin and Range Physiographic Province (Fenneman, 1931). The study area (fig. 1) consists of southeastern Tooele Valley and part of northeastern Rush Valley and the adjacent Oquirrh Mountains.

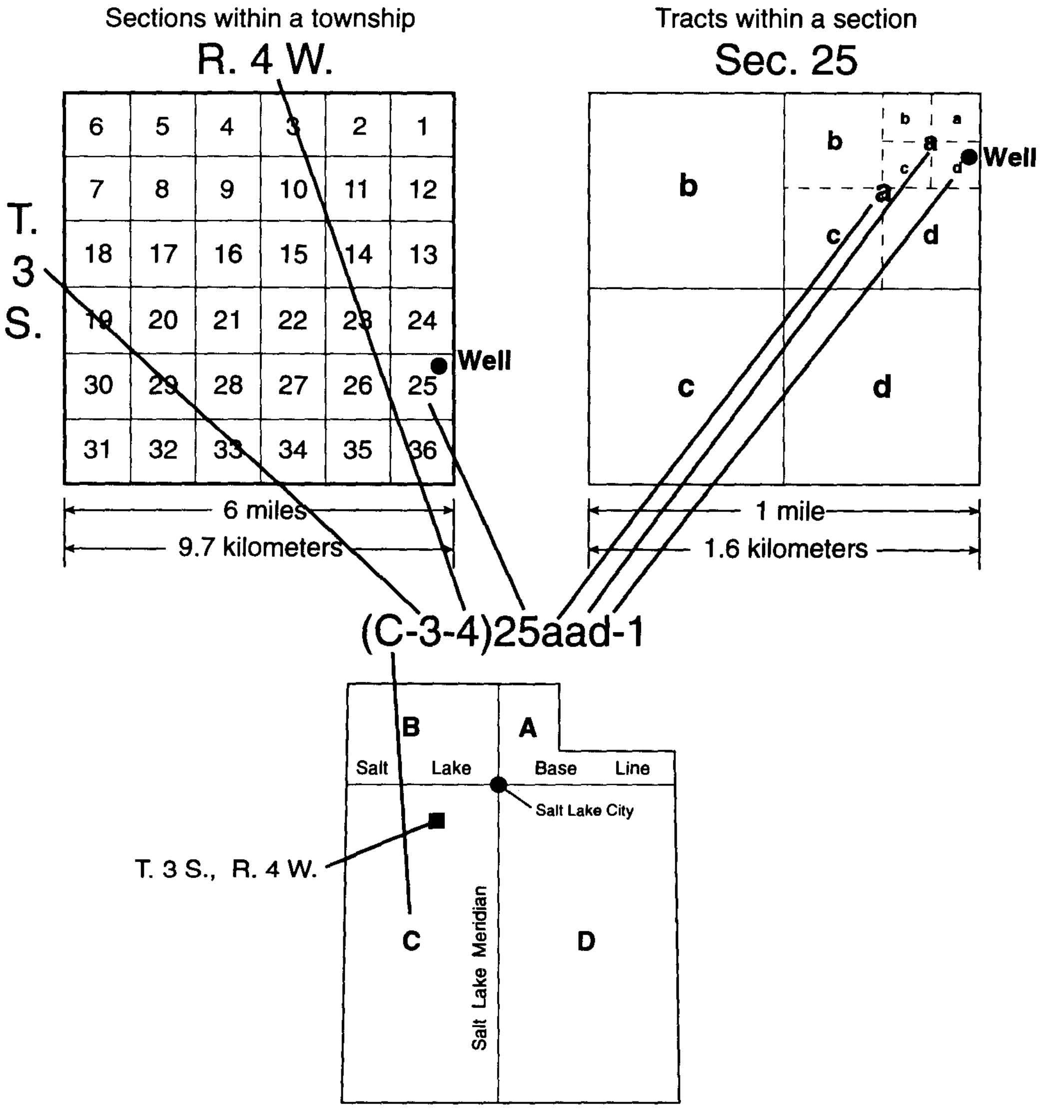
Southeastern Tooele Valley slopes gently from an altitude of about 5,200 feet east of Tooele City to about 4,400 feet at the northern boundary of the study area. The predominant soil type in the valley is described as moderately well drained (Wilson and others, 1975, p. 28). No deeply incised stream channels are present on the valley floor.

The Oquirrh Mountains are generally rugged and have sharp ridges and deep canyons. Areas of flat, meadow-like terrain and gentle hillsides are limited. Soil cover is usually deep and in most cases well drained, and surface runoff and sediment production are low to moderate (Wilson and others, 1975, p. 24-26). Substantial quantities of unconsolidated material are rare and are found in the canyon bottoms as stream-channel deposits or in the upper parts of the canyons as glacial deposits.

The basin fill in southeastern Tooele Valley consists of unconsolidated and semiconsolidated alluvial, colluvial, and lacustrine deposits (Gates, 1965, p. 16; Tooker, 1980). These deposits can rarely be correlated from one valley location to another because of intertonguing and alternate layering (Gates, 1965, p. 17). Thickness of the basin-fill deposits ranges from zero at the mountain fronts to a minimum of 1,500 feet near the northern boundary of the study area (Ryan and others, 1981, p. 20). Thickness of the basin fill in the north-central parts of Tooele Valley has been reported to be greater than 8,000 feet (James M. Montgomery, Consulting Engineers, Inc., 1986, p. 3-1).

The consolidated rock in the study area is almost exclusively in the Oquirrh Mountains. The predominant lithology of the consolidated rock is sandstone, quartzite, and limestone, with some shale and dolomite (Gilluly, 1932, p. 6; Gates, 1963a, p. K8; Tooker, 1980; Tooker and Roberts, 1988, p. 2). The consolidated rock has been subjected to structural deformation that includes faults and joints (Gates, 1963a, p. K12-K15). In limestone, solution openings may have developed along joints (Gates, 1963a, p. K25).

The system of numbering wells and springs in Utah is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating the well or spring, describes its position in the land net. The land-survey system divides the State into four quadrants separated by the Salt Lake Base Line and the Salt Lake Meridian. These quadrants are designated by the uppercase letters A, B, C, and D, indicating the northeast, northwest, southwest, and southeast quadrants, respectively. Numbers designating the township and range, in that order, follow the quadrant letter, and all three are enclosed in parentheses. The number after the parentheses indicates the section and is followed by three letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section—generally 10 acres for a regular section[1]. The lowercase letters a, b, c, and d indicate, respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision. The number after the letters is the serial number of the well, spring, or miscellaneous site within the 10-acre tract. The letter 'S' preceding the serial number designates a spring, and the letter 'M' preceding the serial number designates a miscellaneous stream-measurement or diversion-measurement site. Thus, (C-3-4)25aad-1 designates the first well constructed or visited in the northeast 1/4, northeast 1/4, southeast 1/4, section 25, T. 3 S., R. 4 W., and (C-3-3)16cca-S1 designates a spring in the southwest 1/4, southwest 1/4, northeast 1/4, section 16, T. 3 S., R. 3 W.



[1] Although the basic land unit, the section, is theoretically 1 square mile, many sections are irregular in size and shape. 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. Numbering system for hydrologic-data sites.

Climate

Normal annual precipitation (1960-89) in Tooele City is 18.34 inches (National Oceanic and Atmospheric Administration, annual summaries, 1960-89). Annual precipitation from 1960 through 1989, normal monthly precipitation from 1960 through 1989, and monthly precipitation from January 1987 through December 1989 are shown in figure 3. Annual precipitation from 1980 through 1987 was greater than the 1960-89 normal annual precipitation.

Precipitation during October through April usually comes from frontal-type storms (Jeppson and others, 1968, p. 25). Precipitation from these storms falls over large areas at small to moderate intensity and, in the Oquirrh Mountains, usually falls as snow. During May through September, precipitation is usually from thunderstorms that are more localized and have higher precipitation rates than the frontal-type storms. If thunderstorm precipitation lasts longer than 20 to 30 minutes, surface runoff may occur. In the study area, the months of greatest precipitation are March and April and the months of least precipitation are July and August.

Precipitation in the Oquirrh Mountains is monitored by the U.S. Soil Conservation Service at two locations in Settlement Canyon and one location in Middle Canyon. Information from these stations indicates the seasonal distribution of precipitation in the Oquirrh Mountains is similar to that observed at Tooele, and the quantity is about three times greater than that at Tooele.

Normal annual air temperature (1960-89) at Tooele is 50.8 ^{o}F (National Oceanic and Atmospheric Administration, annual summaries, 1960-89). The coldest temperatures occur in January and the warmest occur in July.

The graph of monthly precipitation from January 1987 through December 1989 at Tooele (fig. 3) indicates the climatic conditions preceding and during the collection of field data. Although annual precipitation during 1987, 1988, and 1989 was near normal, large departures from the 1960-89 normal monthly precipitation occurred. Precipitation during April 1987 was much less than normal and during July 1987 was much greater than normal. June through October 1988 was drier than normal; however, greater-than-normal precipitation occurred during May and November 1988. The monthly distribution of precipitation during 1989 was closer to the 1960-89 normal monthly pattern with the exception of April and December, which were much drier than normal.

Vegetation

The types of vegetation growing in the study area are determined predominantly by temperature and precipitation. The dominant plants on the upper slopes of the Oquirrh Mountains are Douglas fir, yellow pine, spruce, and aspen (Gates, 1963a, p. K5). The mid- and lower-elevation slopes of the Oquirrh Mountains contain juniper, oak, maple, mountain mahogany, and sagebrush. Vegetation in Tooele Valley, where precipitation is less and temperatures are higher than in the mountain areas, includes greasewood and rabbitbrush (Razem and Steiger, 1981, p. 7).

SURFACE-WATER HYDROLOGY

The largest perennial streams in the study area are in Settlement, Middle, and Soldier Canyons. Smaller perennial streams are found in Pine, Pole, Swensons, Leavetts, and Pass Canyons. All these canyons drain areas of the Oquirrh Mountains adjacent to southeastern Tooele Valley and northeastern Rush Valley (pl. 1). Most of the streamflow from Settlement, Middle, and Soldier

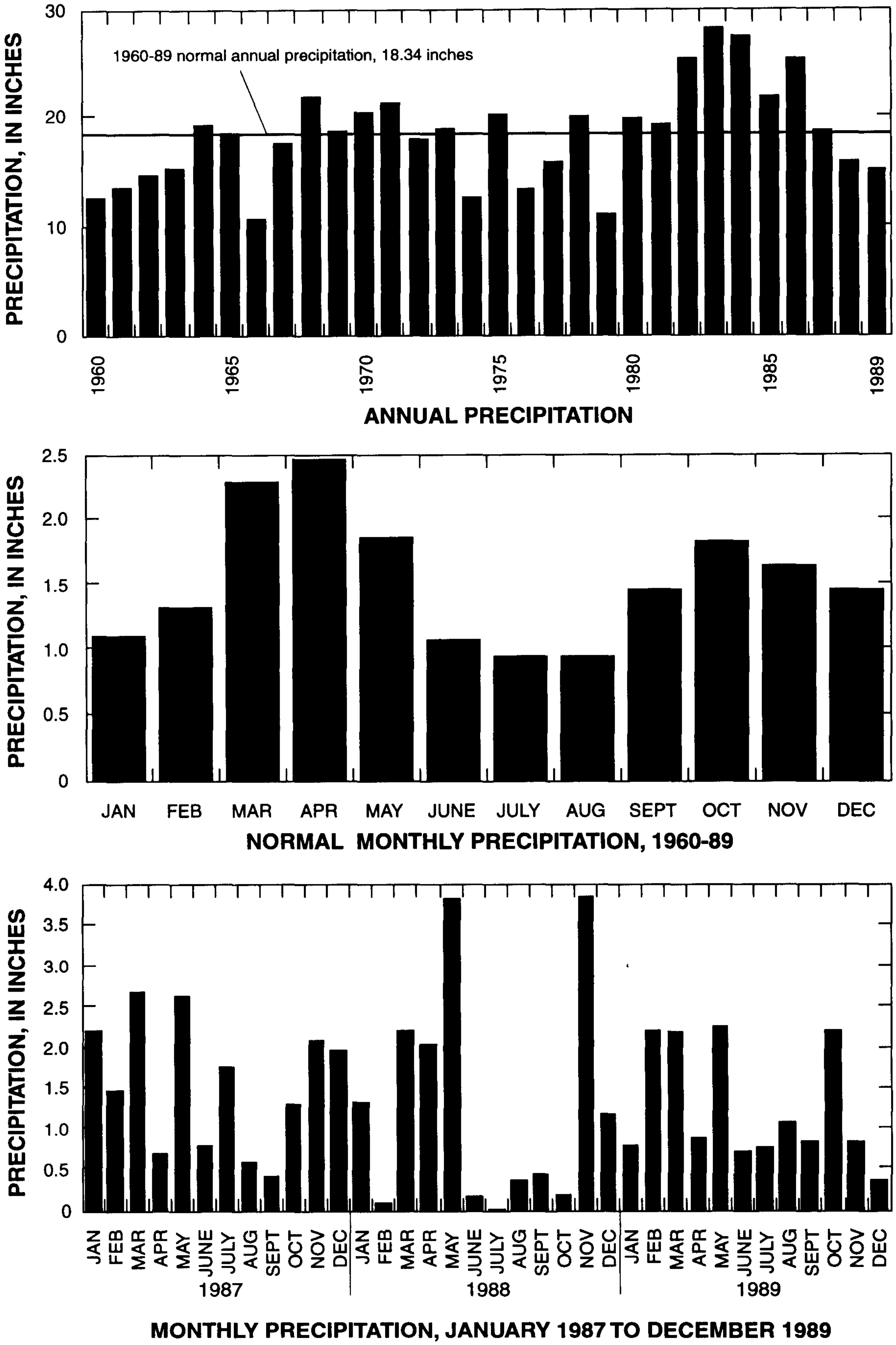


Figure 3. Annual precipitation, 1960-89; normal monthly precipitation, 1960-89; and monthly precipitation, 1987-89; at Tooele, Utah.

Canyons is diverted for irrigation and public-supply uses. The sources of base flow to the perennial streams are springs and tunnels. Average annual streamflows in Settlement, Middle, and Soldier Canyons were estimated and are discussed below. The combined average perennial streamflow, based on limited measurements of spring and tunnel discharge (table 9, at back of report) of Pine, Pole, Swensons, Leavetts, and Pass Canyons, is estimated to be about 700 acre-feet per year.

Settlement Canyon Creek

Settlement Canyon creek is in the central part of the study area (pl. 1) and flows northwestward out of the Oquirrh Mountains toward southeastern Tooele Valley. The size of the Settlement Canyon drainage basin is about 18.4 square miles. Water from the canyon is currently being used by both Settlement Canyon Irrigation Company and Tooele City. Settlement Canyon Reservoir, completed in March 1966, is near the mouth of the canyon and has a storage capacity of about 1,200 acre-feet.

Average annual streamflow in Settlement Canyon creek is estimated to be about 6,000 acre-feet. This estimate represents streamflow at (C-3-4)33dda if no storage, conveyance, or diversion structures were present in the canyon. The U.S. Soil Conservation Service (1986) estimated average annual streamflow for Settlement Canyon creek to be about 5,500 acre-feet. Estimates of annual streamflow in Settlement Canyon creek are listed in table 1.

Table 1. ***Estimated annual streamflow in Settlement Canyon creek at (C-3-4)33dda***

[Location shown on plate 1]

Year	Streamflow (acre-feet)	Year	Streamflow (acre-feet)	Year	Streamflow (acre-feet)
1949	[1]5,400	1956	[1]3,230	1969	[2]7,230
1950	[1]5,080	1957	[1]5,790	1970	[2]5,370
1951	[1]4,020	1958	[1]5,100	1971	[2]7,780
1952	[1]6,110	1959	[1]4,390	1975	[2]6,680
1953	[1]5,130	1960	[1]3,550	1978	[2]6,270
1954	[1]2,960	1961	[1]3,130	1983	[2]12,330
1955	[1]3,590	1968	[2]5,210	1984	[2]18,890
				1989	[3]3,980

[1] Adjusted from measurements made at (C-3-4)33acc.
[2] Adjusted from measurements made at (C-4-4)3bca.
[3] Adjusted from measurements made at U.S. Geological Survey streamflow-gaging station 10172791, (C-4-4)3bbd.

The major perennial sources of streamflow in Settlement Canyon are Rench Spring [(C-3-4)33dda-S1], Left Hand Fork Spring [(C-4-4)2dcc-S1], the spring complex at Spring Flats [(C-4-4)3cab-S1], Greens Tunnel [(C-4-4)10dcd], and Right Hand Fork Spring [(C-4-4)14bbc-S1] (pl. 1 and table 9). Greens Tunnel, a man-made water tunnel, is considered part of the natural streamflow in the canyon, and discharge from the tunnel is included in the streamflow estimates. Snowmelt runoff is a significant component of streamflow in Settlement Canyon creek from April through July.

Measurements of streamflow in Settlement Canyon creek during 1949-61 were made with a 4-foot Parshall flume at (C-3-4)33acc. About 10 percent of Settlement Canyon creek streamflow and all discharge from Rench Spring bypassed the flume through diversions (Daniel Lawrence, Utah Division of Water Resources, retired, written commun., 1990). Average discharge from Rench Spring [(C-3-4)33dda-S1], based on 29 months (March 1954-July 1956) of recorded discharge, was estimated to be about 53 acre-feet per month. Rench Spring discharge and the 10-percent streamflow diversion were added to the Parshall flume measurements to estimate streamflows at (C-3-4)33dda for 1949-61.

Annual streamflow estimates for Settlement Canyon creek at (C-3-4)33dda for 1968-71, 1975, 1978, 1983, and 1984 are the summation of discharges from Greens Tunnel [(C-4-4)10dcd], Right Hand Fork Spring [(C-4-4)14bbc-S1], Left Hand Fork Spring [(C-4-4)2dcc-S1], and Rench Spring [(C-3-4)33dda-S1], and Settlement Canyon creek streamflow measured at a flume at (C-4-4)3bca. Discharge records for Greens Tunnel, Right Hand Fork Spring, and the flume at (C-4-4)3bca were collected and compiled by Settlement Canyon Irrigation Company (Daniel Lawrence, Utah Division of Water Resources, retired, written commun., 1990). The discharge from Left Hand Fork Spring was recorded by both the Settlement Canyon Irrigation Company and Tooele City Corporation. No discharge data exist for Rench Spring for the time period discussed, so an average discharge of 53 acre-feet per month was assumed (see previous paragraph).

Annual streamflow for 1989 was estimated partly on the basis of data from U.S. Geological Survey streamflow-gaging station 10172791, upstream from Settlement Canyon Reservoir at (C-4-4)3bbd (U.S. Geological Survey, 1990). This site is about 450 feet downstream from the flume at (C-4-4)3bca. The gaging station does not measure diversions from Greens Tunnel [(C-4-4)10dcd] and Right Hand Fork Spring [(C-4-4)14bbc-S1] nor discharge from Left Hand Fork Spring [(C-4-4)2dcc-S1] and Rench Spring [(C-3-4)33dda-S1]. Discharge from the tunnel and springs was added to the streamflow at the gaging station to estimate annual streamflow at (C-3-4)33dda.

Estimated average monthly streamflow in Settlement Canyon creek at (C-3-4)33dda is listed in table 2. These estimates are based on the individual monthly streamflow values used to determine the annual streamflows listed in table 1. The highest average monthly streamflow in Settlement Canyon creek occurs in June, and the lowest average monthly streamflow occurs in February.

The U.S. Geological Survey operated a crest gage, station 10172790, in Settlement Canyon at (C-4-4)10dcb. The crest gage was about 2.1 miles upstream from (C-3-4)33dda and was operated from 1960 through 1970. This type of streamflow measurement identifies the date and magnitude of the largest instantaneous streamflow for the given year. Values for the 11 years of record are listed in table 3. Peak flows that occur in May and June probably result from snowmelt runoff. Peak flows in July and August probably result from thunderstorm runoff. During 1961 and 1963, no streamflow was recorded at the crest gage, indicating that no snowmelt runoff occurred and no

Table 2. *Estimated average monthly streamflow in Settlement Canyon creek at (C-3-4)33dda*

[Location shown on plate 1]

Month	Streamflow (acre-feet)	Month	Streamflow (acre-feet)
January	250	July	760
February	240	August	520
March	260	September	420
April	350	October	350
May	970	November	310
June	1,270	December	300

Table 3. *Maximum annual instantaneous streamflow in Settlement Canyon creek at (C-4-4)10dcb*

[Location shown on plate 1]

Date	Streamflow (cubic feet per second)
08-17-60	0.9
[1]1961	0
[2]1962	31.0
[1]1963	0
06-01-64	47.0
07-18-65	49.0
05-10-66	7.6
06-14-67	40.0
08-11-68	64.0
06-24-69	155.0
06-10-70	11.0

[1] No evidence of flow during water year.
[2] Exact date of maximum streamflow was not determined.

large amounts of precipitation fell in the drainage area during those years and that all perennial flow originating in the canyon above the gage was diverted. Streamflow reported at the crest gage has not been adjusted to include diversions and discharges from other sources in the canyon.

Surface water in the stream channel in Settlement Canyon during 1988-89 originated at the spring complex at Spring Flats [(C-4-4)3cab-S1] and Right Hand Fork Spring [(C-4-4)14bbc-S1] (table 9). Water from springs at Spring Flats is not diverted and flows in the natural channel to the reservoir. Water in the stream channel above Spring Flats comes from controlled releases from Right Hand Fork Spring. Above Right Hand Fork Spring, water in the stream channel is intermittent and moves into and out of the stream-channel deposits at several locations. Discharge from perennial springs in Right and Left Hand Forks of Kelsey Canyon [(C-4-4)24abd-S1, (C-4-3)18cbb-S1], Water Fork [(C-4-4)25cab-S1, (C-4-4)25cba-S1], and Balsam Hollow [(C-4-4)26aca-S1] seeps into stream-channel deposits and does not reach the main stream channel as surface water.

Middle Canyon Creek

Middle Canyon creek flows into southeastern Tooele Valley, draining about 12.1 square miles of the Oquirrh Mountains (pl. 1). Water from Middle Canyon creek is distributed by the Middle Canyon Irrigation Company, and springs near the mouth of the canyon are a source of public-supply water for Tooele City and Lincoln.

Average streamflow in Middle Canyon creek is estimated to be about 2,100 acre-feet per year. This estimate represents the streamflow at (C-3-4)35aba, with the assumption that all perennial streamflow is piped to the mouth of the canyon. The streamflow estimate includes the discharge from Big Spring [(C-3-4)35adb-S1] and Lincoln Spring [(C-3-4)35aac-S1]. The U.S. Soil Conservation Service (1986) estimated average streamflow for Middle Canyon creek to be 4,865 acre-feet per year. Estimates of annual streamflow in Middle Canyon creek at (C-3-4)35aba are listed in table 4 and discussed below.

Perennial streamflow in Middle Canyon originates in Harkers Canyon, White Pine Canyon, and Hansen Fork (pl. 1). Some of the water in White Pine Canyon and Hansen Fork is piped out of the drainage basin to the east through Utah Metals Tunnel [(C-4-3)9bcd] for use in Salt Lake Valley. This export is offset by an approximately equal volume of water discharging from the Utah Metals Tunnel into Middle Canyon (Gates, 1963a, p. K19). During 1988-89, all perennial streamflow, including discharge from the Utah Metals Tunnel, was piped to the mouth of the canyon. Snowmelt runoff is a significant component of streamflow in Middle Canyon from April through July. When streamflow exceeds the capacity of the conveyance structures in the canyon, water flows in the stream channel.

Annual streamflows listed in table 4 for the years 1906, 1909, 1939-42, and 1953-54 are estimated on the basis of data compiled by Gates (1963a, p. K21). Conveyance structures in the canyon were altered during these times but, for purposes of comparison, it was assumed that the efficiency of water delivery from the upper parts of the canyon to the canyon mouth remained constant. The streamflow values compiled by Gates (1963a) include discharge from Big Spring and Lincoln Spring.

Annual streamflow listed in table 4 for 1985 is estimated on the basis of information from U.S. Geological Survey streamflow-gaging station 10172794 in Middle Canyon creek at (C-3-4)26bbd. During the period of operation, no diversions bypassed the gaging station (Ross

Table 4. *Estimated annual streamflow in Middle Canyon creek at (C-3-4)35aba*

[Location shown on plate 1]

Year	Streamflow (acre-feet)	Year	Streamflow (acre-feet)	Year	Streamflow (acre-feet)
1906	2,660	1941	1,780	1985	3,780
1909	4,890	1942	1,960	1989	1,670
1939	750	1953	1,710		
1940	930	1954	400		

Johnson, Middle Canyon Irrigation Company, oral commun., 1989) and the recorded streamflow represents the total flow in Middle Canyon creek. The efficiency of the water-delivery system in 1985 is assumed to be equivalent to the efficiency during 1906-54. Streamflow values at the gaging station were adjusted to account for stream-channel losses between the gaging station and site (C-3-4)35aba, which is about 0.9 miles upstream from the gaging station.

Annual streamflow listed in table 4 for 1989 is estimated on the basis of instantaneous streamflow measurements made by the U.S. Geological Survey (table 5, (C-3-4)35aac-M1) and flow through a weir at the outlet of the Middle Canyon Irrigation Company pipeline in Angels Grove. The stage in the weir was monitored by Tooele City during the summers of 1988 and 1989 (Joe D. England, Tooele City, written commun., 1990). The efficiency of the water delivery system in 1989 is assumed to be equivalent to the efficiency during 1906-54.

Estimates of the average monthly streamflow in Middle Canyon creek at (C-3-4)35aba are listed in table 6. These estimates are based on the individual monthly streamflow values used to determine the annual streamflows listed in table 4. The highest average monthly streamflow in Middle Canyon creek occurs in June and the lowest average monthly streamflows occur in November, December, January, and February.

Stream-channel losses were determined for two reaches of Middle Canyon creek in southeastern Tooele Valley. In May 1984, stream-channel losses between (C-3-4)26bbd-M1 and (C-3-4)15bbb-M1, 2.5 miles downstream, equaled about 10 percent of the total streamflow (table 5). Diversions, measured at (C-3-4)10caa-M1 and (C-3-4)16dcd-M1, were subtracted from streamflow in the main stream channel to determine the volume of loss. Streamflow loss between (C-3-4)35aac-M1 and 26bbd-M1, 1.1 miles downstream, was measured nine times from August 1988 to May 1989 (table 5). The average percent of measured streamflow loss equaled about 32 percent of the total streamflow. Streamflow losses occur where the stream channel crosses coarse-grained and permeable basin-fill deposits. Streamflow losses are a source of recharge to the basin-fill deposits.

