STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

Technical Publication No. 40

GROUND-WATER CONDITIONS IN THE CENTRAL VIRGIN RIVER BASIN, UTAH

by

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U. S. Geological Survey

Prepared by
the U. S. Geological Survey
in cooperation with
the Utah Department of Natural Resources
Division of Water Rights
Salt Lake City, Utah
1972

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ABSTRACT

The central Virgin River basin, in Washington and Iron Counties, Utah, includes about 1,000 square miles in the drainage basin of the Virgin River downstream from the Hurricane Cliffs. Aquifers in both consolidated and unconsolidated rocks supply water for public supply, irrigation, stock, industry, and domestic uses. The chief unconsolidated-rock aquifers are alluvial fans and channel-fill deposits, which supply about 80 percent of the water withdrawn by wells in the basin. The chief consolidated-rock aquifers include the Moenkopi, Chinle, Moenave, and Kayenta Formations, the Navajo Sandstone, basalt, and Tertiary igneous rocks of the Pine Valley Mountains. These aquifers supply water to about half the wells and most of the springs in the project area.

Long-term average annual recharge to the aquifers of the central Virgin River basin is estimated to be 100,000 acre-feet. Recharge is by (1) infiltration of precipitation, (2) infiltration of streamflow from adjacent areas, and (3) subsurface inflow. The general direction of ground-water movement is from the areas of recharge toward the Virgin River and its tributaries. Discharge from the aquifers averaged about 80,000 acre-feet for the 2 years 1968 and 1970. Discharge is by (1) seepage into streams, (2) springs and drains, (3) evapotranspiration by phreatophytes, (4) wells, and (5) subsurface outflow. Discharge from wells averaged 6,600 acre-feet annually for the years 1968-70. Water-level hydrographs give no indication that withdrawals of ground water to date have had any significant effect on the amount of ground water in storage.

The dissolved-solids concentration in the ground water differs considerably from aquifer to aquifer and from place to place. The aquifers that are most likely to yield water containing less than 1,000 milligrams per liter are the Navajo Sandstone and basalt. By contrast, the Chinle and Moenkopi Formations are most likely to yield water containing more than 3,000 milligrams per liter. The areas that are most likely to yield water containing less than 1,000 miligrams per liter are those in or close to the Pine Valley Mountains. The dissolved-solids concentration generally increases toward the lower parts of the project area.

The largest spring in the area, Upper Toquerville Springs, discharged an average of about 11,000 acre-feet of water per year during the years 1968 and 1970, which is considerably more than the discharge during previous years of record. The change in discharge may correlate with an increase in precipitation in the New Harmony area. Some of the water impounded in Ash Creek Reservoir possibly has contributed to the increase in discharge from the springs, but it has not been possible to demonstrate this directly.

INTRODUCTION

Purpose and scope of the investigation

Water-rights problems have occurred in the central Virgin River basin and are expected to increase as development of the water resources increases. The Utah State Engineer needs a basic knowledge of ground-water conditions and of the relation of ground water to surface water as a first step to understanding and resolving the problems. Accordingly, the State Engineer requested the U. S. Geological Survey to make a ground-water investigation of the central Virgin River basin as part of the Statewide cooperative agreement with the Utah Department of Natural Resources. The investigation was begun July 1, 1968, and fieldwork was completed in August 1970. Detailed information was obtained for the principal aquifers and for recharge, movement, discharge, storage, utilization, and chemical quality of ground water. A progress report (Cordova, Sandberg, and McConkie, 1970) describes the general findings in the first year of the investigation.

Location and extent of the area

The project area, in Washington and Iron Counties, Utah, includes about 1,000 square miles in the drainage basin of the Virgin River downstream from the Hurricane Cliffs (pl. 1). The boundary on the west and north is the drainage divide between the Virgin and Santa Clara River basins and adjacent drainage basins along the Beaver Dam Mountains, Bull Valley Mountains, Pine Valley Mountains, and Harmony Mountains; on the east it is the Hurricane Cliffs, and on the south it is the Utah-Arizona State Line.

Previous investigations and acknowledgments

Previous ground-water investigations in the project area, other than the collection of basic data, were confined to the Kanarraville area. Results of these investigations were published in reports by Thomas and Taylor (1946) and by Sandberg (1963, 1966). Previously collected basic ground-water data include water levels in several observation wells, chemical analyses of water from many springs and wells, and the discharges of many springs and wells.

The geologic map of Utah (Stokes, 1964) and a report of the geology of Washington County (Cook, 1960) are the principal sources of geologic information referred to for the investigation.

For their valuable time and information, thanks are due the residents and the officials of communities and irrigation companies in the project area and to personnel of the Bureau of Reclamation, Soil Conservation Service, Bureau of Land Management, Agricultural Stabilization and Conservation Service, and the Utah State Department of Health.

Physiography and drainage

Most of the project area is characterized by post-Paleozoic sedimentary formations with generally low angles of dip (pl. 2), rapidly eroding escarpments, and youthful drainage. West of St. George, however, the sedimentary formations are steeply upturned on the flanks of the Beaver Dam Mountains—a strongly faulted and folded range of Paleozoic and pre-Paleozoic rocks. Altitudes above mean sea level range from about 2,400 feet where the Virgin River crosses into Arizona to about 10,300 feet in the Pine Valley Mountains.

The area is drained by the Virgin River and its tributaries, which are part of the Colorado River system. The Virgin River is perennial, and the tributaries are perennial, intermittent, or ephemeral. The flow of selected streams measured by the U. S. Geological Survey is summarized in table 1. The variability of streamflow in the Virgin River drainage basin is indicated by histograms in figure 1. The variation between years of maximum and minimum flow for the 19 years of record shown on the histograms is about 500 percent for the Santa Clara River and about 200 percent for the Virgin River.

Table 1.—Average annual streamflow of selected streams in the central Virgin River basin

Average annual streamflow based on gaging-station records for the calendar years shown in parentheses; except values followed by E, which were estimated from miscellaneous measurements in 1968-70.

Location	Average annual streamflow (acre-ft)
Streams entering basin from adjacent areas:	
Virgin River at Virgin (about 4 miles east of Hurricane)	145,400 (1910-68)
LaVerkin Creek	3,100E
Kanarra Creek	2,400 (1959-68)
Fort Pierce Wash	2,000E
Camp Creek	210E
Taylor Creek	180E
Spring Creek	160E
Streams originating in the basin:	
Ash Creek near New Harmony	7,560 (1939-47)
Leeds Creek near Leeds	4,980 (1965-68)
South Ash Creek below Mill Creek, near Pintura	3,540 (1967-68)
Santa Clara River near Pine Valley	5,590 (1960-68)
Santa Clara River above Winsor Dam, near Santa Clara	14,600 (1943-68)

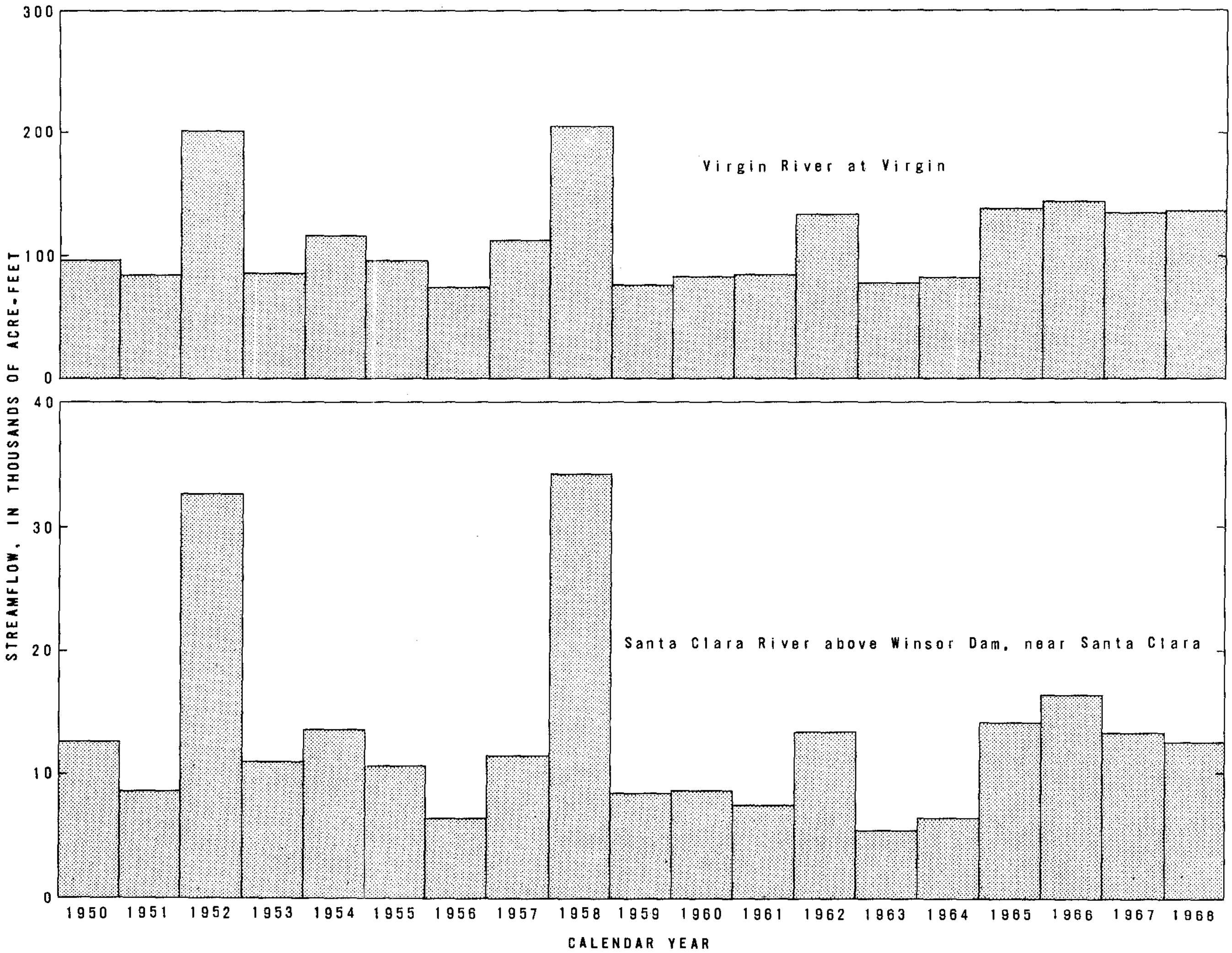


Figure 1.—Histograms of streamflow of the Virgin River at Virgin and of the Santa Clara River above Winsor Dam, near Santa Clara for the period 1950-68.

Climate

The climate of the project area is generally characterized by a small amount of precipitation, mild winters, hot summers, and a high rate of evaporation. Precipitation and temperature data are summarized in table 2, and the areal distribution of precipitation is shown in figure 2.

The largest amounts of precipitation generally fall during December, January, February, and March, but significant amounts also fall during the summer. In the winter, precipitation is commonly snow in the mountains and rain in the low elevations; but in the summer, precipitation is commonly in the form of torrential rainstorms which cause rapid runoff. The winter precipitation, therefore, probably contributes the greatest amount of recharge to the ground-water reservoir.

Average monthly temperatures at low altitudes are usually above freezing in the winter and exceed 80°F (26.5°C) in July and August. The estimated pan-evaporation rates at St. George, based on studies by the U. S. Bureau of Reclamation (oral commun., 1968), are as follows:

	Inches		Inches
Jan.	2.2	July	13.5
Feb.	3.0	Aug.	11.1
Mar.	5.8	Sept.	8.9
Apr.	8.2	Oct.	6.1
May	11.4	Nov.	3.2
June	13.7	Dec.	2.1
		Total (rounded)	89

The estimated evaporation from a free-water surface at St. George, therefore, using a pan coefficient of 0.70, is about 62 inches.

Culture and economy

Mormon pioneers established the first settlement, in the New Harmony area,in 1852; all the present communties were settled by 1905. St. George, the largest community in the project area, was settled in 1861 and is the county seat of Washington County.

Agriculture forms the economic base, but a large part of the income is derived from tourism. Irrigation farming and livestock are the main sources of agricultural income. The main irrigated crops are small grains, fruits, vegetables, and sugar beet seed.

Irrigation is necessary for the success of agriculture in the area. About 17,000 acres of land are irrigated, mostly by streamflow that is distributed by nonprofit stock irrigation companies. The flow of most streams is unregulated, and many irrigators use ground water as a supplementary source of supply during periods of low streamflow.

The Dixie Project of the U. S. Bureau of Reclamation was planned to construct a storage reservoir on the Virgin River to (1) utilize during low-flow periods water that is impounded during high flows; (2) provide supplemental irrigation water to presently developed land; (3) provide a full supply of water for irrigating 6,900 acres of new land; (4) provide additional water for industry and public supply; and (5) provide for recreation and conservation. The project was authorized by Act of Congress on Sept. 2, 1964, and as of July 1, 1970, the project was in the planning stage.

Table 2.—Precipitation and temperature data for stations in and near the project area

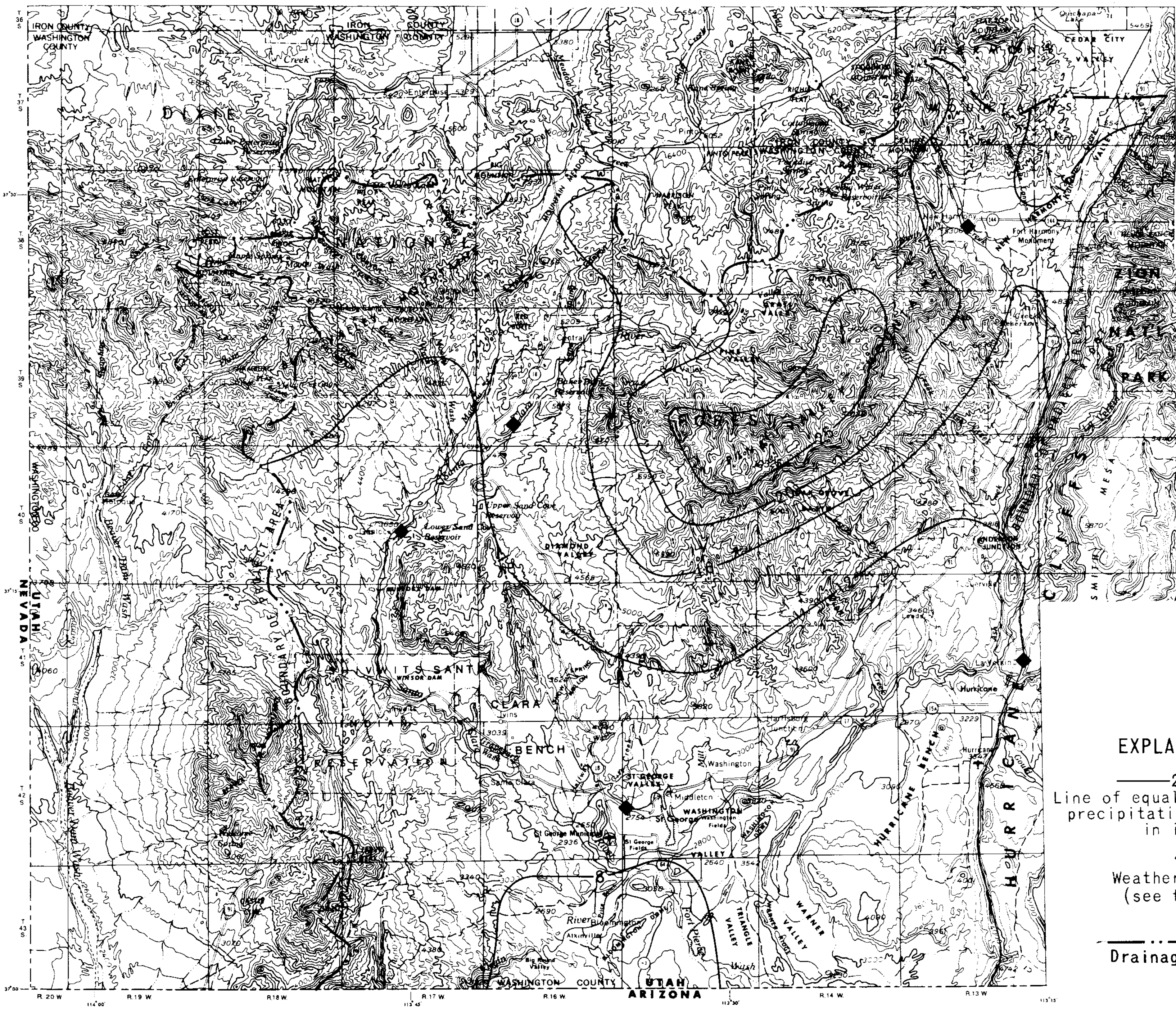
[Precipitation, in inches; temperature, in degrees Fahrenheit]

Station and altitude: See figure 2 for station locations; altitude in feet above mean sea level.

Total annual precipitation: E, estimated by U. S. Weather Bureau.

Station and altitude	Selected data	Period of record	Average monthly precipitation and temperature: Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average annual precipitation and temperature	Total annual precipitation: 1968	1969	1970
St. George 2,820	Precipitation	1931-60	0.98	1.03	0.91	0.48	0.39	0.24	0.60	0.61	0.60	0.68	0.58	1.03	8.13	5.01	9.41	7.80
	Temperature		39.2	44.5	51.8	60.5	68.3	76.6	83.7	82.1	74.7	62.1	48.0	40.8	61.0			
Zion National Park[1] 4,050	Precipitation	1931-60	1.61	1.76	1.68	1.19	.75	.56	.84	1.23	1.03	1.08	1.00	1.65	14.38	13.01	15.49	13.97
	Temperature		39.7	43.9	50.2	59.0	67.8	77.6	84.4	82.3	76.3	64.0	50.3	42.2	61.5			
Gunlock Power House 4,060	Precipitation	1931-60	1.34	1.36	1.48	.82	.57	.29	1.00	1.02	.71	.94	.76	1.36	11.65	8.63	15.95	12.39E
LaVerkin 3,450	Precipitation	1951-68	1.01	1.02	1.39	.88	.52	.33	.68	.83	.77	.55	.83	1.03	9.84	6.62	13.17E	6.79
Veyo Power House 4,500	Precipitation	1958-68	.72	1.59	1.38	1.22	.64	.35	.44	.78	1.26	.60	1.35	1.26	11.59	8.35	15.56E	12.21
New Harmony 5,280	Precipitation	1945-68	1.90	1.39	1.78	1.26	.84	.66	.96	1.52	1.06	1.34	1.44	1.86	16.01	11.27	26.67	18.00

[1] About 18 miles northeast of Hurricane.



EXPLANATION

——20——
Line of equal normal annual precipitation (1931-60), in inches

◆
Weather station (see table 2)

—·—·—
Drainage divide

Base from U.S. Geological Survey 1:250,000 series: Cedar City, 1961

0 6 MILES

CONTOUR INTERVAL 200 FEET
DATUM IS MEAN SEA LEVEL

Line of equal normal annual precipitation from U.S. Weather Bureau, 1963

Figure 2.—Map of the central Virgin River basin showing areal distribution of precipitation.

GROUND WATER

Both unconsolidated and consolidated rocks in the area contain aquifers. Plate 2 shows the geology of the central Virgin River basin. Table 3 describes the geologic units, yields of wells and springs from these units, and the chemical quality of the water in these units. Table 17 shows selected drillers' logs of wells.

Unconsolidated-rock aquifers

Unconsolidated rocks crop out in about 20 percent of the project area and supply about 80 percent of the water discharged by wells. Most of these rocks were deposited by streams as alluvial fans and channel fill. The locations of the thickest and most extensive deposits containing aquifers are shown on plate 1 and the deposits are described in table 4. Most wells and springs in the unconsolidated rocks yield less than 250 gpm (gallons per minute). Larger yields are reported from a few areas (table 4). The fairly large range in yield from wells results mainly from differences in the amounts of gravel penetrated. The largest yields are from zones containing large amounts of gravel.

Two extensive and thick deposits of unconsolidated rocks not included in table 4 are in Warner Valley and on the Santa Clara Bench. The only well drilled in Warner Valley did not reach the water table, although it did penetrate the full thickness of unconsolidated rocks. This suggests that the unconsolidated rocks in Warner Valley do not contain aquifers. The few wells drilled through the unconsolidated deposits on the Santa Clara Bench indicate that these deposits differ in thickness locally, and where thickest they do contain ground water. The local differences in thickness are shown by the logs of wells (C-42-16)5bbb-1, (C-42-16)6ada-1, and (C-42-16)22baa-1. The first well penetrated 17 feet of unsaturated unconsolidated rock and bottomed in shale; the second well, about 1,800 feet away from the first, penetrated 40 feet of saturated unconsolidated rock and bottomed in shale; the third well bottomed in saturated unconsolidated rock at 100 feet. The differences in thickness, especially in short distances, suggest that erosional depressions, perhaps old stream channels, locally lie buried beneath the surface and may be potential sources of water to wells. The extent of such channels could be determined by test drilling or by geophysical study.

Thin channel-fill deposits, which are generally of small areal extent, are common in drainageways throughout the project area. Some of these thin deposits discharge water to springs and wells that supply small amounts of water for irrigation, industry, and public supply. Examples are the saturated deposits of (1) Oak Grove basin that supply water to Leeds; (2) Halfway Wash in the SE¼ sec. 11, T. 42 S., R. 16 W., that supply Santa Clara; (3) Snow Spring Hollow in the NW¼ sec. 34, T. 41 S., R. 16 W., that supply Ivins; and (4) City Creek that supply water to well (C-42-16)13ccd-1.

Consolidated-rock aquifers

The principal consolidated-rock aquifers in the area are in the Moenkopi, Chinle, Moenave, and Kayenta Formations, the Navajo Sandstone, igneous rocks in the Pine Valley Mountains, and the basalts of Quaternary age. Most springs in the area discharge from the consolidated rocks, and generally yield less than 50 gpm. A few large springs, mostly in areas underlain by basalt, yield more than 1,000 gpm. Although about half the wells in the area derive their water from consolidated-rock aquifers, most of them yield only small amounts of water for stock and domestic use. A few public-supply and irrigation wells yield from 500 to 3,000 gpm, but only about 20 percent of the water withdrawn by wells in the project area comes from the consolidated rocks.

