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GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1870-A

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By ELMER BUTLER *and* J. C. MUNDORFF

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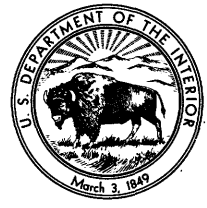

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FLOODS OF DECEMBER 1966 IN SOUTHWESTERN UTAH

By ELMER BUTLER and J. C. MUNDORFF

ABSTRACT

Severe floods occurred in parts of southwestern Utah on December 5–6, 1966, as a result of precipitation of about 1 inch to more than 12 inches during December 3–6. The flood on the Virgin River was the greatest since the first settlers arrived in 1860.

The peak discharge of the Virgin River at Virgin, Utah, was 22,800 cubic feet per second on December 6; this exceeded the previous maximum discharge of 13,500 cubic feet per second on March 3, 1938, and September 17, 1961, and probably has a recurrence interval of 100 years. At eight other gage sites in the flood area, the peak discharge in December 1966 was the highest of record; the recurrence intervals of some of the peak discharges may be 100 years. The flood peaks were generally of short duration and most streams receded to near base flow within 24 hours.

The dissolved-solids content was significantly lower in the Virgin River at Virgin than at St. George, about 25 miles downstream; the water was of the calcium sulfate type at both sites. Data for the Santa Clara River above Winsor Dam and the Santa Clara River near Santa Clara show a significant increase in dissolved solids between the two sites. The water above Winsor Dam was of the calcium bicarbonate type, and the water near Santa Clara was of the calcium bicarbonate sulfate type.

The suspended-sediment discharge during the period December 5–8, 1966, at Santa Clara River above Winsor Dam, near Santa Clara was about four times greater than all the suspended-sediment discharge during the preceding 3 years; the suspended-sediment discharge of the Virgin River at Virgin was greater during the 4-day period than during any one of the preceding 3 years.

Nearly all the flood damage in the area occurred in the Virgin River basin. According to the Soil Conservation Service, total damage in the Dixie Soil Conservation District in Washington County was about $835,000; 60 percent of the damage was caused by floodwater and 40 percent by deposited sediment.

INTRODUCTION

This report describes the amounts and areal distribution of precipitation, the quantity and quality of streamflow at selected sites, and

the flood damage that resulted from an intense storm in southwestern Utah during the period December 3–7, 1966.

The average annual precipitation in the Virgin River and Paria River basins (pl. 1) ranges from about 8 inches along the Utah-Arizona border south of St. George to about 40 inches at altitudes above about 8,500 feet in the headwaters of the North Fork Virgin River. The annual precipitation exceeds 20 inches in less than 15 percent of the area and is less than 12 inches throughout the southern half of the area. During the period December 3–7, 1966, total recorded precipitation in the area ranged from 1.05 inches at Castle Cliff in the southwestern part of the area to 12.60 inches at Grassy Flat in the northwestern part of the area. The large amount and high intensity of the rainfall and the simultaneous melting of an existing snowpack resulted in severe flooding in parts of the area.

The Soil Conservation Service and the Forest Service (U.S. Dept. of Agriculture), the Bureau of Reclamation (U.S. Dept. of the Interior), and the Weather Bureau of the Environmental Science Service Administrations (U.S. Dept. of Commerce) were extremely helpful in furnishing information for inclusion in this report. Their contributions are acknowledged in various parts of the report.

PHYSICAL SETTING

The eastern half of the area flooded is in the High Plateaus of Utah section of the Colorado Plateaus, and the western half is in the Great Basin section of the Basin and Range province (Fenneman, 1931).

The surface rocks are mainly sedimentary rocks of Jurassic and Cretaceous age in the eastern two-thirds of the area (pl. 1). Intrusive and volcanic rocks of Tertiary or Quaternary age underlie much of the northwestern part of the area.

Vegetation classed as "woods and brushwood" covers about three-fourths of the area (U.S. Geological Survey, 1961); the remainder is covered by agricultural crops, native grasses, and desert vegetation or is unvegetated (pl. 1).

Altitudes range from about 2,400 feet above mean sea level in the extreme southwestern part of the area to about 10,300 feet in the Pine Valley Mountains north of St. George. Figure 1 is generalized to show the major changes in altitude. An increase in normal annual precipitation with an increase in altitude is evident from figures 1 and 2.

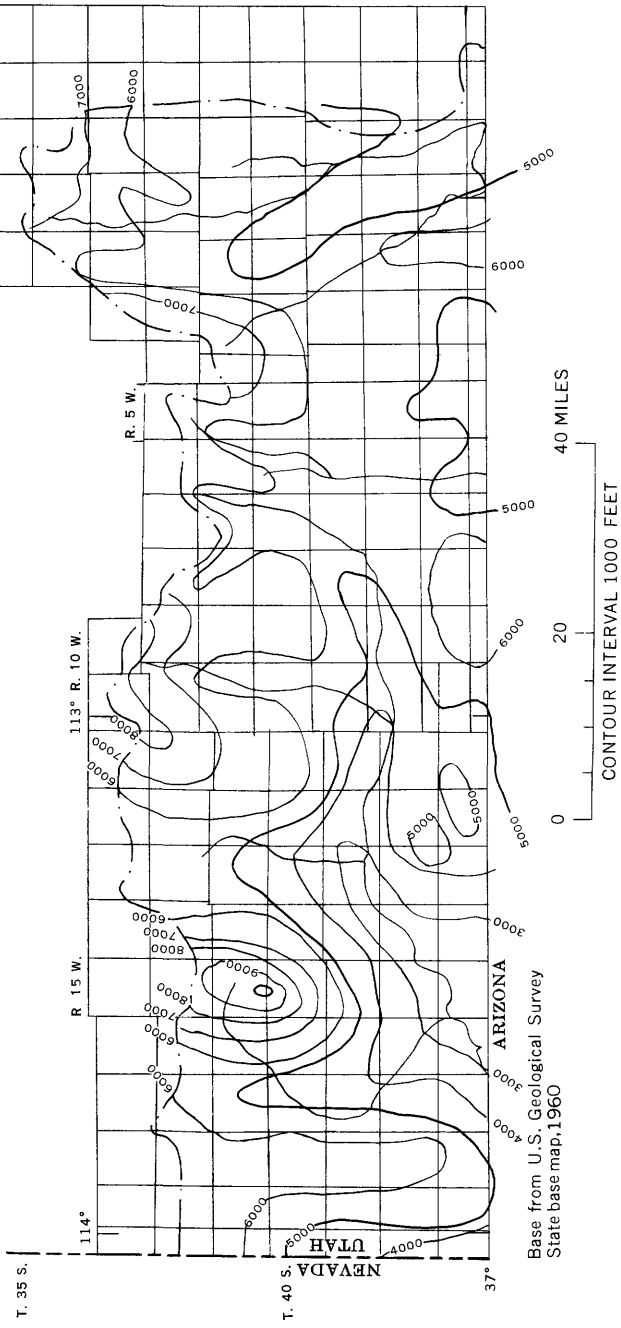

FIGURE 1.—Altitudes in part of southwestern Utah.

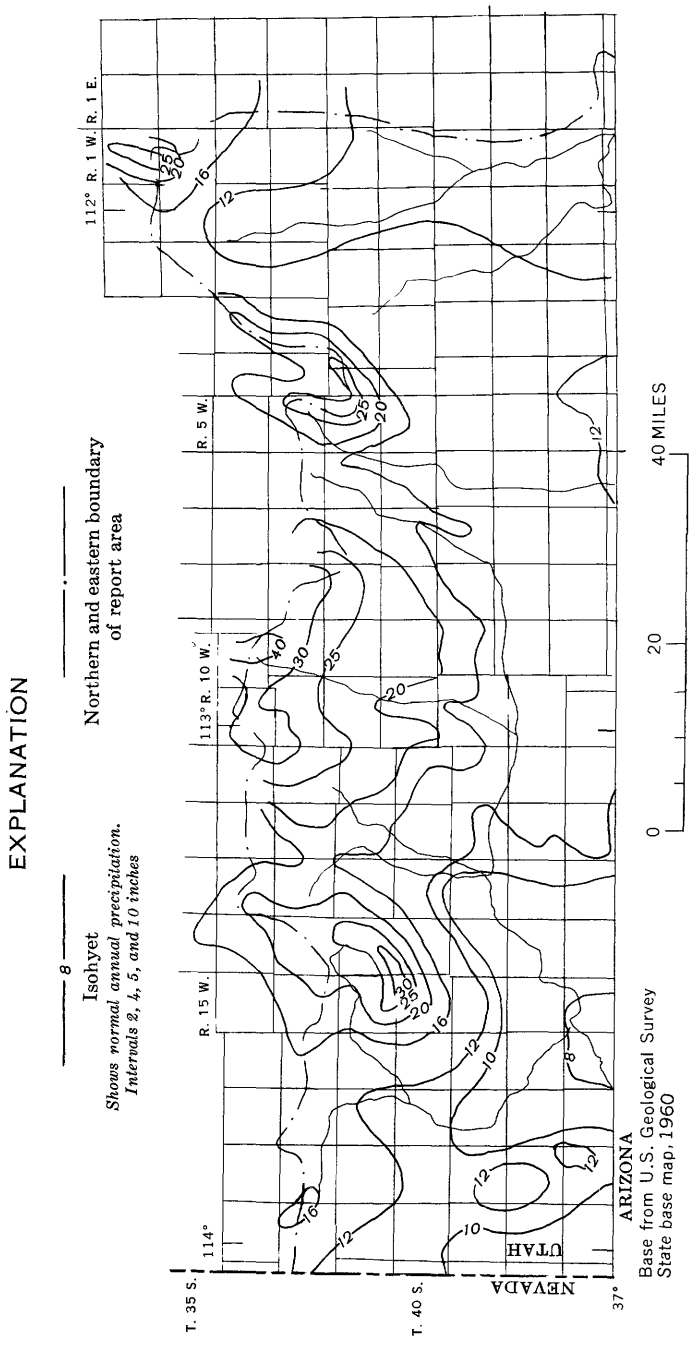

FIGURE 2.—Normal annual precipitation, in inches, in part of southwestern Utah.