Table 5. *Miscellaneous measurements of streamflow at selected sites*

Location: See figure 2 for an explanation of the numbering system for hydrologic-data sites.
Streamflow: Values less than 0.10 cubic foot per second are reported in gal/min, gallons per minute.

Location	Date	Streamflow	Site description
(C-3-4)10caa-M1	05-21-84	14.9	Diversion out of Middle Canyon creek
(C-3-4)15bbb-M1	05-21-84	2.43	Middle Canyon creek at road leading to Lincoln
(C-3-4)16dcd-M1	05-21-84	21.2	Diversion out of Middle Canyon creek
(C-3-4)26bbd-M1	05-21-84	42.2	Middle Canyon creek at abandoned railroad fill
	05-26-84	36.2	
	06-16-84	47.1	
	06-26-84	34.3	
	07-25-84	15.6	
	08-31-88	2.41	
	10-05-88	.76	
	11-16-88	.91	
	12-22-88	.61	
	01-23-89	.49	
	02-13-89	.36	
	03-07-89	.52	
	03-28-89	.30	
	04-13-89	.75	
(C-3-4)34ccc-M1	08-25-89	1.10	Settlement Canyon creek at reservoir
(C-3-4)35aac-M1	05-14-84	32.5	Middle Canyon creek at Angels Grove
	05-15-84	51.0	
	08-31-88	2.44	
	10-05-88	1.24	
	11-16-88	1.25	
	12-22-88	.95	
	01-23-89	.90	
	02-13-89	.93	
	03-07-89	1.06	
	03-28-89	.95	
	04-13-89	.95	
	05-10-89	2.03	
(C-4-3)16abd-M1	08-10-89	28 gal/min	Hansen Fork creek, west fork
(C-4-3)16abd-M2	08-10-89	24 gal/min	Hansen Fork creek, east fork
(C-4-3)17adc-M1	08-03-89	.10	White Pine Canyon creek, west fork
	08-07-89	.11	
(C-4-3)17adc-M2	08-03-89	.20	White Pine Canyon creek, south fork

Table 5. *Miscellaneous measurements of streamflow at selected sites*—Continued

Location	Date	Streamflow	Site description
(C-4-3)17adc-M2	08-07-89	0.20	
(C-4-3)17caa-M1	08-07-89	14 gal/min	White Pine Canyon creek, upper west fork
(C-4-4) 3bca	10-07-88	1.45	Settlement Canyon creek at cutthroat flume
	11-16-88	1.53	
	01-23-89	1.64	
	02-10-89	1.70	
	03-06-89	1.64	
	03-28-89	1.73	
	04-13-89	1.60	
(C-4-4) 3bcd-M1	08-25-89	1.43	Settlement Canyon creek below Spring Flats
(C-4-4) 3cac-M1	08-25-89	.13	Settlement Canyon creek above Spring Flats
(C-4-4)13cda-M1	09-07-89	.13	Left Hand Fork Kelsey Canyon creek
(C-4-4)15aaa-M1	08-25-89	.54	Settlement Canyon creek below Right Hand Fork
(C-4-4)24baa-M1	09-08-89	37 gal/min	Right Hand Fork Kelsey Canyon creek
(C-4-4)25bca-M1	09-28-89	.14	Settlement Canyon, Water Fork
(C-4-4)33adc-M1	05-07-85	13.0	Soldier Creek
	05-19-85	14.3	
	06-27-85	10.7	
(C-4-4)35dbd-M1	01-23-89	1.14	Soldier Creek above South Fork
	02-10-89	1.14	
	03-06-89	1.02	
	03-28-89	1.48	
	04-13-89	1.69	
	05-03-89	1.98	
	06-13-89	3.02	
	06-28-89	2.84	
	07-11-89	2.67	
	08-02-89	2.37	
	08-28-89	1.97	
	09-15-89	1.65	
	10-11-89	1.53	
	11-15-89	1.19	
	12-13-89	1.12	
(C-4-4)36bcd-M1	10-11-89	.69	Soldier Creek, North Fork
(C-4-4)36bcd-M2	10-11-89	.32	Soldier Creek
(C-4-4)36dbb-M1	10-12-89	7.5 gal/min	Tributary to Soldier Creek below Right Hand Fork

Table 6. *Estimated average monthly streamflow in Middle Canyon creek at (C-3-4)35aba*

[Location shown on plate 1]

Month	Streamflow (acre-feet)	Month	Streamflow (acre-feet)
January	60	July	370
February	60	August	250
March	70	September	150
April	130	October	70
May	360	November	50
June	480	December	50

Soldier Creek

Soldier Creek flows westward into northeastern Rush Valley and drains an area of about 9.2 square miles (pl. 1). Water from Soldier Creek is distributed by the Soldier Canyon Irrigation Company and used by Stockton City for public-supply needs.

Average annual streamflow in Soldier Creek is estimated to be about 3,900 acre-feet per year (U.S. Soil Conservation Service, 1986). This estimate is an extrapolation from streamflow in Settlement Canyon creek determined by using an area-elevation method and represents streamflow in Soldier Creek at (C-4-4)33add (Robert King, Utah Division of Water Resources, oral commun., 1989). An estimate of average annual streamflow based on measurement values was not made because minimal quantitative streamflow data are available for Soldier Creek. The extrapolated monthly streamflow estimates for (C-4-4)33add are listed in table 7.

Perennial streamflow in Soldier Creek comes from springs in Soldier Canyon above the confluence with South Fork (pl. 1). Discharge from two perennial springs below the confluence (table 9, (C-4-4)27ccc-S1 and 34bab-S1) normally do not reach the main stream channel (Grant Watkins, Soldier Canyon Irrigation Company, oral commun., 1989). Streamflow in Soldier Creek is largest in May, June, and July as a result of snowmelt runoff. Snowmelt runoff is generated from the South, North, Left Hand, and Right Hand Forks of Soldier Canyon.

Estimates of monthly streamflow in 1989 in Soldier Creek at (C-4-4)35dbd-M1 are listed in table 7 and were made on the basis of 15 instantaneous streamflow measurements (table 5). On the basis of these measurements, annual streamflow in 1989 was estimated to be about 1,250 acre-feet, which is about 32 percent of the average annual streamflow estimated by the U.S. Soil Conservation Service (1986) at (C-4-4)33add. Streamflow in 1989 in Settlement and Middle Canyons was 71 and 86 percent of their average annual streamflow, respectively. If it is assumed that streamflow at (C-4-4)35dbd-M1 is comparable with streamflow at (C-4-4)33add, the extrapolated

Table 7. ***Estimated monthly streamflow at four locations in Soldier Canyon***

[Location shown on plate 1; —, no data]

Month	Streamflow at (C-4-4)33add [1] (acre-feet) [2]	Streamflow at (C-4-4)35dbd-M1 (acre-feet) [3]	Streamflow at (C-4-4)35cac (acre-feet) [4]	Streamflow at (C-4-4)33cbd (acre-feet) [5]	Streamflow at (C-4-4)35cac (acre-feet) [5]
January	90	70	263	—	—
February	81	62	281	—	—
March	105	76	311	—	—
April	234	102	657	—	—
May	656	142	679	585	—
June	848	171	825	549	—
July	671	160	853	385	474
August	464	133	572	125	195
September	326	101	554	—	135
October	203	91	325	—	—
November	129	71	314	—	—
December	86	68	270	—	—

[1] See figure 2 for an explanation of the numbering system for hydrologic-data sites.
[2] Average streamflow estimates based on area-elevation method (U.S. Soil Conservation Service, 1986).
[3] Streamflow estimates based on instantaneous discharge measurements made by the U.S. Geological Survey during 1989.
[4] Average streamflow estimates made by Soldier Canyon Irrigation Company (Grant Watkins, Soldier Canyon Irrigation Company, written commun., 1989).
[5] Streamflow estimated on the basis of flume measurements by the U.S. Soil Conservation Service during 1985 (Carlos Garcia, U.S. Soil Conservation Service, written commun., 1988).

average annual streamflow of 3,900 acre-feet may be an overestimate of actual streamflow. Site (C-4-4)35dbd-M1 is about 1.8 miles upstream from (C-4-4)33add; it is assumed that tributary inflow from the South Fork of Soldier Canyon compensates for any streamflow loss between the sites.

A qualitative estimate of monthly streamflow in Soldier Creek at (C-4-4)35cac was made by Soldier Canyon Irrigation Company (Grant Watkins, Soldier Canyon Irrigation Company, written commun., 1989) and is listed in table 7. Average annual streamflow, based on these estimates, is about 5,900 acre-feet per year.

Streamflow at (C-4-4)33cbd and (C-4-4)35cac was measured with flumes from May through August 1985 and July through September 1985, respectively (Carlos Garcia, U.S. Soil Conservation Service, written commun., 1988). Monthly streamflow, estimated from instantaneous flume measurements, is listed in table 7. Average streamflow loss from July through August 1985, when both flumes operated simultaneously, was 80 acre-feet per month (1.3 cubic feet per second). Miscellaneous streamflow measurements were also made in 1985 at (C-4-4)33adc-M1, an intermediate point between the two flume sites (table 5).

GROUND-WATER HYDROLOGY

Ground water in the study area is found in both unconsolidated and consolidated rocks. Unconsolidated rocks occur as basin-fill deposits in Tooele and Rush Valleys and stream-channel deposits in the bottoms of major canyons in the Oquirrh Mountains. Consolidated rocks are found throughout the Oquirrh Mountains and crop out at isolated locations in southeastern Tooele Valley.

Basin-Fill Deposits

Most of the basin-fill deposits in the study area are in southeastern Tooele Valley (pl. 1) and extend from the base of the Oquirrh Mountains to the northern and western boundaries of the study area. The deposits are unconsolidated to semiconsolidated and consist mainly of poorly sorted, angular to rounded boulders, gravel, sand, silt, and clays (Tooker, 1980). The quantity of coarse material decreases as distance from the mountain front increases. The basin-fill deposits of northeastern Rush Valley, near Stockton at the mouth of Soldier Canyon, were not included in this study.

Basin-fill deposits are the principal source of ground water in the study area. Numerous irrigation and public supply wells have been completed in these deposits. Selected wells are listed in table 10 (at back of report) and their locations shown on plate 1. The depth to water in the basin-fill deposits in March 1989 was more than 500 feet in the vicinity of Lincoln at well (C-3-4)14adb-1. In areas near Erda, where artesian conditions exist in the basin-fill deposits, the water level in March 1989 at well (C-2-4)33add-1 was about 20 feet below land surface.

On the basis of resistivity logs of test wells (C-2-4)34bcd-1 and (C-3-4)11ccc-1 (Ryan and others, 1981, p. 21, 36), basin-fill deposits in southeastern Tooele Valley are assumed to contain freshwater to depths of about 850 feet in the Erda area and 950 feet in the vicinity of Tooele. The saturated thickness of the basin-fill deposits containing freshwater varies from a few feet near the Oquirrh Mountains to as much as 800 feet in the Erda area (pl. 3).

The basin-fill deposits are unsaturated in two areas in southeastern Tooele Valley (pl. 3). The unsaturated basin-fill area west of Tooele City on Tooele Army Depot was defined by James M. Montgomery, Consulting Engineers, Inc. (1988) on the basis of geophysical surveys, well data, and surface outcrops of consolidated rock. The unsaturated area east of Tooele City was defined by Gates (1965, fig. 5 and p. 33) on the basis of geophysical information and drillers' logs of wells (C-3-4)21adc-1 and (C-3-4)23ccd-1 (table 11, at back of report).

Recharge

Recharge to the basin-fill deposits in southeastern Tooele Valley is primarily from subsurface inflow from adjoining areas. This recharge includes subsurface inflow from consolidated rocks and stream-channel deposits, and from Rush Valley through the Stockton Bar. Additional recharge occurs from unconsumed irrigation water, precipitation on the basin-fill deposits, seepage from perennial streams, and ephemeral runoff; however, these processes account for only a small percentage of the total recharge.

Average recharge to the basin-fill deposits in southeastern Tooele Valley is estimated to be about 44,000 acre-feet per year on the basis of information from a ground-water model of the principal artesian aquifers in Tooele Valley calibrated by Razem and Bartholoma (1980). The quantity of recharge used by Razem and Bartholoma (1980) was adjusted from initial estimates of recharge to Tooele Valley made by Razem and Steiger (1981, table 2). Actual recharge to the basin-fill deposits in southeastern Tooele Valley is greater than 44,000 acre-feet per year because that figure represents recharge to the principal artesian aquifers only and does not include recharge from precipitation, seepage from streams, and unconsumed irrigation water in the central parts of the valley where the principal artesian aquifer is overlain by a water-table aquifer. In southeastern Tooele Valley, the quantity of recharge to the basin fill in areas where both water-table and artesian conditions exist is considered insignificant.

Razem and Bartholoma (1980) estimated that an average of about 18,000 acre-feet per year of recharge occurs along and near the basin-fill /consolidated-rock boundary between the Stockton Bar and the mouth of Middle Canyon. About 15,000 acre-feet per year of recharge is estimated to occur between the mouth of Middle Canyon and the mouth of Dry Canyon (Razem and Bartholoma, 1980, table 2 and fig. 2). From Dry Canyon north to the boundary of the study area, Razem and Bartholoma (1980) estimated recharge to be about 6,000 acre-feet per year. The quantity of recharge to southeastern Tooele Valley from Rush Valley underneath the Stockton Bar is estimated to be 5,000 acre-feet per year (Razem and Bartholoma, 1980, table 2 and fig. 2).

The recharge discussed in the previous paragraph comes from unconsumed irrigation water, precipitation, seepage from streams, and subsurface inflow from adjoining areas. The average quantity of recharge to the basin-fill deposits from unconsumed irrigation water is estimated to be about 1,400 acre-feet per year if it is assumed that about 25 percent of applied irrigation water in southeastern Tooele Valley is unconsumed and becomes recharge to the basin-fill deposits (Carlos Garcia, U.S. Soil Conservation Service, oral commun., 1991). Water delivered by Settlement Canyon Irrigation Company averages 3,300 acre-feet per year (Daniel Lawrence, Utah Division of Water Resources, retired, written commun., 1990; Dean Maloney, Settlement Canyon Irrigation Company, written commun., 1990). On the basis of differences in summer and winter water deliveries by Tooele City (Richard Jorgensen, Tooele City Engineering Department, oral commun., 1990), water use for lawn irrigation is estimated to be about 700 acre-feet per year. As determined by adding values of average monthly streamflow in Middle Canyon creek for May through September (table 6), Middle Canyon Irrigation Company is estimated to deliver about 1,600 acre-feet per year for irrigation purposes.

Recharge from direct precipitation on the basin-fill deposits is estimated to be about 800 acre-feet per year and occurs primarily where there are no confining layers (that is, artesian conditions do not exist) in the basin-fill deposits. The minimum area of Tooele Valley where no confining layers exist was defined by Gates (1965, fig. 2) and includes about 11 square miles of the study area. Precipitation on that area averages about 17 inches per year, of which 8 percent (Hood and Waddell, 1969, table 8) is estimated to contribute to recharge.

In most years, recharge to the basin-fill deposits from downward seepage of streamflow is not substantial. Because of storage and conveyance structures in Settlement and Middle Canyons and piped irrigation diversions near the canyon mouths, large quantities of streamflow from these canyons rarely cross the basin-fill deposits. Streamflow from Pine, Swensons, Leavetts, and Pole Canyons does cross the basin-fill deposits, but the streamflow quantities are not substantial when compared with the total quantity of recharge to the basin-fill deposits. Streamflow and subsequent recharge from the major ephemeral drainages into southeastern Tooele Valley (Silcox, Spring, Dry, and Flood Canyons) also is not substantial. Recharge from downward seepage of streamflow, both ephemeral and perennial, is important during years of high precipitation and snowmelt runoff when streamflows are high for extended periods.

The quantity of recharge to the basin-fill deposits in southeastern Tooele Valley from subsurface inflow from adjoining areas is estimated to be about 41,800 acre-feet per year. This recharge includes subsurface inflow from Rush Valley through the Stockton Bar and from stream-channel deposits and consolidated rocks of the Oquirrh Mountains. Subsurface inflow from Rush Valley was estimated to be about 5,000 acre-feet per year from simulation results produced by using the ground-water-flow model of Tooele Valley by Razem and Bartholoma (1980). Subsurface inflow from adjoining stream-channel deposits is estimated to be about 2,800 acre-feet per year on the basis of the areal extent and hydraulic properties of the deposits near the mouths of Settlement and Middle Canyons. Subsurface inflow from stream-channel deposits in other parts of the study area was not estimated because of insufficient data; inflow from these areas is thought to be small. The quantity of subsurface inflow to the basin fill from the consolidated rocks of the Oquirrh Mountains could not be estimated directly because of incomplete data; therefore, recharge from this source was assumed to be equal to the difference between the total estimated recharge from subsurface inflow, 41,800 acre-feet per year, and the sum of the estimated recharge from Rush Valley and the stream-channel deposits, 7,800 acre-feet per year. Thus, the estimated recharge from subsurface inflow from consolidated rock is about 34,000 acre-feet per year.

Flow

The potentiometric surface of the basin-fill deposits in southeastern Tooele Valley (pl. 2) indicates that ground water generally flows northwest (perpendicular to the contours), away from the Oquirrh Mountains and toward the central and northern parts of Tooele Valley. The hydraulic gradient decreases from about 250 feet per mile near the mountain front to less than 10 feet per mile in the northern parts of the study area near Erda.

Local anomalies in the general direction of flow are found near the mouth of Settlement Canyon and west of Tooele City. The potentiometric-surface contours are convex to the northwest near the mouth of Settlement Canyon, indicating that recharge to the basin fill occurs in that area. This recharge is thought to come mainly from subsurface outflow from the consolidated rock at the mouth of Settlement Canyon.

The potentiometric surface west of Tooele City shows the hydraulic gradient between wells (C-3-4)32bcc-1 and (C-3-5)25abd-1 to be noticeably less than in surrounding areas. This decreased gradient is probably caused by ground-water withdrawals at wells (C-3-4)29cba-1, 29ccb-1, 30aac-1, 31bba-1, 32bbc-1, and (C-3-5)36ddd-1, and possible impedance of ground-water flow by subsurface consolidated rock.

Discharge

Average discharge from the basin-fill deposits in southeastern Tooele Valley is estimated to be about 44,000 acre-feet per year, the same as the estimated average annual recharge. The assumption that average discharge is roughly equal to average recharge is based on 53 years of recorded water-level changes at well (C-2-4)33add-1 (fig. 4). Water levels at the well fluctuate both seasonally and annually but do not show a consistent rise or decline during the period of record. The maximum water-level change for the period of record is about 50 feet, which represents about 6 percent of the basin fill saturated with freshwater at the well. These factors indicate that the ground-water system in southeastern Tooele Valley is not undergoing a large or consistent change and the assumption that average discharge equals average recharge seems reasonable.

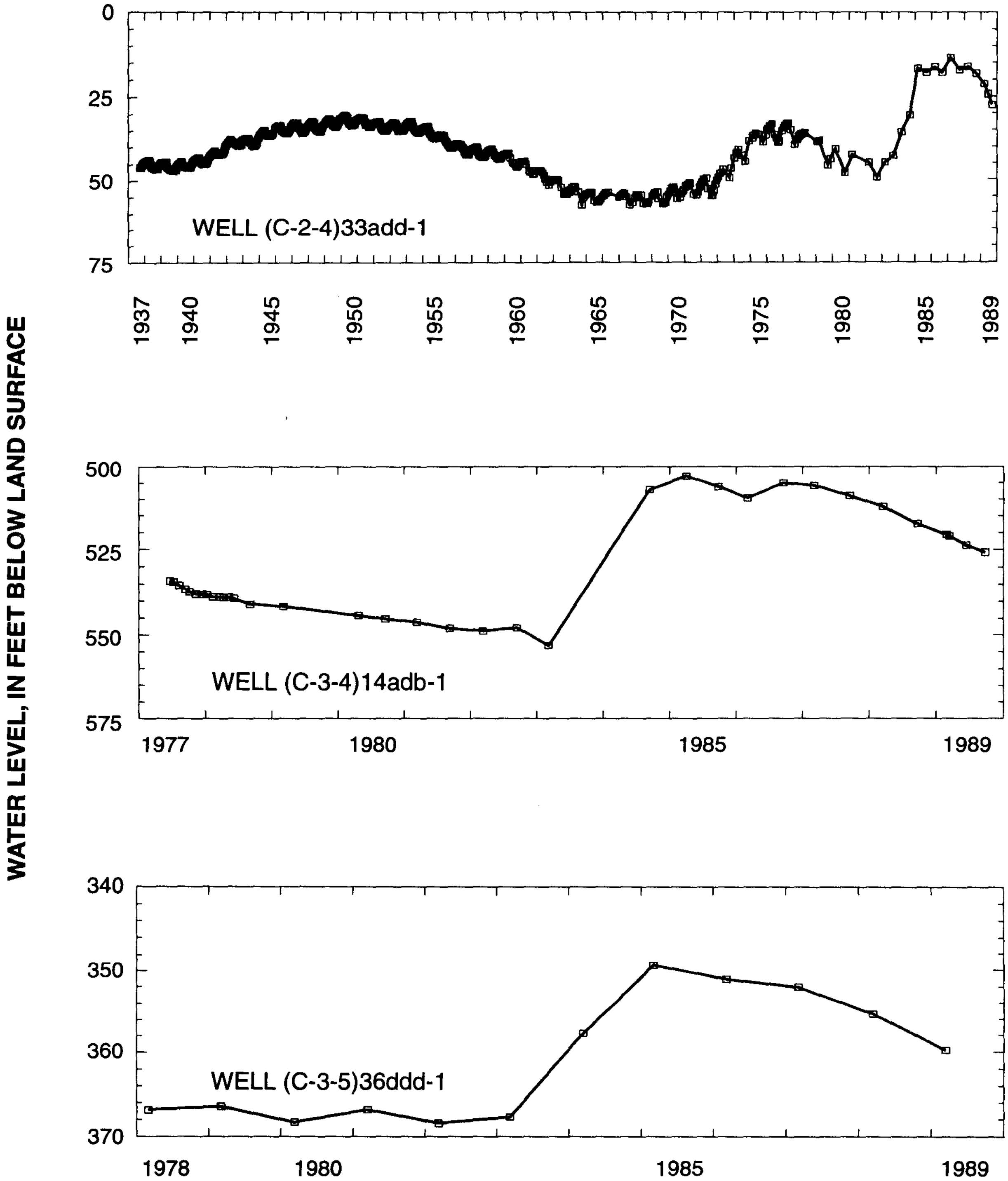


Figure 4. Long-term water-level fluctuations in three wells completed in basin-fill deposits. (Well locations shown on plate 1.)

Discharge from the basin-fill deposits is by subsurface outflow to adjoining areas, mainly to northern Tooele Valley, and by ground-water withdrawals from wells. Ground-water withdrawals from the basin-fill deposits in southeastern Tooele Valley in 1989 were about 3,200 acre-feet and included about 800 acre-feet withdrawn through four wells owned by Tooele City (table 10, wells (C-3-4)28cdc-2, 29cba-1, 29ccb-1, and 32bbc-1). Wells at Tooele Army Depot (table 10, wells (C-3-4)30aac-1, 31bba-1, and (C-3-5)36ddd-1) accounted for about another 1,200 acre-feet of withdrawals in 1989. Ground-water withdrawals from the basin-fill deposits near Erda, mainly for irrigation, were about 1,200 acre-feet in 1989.

Total ground-water withdrawals from all of Tooele Valley during 1989 were about 27,000 acre-feet, 2,000 acre-feet more than the 1979-88 average (Herbert and others, 1990, p. 7). On this basis, withdrawals in southeastern Tooele Valley were also assumed to be greater than average during 1989. By adjusting the 3,200-acre-foot quantity by the same proportion as that observed for total withdrawals from all of Tooele Valley, average ground-water withdrawals in the study area were estimated to be about 3,000 acre-feet per year.

Average discharge by subsurface outflow from the basin-fill deposits in southeastern Tooele Valley to adjoining areas is estimated to be about 41,000 acre-feet per year. This discharge was estimated by subtracting the average annual ground-water withdrawals from wells in southeastern Tooele Valley, 3,000 acre-feet, from the total annual average discharge of 44,000 acre-feet. Most of this subsurface outflow occurs at the northwestern border of the study area.

Hydraulic Properties

Hydraulic properties of the basin-fill deposits in southeastern Tooele Valley were determined or estimated from results of aquifer tests and lithologic data from drillers' logs. Values of specific capacity, transmissivity, and hydraulic conductivity for specific locations are listed in table 8.

Specific-capacity values of wells completed in the basin-fill deposits ranges from less than 1 to 180 gallons per minute per foot of drawdown. Specific capacity depends on well construction and hydraulic properties of the basin fill at the well. The variability noted above is thought to be partly the result of well construction—specifically, the length of the screened interval. Specific-capacity values of wells (C-3-5)24cad-1, 24ccc-1, 25add-1, and 25cac-1, west of Tooele on Tooele Army Depot, are less than 10 gallons per minute per foot of drawdown. These wells have short screened intervals (table 10) and their specific-capacity values probably underestimate the hydraulic properties of the basin fill in the area. Specific-capacity values of wells (C-3-4)28cdc-2, 29cba-1, 29ccb-1, 31bba-1, 32bbc-1, and (C-3-5)36ddd-1, which are in the same general area, range from 10 to 75 gallons per minute per foot of drawdown. These wells have longer screened intervals (table 10) and their specific-capacity values are thought to be more representative of the hydraulic properties of the basin fill in the area. Specific-capacity values for wells (C-2-4)27cdc-1, 33aab-1, (C-3-4)8aaa-1, 9aaa-1, 14adb-1, and 16aaa-1, north of Tooele City, ranged from 14 to 180 gallons per minute per foot of drawdown (table 8). The specific-capacity value reported for well (C-3-4)16aaa-1, 180 gallons per minute per foot of drawdown, is three to six times the values for other wells in the area and is thought to be anomalously high.

The observed transmissivity of the basin-fill deposits in southeastern Tooele Valley ranges from 30 feet squared per day at well (C-4-4)7aaa-1 to 56,000 feet squared per day at well (C-3-4)30aac-1 (table 8). Generally, the largest transmissivity values are found south and west of

Table 8. *Hydraulic properties of the basin-fill deposits, stream-channel deposits, and consolidated rock*

[—, no data; /, could not be determined; <, less than]

Location: See figure 2 for an explanation of the numbering system for hydrologic-data sites.