Table 3.—Generalized geology, yields of wells and springs, and chemical quality of ground water in the central Virgin River basin

[Geology modified from Cook (1960)]

Yields of wells and springs and chemical quality of water: Small yield is 10 gpm (gallons per minute) or less; moderate yield is more than 10 gpm to 100 gpm; large yield is more than 100 gpm to 1,000 gpm; very large yield is more than 1,000 gpm. Fresh water has a dissolved-solids concentration of less than 1,000 mg/l (milligrams per liter), slightly saline water 1,000 to 3,000 mg/l, and moderately saline water 3,000 to 10,000 mg/l.

Geologic age	Unit	Approximate maximum thickness (ft)	Type of material	Yields of wells and springs and chemical quality of water
Quarternary	Basalt, some pyroclastics	900	Dark flow rock, cinder cones	Yield from basalt locally is large to very large, water is fresh. Yield from pyroclastics is probably small and water probably is fresh.
Quaternary and Tertiary (?)	Alluvial fans and terraces, channel-fill deposits, and dunes, landslides, talus, and mudflows	Generally less than 200; but in places more than 500	Unconsolidated sedimentary materials from clay to boulders in size	Moderate to very large yields to irrigation wells from alluvial-fan and channel-fill deposits. Small yield from some other deposits locally. Water is fresh to moderately saline.
Tertiary	Undifferentiated sedimentary and igneous rocks confined mainly to the Harmony, Bull Valley, and Pine Valley Mountains; includes Claron Formation	9,000	Light to dark intrusive and extrusive igneous rocks, with some limestone, sandstone, siltstone, and conglomerate	Yield is small to large. Water is generally fresh.
Cretaceous	Undifferentiated: Includes Kaiparowits Formation, Straight Cliffs Sandstone, Wahweap Sandstone, Tropic Formation, and Dakota (?) Sandstone	4,100	Sandstone, shale, coal, and conglomerate	No well or spring data are available. Yield probably is small to moderate, and water probably is fresh to slightly saline.
Jurassic	Entrada Sandstone and Carmel Formation undifferentiated	310	Limestone, sandstone, shale, and gypsum	Yield is small to moderate. Water is fresh.
Jurrassic and Triassic(?)	Navajo Sandstone	2,200	Red and white crossbedded sandstone	Yields moderate to very large quantities of fresh to slightly saline water.
Triassic(?)	Kayenta Formation	740	Red shale, siltstone	Yields small quantities of fresh to moderately saline water.
Triassic(?) and Triassic	Moenave Formation, Chinle Formation (including Shinarump Member), and Moenkopi Formation	3,200	Mainly shale and siltstone; some mudstone and sandstone	Yield small to moderate. Water is fresh to moderately saline.
Permian	Kaibab Limestone	1,100	Mainly limestone	Few well or spring data are available. Yield probably is small to large. Water probably is fresh, but springs close to the east and southwestern boundaries of the project area yield moderately saline water
Cambrian to Permian	Undifferentiated: Includes Toroweap Formation, Supai Formation, Coconino Sandstone, Callville Limestone, Redwall Limestone, Devonian to Cambrian limestone and dolomite, Pioche Shale, and Prospect Mountain Quartzite	7,400	Mainly limestone, dolomite, and sandstone; some shale and quartzite	No well or spring data are available. Yield probably is small and water probably is fresh.

Table 4.—Generalized descriptions of unconsolidated-rock aquifers

Remarks: Fresh water has a dissolved-solids concentration of less than 1,000 mg/l, slightly saline water 1,000 to 3,000 mg/l, and moderately saline water 3,000 to 10,000 mg/l.

Location of aquifer (see pl. 1)	Maximum saturated thickness (ft)	Lithologic character	Approximate depth to saturated zone (ft)	Yields of wells (gallons per minute)	Remarks
Anderson Junction and Leeds areas	Exceeds 100 at Anderson Junction; about 90 at Leeds	Sand and gravel	Near surface at Leeds but 250 at Anderson Junction	500 or less	Only two wells at Leeds and one at Anderson Junction. The well at Leeds is in old channel-fill deposit of Quail Creek drainage. At Anderson Junction aquifer is old channel-fill deposit of Ash Creek, probably upraised by faulting. Water is fresh.
Diamond Valley	270	Mainly sand	90	250 or less	Several wells drilled, but not used. Probably can supply water only to domestic and stock wells. Water probably is fresh.
Grass Valley	Unknown, but exceeds 160	Mainly sand	0 - 30	250 or less	Only one well. Potential should be tested by drilling. Water probably is fresh.
Hurricane Bench	Unknown, but probably less than 100	Gravel mixed with sand and clay	Minimum of 300	250 or less	No development. Probably little potential in most of area. Water is slightly saline.
New Harmony Valley	Exceeds 250 in New Harmony area and 500 in Kanarraville area	Sand and gravel	From near land surface to about 80	1,000 or less	Most wells used for irrigation. Potential should be explored further. Water is fresh to slightly saline.
Oak Grove basin	Unknown, but probably generally less than 50	Sand to boulders	Near land surface	No wells	Supplies springflow and stream base flow used for public supply and irrigation in Leeds area. Water is fresh.
Pine Valley	Unknown, but exceeds 75	Mainly sand	0 - 50	250 or less	Significant amount of development by wells used for domestic purposes. Water is fresh.
Stream valley of the Santa Clara River downstream from Santa Clara and locally in valleys of Virgin River, Ash Creek (Pintura), and Fort Pierce Wash	100 along Virgin River, Santa Clara River, and Ash Creek; unknown along Fort Pierce Wash, but probably exceeds 100 at upper end	Sand and gravel	From near land surface locally along the Virgin and Santa Clara Rivers to 200 along Ash Creek at Pintura	Generally less than 500 but maximum of 2,700 at Bloomington in Virgin River alluvium	Wells along Virgin River, mainly from Washington Dome to Atkinville; along Santa Clara River, mainly downstream from Santa Clara; and upper end of Fort Pierce Wash; none on Ash Creek. Wells used mainly for irrigation. Water is fresh to moderately saline.
St. George Valley	25	Mainly sand	10 - 50	50 or less	Little development. Potential probably limited to domestic and stock wells. Water is slightly saline.
Triangle Valley	100	Sand and gravel	90	250 or less	Only one well, drilled but not used because yield is too small for irrigation. Unconsolidated rocks on eastern side of valley were deposited in a long narrow depression caused by faulting. Water is probably moderately saline.
Washington Valley	Generally less than 50, but locally thicker	Mainly sand, gravel locally	10 - 60	700 or less	Little development; wells with largest discharges are south of Virgin River. Potential probably limited to domestic and stock wells in most of area. Water is fresh to moderately saline.

The large range in yield results mainly from movement of water through fracture systems, which vary widely in their cross-sectional size and lateral extent. Hard, brittle rocks, such as basalt and sandstone, generally contain larger and more extensive fractures than softer, less brittle rocks such as shale and siltstone. In addition, some sandstone formations, such as the Navajo Sandstone, probably locally contain a significant amount of intergranular openings through which water moves.

Recharge

Recharge to the ground-water reservoir in the central Virgin River basin is by infiltration of precipitation that falls on the area, infiltration of streamflow from adjacent areas, and subsurface inflow from adjacent areas. The estimated average annual recharge, in acre-feet, is broken down as follows:

Infiltration of precipitation	70,000
Infiltration of streamflow	15,000
Subsurface inflow	20,000
Total (rounded)	100,000

Infiltration of precipitation

Precipitation on the project area contributes the largest percentage of the water that recharges the ground-water reservoir. Recharge from precipitation occurs mainly above the 12-inch line of equal precipitation (see fig. 2).

The recharge of 70,000 acre-feet each year from precipitation was estimated by taking 13 percent of the average (normal) annual precipitation of 550,000 acre-feet on the area that receives more than 12 inches. The factor of 13 percent was derived by relating the volume of average annual precipitation to the volume of base flow (ground-water runoff) from four small drainage basins in or close to the project area (table 5). In determining the infiltration factor, it was assumed that: (1) base flow is at a constant rate; (2) all water entering each drainage basin is derived from precipitation on that basin; (3) all water leaving each basin (ground and surface waters) is measured at the gaging station; and (4) the effects of bank storage are nullified by considering periods longer than 1 year.

Comparison of the percentage factors in the last column of table 5 shows a large disparity in magnitude between the factor for the drainage basin of the Santa Clara River and the factors for the other three drainage basins. This disparity probably results from differences in geology. The drainage basin of the Santa Clara River above the gaging station near Pine Valley is underlain by Tertiary igneous rocks. These rocks weather to form relatively thick clayey soils that are generally conducive to rapid overland flow and a low rate of infiltration. The other three drainage basins, in contrast, are generally underlain by sandstone, which weathers to form sandy soils that are conducive to relatively high rates of infiltration, thus resulting in less overland flow.

Infiltration of streamflow

About 153,000 acre-feet of water enters the project area each year in the streams listed in table 1. An estimated 15,000 acre-feet (about 10 percent) of this water recharges the ground-water reservoir by infiltration directly from the waterways or from land that is irrigated with water from these streams. Much of the 15,000 acre-feet of recharge infiltrates in Washington Fields and St. George Fields, which are irrigated with water that enters the project area in the Virgin River.

Table 5.—Relation between precipitation and base flow in selected drainage basins

Drainage basin: The lower end of the drainage basin is marked by the stream-gaging station of the U. S. Geological Survey.

Annual average streamflow: Base flow estimated from stream-gaging records

Drainage basin	Area of drainage basin (acres)	Average annual precipitation in basin (acre-ft)	Annual average streamflow (acre-ft)		Period of stream-flow record	Relation of base flow to precipitation (percent)
			Total	Base flow		
Santa Clara River near Pine Valley	12,000	25,000	5,590	1,900	1960-68	0.076
Leeds Creek near Leeds	9,900	13,200	4,980	2,440	1965-68	.18
South Ash Creek below Mill Creek, near Pintura	7,000	9,360	3,540	1,220	1967-68	.13
Kanarra Creek at Kanarraville[1]	6,300	10,500	2,400	1,740	1960-68	.17
Arithmetic mean, weighted according to area of drainage basin						.13

[1] Kanarra Creek station is about 1 mile east of Kanarraville.

Infiltration of water from streams that originate in the project area was not calculated separately. Recharge from this source is included in the calculation of recharge from precipitation.

Recharge by irrigation water infiltrating in Washington Fields and St. George Fields is indicated by water-level hydrographs of wells (C-42-15)34dba-2 and (C-43-16)1ada-1 (fig. 3). Well (C-42-15)34dba-2 is in Washington Fields where the depth to water was generally less than 30 feet during this investigation, where the upper part of the saturated zone is in both consolidated and unconsolidated rocks, and where the only source of water for irrigation was the Virgin River. In the vicinity of well (C-42-15)34dba-2, irrigation with Virgin River water in 1970 was begun in early February but the infiltration of unconsumed irrigation water did not begin to cause a water-level rise until the middle of April. The water level at the beginning of irrigation reflected the recharge of the previous year's irrigation; the subsequent decline is a result of discharge, mainly by underflow, exceeding recharge. The relatively long time between the beginning of irrigation and the beginning of the rise of the water level is mainly a result of the small amount of irrigation water remaining for deep infiltration after consumption and runoff and the low average hydraulic conductivity of the section of rock in the vicinity of the well above the saturated zone.

Well (C-43-16)1ada-1 is in St. George Fields where the depth to water was generally less than 20 feet and where the upper part of the saturated zone is in unconsolidated rocks. In the vicinity of well (C-43-16)1ada-1, irrigation in 1969 was begun in January, and the periodic application of irrigation water diverted from the Santa Clara River thereafter is reflected in periodic rises and falls of the water level.

Subsurface inflow

Subsurface inflow to the ground-water reservoir in the upper 500 feet of saturated rock is estimated to be 20,000 acre-feet annually. The inflow is from east of the Hurricane Cliffs and from Arizona (see fig. 4 and pl. 3). The computation of the inflow, which is shown in table 6, is by means of the form of Darcy's law that states that the discharge is equal to the product of the hydraulic conductivity, the hydraulic gradient, and the cross-sectional area ($Q = KIA$).

Previous investigations by Thomas and Taylor (1946) and Sandberg (1966) indicated that ground water was moving from a small area in the southern part of Cedar City Valley southward into New Harmony Valley. The ground-water divide shown in the southern part of Cedar City Valley by Thomas and Taylor and by Sandberg, however, approximately coincides with the surface-drainage divide, which is the northern boundary of New Harmony Valley as used in this report. Figure 4 (profile A - A') indicates that in March-April 1970 the ground-water divide coincided with the surface divide; thus there was no movement of ground water into the project area from Cedar City Valley.

Movement

The direction of ground-water movement in the project area is generally toward the Virgin River and its tributaries, as indicated for parts of the area on plates 1 and 3 and in figure 4.

Some ground water is moving into the project area from Arizona east of the Virgin River, from east of the Hurricane Cliffs, and some ground water is moving out of the area into Arizona beneath and probably west of the valley of the Virgin River. Movement in the latter area may be facilitated by the Cedar Pocket Canyon fault, but hydrologic data are not available to substantiate that possibility.

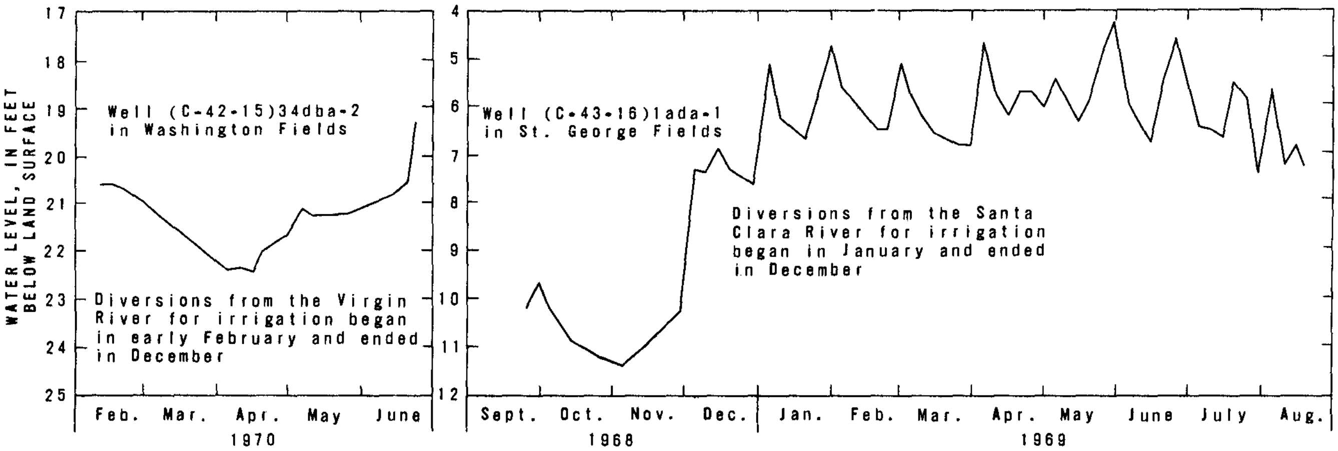
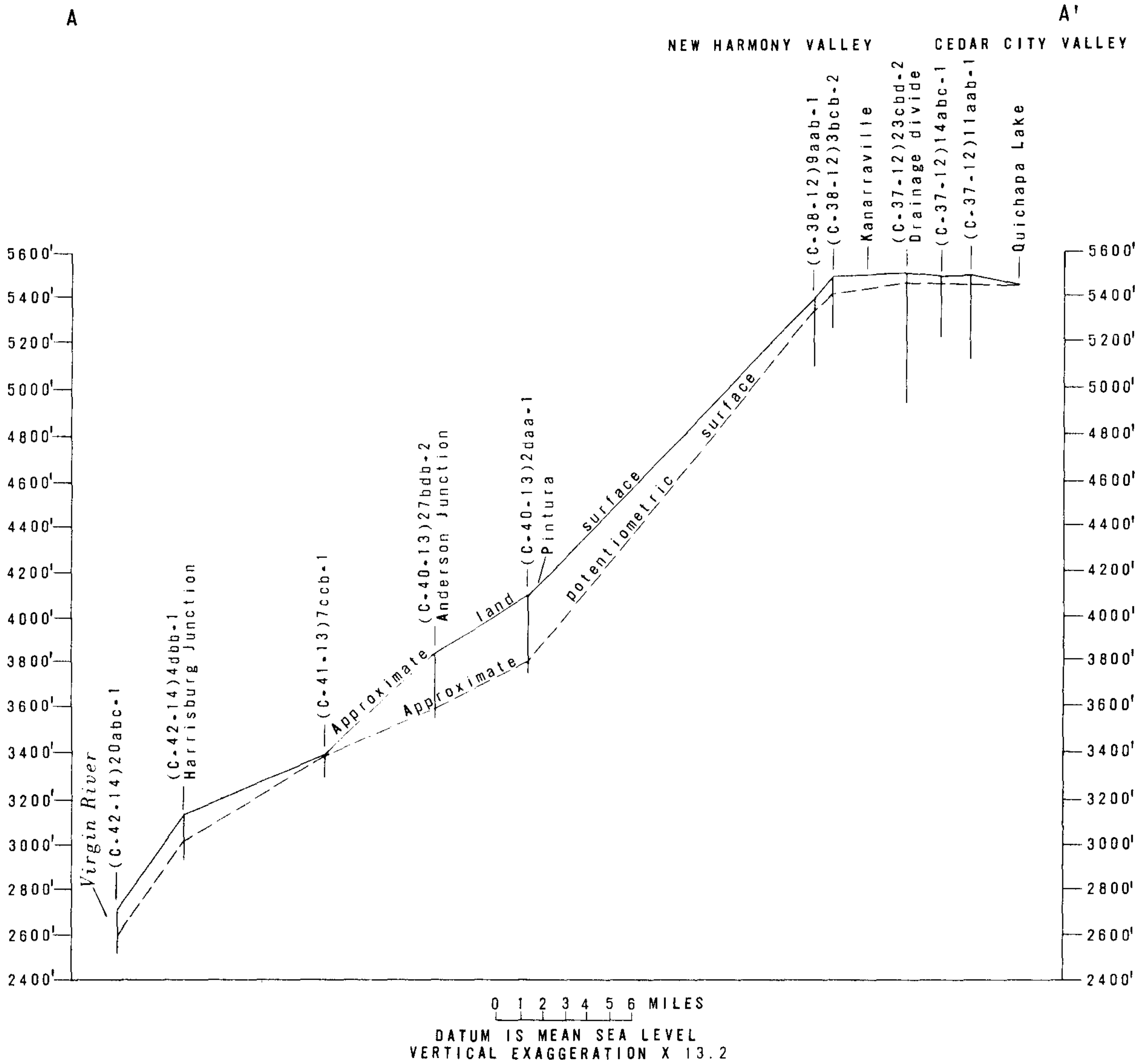


Figure 3.—Hydrographs of water levels in wells in Washington Fields and St. George Fields.



Lines of profiles shown on plate 1. Direction of ground-water movement approximately follows the downward slope of the potentiometric surface. See table 15 for dates of water-level measurements used for profile B-B' and for the part of profile A-A' downslope from New Harmony Valley. Water-level measurements for the part of profile A-A' in New Harmony and Cedar City Valleys made in March-April 1970; land-surface altitudes north of Pintura determined by instrumental leveling

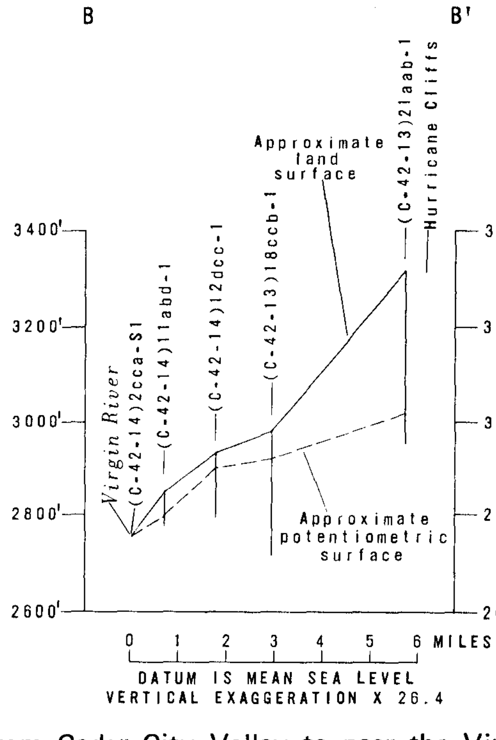


Figure 4.—Profiles of the potentiometric surface from Cedar City Valley to near the Virgin River and from near the Hurricane Cliffs westward to the Virgin River.

Table 6.—Subsurface inflow and outflow estimated for the upper 500 feet of saturated rock

Source area	Aquifer	Cross section through which flow occurs			Hydraulic conductivity (K) (ft/day)	Hydraulic gradient (I) (ft/ft)	Subsurface flow (Q)	
		Length (ft)	Depth (ft)	Area (A) (ft^2)			ft^3/day	Acre ft/yr
				Subsurface inflow				
East of Hurricane Cliffs	Mainly Kaibab Limestone	200,000	500	100,000,000	1[1]	0.01	1,000,000	8,000
Arizona, between the Hurricane Cliffs and the Virgin River at the Arizona State line	Mainly Triassic shale and sandstone, some limestone and alluvium	100,000	500	50,000,000	1[2]	.01	500,000	4,000
	Alluvium in Fort Pierce Wash	2,000	200	400,000	300[3]	.01	1,000,000	8,000
Total							2,000,000	20,000
				Subsurface outflow				
Utah, at the Arizona State line between the Virgin River and the drainage divide in the Beaver Dam Mountains	Mainly Kaibab Limestone, some alluvium	40,000	500	20,000,000	1[1]	.01	200,000	2,000

[1] Estimated from type of rock in section.
[2] Estimated from specific capacities of wells.
[3] Based on aquifer test at one well.