PRECIPITATION

During the first 11 months of 1966, precipitation was much below normal in southwestern Utah. For example, precipitation at Gunlock was 3.86 inches below normal; at St. George, 3.66 inches below normal; at Zion National Park, 2.53 inches below normal; at Kanab, 3.10 inches below normal; and at Orderville, 3.20 inches below normal. Normal annual precipitation at these stations ranges from 8.13 inches at St. George to 14.56 inches at Zion National Park.

In contrast to the below normal precipitation during the first 11 months of 1966, precipitation during December, particularly during the period December 3–7, was much above normal. Record 24-hour amounts of precipitation were measured on December 6, at three stations. At Orderville, 4.44 inches was the greatest ever recorded at the station and the third largest amount in the history of the State; at Alton, 3.21 inches was the greatest ever recorded at the station in December; and at Kanab, 2.80 inches was the greatest for all months of record at the station. Precipitation data obtained by the Weather Bureau during this period are given in table 1.

TABLE 1.—*Daily precipitation at selected Weather Bureau stations in southwestern Utah during December 3–7, 1966*

Station	Precipitation, in inches						
	December					Total Dec. 3–7	Normal for entire month of December based on 1931–60 figures
	3	4	5	6	7		
Gunlock	0.42	0.30	0.47	0.80	0	1.99	----------
LaVerkin	.55	.01	.66	.95	.15	2.32	----------
St. George	.18	.11	.33	.58	.25	1.45	1.03
Veyo	.45	.47	1.10	1.12	0	3.14	----------
Zion National Park	.59	.13	.58	2.02	.56	3.88	1.65
Kanab	1.05	.15	1.80	2.80	.15	5.95	1.48
New Harmony	.84	.26	.67	1.24	.66	3.67	----------
Orderville	1.12	0	1.67	4.44	0	7.23	1.76
Alton	.91	.28	.67	3.21	.51	5.58	1.80

In addition to precipitation data obtained by the Weather Bureau, data on the total precipitation (table 2) during the period December 3–7 were obtained by the Dixie Project Field Office of the Bureau of Reclamation, from private citizens, and from other Federal agencies at many other sites in the area.

The locations of the sites listed in tables 1 and 2 and the total precipitation at each site are shown on plate 1.

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TABLE 2.—*Total precipitation at selected sites in southwestern Utah during the period December 3–7, 1966*

Location	Inches	Location	Inches
Hurricane	2. 1	Motoqua	3. 6
Pine Valley	[1] 11	Tobin	3. 05
Leeds	[1] 3. 75	Diamond Valley	1. 95
Pintura	[1] 7. 5	Black Ridge	7. 95
Kanarraville	[1] 3. 0	Castle Cliff	1. 05
Springdale	[1] 4. 0	Cove Reservoir (Long Flat)	3. 90
Rockville	[1] 4. 0	Grassy Flat	12. 60
Virgin	[1] 4. 0	Duck Creek	11. 39
Toquerville	[1] 4. 5	Blowhard Mountain	3. 14
Apex Burn	2. 3	Webster Flat	6. 21
Gould's Enclosure	2. 0	Central	5. 60
Little Creek Mountain	4. 5		

[1] Approximate.

The storm, which originated in the Pacific Ocean, moved eastward over Utah. The general movement of the storm from west to east is suggested by the series of radar-echo maps (pl. 2) that show the locations of storm cells in the area during the period December 3–6. The data in table 1 show moderate precipitation on December 3, fairly light precipitation on December 4, heavy precipitation on December 5 and 6, and scattered light to moderate precipitation on December 7. The radar maps, which were supplied by the Weather Bureau of the Environmental Science Services Administration, show the size and location of the different storm cells and the days and times of most intense development of the cells. Precipitation fell on December 3 mainly in the early afternoon, on December 5 in the afternoon and evening, and on December 6 throughout the day. No radar-echo maps are shown for December 4, but precipitation was light on that day (table 1). When only total precipitation during a day or several days is known, such radar maps can be extremely useful in estimating the probable time and duration of precipitation.

STREAMFLOW

DESCRIPTION OF THE FLOODS

The floods of December 1966 in southwestern Utah were caused by a storm of unprecedented intensity and areal coverage for that region. Damaging floods, probably from the same storm, occurred on the Kern River in California and on drainages from Charleston Mountain in southeastern Nevada. The floods in southwestern Utah were outstanding in magnitude and were unusual in the coincidence of their occurrence on the tributaries of the Virgin and Santa Clara Rivers. The resulting concentration of runoff produced a flood on the main stem

of the Virgin River which was the highest known since the first settlers arrived in 1860. In 1862, however, a flood of unknown magnitude on the Santa Clara River at Santa Clara forced the settlers to move the newly settled town to higher ground. It is believed that this early flood was comparable in size to the 1966 flood. Most drainages in the area are subject to serious flooding from summer thunderstorms caused by heavily moisture ladened air moving in from the Gulf of Mexico. These summer storms have caused higher peak flows on some streams but never such widespread flooding.

The peak discharge of the Virgin River at Virgin, Utah, on December 6, 1966, was 22,800 cfs (cubic feet per second), which exceeded the previous record runoff at this site of 13,500 cfs on March 3, 1938, and September 17, 1961. The 1966 flood on the Virgin River at Virgin probably has a recurrence interval [1] of 100 years. At eight other gage sites in the flood area, the peak flow in December was the highest of record, and the recurrence intervals of some of these peak discharges may be 100 years.

Prior to the 1966 storm, most perennial streams in southwestern Utah were flowing at or near base flow, while most intermittent streams were dry. The storm moved into the area on December 3, 1966, and flood-flows began to appear on the evening of December 5. Most streams reached their peaks late in the evening of December 6, or early in the morning of December 7 (figs. 3, 4). The flood peaks were generally of short duration, and most streams receded to near base flow within 24 hours.

The Forest Service reported that floodwater filled or nearly filled all reservoirs in the area. The storage behind Baker Dam increased an estimated 500 acre-feet in about 5 hours, and the peak flow over the spillway was 1,080 cfs. Ash Creek Reservoir below New Harmony was filled by an unknown amount of floodwater and spilled during the storm.

DETERMINATION OF FLOOD DISCHARGES

The procedure followed by the U.S. Geological Survey for determining peak discharge at gaging stations by means of current-meter measurements and stage-discharge relation curves has been described in detail by Corbett and others (1943). The general procedure involves computing the stage-discharge relation from current-meter measurements of discharge at stages varying from low to high and applying this relation to the records of stage. Short extensions of the stage-

[1] Recurrence interval is defined as the average interval of time within which a flood of a given magnitude will be equaled or exceeded once. A flood having a recurrence interval of 10 years is one that has a 10-percent chance of occurring in any year; likewise a 25-year flood has a 4-percent chance and a 50-year flood has a 2-percent chance of occurring in any year.

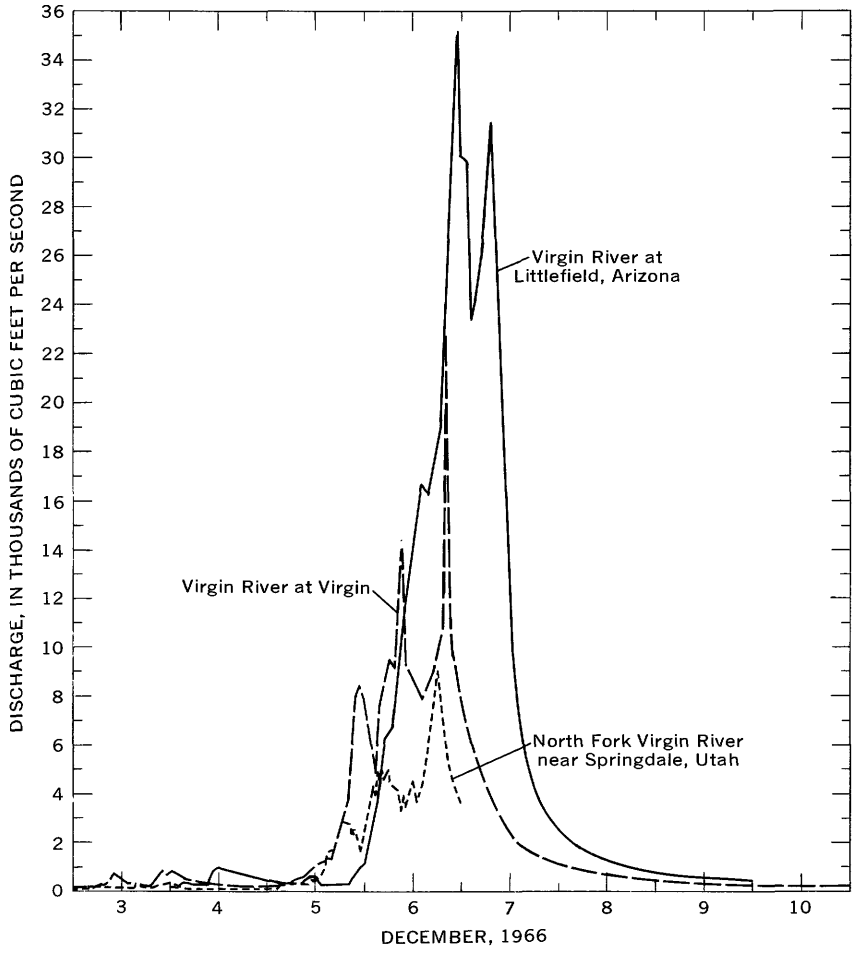

FIGURE 3.—Discharge at selected gaging stations in the Virgin River basin.

discharge relation curves are made on the basis of area-velocity studies, slope-conveyance studies, by logarithmic plotting, or by other hydraulic methods.