Method of analysis: KA, method of Kelly and Anderson (1980); MNF, Modified nonequilibrium formula (Ferris and others, 1962, p. 98-110); NU, Numerical solution to transient ground-water-flow equation; S, Straight-line method (Cooper and Jacob, 1946); S2, Straight-line method (Lohman, 1972, p. 23); T, Theis method (Theis and others, 1963, p. 331-341).

Hydraulic conductivity: Transmissivity divided by the perforated or screened interval of the well.

Source of data: D, discharge, drawdown, and pumping period from drillers' logs; DM, Dames and Moore Consulting Engineers, written commun., 1979; G, Gates, 1965; JMM, James M. Montgomery, Consulting Engineers, Inc., 1986 and 1988; R, Razem and Steiger, 1981.

Location of well used to test hydraulic properties	Discharge of well (gallons per minute)	Drawdown in well (feet)	Specific capacity (gallons per minute per foot of drawdown)	Length of pumping period (hours)[1]	Method of analysis	Transmissivity (feet squared per day)	Hydraulic conductivity (feet per day)	Source of data
			Basin-fill deposits[2]					
(C-2-4)27cdc-1	1,130	24	47	4	T	11,000	130	D
(C-2-4)33aab-1	1,500	90	17	—	MNF	25,000	260	D,R
(C-3-4) 8aaa-1	1,375	43	32	265	T	9,100	40	D
(C-3-4) 9aaa-1	1,320	53	25	139	T	6,700	30	D
(C-3-4)14adb-1	400	28	14	11	T	2,400	30	D
(C-3-4)16aaa-1	1,083	6	180	64	T	40,000	120	DM
(C-3-4)28cdc-2	620	47	13	64	T	2,400	10	D
(C-3-4)29cba-1	1,040	100	10	52	T	1,600	10	D
(C-3-4)29ccb-1	1,200	22	54	48	T	11,000	20	D
(C-3-4)30aac-1	630	—	/	12	MNF	56,000	620	G,R
(C-3-4)31bba-1	1,000	25	40	—	T	6,400	20	D
(C-3-4)32bbc-1	895	16	56	—	T	9,800	20	D
(C-3-5)22add-1	830	31	27	48	NU	10,000	220	JMM[3]
(C-3-5)24cad-1	14.3	2.3	6	.25	S	320	30	JMM
(C-3-5)24ccc-1	4.0	4.75	1	.25	S	50	10	JMM
(C-3-5)24dac-1	7.5	.67	11	.25	S	90	10	JMM
(C-3-5)25add-1	13	4.11	3	.25	S	120	10	JMM
(C-3-5)25cac-1	14.3	2.34	6	.25	S	510	50	JMM
(C-3-5)36ddd-1	900	12	75	—	T	12,000	60	D
(C-4-4) 7aaa-1	6	20	<1	—	T	30	1	D
			Stream-channel deposits[4]					
(C-3-4)33dac-1	160	105	2	8	T	130	2	D
(C-3-4)35aba-1	450	10	45	—	T	8,200	430	D
(C-3-4)35abd-1	300	40	8	—	T	1,200	20	D
(C-4-3) 6bdb-1	1,195	55	22	8	T	2,900	50	D
(C-4-3) 6bdb-2	722	35	21	8	T	3,200	90	D
(C-4-4)33cbd-1	40	45	<1	—	T	120	/	D

Table 8. ***Hydraulic properties of the basin-fill deposits, stream-channel deposits, and consolidated rock*—Continued**

Location of well used to test hydraulic properties	Discharge of well (gallons per minute)	Drawdown in well (feet)	Specific capacity (gallons per minute per foot of drawdown)	Length of pumping period (hours)[1]	Method of analysis	Transmissivity (feet squared per day)	Hydraulic conductivity (feet per day)	Source of data
				Consolidated rock[5]				
(C-3-4)25aaa-1	211	449	<1	—	T	60	<1	D
(C-3-4)25aad-1	50	75	<1	1	T	60	/	D
(C-3-4)33acd-1	967	10	97	20	S2	14,000	140	D
(C-3-4)33dab-1	553	47	12	6	T	1,900	40	D
(C-3-4)35add-1	312	160	2	—	T	230	/	D
(C-3-5)23aad-1	—	—	/	—	KA	800	20	JMM[6]

[1] If pumping period was not known (—) and was required to determine transmissivity, a 10-hour pumping period was assumed.

[2] Specific yield of 0.10 was used for the basin-fill deposits (Razem and Steiger, 1981, p. 20); Storage coefficient of 0.002 was used for the basin-fill deposits (Gates, 1965, p. 29; Razem and Bartholoma, 1980).

[3] Hydraulic conductivity reported as 220 feet per day; Specific yield reported to be 0.30; Storage coefficient, calculated from reported specific storage, for an upper and lower zone, reported as 0.0065 and 0.002; Well is about 1.5 miles west of study area.

[4] Specific yield of stream-channel deposits was assumed to be 0.20.

[5] Specific yield of the consolidated rock was assumed to be 0.05.

[6] Storage coefficient of 0.0001 was used for analysis.

Tooele City; transmissivity values of less than 600 feet squared per day were observed at wells with limited screened intervals and probably underestimate actual transmissivity. In most cases, transmissivity values were determined from specific capacity by using the method of Theis and others (1963) (table 8). Transmissivity values determined by using this method of analysis may be lower than actual transmissivity values because the assumptions associated with the method are rarely met.

Specific yield, specific storage, and storage coefficient of the basin-fill deposits were determined at wells west and north of the study area. The value of specific yield at well (C-3-5)22add-1, 1.5 miles west of the study area, was estimated to be 0.30 (James M. Montgomery, Consulting Engineers, Inc., 1988, appendix C) (table 8, footnote). Razem and Steiger (1981, p. 20) estimated the value of average specific yield for the entire basin fill in Tooele Valley to be 0.10. The value of specific storage at well (C-3-5)22add-1 was determined to be 5×10^{-5} per foot in an upper zone of the saturated basin fill and 1×10^{-5} per foot in a lower zone (James M. Montgomery, Consulting Engineers, Inc., 1988, appendix C). As determined by multiplying by the respective thicknesses, storage-coefficient values for the upper and lower zones are 0.0065 and 0.002. On the basis of results of three aquifer tests, Gates (1965, p. 29) determined an average storage-coefficient value for the principal aquifer in Tooele Valley to be 0.002. Razem and Bartholoma (1980) used a storage-coefficient value of 0.002 for simulation of ground-water flow in Tooele Valley.

Ground water in the basin-fill deposits south and west of Tooele City is considered to be under water-table conditions. Results of an aquifer test done in December 1989 verified that water-table conditions exist at the municipal airport west of Tooele City (pl. 1). Well (C-3-4)29ccb-1 was pumped for 96 hours with no measurable drawdown at well (C-3-4)29cba-1, 0.32 miles north of the pumped well, or at well (C-3-4)32bbc-1, 0.33 miles south of the pumped well. Water-table conditions were also reported at well (C-3-5)22add-1 (James M. Montgomery, Consulting Engineers, Inc., 1988, appendix C), 4 miles west of the airport.

Ground water in the basin-fill deposits in the northern parts of the study area, near Erda, is mainly under artesian conditions (Gates, 1965, p. 21). The seasonal water-level fluctuations at well (C-2-4)33add-1 (figs. 4 and 5) at Erda show drawdown and recovery typical for artesian aquifers from which ground-water withdrawals are seasonal. In the area between Tooele and Erda, water in the basin-fill deposits exists under both artesian and water-table conditions. At well (C-3-4)9aaa-1 (fig. 5), 3 miles north of Tooele, typical artesian drawdown and recovery occurs. At well (C-3-4)16aaa-1 (fig. 5), 2 miles north of Tooele, drawdown and recovery is not as pronounced, indicating that artesian conditions may not be as prevalent there. The thickness of clay in the basin-fill deposits, as indicated on drillers' logs (table 11), also decreases from well (C-3-4)9aaa-1 to (C-3-4)16aaa-1. Seasonal water-level fluctuations at well (C-3-4)14adb-1 (pl. 1 and fig. 5), 2.5 miles northeast of Tooele, do not show a drawdown recovery cycle and indicate that water-table conditions may exist there. The thickness of clay in the basin fill, based on drillers' logs, is similar at wells (C-3-4)14adb-1 and (C-3-4)16aaa-1 (table 11). The drillers' log of well (C-3-4)13abb-1 (pl. 1 and table 11), 3 miles northeast of Tooele, shows that the thickness of clay is small in the basin-fill deposits there.

Storage and Water-Level Fluctuations

The quantity of fresh ground water that theoretically can be recovered from the basin-fill deposits in southeastern Tooele Valley is estimated to be about 600,000 acre-feet. This estimate is based on about 18,000 acres (28 square miles) in the study area where the average thickness of the basin fill saturated with freshwater was estimated to be about 340 feet, and a specific yield of 0.10 (Razem and Steiger, 1981, p. 20). To recover this quantity of water, the basin-fill deposits would have to be completely dewatered. The effects of extensive dewatering include declines in water levels, possible migration of water containing higher concentrations of dissolved solids to wells, and possible land subsidence.

Water levels in the basin-fill deposits in southeastern Tooele Valley fluctuate both seasonally and annually. Seasonal water-level fluctuations are primarily the result of ground-water withdrawals during the irrigation season. Annual water-level fluctuations are typically caused by variation in the quantity of recharge to the basin-fill deposits; recharge variation is caused by changes in annual precipitation. Water levels in selected wells are listed in tables 10 and 12, and hydrographs of selected wells are shown in figures 4 and 5.

Hydrographs in figure 5 show seasonal water-level fluctuations in the basin fill at selected locations in southeastern Tooele Valley. Water levels in the basin fill generally are highest in March and April, decline 5 to 10 feet through the summer months, and are lowest in August, September, and October. Water levels in wells (C-2-4)33add-1, (C-3-4)9aaa-1, and 16aaa-1 show a seasonal drawdown and recovery cycle, which is probably caused by ground-water withdrawals in the Erda area. Water-level fluctuations at well (C-3-4)14adb-1 (pl. 1) do not indicate seasonal

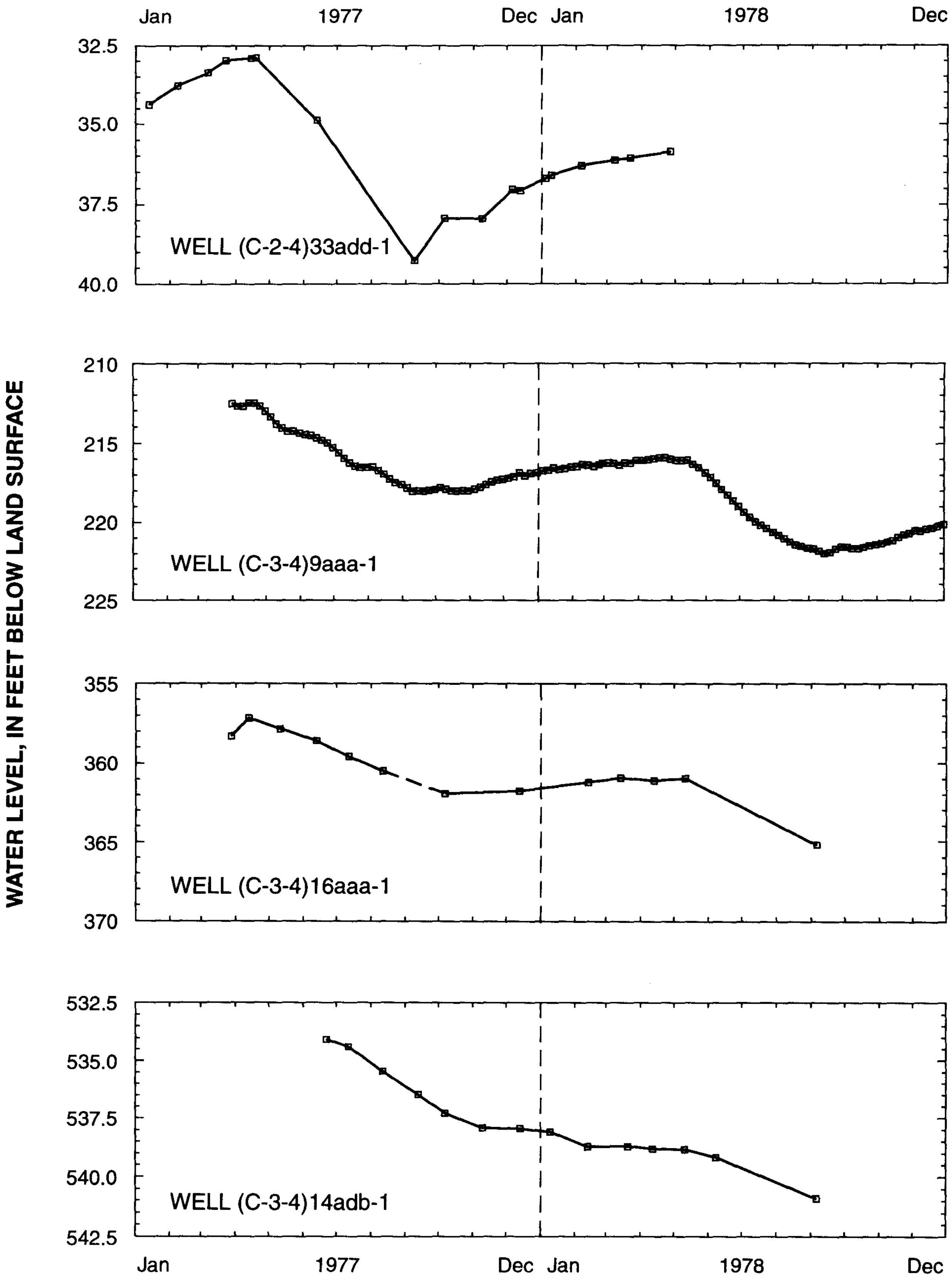


Figure 5. Short-term water-level fluctuations in four wells completed in basin-fill deposits. (Well locations shown on plate 1.)

drawdown and recovery; fluctuations are probably caused by variations in the quantity of recharge to the basin-fill deposits.

Long-term water-level fluctuations in the basin-fill deposits of southeastern Tooele Valley are illustrated in hydrographs for three wells in figure 4. These hydrographs show rapid water-level rises, beginning in 1983, which were caused by greater-than-average precipitation (fig. 3). The hydrographs indicate that water levels were highest in 1985. Water levels increased by as much as 50 feet during 1983-85 and in 1989 were still about 25 feet above their pre-1983 levels.

Water Quality

The chemical composition of ground water in the basin-fill deposits depends on location and depth. Dissolved-solids concentrations in the ground water ranged from 363 to 1,550 milligrams per liter. Results of chemical analyses of ground water from selected wells are listed in table 13.

Water in the basin-fill deposits south and west of Tooele City, as measured by dissolved solids-concentration, is generally suitable for domestic use. Water from wells (C-3-4)28cdc-2, 29cba-1, 29ccb-1, 30aac-1, and 32bbc-1 contained dissolved solids in concentrations ranging from 363 to 572 milligrams per liter. The State of Utah Secondary Drinking Water Standard for dissolved-solids concentration is 500 milligrams per liter (Utah Division of Environmental Health, 1986, p. 3-6). At wells farther west and south (table 13, (C-3-4)31bba-1, 32bcc-1, (C-3-5)36ddd-1), dissolved-solids concentrations ranged from 687 to 1,150 milligrams per liter.

The dissolved-solids concentrations in water in the basin-fill deposits increase north of Tooele and northwest of Tooele Army Depot mainly because of increases in sodium, sulfate, and chloride. The dissolved-solids and chloride concentrations in water from wells west of the line separating Ranges 4 and 5 West, and from most wells north of Tooele, generally exceeded the State of Utah Secondary Drinking Water Standard of 500 milligrams per liter for dissolved solids and 250 milligrams per liter for chloride (Utah Division of Environmental Health, 1986, p. 3-6). Ground water from wells (C-3-4)8aaa-1, 9aaa-1, and 16aaa-1 contains large concentrations of sodium, chloride, and dissolved solids; the concentrations of these constituents average about 400, 660, and 1,380 milligrams per liter (table 13), respectively.

A ground-water investigation at Tooele Army Depot identified geothermal waters (for this discussion, geothermal is defined as temperature above 25°C) in several wells about 0.5 miles west of the study area. Dissolved-solids concentrations in the geothermal water ranged from 5,100 to 6,100 milligrams per liter, and the dominant ions were sodium and chloride (James M. Montgomery, Consulting Engineers, Inc., 1988). The mineralized geothermal water could be the cause of large dissolved-solids concentrations in the basin-fill deposits at wells (C-3-4)8aaa-1, 9aaa-1, and 16aaa-1. The average temperature of water from wells (C-3-4)8aaa-1, 9aaa-1, and 16aaa-1 was about 17°C.

Dissolved-solids concentrations in water in the basin-fill deposits north of Tooele City and near Lincoln (pl. 1) ranged from 628 milligrams per liter at well (C-3-4)13abb-1 to 774 milligrams per liter at well (C-3-4)14adb-1. The dissolved-solids and sulfate concentrations in water in the basin-fill deposits in this area generally exceed the State of Utah Secondary Drinking Water Standards for dissolved solids (500 milligrams per liter) and sulfate (250 milligrams per liter)(Utah Division of Environmental Health, 1986, p. 3-6). Razem and Steiger (1981) suggest that sulfate in the ground water in this area may be a result of mining activities in the Pine Canyon area. Water from the Pine Canyon mining operations, collected in 1978 at a settling pond, (C-3-3)18cbb, and an irrigation ditch near the pond, (C-3-3)18cba, contained sulfate concentrations in excess of 500 milligrams per liter (table 13); sodium and chloride concentrations were less than 20 milligrams per liter. Westward and downgradient from these sites and wells, and along inferred flow paths to wells (C-3-4)8aaa-1, 9aaa-1, and 16aaa-1, concentrations of sodium and chloride exceeded 300 milligrams per liter, and concentrations of sulfate were about 50 milligrams per liter.

The dissolved-solids concentration in water in the basin-fill deposits in the northern parts of the study area, near Erda, was between 500 and 1,000 milligrams per liter (Razem and Steiger, 1981, p. 30). Calcium, chloride, and sulfate are the predominant ions; only dissolved-solids concentrations exceeded the State of Utah Secondary Drinking Water Standards (Utah Division of Environmental Health, 1986, p. 3-6).

Stream-Channel Deposits

Stream-channel deposits occur in Soldier, Settlement, Middle, Pine, and Pass Canyons. These deposits have alluvial and colluvial origins and consist mainly of silt, sand, gravel, talus, and boulders (Gates, 1963a, p. K11; Tooker, 1980; Tooker and Roberts, 1988, p. 3). The average thickness of the stream-channel deposits in Settlement Canyon downstream from Settlement Canyon Reservoir is 126 feet (table 11, (C-3-4)33acd-1, 33dab-1, and 33dac-1). Thickness of the stream-channel deposits at Settlement Canyon Dam is 20 feet near the northeast abutment to greater than 50 feet at the southwest abutment (Daniel Lawrence, Utah Division of Water Resources, retired, oral commun., 1990). Thickness of the stream-channel deposits at the mouth of Middle Canyon is unknown. On the basis of the drillers' log, stream-channel deposits at test well (C-3-4)35abd-2 are estimated to be a minimum of 515 feet thick (table 11). At well (C-3-4)35ada-1, about 100 feet northwest of well (C-3-4)35abd-2, stream-channel deposits, according to the drillers' log, are estimated to be 76 feet thick (table 11). A seismic survey of the area at the mouth of Middle Canyon in 1988 shows that the lithology changes at a depth of about 145 feet. Data were not conclusive to identify it as the stream-channel/consolidated-rock boundary. Two miles upstream from the mouth of Middle Canyon the minimum thickness of the stream-channel deposits is 142 feet (table 11, (C-4-3)6bdb-1). Between the mouth of the canyon and well (C-4-3)6bdb-1, the stream-channel deposits are estimated to be about 50 feet thick (Gates, 1963a, p. K11).

The stream-channel deposits of Settlement, Middle, and Pine Canyons contain ground water. Test well (C-3-4)35abd-2, located near the mouth of Middle Canyon, was drilled to determine whether water exists at depth. The deposits penetrated by the test well did not yield substantial quantities of water from 265 feet to 515 feet below land surface. Well (C-3-4)26cda-1, next to Middle Canyon creek and about 0.6 miles downstream from the mouth of Middle Canyon, was drilled to a depth of 245 feet and was reported to be dry. As indicated by information from well (C-4-4)33cbd-1 (table 8), the stream-channel deposits in Soldier Canyon probably would not yield substantial quantities of ground water at any depth. No data are available concerning the presence of ground water in the stream-channel deposits of Pass Canyon.

Water levels in the stream-channel deposits in Settlement Canyon range from land surface at Spring Flats to about 35 feet below land surface at well (C-3-4)33dac-1 (table 12). Water levels in the stream-channel deposits in Middle Canyon vary from about 20 feet below land surface at Angels Grove (table 10, (C-3-4)35aba-3) to about 80 feet below land surface at well (C-4-3)6bdb-1 (table 10), 2 miles above the mouth of the canyon.

Recharge

Stream-channel deposits are recharged mainly by streamflow losses and subsurface inflow. The quantity of recharge to the stream-channel deposits in Settlement, Middle, Pine, and Pass Canyons could not be estimated with available data. Streamflow losses to the stream-channel deposits for Settlement Canyon, however, were estimated. In Middle Canyon, a major source of recharge that could not be estimated is subsurface inflow from stream-channel and glacial deposits in adjoining tributary canyons (Gates, 1963a, p. K25).

Stream-channel losses in Settlement Canyon during 1989 were estimated from a limited number of streamflow measurements (pl. 1 and table 5) to be about 820 acre-feet. All spring discharge that occurs in Settlement Canyon above Right Hand Fork Spring [(C-4-4)14bbc-S1] is considered streamflow loss to the stream-channel deposits and accounts for about 280 acre-feet. Streamflow losses between Right Hand Fork Spring and Spring Flats accounts for about 300 acre-feet (table 5, (C-4-4)15aaa-M1 and 3cac-M1). Losses from Spring Flats to Settlement Canyon Reservoir are about 240 acre-feet (table 5, (C-4-4)3bcd-M1 and (C-3-4)34ccc-M1).

Stream-channel deposits in Settlement Canyon also are recharged by leakage from Settlement Canyon Reservoir. Prior to 1984, leakage from the reservoir was estimated to be about 10 to 20 percent of the reservoir inflow (Daniel Lawrence, Utah Division of Water Resources, retired, written commun., 1990). During flooding in the spring of 1984, a large quantity of fine-grained sediments was deposited on the bottom of the reservoir, probably reducing leakage. Leakage is still occurring, however, from the reservoir to the stream-channel deposits. The hydrograph of well (C-3-4)33dac-1, which is about 200 feet downcanyon from Settlement Canyon Dam and completed in stream-channel deposits, shows that water levels in the well are influenced by the altitude of the water surface in the reservoir (fig. 6). This relation shows that leakage is occurring, but data were not available to quantify the amount.

Recharge to stream-channel deposits from stream-channel losses in Middle Canyon occurs only when streamflows exceed the carrying capacity of the conveyance structures in the canyon (pl. 1). Perennial streamflow in Middle Canyon does not exceed the capacity of the conveyance structures and therefore does not contribute recharge to the stream-channel deposits. Recharge to the stream-channel deposits from subsurface flow from unconsolidated glacial and stream-channel deposits in White Pine Canyon does occur (Gates, 1963a, p. K25). These deposits absorb and store snowmelt and precipitation for later release through the subsurface to the stream-channel deposits. Data were not available to estimate the quantity of recharge occurring by this process, which probably accounts for a substantial part of the total recharge to the stream-channel deposits.

Stream-channel deposits in Pine Canyon are thought be recharged mainly from snowmelt and direct precipitation. Perennial water from sources in the upper parts of the canyon (table 9, (C-3-3)28bdc) is conveyed downcanyon in lined ditches and therefore does not contribute to recharge of the stream-channel deposits.

Flow

Ground-water flow in the stream-channel deposits is from the heads of the canyons toward basin-fill deposits at the canyon mouths. In addition, water may be moving into and out of the consolidated rock underlying the stream-channel deposits.

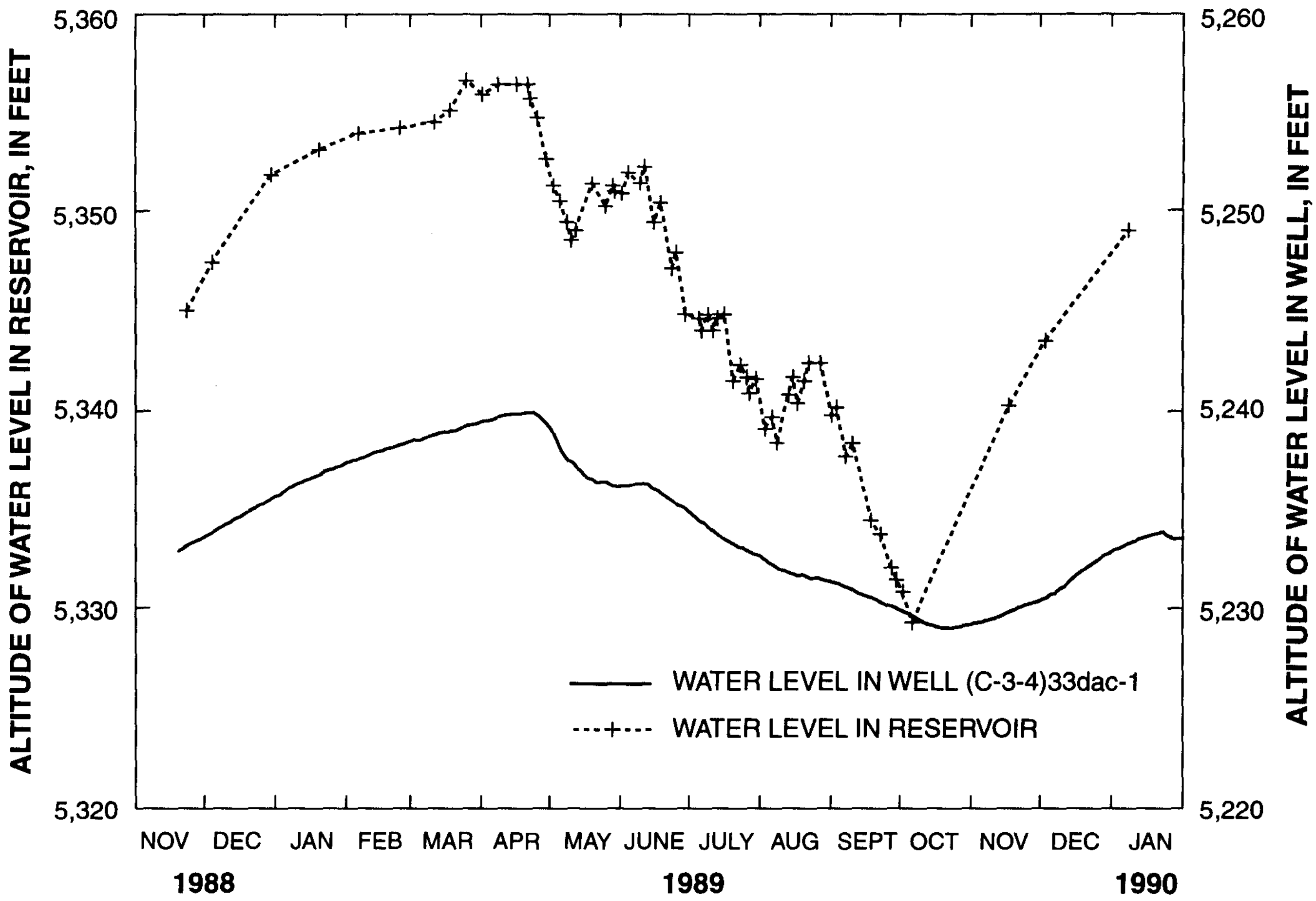


Figure 6. Altitude of water level in well (C-3-4)33dac-1 and water level in Settlement Canyon Reservoir. (Well locations shown on plate 1.)