Discharge

Discharge of ground water in the project area is by seepage into streams, flow from springs and drains, evapotranspiration by phreatophytes (water-loving plants), well discharge, and subsurface outflow. A breakdown of the discharge, in acre-feet, for 1968 and 1970 is estimated as follows:

	1968		1970
Seepage into streams	23,000		24,000
Springs and drains	32,000		40,000
Evapotranspiration by phreatophytes	13,000		13,000
Wells	6,100		9,100
Subsurface outflow	2,000		2,000
Totals (rounded)	76,000		88,000
2-year average (rounded)		80,000	

The apparent difference between the figure of 80,000 acre-feet for average discharge and the corresponding figure of 100,000 acre-feet for average recharge stated earlier in this report is not an indication that the discharge-recharge relation is in disequilibrium. The difference results from inherent inaccuracies in the methods used to obtain the two figures, and also from comparing a long-term average with a short-term average that is not necessarily representative of long-term average conditions.

Seepage into streams

The estimated ground-water seepage into streams in 1970 was about 24,000 acre-feet (table 7). This amount may have been somewhat greater than normal because of the abnormally high precipitation in 1969. Complete data were not available for 1968, and the figure of 23,000 acre-feet shown above was estimated by applying the percentage relationship between the 1968 and 1970 measurements for discharge from springs and drains to the entries in table 7 that were measured in 1970.

Springs and drains

Nearly all springs and drains in the project area discharge water from consolidated rocks; the water is used mainly for irrigation but also for public supply, stock, and domestic purposes. The distribution of selected springs and drains is shown on plate 1, and records of both are shown in table 16. Discharge from springs and drains was about 32,000 acre-feet in 1968 and 40,000 acre-feet in 1970. The increase of 8,000 acre-feet in 1970 compared to 1968 is mainly the result of the increase in discharge of the Toquerville Springs:

	Discharge, in acre-feet	
	1968	1970
Upper Toquerville Springs	7,590	14,340
Lower Toquerville Springs	4,240	5,018

Upper Toquerville Springs

Loss of water through the basalt that forms the bottom and sides of Ash Creek Reservoir may contribute to flow from the Upper Toquerville Springs, which are about 11 miles downstream from the reservoir in the Toquerville reach of Ash Creek and which discharge from basalt. An increase in the rate of discharge of the springs reportedly began soon after the construction of the reservoir in 1961. Measurements of discharge of the springs prior to 1961 are not available. The recorded measurements since 1961 (table 8) indicate that the discharge of the springs has increased during the period of record, and possible explanations for this increase are discussed in the following pages.

Ash Creek Reservoir was constructed in 1961 to conserve the high flow of Ash Creek for irrigation. A significant amount of water has been impounded only in 1969, the only year in which water was discharged from the spillway. The dam is constructed of earth and rock placed in a deep rock-walled gorge of Ash Creek valley. The rock forming the bottom and sides of the gorge is a highly jointed basalt and the joints are wide and extensive. The basalt extends from the area of the reservoir southward through the area of Upper Toquerville Springs as an apparently continuous formation. Projected water-level data indicate that the water table is below the bottom of the reservoir.

Water-level data are not available in the immediate vicinity of the Ash Creek Reservoir; however, water-level data from adjacent areas indicate that ground water in the lower part of New Harmony Valley and near the reservoir is moving generally southward toward the Virgin River.

To demonstrate a direct relation (or absence thereof) between water in the reservoir and spring discharge, a dye test was made to trace the path of ground-water movement from the reservoir. Pre-test probing of the bed of the reservoir had indicated that as much as 30 feet of mud had been deposited in the reservoir, so that infiltration through the bottom would be negligible. Therefore, a fluorescent dye, Rhodamine WT, was injected into water that was released from the reservoir through a tunnel in the fractured basalt and which flowed downstream in an alluvial channel for 3.4 miles to near Pintura. The dye was injected at a constant rate directly into the tunnel to allow opportunity for the dye-laden water to infiltrate the fractured tunnel rock as well as the coarse alluvial fill in the stream channel below the dam. The test was started on July 14, 1970, and waters from the Pintura public-supply well and from the springs at Toquerville were periodically analyzed for change of fluorescence from that date until June 25, 1971, with no indication that the dye had reached either the well or springs.

The lack of a positive result means one of four things: (1) the dye did not reach the water table; (2) the dye-laden water reached the water table but bypassed the well and the springs; (3) the dye-laden water reached the water table but the dye either lost its fluorescence or the fluorescence became too small to be measurable; or (4) the velocity of the ground water is so slow that the dye-laden water had not yet arrived at the Pintura well.

An indirect attempt to determine the source of the spring water was made by comparing records of spring discharge with records of precipitation. A continuous water-stage recorder was installed (Oct. 7, 1969) on the Upper Toquerville Springs, but the record is not yet long enough to allow a meaningful comparison between the flow of the springs and precipitation. A comparison of the precipitation record at New Harmony with a long-term hydrograph for well (C-38-12)3bcb-2 (fig. 5), however, does show that ground-water levels in the area fluctuate in response to variations of precipitation. It is reasonable to assume, therefore, that spring discharge also fluctuates in response to variations of precipitation.

Table 7.—Estimated ground-water seepage into streams, 1970

Ground-water seepage: Estimated from U. S. Geological Survey streamflow-gaging records for 1970 except M, based on measurement in month and year given in parentheses.

Stream	Ground-water seepage (acre-ft)
Ash Creek at New Harmony	2,200M (5-70)
South Ash Creek above Pintura	1,100
Leeds Creek above Leeds	1,900
Santa Clara River near Santa Clara	1,300
Grass Valley Creek	500M (7-70)
Quail Creek below U. S. Highway 91	200M (10-70)
Virgin River from Hurricane to Utah-Arizona State line	17,000[1]
Total (rounded)	24,000

[1] Based on a seepage run in the low-flow season during November 1968.

Table 8.—Discharge measurements of Upper Toquerville Springs

Measured in SE¼SW¼NE¼ sec. 35, T. 40 S., R. 13 W.

Discharge (cfs)	Date	Remarks
5.04	Apr. 21, 1961	
5.02	1961	
4.70	May 15, 1961	Measurements by Coon, King, and Knowlton, Consulting Engineers, using weir and flume.
4.87	July 11, 1961	
4.77	Aug. 28, 1961	
7.35	June 1, 1962	
6.20	June 23, 1962	
8.97	May 28, 1963	
10.92	July 25, 1967	Measurement by Hurricane City using weir and flume.
10.53	Sept. 18, 1968	Measurements by U. S. Geol. Survey using weir and flume.
10.52	Nov. 1, 1968	
8.02	Dec. 3, 1968	Measurement by U. S. Geol. Survey using weir and current meter.
16.13	Sept. 1969	Measurement by Coon, King, and Knowlton, Consulting Engineers, using weir and flume.
21.68	Oct. 8, 1969	
21.61	Feb. 12, 1970	Measurements by U. S. Geol. Survey using current meter.
20.55	May 5, 1970	
18.07	July 22, 1970	
14.98	Nov. 19, 1970	
10.95	Apr. 23, 1971	Measurement by U. S. Geol. Survey using current meter and weir.

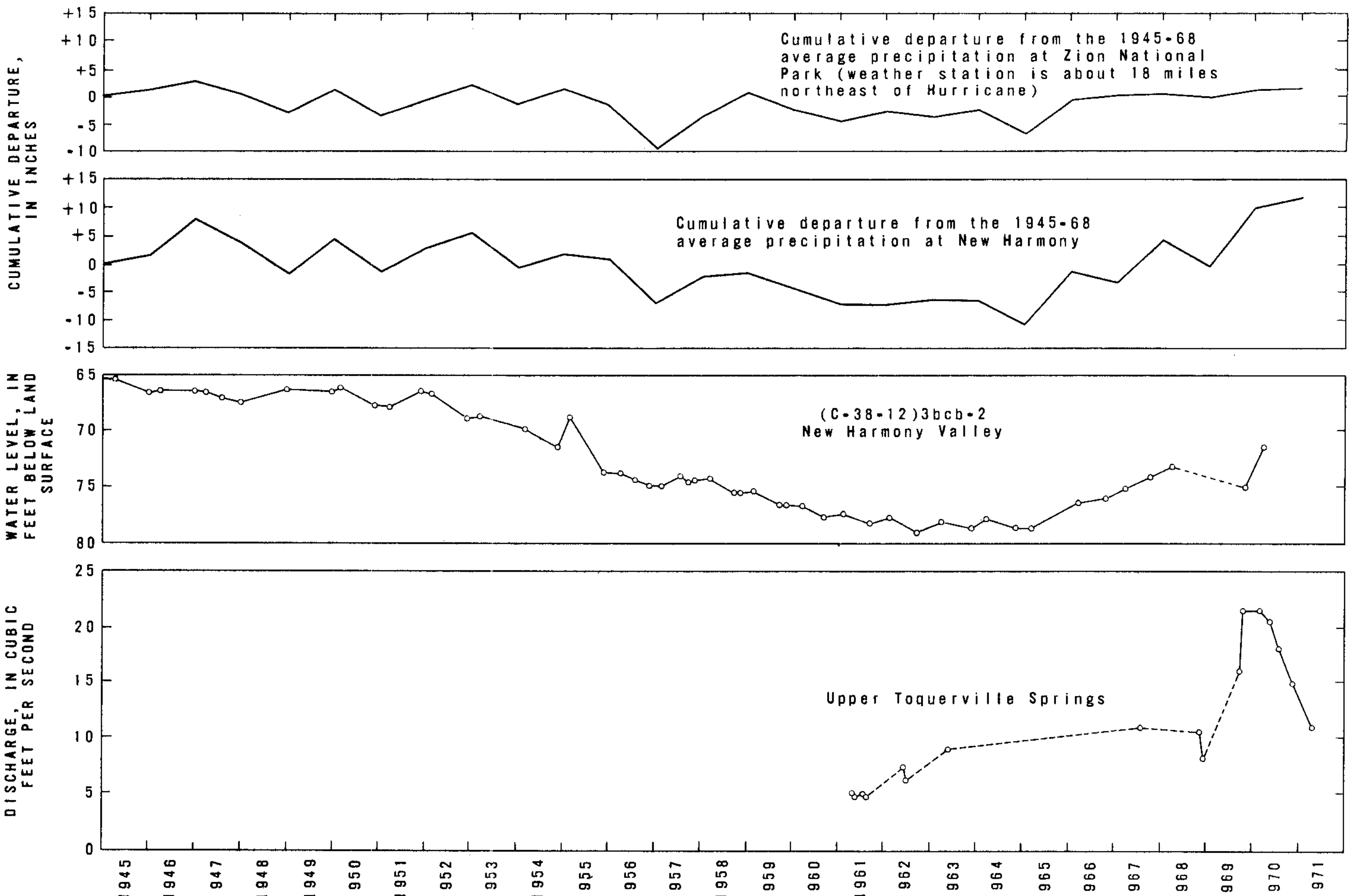


Figure 5.—Relation of water levels in observation well (C-38-12)3bcb-2 and of discharge of Upper Toquerville Springs in the central Virgin River basin to the cumulative departure from the average annual precipitation at New Harmony and Zion National Park.

Graphs of cumulative departure from average annual precipitation are shown in figure 5 for two stations that represent conditions in the Virgin River basin. The graph for Zion National Park shows that from 1962 to 1970, precipitation was above average during six of the nine years; it was significantly above average during only one year. The graph for New Harmony, however, shows that from 1962 to 1970, precipitation was above average during five of the nine years and was significantly above average during three of these (1965, 1967, and 1969).

A comparison of fluctuations of precipitation in the New Harmony area with discharge fluctuations of Upper Toquerville Springs (table 8 and fig. 5) indicates that although correlation is not conclusive, some degree of correlation is possible. Based on this correlation and the correlation between the rise of water levels in well (C-38-12)3bcb-2 and above-average precipitation in New Harmony Valley since 1964, New Harmony Valley seems most likely as a source of recharge for the springs.

It has not been possible to demonstrate it directly, but is is possible that some of the water impounded in Ash Creek Reservoir that formerly flowed directly to the Virgin River has contributed to the increase in discharge from the springs. This is suggested by the relation of the hydrograph for Upper Toquerville Springs and the precipitation curve for New Harmony in figure 5. The spring hydrograph indicates a gradual increase of discharge between 1961 and 1968, reflecting the general trend of the precipitation curve during that period. The marked increase in spring discharge during 1969 reflects the above-normal precipitation during 1969 or the impoundment of water in the reservoir during that year, or both. The decrease of spring discharge during 1970—a year of above-normal precipitation—may reflect a return of spring discharge to normal conditions after the recharge wave of 1969. Measurements are not available to show whether spring discharge increased during 1965 and 1967—other years of above-normal precipitation.

Measurements of discharge of the springs and of reservoir storage should be continued until the record is adequate to make a conclusive comparison with precipitation.

Evapotranspiration by phreatophytes

The average annual evapotranspiration of ground water by phreatophytes from areas where the water table is at or near the land surface is estimated to be about 13,000 acre-feet (table 9). Phreatophytes are concentrated mainly in and next to the channels of the Santa Clara and Virgin Rivers; but they are also present locally in the vicinity of Ivins, along some reaches of Ash and LaVerkin Creeks, and in Fort Pierce Wash and some other dry washes (see pl. 1). Field reconnaissance showed that the common phreatophytes in the area are cottonwood (*Populus* sp.), saltcedar (*Tamarix gallica*), alfalfa (*Medicago sativa*), and pasture grasses including saltgrass (*Distichlis stricta*) and fescue (*Festuca* sp.). Mixed stands of saltcedar and cottonwood are common with one or the other generally dominating. Alfalfa is in cultivated fields as are fescue pasture grasses. Saltgrass grows in uncultivated wet areas where alfalfa and fescue cannot be grown or cultivation is impractical.

Saltcedar is a phreatophyte of special interest because it uses large amounts of ground water and spreads rapidly. This plant, according to a consensus of several older residents, was planted for shade in St. George and other nearby communities prior to 1890 but was not seen in the stream channels and washes until after that time. Between 1910 and 1920 plants became numerous in the Virgin River channel, and since the 1930's the growth has been dense. A comparison of aerial photography indicates that in 1967 saltcedar covered essentially the same areas as it did in 1952. The only differences in distribution were local and resulted from changes in the position of streams in their channels or changes in the acreage of cultivated land. Field reconnaissance in each of the 3 years from 1968 to 1970 indicated that the distribution of saltcedar had not changed since 1967.

Table 9.—Estimated average annual evapotranspiration of ground water by phreatophytes

Rate of evapotranspiration determined by the Blaney-Criddle method (Criddle, Harris, and Willardson, 1962, p. 12).

Total evapotranspiration determined by multiplying the rate of evapotranspiration by the number of acres adjusted to 100-percent density.

Phreatophyte	Area (acres) Total	Area (acres) Adjusted to 100-percent density	Evapotranspiration Rate (acre-ft per acre)	Evapotranspiration Total (acre-ft)
Saltcedar	2,300	1,310	5	6,550
Cottonwood	990	430	3.6	1,550
Alfalfa	900[1]	900	3.2	2,880
Pasture grasses	800[1]	800	2.9	2,320
Totals (rounded)	5,000	3,400		13,000

[1] Estimated by L. B. Blackham, Soil Conserv. Service, (oral commun., 1968).

Wells

The distribution of selected wells is shown on plates 1 and 3, and records of selected wells are in table 15. The average annual discharge from wells in the project area for the years 1968-70 was 6,600 acre-feet, broken down as follows:

Use	Number of wells[1]	Discharge, acre-feet 1968	1969	1970
Irrigation:				
Yields of more than 100 gpm	41	5,600	4,000	7,500
Yields of 100 gpm or less	58	120	120	120
Stock	24	50	50	50
Public supply (includes industry)	9	230	270	1,370
Domestic	69	60	60	60
Totals (rounded)	209	6,100	4,500	9,100

[1]As of September 1, 1970, based on Utah Division of Water Rights files and field checking. In addition to those listed, records of 101 unused wells are on file.

The discharge for irrigation was calculated separately for wells discharging more than 100 gpm and for those discharging 100 gpm or less. The discharge from each of the former irrigation wells was calculated for each of the 3 years. From table 10 it can be seen that most of the discharge is from the Santa Clara River valley, Fort Pierce Wash, and New Harmony Valley. The discharge for irrigation from the 58 wells discharging 100 gpm or less is used for small pastures, lawns, and gardens and is estimated to average 2 acre-feet per year from each well.

The estimate of discharge for public supply (includes industry) is based partly on meter records and partly on reported pumping rates and hours of pumping. A breakdown by community of discharge, in acre-feet, is as follows (e, estimated):

	1968	1969	1970
Gunlock	64	64e	64e
Kanarraville	7	7e	7e
Pintura	.8	1e	1e
St. George	163	202	1,295[1]
Totals (rounded)	230	270	1,370

[1]The large increase compared to the previous 2 years is partly the result of water being supplied to Bloomington, a new resort community, partly to a dry January-June period, and partly to test pumping a new well.

Table 10.—Discharge in 1968-70 from irrigation wells yielding more than 100 gallons per minute

Discharge: Measured except E (estimated). Dash indicates either that the well was not constructed or that a pump was not installed.

Location	Owner or user	(Discharge (acre-ft) 1968	1969	1970
Fort Pierce Wash				
(C-43-15)16dcc-1	W. Seegmiller	0	496	1,111
25ddd-1	G. Seegmiller	1,550	900	1,070
Hurricane Bench				
(C-42-13)7ccc-1	Royal Garden Farms	-	10	9
(C-42-14)11abd-1	E. Stringham	170E	184	178
12dcc-1	Dixie Springs Farm	-	0	15
15cba-1	M. Faucet	60E	0	20
Leeds area				
(C-41-13)7ccb-1	L. Sullivan	0	0	80
New Harmony Valley				
(C-37-12)23aca-1	J. Prestwich	464	374	239
23acb-1	J. Prestwich			31
34aba-1	L. Prestwich		100E	100E
23cbd-2	W. Williams	45	106	113
34abb-1	Kanarraville Irrigation Co.	300E	300E	300E
(C-38-12)19aab-1	E. Graff	-	-	15
20bba-1	E. Graff	100	228	185
20bcc-1	E. Graff	58	236	232
(C-38-13)16cad-1	J. Prince	20E	0	37E
Santa Clara Bench				
(C-42-16)14daa-1	City of St. George	20E	0	0
22baa-1	R. Hafen	100E	106	88
Santa Clara River valley				
(C-42-16)16bcc-1	St. George-Clara Field Canal Co.	317	0	140
16cab-1	St. George-Clara Field Canal Co.	117	0	143
16cab-2	H. Tobler	30E	0	0
16dcb-1	St. George-Clara Field Canal Co.	64	0	266
17aac-1	New Santa Clara Field Canal Co.	70E	0	73
17aba-1	New Santa Clara Field Canal Co.	40E	0	258
22cba-1	S. Frei	60E	0	191
22dca-1	L. Frei	40E	0	89
26bcb-1	Mathis Market Supply Co.	30E	0	0
26bcc-1	W. Snow	1,100	199	145
26bcc-2	W. Snow			
26cdd-1	R. Snow	470	251	302
27adb-1	Mathis Market Supply Co.	40E	15	47
35adb-1	O. Gubler	45	.2	47
(C-43-16)1aca-1	C. Blake	64	12	88
1baa-1	C. Blake	60E	0	224
Triangle Valley				
(C-43-15)12ccc-1	S. Stucki	10E	19	0
12ccd-2	S. Stucki	40E	93	0
Virgin River valley				
(C-42-14)20dbc-1	D. Iverson	-	-	1E
(C-43-16)12adb-1	Bloomington	0	0	1,149
Washington Valley				
(C-42-15)14dad-1	D. Nisson	80	47	48
34dba-2	St. George East Stake	-	-	152
(C-43-15)2aaa-1	I. Andrus	75	298	306
	Total annual (rounded)	5,600	4,000	7,500
	3-year average		5,700	

Average annual use per stock well is estimated to be 2 acre-feet. Average annual discharge for domestic use (includes some irrigation and stock use) is estimated to be 0.8 acre-foot per well, based on information on rural-family use published by Criddle, Harris, and Willardson (1962, p. 23) and modified for use in the project area.

Subsurface outflow

Subsurface outflow in the upper 500 feet of saturated rock is estimated to be 2,000 acre-feet per year (table 6). Such outflow from the project area probably occurs at the Arizona State line between the Virgin River and the drainage divide in the Beaver Dam Mountains (see section on movement).

Ground-water development by wells

Development of the ground-water reservoir in the central Virgin River basin by wells was begun in the early 1930's, according to the records of the Utah Division of Water Rights. By September 1, 1970, records of 310 wells were on file for the area. The classification of these wells according to use is given in the preceding section. Records of selected wells are in table 15. The following summary indicates the classification of wells by depth, diameter, and aquifer:

Depth (ft.)	Number of wells
Less than 100	141
100-199	92
200-299	38
300-399	14
400-499	7
500 and more	14
Unknown	4
Diameter (in.)	
Less than 6	8
6-8	142
10-12	46
14-16	83
18-20	1
More than 20	23
Unknown	7
Aquifer	
Unconsolidated	145
Consolidated	147
Unknown	18

The hydraulic properties of aquifers

The determination of hydraulic properties of aquifers is essential for a full understanding of quantitative aspects of the ground-water reservoir such as the amount of water in storage and the prediction of the effects of interference produced by a discharging well on other wells or on streamflow. The properties of hydraulic conductivity, storage coefficient, and specific yield[1] were calculated for several aquifers from 23 aquifer tests involving 27 pumped and observation wells. Most of the aquifer tests were of less than 12 hours duration, and water levels generally could only be observed in the discharging well. Further evaluation of these properties was made by studying drillers' logs, bore-hole samples, and formational outcroppings. Table 11 lists the values for these properties for selected locations.