It was often impossible to obtain current-meter measurements of the peak discharges because of the short duration of the floods, impassable roads, and interference of floating debris. Where such measurements could not be obtained, the peak discharge was determined by indirect measurements.

Indirect measurements of peak discharge were made at seven gaging stations and at two miscellaneous sites; seven measurements were by slope-area method, one by culvert method, and one by flow-over-dam

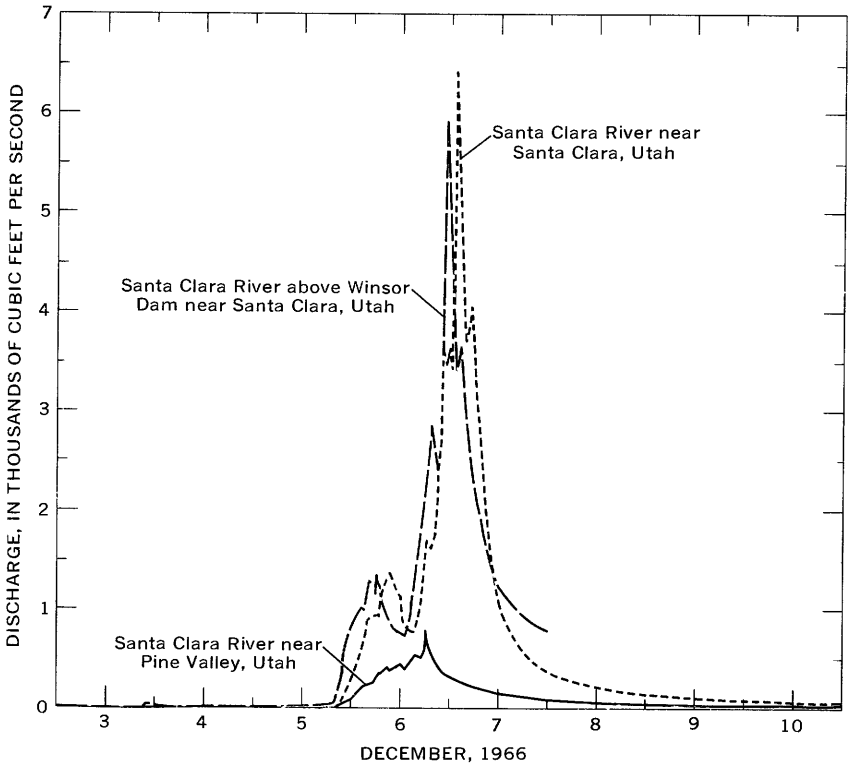

FIGURE 4.—Discharge at selected gaging stations in the Santa Clara River basin.

method. Indirect measurements are computed by established hydraulic principles based on channel geometry and high-water profiles obtained by a field survey. They are considered to be indirect only because the data are collected subsequent to the passage of the peak flow.

STAGES AND DISCHARGES AT SELECTED SITES

This section of the report presents detailed information regarding stage and discharge of streams in southwestern Utah during the floods of December 1966. Data in addition to that usually published in the regular annual reports of the Geological Survey are presented here in sufficient detail for use in hydraulic and hydrologic studies. Records of stage and discharge are presented for 11 stream-gaging stations, nine crest-stage stations, and two miscellaneous sites.

The basic data systematically collected at stream-gaging stations consist of records of stage, measurement of discharge, and any other general information pertinent to the determination of the daily flow of the stream at the gaging station. The record of stage is obtained

either from periodic readings of a nonrecording crest-stage gage or from an automatic water-stage recorder installation, which provides a continuous record of stage.

Crest-stage stations are equipped with a device that records only the peak stages between inspections. The date of the peaks may usually be determined by comparison with nearby continuous-record stations or weather records or by local inquiry.

The streamflow data (see section "Station data") consist of a description of the measuring site; and, for gaging stations, a tabulation of the daily mean discharges for December 1966 and a tabulation of stages and discharges at indicated times during each day, generally for the period December 3–10. The latter tabulation is given to show the flood rise and recession in sufficient detail to delineate the flood hydrograph. The first tabulation also shows the monthly mean discharge and the monthly volume of runoff, in acre-feet.

The description of the gaging station includes information about the location, datum, type of gage, and size of drainage area. It also gives the method used to determine the stage during the flood period and the definition of the stage-discharge relation. The maximum stage and discharge at each station are given for December 1966 and for the period of previous record. Remarks on regulation and diversions and other pertinent information are included where applicable.

The stages of 11 stations were obtained from records of continuous water-stage recorders. For periods of missing record, the stage graph was sketched in by using a floodmark or supplemental readings or by comparing records on the same stream or nearby streams.

The stations on the rivers are numbered and listed in downstream order from headwater to mouth; the stations on tributaries are inserted in corresponding order following the order in which the tributaries enter the main stream. These numbers identify the locations on plate 1. The permanent station number (shown in parentheses to the left of the station name in the station description) corresponds to the number shown in the annual reports of surface-water records of the Geological Survey.

SUMMARY OF FLOOD STAGES AND DISCHARGES

The maximum floodflows at 22 selected sites on streams in the area covered by this report are summarized in table 3.

The flood discharges given in table 3 were converted to cubic feet per second per square mile and plotted against the corresponding drainage areas (fig. 5). The points in the upper part of the graph have a consistent trend; however, the points in the lower part of the graph scatter

widely because they mostly represent measuring sites that were on the fringe of the storm area. The flood-frequency curves for recurrence intervals of 2.33, 10, 25, and 50 years, as defined by Patterson and Somers (1966), and a guideline expressing discharge in terms of the square root of the drainage area were also drawn in figure 5.

The basic data and computations for the determinations of discharge are filed in the District Office of the Water Resources Division, U.S. Geological Survey, in Salt Lake City, Utah.

WATER QUALITY

Data on chemical quality and on suspended-sediment discharge were collected at several sites in the Virgin River basin during the period December 6–15, 1966. Data on suspended-sediment discharge have been collected regularly since 1962 at Virgin River at Virgin and at Santa Clara River above Winsor Dam, near Santa Clara. Data on chemical quality of the streams have not been regularly collected in the Virgin River basin in Utah since the period 1950–56; then the data were obtained at four sites (Connor and others, 1958, p. 235–240; U.S. Geol. Survey, 1960, p. 147–149, 151–159).

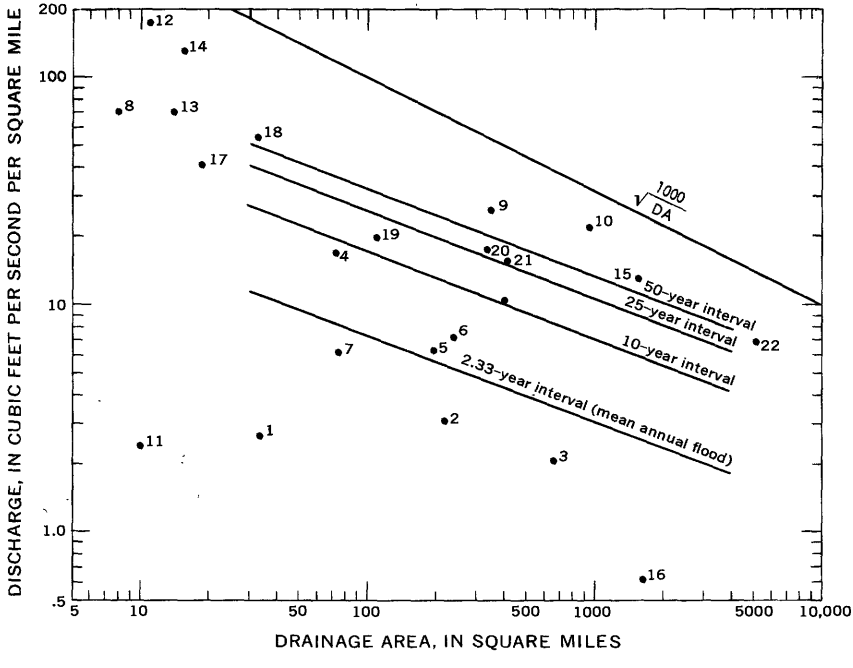

FIGURE 5.—Relation of peak unit discharge, size of drainage basin, and recurrence interval. Numbers refer to sampling sides plotted on plate 1 and listed in table 3.

TABLE 3.—*Summary of flood*

Map No. (pl. 1)	Station No. 9–	Stream and place of determination	Drainage area (sq mi)
		Paria	
1	3811	Henrieville Creek at Henrieville, Utah	34
2	3815	Paria River near Cannonville, Utah	220
3	3818	Paria River near Kanab, Utah	668
		Kanab	
4	4035	Kanab Creek near Glendale, Utah	72
5	4036	Kanab Creek near Kanab, Utah	198
6	4037	Johnson Wash near Kanab, Utah	237
		Virgin	
7	4044.5	East Fork Virgin River near Glendale, Utah	74
8	4045	Mineral Gulch near Mt. Carmel, Utah	7.6
9	4055	North Fork Virgin River near Springdale, Utah	350
10	4060	Virgin River at Virgin Utah	934
11	4063	Kanarra Creek at Kanarraville, Utah	10.0
12	4067	South Ash Creek below Mill Creek, near Pintura, Utah	11.0
13	4068	South Ash Creek near Pintura, Utah	14.0
14	4080	Leeds Creek near Leeds, Utah	15.5
15	4081.5	Virgin River near Hurricane, Utah	1,530
16	4082	Fort Pierce Wash near St. George, Utah	1,650
17	4084	Santa Clara River near Pine Valley, Utah	18.7
18	4095	Moody Wash near Veyo, Utah	33
19	----------	Santa Clara River at Baker Dam, near Central, Utah	108
20	4100	Santa Clara River above Winsor Dam, near Santa Clara, Utah	338
21	4104	Santa Clara River near Santa Clara, Utah	410
22	4150	Virgin River at Littlefield, Ariz	5,090

[1] At site 1¼ miles downstream.
[2] Not defined for small drainage areas.
[3] Ratio of peak discharge to 50-year flow.