Near the mouth of Settlement Canyon, ground water in the stream-channel deposits apparently is not in hydraulic connection with ground water in the adjacent consolidated rock. Water levels in the stream-channel deposits at well (C-3-4)33dac-1, which is completed in the stream-channel deposits, were monitored during pumping of wells (C-3-4)33acd-1 and 33dab-1, both completed in the underlying consolidated rock. Pumping in the two consolidated-rock wells had no measurable effect on water levels in well (C-3-4)33dac-1.

Ground water in Middle Canyon does flow between the stream-channel deposits and surrounding consolidated rock. A comparison of water levels in well (C-3-4)35add-1, completed in consolidated rock at the mouth of Middle Canyon, and pumping at well (C-4-3)6bdb-1, completed in stream-channel deposits about 2 miles upcanyon, is shown in figure 7. Water levels in the consolidated rock at the mouth of Middle Canyon decline during pumping of well (C-4-3)6bdb-1 and recover when pumping stops. Water-level fluctuations at well (C-3-4)35add-1 from November 1988 to April 1989 and from August 1989 to January 1990, after recovery from the July 1988 to October 1988 and the May 1989 to July 1989 pumping at well (C-4-3)6bdb-1, represent natural water-level changes in the consolidated rock. The response of water levels in well (C-3-4)35add-1 to withdrawals at well (C-4-3)6bdb-1 shows that a hydraulic connection exists between ground water in the stream-channel deposits and in the adjacent consolidated rock.

Discharge

Discharge from the stream-channel deposits is by subsurface outflow to adjoining basin-fill deposits and to springs, tunnels, and wells. Discharge from the stream-channel deposits in Settlement Canyon in 1989 to wells and to Greens Tunnel, and as subsurface outflow, was estimated to be 2,100 acre-feet. For purposes of analysis, discharge from springs located in the stream-channel deposits (table 9, (C-3-4)33dda-S1, (C-4-4)3cab-S1 and 14bbc-S1) was considered to be from the underlying consolidated rocks and not from the stream-channel deposits because data are unavailable to determine the source of the discharge. Discharge from wells (table 11, (C-3-4)34ccc-1 and 34ccc-2) in 1989 was about 1,200 acre-feet. Greens Tunnel [(C-4-4)10dcd] discharged about 800 acre-feet in 1989 (Dean Maloney, Settlement Canyon Irrigation Company, written commun., 1990). Discharge to the adjoining basin-fill deposits was estimated by using the following form of Darcy's equation:

$$Q = TIL \tag{1}$$

where

Q = discharge, in cubic feet per day;

T = transmissivity, in feet squared per day;

I = hydraulic gradient; and

L = width of the stream-channel deposits at the canyon mouth, in feet.

Transmissivity of the stream-channel deposits at the mouth of Settlement Canyon was about 130 feet squared per day (table 8) on the basis of an aquifer test at well (C-3-4)33dac-1. The hydraulic gradient between wells (C-3-4)33acd-1 and (C-3-4)33dac-1 in January 1990 was about 0.1. Well (C-3-4)33acd-1 is completed in consolidated rock and water levels in the well are probably not a good representation of actual water levels in the stream-channel deposits. The well was used because no other data were available. The width of the saturated stream-channel deposits at the mouth of the canyon is about 700 feet. Estimated subsurface discharge from stream-channel to basin-fill deposits at the mouth of Settlement Canyon is about 100 acre-feet per year.

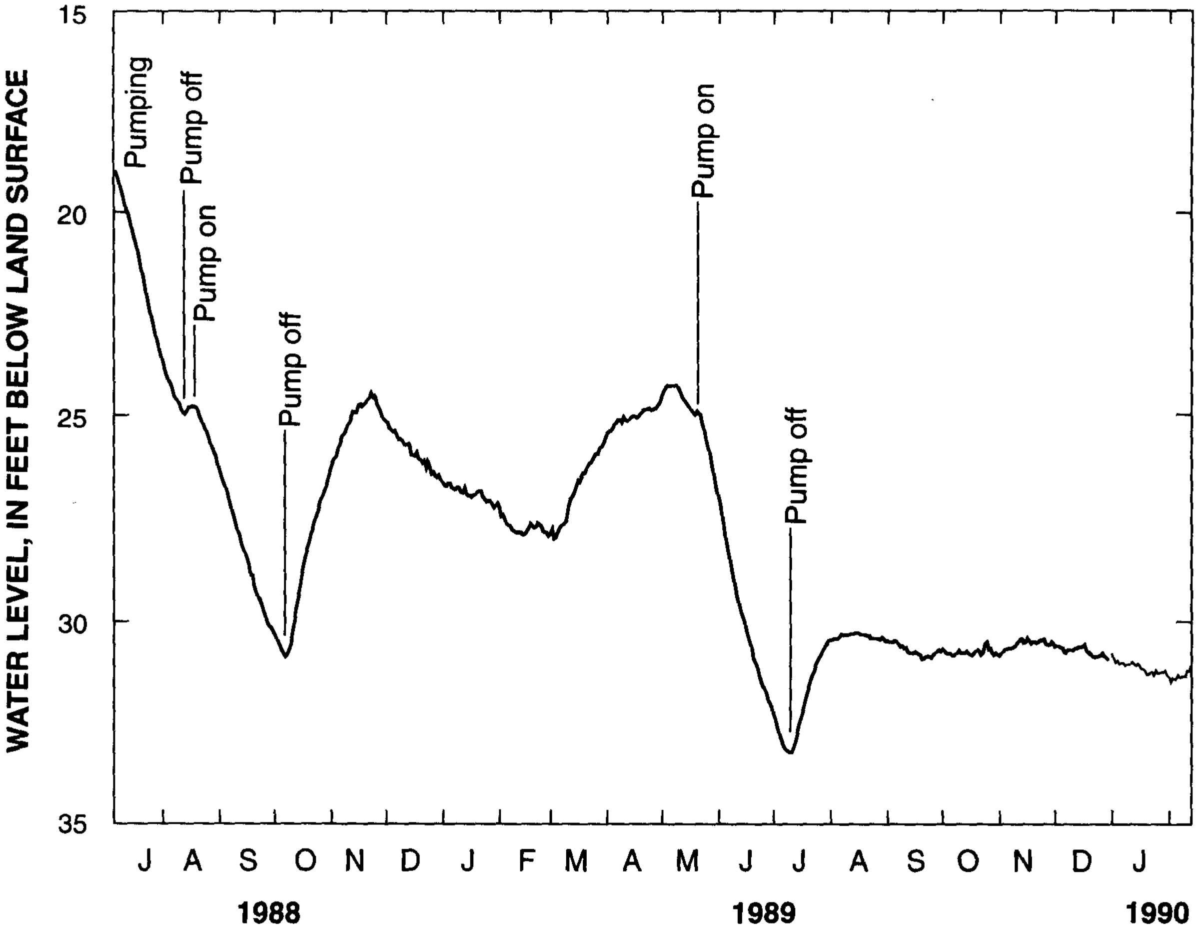


Figure 7. Water level in well (C-3-4)35add-1 and periods of pumping from well (C-4-3)6bdb-1. (Well locations shown on plate 1.)

Discharge from stream-channel deposits in Middle Canyon in 1989 to wells and subsurface outflow was estimated to be about 3,400 acre-feet. Big Spring [(C-3-4)35adb-S1] and Lincoln Spring [(C-3-4)35aac-S1], which are thought to discharge water from stream-channel deposits, did not flow in 1989. Subsurface flow to the basin-fill deposits was estimated to be about 2,700 acre-feet per year by using the form of Darcy's equation presented above. Transmissivity of the stream-channel deposits at well (C-3-4)35aba-1, on the basis of an aquifer test, was estimated to be 8,200 feet squared per day (table 8). Data to determine a hydraulic gradient were not available, and a hydraulic gradient of 0.1 was assumed. The width of the saturated stream-channel deposits at (C-3-4)35aba-1 is about 400 feet.

Discharge from wells (table 10, (C-3-4)35aba-1, 35aba-2, 35aba-3, (C-4-3)6bdb-1, and 6bdb-2) was about 700 acre-feet in 1989 (Joe D. England, Tooele City, written commun., 1990; Ross Johnson, Middle Canyon Irrigation Company, oral commun., 1989; Douglas Deem, Lincoln Culinary, oral commun., 1990). Total discharge from the stream-channel deposits in Pine Canyon could not be estimated because of a lack of data.

Hydraulic Properties

Hydraulic properties of the stream-channel deposits in the study area were determined from specific-capacity data reported in drillers' logs. The hydraulic properties of the stream-channel deposits determined at selected wells are listed in table 8. On the basis of lithology reported in drillers' logs, ground water in the stream-channel deposits is assumed to be under water-table conditions.

Specific capacity of the stream-channel deposits ranged from less than 1 gallon per minute per foot of drawdown at (C-4-4)33cbd-1 to 45 gallons per minute per foot of drawdown at well (C-3-4)35aba-1. The specific-capacity values of two wells completed in the stream-channel deposits of Middle Canyon 2 miles above the mouth were 22 and 21 gallons per minute per foot of drawdown, respectively (table 8, (C-4-3)6bdb-1 and 6bdb-2).

Two wells completed in the stream-channel deposits just upstream from Settlement Canyon Reservoir (table 10, (C-3-4)34ccc-1 and 34ccc-2) are each reported to discharge about 1,000 gallons per minute (Dean Maloney, Settlement Canyon Irrigation Company, written commun., 1990). The depths of the wells are 80 and 135 feet, respectively (Howard Clegg, Settlement Canyon Irrigation Company, oral commun., 1990). If it is assumed that the static water level is at land surface and that during pumping the water level is drawn down to the bottom of the well, specific capacities at the wells are 12.5 and 7.4 gallons per minute per foot of drawdown, respectively. Specific capacity at well (C-3-4)33dac-1, completed in the stream-channel deposits 200 feet downstream from the Settlement Canyon Dam, is 2 gallons per minute per foot of drawdown, which is 3 to 20 times less than values of specific capacity determined for the stream-channel deposits in Middle Canyon.

The estimated transmissivity of the stream-channel deposits in the study area ranges from 120 feet squared per day at well (C-4-4)33cbd-1 to 8,200 feet squared per day at well (C-3-4)35aba-1. Transmissivity values for the stream-channel deposits are largest in Middle Canyon and smallest at the mouth of Soldier Canyon. On the basis of lithology reported in drillers' logs, the specific yield of the stream-channel deposits is estimated to be about 0.20.

Storage

The volume of recoverable water stored in the stream-channel deposits in the study area is estimated to be about 7,300 acre-feet. This estimate is based on a surface area of the stream-channel deposits in Settlement, Middle, Pine, and Pass Canyons of about 610 acres, an average saturated thickness of 60 feet, and a specific yield of 0.20.

Water Quality

Results of chemical analyses are available for water from wells (C-3-4)35aba-1 and (C-4-3)6bdb-2, both completed in the stream-channel deposits of Middle Canyon (table 13). The dissolved-solids concentrations in water from the wells were 350 and 320 milligrams per liter, respectively. The predominant ions were calcium and bicarbonate. None of the dissolved constituents measured exceeded State of Utah Secondary Drinking Water Standards (Utah Division of Environmental Health, 1986, p. 3-6).

Water from wells (C-3-4)35aba-1 and (C-4-3)6bdb-2 and from spring (C-4-3)17cbd-S1 in White Pine Canyon (pl. 1) was compared. The spring water is thought to be representative of water recharging the stream-channel deposits in the upper parts of Middle Canyon. The dissolved-solids concentration in the spring water was 201 milligrams per liter, and the predominant ions were calcium and bicarbonate. Comparison of the analyses showed that, with the exception of slight increases in sodium, chloride, and calcium concentrations, water in the stream-channel deposits of Middle Canyon changes little chemically as it moves downgradient from the higher-altitude recharge areas to the canyon mouth.

Consolidated Rock

In the study area, consolidated rock is at or near land surface throughout most of the Oquirrh Mountains. Consolidated rock underlies the basin-fill deposits and crops out in small areas of southeastern Tooele Valley. The consolidated rock consists mainly of sandstone, quartzite, and limestone, with smaller amounts of shale and dolomite (Gilluly, 1932, p. 6; Gates, 1963a, p. K8; Tooker, 1980; Tooker and Roberts, 1988, p. 2). Intrusive igneous rock is found in several isolated parts of the study area. The consolidated rock has been subjected to structural deformation, including folding and faulting, some of which is the result of volcanic intrusions.

The presence of ground water in the consolidated rock is confirmed by discharge from springs, tunnels, and wells completed in consolidated rock. They are listed in tables 9 and 10 and shown on plate 1. Thirty-one springs whose source of water is identified as consolidated rock were located during this study. In general, the locations of springs did not correlate with known topographic or geologic features. Water in consolidated rock was encountered during underground mining operations near Stockton and in the Pine Canyon area. Ground water in consolidated rock drains into the Honerine, Utah Metals, Bingham West Dip, Pine Canyon, and Pass Canyon Tunnels. Wells completed in consolidated rock near the mouths of Settlement, Middle, and Spring Canyons, and at Tooele Army Depot confirm the presence of ground water in consolidated rock. Depth to water in the wells ranges from about 10 to about 225 feet below land surface.

Recharge

Average recharge to the consolidated rock in the Oquirrh Mountains adjacent to southeastern Tooele Valley is estimated to be about 42,000 acre-feet per year. Recharge was not estimated directly and was determined by equating it to discharge from the consolidated rock; discharge from consolidated rock is discussed in the section on recharge to basin-fill deposits. The assumption was made that recharge equals discharge, which means ground water in the consolidated rock is under steady-state conditions.

Recharge to the consolidated rock is primarily from downward percolation of snowmelt. Snowmelt generally occurs during March, April, May, and June. Observations at the Carr Fork Mine [(C-3-3)28bca] indicate rapid movement of snowmelt into the consolidated rock. The quantity of water draining into the mine increased as much as three times from 30 to 45 days after the beginning of the snowmelt runoff (Randy Harden, Utah Division of Oil, Gas, and Mining, oral commun., 1989).

Water-level rises for March-April 1989 in well (C-3-4)35add-1, which is completed in consolidated rock, also indicate recharge during snowmelt (fig. 7). Discharge from springs and tunnels and water levels in wells in 1989 (tables 9 and 12, (C-2-4)26ddd-S1, 35aaa-S1; (C-3-3)4ccb, (C-4-3)9bcd, (C-4-5)13cab; (C-3-4)25aaa-1 and 25aad-1) did not show fluctuations that could be attributed to seasonal recharge to the consolidated rock. This lack of correlation may be a result of the small quantity of snowmelt that occurred during 1989. Discharge from spring (C-2-4)26ddd-S1 does show a relation to fluctuations in yearly precipitation. During 1984, discharge at the spring averaged about six times the discharge measured in 1989 (table 9); yearly precipitation in 1983 and 1984 was about 150 percent of the 1960-89 average (fig. 3). Some recharge to the consolidated rock in the study area could be from consolidated rock adjoining the study area, but data are not available to verify this possibility.

The consolidated rock and stream-channel deposits in Middle and Dry Canyons are hydraulically connected. In Middle Canyon, water levels in well (C-3-4)35add-1, near the mouth of the canyon and completed in consolidated rock, decline in response to withdrawal from the stream-channel deposits, 2 miles upcanyon at well (C-4-3)6bdb-1, and rise when pumping stops (fig. 7). In the Elton Tunnel [(C-3-4)13adc], increased flow from consolidated rock was noted where the tunnel traversed beneath Dry Canyon, indicating the presence of a hydraulic connection between the consolidated rock and stream-channel deposits in Dry Canyon (Thomas, 1946, p. 157).

Flow

The general direction of ground-water flow in the consolidated rocks of the study area in the Oquirrh Mountains is from the higher-altitude areas toward the basin-fill deposits of southeastern Tooele Valley, although local flow is probably toward canyon bottoms. In the vicinity of Tooele Army Depot, ground water in the consolidated rock generally flows northwest and parallel to the direction of water movement in the surrounding basin-fill deposits (James M. Montgomery, Consulting Engineers, Inc., 1988, p. 4-15 to 4-24). In areas adjacent to tunnels that discharge water, ground water flows toward the tunnel.

Flow in the consolidated rock is primarily through fractures and solution openings (Thomas, 1946, p. 156). Water was found in fractures in wells (C-3-4)25aaa-1, 33acd-1, and 33dab-1; (C-3-5)23aad-1; and (C-4-4)2cbd-1. Flow in the consolidated rock in the Carr Fork Mine [(C-3-3)28bca], even at 3,200 feet beneath the land surface, was through fractures (James Garmoe, Carr Fork Mining Operation, oral commun., 1989). In the consolidated rock underlying the basin-fill deposits at Tooele Army Depot, flow also is through fractures and solution openings (James M. Montgomery, Consulting Engineers, Inc., 1988, p. 4-9).

Discharge

Average discharge from consolidated rock in the Oquirrh Mountains adjacent to southeastern Tooele Valley is estimated to be about 42,000 acre-feet per year. Ground water discharges by subsurface flow to the basin fill in southeastern Tooele Valley and to springs, tunnels, and wells. The average subsurface discharge from the consolidated rocks of the Oquirrh Mountains to the basin-fill deposits in southeastern Tooele Valley is estimated to be about 34,000 acre-feet per year (see section on recharge to the basin-fill deposits).

Subsurface discharge from the consolidated rocks to the basin fill was determined for local areas near the mouths of Settlement and Spring Canyons by using equation 1. On the basis of aquifer tests reported in table 8, transmissivity of the consolidated rock at the mouth of Settlement Canyon is estimated to be about 10,000 feet squared per day and the hydraulic gradient is about 0.1. The length of the consolidated rock/basin-fill boundary at the mouth of the canyon is about 800 feet. The quantity of discharge occurring along this section of the consolidated rock/basin-fill boundary is calculated to be 6,700 acre-feet per year. Transmissivity of the consolidated rock at the mouth of Spring Canyon is estimated to be 60 feet squared per day (table 8) on the basis of drawdown information from test well (C-3-4)25aaa-1. A hydraulic gradient of 0.03 was measured, and the length of the consolidated rock/basin-fill boundary used in the analysis was 1,000 feet. The quantity of discharge occurring along this section of the consolidated rock/basin-fill boundary is calculated to be 15 acre-feet per year. The variation in subsurface flow from the consolidated rock to the basin-fill deposits probably is due in large part to fracturing in the consolidated rock.

Average annual discharge from the consolidated rock to springs is estimated to be about 5,400 acre-feet. Discharge from selected springs used in this estimate are listed in table 9. The estimate is based primarily on one-time measurements of discharge and therefore is only approximate. No attempt was made to normalize the data to compensate for less-than-average precipitation during the study period.

The average annual discharge from consolidated rock to tunnels is estimated to be about 1,600 acre-feet. This estimate is the sum of the average discharge measured and estimated for the Pass Canyon, Bingham West Dip, Utah Metals, and Honerine Tunnels during the study period (table 9, (C-3-3)4ccb, (C-3-3)17ddc, (C-4-3)9bcd, and (C-4-5)13cab). Water stopped discharging from the entrance of the Elton Tunnel [(C-3-4)13adc] in 1958 as a result of collapses in the tunnel (Gates, 1965, p. 20). Average discharge from the tunnel during 1941-51 was about 4,100 acre-feet per year. More than 90 percent of the water discharged from the Elton Tunnel originated from consolidated rock (Thomas, 1946, p. 158). During operation of the Carr Fork Mine [(C-3-3)28bca], an average of about 5,200 acre-feet of water per year was pumped from the mine to keep the workings dry (Randy Harden, Utah Division of Oil, Gas, and Mining, oral commun., 1989). The mine is about 3,200 feet deep. The water discharged by the Elton Tunnel and withdrawn from the Carr Fork Mine probably was derived partly from storage in the consolidated rock.

Water-level rises in the basin-fill deposits in the Erda area during 1941-58 are attributed partly to discharge from the Elton Tunnel, which then recharges the basin fill (Gates, 1963, p. 40).

Water-level rises for the same area during 1972-76 may be related to discharge from the Carr Fork Mine (Razem and Steiger, 1981, p. 23).

Average ground-water withdrawal from the consolidated rock from two wells at the mouth of Settlement Canyon (table 10, (C-3-4)33acd-1 and 33dab-1) is estimated to be about 600 acre-feet. In 1989, the total quantity of withdrawal from these wells was 630 acre-feet (Joe D. England, Tooele City, written commun., 1990).

Hydraulic Properties

The hydraulic properties of the consolidated rock in the study area were estimated from results of aquifer tests and drillers' logs. The specific capacities of selected wells completed in the consolidated rock are listed in table 8. The specific-capacity values range from less than 1 gallon per minute per foot of drawdown at well (C-3-4)25aaa-1 to 97 gallons per minute per foot of drawdown at well (C-3-4)33acd-1. The large variation is probably caused by the variability of fracturing of the consolidated rock. Hydraulic conductivity of the consolidated rock is probably controlled by the amount of fracturing and degree of hydraulic communication between the fractures. The degree of fracturing depends on rock type and the amount of structural deformation the rock has undergone and is not uniform throughout the part of the study area where consolidated rock crops out. Solution openings can also be an important factor in the hydraulic conductivity of limestone, which makes up a part of the consolidated rock in the study area.

In January 1990, well (C-3-4)33acd-1, at the mouth of Settlement Canyon, was pumped at a rate of 1,100 gallons per minute for 73 hours. Water levels were monitored at well (C-3-4)33dac-1, 1,880 feet from the pumped well and completed in the stream-channel deposits overlying the consolidated rock, and at well (C-3-4)33dab-1, 1,360 feet from the pumped well and completed in the consolidated rock. The pumping did not affect the water level in either observation well. Transmissivity of the consolidated rock at the pumped well was determined to be 14,000 feet squared per day (table 8). A storage coefficient could not be determined with the available data.

In October 1986, James M. Montgomery, Consulting Engineers, Inc., (1988, p. 4-7) conducted a 24-hour aquifer test at well (C-3-5)23aad-1 to determine the hydraulic properties of the consolidated rock underlying the basin-fill deposits at Tooele Army Depot. Test results showed large variability in hydraulic properties of the consolidated rock in the vicinity of the pumped well. Hydraulic conductivity determined by using data from the test well and two observation wells ranges from 23 to 111 feet per day. The storage coefficient derived from data from the three wells ranges from 0.0001 to 0.003. The variability is thought to be caused by the heterogeneity of the fractures in the consolidated rock (James M. Montgomery, Consulting Engineers, Inc., 1988, p. 4-12).

Storage

The quantity of ground water stored in the consolidated rock in the study area was not quantified. Data were not available to describe the spatial variability of the saturated thickness and specific yield of the consolidated rock; therefore, an estimate of the volume of ground water stored in the consolidated rock could not be made.

Water Quality

Results of chemical analyses of water discharged from consolidated rock at selected wells, springs, tunnels, and streams are listed in table 13. Dissolved-solids concentrations ranged from 220 to 647 milligrams per liter in water discharging from wells and springs, and the predominant ions in the water were calcium and bicarbonate. The dissolved-solids concentrations in ground water collected at springs (C-3-3)8dcb-S1, 9bbc-S1, and (C-4-4)34bab-S1 exceeded the State of Utah Secondary Drinking Water Standard of 500 milligrams per liter (Utah Division of Environmental Health, 1986, p. 3-6).

Ground water discharging from tunnels in the consolidated rock in the Oquirrh Mountains contained dissolved solids in concentrations ranging from 312 to 1,400 milligrams per liter. The predominant ions were calcium and sulfate. The increased concentration of sulfate is probably a result of ground-water flow through areas of mineralization. The dissolved-solids and sulfate concentrations in water collected at tunnels (C-3-3)28bdc and (C-4-5)13cab exceeded the State of Utah Secondary Drinking Water Standards of 500 and 250 milligrams per liter, respectively (Utah Division of Environmental Health, 1986, p. 3-6).

POTENTIAL FOR GROUND-WATER DEVELOPMENT

For purposes of this report, the potential for ground-water development in the study area is based on the ability of the aquifers to yield fresh water (less than 1,000 milligrams per liter of dissolved solids) with minimal effect on existing wells. Areas of freshwater are shown on plate 3. Specific capacities (yield in gallons per minute per foot of drawdown) and saturated thickness of the basin-fill deposits at wells where it could be determined also are shown on plate 3.

Basin-Fill Deposits

Potential exists for ground-water development from the basin fill in selected areas in southeastern Tooele Valley. About 3,000 acre-feet per year is currently withdrawn from the basin-fill deposits in southeastern Tooele Valley. This withdrawal accounts for less than 10 percent of the total quantity of water moving through the basin-fill deposits in that area. On the basis of hydraulic properties and water quality, additional ground water could be withdrawn from localized areas southwest of Tooele City near the municipal airport and in the vicinity of Lincoln.