Storage

Changes in storage in the ground-water reservoir are indicated by fluctuations of water levels in wells. For example, a hydrograph of the water level in an observation well, (C-38-12)3bcb-2, in New Harmony Valley is shown in figure 5, together with a graph of the cumulative departure from average precipitation at New Harmony. A comparison of the water-level hydrograph with the cumulative-departure graph shows that trends of above-average precipitation are accompanied by general rises in water levels and therefore increases in storage, and that trends of below-average precipitation are accompanied by general declines in water levels and therefore decreases in storage. The hydrograph in figure 5, together with water-level fluctuations in observation wells elsewhere in the project area, gives no indication that withdrawals of ground water to date have had any significant effect on the amount of ground water in storage.

The amount of ground water in storage that is recoverable by wells was estimated for selected areas (see table 12). Present (1970) withdrawals from wells in these areas range from small to moderate, and withdrawals probably could be increased in all areas without significantly affecting ground-water storage.

Hydrologic effects of discharging wells

The discharge of ground water from a well results in a cone of depression in the water table or potentiometric surface around the well. Such a cone continues to enlarge in area and deepen until a balance is reached between the amounts of water demanded at the well and supplied to the well. Changes in the demand at the well cause the cone of depression to change in size. Assuming a constant discharge rate, long periods of pumping cause relatively extensive and deep cones, whereas short ones result in cones of relatively small extent and depth.

The hydrologic effects of discharging wells in the central Virgin River basin are local in extent and include interference between wells and reduction of streamflow.

Interference between wells

Interference occurs between wells when the cone of depression of one discharging well overlaps the cone of another. Such overlaps reduce the rates of discharge and increase the drawdowns in the affected wells. The magnitude of these effects is dependent upon the hydraulic properties of the aquifers, the rates of discharge, the distance between wells, and the length of the discharging period.

Interference between wells is known to occur in measurable amounts, based on aquifer testing, in the Santa Clara River Valley below Santa Clara, the Gunlock area, Triangle Valley, lower Fort Pierce Wash, and the Kanarraville area. Tests were not conducted to determine interference in other parts of the project area; however, interference in varying degree can be assumed where the ground water is under artesian or confined conditions (see table 11) or where wells are closely spaced.

[1] See definitions in the Appendix.

Table 11.—Hydraulic properties of aquifers for selected locations

Storage coefficient *(S)* or specific yield *(y)*: See appendix for definitions.

Methods of obtaining hydraulic properties: Character refers to lithology, texture, and grain size.

Location	Hydraulic conductivity (ft/day)	Formation	Storage coefficient *(S)* or specific yield *(y)*	Methods of obtaining hydraulic properties
			Unconsolidated rocks	
Anderson Junction	-	-	0.25*y*	Estimated from character of water-bearing material sec. 27, T. 40 S., R. 13 W.
Fort Pierce Wash	270	-	.20*y*	Based on aquifer tests in three wells and on character of water-bearing material in secs. 16 and 25, T. 43 S., R. 15 W.
Leeds area	45	-	.25*y*	Estimated from an aquifer test in one well and from character of water- bearing material in sec. 7, T. 41, S., R. 13 W.
New Harmony Valley (northern part)	200	-	.0004*S* .30*y*	Based on aquifer tests in three wells and on character of water-bearing material in secs. 23 and 34, T. 37 S., R. 12 W.
New Harmony Valley (southern part)	35	-	.0001*S* .30*y*	Estimated from specific capacity of three wells, an aquifer test in one of these, and from character of water-bearing material in secs. 19 and 20, T. 38 S., R. 12 W.
Pine Valley	-	-	.30*y*	Estimated from character of water-bearing material in T. 39 S., R. 15 W.
Santa Clara River valley	200	-	.001*S* .20*y*	Based on aquifer tests in nine wells and on character of water-bearing material in secs. 16, 17, 22, 26, and 35, T. 42 S., R. 16 W.
Washington Fields	240	-	.20*y*	Based on aquifer test in one well and on character of water-bearing material in sec. 2, T. 43 S., R. 15 W.
			Consolidated rocks	
Gunlock area	20	Navajo Sandstone	0.003*S* .30*y*[1]	Based on aquifer tests in three wells and on character of water-bearing material in secs. 7, 8, and 17, T. 41 S., R. 17 W.
Hurricane Bench	15	Navajo Sandstone	.003*S* .30*y*[1]	Based on aquifer test in one well and on character of water bearing material in sec. 12, T. 41 S., R. 14 W.
St. George Valley	1	Kayenta Formation	.006*S*	Estimated from specific capacity of one well and on character of water-bearing material in sec. 19, T. 42 S., R. 15 W.
Triangle Valley	3[2] 25	Chinle Formation	.006*S*	Estimated from specific capacity of one well and aquifer tests in two wells in sec. 12, T. 43 S., R. 15 W.
Washington Fields	100	Consolidated alluvium and Shinarump Member of Chinle Formation	.003*S*	Based on aquifer test in one well and on character of water-bearing material in sec. 34, T. 42 S., R. 15 W.

[1]Specific yield considered to be as high as in unconsolidated rocks because of geologic deformation by folding and faulting.

[2]Values obtained by separate tests within a distance of 0.2 mile.

Table 12.—Ground water recoverable by wells from storage in selected areas

Area of aquifer: From plate 2 and large-scale aerial photograph or topographic maps.

Estimated thickness of saturated zone: Interpreted from drillers' logs; p, indicates a minimum thickness.

Coefficient of storage (*S*) or specific yield (*y*): For entries of both (*S*) and (*y*), the amount of confined water was calculated using the storage coefficient and added to the amount of unconfined water in storage determined by using the specific yield.

Area (see pl. 1)	Aquifer	Area of aquifer (acres)	Estimated thickness of saturated zone (ft)	Coefficient of storage (*S*) or specific yield (*y*)	Volume of recoverable ground water (acre-ft)
Hurricane Bench[1]	Navajo Sandstone	22,000	2,000	0.003S; 0.30*y*	10,000,000
Gunlock[2]	Navajo Sandstone	9,300	2,500 and 5,000[3]	.003S; .30*y*	10,000,000
New Harmony Valley	Unconsolidated rock	23,700	300p	.0001S; .30*y*	2,000,000
Fort Pierce Wash[4]	Unconsolidated rock	1,500	100p	.20*y*	30,000
Santa Clara River valley[5]	Unconsolidated rock	1,300	50	.001S; .20*y*	10,000
Pine Valley	Unconsolidated rock	1,000	75p	.30*y*	20,000
Anderson Junction	Unconsolidated rock	100	100p	.25*y*	3,000
Leeds	Unconsolidated rock	300	30[6]	.25*y*	2,000

[1] Refers to the continuous area of outcrop southwest of Hurricane (see pl. 2).

[2] Refers to continuous block on the west side of the Gunlock fault (see pl. 2).

[3] The normal thickness (see table 3) has been increased by geologic deformation. The saturated zone is estimated to be 2,500 feet thick in the north half and 5,000 feet thick in the south half of the area of outcrop.

[4] Refers to that part of the alluvial valley that is upstream from the stream gap in the Bloomington Dome.

[5] Refers to that part of the alluvial valley that is downstream from Santa Clara.

[6] Thickness of gravel zone.

Reduction of streamflow

Discharge from a well can affect streamflow where there is hydraulic connection between a stream and the aquifer from which a discharging well is withdrawing water. Where an aquifer is hydraulically connected to a stream channel, wells discharging water from the aquifer may divert streamflow or water that would otherwise discharge into the stream channel as springs or seeps. The percentage of the water discharged by a well, which is thus diverted from a stream, can be roughly estimated from a graph prepared by Theis and Conover (1963).

In the project area, hydraulic connection between developed aquifers and streams is known (1) in the Santa Clara River valley upstream from the U. S. Geological Survey gaging station in the NW¼NW¼SE¼ sec. 17, T. 41 S., R. 17 W., and downstream from Santa Clara; (2) in the Virgin River valley upstream from the U. S. Geological Survey gaging station in the NE¼NE¼SW¼ sec. 2, T. 42 S., R. 14 W., and in the reach of St. George Fields and Washington Fields, and (3) in Fort Pierce Wash upstream from the stream gap through the Bloomington Dome.

Along the Santa Clara River upstream from the gaging station, springs and seeps were observed in the channel, and seepage runs in May-July 1970 showed a net gain in surface flow resulting from discharge by seeps and springs. Along the Santa Clara River downstream from Santa Clara and along Fort Pierce Wash upstream from the stream gap through the Bloomington Dome, a comparison of water-level elevations with elevations of the stream channel as well as a comparison of fluctuations of water levels in observation wells with stream stage showed a possible hydraulic connection. Along the Virgin River, a net gain in flow resulting from subsurface discharge was measured for the reach upstream from the gaging station and for the reach crossing St. George Fields and Washington Fields.

Chemical quality

General relations

Important factors affecting the chemical quality of ground water are the availability of soluble substances in the aquifers through which the water moves and the length of time the water is in contact with these soluble substances. Among consolidated-rock aquifers in the project area, shale and limestone contain the largest amountsof soluble substances, whereas basalt, sandstone, and intrusive igneous rocks generally contain the smallest amounts. The amounts of soluble substances in an unconsolidated-rock aquifer depend on the source rock of the materials comprising the aquifer.

The dissolved-solids concentration in ground water in the project area varies considerably according to aquifer and locality, as is shown in tables 13 and 18. The aquifers that are most likely to yield water containing less than 1,000 mg/l (milligrams per liter) are the Navajo Sandstone and basalt. By contrast, the Chinle and Moenkopi Formations are most likely to yield water containing more than 3,000 mg/l. The areas that are most likely to yield water containing less than 1,000 mg/l are those in or close to the Pine Valley Mountains. The dissolved-solids concentration generally increases toward the lower parts of the project area. (See figs. 6 and 7.)

Dissolved-solids concentration in water is related to the specific conductance, which is a measure of the ability of the water to conduct an electrical current. This relation, for ground water in the project area, is shown in figures 6 and 7, which can be used to estimate the dissolved-solids concentration in the water if the specific conductance is known.

Table 13.—Summary of dissolved-solids concentration of water from wells and springs according to aquifer

Aquifer	Dissolved solids		
	Range or single value (mg/l)	Average (rounded)	Number of samples
Unconsolidated rocks	144 - 6,860	1,400	24
Basalt	390 - 1,300	700	6
Claron Formation	246	-	1
Navajo Sandstone	215 - 1,240	400	9
Kayenta Formation	327 - 2,450	1,200	5
Moenave Formation	334 - 4,030	2,200	4
Chinle Formation including Shinarump Member	1,180 - 5,460	3,300	6
Moenkopi Formation	1,400 - 5,960	3,800	3
Kaibab Limestone	633	-	1

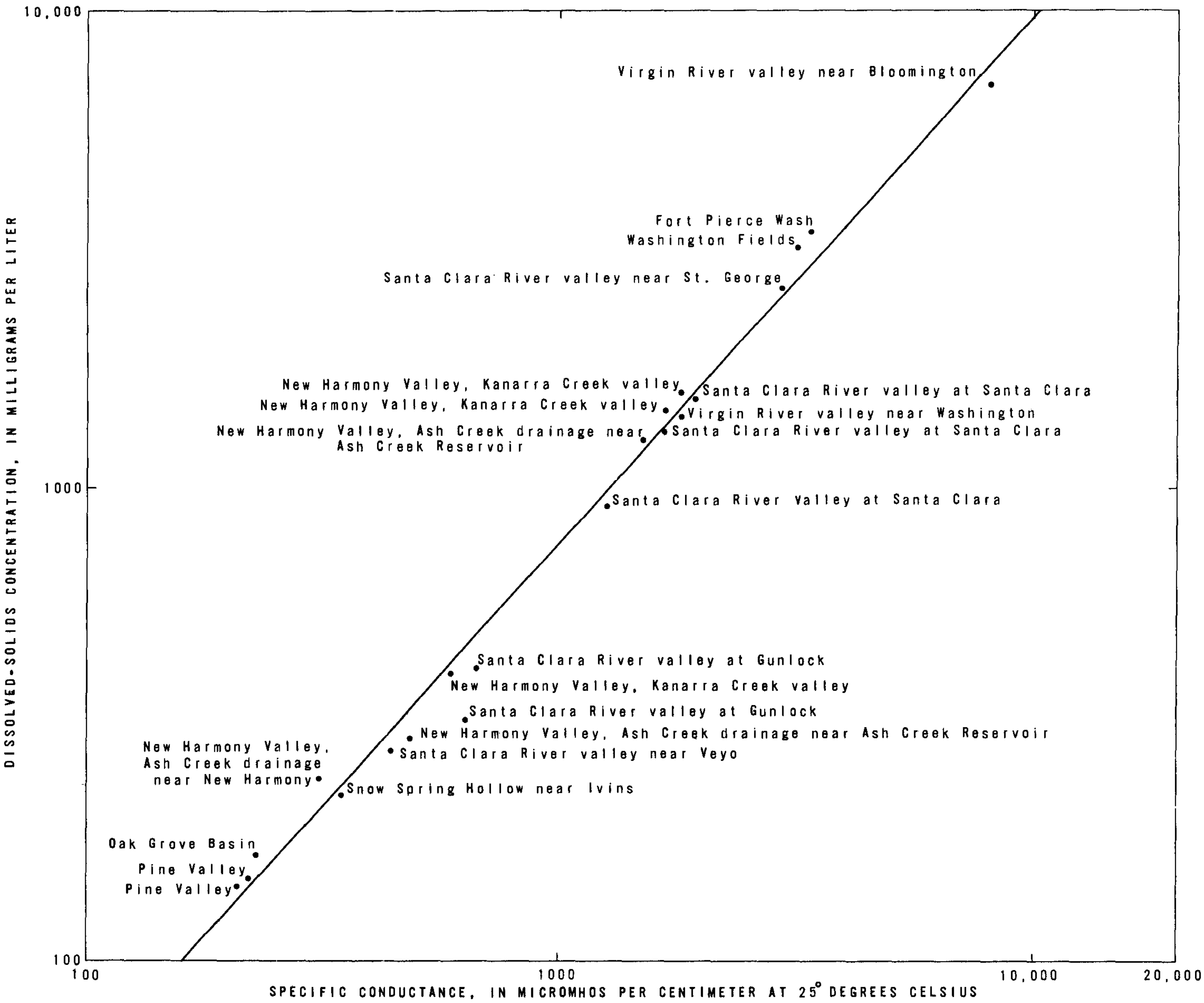


Figure 6.—Relation of dissolved-solids concentration to specific conductance of water from wells and springs in the unconsolidated rocks of the central Virgin River basin.

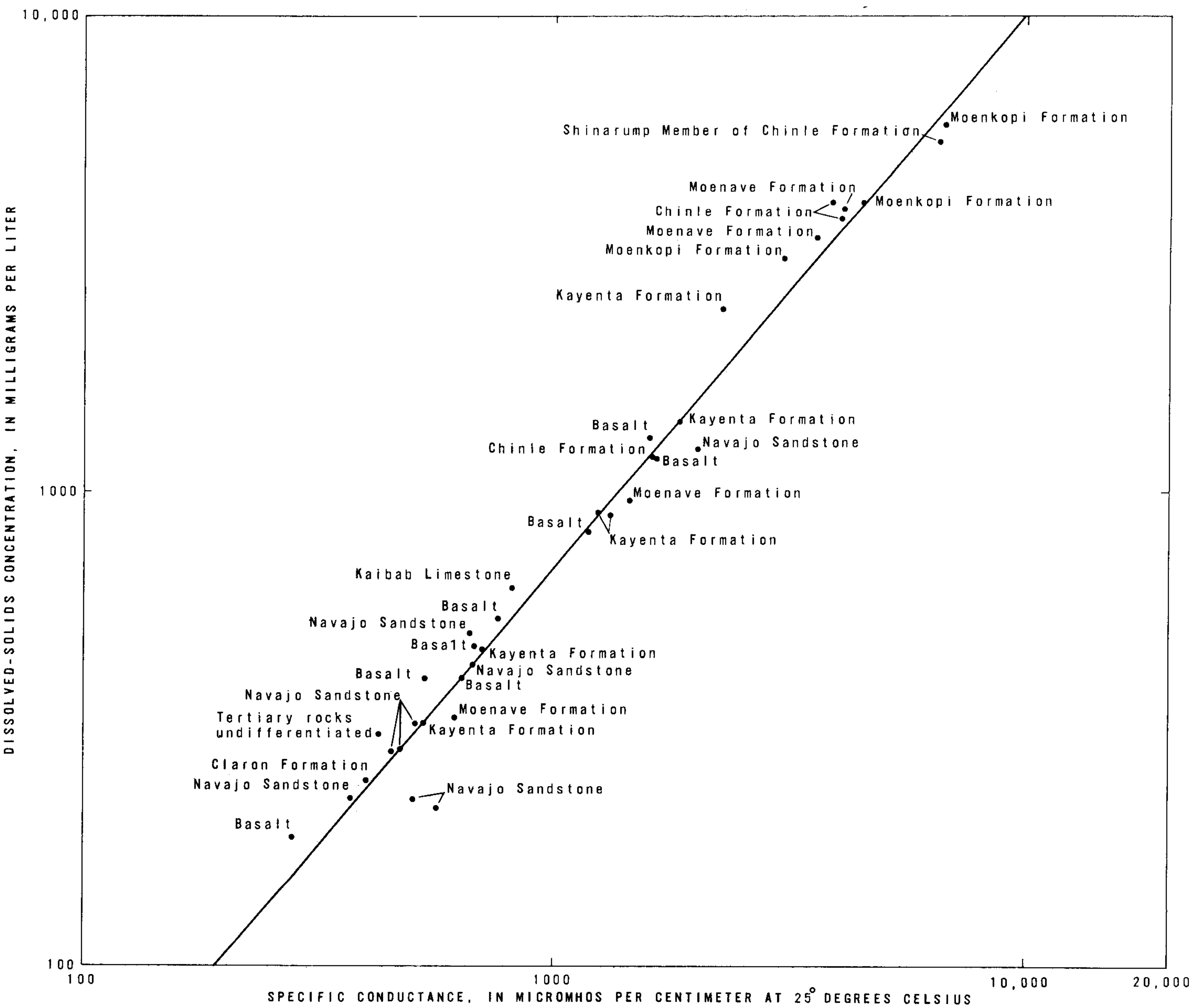


Figure 7.—Relation of dissolved-solids concentration to specific conductance of water from wells and springs in the consolidated rocks of the central Virgin River basin.

Relation to use

Public supply.—The U. S. Public Health Service (1962) has recommended quality standards for public drinking water and water-supply systems. A partial list of these standards is as follows:

Constituent	Recommended maximum limit (mg/l)
Dissolved solids	500
Sulfate	250
Chloride	250
Nitrate	45

The analyses in table 18 indicate that most wells in the project area yield water that contains dissolved-solids and sulfate concentrations that exceed the recommended maximums. Most springs, however, yield water that contains dissolved-solids and sulfate concentrations that are less than the recommended maximums. The chloride and nitrate concentrations of water from both wells and springs are generally less than the recommended maximums.

Irrigation.—The ground water in the project area was classified in figure 8 according to salinity hazard and sodium hazard, using the method of the U. S. Salinity Laboratory Staff (1954, p. 69). In classifying water for irrigation by this method, it is assumed that an average quantity of water will be used under average conditions of soil texture, salt tolerance of crops, climate, drainage, and infiltration. The classification in figure 11 is based on the relation between sodium-adsorption ratio (SAR) and specific conductance of the water. The SAR is a measure of the sodium hazard, and the specific conductance is a measure of the salinity hazard. The classification diagram is divided into 16 areas that are used to rate the degree to which a given water may give rise to salinity problems and undesirable ion exchange effects. The higher the salinity or sodium hazards the more unsuitable the water is for irrigation.

The water from 20 selected wells and springs in the unconsolidated rocks (fig. 8) has a sodium hazard that is low and a salinity hazard that ranges from low to very high. The water from 34 selected wells and springs in the consolidated rocks has a sodium hazard that ranges from low to medium and a salinity hazard that ranges from low to very high.

Boron in solution in excessive amounts also may present an irrigation hazard because of its toxicity to some type of plants. Table 14 shows a classification of irrigation water based on the boron content. The quantity of boron in solution in ground-water samples from the project area ranged from 0.00 to 2.00 mg/l, but most samples contained less than 0.33 mg/l (see table 18). The largest quantity was in water from the Chinle and Moenkopi Formations in their areas of outcrop and from some unconsolidated rocks overlying these formations.

Temperature

The temperature of ground water in the project area (see table 18) ranges from 6°C (43°F) to 32°C (90°F). The relation of ground-water temperature to the altitude of the top of the saturated zone in the area is shown in figure 9.