During December 1966, the dissolved-solids content was significantly lower at Virgin River at Virgin (drainage area, 934 sq mi) than at the Virgin River at St. George (drainage area, 3,820 sq mi); the water was distinctly of the calcium sulfate type at both sites (tables 4, 5). A comparison of the data obtained during 1950–56 to that obtained during December 1966 indicates that the dissolved-solids content of the Virgin River at Virgin was unexpectedly high during the flood in December 1966. The dissolved-solids content during floods commonly is markedly lower than it is during normal

stages and discharges

Period	Maximum previously known			Maximum December 1966			
	Year	Gage height (ft)	Discharge (cfs)	Day	Gage height (ft)	Discharge	
						Cfs	Recurrence interval (yr)
River basin							
1959–66	1961	15.6	7,360	6	11.81	89	2
1950–55, 1959–66	1963	18.0	11,400	6	6.33	670	2
1959–66	1963	16.26	15,400	7	13.62	1,390	2
Creek basin							
1959–66	1963	6.37	1,600	6	5.61	1,210	8
1959–66	1961	15.70	3,030	6	14.40	1,230	2
1959–66	1963	[1] 17.11	1,540	6	16.00	1,700	4
River basin							
				6	3.40	450	2
1959–66	1963	19.69	3,210	6	12.03	500	(2)
1913–14, 1923, 1925–66	1938	12.29	7,000	6	12.98	9,150	[3] 1.31
1909–66	1938	[4] 10.7	13,500	6	18.00	22,800	[3] 1.76
	1961	13.29	13,500				
1959–66	1963	3.28	555	6	.95	24	(2)
				6	5.83	1,910	(2)
1959–66	1965	13.43	938	6	13.54	985	(2)
[5] 1915, 1917–19, 1920, 1964–66	1964	6.00	2,980	6	5.33	2,050	(2)
				6	27.34	20,100	[3] 1.07
1959–66	1964	17.23	8,760	6	13.68	1,000	1
1959–66	1960	4.86	340	6	6.85	[6] 776	15
1954–66	1961	8.60	1,400	6	9.75	1,810	[3] 1.12
				6		2,080	14
1942–66	1955	10.25	6,190	6	10.88	5,930	34
1965–66	1965	6.87	1,260	7	12.60	6,390	34
1929–66	1938	13.60	22,000	6	15.66	35,200	43

[4] At site about 3 miles upstream.
[5] Gage heights, or gage heights and discharge measurements only.
[6] Slightly affected by Pine Valley Reservoir.

flow, but during the flood of December 1966, the dissolved-solids content was not appreciably lower than during normal flow. The 1950–56 data also indicate that the water was generally of the calcium bicarbonate or calcium bicarbonate sulfate type during the period sampled. The water in the Virgin River was of the calcium sulfate type both near St. George during 1950–56 and at St. George in December 1966.

The specific conductance and the concentrations of dissolved solids and sulfate in the water at Virgin River at Virgin and at St. George, Utah, and at Littlefield, Ariz., in December 1966 are shown in table 5.

TABLE 4.—*Chemical quality of water from selected*

[Concentration of dissolved constituents, dissolved

Date of collection	Time	Temperature (° F)	Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
									7. (4044.5) East Fork Virgin
12–15–66	1700	41	18	8.6	61	39	3.9	1.9	346
									10. (4060) Virgin
12– 6–66	0745	------	9,220	------	133	23	45	------	116
12– 6–66	1040	------	8,780	6.1	136	16	49	------	106
12– 6–66	1345	------	[2] 7,970	------	139	19	41	------	108
12– 6–66	1600	------	[2] 8,530	------	131	22	47	------	110
12– 6–66	2100	------	[2] 13,000	8.3	169	30	50	------	156
12– 7–66	0800	------	[2] 3,620	------	143	24	33	------	120
12– 7–66	1700	------	1,520	6.9	98	26	40	------	136
12–13–66	1045	40	189	9.0	92	42	61	------	248
									12. (4067) South Ash Creek
12–15–66	1000	37	9.0	21	30	9.0	4.0	0.7	134
									16. (4082) Fort Pierce
12– 6–66	0830	54	950	14	591	62	95	------	160
									19. Baker Dam Spillway
12–10–66	1600	39	14.4	14	16	3.9	3.3	2.7	63
									20. (4100) Santa Clara River above
12– 6–66	1140	60	744	20	31	9.7	5.9	------	132
12– 6–66	1525	------	1,230	22	35	11	8.5	------	156
12– 6–66	1730	------	1,680	26	45	13	7.6	------	192
12– 7–66	0915	------	1,520	19	29	12	10	------	140
12– 8–66	1410	47	[3] 170	19	30	14	8.9	------	136
12–11–66	1040	38	[3] 45	22	58	13	20	------	200
12–11–66	1250	49	[3] 45	------	41	22	13	------	192
									21. (4104) Santa Clara
12– 9–66	1750	44	83	20	74	19	23	4.3	180
									23. Virgin River
12– 5–66	1750	------	[4] 500	6.5	265	17	32	------	96
12– 6–66	1310	------	[4] 8,000	8.4	204	35	77	------	132
12– 7–66	1100	------	[4] 8,000	------	210	35	85	------	132
									24. Santa Clara River
12– 6–66	0700	51	----------	18	29	4.9	11	------	116
12– 6–66	1400	51	----------	19	27	6.8	10	------	124
12– 6–66	1800	----------		19	34	9.7	9.9	------	152

[1] Residue at 180°.
[2] From estimated gage height.

streams in southwestern Utah, December 1966

solids, and hardness given in parts per million]

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
River near Glendale									
0	38	3.9	------	327	314	30	0.1	562	8.2
River at Virgin									
0	402	8.6	------	[1] 709	428	333	0.9	910	7.8
0	397	8.9	------	[1] 684	406	319	1.1	880	7.7
0	402	7.8	------	[1] 693	428	339	.9	892	7.7
0	403	8.5	------	[1] 677	420	330	1.0	882	7.8
0	489	11	------	[1] 878	544	416	.9	1,090	7.8
0	400	9.3	------	[1] 707	456	358	.7	914	7.8
0	288	18	------	[1] 528	352	240	.9	761	7.9
0	262	66	------	660	404	201	1.3	1,000	8.1
below Mill Creek, near Pintura									
0	8.5	2.3	0.3	142	112	2	0.2	224	7.7
Wash near St. George									
0	1,700	24	0.7	2,570	1,730	1,600	1.0	2,610	8.1
near Pine Valley									
0	5.5	3.3	0.7	81	55	3	0.2	118	7.2
Winsor Dam, near Santa Clara									
0	12	6.7	0.9	151	118	10	0.2	242	7.8
0	14	5.3	.7	174	132	4	.3	271	7.8
0	14	5.9	.8	206	164	7	.3	338	8.1
0	18	7.2	.8	165	122	7	.4	274	8.0
0	20	13	1.0	173	132	20	.3	294	8.0
0	56	23	.5	295	200	36	.6	449	7.4
0	33	21	------	[1] 260	192	35	.4	422	8.1
River near Santa Clara									
0	139	24	0.9	394	262	114	0.6	595	8.0
at St. George									
0	683	4.8	------	1,060	728	649	0.5	1,230	7.7
0	637	34	------	1,060	652	544	1.3	1,320	7.9
0	644	52	------	[1] 1,090	668	560	1.4	1,380	7.9
at Gunlock Bridge									
0	12	5.4	------	137	92	0	0.5	212	7.5
0	9.2	5.0	------	138	96	0	.5	220	8.0
0	14	4.6	------	166	124	0	.4	268	7.7

[3] Daily mean.
[4] Estimated.

TABLE 5.—*Selected chemical determinations for the Virgin River at Virgin, at St. George, Utah, and at Littlefield, Ariz., on December 6–7, 1966*

Sampling site	Date	Time	Specific conductance (micromhos per cm at 25°C)	Dissolved solids (ppm)	Sulfate (ppm)
Virgin River at Virgin	Dec. 6	0745	910	709	402
		1040	880	684	397
		1345	892	693	402
		1600	882	677	403
		2100	1,090	878	489
Do	Dec. 7	0800	914	707	400
		1700	761	528	288
Virgin River at St. George	Dec. 6	1310	1,320	1,060	637
Do	Dec. 7	1100	1,380	1,090	644
Virgin River at Littlefield	Dec. 6	1600	1,610	1,340	760
Do	Dec. 7	0800	1,690	1,440	808

Data obtained at Santa Clara River above Winsor Dam, near Santa Clara during 1950–56 and during December 1966 show no significant differences in either dissolved-solids content or type, whereas data collected during December 1966 at Santa Clara River near Santa Clara, which is several miles downstream from the site above Winsor Dam, show an increase in dissolved-solids content. The water type above Winsor Dam was calcium bicarbonate; the water type near Santa Clara was calcium bicarbonate sulfate. The increased concentrations of dissolved solids and sulfate in the waters in the downstream parts of the Virgin and Santa Clara Rivers in Utah may be due mainly to the contribution from the Moenkopi Formation of Triassic age, which forms a significant part of the drainage area downstream from Virgin and from Santa Clara (pl. 1).

Of the streams listed in table 4, only Fort Pierce Wash near St. George shows exceptionally high concentrations of dissolved solids and sulfate. The drainage area of Fort Pierce Wash is underlain mainly by the Moenkopi Formation and alluvium of Quaternary age, and much of it is irrigated.