The basin-fill deposits southwest of Tooele City near the municipal airport are considered to be under water-table conditions and have an average specific capacity of 35 gallons per minute per foot of drawdown (table 8, (C-3-4)28cdc-2, 29cba-1, 29ccb-1, 30aac-1, 31bba-1, and 32bbc-1). The interference from additional ground-water withdrawals at existing wells in the area is expected to be minimal. By using an average transmissivity of 14,500 feet squared per day (determined from information for the listed wells) and a specific yield of 0.10, drawdown 0.25 mile away from a well pumping 1,000 gallons per minute for 1 year would be about 5 feet. In this example, it is assumed that no large changes in hydraulic properties occur in the vicinity of the well. Generally, ground-water quality in the basin-fill deposits southwest of Tooele City is suitable for domestic use, with an average dissolved-solids concentration of 466 milligrams per liter (determined from information for the listed wells). North of well (C-3-4)29ccb-1, specific-capacity values and saturated thickness indicate that less ground water could be withdrawn; south and west of well (C-3-4)32bbc-1, concentrations of sodium and chloride increased.

Specific capacity of the basin-fill deposits in the vicinity of Lincoln, based on results of an aquifer test conducted at well (C-3-4)14adb-1, is 14 gallons per minute per foot of drawdown. In 1989, the pumped wells nearest this area were about 3 miles to the north. Ground-water withdrawals from basin-fill deposits, which are under water-table conditions in the Lincoln area, are not expected to lower water levels substantially in wells to the north. The quality of water in the basin-fill deposits in the Lincoln area, based on chemical analysis of water from wells (C-3-4)13abb-1 and (C-3-4)14adb-1, exceeds the State of Utah Secondary Drinking Water Standard for dissolved-solids concentration. West of the Lincoln area, sodium and chloride concentrations in the ground water increase, and dissolved-solids concentrations exceed 1,000 milligrams per liter. The thickness of basin fill saturated with freshwater near Lincoln, based on resistivity logs at well (C-3-4)11ccc-1, is estimated to exceed 500 feet (pl. 3).

Stream-Channel Deposits

Potential does not exist for additional ground-water development from the stream-channel deposits in Settlement and Middle Canyons. Numerous wells and springs have already been developed in these areas. Further development likely would cause ground-water-level declines, reduce spring discharges, and affect current water development in the canyons. Near the mouth of Settlement Canyon, wells completed in the stream-channel deposits have low specific capacities, and yield to wells would be minimal. Above Settlement Canyon Reservoir, additional pumping likely would cause water-level declines at wells (C-3-4)34ccc-1 and 34ccc-2.

At the mouth of Middle Canyon at Angels Grove, three wells withdraw ground water from the stream-channel deposits (table 10, (C-3-4)35aba-1, 35aba-2, and 35aba-3). These wells cannot be pumped simultaneously without causing large water-level declines in all three wells (Joe D. England, Tooele City, oral commun., 1989). The wells are completed at depths ranging from 59 feet to 75 feet, and further development at those depths would cause additional interference. Results of seismic surveys and test drilling at Angels Grove (table 10, (C-3-4)35abd-2) indicate that water yield to wells may be minimal at depths greater than about 120 feet. Wells completed in the stream-channel deposits about 2 miles upstream from the mouth of the canyon (table 10, (C-4-3)6bdb-1 and 2) also interfere with one another (Ross Johnson, Middle Canyon Irrigation Company, oral commun., 1989). Additional development of ground water from the stream-channel deposits in the vicinity of these wells is also not considered possible.

Four wells are completed in the stream-channel deposits of Pine Canyon near its mouth (table 10, (C-3-3)20baa-1, 20bab-1, 20bad-1, and 20bba-1). These wells were not pumped during the study period. On the basis of historic records, the combined withdrawals from these wells was between 500 and 800 acre-feet per year (Gates, 1963b, p. 8, 20). The effect the wells have on one another during pumping is not known. The quality of ground water in the stream-channel deposits of Pine Canyon also is unknown, but the proximity to a major mining area indicates that the water may be mineralized.

No wells are completed in the stream-channel deposits in Pass Canyon. The presence of surface water in the canyon and ground water in the consolidated rock in the area indicates that ground water may exist in the stream-channel deposits in Pass Canyon. The quality of water in the stream-channel deposits in this area is likely to be similar to the water quality at Pass Canyon Tunnel, where the dissolved-solids concentration is 442 milligrams per liter (table 13, (C-3-3)4ccb).

Consolidated Rock

Potential exists for ground-water development from consolidated rock along the basin-fill/consolidated-rock boundary between Middle and Dry Canyons. The locations of springs discharging from the consolidated rocks do not indicate specific geologic units or rock types with large potential for development. Water from the large-discharge springs in the study area is already appropriated and used.

Development of moderate quantities of water from the consolidated rock along the basin-fill/consolidated-rock boundary between Middle and Dry Canyons is possible. On the basis of information from well (C-3-4)25aaa-1, the specific capacity of consolidated rock in this area is about 1 gallon per minute per foot of drawdown. On the basis of specific-conductance measurements, the dissolved-solids concentration of ground water at the well is estimated to be about 400 milligrams per liter. Additional ground-water withdrawals from the consolidated rock underlying the stream-channel deposits at the mouth of Settlement Canyon probably would interfere with existing wells in the area. Ground-water development from the consolidated rock underlying the stream-channel deposits at the mouth of Pass Canyon may be possible. Data are not available to determine the presence of water or hydraulic properties of the consolidated rock near the mouth of Pass Canyon.

SUMMARY AND CONCLUSIONS

Communities in southeastern Tooele Valley, Utah, are growing, and future demand for water is expected to increase. To prepare for this demand, the U.S. Geological Survey studied the surface- and ground-water resources of southeastern Tooele Valley and the adjacent Oquirrh Mountains during 1988-90 in cooperation with Tooele City and Tooele County.

The largest perennial streams in the study area are in Settlement, Middle, and Soldier Canyons. Smaller perennial streamflows are found in Pine, Pole, Swensons, Leavetts, and Pass Canyons. All these canyons drain areas of the Oquirrh Mountains adjacent to southeastern Tooele Valley and northeastern Rush Valley. Most streamflow from Settlement, Middle, and Soldier Canyons is diverted for irrigation and public-supply uses. The sources of base flow to the perennial streams are springs and tunnels. Average annual streamflows for Settlement, Middle, and Soldier Canyons are estimated to be about 6,000, 2,100, and 3,900 acre-feet, respectively. On the basis of limited measurements of spring and tunnel discharge, the combined average perennial streamflow of Pine, Pole, Swensons, Leavetts, and Pass Canyons is estimated to be about 700 acre-feet per year.

Ground water in the study area is present in both unconsolidated and consolidated rocks. Unconsolidated rocks occur as basin-fill deposits in Tooele and Rush Valleys and stream-channel deposits in the bottoms of major canyons in the Oquirrh Mountains. Consolidated rocks are found throughout the Oquirrh Mountains and crop out at isolated locations in southeastern Tooele Valley.

Average recharge to the basin-fill deposits in southeastern Tooele Valley is estimated to be about 44,000 acre-feet per year. Recharge to southeastern Tooele Valley from Rush Valley underneath the Stockton Bar is estimated to be about 5,000 acre-feet per year. Average recharge to the basin fill from unconsumed irrigation water is estimated to be about 1,400 acre-feet per year. Recharge from direct precipitation on the basin-fill deposits is estimated to be about 800 acre-feet per year. Subsurface inflow from adjoining stream-channel deposits is estimated to be about 2,800 acre-feet per year. Estimated recharge from subsurface inflow from consolidated rock is about 34,000 acre-feet per year.

The general direction of ground-water flow in the basin-fill deposits of southeastern Tooele Valley is to the northwest, away from the Oquirrh Mountains and toward the central and northern parts of Tooele Valley. Local anomalies in the general direction of flow are present at the mouth of Settlement Canyon and west of Tooele City.

Average discharge from the basin-fill deposits in southeastern Tooele Valley is estimated to be about 44,000 acre-feet per year, the same as the estimated average annual recharge. Average ground-water withdrawals in southeastern Tooele Valley are estimated to be about 3,000 acre-feet per year. Average discharge by subsurface outflow to adjoining areas is estimated to be about 41,000 acre-feet per year.

Hydraulic properties of the basin-fill deposits in southeastern Tooele Valley were determined or estimated from results of aquifer tests and lithologic information from drillers' logs. Transmissivity of the basin-fill deposits ranges from 30 to 56,000 feet squared per day. Estimates of specific yield range from 0.10 to 0.30. Storage coefficient estimates of the basin-fill deposits in southeastern Tooele Valley range from 0.0065 to 0.002. Ground water in the basin-fill deposits south and west of Tooele City is considered to be under water-table conditions. Ground water in the basin fill north of well (C-3-4)16aaa-1 and in the Erda area is considered to be under artesian conditions.

The quantity of fresh ground water that theoretically can be removed from the basin-fill deposits in southeastern Tooele Valley is estimated to be about 600,000 acre-feet. To recover this quantity of water, the basin fill would have to be completely dewatered.

Water levels in the basin-fill deposits fluctuate both seasonally and annually. Seasonal water-level changes are primarily the result of ground-water withdrawals during the irrigation season. Annual water-level fluctuations are typically caused by variations in the quantity of recharge to the basin-fill deposits; recharge variations are caused by changes in annual precipitation. Seasonally, water levels are highest in March and April. Because of increased precipitation during 1983 and 1984, water levels rose rapidly, beginning in 1983, and increased by as much as 50 feet during 1983-85. In 1989, water levels were still about 25 feet above their pre-1983 levels.

The chemical composition of ground water in southeastern Tooele Valley depends on location and depth. Water in the basin-fill deposits south and west of Tooele City is generally suitable for domestic use, with dissolved-solids concentrations ranging from 363 to 572 milligrams per liter. The dissolved-solids concentrations in the water increases north of Tooele and northwest of Tooele Army Depot because of increases in sodium, sulfate, and chloride; this increase is probably caused by mixing with geothermal waters. Dissolved-solids concentrations in ground water in the basin-fill deposits north of Tooele City and near Lincoln range from 628 to 774 milligrams per liter. The dissolved-solids concentration in water in the northern parts of the study area, near Erda, is between 500 and 1,000 milligrams per liter.

The stream-channel deposits in Settlement, Middle, and Pine Canyons contain ground water. Stream-channel deposits in Soldier Canyon probably do not contain substantial quantities of ground water. The primary sources of ground-water recharge to the stream-channel deposits in Settlement and Middle Canyons are streamflow losses and subsurface inflow from adjoining areas. The quantity of recharge to the stream-channel deposits could not be estimated with available data, although streamflow losses in Settlement Canyon during 1989 were estimated to be about 820 acre-feet. Stream-channel deposits in Pine Canyon are thought to be recharged mainly from snowmelt and direct precipitation.

Ground water in the stream-channel deposits flows from the heads of the canyons toward basin-fill deposits at the canyon mouths. There is a hydraulic connection between the stream-channel deposits and surrounding consolidated rock in Middle and Dry Canyons.

Discharge from the stream-channel deposits is by subsurface outflow to adjoining basin-fill deposits, and from springs, tunnels, and wells. Discharge from the stream-channel deposits in Settlement Canyon in 1989 is estimated to be about 2,100 acre-feet. Discharge from stream-channel deposits in Middle Canyon in 1989 is estimated to be about 3,400 acre-feet.

The hydraulic properties of the stream-channel deposits were determined from specific-capacity data reported in drillers' logs; specific capacity ranged from less than 1 to 45 gallons per minute per foot of drawdown. On the basis of lithologic information reported in drillers' logs, ground water in the stream-channel deposits is assumed to be under water-table conditions. A specific yield of 0.20 is estimated for the stream-channel deposits. The quantity of recoverable water stored in the stream-channel deposits in the study area is estimated to be about 7,300 acre-feet.

The dissolved-solids concentrations in water in the stream-channel deposits, on the basis of limited data, ranged from 320 to 350 milligrams per liter. The predominant ions were calcium and bicarbonate.

The presence of ground water in the consolidated rock is confirmed by discharge from springs, tunnels, and wells. Thirty-one springs whose source of water is identified as consolidated rock were located during this study. Average recharge to the consolidated rock in the Oquirrh Mountains, adjacent to southeastern Tooele Valley, is estimated to be about 42,000 acre-feet per year. The primary source of recharge is from downward percolation of snowmelt.

The general direction of ground-water flow in the consolidated rock of the study area in the Oquirrh Mountains is from the higher-altitude areas toward the basin-fill deposits of southeastern Tooele Valley, although local flow is probably toward canyon bottoms. In areas adjacent to tunnels that discharge water, ground water flows toward the tunnel. Water in the consolidated rock flows primarily through fractures and solution openings. Average discharge from consolidated rock in the Oquirrh Mountains, adjacent to southeastern Tooele Valley, is estimated to be about 42,000 acre-feet per year.

Hydraulic properties of the consolidated rock were estimated using information from aquifer tests and drillers' logs. Specific capacities of selected wells completed in the consolidated rock range from less than 1 to 97 gallons per minute per foot of drawdown. Hydraulic conductivity of the consolidated rock is probably controlled by the amount of fracturing and degree of hydraulic communication between the fractures. The quantity of ground water stored in the consolidated rock could not be estimated from available data.

Dissolved-solids concentrations ranged from 220 to 647 milligrams per liter in water discharging from wells and springs; the predominant ions in the water were calcium and bicarbonate. Ground water discharging from tunnels contained dissolved solids in concentrations ranging from 312 to 1,400 milligrams per liter, and the predominant ions were calcium and sulfate.

Potential for ground-water development in the study area is based on the ability of the aquifers to yield fresh water (less than 1,000 milligrams per liter of dissolved solids) with minimal effect on existing wells. On the basis of hydraulic properties and water quality, potential exists for ground-water development in localized areas southwest of Tooele City near the municipal airport and in the vicinity of Lincoln. Potential does not exist for additional ground-water development from the stream-channel deposits in Settlement and Middle Canyons. Development of moderate quantities of ground water from the consolidated rock is possible along the basin-fill/consolidated-rock boundary between Middle and Dry Canyons. The locations of springs discharging from the consolidated rocks did not indicate specific geologic units or rock types with large potential for development of ground water.

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Table 9. *Records of selected springs and tunnels*

[—, no data]

Location: See figure 2 for an explanation of the numbering system for hydrologic-data sites.

Name/area: Unnamed springs are identified by the area in which they are located.

Altitude of land surface: Given in feet above sea level.

Date: Listed as month, day, year.

Discharge: gal/min, gallon per minute; values greater than 20 gallons per minute rounded to nearest whole number; E, estimate.

Geologic source: The deposits from which water is discharging; BF, basin-fill deposits; SC, stream-channel deposits; CR, consolidated rock.

Specific conductance: µS/cm, microsiemens per centimeter at 25 degrees Celsius; CA, see table 13 for additional water-quality data.

Water temperature: °C, degrees Celsius.

Location	Name/area	Altitude of land surface (feet)	Date	Discharge (gal/min)	Geologic source	Specific conductance (µS/cm)	Water temperature (°C)
(C-2-4)26ddd-S1	Rose Spring	4,600	06-27-78	—	CR	600 CA	16.0
			09-26-84	1,570		—	—
			10-01-84	1,770		—	—
			12-12-84	1,220		—	—
			05-06-85	539		—	—
			06-10-88	—		650 CA	16.5
			01-12-89	297		—	—
			02-23-89	274		—	—
			04-27-89	297		—	—
			06-30-89	133		—	—
			08-04-89	188		—	—
			09-14-89	246		—	—
			11-15-89	182		—	—
			12-14-89	203		—	—
(C-2-4)35aaa-S1	South Bryan Spring	4,600	01-12-89	28	CR	—	16.0
			02-23-89	27		—	—
			04-25-89	22		—	—
			06-30-89	14.3		—	—
			08-08-89	17.4		—	—
			09-15-89	17.1		—	—
			11-15-89	7.9		—	—
(C-3-3)4ccb	Pass Canyon Tunnel	6,240	07-11-88	131	CR	770 CA	10.0
			10-11-88	170		—	—
			11-16-88	144		—	—
			12-13-88	153		—	—
			01-25-89	154		—	—
			03-09-89	163		—	—
			04-20-89	152		—	—
			06-15-89	142		—	—
			07-11-89	136		—	—

Table 9. *Records of selected springs and tunnels*—Continued

Location	Name/area	Altitude of land surface (feet)	Date	Discharge (gal/min)	Geologic source	Specific conductance (µS/cm)	Water temperature (°C)
(C-3-3)4ccb	Pass Canyon Tunnel	6,240	08-08-89	136	CR	—	—
			09-14-89	124		—	—
			11-02-89	124		—	—
			12-15-89	126		—	—
(C-3-3)6cda-S1	Murray Canyon	5,600	06-10-88	30	CR	730 CA	11.5
			06-28-88	29		—	—
			07-19-88	22		—	—
			08-17-88	17.5		—	—
			09-14-88	13.2		—	—
			10-05-88	13.0		—	—
			11-10-88	12.0		—	—
			12-13-88	9.8		—	—
			01-24-89	9.3		—	—
			03-09-89	11.5		—	—
			04-25-89	9.1		—	—
			06-16-89	6.7		—	—
			07-11-89	9.4		—	—
			08-08-89	9.3		—	—
			09-22-89	9.5		—	—
			11-01-89	11.4		—	—
			12-14-89	11.6		—	—
(C-3-3)8dcb-S1	Lower Leavetts Canyon	6,220	07-25-88	29	CR	1,030 CA	9.0
			08-17-88	18.0		—	—
(C-3-3)8ddd-S1	Upper Leavetts Canyon	6,600	08-17-88	7.4	CR	800 CA	11.0
(C-3-3)9bbc-S1	Pass Canyon	6,320	07-08-88	4.7	CR	960 CA	10.0
(C-3-3)16cca-S1	Pole Canyon	6,600	08-19-88	6.4	CR	730 CA	10.0
(C-3-3)17acb-S1	North fork Swensons Canyon	6,250	08-22-88	9.0	CR	680 CA	10.0
(C-3-3)17adc-S1	South fork Swensons Canyon	6,480	08-22-88	23	CR	650 CA	10.5
(C-3-3)17ddc	Bingham West Dip Tunnel	6,160	11-01-89	200 E	CR	—	—
(C-3-3)20bad-S1	Pine Canyon	5,560	11-01-89	247	—	—	—
			01-09-90	220	—	—	—
(C-3-3)28bdc	Pine Canyon Tunnel	6,600	01-11-78	—	CR	1,650 CA	17.0
			11-01-90	—		—	—
(C-3-3)30bcc-S1	Spring Canyon	6,330	07-20-88	0.6	CR	—	—
(C-3-3)31cab-S1	Middle Canyon	7,300	07-01-88	3.1	CR	500 CA	8.5
(C-3-4)13adc	Elton Tunnel	5,070	—	—	BF/CR	—	—
(C-3-4)33dda-S1	Rench Spring	5,310	—	—	—	—	—
(C-3-4)35aac	DeLaMare Tunnel	5,380	—	—	—	—	—
(C-3-4)35aac-S1	Lincoln Spring	5,400	—	—	—	—	—
(C-3-4)35adb-S1	Big Spring	5,420	—	—	—	—	—
(C-3-4)36ddb-S1	Middle Canyon	6,080	08-23-89	1.1	CR	620	11.0
(C-4-3)7add-S1	Harkers Canyon	7,500	09-20-88	36	CR	460 CA	6.0
(C-4-3)7baa-S1	Middle Canyon	6,920	09-07-88	4.7	CR	470 CA	7.5
[1] (C-4-3)9bcd	Utah Metals Tunnel	6,933	06-27-78	—	CR	480 CA	8.0
			09-01-88	360		550 CA	8.5
			11-22-88	289		—	—

Table 9. *Records of selected springs and tunnels*—Continued

Location	Name/area	Altitude of land surface (feet)	Date	Discharge (gal/min)	Geologic source	Specific conductance (μS/cm)	Water temperature (°C)
(C-4-3)9bcd	Utah Metals Tunnel	6,933	12-13-88	244	CR	—	—
			01-25-89	229		—	—
			03-24-89	229		—	—
			04-19-89	226		—	—
			06-16-89	261		—	—
			07-12-89	236		—	—
			08-09-89	272		—	—
			09-14-89	240		—	—
			11-02-89	200		—	—
			12-14-89	201		—	—
(C-4-3)9dba-S1	Middle Canyon	7,440	08-23-89	4.3	—	520 CA	10.0
(C-4-3)16abd-S1	Hansen Fork	7,760	08-10-89	—	—	405	6.0
(C-4-3)16bdd-S1	Hansen Fork	8,200	08-10-89	—	—	425 CA	5.0
(C-4-3)17adb-S1	White Pine Canyon	7,440	08-03-89	4.5	—	445	6.5
(C-4-3)17adb	White Pine Canyon, tunnel	7,500	08-03-89	1.6	—	580	6.5
(C-4-3)17cba-S1	White Pine Flat	8,360	08-07-89	4.3	CR	360	7.0
(C-4-3)17cbd-S1	White Pine Flat	8,400	08-07-89	6.2	—	345 CA	5.5
(C-4-3)17dbc	White Pine Canyon, tunnel	8,000	08-07-89	—	—	405 CA	4.5
(C-4-3)18cbb-S1	Left hand fork Kelsey Canyon	7,490	09-07-89	50	CR	375 CA	5.5
(C-4-3)31cbc-S1	Soldier Canyon	8,420	10-12-89	34	CR	340 CA	4.5
(C-4-4)2ada-S1	—	6,480	08-29-89	1.0	—	790 CA	8.0
(C-4-4)2dcc-S1	Left Hand Fork	6,180	08-30-89	—	CR	—	—
(C-4-4)3cab-S1	Spring Flats complex	5,440	08-25-89	584	—	—	—
(C-4-4)10dcd	Greens Tunnel	5,750	07-13-88	—	SC	—	—
(C-4-4)11baa-S1	Left Hand Fork	6,280	10-04-89	9.0	—	570 CA	8.0
(C-4-4)14bbb-S1	Settlement Canyon	5,910	09-01-89	4.2	—	780	10.5
(C-4-4)14bbc-S1	Right Hand Fork	5,840	07-13-88	—	—	—	—
(C-4-4)14bdc-S1	Settlement Canyon	6,100	09-26-89	4.0	CR	620 CA	8.5
(C-4-4)14cad-S1	Settlement Canyon	6,360	09-27-89	5 E	CR	640	8.0
(C-4-4)14dbd-S1	Settlement Canyon	6,140	09-19-89	1.1	CR	650 CA	8.5
(C-4-4)24abd-S1	Right hand fork Kelsey Canyon	6,990	09-08-89	20	CR	520 CA	8.0
(C-4-4)25abb-S1	Settlement Canyon	7,520	10-03-89	4.1	—	425 CA	5.5
(C-4-4)25acb-S1	Settlement Canyon	7,840	10-03-89	2.0	—	480	6.5
(C-4-4)25cab-S1	Water Fork	7,740	09-28-89	5.0	CR	420 CA	6.0
(C-4-4)25cba-S1	Water Fork	7,680	09-28-89	21	CR	480	7.0
(C-4-4)26aca-S1	Balsam Hollow	7,520	10-04-89	1.0	—	510 CA	5.5
(C-4-4)27ccc-S1	Pipe Hollow	6,800	10-11-88	48	CR	620 CA	—
(C-4-4)34bab-S1	Soldier Canyon	6,920	10-06-88	18	CR	880 CA	10.0
(C-4-4)35dac-S1	Soldier Canyon	6,980	10-17-89	30	CR	470 CA	9.0
(C-4-4)36bba-S1	North fork, Soldier Canyon	7,800	10-13-88	30	CR	400 CA	5.5
(C-4-4)36bbd-S1	North fork, Soldier Canyon	7,700	10-17-89	60	CR	420 CA	6.0
(C-4-4)36cba-S1	Soldier Canyon	7,440	10-17-89	—	CR	460	6.0
(C-4-4)36dba-S1	Soldier Canyon	7,940	10-12-89	7.5	CR	410	5.0
[2] (C-4-5)13cab	Honerine Tunnel	4,950	06-23-78	—	CR	1,600 CA	19.5
			04-12-89	396		—	—

Table 9. *Records of selected springs and tunnels*—Continued

Location	Name/area	Altitude of land surface (feet)	Date	Discharge (gal/min)	Geologic source	Specific conductance (μS/cm)	Water temperature (°C)
[2] (C-4-5)13cab	Honerine Tunnel	4,950	06-16-89	396	CR	—	—
			07-12-89	381		—	—
			08-09-89	387		—	—
			09-14-89	381		—	—
			11-01-89	383		—	—
			12-15-89	374		—	—
(C-5-4)2bac-S1	South fork, Soldier Canyon	7,140	10-18-89	5.7	—	435	6.0
(C-5-4)2bba-S1	South fork, Soldier Canyon	7,020	10-20-89	12.9	—	500 CA	6.5
(C-5-4)2bda-S1	South fork, Soldier Canyon	7,390	10-18-89	0.6	—	400	3.5
(C-5-4)2dac-S1	South fork, Soldier Canyon	7,980	10-18-89	0.5	—	—	5.5
(C-5-4)2ddc-S1	South fork, Soldier Canyon	8,200	10-18-89	0.3	—	460	3.0
(C-5-4)10add-S1	Soldier Canyon	9,060	10-20-89	—	—	—	—

[1] Previously reported as: location (C-3-4) 9bcc (Razem and Steiger, 1981, p. 82-83).
[2] Previously reported as: location (C-4-5)13cac (Razem and Steiger, 1981, p. 82-83).