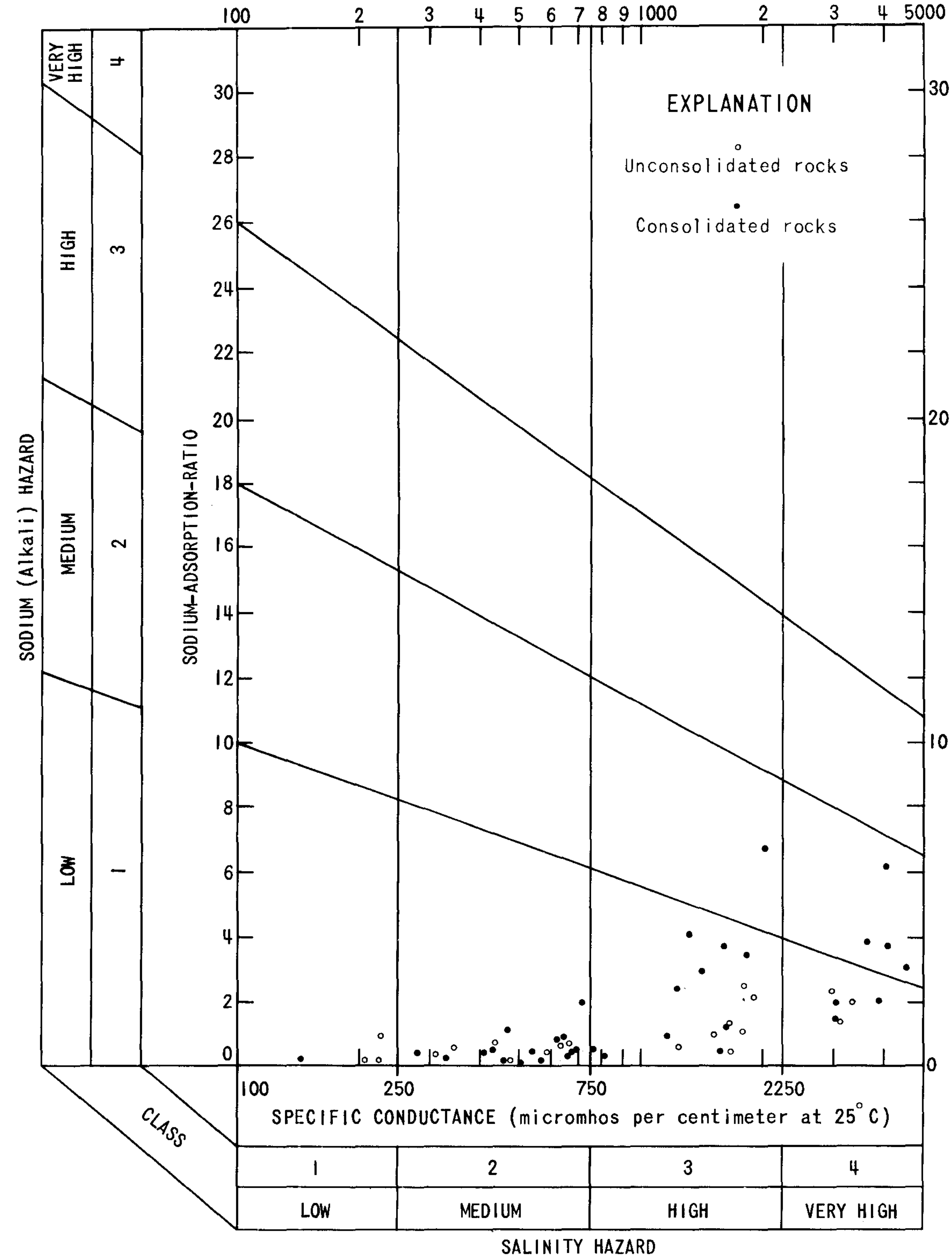


Figure 8.—Relation between specific conductance and sodium-adsorption ratio of water from wells and springs in the central Virgin River basin.

Table 14.—Classification of irrigation water based on the boron content

(Modified from Scofield and Wilcox, 1931)

Sensitive crops: Include most deciduous fruit and nut trees.

Semitolerant crops: Include most small grains, potatoes, and some other vegetables.

Tolerant crops: Include alfalfa and most root vegetables.

(For a more complete listing of crop tolerances, see U. S. Salinity Laboratory Staff, 1954, p. 67.)

Classes of water	Sensitive Crops (mg/l)	Semitolerant crops (mg/l)	Tolerant crops (mg/l)
Excellent	Less than 0.33	Less than 0.67	Less than 1.00
Good	0.33 - .67	0.67 - 1.33	1.00 - 2.00
Permissible	.67 - 1.00	1.33 - 2.00	2.00 - 3.00
Doubtful	1.00 - 1.25	2.00 - 2.50	3.00 - 3.75
Unsuitable	More than 1.25	More than 2.50	More than 3.75

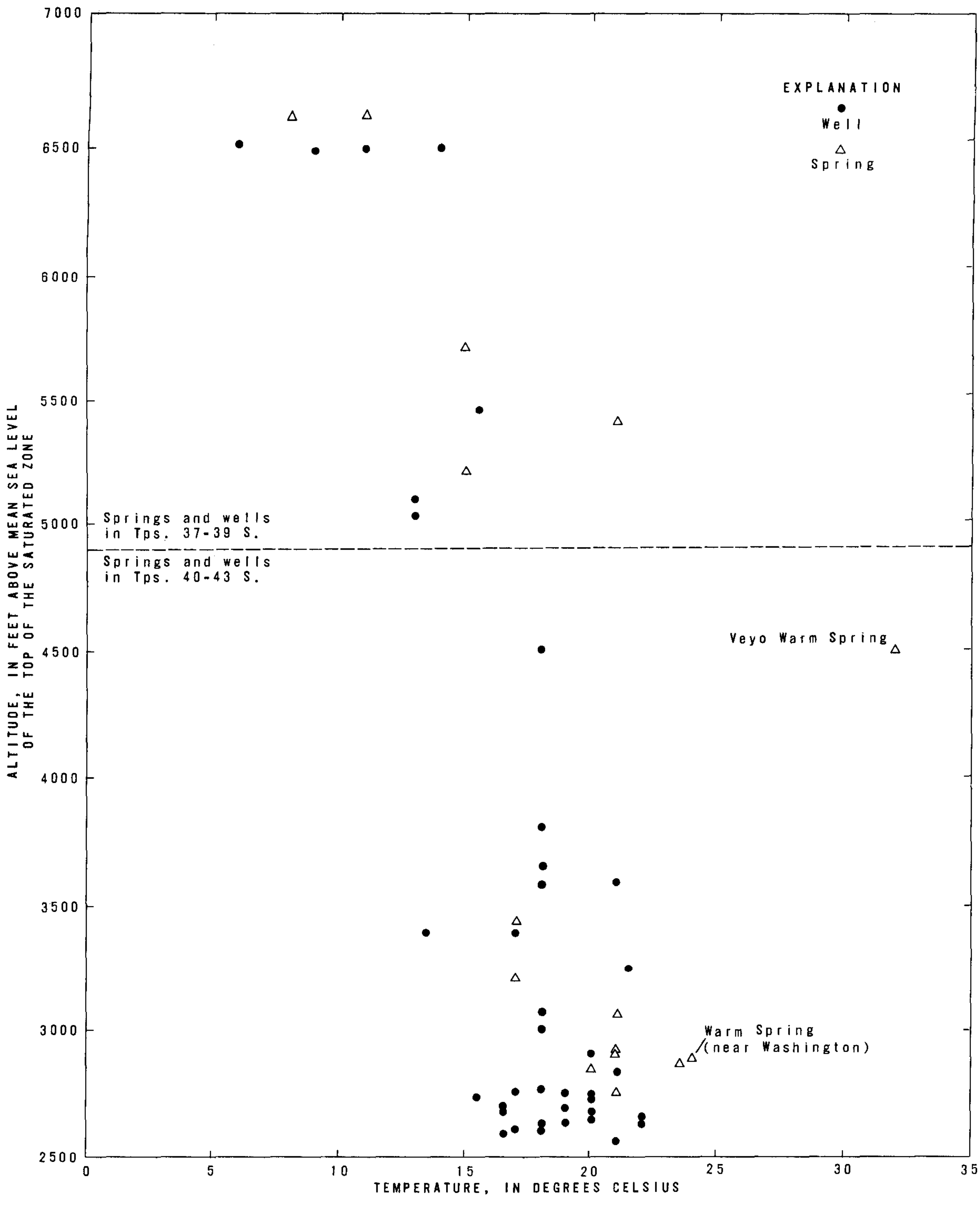


Figure 9.—Relation of ground-water temperature to the altitude of the top of the saturated zone.

The figure shows that the temperatures at higher altitudes are generally lower than the temperatures at lower altitudes. As a result of the effect of altitude on ground-water temperatures, the temperatures in Tps. 37-39 S., which have altitudes generally exceeding 5,000 feet, are generally less than those in Tps. 40-43 S., which have altitudes generally less than 5,000 feet.

Summary

Aquifers in the central Virgin River basin are in both consolidated and unconsolidated rocks. The chief aquifers in the unconsolidated rocks are in channel-fill deposits and alluvial fans. The main consolidated-rock aquifers are in the Moenkopi, Chinle, Moenave, and Kayenta Formations, the Navajo Sandstone, basalt, and the igneous rocks in the Pine Valley Mountains.

Long-term average annual recharge to aquifers is estimated to be 100,000 acre-feet. Recharge is by (1) infiltration of precipitation, (2) infiltration of streamflow from adjacent areas, and (3) subsurface inflow.

Ground-water discharge for 1968 and 1970 averaged about 80,000 acre-feet. Discharge is by (1) seepage into streams, (2) springs and drains, (3) wells, (4) evapotranspiration, and (5) subsurface outflow. Discharge from wells, which came mainly from the unconsolidated rocks, was about 6,100 acre-feet in 1968, 4,500 acre-feet in 1969, and 9,100 acre-feet in 1970. Long-term water-level data give no indication that withdrawals of ground water to date have had any significant effect on the amount of ground water in storage. Discharge from wells, however, locally results in well interference or interception of ground water moving toward streams. Most ground water in the area moves toward the Virgin River and its tributaries.

The dissolved-solids concentration in ground water varies considerably according to aquifer and locality. The aquifers that are most likely to yield water containing less than 1,000 mg/l are the Navajo Sandstone and basalt. By contrast, the Chinle and Moenkopi Formations are most likely to yield water containing more than 3,000 mg/l. The areas that are most likely to yield water containing less than 1,000 mg/l are those in or close to the Pine Valley Mountains. The dissolved-solids concentration generally increases toward the lower parts of the project area.

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APPENDIX

Well- and spring-numbering system

The system of numbering wells and springs in Utah is based on the cadastral land-survey system of the U. S. Government. The number, in addition to designating the well or spring, describes its position in the land net. By the land-survey system, the State is divided into four quadrants by the Salt Lake base line and meridian, and these quadrants are designated by the uppercase letters A, B, C, and D, indicating the northeast, northwest, southwest, and southeast quadrants, respectively. Numbers designating the township and range (in that order) follow the quadrant letter, and all three are enclosed in parentheses. The number after the parentheses indicates the section, and is followed by three letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section (generally 10 acres[1]); the letters a, b, c, and d indicate, respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision. The number after the letters is the serial number of the well or spring within the 10-acre tract; the letter "S" preceding the serial number denotes a spring. If a well or spring cannot be located within a 10-acre tract, one or two location letters are used and the serial number is omitted. Thus (C-42-16)22dca-1 designates the first well constructed or visited in the NE¼SW¼SE¼ sec. 22, T. 42 S., R. 16 W., and (C-42-16)22b-S designates a spring known only to be in the northwest quarter of the same section. Other sites where hydrologic data were collected are numbered in the same manner, but three letters are used after the section number and no serial number is used. The numbering system is illustrated in figure 10.

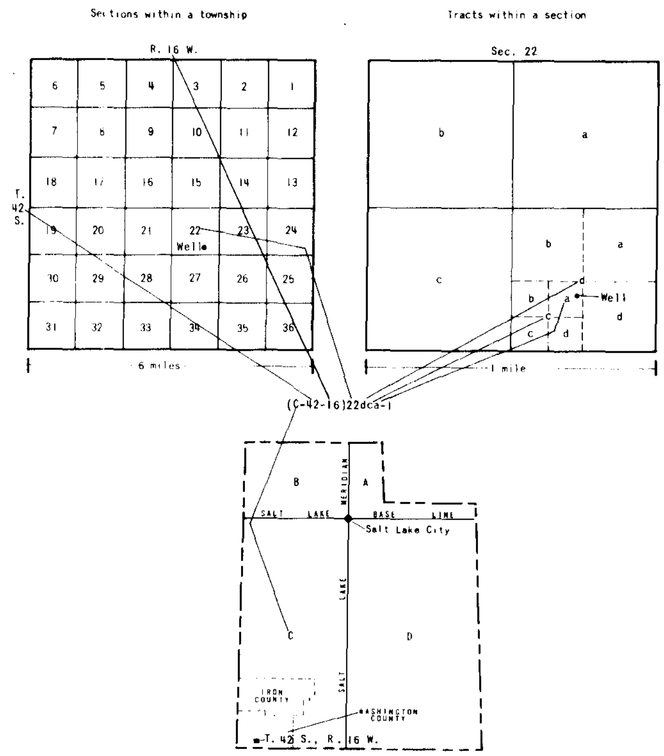

Figure 10.—Well-and spring-numbering system used in Utah.

1 Although the basic land unit, the section, is theoretically a 1-mile square, many sections are irregular. Such sections are subdivided into 10-acre tracts, generally beginning at the southeast corner, and the surplus or shortage is taken up in the tracts along the north and west sides of the section.

Use of metric units

The results of chemical analyses and temperature measurements are given in this report in metric units, rather than the more familiar English units. Temperatures are given in degrees Celsius, and concentrations are reported in milligrams per liter or milliequivalents per liter.

Degrees Celsius (°C) are the units used for reporting temperature in the metric system. One degree Celsius is equal to 9/5 degrees Fahrenheit, and the freezing point of water is 0°on the Celsius scale. The following table may be used to convert the temperature data given in this report to the more familiar Fahrenheit scale:

TEMPERATURE-CONVERSION TABLE

Temperatures in °C are rounded to nearest 0.5 degree. Underscored temperatures are exact equivalents. To convert from °F to °C where two lines have the same value for °F, use the line marked with an asterisk (*) to obtain equivalent °C.

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-20.0	-4	-10.0	14	0.0	32	10.0	50	20.0	68	30.0	86	40.0	104
-19.5	-3	-9.5	15	+0.5	33	10.5	51	20.5	69	30.5	87	40.5	105
-19.0	-2	-9.0	16	1.0	34	11.0	52	21.0	70	31.0	88	41.0	106
-18.5	-1	-8.5	17	1.5	35	11.5	53	21.5	71	31.5	89	41.5	107
-18.0 *	0	-8.0 *	18	2.0 *	36	12.0 *	54	22.0 *	72	32.0 *	90	42.0 *	108
-17.5	0	-7.5	18	2.5	36	12.5	54	22.5	72	32.5	90	42.5	108
-17.0	1	-7.0	19	3.0	37	13.0	55	23.0	73	33.0	91	43.0	109
-16.5	2	-6.5	20	3.5	38	13.5	56	23.5	74	33.5	92	43.5	110
-16.0	3	-6.0	21	4.0	39	14.0	57	24.0	75	34.0	93	44.0	111
-15.5	4	-5.5	22	4.5	40	14.5	58	24.5	76	34.5	94	44.5	112
-15.0	5	-5.0	23	5.0	41	15.0	59	25.0	77	35.0	95	45.0	113
-14.5	6	-4.5	24	5.5	42	15.5	60	25.5	78	35.5	96	45.5	114
-14.0	7	-4.0	25	6.0	43	16.0	61	26.0	79	36.0	97	46.0	115
-13.5	8	-3.5	26	6.5	44	16.5	62	26.5	80	36.5	98	46.5	116
-13.0	9	-3.0	27	7.0	45	17.0	63	27.0	81	37.0	99	47.0	117
-12.5	10	-2.5	28	7.5	46	17.5	64	27.5	82	37.5	100	47.5	118
-12.0 *	10	-2.0 *	28	8.0 *	46	18.0 *	64	28.0 *	82	38.0 *	100	48.0 *	118
-11.5	11	-1.5	29	8.5	47	18.5	65	28.5	83	38.5	101	48.5	119
-11.0	12	-1.0	30	9.0	48	19.0	66	29.0	84	39.0	102	49.0	120
-10.5	13	-0.5	31	9.5	49	19.5	67	29.5	85	39.5	103	49.5	121

For temperature conversions beyond the limits of the table, use the equations °C = 0.5556 (°F - 32) and °F = 1.8(°C) + 32. The formulae say, in effect, that from the freezing point of water (0°C, 32°F) the temperature in °C rises (or falls) 5° for every rise (or fall) of 9°F.

Milligrams per liter (mg/l) is the base unit for expressing the concentration of chemical constituents in solution, and it represents the weight of solute per unit volume of water. For concentrations of less than about 7,000 mg/l, this unit is numerically very nearly equal to the unit parts per million (ppm), which was formerly used by the U. S. Geological Survey.

Terms describing aquifer characteristics

The *hydraulic conductivity (K)* of a water-bearing material is the volume of water that will move through a unit cross section of the material in unit time under a unit hydraulic gradient. The units for *K* are cubic feet per day per square foot ($ft^3/day/ft^2$), which reduces to ft/day. The term hydraulic conductivity replaces the term field coefficient of permeability, which was formerly used by the U. S. Geologocal Survey and which was reported in units of gallons per day per square foot. To convert a value for field coefficient of permeability to the equivalent value of hydraulic conductivity, multiply by 0.134; to convert from hydraulic conductivity to coefficient of permeability, multiply by 7.48.

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

The *specific yield (y)* of an aquifer is the ratio of the volume of water it will yield by gravity after being saturated to the volume of dry aquifer. For all practical purposes, it is equivalent to the storage coefficient of an unconfined aquifer.

BASIC DATA

Table 15.--Records of selected wells

Well No.: See appendix for description of well-numbering system.
Casing : Depth - Total depth of casing or depth to first perforations.
Well finish: F, gravel-pack with perforated casing; P, perforated casing; O, open-end casing; X, open hole.
Aquifer: Jc, Carmel Formation; Trk, Kayenta Formation; JTrn, Navajo Sandstone; Pka, Kaibab Limestone; Qb, basalt; Qg, gravel or sand; Qt, unconsolidated terrace deposits; Qu, unconsolidated rocks undifferentiated; Trc, Chinle Formation; Trcs, Shinarump Member of Chinle Formation; Trm, Moenkopi Formation; Trmo, Moenave Formation.
Use of water: H, domestic; I, irrigation; N, industrial; P, public supply; S, stock; U, destroyed or unused.
Altitude: Above mean sea level as interpolated from topographic maps.
Other data available: C, chemical and temperature data in table 18; H, water-level hydrograph in figure 3 or 5; L, driller's log in table 17; Q, annual discharge data in table 10.

Well No.	Owner or user	Year constructed	Depth of well (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Well finish	Aquifer	Use of water	Water level: Below land-surface datum (feet)	Water level: Date of measurement	Altitude (feet)	Yield (gpm)	Other data available
	Ash Creek valley												
(C-40-13)													
2daa-1	Town of Pintura	1934	345	6	-	-	-	P	297	10-68	4,100	-	C
23aba-1	McCullock G. W. No. 1	1964	7,315	-	-	-	Pka	U	765	9-64	3,800	-	C
(C-41-13)													
23bcd-1	W. Wilson	1969	1,835	12	140	X	Trcs	S	15	-	3,040	100	-
	Diamond Valley												
(C-40-16)													
35dcc-1	E. Blake	1966	40	16	20	O	Jc	U	1	11-66	4,500	50	C
(C-41-16)													
1ccc-1	H. D. Moore	-	385	16	60	X	Qu	U	91	10-68	4,800	-	-
	Fort Pierce Wash												
(C-43-14)													
31ddd-1	G. Seegmiller	1962	14	14	14	P	Qu	U	12	10-68	2,820	-	-
(C-43-15)													
5dbd-1	J. Holt	1967	153	14	25	X	Qu	U	10	11-67	2,580	-	-
9cba-1	Hanning and others	1967	125	14	20	P	Qu	U	40	8-67	2,615	-	-
16aad-1	K. Bentley	1970	195	10	-	-	Trm	U	53	2-70	2,680	-	-
16cab-1	City of St. George	1962	264	16	-	-	-	U	73	10-68	2,660	-	-
16dbc-1	K. Bentley	1966	105	16	40	P	Qu	U	42	3-66	2,655	-	-
16dcc-1	W. Seegmiller	-	160	16	30	P	Qg	I	31	10-68	2,660	1,570	C,Q
25ddd-1	G. Seegmiller	1960	144	16	50	P	Qu	I	45	11-60	2,795	1,572	C,L,Q
	Grass Valley												
(C-38-14)													
31bda-1	E. Gardner	1963	200	16	42	P	-	U	37	10-68	6,960	-	L
	Hurricane Bench												
(C-42-13)													
7ccc-1	Royal Garden Farms	1964	129	16	15	X	JTrn	I	34	10-64	2,960	-	C,Q
18ccb-1	W. Wilson	1958	258	8	18	-	JTrn	U	60	1-58	2,980	-	-
18ccb-2	do	1959	194	14	17	X	JTrn	I	60	1-59	2,980	-	-
21aab-1	E. Graff	1952	365	14	-	-	Qu	U	300	1-52	3,320	-	-
33ada-1	do	1969	473	10	448	O	-	U	434	9-69	3,380	500	-
33ada-2	do	1970	480	10	357	O	-	U	444	1-70	3,380	-	-
(C-42-14)													
11abd-1	E. Stringham	1956	67	10	44	P	Qt	I	44	3-56	2,850	-	C,Q
12dcc-1	Dixie Springs Farm	1964	140	16	23	X	JTrn	I	32	1-64	2,940	101	C,Q
15aba-1	E. Stratton	1961	175	10	175	O	Trk	U	-	-	2,820	-	-
15cba-1	M. Fawcett	1961	320	14	75	X	Trmo	I	78	5-61	2,820	110	C,Q
25abb-1	Terracor	1970	720	8	4	X	JTrn	U	74	8-70	3,010	-	-
(C-43-13)													
5bdd-1	Spillsbury Co.	1956	530	6	46	X	JTrn	S	500	2-56	3,440	-	C
	Leeds area												
(C-41-13)													
4bab-1	W. Scheuber	1966	115	10	-	-	JTrn	H	16	10-68	3,680	-	C
5dbb-1	A. Howard	1953	48	12	8	X	JTrn	H	15	11-53	3,600	-	C
7ccb-1	L. Sullivan	1946	98	12	12	P	Qu	I	5	3-47	3,400	117	C,Q
16bcd-1	Utah State Land Board	1969	1,128	7	-	-	-	S	(1/)	5-70	3,240	94	C
	New Harmony Valley												
(C-37-12)													
11aab-1	G. Vandenburghe	1953	365	14	-	-	Qg	I	38	3-70	5,490	855	-
14abc-1	A. Graff	1950	264	14	-	-	Qg	I	31	3-70	5,485	639	-
23aca-1	J. Prestwich	1954	276	16	83	P	Qg	I	-	-	5,525	-	Q
23acb-1	do	1940	300	16	96	P	Qg	I	-	-	5,520	575	Q
23cbd-2	W. Williams	1968	561	14	230	F	Qg	I	50	3-70	5,500	1,100	C,L,Q
27dad-1	L. Heywood	1953	216	16	112	P	Qg	I	67	-	5,520	-	-
34aba-1	L. Prestwich	1953	220	16	-	P	Qg	I	62	-	5,522	-	Q
34abb-1	Kanarraville Irrigation Co.	1934	190	12	-	-	Qg	I	43	3-70	5,508	800	Q
34dbd-1	L. Prestwich	1965	342	16	70	P	Qg	I	64	-	5,520	-	-
35bbc-1	Town of Kanarraville	1952	190	12	120	P	Qg	P	-	-	-	160	-
(C-38-12)													
3bcb-2	L. Davis and others	1953	227	16	75	P	Qg	U	71	3-70	5,483	-	H
4cdc-1	Utah State Road Comm.	1965	404	8	262	P	Qg	P	75	10-69	5,482	-	-
9aab-1	R. Williams	1967	300	12	100	F	Og	U	58	4-70	5,397	-	-
9bba-1	do	1936	135	12	11	P	-	U	11	-	5,320	20	-
19aab-1	E. Graff	1969	200	14	-	P	Qg	I	75	11-69	5,120	-	Q
20bba-1	do	1946	220	16	62	P	Qg	I	41	12-47	5,125	210	C,Q
20bcc-1	do	1949	216	16	40	P	Qg	I	49	12-68	5,084	277	C,Q
20cca-1	do	1967	290	14	80	P	Qg	U	39	11-69	5,050	-	-
32bbc-1	do	1949	216	16	-	-	-	I	2	10-68	4,980	-	C
(C-38-13)													
9dcd-1	J. Prince	1952	154	10	28	P	-	I	31	10-68	5,500	193	L
16cad-1	do	1952	156	14	16	P	Qu	I	6	10-68	5,400	211	Q