Water-quality data have been obtained daily since 1949 at Virgin River at Littlefield, Ariz., which is about 20 miles downstream from the Utah-Arizona State line. The specific conductance of the water was only about half as great during the flood period as it was immediately before the flood (fig. 6). Minimum specific conductance occurred not at maximum water discharge but apparently at a much lower water discharge several hours after the flood crest. The improvement in water quality lasted for about 2 weeks after the flood. By December 24, specific conductance had risen to its pre-flood level.

Suspended-sediment discharges at the two sediment stations in the Virgin River basin—Virgin River at Virgin and at Santa Clara River

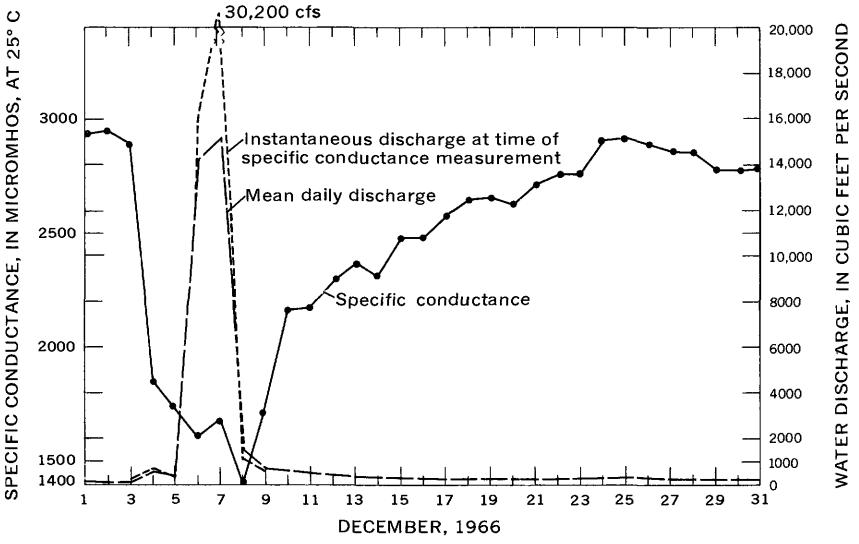

FIGURE 6.—Specific conductance and water discharge at Virgin River at Littlefield, Ariz., during December 1966.

above Winsor Dam, near Santa Clara—were extremely large during the flood. Suspended-sediment discharges for these two stations for the 1964–66 water years and for December 5–8, 1966, are shown below:

Station	Period	Suspended-sediment discharge (tons)
Santa Clara River above Winsor Dam, near Santa Clara.	1964 water year	36, 415
Do	1965 water year	26, 067
Do	1966 water year	28, 638
Do	Dec. 5–8, 1966	415, 000
Virgin River at Virgin	1964 water year	1, 165, 000
Do	1965 water year	958, 000
Do	1966 water year	786, 602
Do	Dec. 5–8, 1966	1, 822, 000

During the period December 5–8, 1966, the suspended-sediment discharge near Santa Clara was about four times greater than all the suspended-sediment discharge during the preceding 3 years; the suspended-sediment discharge at Virgin was greater during the 4-day period than during any one of the preceding 3 years.

Large quantities of sand were transported during the flood in the Virgin River basin (table 6). The data suggest that the total-sediment discharge, including bedload, was significantly greater than the measured suspended-sediment discharge.

TABLE 6.—*Suspended-sediment discharges and particle-size distributions for selected streams in southwestern Utah, December 1966*

[Each sample analyzed was subjected to the following methods: visual accumulation tube, pipet, in distilled water, and chemically dispersed]

Date in December 1966	Time	Water temperature (°F)	Discharge (cfs)	Suspended sediment								
				Mean concentration (ppm)	Discharge (tons per day)	Percent finer than indicated size, in millimeters						
						0.002	0.004	0.016	0.062	0.125	0.250	0.500	1.000
9. (4055) North Fork Virgin River near Springdale													
12	1435		[1] 160	809	349								
10. (4060) Virgin River at Virgin													
3	1340		288	10,400	8,090	21	25	39	57	74	96	100	
5	1515		1,330	27,600	99,100	11	13	17	35	67	94	100	
6	0745		9,220	40,300	1,040,000	23	25	39	60	80	96	100	
6	1040		8,780	33,800	831,000	26	27	40	63	85	97	99	100
6	1345		[1] 7,970	56,500	1,260,000	15	19	26	44	75	96	100	
6	1600		[1] 8,530	45,900	1,100,000	20	20	30	53	79	96	100	
6	2100		[1] 13,000	57,200	2,080,000	22	26	44	65	87	98	100	
7	0800		[1] 3,620	56,600	574,000	20	24	34	50	75	96	99	100
7	1700		1,520	19,600	80,400	24	28	43	60	84	98	99	100
8	1000		771	4,990	10,400	18	23	35	48	72	97	100	
29	1540	35	135	1,250	456								
16. (4082) Fort Pierce Wash near St. George													
6	0830	54	950	90,300	249,000	35	38	74	97	99	100		
7	1130		[2] 75	46,700	9,460	45	53	85	99	100			
20. (4100) Santa Clara River above Winsor Dam, near Santa Clara													
5	1430	53	30	9,630	780	47	57	90	99	100			
6	0700	51	1,300	18,900	66,300	15	18	32	57	77	93	99	100
6	1140	60	744	17,500	35,200	17	23	30	54	76	93	100	
6	1525		1,230	29,100	96,600	16	16	29	55	76	93	100	
6	1730		1,680	43,800	206,000	19	19	41	64	88	98	100	
6	1800		1,910	47,800	256,000	23	23	39	67	85	95	99	100
7	0915		1,520	18,800	77,200	13	15	22	41	60	88	98	100
8	1410	47	[1] 170	2,570	1,180	9	12	18	27	38	70	95	100
11	1250	49	[1] 45	1,220	148	10	12		17	23	56	91	100
23. Virgin River at St. George													
6	1310		[2] 8,000	37,200	833,000	25	29	49	68	89	100		
7	1100		[2] 8,000	62,800	1,410,000	18	19	34	60	93	100		
25. La Verkin Creek near La Verkin													
5	1715		[2] 500	66,300	92,800	4	5	11	20	50	90	100	

[1] Daily mean discharge.
[2] Estimated.

FLOOD DAMAGE

Nearly all the flood damage in the area occurred in the Virgin River basin. Most of the information on this flood damage was furnished by the Soil Conservation Service and the Forest Service (U.S. Dept. of Agriculture) and the Bureau of Reclamation (U.S. Dept. of the Interior).

The Soil Conservation Service prepared estimates of flood damage in the Dixie Soil Conservation District in Washington County. Total damage to crops and fences was about $130,000; 75 percent of the damage was caused by sediment. Total damage to roads, bridges, and diversion structures, including damage in Zion National Park, was about $425,000; 95 percent of this damage was caused by floodwater. Cost of sediment and debris removal including that from cropland and irrigation systems, was about $250,000; 50 percent of this cost was due to floodwater and 50 percent to sediment. Total damage in the Soil Conservation District was about $835,000; 60 percent of the damage was caused by floodwater and 40 percent by sediment.

According to the Dixie Project Field Office, U.S. Bureau of Reclamation, St. George, Utah, damage along the Virgin River between Springdale and Virgin was extensive. More than 90 acres of improved and semi-improved land was washed away, and flooding was extensive on the remaining cropland. Flooding along the Virgin River south of Washington (fig. 7) resulted in 43 acres being washed away. The approach to the highway bridge across the Virgin River about 1 mile south of St. George washed out when riprapping up to 2 feet in diameter proved to be inadequate protection (fig. 8).

According to estimates of the U.S. Forest Service, damage to agricultural lands and facilities near the Virgin River in Washington County was $350,600. Total damage to State highways was about $75,000. Roads, trails, bridges, water systems, and fences in the National Forest lands were also damaged. Other damage consisted of channel erosion and sedimentation in reservoirs, in stock ponds, and on re-vegetation projects and rangelands. Soil productivity was decreased because of soil losses or debris accumulation. Damage to roads and bridges on National Forest lands was estimated at about $46,600. Total damage to National Forest improvements and lands is estimated at about $70,750.

During the flood on the Santa Clara River, the channel changed markedly in the vicinity of the U.S. Geological Survey gaging station at Santa Clara River above Winsor Dam. In addition to changes in

FIGURE 7.—Floodwater and sediment damage to cropland along the Virgin River near St. George. Photograph by Utah State Division of Water Resources.

the main channel in front of the station, a new secondary channel was eroded behind the station leaving it isolated and inoperable between the two channels. The gaging station had to be moved several hundred feet downstream beyond the point at which the new channel joins the main channel. Figure 9 shows the positions of the channels of the

FIGURE 8.—Damage to highway at the Virgin River bridge south of St. George. Photograph by Utah State Division of Water Resources.

Santa Clara River at the location of the station before and during the flood. The main channel is on the left, the newly eroded channel is on the right, and the gaging station is at the right center.

Other examples of floodwater and sediment damage are shown in figures 10–12.

FIGURE 9.—Santa Clara River above Winsor Dam, near Santa Clara. Main channel is on the left; channel formed during flood of December 1966 is in foreground. Flow is from left to right. Note location of gage in right center. Gage has been relocated several hundred feet downstream. Photograph by Elmer Butler.

FIGURE 10.—Road damage to highway along the Virgin River near Rockville. Photograph by Utah State Division of Water Resources.

FIGURE 11.—Land loss along the Virgin River near St. George. Photograph by Utah State Division of Water Resources.

FIGURE 12.—Damage to the emergency spillway of Baker Dam on the Santa Clara River. Photograph by Utah State Division of Water Resources.