Table 10. *Records of*

[—,

Location: See figure 2 for an explanation of the numbering system for hydrologic-data sites.
Owner/location/name: Refers to the last known owner and/or general location and/or name of the well; Irr. Comp.,
Use of water: A, abandoned; H, domestic or household; I, irrigation; P, public supply; S, stock; U, unused.
Depth drilled: R, reported.
Well construction: Casing diameter, reported from drillers' log or measured in the field; Finish: O, open end; P,
Source of water: The deposits that furnish water to the well; BF, basin-fill deposits; SC, stream-channel deposits;
Altitude of land surface: Given in feet above sea level.
Water level: Given in feet and decimal fractions. Measured except where noted R, reported. JMM, water level
Yield: Rate: gal/min, gallons per minute; P, pumped. Measured except where noted R, reported.
Water-quality parameters: °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius. Measured
Other data available: CA, chemical analysis (table 13); L, drillers' log (table 11); W, water-level measurements (table

Location	Owner/location/name	Year drilled	Use of water	Depth drilled (feet)	Well construction: Casing diameter (inches)	Well construction: Casing depth (feet)	Well construction: Finish (feet)
(C-2-4)26cbc-2	Hall, J.	1989	H	286	6	284	—
(C-2-4)26cdd-1	Pendleton, D.	1977	H	350	6	350	P318-348
(C-2-4)27cdc-1	Buzianis, J.	1975	I	220	10	220	P 97-138
							167-175
							184-214
							214-220
(C-2-4)33aab-1	Latter-Day Saints Church	1959	I	403	16	400	P305-400
(C-2-4)33add-1	Clegg, H.	1931	I	165	8	160	—
[1] (C-2-4)33dac-2	Coon, E.	1975	I	140	8	140	P100-140
(C-2-4)34bcd-1	U.S. Geological Survey	1978	U	1,502	8	195	O
(C-2-4)34bdd-1	Sagers, W.	1949	H	215	6	215	P100-215
(C-2-4)34bdd-2	Sagers, W.	1961	I	254	12	254	P 98-100
							112-151
							180-201
							208-238
							240-248
(C-2-4)35ada-1	Droubay, J.	1940	U	71	6	71	P 51-69
(C-2-4)35cbc-1	Terracor	1952	I	304	16	304	P200-220
							265-304
(C-3-3)19dab-1	Anaconda	—	U	—	—	—	—
(C-3-3)19dac-1	Anaconda	—	U	—	—	—	—
[2] (C-3-3)20baa-1	Kennecott, well # 1	1936	U	180	8	—	—
[3] (C-3-3)20bab-1	Kennecott, well # 2	1936	U	200	8	200	P 70-200
[4] (C-3-3)20bad-1	Kennecott, well # 3	1946	U	285	12	251	P 80-90
							168-190
							241-252
(C-3-3)20bba-1	Kennecott, well # 4	1962	U	212	12,8	212	P 176-204
[5] (C-3-3)28bcd	Service shaft, Pine Canyon	—	U	—	—	—	—
[6] (C-3-4) 8aaa-1	Jelco Inc.	1974	U	675	16,12	532	P 260-512
(C-3-4) 9aaa-1	Jelco Inc.	1974	U	575	16,12	573	P 300-500
(C-3-4)11ccc-1	U.S. Geological Survey	1978	U	1,518	8	130	O
[7] (C-3-4)13abb-1	Pine Canyon Boys Ranch	1970	U	660	20,16	660	—

selected wells

no data]

irrigation company.

perforated; S, screened. Upper or lower limits of perforations or screen given in feet below land surface.
CR, consolidated rock.

measured by James M. Montgomery, Consulting Engineers, Inc., written commun., 1990.

in the field except where noted L, measured in laboratory.
12).

Source of water	Altitude of land surface (feet)	Water level: Above (+) or below (-) land surface (feet)	Water level: Date	Yield: Rate (gal/min)	Yield: Date	Water-quality parameters: Temperature (°C)	Water-quality parameters: Specific conductance (µS/cm)	Water-quality parameters: Date	Other data available
BF	4,425	-28.88	03-27-89	—	—	—	—	—	W
BF	4,465	-67.04	03-31-89	—	—	—	—	—	—
BF	4,396	-5.34	09-14-89	220 P	07-14-81	14.0	1,300	07-14-81	CA, W
BF	4,382	-.97	03 07-84	972 P	06-21-89	15.5	750	06-21-89	CA
BF	4,418	-21.18	03-15-89	173 P	07-05-83	14.5	680	07-05-83	CA, W
BF	4,436	-38.99	03-15-89	484 P	06-20-88	13.5	920	07-18-86	CA, W
BF	4,425	—	—	—	—	—	—	—	—
BF	4,443	-44.58	03-31-89	—	—	—	—	—	CA
BF	4,443	-71.10	03-22-62	328 P	07-18-86	13.0	960	07-18-86	CA
BF	4,590	-38.99	03-27-89	—	—	—	—	—	W
BF	4,492	-92.33	03-27-89	1,130 P	06-20-80	16.0	1,000	08-07-81	CA, W
—	5,855	-202.38	11-01-88	—	—	—	—	—	—
—	5,940	-253.85	03-30-89	—	—	—	—	—	W
SC	5,540	-42.48	01-09-90	122 P	1963	—	—	—	—
SC	5,540	-106.10	01-09-90	319 P	1963	—	—	—	—
SC	5,570	-21.94	01-09-90	164 P	1963	—	—	—	—
SC	5,520	-156.88	01-09-90	157 P	1963	—	—	—	—
CR	6,520	-291.30	11-01-89	—	—	—	—	—	—
BF	4,545	-148.89	03-31-89	971 P	06-24-81	17.5	2,700	06-24-81	CA,W
BF	4,596	-198.70	03-15-89	—	—	15.5	1,850	06-06-78	CA, L, W
BF	4,810	—	—	—	—	—	—	—	—
BF	4,998	-573.59	03-31-89	—	—	—	—	—	CA, L, W

Table 10. *Records of*

					Well construction		
Location	Owner/location/name	Year drilled	Use of water	Depth drilled (feet)	Casing diameter (inches)	Casing depth (feet)	Finish (feet)
(C-3-4)13cdb-1	Anaconda	—	U	739	6	739	—
(C-3-4)14adb-1	Sagers, R.	1963	U	656	8	656	P580-652
[8] (C-3-4)16aaa-1	Jelco Inc.	1970	U	950	16	927	P410-510
							550-656
							750-880
(C-3-4)17acc-1	Jelco Inc.	1964	U	360	6	360	P348-360
(C-3-4)19ddb-1	Tooele Army Depot, B-2	—	U	—	5	—	S335-345
(C-3-4)21adc-1	Johnson, E.	1947	A	329	8	—	—
(C-3-4)23ccd-1	Lincoln Culinary Water Ass.	1963	A	297	—	—	—
(C-3-4)25aaa-1	U.S. Geological Survey	1989	U	557	6	35	O
(C-3-4)25aad-1	Buzianis, G.	1987	U	400 R	6	400	—
[9] (C-3-4)26aca-1	Buzianis, G.	1967	U	505	10	505	—
(C-3-4)26cda-1	Buzianis, J.	1948	A	245	10	—	—
[10] (C-3-4)28cdc-2	Tooele City, well # 5	1964	P	589	16,12	589	P378-587
(C-3-4)29cba-1	Tooele City, well # 6	1962	P	586	20	586	P430-580
[11] (C-3-4)29ccb-1	Tooele City, well # 7	1965	P	1,000	20,16,12	1,000	P500-1,000
(C-3-4)30aac-1	Tooele Army Depot, well # 2	1942	P	515	20	496	P390-480
(C-3-4)31bba-1	Tooele Army Depot, well # 3	1953	P	701	16	700	P425-700
(C-3-4)32bbc-1	Tooele City, well # 8	1954	P	1,025	16,12	1,020	P480-1,020
[12] (C-3-4)32bcc-1	Tooele City, well # 9a	1956	P	710	18	710	P472-710
(C-3-4)33acd-1	Tooele City, well # 9	1981	P	330	16,10	275	P175-275
(C-3-4)33dab-1	Tooele City, well #10	1981	P	400	12,10,8	191	P140-190
(C-3-4)33dac-1	Settlement Canyon Irr. Comp.	1977	U	116	20,16	110	P 25-108
(C-3-4)33dca-1	Settlement Canyon	1979	H	200	6	80	O
[13] (C-3-4)34ccc-1	Settlement Canyon Irr. Comp.	1971	I	80 R	—	—	—
[13] (C-3-4)34ccc-2	Settlement Canyon Irr. Comp.	1971	I	135 R	—	—	—
(C-3-4)35aba-1	Tooele City, Angels Grove	1948	P	77	6	77	P 56-75
(C-3-4)35aba-2	Tooele City, Angels Grove	1951	P	59	16	59	P 25-59
[14] (C-3-4)35aba-3	Tooele City, Angels Grove	1951	P	60	6	—	P 15-18
							23-31
(C-3-4)35abd-1	Tooele City, Angels Grove	1953	U	132	10	—	P 36-96
(C-3-4)35abd-2	U.S. Geological Survey	1989	U	515	6	256	O
(C-3-4)35add-1	Tooele City, Middle Canyon	1978	U	230	8	202	—
(C-3-5)13adb-1	Tooele Army Depot, B-11	—	U	—	5	—	S274-284
(C-3-5)13bbd-1	Tooele Army Depot, B-16	—	U	—	5	—	S285-295
(C-3-5)13ccb-1	Tooele Army Depot, B-12	—	U	—	5	—	S256-266
[15] (C-3-5)22add-1	Tooele Army Depot, WW-7	—	U	510	16,10	510	S440-490
(C-3-5)23aad-1	Tooele Army Depot, WW-8	—	U	—	—	—	S215-250
(C-3-5)24cad-1	Tooele Army Depot, B-21	—	U	—	5	—	S244-254
(C-3-5)24ccc-1	Tooele Army Depot, B- 4	—	U	—	5	—	S170-180
(C-3-5)24dac-1	Tooele Army Depot, B-54	—	U	—	5	—	S352-362
(C-3-5)25abd-1	Tooele Army Depot, A- 4	—	U	—	—	—	S236-246
(C-3-5)25add-1	Tooele Army Depot, B-26	1987	U	—	5	—	S314-324
(C-3-5)25cac-1	Tooele Army Depot, B- 1	—	U	—	5	—	S288-298
(C-3-5)25dbd-1	Tooele Army Depot, A- 2	—	U	—	—	—	S272-282

selected wells—Continued

Source of water	Altitude of land surface (feet)	Water level: Above (+) or below (-) land surface (feet)	Water level: Date	Yield: Rate (gal/min)	Yield: Date	Water-quality parameters: Temperature (°C)	Water-quality parameters: Specific conductance (μS/cm)	Water-quality parameters: Date	Other data available
—	5,065	-676. R	01-07-81	—	—	—	—	—	—
BF	4,930	-521.01	03-15-89	—	—	13.0	980	06-08-78	CA, L, W
BF	4,742	-342.96	03-14-89	—	—	14.0	2,550	09-21-78	CA, L, W
BF	4,691	-300.12	03-15-89	—	—	—	—	—	W
BF	4,813	-334.03 JMM	04-19-89	—	—	16.1	620	04-19-89	CA
—	4,920	—	—	—	—	—	—	—	—
—	5,120	—	—	—	—	—	—	—	—
CR	5,918	-119.22	12-14-89	—	—	11.0	560	05-28-89	W
CR	6,040	-222.71	12-14-89	—	—	11.0	—	10-29-87	W
BF	5,330	-488.52	03-09-89	—	—	—	—	—	W
—	5,285	—	—	—	—	—	—	—	—
BF	5,077	-346.65	03-30-89	—	—	—	840 L	08-09-88	CA
BF	4,922	-393.30	01-09-89	—	—	—	595 L	08-02-88	CA, L
BF	4,931	-439.48	01-12-89	900 P	01-09-89	—	600 L	08-02-88	CA, L
BF	4,857	-376.28	03-14-89	630 P	06-20-63	—	624	02-28-77	CA
BF	4,832	-356.7	03-11-71	470 P	1963	—	1,210	02-28-77	CA
BF	4,944	-464.13	12-17-89	—	—	—	630 L	08-02-88	CA
BF	4,975	-489.07	03-14-89	—	—	—	1,435 L	05-08-90	CA, W
CR	5,193	-146.44	01-16-90	1,100 P	01-16-90	—	550 L	08-09-88	CA, L, W
CR	5,257	-53.13	01-22-90	—	—	—	537 L	08-09-88	CA, L
SC	5,267	-32.45	02-14-90	—	—	—	—	—	L, W
CR	5,349	-149.88	09-19-89	—	—	—	—	—	W
SC	5,340	—	—	1,000 R	—	—	—	—	—
SC	5,340	—	—	1,000 R	—	—	—	—	
SC	5,373	—	—	—	—	—	550	07-26-88	CA, L
SC	5,370	—	—	—	—	—	—	—	—
SC	5,370	-23.28	04-19-89	—	—	—	—	—	—
SC	5,377	—	—	—	—	—	—	—	—
—	5,377	—	—	—	—	—	—	—	—
CR	5,520	-32.18	02-14-90	—	—	—	—	—	L, W
BF	4,587	-199.77 JMM	04-24-89	—	—	20.9	1,200	04-24-89	CA
BF	4,533	-210.31 JMM	04-24-89	—	—	22.4	1,250	04-24-89	CA
BF	4,568	-239.92 JMM	04-25-89	—	—	21.6	2,150	04-25-89	CA
BF	4,549	-222.56 JMM	09-26-88	—	—	—	—	—	—
CR	4,598	-205.53 JMM	09-26-88	—	—	—	—	—	—
BF	4,680	-230.66 JMM	05-04-89	—	—	21.3	1,400	05-04-89	CA
BF	4,643	-168.46 JMM	04-26-89	—	—	18.1	1,400	04-26-89	CA
BF	4,786	-306.19 JMM	04-27-89	—	—	18.0	850	04-27-89	CA
BF	4,717	-237.71 JMM	05-10-89	—	—	20.2	1,800	05-10-89	CA
BF	4,777	-295.20 JMM	04-27-89	—	—	22.3	1,200	04-27-89	CA
BF	4,678	-198.02 JMM	04-26-89	—	—	16.8	1,500	04-26-89	CA
BF	4,757	-274.60 JMM	04-26-89	—	—	18.9	1,650	04-26-89	CA

Location	Owner/location/name	Year drilled	Use of water	Depth drilled (feet)	Well construction: Casing diameter (inches)	Well construction: Casing depth (feet)	Well construction: Finish (feet)
(C-3-5)26aba-1	Tooele Army Depot, B-36	1987	U	—	5	—	S229-239
[16] (C-3-5)36ddd-1	Tooele Army Depot, well # 1	1942	P	752	20	752	P392-400 406-423 434-470 475-502 510-520 573-604 630-645 700-743
(C-4-3) 6bdb-1	Middle Canyon Irr. Comp.	1966	I	142	16	142	P 80-140
(C-4-3) 6bdb-2	Lincoln Culinary	1966	P	140	8	140	P105-140
(C-4-3) 6bdb-3	Middle Canyon Irr. Comp.	1990	U	78	—	—	—
(C-4-4) 2cbb-1	Tooele City	1982	U	502	16	60	O
(C-4-4) 2cbd-1	Tooele City	1982	U	440	12,8	280	P250-270
(C-4-4) 7aaa-1	Atkins, M.	1958	S	425	6	425	P400-425
(C-4-4)33cbd-1	Stockton City	1985	U	500	6	360	—
(C-4-5)13bad-1	Hercules Inc.	1986	U	—	—	—	—
(C-4-5)26dda-1	Wheeler, R.	1975	H	253	8	253	P185-215

[1] Replacement for well (C-2-4)33dac-1 reported in Gates (1963b, p. 5), (Razem and Steiger, 1981, p. 44-45).

[2] Previously reported as: depth drilled, 130 feet (Gates, 1963b, p. 8).

[3] Previously reported as: casing diameter, 10 inches (Gates, 1963b, p. 8).

[4] Previously reported as: location, (C-3-3)20baa-2 (Gates, 1963b, p. 8).

[5] Top of the shaft is covered, water levels in the shaft are measured through a stand pipe.

[6] Previously reported as: casing depth, 675 feet; altitude, 4,550 feet (Razem and Steiger, 1981, p. 46-47).

[7] Previously reported as: altitude, 4,990 feet (Razem and Steiger, 1981, p. 46-47).

[8] Previously reported as: altitude, 4,950 feet (Razem and Steiger, 1981, p. 46-47).

[9] Previously reported as: location, (C-3-4)26dbd-1; year drilled, 1974; depth drilled, 500 feet; casing diameter, 10 inches; casing depth, 500 feet; altitude, 5,409 feet (Razem and Steiger, 1981, p. 46-47).

[10] Replacement for well (C-3-4)28cdc-1 reported in Gates (1963b, p. 8), Razem and Steiger (1981, p. 46-47).

[11] Previously reported as: altitude, 4,930 feet (Razem and Steiger, 1981, p. 46-47).

[12] Previously reported as: altitude, 4,977 feet (Razem and Steiger, 1981, p. 46-47).

[13] Estimate of the well depth and yield rate by Howard Clegg, Settlement Canyon Irrigation Company (oral commun., 1990).

[14] Previously reported as: year drilled, 1953; depth drilled, 53 feet; altitude, 5,375 feet (Gates, 1963b, p. 8).

[15] Well about 1.5 miles west of the study area.

[16] Previously reported as: depth drilled, 763 feet (Razem and Steiger, 1981, p. 46-47).

Source of water	Altitude of land surface (feet)	Water level: Above (+) or below (-) land surface (feet)	Water level: Date	Yield: Rate (gal/min)	Yield: Date	Water-quality parameters: Temperature (°C)	Water-quality parameters: Specific conductance (µS/cm)	Water-quality parameters: Date	Other data available
BF	4,621	-150.57 JMM	04-20-89	—	—	20.3	1,800	05-19-89	CA
BF	4,848	-359.79	03-14-89	490 P	1963	—	1,910	02-28-77	CA
SC	6,160	-84.07	01-25-89	—	—	—	—	—	L
SC	6,155	-81.12	01-25-89	—	—	—	520	05-10-88	CA
SC	6,150	—	—	—	—	—	—	—	—
CR	5,800	-201.25	01-09-90	—	—	—	—	—	—
CR	5,930	-10.56	01-09-90	—	—	—	—	—	—
BF	5,150	-352.52	03-30-89	—	—	—	—	—	W
—	5,720	—	—	—	—	—	—	—	—
BF	4,940	-94.91	09-19-89	—	—	—	—	—	W
BF	5,080	-170.06	04-12-89	—	—	—	—	—	—

Table 11. *Drillers' logs of selected wells*

Location number for well: See figure 2 for an explanation of the numbering system for hydrologic-data sites.
Elevation (Elev.): Elevation of land surface in feet above sea level.
Thickness: In feet.
Depth: Depth to bottom of interval in feet below land surface.

Material	Thickness	Depth
(C-3-4)9aaa-1 Elev. 4,596		
Log by Robinson Drilling Company		
Clay, gravel, and cobbles	10	10
Clay, gravel, and boulders	61	71
Sand	8	79
Gravel (water)	154	233
Clay, gravel, and boulders	93	326
Clay and sand	6	332
Clay, gravel, and boulders	6	338
Clay, red and brown	14	352
Clay, gravel, and boulders	20	372
Clay and gravel	25	397
Clay, gravel, and boulders	23	420
Clay, yellow	15	435
Clay, gravel	47	482
Clay, gravel, and cobbles	90	572
Clay, yellow	3	575
(C-3-4)13abb-1 Elev. 4,998		
Log by M. Church Drilling Company		
Clay and cobbles	18	18
Conglomerate	27	45
Clay, sand, and gravel	5	50
Conglomerate	25	75
Clay and cobbles	15	90
Conglomerate	520	610
Cobbles and boulders (water)	50	660
(C-3-4)14adb-1 Elev. 4,930		
Log by Ben B. Gardner Drilling Company		
Sandy loam	32	32
Conglomerate	4	36
Clay and gravel	30	66
Gravel and boulders	44	110
Clay, sand, and gravel	6	116
Gravel and boulders	52	168
Clay	5	173
Clay and boulders	27	200
Gravel and boulders	12	212
Clay, brown	11	223
Clay, gravel, and boulders	352	575
Gravel (water)	29	604
Clay, red	3	607
Gravel (water)	31	638
Conglomerate	2	640
Gravel	16	656
(C-3-4)16aaa-1 Elev. 4,742		
Log by Robinson Drilling Company		
Clay, silt, and gravel	4	4
Gravel	24	28
Clay and gravel	354	382
Sand and gravel (water)	8	390
Clay and gravel	161	551
Clay, gravel, and boulders	19	570
Clay	3	573
Gravel and boulders	32	605
Clay, gravel, and boulders	36	641
Clay	5	646
Clay and gravel	152	798
Clay, boulders, and conglomerate	97	895
Clay	4	899
Gravel, boulders, and conglomerate	7	906
Clay and gravel	34	940
Clay and gravel	10	950
(C-3-4)21adc-1 Elev. 4,920		
Log by J. S. Lee and Sons Drilling Company		
Top soil	8	8
Conglomerate	119	127
Clay	8	135
Conglomerate	82	217
Clay	8	225
Conglomerate	55	280
Clay	30	310
Conglomerate	15	325
Quartzite (dry)	4	329
(C-3-4)23ccd-1 Elev. 5,120		
Log by John A. Nak Drilling Company		
Top soil	8	8
Cobbles	8	16
Gravel	3	19
Cobbles	3	22
Clay	3	25
Cobbles and boulders	20	45
Clay	1	46
Boulders	76	122
Clay	4	126
Cobbles and boulders	18	144
Clay	4	148
Cobbles and boulders	19	167
Clay	4	171

Table 11. *Drillers' logs of selected wells*—Continued

Material	Thickness	Depth
(C-3-4)23ccd-1—Continued		
Cobbles and boulders	8	179
Clay and sand	23	202
Boulders	3	205
Consolidated rock	47	252
Clay	7	259
Consolidated rock (dry)	38	297
(C-3-4)25aaa-1 Elev. 5,918 Log by U. S. Geological Survey		
Alluvium	10	10
Quartzite, tan, fractured	353	363
Quartzite, grey, fractured	11	374
Quartzite, yellow, fractured	13	387
Quartzite, grey, fractured	95	482
Calcite, white	1	483
Quartzite, grey, fractured	74	557
(C-3-4)28cdc-2 Elev. 5,077 Log by J. S. Lee and Sons Drilling Company		
Clay	4	4
Clay and gravel	576	580
Bedrock	9	589
(C-3-4)29cba-1 Elev. 4,922 Log by J.S. Lee and Sons Drilling Company		
Top soil	1	1
Clay, gravel, and boulders	34	35
Clay and gravel	395	430
Conglomerate	130	560
Gravel (water)	15	575
Clay and gravel	7	582
Limestone	4	586
(C-3-4)29ccb-1 Elev. 4,931 Log by J. S. Lee and Sons Drilling Company		
Top soil	1	1
Clay and gravel	14	15
Boulders	10	25
Clay and gravel	620	645
Gravel	150	795
Clay and gravel	155	950
Shale	50	1,000
(C-3-4)30aac-1 Elev. 4,857 Log by Roscoe Moss Company		
Top soil	1	1
Sand, gravel, boulders	17	18
(C-3-4)30aac-1—Continued		
Clay, sand, gravel	376	394
Sand, gravel	100	494
Limestone	21	515
(C-3-4)33acd-1 Elev. 5,193 Log by Clair A. Stephenson Drilling Company		
Clay, gravel, and boulders	180	180
Quartzite, fractured (water)	95	275
Limestone, black	10	285
Quartzite, fractured (water)	45	330
(C-3-4)33dab-1 Elev. 5,257 Log by Clair A. Stephenson Drilling Company		
Clay, gravel, and boulders	75	75
Gravel	15	90
Quartzite, fractured, yellow (water)	310	400
(C-3-4)33dac-1 Elev. 5,267 Log by M. Church Drilling Company		
Clay and silt	20	20
Clay and gravel	5	25
Gravel	3	28
Cobbles and conglomerate	12	40
Gravel	8	48
Clay and sand	14	62
Gravel	8	70
Clay and conglomerate	14	84
Gravel	11	95
Cobbles and conglomerate	6	101
Boulders	7	108
Consolidated rock	8	116
(C-3-4)35aba-1 Elev. 5,373 Log by J.S. Lee and Sons Drilling Company		
Top soil	18	18
Clay and gravel	27	45
Gravel	8	53
Gravel (water)	3	56
Clay and gravel	5	61
Sand (water)	5	66
Sand and clay	7	73
Gravel (water)	3	76
Consolidated rock	1	77

Table 11. *Drillers' logs of selected wells*—Continued

Material	Thickness	Depth
(C-3-4)35abd-2 Elev. 5,377 Log by U. S. Geological Survey		
Soil	5	5
Clay	3	8
Gravel	20	28
Clay, gravel, cobbles	147	175
Clay, sand, gravel, cobbles	120	295
Gravel	20	315
Clay, gravel, cobbles	20	335
Gravel and cobbles	180	515
(C-3-4)35add-1 Elev. 5,520 Log by Clair A. Stephenson Drilling Company		
Overburden	9	9
Quartzite, yellow	13	22
(C-3-4)35add-1—Continued		
Limestone, grey	14	36
Quartzite, tan	4	40
Quartzite, grey-brown	15	55
Limestone, black (water)	39	94
Quartzite, brown (water)	136	230
(C-4-3)6bdb-1 Elev. 6,160 Log by M. Church Drilling Company		
Clay	79	79
Gravel, cobbles, and boulders	63	142

Table 12. *Water levels in selected wells*

Location number for well: See figure 2 for an explanation of the numbering system for hydrologic-data sites.
Elevation (Elev.): Elevation of land surface in feet above sea level.
Water levels are in feet above (+) or below land surface; E, estimated.