Well No.	Owner or user	Year con-structed	Depth of well (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Well finish	Aquifer	Use of water	Water level: Below land-surface datum (feet)	Water level: Date of measure-ment	Altitude (feet)	Yield (gpm)	Other data available
						New Harmony Valley--Continued							
(C-38-13)													
22cbd-1	E. Wood	1947	190	14	-	P	Qg	U	2	10-68	5,240	700	-
23cca-1	L. Iverson	1946	130	12	36	P	Qg	I	36	10-68	5,200	75	-
						Pine Valley							
(C-39-15)													
14cbc-1	Pine Valley Irrigation Co.	1968	97	6	40	P	Qg	H	20	7-68	6,500	-	L
14ccb-1	B. Snow	-	20	36	20	O	Qu	H	11	10-68	6,500	-	C
14dad-1	P. McDermott	-	9	36	9	O	Qu	H	3	10-68	6,500	-	C
14dcc-2	E. Jacobsen	-	21	36	21	O	Qu	H	12	10-68	6,500	-	C
14dcd-1	M. Beckstrom	1967	100	6	38	P	Qu	H	25	4-67	6,500	25	C
15daa-1	L. Paxman	-	15	40	15	O	Qu	H	8	10-68	6,500	-	C
						St. George Valley							
(C-42-15)													
19cac-1	R. Prince	1960	100	8	11	X	Trk	I	40	8-60	3,040	-	C
29bbd-1	S. Prisbrey	1964	105	8	20	X	Trk	I	34	7-64	2,760	-	-
29cac-1	A. Iverson	1951	25	96	25	O	Qg	H	20	10-68	2,680	-	-
29ddc-1	P. Formaster	1966	300	16	200	P	Trc	U	50	11-66	2,640	-	-
30ada-1	W. Oliphant	1960	90	8	29	X	Trk	I	10	6-60	2,740	-	C
30adc-1	E. McArthur	1966	95	6	40	X	Trk	H	30	9-66	2,695	20	L
30bdb-1	W. Milne	1960	88	8	33	X	Trk	I	12	-	2,700	-	-
30caa-2	E. Blackburn	1959	36	10	23	X	Trk	I	6	6-59	2,680	-	C
30cbd-1	E. Stringham	1957	30	10	11	X	Trmo	I	8	9-57	2,660	-	C
30dac-3	S. Stucki	1959	60	10	12	X	Trc	I	13	6-59	2,670	-	-
30dbb-1	E. Spendlove	1965	80	8	47	X	Trc	U	13	8-68	2,675	-	-
30dcd-2	K. Empey	1961	25	8	20	O	Trc	I	7	10-68	2,645	-	C
31ccd-1	H. Hafen	-	100	6	-	-	Trc	S	7	10-68	2,560	-	-
32abc-1	R. Hazen	1958	53	10	17	P	Trc	U	4	10-68	2,630	-	-
32dba-1	R. McArthur	1969	145	8	23	P	Qu	S	20	8-69	2,600	-	-
32dcc-1	G. Cox	1966	72	10	20	P	-	N	6	2-68	2,580	-	L
33cab-1	P. Formaster	1964	259	16	27	X	Trcs	I	8	9-64	2,630	-	-
(C-42-16)													
24dbd-1	J. Callahan	1965	90	8	57	X	Trk	U	14	1-65	2,800	-	-
24ddd-1	C. Dean	1964	84	8	46	-	Trk	I	6	10-68	2,760	-	C
25aab-1	G. Johnson	1960	56	8	18	P	Qu	I	8	1-60	2,755	-	C
25dab-1	B. Leavitt	1958	50	12	25	P	Qu	I	8	9-58	2,700	-	C
(C-43-16)													
1ada-1	C. Blake	1956	53	16	28	P	Qu	U	9	8-68	2,580	240	H
1add-1	do	1956	53	16	34	P	Qu	U	8	8-68	2,560	440	-
						Santa Clara Bench							
(C-42-16)													
5bbb-1	W. Hafen	1963	110	16	36	X	Trc	I	23	5-67	3,080	55	C,L
5bbb-2	D. Hafen	1957	172	8	40	P	Trc	H	-	-	3,080	-	-
6ada-1	C. Mannering	1970	100	6	22	P	Trmo	H	9	2-70	3,040	7	-
13ccd-1	J and J Mill and Lumber Co.	1965	68	10	20	P	Qu	N	21	1-65	2,920	15	-
14daa-1	City of St. George	1964	500	8	27	X	Trk	I	78	1964	2,915	-	C,Q
22baa-1	R. Hafen	1963	100	16	62	P	Qu	I	55	2-63	2,760	465	Q
23abd-1	R. Hammer	1965	105	8	30	X	Trk	S	45	12-66	2,840	20	-
24bba-1	B. Thornton	1949	185	5	-	-	-	H	18	5-70	2,880	-	-
						Santa Clara River valley							
(C-40-17)													
21ddb-1	Town of Gunlock	1961	127	6	52	P	Qu	P	33	-	4,000	30	C
(C-42-16)													
16acc-1	Town of Santa Clara	1968	415	14	-	-	-	U	53	3-68	2,790	3	L
16bcc-1	St. George-Clara Field Canal Co.	1953	63	16	33	P	Qu	I	17	10-68	2,780	-	C,Q
16cab-1	do	1953	63	16	30	P	Qu	I	8	6-53	2,760	-	Q
16cab-2	H. Tobler	1967	76	10	26	P	Qu	I	21	2-67	2,760	-	Q
16dcb-1	St. George-Clara Field Canal Co.	1959	63	14	14	P	Qu	I	5	7-59	2,760	300	C,Q
17aac-1	New Santa Clara Field Canal Co.	1934	60	12	-	-	-	I	12	9-34	2,800	-	Q
17aba-1	do	1964	90	14	60	P	Qu	I	42	5-64	2,800	-	Q
17adb-2	Gates Service Station	1939	60	6	60	O	Qu	U	26	10-68	2,800	30	-
22cba-1	S. Frei	1946	92	16	18	P	Qu	I	23	7-46	2,730	-	Q
22dca-1	L. Frei	1966	88	14	30	P	Qu	I	28	3-66	2,700	-	C,Q
26bbc-1	Mathis Market Supply Co.	1966	70	14	32	P	Qu	U	28	3-66	2,655	-	-
26bcb-1	do	1963	72	14	28	P	Qu	I	25	5-63	2,660	-	Q
26bcc-1	W. Snow	1961	75	14	37	P	Qu	I	21	9-61	2,640	-	Q
26bcc-2	do	1961	78	14	35	P	Qu	I	21	9-61	2,660	-	Q
26cdd-1	R. Snow	1966	70	14	33	P	Qu	I	15	7-66	2,615	-	L,Q
27adb-1	Mathis Market Supply Co.	1964	75	14	28	F	Qu	I	20	3-64	2,680	-	Q
35adb-1	O. Gubler	1959	61	14	28	P	Qu	I	21	7-59	2,600	-	Q
35add-1	R. Barrett	1967	47	8	32	P	Qu	I	25	5-67	2,625	-	C
(C-43-16)													
1aca-1	C. Blake	1956	52	16	27	P	Qu	I	13	10-68	2,585	360	Q
1baa-1	do	1956	140	16	27	P	Qu	I	4	5-56	2,600	240	C,Q
						Triangle Valley							
(C-43-15)													
12bdd-1	K. Stucki	1965	497	16	95	P	Qu	U	78	10-65	2,770	200	L
12ccc-1	S. Stucki	1968	407	16	265	O	Trc	I	239	10-68	2,800	-	Q

Table 15.--Records of selected wells--Continued

Well No.	Owner or user	Year constructed	Depth of well (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Well finish	Aquifer	Use of water	Water level: Below land-surface datum (feet)	Water level: Date of measurement	Altitude (feet)	Yield (gpm)	Other data available
							Triangle Valley--Continued						
(C-43-15)													
12ccd-2	S. Stucki	1964	172	16	91	X	Trc	I	89	9-64	2,780	1,100	C,Q
							Virgin River valley						
(C-42-14)													
19add-1	N. Sullivan	1965	200	16	193	O	Qu	U	185	9-65	2,680	-	L
20abc-1	S. Sorensen	1963	205	6	165	-	Trm	S	115	8-63	2,720	4	C
20cac-1	L. Atkin	1967	53	6	30	P	-	U	31	1-67	2,720	-	-
20dbc-1	D. Iverson	1970	71	16	10	F	Qu	I	7	7-70	2,700	-	Q
21ccb-1	St. George-Washington Canal Co.	1963	80	16	35	-	Qu	U	16	7-63	2,760	-	C
(C-43-16)													
12aaa-1	W. Hackwell	1965	50	14	18	F	Qu	N	8	10-65	2,540	-	C
12adb-1	Bloomington	1969	107	-	-	-	Qg	I	30	-	2,520	2,700	C,Q
12ccb-1	Johnson Land Development	1956	105	14	60	O	Trcs	I	47	10-68	2,725	450	-
14bbb-1	do	-	-	10	-	-	Trm	U	58	11-68	2,560	-	-
22dab-1	E. Jones	1966	45	8	36	X	Qt	U	30	1-66	2,490	10	C
							Warner Valley						
(C-43-14)													
20abb-1	G. Thomas	1968	260	10	170	X	-	U	-	7-68	3,050	-	L
							Washington Valley						
(C-42-15)													
14dad-1	D. Nisson	1958	302	10	234	P	Trc	I	125	3-58	2,840	115	C,Q
21abd-1	F. Hawkes	1965	200	8	40	X	Trk	S	12	9-65	2,840	-	-
21bad-1	C. Holm	1965	200	8	38	X	Trk	U	21	9-65	2,860	20	-
22ccb-1	D. Bundy	1964	125	8	46	X	Trmo	H	19	9-64	2,720	-	C
33ddb-1	R. Shurtliff	1961	70	8	10	X	Trm	S	30	8-61	2,600	-	C
33ddd-1	Schmutz Bros.	1963	45	3	0	X	Trcs	S	40	1963	2,600	-	C
34dba-1	St. George East Stake	1968	104	6	88	X	(2/)	S	19	7-68	2,620	-	C
34dba-2	do	1968	265	16	21	X	Trcs	I	18	8-68	2,620	-	H,L,Q
35baa-1	C. Prisbrey	1967	45	5	18	F	Qu	H	18	1967	2,640	-	C
35dad-1	W. Staheli	1965	160	6	55	F	Qu	S	45	10-65	2,675	50	C
(C-43-15)													
2aaa-1	I. Andrus	1965	160	16	105	P	Qu	-	53	2-65	2,685	-	C,L,Q
							Other areas						
(C-40-13)													
27bdb-2	Anderson Ranch	1958	300	6	-	-	Qu	S	245	5-58	3,840	21	C
(C-40-15)													
27dba-1	City of St. George	1957	507	6	-	-	-	U	130	-	-	-	-
(C-41-13)													
12cbb-1	Town of La Verkin	1957	165	8	16	-	Trcs	U	35	5-57	3,200	-	C
(C-41-14)													
15ada-1	U.S. Bureau of Land Management	1963	65	6	30	F	JTrn	P	30	6-63	3,240	-	-
(C-41-17)													
7ada-1	City of St. George	1966	375	12	203	P	JTrn	P	203	2-66	3,600	-	-
7dca-1	do	1965	400	16	176	F	JTrn	P	178	3-65	3,580	1,200	C
8cca-1	do	1964	509	16	100	F	JTrn	P	100	7-68	3,480	700	C
8cdc-1	do	1970	500	14	-	X	JTrn	U	71	6-70	3,460	-	-
17cba-1	do	1965	626	16	9	F	JTrn	P	76	10-65	3,480	1,600	C
(C-42-14)													
4dbb-1	W. Post	1955	200	6	160	P	Trmo	H	123	9-68	3,140	-	-
(C-42-16)													
24aca-1	E. Earl	1965	134	8	20	X	Trk	I	40	10-65	2,870	-	C
(C-43-15)													
4dac-1	Milne and others	1966	190	8	45	X	Trm	U	98	3-66	2,730	40	C
9ada-1	K. Bentley	1969	145	18	-	X	Qu	S	21	11-69	2,660	-	-
10aca-1	St. George-Washington Canal Co.	1963	300	16	0	X	Trm	U	22	10-68	2,660	-	-
10acc-1	W. Seegmiller	1965	100	8	40	O	Trm	H	28	10-68	2,670	60	C

1/ Flowing.
2/ Consolidated alluvium and Shinarump Member of Chinle Formation.

Table 16.--**Records of selected springs and drains**

Location No.: See appendix for description of spring-numbering system.
Altitude: Above mean sea level interpolated from topographic maps.
Aquifer: Jc, Carmel Formation; Trk, Kayenta Formation; JTrn, Navajo Sandstone; Qb, basalt; Qu, unconsolidated rocks; Tc, Claron Formation; Trc, Chinle Formation; Trcs, Shinarump Member of Chinle Formation; Trmo, Moenave Formation; Tu, Tertiary sedimentary and igneous rocks undifferentiated.
Discharge: Measured unless indicated E, estimated, or R, reported. Total discharge for 1968 is given in Cordova, Sandberg, and McConkie (1970, table 7).
Total discharge 1970: Measured unless indicated E, estimated, or R, reported.
Use of water: H, domestic; I, irrigation; P, public supply; R, recreation; S, stock.
Other data available: C, chemical and temperature data in table 18.

Location No.	Name or owner	Altitude (ft)	Aquifer	Discharge (gpm)	Date measured	Total discharge 1970 (acre-ft)	Use of water	Other data available
			Ash Creek valley					
(C-40-13)35acd-S1	Upper Toquerville	3,440	Qb	(1/)	-	14,340	P	C
(C-41-13)11cad-S1	Lower Toquerville	3,200	Qb	2,700	Sept. 1968	5,018	P	C
			Diamond Valley					
(C-40-16)35dad-S1	Moore	-	Jc	10E	Oct. 1968	16E	S	C
			Hurricane Bench					
(C-42-14)2dab-S1	Unnamed spring	-	Qb	5E	Aug. 1968	8E	S	C
			Leeds area					
(C-41-13)7bca-S1	Unnamed spring	3,480	Trcs	47	May 1970	76	S	-
(C-41-14)1da-S1	Haven	3,700	-	10E	May 1970	16E	S	-
			New Harmony Valley					
(C-38-13)16bdb-S1	Town of New Harmony	5,520	Qu	-	-	1R	P	C
17bbd-S1	Comanche	5,800	-	240R	July 1968	400E	I	-
21acd-S1	Lawson	5,280	-	280R	May 1959	604	I	-
			Pine Valley					
(C-39-15)15dbc-S1	Snow and Gardner	6,600	Tu	10E	Oct. 1968	16E	H	C
15dcd-S1	B. Snow	6,600	Tu	10E	Oct. 1968	16E	H	C
24cac-S1	Spring Branch	6,600	-	940	July 1970	1,518	I	-
			St. George Valley					
(C-42-15)31dcc	Ditch	-	-	-	-	960	-	-
			Santa Clara Bench					
(C-41-16)34bda-S1	Snow	3,060	Qu	26	-	42R	P	C
(C-42-16)10adb-S1	Beecham	2,940	Trk	-	-	32	P	C[2,3]
11cbb-S1	Gray No. 1	2,920	Trk	-	-	(4/)	P	C[2,3]
11cbb-S2	Gray No. 2	2,920	Trk	-	-	(4/)	P	(3/)
11cbb-S3	Gray No. 3	2,920	Trk	-	-	(4/)	P	(3/)
11dba-S1	Big Miller	3,020	Qu	-	-	(4/)	P	C[2,3]
14bab-S1	Sheep	2,920	Trc	-	-	(4/)	P	(3/)
			Santa Clara River valley					
(C-39-16)11dcb-S1	Saucer C Ranch	5,200	Qb	900E	Dec. 1966	1,400E	I	C
28dbb-S1	Veyo Culinary Water Association	-	Qu	20E	Oct. 1968	54R	P	C
32cdc-S1	Warm	-	Qb	422	June 1970	680	I	-
(C-40-16)6cdb-S1	Veyo Warm	4,500	Qb	110	Oct. 1968	180E	I,R	C
(C-40-17)22bcd-S1	Town of Gunlock	-	Qu	12	-	16E	P	C
			Virgin River valley					
(C-42-14)1bcb-S1	Berry	2,860	Qb	33E	Sept. 1968	246	I	C
2cca-S1	Virgin River	2,760	Qb	100E	Oct. 1968	160E	I	C
			Warner Valley					
(C-42-14)32abb-S1	Warner Valley	2,920	Trmo	-	-	-	-	C
			Washington Valley					
(C-42-15)14bab-S1	Boggs	2,880	-	-	-	0.6E	I	-
14bab-S2	Gould	2,880	-	-	-	27	I	-
14bac-S1	C. Averett	2,860	-	-	-	4.5	I	-
14bbc-S1	Myers	2,840	JTrn	-	-	25	I	C
15ccd	Drain 175 + 00	-	-	-	-	28	-	-
15daa	Tanner drain	-	-	-	-	831	-	-
16ccd-S1	Middleton Right Branch	2,920	Trk	-	-	55	I	-

Table 16.--Records of selected springs and drains--Continued

Location No.	Name or owner	Altitude (ft)	Aquifer	Discharge (gpm)	Date measured	Total discharge 1970 (acre-ft)	Use of water	Other data available
				Washington Valley--Continued				
(C-42-15) 16ccd-S2	Middleton Left Branch	2,900	Trk	-	-	32	I	-
16cdc-S1	Middleton Domestic	2,940	Trk	-	-	35E	P	-
16ddd-S1	Moore	2,860	Trk	-	-	94E	I	-
23bab-S1	R. L. Gould	2,720	-	-	-	28	I	-
27ccc	Harder Ditch	-	-	-	-	3,400E	-	-
				Other areas				
(C-39-14) 20acd-S1	Pine Valley Recreation Area	-	-	30E	Oct. 1968	50E	P	C
(C-39-15) 15dd-S1	Forsythe and Pole Canyons	-	-	-	-	95	I	-
22ccd-S1	Lloyd	-	-	-	-	-	I	C
(C-39-16) 13abb-S1	Fleming Ranch	5,700	Tc	50E	Oct. 1968	226	I	C
13ddd-S1	Town of Central	-	-	8R	-	13R	P	C
14abd-S1	Saucer C Ranch	-	Tc	18	Aug. 1970	28	S	-
14dba-S1	Irvine	5,400	Tc	47	Oct. 1968	82	I	C
(C-40-14) 16dbc-S1	Town of Leeds	5,680	Qu	-	-	60E	I	C
(C-40-15) 4ddc-S1	Carter Canyon	7,300	-	-	-			
10acc-S1	Quaking Aspen	8,600	-	-	-			
10bbb-S1	Slide Canyon	7,500	-	-	-			
10cbd-S1	Big Pine	7,800	-	-	-			
14bab-S1	Cottonwood	7,800	-	-	-			
14bdb-S1	Middle	7,000	-	-	-	1,600E	P	([5])
15ccb-S1	West Fork	-	-	-	-			
22dda-S1	Cougar	6,000	-	-	-			
23bbc-S1	Lower No. 1	6,300	-	-	-			
23bbc-S2	Lower No. 2	-	-	-	-			
23bcb-S1	East Fork	6,400	-	-	-			
(C-41-18) 2ddd-S1	Pahcoon	3,760	Trmo	2	June 1970	3.7	-	C
(C-42-14) 5aba-S1	Harrisburg	3,120	-	-	-	3.4	S	-
5bcc-S1	Seegmiller	3,160	-	5	July 1970	11	S	-
6cca-S1	Grapevine No. 1	3,120	Trk	19	July 1970	31	S	-
6cca-S2	Grapevine No. 2	3,120	Trk	7	July 1970	17	S	-
7bbb-S1	Ash Tree	3,040	-	5	Sept. 1968	112	-	-
15dbc-S1	Sand Mountain	2,880	JTrn	2	Sept. 1968	3E	S	-
21cad-S1	Carpenter	2,720	Trmo	-	-	300E	I	-
(C-42-15) 10a-S1	Mill Creek	2,960	JTrn	-	-	[6]2,016	I	-
11caa-S1	Price	2,960	-	-	-	25	I	-
11cad-S2	Middle City	2,960	-	-	-	3E	I	-
11cad-S3	South City	2,960	-	-	-	1E	I	-
11cda-S1	Paxman	2,940	-	9	July 1970	15	S	-
11cda-S2	Prisbrey	2,940	-	-	-	([7])	S	-
11dca-S1	Westover	2,980	Trk	-	-	46	P	C[8]
11dcb-S1	Main Domestic	2,960	Trk	-	-	91	P	C[8]
11dcd-S1	Sproul	2,920	Trk	-	-	120E	P	C[8]
11dcd-S2	Pierce	2,920	Trk	-	-	60E	P	C[8]
12aaa	Drain 350 + 25	-	-	-	-	.07E	-	-
12aaa	Drain 355 + 40	-	-	-	-	5	-	-
12aac	New Highway Drain 341 + 00	-	-	-	-	2	-	-
12aac	Drain 343 + 70	-	-	-	-	.8E	-	-
12aca	Drain 330 + 50	-	-	-	-	2.4	-	-
12bab-S1	West Upper Jumpoff	3,200	Trk	-	-	.1	-	-
12cca-S1	East Kelly	3,000	Trk	-	-	6.6	-	-
12ccb-S1	Kelly	3,000	Trk	-	-	.3	-	-
12ccb-S2	Sanders	3,000	Trk	-	-	8.7	-	-
12cdb-S1	East Blackham	2,960	Trk	-	-	.3	-	-
12dbc-S1	Red Rock	3,000	-	1	Sept. 1970	.8	S	-
13bbb-S1	Bastian No. 1	2,920	-	-	-	173	-	-
14aab-S1	D. Nisson	2,920	Trk	-	-	.9	-	-
14aba-S1	Pierce	2,920	-	-	-	([9])	P	C[8]
14adb-S1	Caldwell	2,880	Trc	-	-	66	I	-
14bbb-S1	Warm	2,880	JTrn	-	Oct. 1968	752	I	C
14bda-S1	C. Hall	2,860	Trmo	12	July 1970	26	I	-
14caa-S1	Adair	2,840	Trc	-	-	159	I	-
14dab-S1	Sullivan	3,000	-	7	July 1970	5.8	S	-
15bba-S1	Green	2,900	JTrn	200E	Oct. 1968	1,399	I	C
15bbd-S1	Hall	2,900	JTrn	-	-	69	I	-
15cab-S1	E. Neilson	2,860	-	2	July 1970	3.3	-	-
16cdb-S1	G. Blake	3,000	Trk	-	-	33	I	-
20cad-S1	East St. George	2,920	Trk	184	Dec. 1968	304	I	C