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STATION DATA

PARIA RIVER BASIN

1. (3811) HENRIEVILLE CREEK AT HENRIEVILLE, UTAH

[Crest-stage station]

Location. Lat 37°33'30", long 111°59'00", in NW¼ sec. 26, T. 37 S., R. 2 W., on right bank at irrigation diversion dam 1 mile east of Henrieville.
Drainage area. 34 sq mi, approximately.
Gage-height record. Crest stages only. Altitude of gage is about 5,980 ft (from U.S. Geol. Survey topographic map, Cedar City, Utah).
Discharge record. Stage-discharge relation defined by current-meter measurements below 4.5 cfs and by critical-depth method at 4,200 cfs and slope-area measurement at 7,360 cfs.
Maxima. December 1966: Discharge, 89 cfs Dec. 6 (gage height, 11.81 ft).
1959 to November 1966: Discharge, 7,360 cfs Aug. 4, 1961 (gage height, 15.6 ft).

2. (3815) PARIA RIVER NEAR CANNONVILLE, UTAH

[Gaging station discontinued 1955, crest-stage station]

Location. Lat 37°30', long 112°02', T. 38 S., R. 2 W.(unsurveyed), on left bank about 3 miles above Sheep Creek and about 6 miles south of Cannonville.
Drainage area. 220 sq mi, approximately.
Gage-height record. Water-stage recorder graph. Altitude of gage is 5,440 ft (by barometer).
Discharge record. Stage-discharge relation defined by current-meter measurements below 98 cfs and by slope-area measurement at 11,400 cfs.
Maxima. December 1966: Discharge, 670 cfs Dec. 6 (gage height, 6.33 ft).
1950–55, 1959 to November 1966: Discharge, 11,400 cfs Aug. 31, 1963 (gage height, 18.0 ft, from high-water profile).

3. (3818) PARIA RIVER NEAR KANAB, UTAH

[Crest-stage station]

Location. Lat 37°04'25", long 111°53'20", in NE¼ sec. 15, T. 43 S., R. 1 W., on left bank 2.65 miles downstream from U.S. Highway 89, and 43 miles east of Kanab.
Drainage area. 668 sq mi, approximately.
Gage-height record. Crest stages only. Altitude of gage is about 4,270 ft (from U.S. Geol. Survey topographic map, Cedar City, Utah).
Discharge record. Stage-discharge relation defined by current-meter measurements below 53 cfs and by slope-area measurement at 15,400 cfs.
Maxima. December 1966: Discharge, 1,390 cfs Dec. 7 (gage height, 13.62 ft, from high-water profile).
1959 to November 1966: Discharge, 15,400 cfs Aug. 31, 1963 (gage height, 16.26 ft).

KANAB CREEK BASIN

4. (4035) KANAB CREEK NEAR GLENDALE, UTAH

[Crest-stage station]

Location. Lat 37°17', long 112°29', in NE¼ sec. 35, T. 40 S., R. 6 W., on right bank 7.4 miles southeast of Glendale and 10 miles south of Alton.
Drainage area. 72 sq mi, approximately.

Gage-height record. Crest stages only. Altitude of gage is about 6,230 ft (from U.S. Geol. Survey topographic map, Cedar City, Utah).
Discharge record. Stage-discharge relation defined by current-meter measurements below 63 cfs and by slope-area measurement at 1,300 cfs.
Maxima. December 1966: Discharge, 1,210 cfs Dec. 6 (gage height, 5.61 ft, from floodmarks).
1959 to November 1966: Discharge, 1,600 cfs Sept. 18, 1963 (gage height, 6.37 ft, from floodmarks).

5. (4036) KANAB CREEK NEAR KANAB, UTAH

[Crest-stage station]

Location. Lat 37°06′, long 112°33′, in SW¼ sec. 5, T. 43 S., R. 6 W., at upstream edge left bridge pier on U.S. Highway 89, 300 feet above Tiny Canyon and 3½ miles north of Kanab.
Drainage area. 198 sq mi.
Gage-height record. Crest stages only. Altitude of gage is about 5,030 ft (from U.S. Geol. Survey topographic map, Cedar Ctiy, Utah).
Discharge record. Stage-discharge relation defined by current-meter measurements below 31 cfs and by slope-area measurement at 1,230 cfs.
Maxima. December 1966: Discharge, 1,230 cfs Dec. 6 (gage height, 14.40 ft, high-water mark on bridge pier).
1959 to November 1966: Discharge, 3,030 cfs Sept. 8, 1961 (gage height, 15.70 ft, high-water mark on bridge pier).

6. (4037) JOHNSON WASH NEAR KANAB, UTAH

[Crest-stage station]

Location. Lat 37°02′, long 112°21′, in SE¼ sec. 24, T. 43 S., R. 5 W., on left bank 1.2 miles north of U.S. Highway 89 and 11 miles east of Kanab.
Drainage area. 237 sq mi.
Gage-height record. Crest stages only. Altitude of gage is about 5,000 ft (from U.S. Geol. Survey topographic map, Cedar City, Utah).
Discharge record. Stage-discharge relation defined by current-meter measurements below 107 cfs and by culvert measurement at 1,540 cfs.
Maxima. December 1966: Discharge, 1,700 cfs Dec. 6 (gage height, 16.00 ft, from floodmarks).
1959 to November 1966: Discharge, 1,540 cfs Oct. 18, 1963 (gage height, 17.11 ft, high-water mark at gage 1¼ miles downstream).

VIRGIN RIVER BASIN

7. (4044.5) EAST FORK VIRGIN RIVER NEAR GLENDALE, UTAH

[Gaging station]

Location. Lat 37°20′20″, long 112°36′10″, in NE¼NW¼ sec. 14, T. 40 S., R. 7 W., 50 ft downstream from Lydia's Creek, 1½ miles north of the town of Glendale on U.S. Highway 89.
Drainage area. 74 sq mi, approximately.
Gage-height record. Water-stage recorder graph. Altitude of gage is 5,900 ft (from topographic map).
Discharge record. Stage-discharge relation defined by current-meter measurements below 37 cfs and by slope-area measurement at 450 cfs.

Maxima. December 1966: Discharge, 450 cfs Dec. 6 (gage height, 3.40 ft, from high-water profile).

Remarks. Station established November 3, 1966.

Mean discharge, in cubic feet per second, December 1966

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1	15	9	22	17	17	25	17
2	15	10	20	18	18	26	18
3	33	11	19	19	18	27	18
4	25	12	18	20	18	28	18
5	78	13	18	21	18	29	18
6	239	14	18	22	17	30	18
7	84	15	18	23	17	31	18
8	33	16	17	24	17		

Monthly mean discharge, in cubic feet per second	30.2
Runoff, in acre-feet	1,860

Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1966

Hour	Gage height	Discharge	Hour	Gage height	Discharge	Hour	Gage height	Discharge
Dec. 2			*Dec. 5*—Con.			*Dec. 7*—Con.		
2400	1.11	15	2200	2.46	215	0900	1.16	60
Dec. 3			2300	2.47	217	1100	1.04	58
0400	1.22	20	2400	2.38	198	1700	.88	52
0800	1.21	20	*Dec. 6*			2400	.77	40
1300	1.35	30	0230	2.17	156	*Dec. 8*		
1600	1.58	55	0500	2.27	174	1000	.65	30
1800	1.52	49	0700	2.30	180	1500	.73	40
2100	1.48	44	1000	2.45	213	1515	.77	40
2300	1.59	57	1015	2.55	236	1530	.73	35
2400	1.54	51	1100	2.42	206	1700	.72	34
Dec. 4			1245	2.70	270	2400	.63	25
0400	1.36	30	1400	2.32	184	*Dec. 9*		
1000	1.23	20	1600	2.75	282	1100	.50	18
1500	1.24	21	1700	2.90	318	1600	.60	24
2100	1.22	20	1730	3.40	450	1800	.60	24
2400	1.27	23	1800	2.93	326	2400	.54	20
Dec. 5			1900	2.85	306	*Dec. 10*		
0100	1.28	24	2000	3.03	350	0600	.50	18
0700	1.25	22	2400	2.67	263	1200	.50	18
0900	1.29	25	*Dec. 7*			1800	.56	22
1400	1.79	84	0100	2.60	247	1830	.62	26
1700	1.85	95	0300	2.17	174	2000	.58	23
1900	1.97	115	0600	1.48	75	2400	.54	20

8. (4045) MINERAL GULCH NEAR MT. CARMEL, UTAH

[Crest-stage station]

Location. Lat 37°14′, long 112°44′, in NW¼ sec. 22, T. 41 S., R. 8 W., on left bank 150 ft below bridge on State Highway 15, 3¼ miles west of Mount Carmel Junction and 6 miles southwest of Orderville.

Drainage area. 7.6 sq mi, approximately.

Gage-height record. Crest stages only. Altitude of gage is about 5,620 ft (from U.S. Geol. Survey topographic map, Cedar City, Utah).

Discharge record. Stage-discharge relation defined by current-meter measurements below 43 cfs and by slope-area measurement at 3,210 cfs.

Maxima. December 1966: Discharge, 500 cfs Dec. 6 (gage height, 12.03 ft). 1959 to November 1966: Discharge, 3,210 cfs Aug. 18, 1963 (gage height, 19.69 ft, from high-water profile).

9. (4055) NORTH FORK VIRGIN RIVER NEAR SPRINGDALE, UTAH

[Gaging station]

Location. Lat 37°12'35", long 112°58'40", in SW¼NW¼ sec. 22, T. 41 S., R. 10 W., on right bank in Zion National Park, 0.2 mile downstream from point of diversion on Springdale Canal, 0.4 mile downstream from Pine Creek, and 1.9 miles northeast of Springdale.

Drainage area. 350 sq mi, approximately.

Gage-height record. Water-stage recorder graph except 1700 Dec. 6 to 1450 Dec. 12 for which graph was reconstructed for balance of Dec. 6 on basis of high-water mark in gage house. Altitude of gage is 3,970 ft (from topographic map).