Date		Water level
(C-2-4)26cbc-2 Elev. 4,425		
MAR	27, 1989	28.88
JUNE	19	31.44
SEPT	26,	35.02
(C-2-4)27cdc-1 Elev. 4,396		
APR	28, 1977	15.72
MAR	21, 1978	16.30
MAR	01, 1979	18.67
SEPT	09, 1980	28.21
MAR	10, 1981	22.43
SEPT	10	30.04
MAR	08, 1982	24.32
SEPT	15	28.70
MAR	01, 1983	23.69
SEPT	14	22.73
MAR	06, 1984	14.89
MAR	03, 1986	+5.00
SEPT	03	+3.43
MAR	02, 1987	+6.20
SEPT	17	+5.10
MAR	08, 1988	+6.00
JUNE	19, 1989	2.23
SEPT	14	5.34
MAR	18, 1990	5.16
(C-2-4)33add-1 Elev. 4,418		
MAR	05, 1938	44.01
MAR	05, 1939	44.57
MAR	05, 1940	44.54
MAR	05, 1941	43.36
MAR	05, 1942	41.67
MAR	05, 1943	38.09
MAR	05, 1944	37.33
MAR	05, 1945	35.56
MAR	05, 1946	33.48
MAR	05, 1947	32.59
MAR	05, 1948	32.68
MAR	05, 1949	31.89
MAR	05, 1950	30.66
MAR	05, 1951	31.14
MAR	05, 1952	32.39

Date		Water level
(C-2-4)33add-1—Continued		
MAR	05, 1953	32.78
MAR	05, 1954	32.29
MAR	05, 1955	33.94
MAR	05, 1956	36.29
MAR	05, 1957	39.00
MAR	05, 1958	40.15
MAR	23, 1959	40.43
MAR	30, 1960	41.82
MAR	28, 1961	44.18
MAR	28, 1962	47.05
MAR	25, 1963	49.80
MAR	30, 1964	52.00
MAR	02, 1965	53.79
	31	53.59
MAR	01, 1966	53.96
MAR	07, 1967	54.26
	28	53.91
MAR	01, 1968	54.84
MAR	03, 1969	53.84
MAR	09, 1970	52.52
MAR	08, 1971	51.33
	18	51.34
MAR	07, 1972	50.12
MAR	08, 1973	47.86
MAR	08, 1974	41.60
MAR	05, 1975	36.70
MAR	08, 1976	33.86
MAR	18,	33.61
MAR	07, 1977	33.37
	23	32.98
MAR	08, 1978	36.12
	22	36.06
MAR	08, 1979	38.16
SEPT	14	45.60
MAR	03,, 1980	40.67
SEPT	30	48.00
MAR	10, 1981	42.40
MAR	08, 1982	44.78
SEPT	15	49.32
MAR	02, 1983	44.70
SEPT	14	42.76
MAR	07, 1984	35.72
SEPT	12	30.55

Date		Water level
(C-2-4)33add-1—Continued		
MAR	04, 1985	16.69
SEPT	17	17.88
MAR	18, 1986	16.25
SEPT	03	17.88
MAR	04, 1987	13.47
SEPT	17	17.08
MAR	14, 1988	16.19
SEPT	22	18.21
MAR	15, 1989	21.18
JUNE	19	24.31
MAR	15, 1990	27.06
(C-2-4)33dac-2 Elev. 4,436		
MAR	27, 1978	55.82
MAR	05, 1979	59.11
MAR	03, 1980	61.38
MAR	16, 1981	62.30
MAR	08, 1982	64.56
MAR	02, 1983	64.17
MAR	07, 1984	54.38
MAR	12, 1985	20.83
MAR	18, 1986	33.86
MAR	04, 1987	31.01
MAR	14, 1988	34.87
MAR	15, 1989	38.99
SEPT	22	44.97
MAR	15, 1990	44.97
(C-2-4)35ada-1 Elev. 4,590		
MAR	27, 1989	38.99
APR	25	38.97
JUNE	30	40.14
AUG	08	40.86
SEPT	15	41.21
NOV	15	40.81
(C-2-4)35cbc-1 Elev. 4,492		
MAR	27, 1989	92.33
JUNE	28	95.81
SEPT	26	98.22

Table 12. *Water levels in selected wells*—Continued

Date		Water level
(C-3-3)19dac-1 Elev. 5,940		
NOV	01, 1988	252.28
MAR	30	253.85
JUNE	19	253.02
SEPT	14	254.06
(C-3-4) 8aaa-1 Elev. 4,545		
MAR	31, 1977	164.09
APR	04	164.17
APR	07	169.08
MAR	07	166.97
MAR	31, 1989	148.89
JUNE	15	150.95
SEPT	22	155.10
(C-3-4) 9aaa-1 Elev. 4,596		
MAR	31, 1977	212.53
APR	05	212.72
MAY	05	213.37
JUNE	05	214.45
JULY	05	215.61
AUG	05	220.80
SEPT	05	217.78
OCT	05	217.77
NOV	05	217.86 E
DEC	05	217.19
JAN	05, 1978	216.73
FEB	05	216.45
MAR	05	216.22
APR	05	216.08
MAY	05	216.06
JUNE	05	217.12
JULY	05	219.36
AUG	05	216.48
SEPT	05	221.71
OCT	05	221.60
NOV	05	221.33 E
DEC	05	220.51
JAN	05, 1979	220.01
MAR	23	219.14
APR	24	217.78
MAY	23	220.56
MAR	03, 1980	221.88
SEPT	19	226.98
MAR	12, 1981	223.13
(C-3-4) 9aaa-1 —Continued		
SEPT	10, 1981	228.95
MAR	08, 1982	225.33
SEPT	15	228.86
MAR	04, 1983	224.34
SEPT	14	222.03
MAR	13, 1984	213.68
SEPT	14	206.48
MAR	04, 1985	193.55
SEPT	14	175.84
MAR	06, 1986	192.38
SEPT	03	193.07
MAR	02, 1987	189.13
SEPT	17	196.35
MAR	08, 1988	192.29
SEPT	22	198.00
MAR	15, 1989	198.70
JUNE	15	200.85
SEPT	30	204.59
MAR	15, 1990	205.30
(C-3-4)13abb-1 Elev. 4,998		
APR	13, 1977	576.44
MAY	11	576.60
JUNE	13	577.07
JULY	12	578.46
AUG	12	580.40
SEPT	13	581.40
OCT	07	582.31
NOV	10	583.09
DEC	14	583.41
JAN	10, 1978	583.86
FEB	13	584.96
MAR	21	585.10
APR	13	584.60
MAY	11	584.85
FEB	27, 1989	574.67
MAR	31	573.59
JUNE	16	574.58
SEPT	27	577.68
(C-3-4)14adb-1 Elev. 4,930		
JUNE	22, 1977	534.07
JULY	12	534.39
AUG	12	535.46
(C-3-4)14adb-1—Continued		
SEPT	13, 1977	536.48
OCT	07	537.29
NOV	10	537.91
DEC	14	537.95
JAN	10, 1978	538.09
FEB	13	538.72
MAR	21	538.71
APR	12	538.81
MAY	11	538.84
JUNE	08	539.17
SEPT	06	540.90
MAR	09, 1979	541.60
APR	24, 1980	544.21
SEPT	19	545.15
MAR	12, 1981	546.12
SEPT	11	547.96
MAR	12, 1982	548.79
SEPT	16	547.77
MAR	09, 1983	553.10
SEPT	14, 1984	507.14
APR	03, 1985	502.88
SEPT	25	506.19
MAR	06, 1986	509.72
SEPT	17	505.05
MAR	04, 1987	505.84
SEPT	17	509.02
MAR	14, 1988	512.18
SEPT	21	517.38
FEB	27, 1989	520.56
MAR	15	521.01
JUNE	16	523.68
SEPT	27	525.69
MAR	15, 1990	529.18
(C-3-4)16aaa-1 Elev. 4,742		
MAR	28, 1977	358.29
APR	13	357.16
MAY	11	357.83
JUNE	13	358.58
JULY	12	359.58
AUG	12	360.49
OCT	07	361.93
DEC	13,	361.77
FEB	13, 1978	361.20
MAR	14	360.93

Table 12. *Water levels in selected wells*—Continued

Date		Water level
(C-3-4)16aaa-1—Continued		
APR	13, 1978	361.10
MAY	11	360.96
SEPT	06	365.22
MAR	05, 1979	363.77
MAR	12, 1980	366.86
MAR	12, 1981	368.13
MAR	11, 1982	370.20
MAR	09, 1983	369.47
MAR	09, 1984	357.70
MAR	04, 1985	335.67
MAR	06, 1986	335.64
MAR	02, 1987	332.23
MAR	14, 1988	336.06
MAR	14, 1989	342.96
JUNE	15	344.66
SEPT	22	348.44
MAR	15, 1990	349.79
(C-3-4)17acc-1 Elev. 4,691		
APR	20, 1977	315.87
MAY	11	316.52
JUNE	13	317.21
JULY	12	318.36
AUG	12	320.68
SEPT	09	320.36
OCT	07	320.75
NOV	10	320.73
DEC	13	320.20
JAN	10, 1978	319.61
FEB	13	319.13
MAR	21	318.68
APR	13	318.48
MAY	10	318.58
JUNE	08	319.56
SEPT	06	323.63
MAR	05, 1979	322.13
MAR	07, 1980	324.84
MAR	12, 1981	325.74
MAR	08, 1982	327.82
MAR	07, 1983	332.05
MAR	12, 1984	324.50
APR	03, 1985	295.27
MAR	06, 1986	294.64
MAR	04, 1987	290.97
MAR	08, 1988	294.24
(C-3-4)17acc-1—Continued		
MAR	15, 1989	300.12
JUNE	15	301.73
SEPT	22	306.29
MAR	15, 1990	306.53
(C-3-4)25aaa-1 Elev. 5,918		
JUNE	19, 1989	108.22
JULY	12	109.52
AUG	08	111.02
SEPT	14	113.38
NOV	02	116.53
DEC	14	119.22
(C-3-4)25aad-1 Elev. 6,040		
JUNE	03, 1988	176.68
JULY	20	182.34
OCT	07	189.70
NOV	10	192.69
JAN	20, 1989	199.34
MAR	09	203.91
APR	19	207.04
MAY	10	207.49
JUNE	19	210.10
JULY	12	211.90
AUG	08	213.68
SEPT	14	216.39
NOV	02	219.81
DEC	14	222.71
(C-3-4)26aca-1 Elev. 5,330		
APR	07, 1977	489.03
JUNE	13	488.93
JULY	12	488.91
AUG	12	496.06
SEPT	13	489.01
OCT	07	489.17
NOV	10	489.12
DEC	13	489.05
JAN	10, 1978	488.79
FEB	13	489.03
JUNE	03, 1988	488.23
JULY	20	488.48
JAN	20, 1989	488.52
(C-3-4)26aca-1—Continued		
MAR	09, 1989	488.52
APR	19	488.44
JUNE	19	488.40
SEPT	14	488.60
NOV	10	488.27
(C-3-4)32bcc-1 Elev. 4,975		
MAR	24, 1977	494.50
APR	21	494.75
MAY	10	494.90
JUNE	10	501.48
JULY	12	506.04
AUG	12	496.22
SEPT	13	516.07
OCT	07	515.03
NOV	10	508.92
DEC	13	497.50
JAN	10, 1978	498.98
FEB	13	497.40
MAR	14	497.60
MAR	09, 1979	498.70
MAR	07, 1980	499.70
MAR	12, 1981	498.91
MAR	11, 1982	499.26
MAR	07, 1983	500.34
MAR	12, 1984	487.80
MAR	04, 1985	480.47
MAR	06, 1986	481.41
MAR	04, 1987	482.29
MAR	08, 1988	485.56
MAR	14, 1989	489.07
	14	489.07
JUNE	20	491.39
SEPT	22	494.12
DEC	06	492.31
MAR	15, 1990	491.90
(C-3-4)33acd-1 Elev. 5,193		
FEB	17, 1989	130.24
MAR	29	123.83
JAN	08, 1990	147.54
JAN	16,	146.44
JAN	19	154.87

Table 12. *Water levels in selected wells*—Continued

Date		Water level
(C-3-4)33dac-1 Elev. 5,267		
JULY	20, 1988	20.57
AUG	17	31.05
	31	32.04
SEPT	14	32.99
OCT	07	34.43
NOV	10	34.68
	20	34.09
	25	33.72
	30	33.45
DEC	05	33.12
	10	32.76
	15	32.44
	20	32.08
	25	31.76
	31	31.35
JAN	05, 1989	30.96
	10	30.67
	15	30.43
	20	30.18
	25	29.95
	31	29.64
FEB	05	29.46
	10	29.23
	15	29.02
	20	28.82
	25	28.66
	28	28.53
MAR	05	28.42
	10	28.21
	15	28.04
	20	27.97
	25	27.70
	31	27.54
APR	05	27.41
	10	27.18
	15	27.10
	20	27.05
	25	27.13
	30	27.65
MAY	05	28.68
	10	29.55
	15	30.07
	20	30.48
	25	30.56
	31	30.81
JUNE	05	30.74
(C-3-4)33dac-1—Continued		
JUNE	10, 1989	30.67
	15	30.91
	20	31.24
	25	31.66
	30	32.01
JULY	05	32.48
	10	32.87
	15	33.34
	20	33.68
	25	33.92
	31	34.22
AUG	05	34.64
	10	34.97
	15	35.19
	20	35.27
	25	35.37
	31	35.54
SEPT	05	35.71
	10	35.95
	15	36.24
	20	36.44
	25	36.73
	30	36.93
OCT	05	37.16
	10	37.49
	15	37.73
	20	37.84
	25	37.81
	31	37.68
NOV	05	37.53
	10	37.32
	15	37.09
	20	36.84
	25	36.59
	30	36.44
DEC	05	36.08
	10	35.72
	15	35.22
	20	34.79
	25	34.40
	31	33.96
JAN	05, 1990	33.68
	10	33.33
	15	33.01
	20	32.83
	25	32.91
(C-3-4)33dac-1—Continued		
JAN	31, 1990	33.02
FEB	05	33.08
	10	32.83
	14	32.45
(C-3-4)33dca-1 Elev. 5,349		
JAN	20, 1989	139.88
APR	25, 1989	134.38
JUNE	28, 1989	141.02
SEPT	19, 1989	149.88
(C-3-4)35add-1 Elev. 5,520		
JUNE	08, 1988	13.66
	16	15.05
	21	16.29
	22	16.42
	23	16.69
	24	16.96
	26	17.51
	28	19.48
	30	18.14
JULY	01	18.30
	07	19.03
	10	19.50
	15	20.30
	20	21.14
	25	22.29
	31	23.41
AUG	05	24.15
	10	24.70
	15	24.80
	20	24.85
	25	25.41
	31	26.11
	05	26.82
	10	27.53
SEPT	15	28.30
	20	28.96
	25	29.63
	30	30.17
OCT	05	30.62
	10	30.53
	15	29.15
	20	28.06

Table 12. *Water levels in selected wells*—Continued

Date		Water level
(C-3-4)35add-1—Continued		
OCT	25, 1988	27.33
	31	26.46
NOV	05	25.78
	10	25.22
	15	24.91
	20	24.60
	25	24.41
	30	25.05
DEC	05	25.26
	10	25.52
	15	25.75
	20	25.98
	25	26.06
	31	26.38
JAN	05, 1989	26.57
	10	26.62
	15	26.84
	20	26.80
	25	27.03
	31	27.02
FEB	05	27.49
	10	27.75
	15	27.74
	20	27.61
	25	27.70
	28	27.74
MAR	05	27.77
	10	27.43
	15	26.66
	20	26.35
	25	25.89
	31	25.40
APR	05	25.15
	10	24.94
	15	24.89
	20	24.85
	25	24.72
(C-3-4)35add-1—Continued		
APR	30, 1989	24.53
MAY	05	24.15
	09	24.09
	10	24.09
	15	24.53
	20	24.76
	25	25.23
	31	26.55
JUNE	05	27.65
	10	28.76
	15	29.74
	20	30.51
	25	31.20
	30	31.83
JULY	05	32.53
	10	32.95
	15	32.31
	20	31.39
	25	30.78
	31	30.32
AUG	05	30.29
	10	30.19
	15	30.14
	20	30.18
	25	30.29
	31	30.37
SEPT	05	30.37
	10	30.54
	15	30.67
	20	30.80
	25	30.82
	30	30.65
OCT	05	30.80
	10	30.75
	15	30.79
	20	30.79
	25	30.53
(C-3-4)35add-1—Continued		
OCT	31, 1989	30.84
NOV	05	30.79
	10	30.67
	15	30.69
	20	30.64
	25	30.63
	26	30.50
	30	30.69
DEC	05	30.85
	10	30.87
	15	30.92
	20	31.13
	25	31.23
	31	31.42
JAN	05, 1990	31.50
	10	31.61
	15	31.76
	20	31.96
	25	32.05
	31	32.19
FEB	05	32.26
	10	32.38
	14	32.18
(C-4-4) 7aaa-1 Elev. 5,150		
FEB	17, 1989	352.37
MAR	30, 1989	352.52
JUNE	28, 1989	352.50
SEPT	22, 1989	352.87
(C-4-5)13bad-1 Elev. 4,940		
MAR	30, 1989	95.89
JUNE	16, 1989	95.41
SEPT	19, 1989	94.91

Table 13. *Results of chemical analyses of water from*

[—, no data; mg/L,

Location: See figure 2 for an explanation of the numbering system for hydrologic-data sites.
Altitude of land surface is given in feet above sea level.
Specific conductance: µS/cm, microsiemens per centimeter at 25 degrees Celsius, measured in the field except where noted L,
Temperature: °C, degrees Celsius.
Source of analysis: USGS, U. S. Geological Survey; JMM, James M. Montgomery, Consulting Engineers, Inc., (1988); Ford,

Location	Owner/location/name	Date of sample	Sampling depth (feet)	Depth of well (feet)	Altitude of land surface (feet)	Specific conductance (µS/cm)	Temperature (°C)	Hardness, total (mg/L as $CaCO_3$)	Alkalinity, total (mg/L as $CaCO_3$)
(C-2-4)26ddd-S1	Rose Spring	06-27-78	—	—	4,600	600	16.0	280	—
		06-10-88	—	—		650	16.5	270	246
(C-2-4)27cdc-1	Buzianis, J.	06-13-78	—	220	4,396	1,340	13.5	460	—
(C-2-4)33aab-1	Latter-Day Saints Church	06-29-78	—	403	4,382	660	15.0	230	—
(C-2-4)33add-1	Clegg, H.	06-13-78	—	165	4,418	750	—	468	—
(C-2-4)33dac-2	Coon, E.	07-13-78	—	140	4,436	690	15.5	—	—
(C-2-4)34bdd-1	Sagers, W.	05-09-77	215	215	4,443	1,980	14.0	—	—
		06-27-78	—		do.	1,100	—	450	—
(C-2-4)34bdd-2	Sagers, W.	05-09-77	254	254	4,443	1,010	14.5	—	—
		06-02-77	—		do.	850	15.0	—	—
		07-13-78	—		do.	1,000	13.5	—	—
		07-13-79	—		do.	1,100	13.0	—	—
		07-17-80	—		do.	1,050	13.0	—	—
		07-13-81	—		do.	1,010	13.5	—	—
		07-18-86	—		do.	960	13.0	—	—
(C-2-4)35cbc-1	Terracor	06-22-76	—	304	4,492	900	14.5	—	—
		05-09-77	—		do.	890	15.0	—	—
		06-06-77	—		do.	850	16.0	—	—
		06-27-78	—		do.	950	14.0	330	—
		07-13-78	—		do.	900	14.5	—	—
		08-09-78	304		do.	—	14.5	330	—
		06-26-79	—		do.	1,000	14.0	—	—
		07-23-79	—		do.	1,030	14.5	320	—
		06-20-80	—		do.	1,050	14.0	—	—
		08-07-81	—		do.	1,000	16.0	340	190
(C-3-3) 4ccb	Pass Canyon Tunnel	07-11-88	—	—	6,240	770	10.0	350	271
(C-3-3) 6cda-S1	Murray Canyon	06-10-88	—	—	5,600	730	11.5	320	275
(C-3-3) 8dcb-S1	Lower Leavetts Canyon	07-25-88	—	—	6,220	1,030	9.0	420	329
(C-3-3) 8ddd-S1	Upper Leavetts Canyon	08-17-88	—	—	6,600	800	11.0	350	275
(C-3-3) 9bbc-S1	Pass Canyon	07-08-88	—	—	6,320	960	10.0	400	326
(C-3-3)16cca-S1	Pole Canyon	08-19-88	—	—	6,600	730	10.0	370	303
(C-3-3)17acb-S1	North fork Swensons Canyon	08-22-88	—	—	6,250	680	10.0	300	262
(C-3-3)17adc-S1	South fork Swensons Canyon	08-22-88	—	—	6,480	650	10.5	310	245
(C-3-3)18cba	Irrigation ditch	01-11-78	—	—	5,200	1,080	8.5	690	—
(C-3-3)18cbb	Settling pond	01-11-78	—	—	5,160	1,000	12.0	690	—
(C-3-3)28bca	Carr Fork production shaft	01-11-78	—	—	6,430	350	26.0	180	—
(C-3-3)28bdc	Pine Canyon Tunnel	01-11-78	—	—	6,600	1,650	17.0	1,100	—
(C-3-3)31cab-S1	Middle Canyon	07-01-88	—	—	7,300	500	8.5	250	216
(C-3-4) 8aaa-1	Jelco Inc.	04-28-77	—	675	4,545	2,350	18.0	—	—
		06-26-78	675		do.	2,400	—	320	—

selected wells, springs, tunnels, and streams

milligrams per liter]

laboratory value.

Ford Chemical Laboratory Inc., Salt Lake City, Utah; S, State of Utah.

Calcium, dis-solved (mg/L as Ca)	Magnesium, dis-solved (mg/L as Mg)	Sodium, dis-solved (mg/L as Na)	Potassium, dis-solved (mg/L as K)	Sulfate, dis-solved (mg/L as SO_4)	Chloride, dis-solved (mg/L as Cl)	Fluoride, dis-solved (mg/L as F)	Silica, dis-solved (mg/L as SiO_2)	Solids, sum of constituents, dissolved (mg/L)	Source of analysis
71	26	30	2.4	30	41	0.10	10	314	USGS
65	25	31	2.1	30	40	0.30	10	352	USGS
110	45	130	2.7	150	220	0.10	16	882	USGS
59	19	63	1.8	51	64	0.10	13	394	USGS
81	27	49	1.6	100	58	0.10	13	468	USGS
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
110	43	76	2.0	160	150	0.10	15	689	USGS
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
77	34	77	2.2	67	150	0.10	17	542	USGS
—	—	—	—	—	—	—	—	—	—
75	35	72	2.3	75	150	0.10	19	551	USGS
—	—	—	—	—	—	—	—	—	—
67	36	76	2.5	71	160	0.10	19	566	USGS
—	—	—	—	—	—	—	—	—	—
77	36	78	2.1	77	180	0.10	19	596	USGS
86	33	34	1.2	77	39	0.10	8.9	442	USGS
75	33	32	1.3	45	40	0.30	9.8	402	USGS
87	50	65	2.2	180	48	0.20	16	647	USGS
71	1	36	1.1	66	33	0.20	11	427	USGS
95	39	62	1.5	120	57	0.20	13	583	USGS
85	39	15	1.0	85	13	0.10	10	431	USGS
66	34	30	1.4	84	20	0.20	12	407	USGS
64	36	23	1.0	73	17	0.20	9.1	373	USGS
160	70	13	3.6	560	18	0.80	20	922	USGS
160	71	12	3.6	520	18	0.70	19	889	USGS
39	21	7.3	3.3	38	18	0.10	15	216	USGS
190	150	17	3.4	860	22	1.2	25	1,400	USGS
65	22	9.8	0.60	15	9.5	0.20	11	263	USGS
—	—	—	—	—	—	—	—	—	—
83	27	400	6.1	51	690	0.30	13	1,390	USGS

Table 13. *Results of chemical analyses of water from*

Location	Owner/location/name	Date of sample	Sampling depth (feet)	Depth of well (feet)	Altitude of land surface (feet)	Specific conductance (μS/cm)	Temperature (°C)	Hardness, total (mg/L as $CaCO_3$)	Alkalinity, total (mg/L as $CaCO_3$)
(C-3-4) 8aaa-1	Jelco Inc.	07-23-79	—	675	4,545	2,300	19.5	330	—
		07-15-80	—		do.	2,400	17.0	330	—
		06-24-81	—		do.	2,700	17.5	—	—
		07-27-82	—		do.	2,530	17.0	—	—
(C-3-4) 9aaa-1	Jelco Inc.	06-06-78	573	575	4,596	1,850	15.5	270	—
(C-3-4)13abb-1	Pine Canyon Boys Ranch	07-02-73	660	660	4,998	—	—	450	—
		08-01-73	—		do.	—	—	480	—
		02-01-74	—		do.	—	—	470	—
		10-31-77	—		do.	—	—	440	—
(C-3-4)14adb-1	Sagers, R.	07-11-74	—	656	4,930	—	—	540	—
		10-31-77	—		do.	—	—	510	—
		06-08-78	656		do.	980	13.0	540	—
(C-3-4)16aaa-1	Jelco Inc.	09-21-78	927	950	4,742	2,550	14.0	440	—
(C-3-4)19ddb-1	Tooele Army Depot, B-2	09-23-88	340	—	4,813	694	—	280	—
(C-3-4)28cdc-2	Tooele City, well # 5	08-09-88	—	589	5,077	840 L	—	286	—
(C-3-4)29cba-1	Tooele City, well # 6	08-02-88	—	586	4,922	595 L	—	284	—
(C-3-4)29ccb-1	Tooele City, well # 7	08-02-88	—	1,000	4,931	600 L	—	266	—
(C-3-4)30aac-1	Tooele Army Depot, well # 2	02-28-77	496	515	4,857	624	—	230	—
(C-3-4)31bba-1	Tooele Army Depot, well # 3	02-28-77	700	701	4,832	1,210	—	370	—
(C-3-4)32bbc-1	Tooele City, well # 8	04-13-65	—	1,025	4,944	900	—	315	—
		08-02-88	—		do.	630 L		260	—
(C-3-4)32bcc-1	Tooele City, well # 9a	05-08-90	—	710	4,975	1,435 L	—	330	—
(C-3-4)33acd-1	Tooele City, well # 9	08-09-88	—	330	5,193	550 L	—	262	—
(C-3-4)33dab-1	Tooele City, well # 10	08-09-88	—	400	5,257	537 L	—	260	—
(C-3-4)35aac	DeLaMare Tunnel	07-26-88	—	—	5,370	578	—	290	—
(C-3-4)35aba-1	Tooele City, Angels Grove	07-26-88	—	77	5,373	550	—	294	—
(C-3-5)13adb-1	Tooele Army Depot, B-11	11-13-86	279	—	4,587	1,350	—	223	—
(C-3-5)13bbd-1	Tooele Army Depot, B-16	09-24-88	290	—	4,533	1,890	—	240	—
(C-3-5)13ccb-1	Tooele Army Depot, B-12	09-23-88	261	—	4,568	2,360	—	500	—
(C-3-5)24cad-1	Tooele Army Depot, B-21	11-07-86	249	—	4,680	2,000	—	670	—
(C-3-5)24ccc-1	Tooele Army Depot, B-4	10-27-86	175	—	4,643	1,500	—	554	—
(C-3-5)24dac-1	Tooele Army Depot, B-54	09-22-88	357	—	4,786	2,340	—	360	—
(C-3-5)25abd-1	Tooele Army Depot, A-4	03-23-88	241	—	4,717	2,000	—	469	—
(C-3-5)25add-1	Tooele Army Depot, B-26	09-23-88	319	—	4,777	1,270	—	320	—
(C-3-5)25cac-1	Tooele Army Depot, B-1	10-28-86	293	—	4,678	1,800	—	568	—
(C-3-5)25dbd-1	Tooele Army Depot, A-2	03-22-88	277	—	4,757	1,700	—	454	—
(C-3-5)26aba-1	Tooele Army Depot, B-36	09-23-88	234	—	4,621	1,942	—	680	—
(C-3-5)36ddd-1	Tooele Army Depot, well # 1	02-28-77	752	752	4,848	1,910	—	720	—
(C-4-3) 6bdb-2	Lincoln Culinary	05-10-88	—	140	6,155	520	—	286	—
(C-4-3) 7add-S1	Harkers Canyon	09-20-88	—	—	7,500	460	6.0	240	209
(C-4-3) 7baa-S1	Middle Canyon	09-07-88	—	—	6,920	470	7.5	240	227

Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, sum of constituents, dissolved (mg/L)	Source of analysis
84	30	470	6.3	49	710	0.30	17	1,500	USGS
82	30	410	6.2	51	630	0.50	11	1,370	USGS
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
67	25	320	4.4	52	470	0.10	13	1,090	USGS
110	44	47	—	240	40	0.50	—	650	USGS
120	45	47	—	250	41	0.50	—	640	USGS
120	43	45	3.6	240	38	0.47	—	656	USGS
100	46	46	3.2	260	30	0.56	—	628	USGS
130	54	38	2.5	320	38	0.36	—	774	USGS
120	52	40	2.2	320	31	0.49	—	732	USGS
120	58	39	1.6	300	39	0.10	13	718	USGS
120	35	420	3.5	49	780	0.10	13	1,550	USGS
73	24	40	<5	38	35	<0.0	—	390	JMM
114	48	23	0.8	29	178	0.14	13	545	Ford
78	22	39	1.5	29	62	0.14	13.2	380	Ford
98	4.8	45	1.5	31	55	0.15	13	388	Ford
57	20	42	0.00	27	50	0.11	14	363	USGS
91	35	98	3.8	86	200	0.25	27	687	USGS
86	24	80	2.7	27	155	—	16	572	S
87	10	53	1.7	31	94	0.21	15.9	408	Ford
71	27	172	4.2	31	354	0.24	19.3	714	Ford
103	1.2	31	1.0	28	51	0.16	13.5	355	Ford
106	0.0	25	0.9	24	48	0.17	12.9	345	Ford
92.8	13.9	14.7	1.0	34	28	0.12	10.4	335	Ford
109	5.8	14.5	1.0	35	34	0.11	10.1	350	Ford
48.8	24.1	198	5.1	54	280	0.6	—	740	JMM
56	23	250	5.6	39	440	<0.3	—	1,000	JMM
120	49	240	5.7	79	600	<0.0	—	1,300	JMM
169	59.4	150	5.1	130	490	0.4	—	1,100	JMM
127	56.7	135	5.4	154	345	0.24	—	1,500	JMM
58	21	84	<5	48	120	<0.0	—	500	JMM
112	45.3	171	4.5	140	360	0.25	—	1,050	JMM
79	31	130	<5	75	200	<0.0	—	700	JMM
126	60.7	123	6.0	175	305	0.3	—	1,050	JMM
111	42.4	187	5.3	136	346	0.3	—	840	JMM
150	71	130	7.0	150	390	0.0	—	1,000	JMM
170	71	120	6.2	240	380	0.26	24	1,150	USGS
97.6	10.0	12.9	0.65	36	16.6	0.20	9.5	320	Ford
71	15	7.5	0.80	17	8.8	0.10	6.5	254	USGS
70	15	11	0.90	18	9.4	0.10	7.2	269	USGS

Table 13. *Results of chemical analyses of water from*

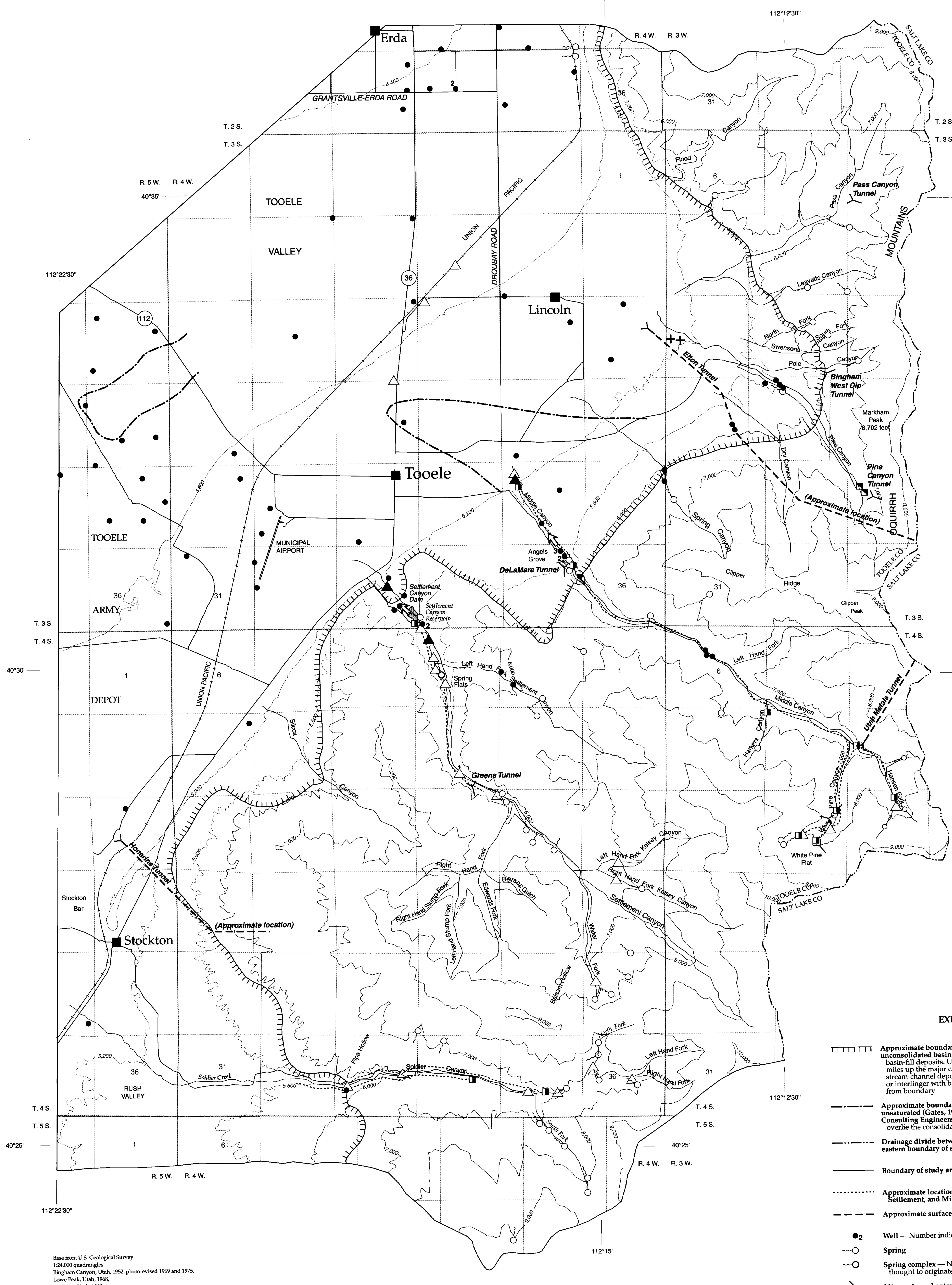
Location	Owner/location/name	Date of sample	Sampling depth (feet)	Depth of well (feet)	Altitude of land surface (feet)	Specific conductance (µS/cm)	Temperature (°C)	Hardness, total (mg/L as $CaCO_3$)	Alkalinity, total (mg/L as $CaCO_3$)
(C-4-3) 9bcd	Utah Metals Tunnel	06-27-78	—	—	6,933	480	8.0	310	—
		09-01-88	—	—	do.	550	8.5	270	202
(C-4-3) 9dba-S1	Middle Canyon	08-23-89	—	—	7,440	520	10.0	260	246
(C-4-3)16bdd-S1	Hansen Fork	08-10-89	—	—	8,200	425	5.0	200	194
(C-4-3)17cbd-S1	White Pine Flat	08-07-89	—	—	8,400	345	5.5	170	168
(C-4-3)17dbc	White Pine Canyon, tunnel	08-07-89	—	—	8,000	405	4.5	210	197
(C-4-3)18cbb-S1	Left hand fork Kelsey Canyon	09-07-89	—	—	7,490	375	5.5	190	176
(C-4-3)31cbc-S1	Soldier Canyon	10-12-89	—	—	8,420	340	4.5	170	165
(C-4-4) 2ada-S1	—	08-29-89	—	—	6,480	790	8.0	390	354
(C-4-4) 3bbd	Settlement Canyon Creek	06-27-78	—	—	5,380	400	10.5	220	—
		12-13-88	—	—		530	9.5	—	—
		01-04-89	—	—		540	7.0	—	—
		03-10-89	—	—		565	13.0	—	—
		04-14-89	—	—		540	10.0	—	—
		05-16-89	—	—		510	11.0	—	—
		06-21-89	—	—		510	11.5	—	—
		07-19-89	—	—		510	19.0	—	—
		08-16-89	—	—		520	13.0	—	—
		10-11-89	—	—		530	11.5	—	—
		11-07-89	—	—		530	10.0	—	—
		12-05-89	—	—		530	9.0	—	—
(C-4-4)11baa-S1	Left Hand Fork	10-04-89	—	—	6,280	570	8.0	250	229
(C-4-4)14bdc-S1	Settlement Canyon	09-26-89	—	—	6,100	620	8.5	270	252
(C-4-4)14dbd-S1	Settlement Canyon	09-19-89	—	—	6,140	650	8.5	290	252
(C-4-4)24abd-S1	Right hand fork Kelsey Canyon	09-08-89	—	—	6,990	520	8.0	260	233
(C-4-4)25abb-S1	Settlement Canyon	10-03-89	—	—	7,520	425	5.5	210	206
(C-4-4)25cab-S1	Water Fork	09-28-89	—	—	7,740	420	6.0	220	207
(C-4-4)26aca-S1	Balsam Hollow	10-04-89	—	—	7,520	510	5.5	260	246
(C-4-4)27ccc-S1	Pipe Hollow	10-11-88	—	—	6,800	620	—	300	278
(C-4-4)34bab-S1	Soldier Canyon	10-06-88	—	—	6,920	880	10.0	440	369
(C-4-4)35dac-S1	Soldier Canyon	10-17-89	—	—	6,980	470	9.0	240	229
(C-4-4)36bba-S1	North fork, Soldier Canyon	10-13-88	—	—	7,800	400	5.5	200	193
(C-4-4)36bbd-S1	North fork, Soldier Canyon	10-17-89	—	—	7,700	420	6.0	220	209
(C-4-5)13cab	Honerine Tunnel	06-23-78	—	—	4,950	1,600	19.5	750	—
(C-5-4) 2bba-S1	South fork, Soldier Canyon	10-20-89	—	—	7,020	500	6.5	85	242

Calcium, dis-solved (mg/L as Ca)	Magnesium, dis-solved (mg/L as Mg)	Sodium, dis-solved (mg/L as Na)	Potassium, dis-solved (mg/L as K)	Sulfate, dis-solved (mg/L as SO_4)	Chloride, dis-solved (mg/L as Cl)	Fluoride, dis-solved (mg/L as F)	Silica, dis-solved (mg/L as SiO_2)	Solids, sum of constituents, dissolved (mg/L)	Source of analysis
82	25	12	1.0	100	14	0.10	9.6	362	USGS
67	26	13	0.80	61	12	0.10	9.1	312	USGS
72	20	14	1.5	19	13	0.20	11	302	USGS
67	9	9.0	0.70	13	10	0.10	7.5	237	USGS
54	9	5.0	0.60	12	4.1	0.20	13	201	USGS
66	10	4.8	0.50	14	4.8	0.10	6.0	229	USGS
56	11	7.3	0.70	15	5.9	0.30	15	220	USGS
50	11	4.0	0.40	7.0	3.4	0.10	5.3	188	USGS
100	34	26	1.5	51	26	0.20	15	429	USGS
63	14	9.4	0.80	17	14	0.10	9.6	231	USGS
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
72	18	19	1.0	30	29	0.30	11	320	USGS
79	18	27	0.90	21	26	0.20	9.9	336	USGS
81	21	29	0.90	24	27	0.20	10	347	USGS
78	16	9.6	0.50	15	9.6	0.30	8.5	280	USGS
66	12	6.9	1.3	13	7.5	0.20	8.0	243	USGS
68	11	6.3	0.50	10	6.7	0.20	6.2	237	USGS
73	18	8.1	0.7	21	8.8	0.20	6.4	287	USGS
74	28	17	1.3	28	25	0.20	21	364	USGS
110	39	30	1.3	60	45	0.10	9.5	518	USGS
64	19	8.0	0.60	20	8.6	0.30	6.5	267	USGS
65	13	5.1	0.40	9.0	4.8	0.10	5.7	237	USGS
58	14	6.4	3.5	10	7.5	0.10	5.8	231	USGS
220	49	110	8.7	460	200	0.90	39	1,220	USGS
10	7.7	0.90	8.4	—	21	0.10	7.2	288	USGS

PREPARED BY THE U.S. GEOLOGICAL SURVEY
IN COOPERATION WITH
TOOELE CITY AND TOOELE COUNTY

UTAH DEPARTMENT OF NATURAL RESOURCES
TECHNICAL PUBLICATION NO. 107
Hydrologic-data sites—PLATE 1

Stolp, B.J., 1994, Hydrology and potential for ground-water development in southeastern Tooele Valley and adjacent areas in the Oquirrh Mountains, Tooele County, Utah



Base from U.S. Geological Survey
1:24,000 quadrangles:
Bingham Canyon, Utah, 1952, photorevised 1969 and 1975,
Lowe Peak, Utah, 1968,
Stockton, Utah, 1980,
Tooele, Utah, 1955, photorevised 1969,
and from U.S. Geological Survey digital data, 1:100,000, 1979
Universal Transverse Mercator projection,
Zone 12

0.5 0 0.5 1 MILE

0.5 0 0.5 1 KILOMETER

CONTOUR INTERVAL, IN FEET, IS VARIABLE
NATIONAL GEODETIC VERTICAL DATUM OF 1929

EXPLANATION

- **Approximate boundary between consolidated rock and the unconsolidated basin-fill deposits** — Hachures point toward the basin-fill deposits. Unconsolidated material extends several miles up the major canyons and in those areas is classified as stream-channel deposits. Some stream-channel deposits overlie or interfinger with basin-fill deposits for several miles downstream from boundary
- **Approximate boundary of areas where basin-fill deposits are unsaturated (Gates, 1965, p. 33 and fig. 5; James M. Montgomery, Consulting Engineers, Inc., 1988)** — No saturated basin-fill deposits overlie the consolidated rock in the interior of the boundary
- **Drainage divide between Tooele and Salt Lake Valleys and eastern boundary of study area**
- **Boundary of study area**
- **Approximate location of water pipelines in Soldier, Settlement, and Middle Canyons**
- **Approximate surface projection of underground tunnel**
- **Well** — Number indicates more than one well
- **Spring**
- **Spring complex** — Numerous closely spaced springs thought to originate from a common source
- **Mine or tunnel entrance**
- **Shaft**
- **Miscellaneous hydrologic-data site** — Water-quality data only
- **Water pipeline intake or outlet**
- **Miscellaneous streamflow-measurement site**
- **Continuous-record streamflow-measurement site**
- **Peak-flow streamflow-measurement site**
- **Point at which average annual streamflow was estimated**

MAP SHOWING THE HYDROLOGIC-DATA SITES, WATER-CONVEYANCE STRUCTURES, AND MAJOR TUNNELS OF SOUTHEASTERN TOOELE VALLEY, NORTHEASTERN RUSH VALLEY, AND ADJACENT AREAS IN THE OQUIRRH MOUNTAINS, UTAH

By
Bernard J. Stolp
1994

PREPARED BY THE U.S. GEOLOGICAL SURVEY
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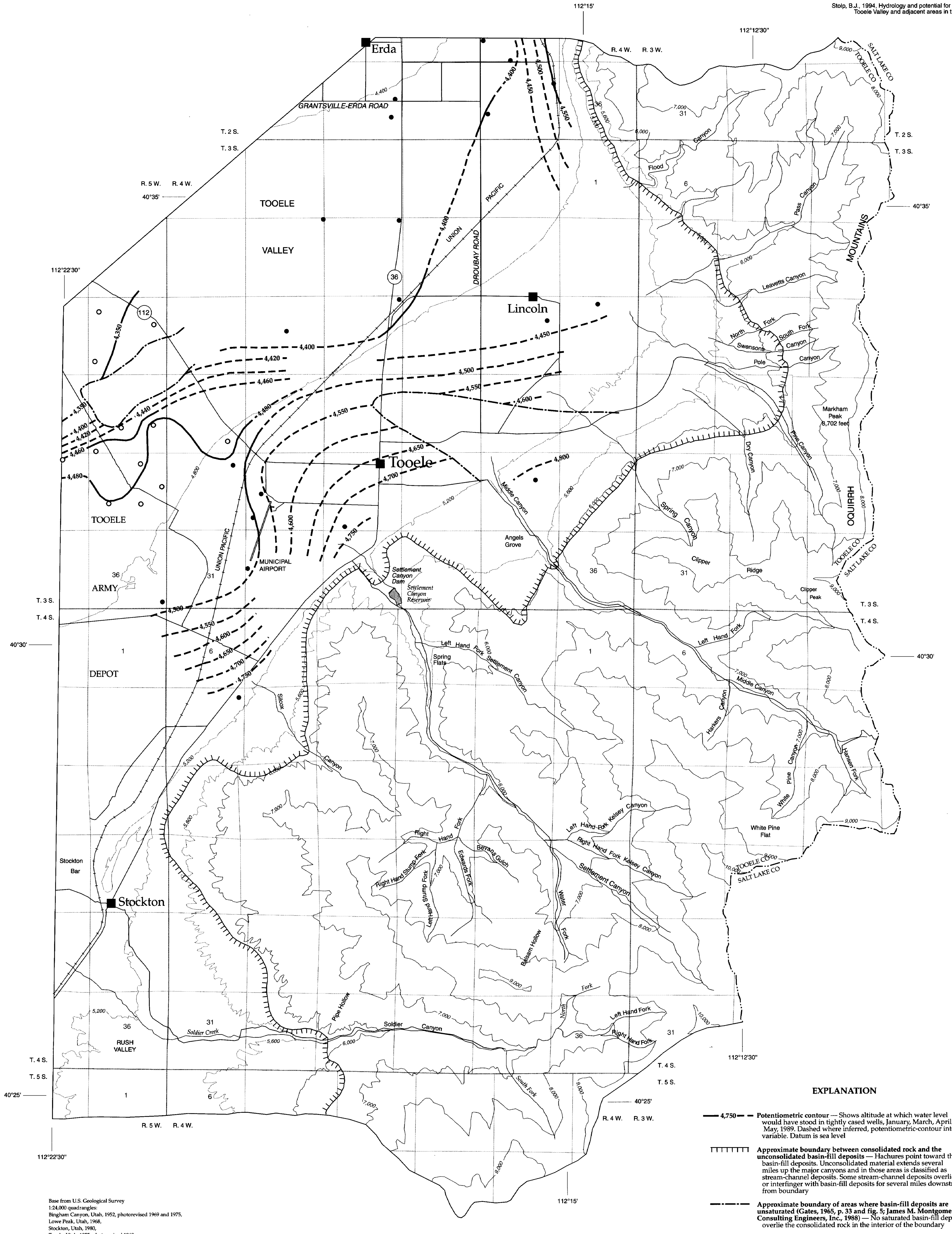
UTAH DEPARTMENT OF NATURAL RESOURCES
TECHNICAL PUBLICATION NO. 107
Potentiometric surface—PLATE 2
Stolp, B.J., 1994, Hydrology and potential for ground-water development in southeastern Tooele Valley and adjacent areas in the Oquirrh Mountains, Tooele County, Utah



Base from U.S. Geological Survey
1:24,000 quadrangles:
Bingham Canyon, Utah, 1952, photorevised 1969 and 1975,
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Tooele, Utah, 1955, photorevised 1969,
and from U.S. Geological Survey digital data, 1:100,000, 1979
Universal Transverse Mercator projection,
Zone 12

0.5 0 0.5 1 MILE
0.5 0 0.5 1 KILOMETER

CONTOUR INTERVAL, IN FEET, IS VARIABLE
NATIONAL GEODETIC VERTICAL DATUM OF 1929

EXPLANATION

4,750 **Potentiometric contour** — Shows altitude at which water level would have stood in tightly cased wells, January, March, April, and May, 1989. Dashed where inferred, potentiometric-contour interval is variable. Datum is sea level

Approximate boundary between consolidated rock and the unconsolidated basin-fill deposits — Hachures point toward the basin-fill deposits. Unconsolidated material extends several miles up the major canyons and in those areas is classified as stream-channel deposits. Some stream-channel deposits overlie or interfinger with basin-fill deposits for several miles downstream from boundary

Approximate boundary of areas where basin-fill deposits are unsaturated (Gates, 1965, p. 33 and fig. 5; James M. Montgomery, Consulting Engineers, Inc., 1988) — No saturated basin-fill deposits overlie the consolidated rock in the interior of the boundary

Drainage divide between Tooele and Salt Lake Valleys and eastern boundary of study area

Boundary of study area

Well

Well — Water level from James M. Montgomery, Consulting Engineers, Inc., 1988

MAP SHOWING THE POTENTIOMETRIC SURFACE IN THE BASIN-FILL DEPOSITS IN SOUTHEASTERN TOOELE VALLEY, UTAH

By
Bernard J. Stolp
1994

PREPARED BY THE U.S. GEOLOGICAL SURVEY
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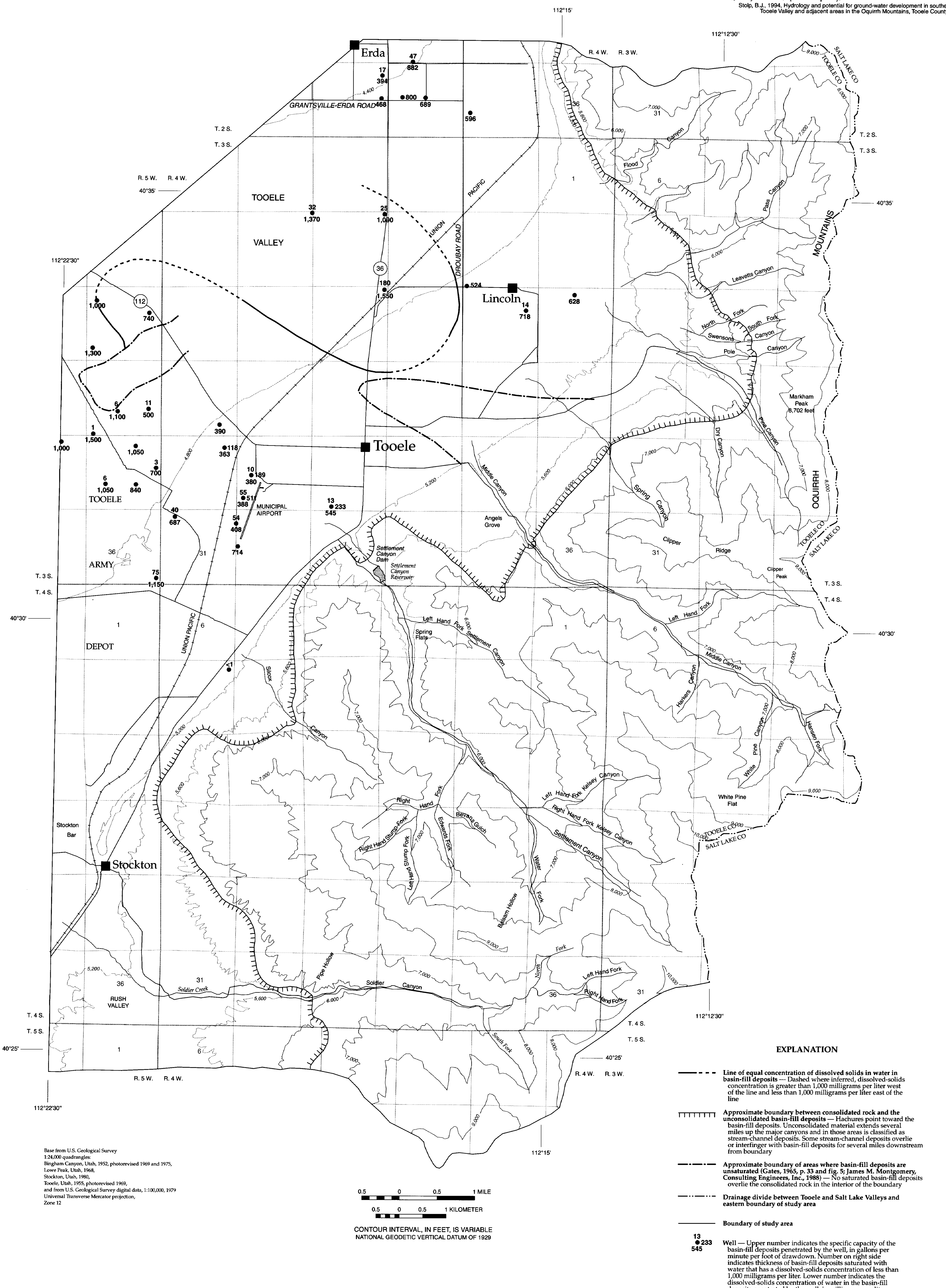
TECHNICAL PUBLICATION NO. 107
Quality of water, specific capacity, and saturated thickness—PLATE 3
Stolp, B.J., 1994, Hydrology and potential for ground-water development in southeastern Tooele Valley and adjacent areas in the Oquirrh Mountains, Tooele County, Utah



MAP SHOWING QUALITY OF WATER IN, SPECIFIC CAPACITY OF, AND SATURATED THICKNESS OF THE BASIN-FILL DEPOSITS IN SOUTHEASTERN TOOELE VALLEY, UTAH

By

Bernard J. Stolp

1994