Table 16.--Records of selected springs and drains--Continued

Location No.	Name or owner	Altitude (ft)	Aquifer	Discharge (gpm)	Date measured	Total discharge 1970 (acre-ft)	Use of water	Other data available
			Other areas--Continued					
(C-42-16)13dcc-S1	West St. George	2,960	JTrn	900	Feb. 1970	1,370	I	-
24aac-S1	C. Mannering	3,100	Trk	4R	-	6.4	S	-
24aac-S2	R. Sheffield No. 1	3,100	Trk	2R	-	3.2	S	-
24aac-S3	R. Sheffield No. 2	3,100	Trk	4R	-	6.4	S	-
24aca-S1	Evan Earl No. 1	2,900	Trk	1E	Aug. 1970	5	S	-
24aca-S2	Evan Earl No. 2	2,900	Trk	1E	Aug. 1970	(10/)	S	-
24aca-S3	Bentley	2,900	Trk	1E	Aug. 1970	(10/)	S	-
24add-S1	Unnamed spring	2,960	Trk	-	-	20	I	-

1/ See table 8.
2/ Chemical analysis in table 18 is of a mixed water, which includes water from this spring.
3/ Santa Clara public supply.
4/ Included in (C-42-16)10adb-S1.
5/ St. George public supply.
6/ Total springflow to Washington (1,775 acre-ft) and to St. George (241 acre-ft).
7/ Included in (C-42-15)11caa-S1.
8/ Washington public supply. Chemical analysis in table 18 is of a mixed water, which includes water from this spring.
9/ Included in (C-42-15)11dcd-S2.
10/ Included in (C-42-16)24aca-S1.

Table 17.--Selected drillers' logs of wells

Altitudes are in feet above mean sea level for land surface at the well, estimated from topographic maps.
Thickness in feet.
Depth in feet below land surface.
Geologic designations by R. M. Cordova.

FORT PIERCE WASH

Material	Thickness	Depth
(C-43-15)25ddd-1. Log by Floyd Hastings. Alt. 2,795 ft.		
Channel-fill deposits:		
Clay and sand.	17	17
Gravel	6	23
Gravel and boulders.	20	43
Hardpan.	3	46
Gravel and conglomerate; water	98	144

GRASS VALLEY

Material	Thickness	Depth
(C-38-14)31bda-1. Log by Floyd Hastings. Alt. 6,960 ft.		
Unconsolidated rocks:		
Silt and sand.	16	16
Clay and sand.	9	25
Clay, yellow	17	42
Sand, gravel; granite composition	10	52
Clay, sand, and gravel	34	86
Clay	4	90
Clay and gravel.	16	106
Hardpan; sand and gravel at 115 ft.	9	115
Sand and gravel; tight	12	127
Clay and gravel; hardpan . . .	73	200

NEW HARMONY VALLEY

Material	Thickness	Depth
(C-37-12)23cbd-2. Log by Grimshaw Drilling Co. Alt. 5,500 ft.		
Alluvial-fan deposits:		
Soil	19	19
Gravel	5	24
Clay and sand.	89	113
Gravel	2	115
Clay and sand.	45	160
Gravel	1	161
Clay and sand.	74	235
Gravel	2	237
Clay and sand.	78	315
Gravel	2	317
Clay and sand.	13	330
Gravel	15	345
Clay and sand.	19	364
Gravel	117	481
Clay and sand.	14	495
Gravel	66	561
(C-38-13)9dcd-1. Log by H. Wilson and F. Hastings. Alt. 5,500 ft.		
Alluvial-fan deposits:		
Gravel	62	62
Clay and rock.	4	66
Gravel and rock.	4	70
Solid rock	2	72
Gravel	10	82
Clay	6	88
Clay and gravel.	12	100
Gravel	54	154

PINE VALLEY

Material	Thickness	Depth
(C-39-15)14cbc-1. Log by Tim Ballard. Alt. 6,590 ft.		
Unconsolidated rocks:		
Clay and sand	10	10
Clay and gravel	40	50
Clay.	25	75
Clay and gravel	15	90
Gravel.	5	95
Clay.	2	97

ST. GEORGE VALLEY

Material	Thickness	Depth
(C-42-15)30adc-1. Log by Tim Ballard. Alt. 2,695 ft.		
Unconsolidated rocks:		
Soil.	10	10
Clay and sand	30	40
Kayenta(?) Formation:		
Shale, red.	55	95
(C-42-15)32dcc-1. Log by Tim Ballard. Alt. 2,580 ft.		
Unconsolidated rocks:		
Clay.	7	7
Sand.	9	16
Sand and gravel	9	25
Sand and gravel, cobbles. . . .	20	45
Sand and gravel	10	55
Chinle Formation:		
Shale, red.	17	72

SANTA CLARA BENCH

Material	Thickness	Depth
(C-42-16)5bbb-1. Log by Floyd Hastings. Alt. 3,080 ft.		
Unconsolidated rocks:		
Clay and sand	17	17
Chinle Formation:		
Shale, sticky	23	40
Shale, red, hard; water	21	61
Shale, red, sticky.	49	110

SANTA CLARA RIVER VALLEY

Material	Thickness	Depth
(C-42-16)16acc-1. Log by Preston C. Bradshaw. Alt. 2,790 ft.		
Channel-fill deposit:		
Sand and gravel	16	16
Chinle Formation:		
Shale, gray, red, and blue. . .	137	153
Sandstone, shale.	12	165
Shale, red and gray	40	205
Sandstone, gray and white . . .	18	223
Shale, sandy, gray.	2	225
Shale, red and gray	85	310
Shinarump Member of Chinle Formation:		
Sandstone, gray, hard	70	380
Sandstone, gray and white . . .	35	415
(C-42-16)26cdd-1. Log by Tim Ballard. Alt. 2,615 ft.		
Channel-fill deposits:		
Soil.	3	3
Sand.	12	15
Clay and sand	18	33
Sand and gravel	10	43
Gravel.	22	65
Chinle Formation:		
Clay, red (weathered shale) . .	5	70

TRIANGLE VALLEY

Material	Thickness	Depth
(C-43-16)12bdd-1. Log by Tim Ballard. Alt. 2,770 ft.		
Unconsolidated rocks:		
Sand	70	70
Sand and gravel.	8	78
Sand	12	90
Gravel	5	95
Sand	7	102
Gravel	23	125
Sand	15	140
Gravel	10	150
Sand	25	175
Gravel	21	196
Silt and gravel.	4	200
Chinle Formation:		
Shale, red	297	497

VIRGIN RIVER VALLEY

Material	Thickness	Depth
(C-42-14)19add-1. Log by Tim Ballard. Alt. 2,680 ft.		
Channel-fill deposits:		
Sand and gravel.	10	10
Gravel and boulders.	33	43
Clay and gravel.	72	115
Clay	17	132
Gravel	68	200

WARNER VALLEY

Material	Thickness	Depth
(C-43-14)20abb-1. Log by Tim Ballard. Alt. 3,050 ft.		
Unconsolidated rocks:		
Sand, red.	50	50
Chinle Formation:		
Shale, alternating red and gray zones.	170	220
Shale, red, sandy.	35	255
Shale, white	5	260

WASHINGTON VALLEY

Material	Thickness	Depth
(C-42-15)34dba-2. Log by Preston C. Bradshaw. Alt. 2,620 ft.		
Unconsolidated rocks:		
Gravel	18	18
Gravel, cemented	57	75
Chinle Formation:		
Shale, red	22	97
Sandrock, gray, white, and yellow (Shinarump Member) . .	161	258
Moenkopi Formation:		
Shale, red	7	265
(C-43-15)2aaa-1. Log by Tim Ballard. Alt. 2,685 ft.		
Unconsolidated rocks:		
Clay and sand.	55	55
Sand and very fine gravel. . .	5	60
Clay and sand.	14	74
Gravel, fine	2	76
Sand	9	85
Sand and fine gravel	23	108
Gravel	52	160

Table 18.--Chemical analyses and temperature

Location No.: See appendix for description of well- and spring-numbering system.
Aquifer: Jc, Carmel Formation; Trk, Kayenta Formation; JTrn, Navajo Sandstone; Pka, Kaibab Limestone; Qb, basalt; Qg, sand or gravel; Qt, unconsolidated terrace deposits; Qu, unconsolidated rocks undifferentiated; Tc, Claron Formation; Trc, Chinle Formation; Trcs, Shinarump Member of Chinle Formation; Trm, Moenkopi Formation; Trmo, Moenave Formation; Tu, Tertiary sedimentary and igneous rocks undifferentiated.
Dissolved solids: Determined values by the U.S. Geological Survey are residue on evaporation at 180°C; by the Utah State Department of Health are at 110°C; and by the U.S. Bureau of Reclamation and the Ford Chemical Laboratory are at 105°C.
Agency making analysis: BR, U.S. Bureau of Reclamation; FC, Ford Chemical Laboratory, Inc., Salt Lake City, Utah; GS, U.S. Geological Survey; SH, Utah State Department of Health.

				Milligrams								
Location No.	Date of collection	Aquifer	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sodium plus potassium (Na+K)	Bicarbonate (HCO_3)	Carbonate (CO_3)
WELLS												
Ash Creek												
(C-40-13)2daa-1	2-20-64	Qb	-	44	0.03	64	27	16	2.6	-	224	1
2daa-1	10-29-68	Qb	18.0	-	-	-	-	-	-	-	-	-
23aba-1	1-15-64	Pka	-	24	.11	126	32	16	2.8	-	217	1
Diamond												
(C-40-16)35dcc-1	10-16-68	Jc	18.0	-	-	-	-	-	-	-	-	-
Fort Pierce												
(C-43-15)16dcc-1	2-18-70	Qg	19.5	-	-	-	-	-	-	-	-	-
16dcc-1	2-24-70	Qg	19.5	-	-	593	141	-	-	17	136	0
25ddd-1	8-22-68	Qu	19.0	14	-	573	153	-	-	213	90	0
Hurricane												
(C-42-13)7ccc-1	[1]11-23-65	JTrn	-	-	-	17	38	7.4	1.6	-	119	0
(C-42-14)11abd-1	7-27-66	Qt	-	-	-	136	53	50	6.2	-	171	0
12dcc-1	9-11-68	JTrn	20.0	-	-	-	-	-	-	-	-	-
15cba-1	9-12-68	Trmo	20.0	-	-	-	-	-	-	-	-	-
(C-43-13)5bdd-1	3-16-66	JTrn	-	-	-	41	16	5.1	1.6	-	131	6
Leeds												
(C-41-13)4bab-1	10-30-68	JTrn	18.0	26	-	35	24	-	-	10	232	0
5dbb-1	10-30-68	JTrn	18.0	-	-	-	-	-	-	-	-	-
7ccb-1	5- 5-70	Qu	13.5	45	-	68	65	16	2.1	-	522	0
16bcd-1	3-25-70	-	21.5	24	-	96	60	103	4.5	-	250	0
New Harmony												
(C-37-12)23cbd-2	8-30-68	Qg	15.5	21	-	57	36	18	1.4	-	216	0
(C-38-12)20bba-1	9-11-56	Qg	12.5	-	-	-	-	39	-	-	246	0
20bba-1	8- 9-60	Qg	13.5	20	0	246	88	39	3.2	-	242	0
20bba-1	7-17-68	Qg	13.0	-	-	-	-	-	-	-	248	0
20bcc-1	6- 8-64	Qg	13.0	19	-	269	97	-	-	86	270	0
20bcc-1	7-25-68	Qg	15.0	18	-	253	114	-	-	60	264	0
32bbc-1	7-14-64	Qg	-	15	-	226	67	-	-	65	243	0
Pine												
(C-39-15)14ccb-1	10-23-68	Qu	11.0	-	-	-	-	-	-	-	-	-
14dad-1	10-23-68	Qu	6.0	-	-	-	-	-	-	-	-	-
14dcc-2	10-23-68	Qu	11.0	34	-	23	11	-	-	3.0	114	0
14dcd-1	10-23-68	Qu	9.0	24	-	27	7.1	-	-	9.8	124	0
15daa-1	10-24-68	Qu	14.0	-	-	-	-	-	-	-	-	-
St. George												
(C-42-15)19cac-1	10-11-68	Trk	18.0	19	-	160	63	-	-	206	404	0
30ada-1	10-15-68	Trk	-	22	-	72	51	-	-	109	210	0
30caa-2	10-16-68	Trk	20.0	-	-	-	-	-	-	-	-	-
30cbd-1	10-15-68	Trmo	22.0	96	-	521	195	-	-	402	388	0
30dcd-2	10-15-68	Trc	22.0	82	-	369	148	-	-	562	320	0
(C-42-16)24ddd-1	10-11-68	Trk	18.0	-	-	-	-	-	-	-	-	-
25aab-1	10-18-68	Qu	20.0	-	-	-	-	-	-	-	-	-
25dab-1	10-18-68	Qu	19.0	-	-	-	-	-	-	-	-	-

per liter												
Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Determined	Dissolved solids: Calculated	Hardness (Ca,Mg)	Noncarbonate hardness	Specific conductance (micromhos/cm at 25°C)	pH	Sodium-adsorption ratio	Agency making analysis
Valley												
109	16	0.1	1.1	0	406	-	270	85	540	-	0.4	SH
-	18	-	-	-	-	-	-	-	635	-	-	GS
257	18	.5	.2	.08	633	-	443	265	820	-	.3	SH
Valley												
-	8.0	-	-	-	-	-	-	-	363	-	-	GS
Wash												
-	90	-	-	-	-	-	2,140	-	3,320	-	-	GS
1,760	68	-	72	-	3,200	2,720	2,060	1,950	3,100	7.6	0.2	GS
2,140	100	-	99	-	3,450	3,340	2,060	1,980	3,360	7.4	2.0	GS
Bench												
52	36	1.3	3.7	0.05	215	-	200	102	570	7.6	0.2	BR
451	51	.6	-	.30	832	-	557	417	1,190	8.0	.9	BR
-	27	-	-	-	-	-	-	-	383	-	-	GS
-	35	-	-	-	-	-	-	-	1,500	-	-	GS
23	27	.3	-	.36	229	-	167	50	502	8.3	.2	BR
area												
9.2	8.1	-	0.8	0.02	227	227	188	0	372	8.0	0.3	GS
-	14	-	-	-	-	-	-	-	418	-	-	GS
14	10	0.4	1.0	.03	497	479	436	8	795	7.9	.3	GS
375	74	.7	1.7	.56	998	862	488	283	1,270	8.0	2.0	FC
Valley												
138	9.0	0.2	1.7	0.05	406	388	288	111	595	7.5	0.5	GS
804	29	-	-	.14	-	-	992	790	1,670	7.2	.5	GS
811	26	.1	5.5	.14	1,430	1,360	975	777	1,680	7.5	.5	GS
-	22	-	-	-	-	-	970	767	1,630	7.3	-	GS
914	58	-	3.1	-	1,590	1,580	1,070	849	1,800	7.4	1.1	GS
925	32	-	7.2	-	1,610	1,540	1,100	884	1,840	7.5	.8	GS
714	27	-	2.1	-	1,250	1,240	840	441	1,510	7.5	1.0	GS
Valley												
-	9.0	-	-	-	-	-	-	-	334	-	-	GS
-	2.6	-	-	-	-	-	-	-	177	-	-	GS
7.5	2.2	-	5.3	0.06	144	142	102	9	207	7.3	0.1	GS
4.5	4.2	-	7.6	.03	150	145	97	0	221	7.2	.4	GS
-	4.1	-	-	-	-	-	-	-	300	-	-	GS
Valley												
660	60	-	7.7	0.62	1,410	1,380	660	329	1,850	7.8	3.5	GS
368	50	-	.3	.37	902	776	388	216	1,250	7.9	2.4	GS
-	100	-	-	-	-	-	-	-	3,990	-	-	GS
2,320	125	-	79	1.30	4,030	3,930	2,100	1,780	4,110	7.8	3.8	GS
2,150	150	-	49	2.00	3,740	3,670	1,530	1,270	4,090	7.6	6.2	GS
-	115	-	-	-	-	-	-	-	3,430	-	-	GS
-	50	-	-	-	-	-	-	-	1,520	-	-	GS
-	80	-	-	-	-	-	-	-	2,550	-	-	GS

Location No.	Date of collection	Aquifer	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sodium plus potassium (Na+K)	Bicarbonate (HCO_3)	Carbonate (CO_3)
				Milligrams								
SPRINGS												
Pine												
(C-39-15)15dbc-S1	10-23-68	Tn	11.0	-	-	-	-	-	-	-	-	-
15dcd-S1	10-23-68	Tn	8.0	-	-	-	-	-	-	-	-	-
Santa Clara												
(C-41-16)34bda-S1	5-15-64	Qu	-	14	0.02	37	13	13	3.8	-	121	0
34bda-S1	8-28-68	Qu	21.0		-	-	-	-	-	-	-	-
(C-42-16)10-S4/	2- 2-62	Trk	-	13	.01	55	17	65	7.7	-	162	0
Santa Clara												
(C-39-16)11dcb-S1	12-10-66	Qb	15.0	31	-	32	11	10	1.7	-	160	0
28dbb-S1	4-20-60	Qu	-	28	0.07	55	12	21	1.6	-	198	0
28dbb-S1	10-25-68	Qu	17.0	-	-	-	-	-	-	-	-	-
(C-40-16)6cdb-S1	3-30-66	Qb	32.0	30	-	59	29	32	4.4	-	220	0
6cdb-S1	4-20-67	Qb	32.0	32	-	53	28	32	3.6	-	230	0
6cdb-S1	4-20-67	Qb	32.0	32	-	35	25	30	3.5	-	164	0
(C-40-17)22bcd-S1	6-22-68	Qu	-	19	.04	58	23	20	4.0	-	200	0
Virgin River												
(C-42-14)1bcb-S1	10- 7-65	Qb	23.5	-	-	200	72	80	9.8	-	182	-
2cca-S1	10-10-68	Qb	21.0	-	-	-	-	-	-	-	-	-
Warner												
(C-42-14)32abb-S1	11- 4-65	Trmo	21.0	-	-	424	175	363	9.8	-	92	0
Washington												
(C-42-15)14bbc-S1	10-16-68	JTrn	20.0	19	-	63	35	-	-	16	220	0
Other												
(C-39-14)20acd-S1	10-24-68	-	8.0	-	-	-	-	-	-	-	-	-
22ccd-S1	2-18-67	-	-	20	0.05	15	9.0	5.0	0.0	-	81	1
(C-39-16)13abb-S1	10-22-68	Tc	15.0	-	-	-	-	-	-	-	-	-
13ddd-S1	5-15-64	-	-	41	.01	66	15	16	1.8	-	268	1
13ddd-S1	10-22-68	-	14.0	-	-	-	-	-	-	-	-	-
14dba-S1	10-22-68	Tc	21.0	26	-	51	16	-	-	13	222	0
(C-40-14)16dbc-S1	2-20-64	Qu	-	2.8	.34	32	7.0	4.0	.5	-	146	-
16dbc-S1	10-30-68	Qu	11.0	-	-	-	-	-	-	-	-	-
(C-41-18)2ddd-S1	8-16-65	Trmo	-	-	-	64	24	25	2.0	-	222	-
(C-42-15)11d-S15/	3-10-64	Trk	-	16	.06	57	24	.0	2.3	-	199	0
14bbb-S1	7-14-62	JTrn	-	12	.06	62	22	8.6	4.7	-	186	0
14bbb-S1	10-16-68	JTrn	24.0	-	-	-	-	-	-	-	-	-
15bba-S1	3-30-66	JTrn	23.5	-	-	100	22	283	25	-	206	4
15bba-S1	10-16-68	JTrn	21.0	-	-	-	-	-	-	-	-	-
20cad-S1	5- 1-66	Trk	-	-	-	60	40	169	16	-	201	-