Discharge record. Stage-discharge relation defined by current-meter measurements below 2,500 cfs and by slope-area measurement at 5,880 cfs.

Maxima. December 1966: Discharge, 9,150 cfs Dec. 6 (gage height, 12.98 ft, from high-water mark in gage house).

1913–14; 1923; 1925 to November 1966: Discharge, 7,000 cfs Mar. 3, 1938 (gage height, 12.29 ft, from floodmark).

Mean discharge, in cubic feet per second, December 1966

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1	45	9	120	17	63	25	44
2	46	10	98	18	63	26	55
3	146	11	90	19	60	27	48
4	83	12	94	20	59	28	38
5	1,060	13	81	21	58	29	35
6	4,990	14	77	22	52	30	52
7	1,000	15	67	23	46	31	48
8	400	16	63	24	45		

Monthly mean discharge, in cubic feet per second 297
Runoff, in acre-feet 18,270

Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1966

Hour	Gage height	Discharge	Hour	Gage height	Discharge	Hour	Gage height	Discharge
Dec. 2			*Dec. 4*—Con.			*Dec. 5*—Con.		
2400	1.20	44	0800	1.54	78	2100	6.45	2,300
Dec. 3			1400	1.34	53	2130	7.15	2,840
0230	1.25	50	1900	1.26	44	2230	6.25	2,160
0315	1.34	60	2200	1.26	44	2300	5.42	1,580
0330	1.70	107	2300	1.31	50	2330	5.65	1,740
0500	1.83	126	2310	1.50	73	2400	6.50	2,340
0515	2.20	190	2320	1.80	114	*Dec. 6*		
0600	2.80	324	2300	2.00	145	0200	8.88	4,370
0730	2.20	188	2400	2.12	166	0215	8.46	3,960
0900	1.77	116	*Dec. 5*			0300	9.52	5,030
1000	1.63	96	0130	2.01	147	0400	9.20	4,690
1130	1.52	81	0230	2.40	220	0415	9.51	5,020
1500	1.52	80	0330	2.54	250	0500	9.05	5,540
1515	1.85	126	0600	2.36	212	0600	9.62	5,140
1530	2.69	292	0730	2.57	257	0615	8.96	4,450
1545	2.60	268	0845	2.55	252	0800	8.80	4,290
1600	2.72	296	1000	2.80	311	0900	7.81	3,380
1730	2.00	149	1045	3.15	412	0930	8.44	3,950
1800	2.27	198	1130	3.69	616	1000	7.86	3,420
1930	2.18	179	1300	3.49	534	1200	9.25	4,740
2000	2.20	183	1400	4.40	966	1300	8.00	3,550
2215	1.90	131	1510	5.30	1,510	1430	9.98	5,550
2245	2.30	202	1700	5.55	1,690	1800	12.98	9,150
2300	2.82	316	1800	6.55	2,390	2000	10.0	5,570
2400	2.47	235	1900	7.19	2,870	2400	8.0	3,550
Dec. 4			2000	7.09	2,790			
0200	1.97	140	2030	6.45	2,300			
0400	1.76	108	2045	6.62	2,420			

10. (4060) VIRGIN RIVER AT VIRGIN, UTAH

[Gaging station]

Location. Lat 37°11'55", long 113°12'25", in NW¼NE¼ sec. 28, T. 41 S., R. 12 W., on right bank 1.1 miles west of Virgin and 2.3 miles downstream from North Creek.

Drainage area. 934 sq mi.

Gage-height record. Water-stage recorder graph. Altitude of gage is 3,440 ft (from topographic map).

Discharge record. Stage-discharge relation defined by current-meter measurements below 900 cfs and by slope-area measurement at 22,800 cfs.

Maxima. December 1966: Discharge, 22,800 cfs Dec. 6 (gage height, 13.90 ft, from high-water mark in gage well, 14.00 ft, from high-water mark on cliff at gage, 18.00 ft from outside high-water mark at right bank overflow).

1909 to November 1966: Discharge, 13,500 cfs Mar. 3, 1938, Sept. 17, 1961 (maximum gage height, 13.29 ft, Sept. 17, 1961).

Mean discharge, in cubic feet per second, December 1966

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1	126	9	349	17	142	25	121
2	126	10	241	18	145	26	130
3	332	11	214	19	145	27	130
4	270	12	195	20	142	28	115
5	2,000	13	183	21	140	29	108
6	9,670	14	175	22	130	30	117
7	3,130	15	158	23	126	31	121
8	725	16	150	24	119		

Monthly mean discharge, in cubic feet per second	648
Runoff, in acre-feet	39,820

Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1966

Hour	Gage height	Discharge	Hour	Gage height	Discharge	Hour	Gage height	Discharge
Dec. 2			*Dec. 5*—Con.			*Dec. 7*		
2400	0.97	123	1500	3.18	1,330	0300	8.00	5,850
Dec. 3			1630	3.13	1,290	0800	6.00	3,670
0800	1.05	142	1800	4.45	2,360	1200	4.46	2,180
0900	1.65	366	1900	5.28	3,030	1430	4.35	2,000
1000	2.29	729	2000	6.10	3,840	1800	3.82	1,440
1300	1.53	344	2100	8.50	6,420	2400	3.53	1,160
1500	1.25	232	2200	9.50	7,830	*Dec. 8*		
1900	1.13	192	2300	9.95	8,460	0600	3.25	901
2000	1.80	473	2400	9.50	7,830	1300	2.94	635
2200	2.17	676	*Dec. 6*			1900	2.80	515
2230	2.58	926	0230	6.95	4,700	2200	2.75	463
2330	2.15	664	0400	9.50	7,830	2400	2.75	453
2400	2.50	876	0630	10.70	9,550	*Dec. 9*		
Dec. 4			0730	10.40	9,100	0300	2.73	433
0030	2.63	958	0930	13.79	14,320	0600	2.71	413
0300	1.90	525	0945	11.87	11,300	1300	2.59	339
1200	1.40	288	1000	10.50	9,250	2100	2.36	257
2400	1.15	198	1400	9.60	7,970	2400	2.37	257
Dec. 5			1700	10.30	8,950	*Dec. 10*		
0600	1.50	330	1900	11.35	10,520	0600	2.40	265
0900	2.00	579	2030	18.00	22,800	2030	2.25	211
1100	2.45	845	2200	11.00	10,000	2400	2.30	228
1230	2.78	1,060	2400	9.50	7,830			
1400	2.93	1,150						

11. (4063) KANARRA CREEK AT KANARRAVILLE, UTAH

[Gaging station]

Location. Lat 37°32'20", long 113°10'15", in SE¼NW¼ sec. 35, T. 37 S., R. 12 W., on left bank 400 ft upstream from mouth of canyon and half a mile northeast of Kanarraville.

Drainage area. 10.0 sq mi.

Gage-height record. Water-stage recorder graph. Altitude of gage is 5,660 ft (from topographic map).

Discharge record. Stage-discharge relation defined by current-meter measurements below 37 cfs and by slope-area measurement at 528 cfs.

Maxima. December 1966: Discharge, 24 cfs Dec. 6 (gage height, 0.95 ft).
1959 to November 1966: Discharge 555 cfs Aug. 1, 1963 (gage height, 3.28 ft, from outside floodmark).

Mean discharge, in cubic feet per second, December 1966

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1	1.9	9	2.4	17	2.0	25	2.0
2	1.9	10	2.3	18	2.0	26	2.0
3	2.9	11	2.3	19	2.0	27	2.0
4	2.4	12	2.1	20	2.0	28	2.0
5	2.8	13	2.1	21	1.9	29	2.0
6	8.8	14	2.1	22	2.0	30	2.0
7	4.5	15	2.1	23	2.0	31	2.3
8	2.5	16	2.0	24	2.0		

Monthly mean discharge, in cubic feet per second	2.43
Runoff, in acre-feet	149

Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1966

Hour	Gage height	Discharge	Hour	Gage height	Discharge	Hour	Gage height	Discharge
Dec. 2			*Dec. 4*—Con.			*Dec. 7*		
2400	0.52	1.9	1400	0.56	2.7	1100	0.57	4.0
Dec. 3			2100	.54	2.3	1700	.56	3.7
0200	.58	3.1	2400	.55	2.4	2400	.52	2.7
0400	.55	2.4	*Dec. 5*			*Dec. 8*		
1100	.54	2.3	1100	.54	2.3	0600	.50	2.3
1300	.56	2.7	1800	.58	3.1	1200	.50	2.3
1400	.54	2.3	2000	.62	4.3	1600	.53	2.9
1445	.59	3.4	2030	.62	4.3	1900	.53	2.9
1500	.71	7.4	2100	.60	3.7	2400	.51	2.4
1600	.58	3.1	2400	.60	3.7	*Dec. 9*		
2000	.57	2.9	*Dec. 6*			0300	.50	2.3
2130	.63	4.6	1000	.61	4.0	1000	.62	2.3
2300	.58	3.1	1400	.73	8.2	1200	.63	2.7
2400	.59	3.4	1730	.89	19.0	1230	.54	2.9
Dec. 4			1900	.83	15.0	1800	.51	2.4
0500	.53	2.1	2000	.95	24.0	2400	.50	2.3
1000	.52	1.9	2200	.78	12.0	*Dec. 10*		
			2400	.68	7.4	2400	.50	2.3

12. (4067) SOUTH ASH CREEK BELOW MILL CREEK, NEAR PINTURA, UTAH

[Gaging station]

Location. Lat 37°21'50", long 113°20'00", in SW¼SW¼SE¼ sec. 29, T. 39 S., R. 13 W., on right bank 150 ft downstream from confluence of Mill Creek and Harmon Creek, and 3½ miles northwest of Pintura.

Drainage area. 11.0 sq mi.

Gage-height record. Water-stage recorder graph except Dec. 1–14. Altitude of gage is 5,290 ft (from topographic map).