1/ Date of analysis.
2/ Date water sample received by laboratory.
3/ Consolidated alluvium and Shinarump Member of Chinle Formation.
4/ Sample includes water from springs (C-42-16)10adb-S1, (C-42-16)11cbb-S1, and (C-42-16)11dba-S1.
5/ Sample includes water from springs (C-42-15)11dca-S1, (C-42-15)11dcb-S1, (C-42-15)11dcd-S1, (C-42-15)11dcd-S2, and (C-42-15)14aba-S1.

of water from selected wells and springs--Continued

per liter												
Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids Determined	Dissolved solids Calculated	Hardness (Ca,Mg)	Noncarbonate hardness	Specific conductance (micromhos/cm at 25°C)	pH	Sodium-adsorption ratio	Agency making analysis
Continued												
Valley												
-	5.0	-	-	-	-	-	-	-	223	-	-	GS
-	5.0	-	-	-	-	-	-	-	282	-	-	GS
Bench												
45	15	0.6	1.4	0.16	226	-	146	47	345	7.8	0.5	SH
-	13	-	-	-	-	-	-	-	360	-	-	GS
179	11	1.3	1.1	.21	470	-	207	194	704	7.8	2.0	SH
River valley												
9.7	8.0	0.3	0.8	0.04	189	184	126	0	280	7.7	0.4	GS
15	21	.2	2.4	.12	280	-	187	25	439	8.0	.7	SH
-	19	-	-	-	-	-	-	-	435	-	-	GS
100	30	.6	8.3	.14	409	402	264	84	640	7.9	.9	GS
90	30	.7	6.9	.14	390	389	248	59	600	7.6	.9	GS
64	30	.7	9.2	.11	334	311	190	56	515	8.1	.9	GS
88	30	.4	.1	.27	326	-	240	76	630	7.4	.6	SH
valley												
667	64	0.8	-	0.45	1,180	-	795	646	1,640	8.0	1.2	BR
-	67	-	-	-	-	-	-	-	1,520	-	-	GS
Valley												
2,310	71	2.5	1.6	0.98	3,400	-	1,780	1,700	3,610	7.9	3.8	BR
Valley												
101	29	-	9.4	.10	435	380	300	120	673	8.0	.4	GS
areas												
-	2.2	-	-	-	-	-	-	-	159	-	-	GS
4.0	10	0.1	0.4	0	94	-	72	4	145	-	0.3	SH
-	7.5	-	-	-	-	-	-	-	311	-	-	GS
7.0	19	.2	.0	.04	310	-	226	5	425	-	.5	SH
-	16	-	-	-	-	-	-	-	480	-	-	GS
17	14	-	1.0	.04	246	247	193	11	405	7.6	.4	GS
4.0	4.0	.0	.0	0	169	-	108	0	225	7.7	.2	SH
-	1.7	-	-	-	-	-	-	-	223	-	-	GS
67	43	.5	-	.22	334	-	260	78	620	7.4	.9	BR
61	11	.3	1.1	.16	327	-	240	78	515	8.0	.0	SH
95	10	.3	3.2	.06	328	-	243	91	516	7.9	.2	SH
-	8.0	-	-	-	-	-	-	-	487	-	-	GS
415	285	1.6	-	.80	1,240	-	340	163	2,010	-	6.7	BR
-	295	-	-	-	-	-	-	-	2,010	-	-	GS
456	48	1.9	-	.45	889	-	314	149	1,320	8.2	4.1	BR

Table 18.--Chemical analyses and temperature

Location No.	Date of collection	Aquifer	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sodium plus potassium (Na+K)	Bicarbonate (HCO_3)	Carbonate (CO_3)
				Milligrams								
WELLS												
Santa Clara												
(C-42-16) [illegible]-1	10-31-68	Tr[illegible]	18.0	34	-	501	292	-	[illegible]	257	272	0
14daa-1	2/4-12-66	Trk	-	32	0.01	373	92	182	10	-	272	0
Santa Clara												
(C-40-17)21ddb-1	6-15-62	Qu	-	25	0.03	82	17	28	4.1	-	270	1
(C-42-16)16bcc-1	5-15-63	Qu	15.5	12	-	194	45	-	-	36	438	0
16dcb-1	10-17-68	Qu	17.0	-	-	-	-	-	-	-	-	-
22dca-1	5-19-67	Qu	16.5	33	-	204	83	148	5.0	-	352	0
22dca-1	6-28-68	Qu	17.0	35	-	214	79	-	-	194	494	0
22dca-1	6- 5-70	Qu	15.0	-	-	-	-	-	-	-	-	-
35add-1	10-17-68	Qu	18.0	29	-	248	63	-	--	89	564	0
(C-43-16)1baa-1	8-20-68	Qu	16.0	37	-	345	185	-	-	222	450	0
Triangle												
(C-43-15)12ccd-2	5-19-67	Trm	16.5	17	-	409	207	143	10	-	96	0
12ccd-2	8-22-68	Trm	19.0	18	-	417	209	-	-	196	100	0
Virgin River												
(C-42-14)20abc-1	10-20-65	Trm	-	-	-	144	41	295	18	-	278	0
21ccb-1	10- 4-65	Qu	-	-	-	141	93	166	14	-	189	-
(C-43-16)12aaa-1	10- 9-68	Qu	-	-	-	-	-	-	-	-	-	-
12adb-1	2/7-22-69	Qg	-	-	0.53	244	168	233	48	-	280	0
22dab-1	10- 8-68	Qt	21.0	17	-	581	365	-	-	1,110	296	0
Washington												
(C-42-15)14dad-1	8-22-68	Trc	20.0	13	-	92	81	-	-	204	366	0
22ccb-1	10-10-68	Trmo	-	20	-	84	45	-	-	140	216	0
33ddb-1	10-15-68	Trm	-	-	-	-	-	-	-	-	-	-
33ddd-1	10-15-68	Trcs	21.0	22	-	597	255	-	-	790	384	0
34dba-1	10-18-68	(3/)	17.0	25	-	501	292	-	-	548	392	0
35baa-1	10-15-68	Qu	18.0	-	-	-	-	-	-	-	-	-
35dad-1	10-15-68	Qu	-	-	-	-	-	-	-	-	-	-
(C-43-15)2aaa-1	8-22-68	Qu	19.0	17	-	467	198	-	-	141	120	0
Other												
(C-40-13)27bdb-2	10-29-68	Qu	21.0	28	-	58	23	-	-	8.0	228	0
(C-41-13)12cbb-1	5-21-57	Trcs	-	10	7.60	300	258	-	-	58	385	0
(C-41-17)7dca-1	3-29-65	JTrn	-	18	.19	109	27	13	2.7	-	245	0
8cca-1	5- 5-65	JTrn	17.0	19	.05	66	14	6.0	.6	-	233	3
17cba-1	12- 2-66	JTrn	-	16	.03	57	16	38	4.0	-	244	0
(C-42-16)24aca-1	10-18-68	Trk	21.0	-	-	-	-	-	-	-	-	-
(C-43-15)4dac-1	3-16-66	Trm	-	-	-	676	484	471	12	-	207	0
10acc-1	10-18-68	Trm	20.5	22	-	581	219	-	-	344	240	0
SPRINGS												
Ash Creek												
(C-40-13)35acd-S1	10-25-68	Qb	17.0	36	-	78	32	-	-	22	220	0
35acd-S1	2-27-70	Qb	16.5	-	-	-	-	-	-	-	-	-
(C-41-13)11cad-S1	10-28-68	Qb	17.0	36	-	84	43	-	-	27	274	0
Diamond												
(C-40-16)35dad-S1	10-16-68	Jc	19.0	-	-	-	-	-	-	-	-	-
Hurricane												
(C-42-14)2dab-S1	8-20-68	Qb	21.0	24	-	172	90	-	-	24	188	0
New Harmony												
(C-38-13)16bdb-S1	3-16-66	Qu	-	57	0.03	40	12	8.9	2.5	-	180	1

of water from selected wells and springs--Continued

per liter									Specific conductance (micromhos/cm at 25°C)	pH	Sodium-adsorption ratio	Agency making analysis
Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Determined	Dissolved solids: Calculated	Hardness (Ca,Mg)	Noncarbonate hardness				
Continued												
Bench												
2,530	90	-	31	1.30	4,070	3,870	2,450	2,230	3,870	7.8	2.3	GS
1,390	60	0.2	1.7	.46	2,450	-	1,310	1,150	2,280	7.4	2.2	SH
River valley												
51	33	0.6	1.2	0.22	412	-	275	54	671	-	0.7	SH
308	48	-	.5	-	904	858	670	311	1,240	7.6	.6	GS
-	55	-	-	-	-	-	-	-	1,420	-	-	GS
706	92	1.1	25	-	1,530	1,470	852	563	1,920	7.7	2.2	GS
692	90	-	34	-	1,590	1,580	858	453	1,920	8.0	2.9	GS
635	-	-	-	-	-	-	830	-	1,780	-	-	GS
508	58	-	.6	.24	1,310	1,270	880	418	1,680	7.8	1.3	GS
1,450	158	-	1.1	-	2,620	2,620	1,620	1,250	2,950	7.9	2.4	GS
Valley												
1,930	52	1.8	7.0	-	3,100	2,820	1,870	1,790	3,090	7.3	1.4	GS
2,050	72	-	12	-	3,060	3,020	1,900	1,820	3,080	7.8	2.0	GS
valley												
432	326	1.5	5.2	0.63	1,400	-	531	303	2,080	7.2	5.6	BR
814	78	1.6	-	.98	1,400	-	734	579	1,800	8.0	2.6	BR
-	600	-	-	-	-	-	-	-	4,370	-	-	GS
170	580	-	-	-	2,900	-	1,290	-	4,520	7.8	-	FC
2,790	1,560	-	15	1.60	6,860	6,590	2,950	2,710	8,190	7.8	8.9	GS
Valley												
616	47	-	0.1	-	1,180	1,230	565	265	1,610	8.2	3.7	GS
303	146	-	.6	.25	958	845	396	219	1,430	7.9	3.0	GS
-	535	-	-	-	-	-	-	-	3,350	-	-	GS
2,230	1,120	-	51	1.30	5,460	5,260	2,540	2,230	6,490	7.6	6.8	GS
2,100	788	-	29	.86	4,590	4,480	2,450	2,730	5,400	7.7	4.8	GS
-	620	-	-	-	-	-	-	-	4,790	-	-	GS
-	620	-	-	-	-	-	-	-	5,240	-	-	GS
1,900	100	-	87	-	3,200	2,970	1,980	1,880	3,150	7.3	1.4	GS
areas												
18	33	-	6.8	0.03	295	287	240	53	484	7.9	0.2	GS
1,510	22	7.5	3.3	-	2,390	2,370	1,810	1,490	-	7.2	.5	SH
166	23	.3	4.7	.19	511	-	382	181	660	7.3	.3	SH
20	20	.3	.5	.20	283	-	221	25	455	8.4	.2	SH
31	20	.4	.2	-	286	-	207	7	470	7.5	1.1	SH
-	110	-	-	-	-	-	-	-	3,630	-	-	GS
3,630	571	3.2	-	1.82	5,960	-	3,680	3,510	6,690	7.9	3.4	GS
2,050	512	-	56	.45	4,080	3,900	1,350	2,150	4,520	7.7	3.1	GS
valley												
159	18	-	3.1	0.06	474	456	326	146	682	7.7	0.5	GS
-	20	-	-	-	-	-	324	-	702	-	-	GS
180	20	-	6.8	.07	544	532	386	161	773	7.7	.6	GS
Valley												
-	10	-	-	-	-	-	-	-	432	-	-	GS
Bench												
562	70	-	19	-	1,300	1,050	800	646	1,600	7.9	0.4	GS
Valley												
5.0	11	0.2	3.6	0.07	244	-	148	0	310	-	0.3	SH

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*No. 12. Test drilling in the upper Sevier River drainage basin, Garfield and Piute Counties, Utah, by R. D. Feltis and G. B. Robinson, Jr., U. S. Geological Survey, 1963.

*No. 13. Water requirements of lower Jordan River, Utah, by Karl Harris, Irrigation Engineer, Agricultural Research Service, Phoenix, Arizona, prepared under informal cooperation approved by Mr. William W. Donnan, Chief, Southwest Branch (Riverside, California) Soil and Water Conservation Research Division, Agricultural Research Service, U.S.D.A., and by Wayne D. Criddle, State Engineer, State of Utah, Salt Lake City, Utah, 1964.

*No. 14. Consumptive use of water by native vegetation and irrigated crops in the Virgin River area of Utah, by Wayne D. Criddle, Jay M. Bagley, R. Keith Higginson, and David W. Hendricks, through cooperation of Utah Agricultural Experiment Station, Agricultural Research Service, Soil and Water Conservation Branch, Western Soil and Water Management Section, Utah Water and Power Board, and Utah State Engineer, Salt Lake City, Utah, 1964.

*No. 15. Ground-water conditions and related water-administration problems in Cedar City Valley, Iron County, Utah, February, 1966, by Jack A. Barnett and Francis T. Mayo, Utah State Engineer's Office.

*No. 16. Summary of water well drilling activities in Utah, 1960 through 1965, compiled by Utah State Engineer's Office, 1966.

*No. 17. Bibliography of U. S. Geological Survey Water Resources Reports for Utah, compiled by Olive A. Keller, U. S. Geological Survey, 1966.

*No. 18. The effect of pumping large-discharge wells on the ground-water reservoir in southern Utah Valley, Utah County, Utah, by R. M. Cordova and R. W. Mower, U. S. Geological Survey 1967.

No. 19. Ground-water hydrology of southern Cache Valley, Utah, by L. P. Beer, 1967.

No. 20. Fluvial sediment in Utah, 1905-65, A data compilation by J. C. Mundorff, U. S. Geological Survey, 1968.

No. 21. Hydrogeology of the eastern portion of the south slopes of the Uinta Mountains, Utah, by L.G. Moore and D.A. Barker, U.S. Bureau of Reclamation, and James D. Maxwell and Bob L. Bridges, Soil Conservation Service, 1971.

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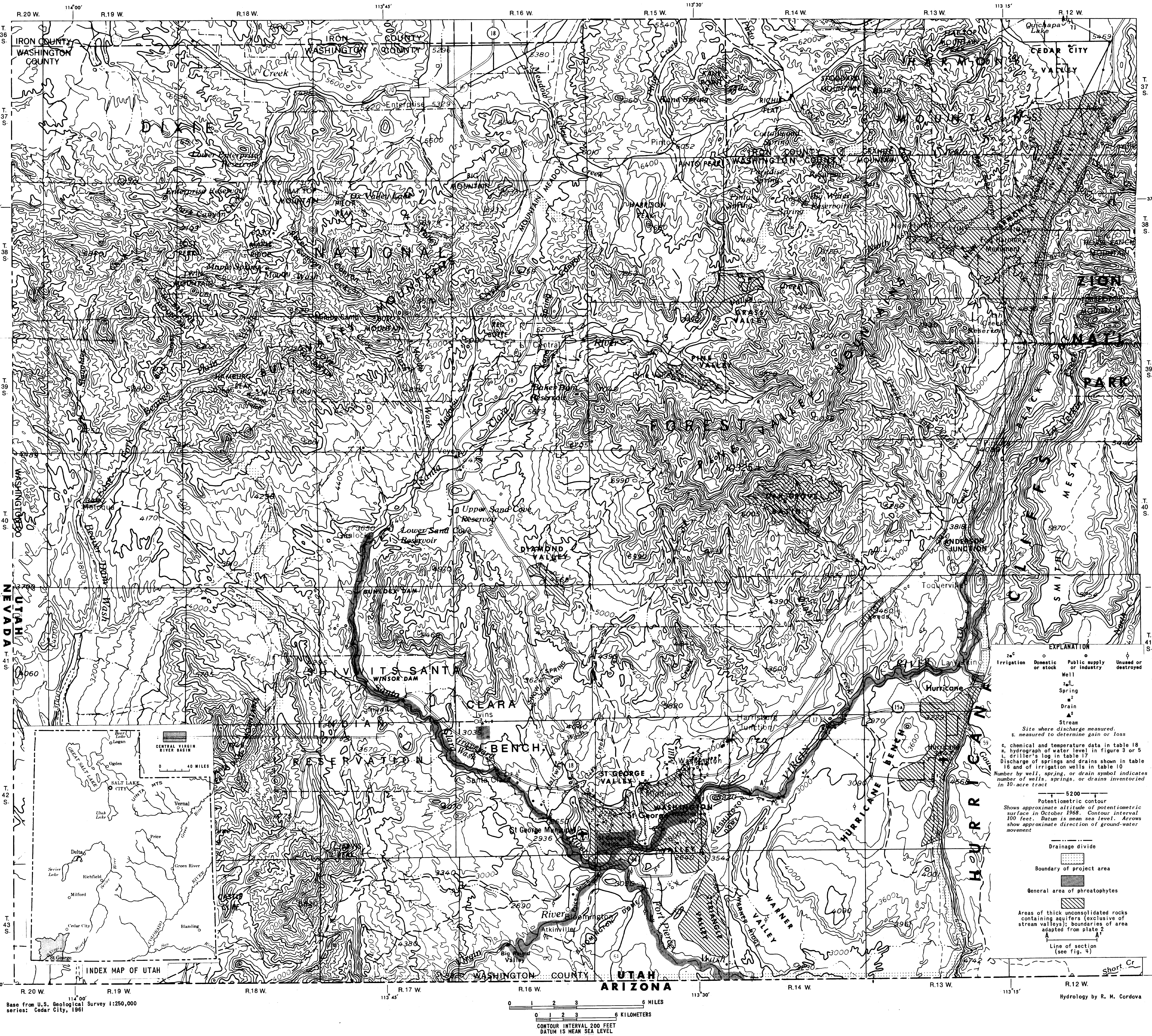

MAP OF THE CENTRAL VIRGIN RIVER BASIN, UTAH, SHOWING SELECTED HYDROGEOLOGIC INFORMATION

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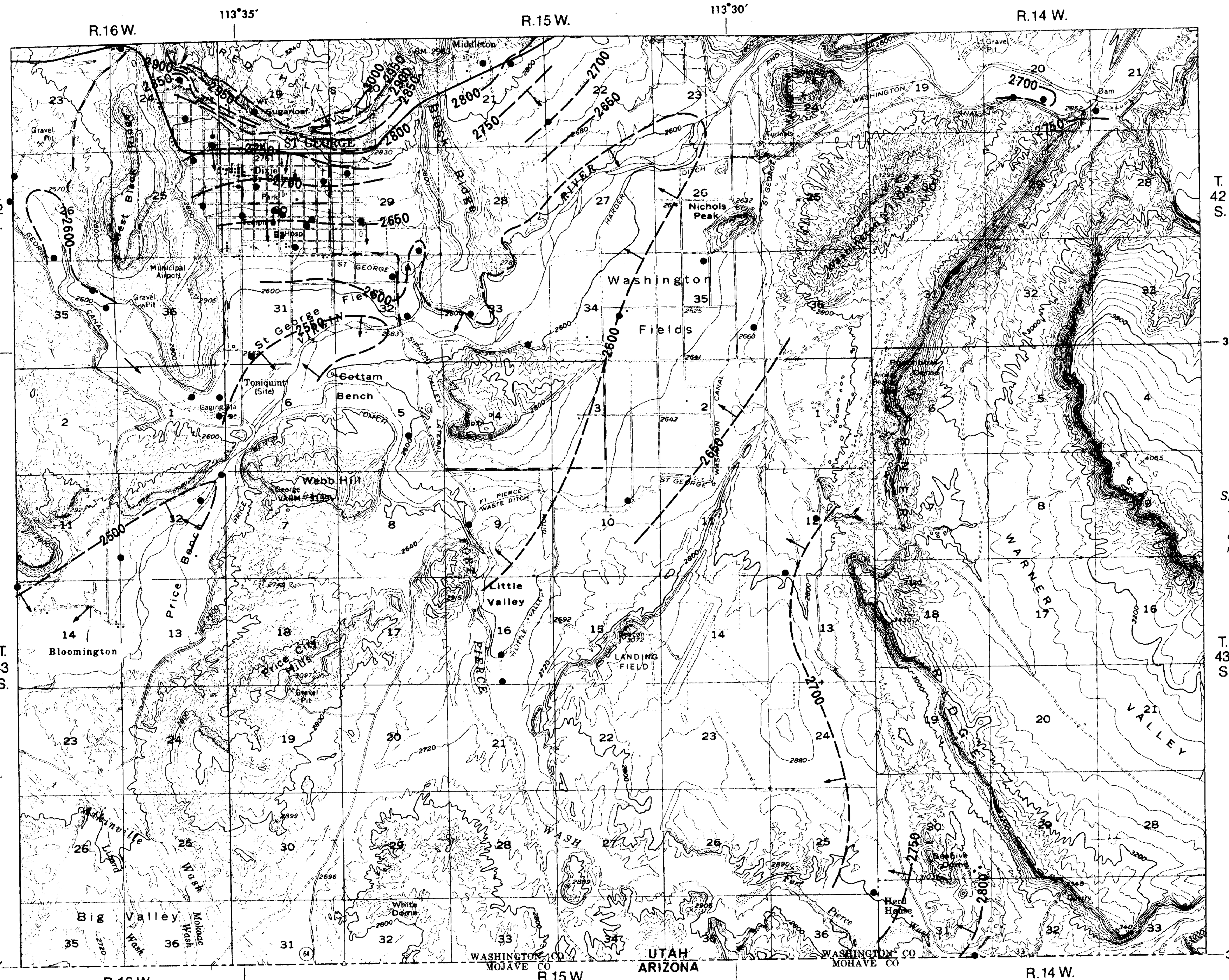

Base from U.S. Geological Survey topographic maps 1:62,500: St. George and Hurricane (1954)

1 ½ 0 1 MILES

Hydrology by R. M. Cordova, 1970

EXPLANATION

Observation well

—2600—

Potentiometric contour

Shows approximate altitude of potentiometric surface in July 1970. Contour interval 50 feet. Datum is mean sea level. Arrow indicates general direction of ground-water movement

MAP OF ST. GEORGE AND VICINITY, UTAH, SHOWING CONTOURS ON THE POTENTIOMETRIC SURFACE AND GENERAL DIRECTION OF GROUND-WATER MOVEMENT IN JULY 1970