Discharge record. Stage-discharge relation defined by current-meter measurements below 18 cfs and by slope-area measurement at 1,910 cfs.

Maxima. December 1966: Discharge, 1,910 cfs Dec. 6 (gage height, 5.83 ft, from outside floodmarks).

August to November 1966: Discharge, 4.2 cfs Sept. 19, 1966 (gage height, 1.03 ft).

Mean discharge, in cubic feet per second, December 1966

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1	[1] 0.6	9	[1] 20	17	8.0	25	5.8
2	[1] 1.6	10	[1] 15	18	7.6	26	5.8
3	[1] 2.5	11	[1] 12	19	7.3	27	5.2
4	[1] 2.1	12	[1] 10	20	7.1	28	4.8
5	[1] 2.5	13	[1] 9.5	21	6.9	29	5.2
6	[1] 350	14	[1] 9.2	22	6.5	30	4.9
7	[1] 30	15	9.0	23	6.3	31	4.8
8	[1] 25	16	8.6	24	6.1		

[1] Estimated.

13. (4068) SOUTH ASH CREEK NEAR PINTURA, UTAH

[Crest-stage station]

Location. Lat 37°21′, long 113°17′, in NE¼ sec. 11, T. 40 S., R. 13 W., 0.9 mile south of Pintura and 3.4 miles north of Anderson Junction.

Drainage area. 14.0 sq mi.

Gage-height record. Crest stages only. Altitude of gage is about 4,100 ft (from U.S. Geol. Survey topographic map, Cedar City, Utah).

Discharge record. Stage-discharge relation defined by current-meter measurements below 58 cfs and by slope-area measurement at 938 cfs.

Maxima. December 1966: Discharge, 985 cfs Dec. 6 (gage height, 13.54 ft).

1959 to November 1966: Discharge, 938 cfs Dec. 30, 1965 (gage height, 13.43 ft, from high-water profile).

14. (4080) LEEDS CREEK NEAR LEEDS, UTAH

[Gaging station]

Location. Lat 37°15′55″, long 113°22′05″, in NE¼SE¼ sec. 36, T. 40 S., R. 14 W., on right bank 150 ft upstream from Leeds Ditch diversion, 2 miles north of Leeds, and 4 miles upstream from mouth.

Drainage area. 15.5 sq mi.

Gage-height record. Water-stage recorder graph. Altitude of gage is 4,000 ft (from topographic map).

Discharge record. Stage-discharge relation defined by current-meter measurements below 47 cfs and by slope-area measurement at 2,980 cfs.

Maxima. December 1966: Discharge, 2,050 cfs Dec. 6 (gage height, 5.33 ft from outside floodmarks).

1915, 1917–19, 1920, 1964 to November 1966: Discharge, 2,980 cfs Aug. 12, 1964 (gage height, 6.00 ft).

Mean discharge, in cubic feet per second, December 1966

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1	2.6	9	18	17	10	25	9.1
2	2.6	10	14	18	9.9	26	9.1
3	4.0	11	12	19	9.7	27	8.6
4	3.2	12	12	20	9.5	28	8.0
5	71	13	12	21	9.5	29	8.4
6	412	14	11	22	9.5	30	8.4
7	66	15	10	23	9.3	31	7.6
8	28	16	10	24	9.3		

Monthly mean discharge, in cubic feet per second 26.6
Runoff, in acre-feet 1,630

Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1966

Hour	Gage height	Discharge	Hour	Gage height	Discharge	Hour	Gage height	Discharge
Dec. 2			*Dec. 6*			*Dec. 7*		
2400	0.51	2.8	0230	3.63	529	0100	2.35	182
Dec. 3			0300	3.47	456	0300	1.92	108
0600	.62	4.6	0330	3.97	726	0600	1.66	69
1300	.56	3.6	0430	3.47	431	0900	1.56	57
1800	.61	4.5	0530	3.97	726	1200	1.50	51
2400	.58	3.9	0620	4.74	1,370	2400	1.34	38
Dec. 4			0640	4.34	1,000	*Dec. 8*		
0600	.54	3.2	0730	5.33	2,050	1200	1.18	27
2000	.52	2.9	0830	4.01	752	2400	1.06	21
2400	.56	3.6	0900	3.97	726	*Dec. 9*		
Dec. 5			1030	2.32	141	0800	1.03	18
0900	.68	5.7	1130	2.57	193	1200	.98	17
1200	.85	8.9	1230	2.24	135	1700	.99	17
1700	1.39	25	1400	2.24	139	2400	.93	15
1900	2.55	180	1600	2.47	182	*Dec. 10*		
2000	2.74	226	1630	3.30	394	0600	.92	14
2200	3.43	439	1800	2.37	160	1300	.92	14
2300	2.49	170	1830	2.48	185	2400	.90	13
2400	2.49	170	1900	2.32	156			
			1930	3.56	216			
			2400	1.80	89			

15. (4081.5) VIRGIN RIVER NEAR HURRICANE, UTAH

[Miscellaneous site]

Location. Lat 37°09'45", long 113°23'40", in NE¼SW¼ sec. 2, T. 42 S., R. 14 W., 1.8 miles downstream from Quail Creek, 6¼ miles west of Hurricane and 15 miles northeast of St. George.

Drainage area. 1,530 sq mi, approximately.

Discharge record. Peak discharge by slope-area measurement.

Maximum. December 1966: Discharge, 20,100 cfs Dec. 6.

Remarks. Recording station 4081.5 Virgin River near Hurricane, Utah was established at this site Mar. 20, 1967 and gage height of peak flow on Dec. 6, 1966 was 27.34 ft, from high-water profile.

16. (4082) FORT PIERCE WASH NEAR ST. GEORGE, UTAH

[Crest-stage station]

Location. Lat 37°03'35", long 113°32'40", in SW¼ sec. 9, T. 43 S., R. 15 W., on right bank 3½ miles southeast of St. George and 5½ miles southwest of Washington.

Drainage area. 1,650 sq mi, approximately.

Gage-height record. Crest stages only. Altitude of gage is about 2,600 ft (from topographic map.

Discharge record. Stage-discharge relation defined by current-meter measurements below 738 cfs and by slope-area measurement at 8,760 cfs.

Maxima. December 1966: Discharge, 1,000 cfs Dec. 6 (gage height, 13.68 ft, from floodmark).

1959 to November 1966: Discharge, 8,760 cfs Aug. 14, 1964 (gage height, 17.23 ft, from floodmarks).

17. (4084) SANTA CLARA RIVER NEAR PINE VALLEY, UTAH

[Gaging station]

Location. Lat 37°23'00", long 113°28'55", in NE¼ sec. 24, T. 39 S., R. 15 W., in Dixie National Forest, on right bank 150 ft upstream from highway bridge, 0.6 mile downstream from Pine Valley Reservoir, 1.6 miles southeast of town of Pine Valley, and 2½ miles upstream from Grass Valley Creek.

Drainage area. 18.7 sq mi.

Gage-height record. Water-stage recorder graph. Altitude of gage is 6,700 ft (from topographic map).

Discharge record. Stage-discharge relation defined by current-meter measurements below 66 cfs and by culvert measurement at 776 cfs.

Maxima. December 1966: Discharge, 776 cfs Dec. 6 (gage height, 6.85 ft, from high-water profile).

1959 to November 1966: Discharge, 340 cfs Nov. 6, 1960 (gage height, 4.86 ft).

Remarks. Floodflow slightly affected by Pine Valley Reservoir.

Mean discharge, in cubic feet per second, December 1966

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1	1.9	9	38	17	11	25	6.5
2	1.9	10	29	18	9.6	26	6.5
3	2.6	11	22	19	8.9	27	6.2
4	2.3	12	19	20	8.2	28	6.5
5	14	13	16	21	7.8	29	6.2
6	397	14	14	22	7.4	30	6.2
7	178	15	13	23	7.2	31	5.8
8	67	16	12	24	6.7		

Monthly mean discharge, in cubic feet per second	30.3
Runoff, in acre-feet	1,860

Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1966

Hour	Gage height	Discharge	Hour	Gage height	Discharge	Hour	Gage height	Discharge
Dec. 2			*Dec. 5*—Con.			*Dec. 6*—Con.		
2400	1.20	2.1	2000	2.15	26.0	2215	5.08	378
Dec. 3			2400	2.98	95.0	2400	4.88	346
0500	1.28	2.7	*Dec. 6*			*Dec. 7*		
1100	1.24	2.4	0300	4.00	220	0600	3.90	210
1700	1.25	2.5	0500	4.15	240	1200	3.48	156
2200	1.33	3.1	0630	4.98	359	1800	3.22	125
2400	1.30	2.8	0730	4.98	359	2400	2.97	96
Dec. 4			0830	5.24	402	*Dec. 8*		
0600	1.24	2.4	0930	5.13	383	1200	2.64	63
1200	1.22	2.2	1130	5.50	450	2400	2.45	47
2400	1.22	2.2	1300	5.21	397	*Dec. 9*		
Dec. 5			1530	5.94	543	1200	2.30	36
1000	1.25	2.5	1600	5.83	519	1700	2.30	36
1500	1.39	3.6	1730	6.16	595	2400	2.25	33
1700	1.50	4.9	1830	6.85	776	*Dec. 10*		
			2030	5.50	452	2400	2.12	25

18. (4095) MOODY WASH NEAR VEYO, UTAH

[Gaging station]

Location. Lat 37°26'00", long 113°44'30", in SE¼ sec. 34, T. 38 S., R. 17 W., on left bank 200 ft downstream from Bellas Canyon and 7 miles northwest of Veyo.

Drainage area. 33 sq mi, approximately.

Gage-height record. Water-stage recorder graph except Dec. 7–31. Altitude of gage is 4,800 ft (from topographic map).

Discharge record. Stage-discharge relation defined by current-meter measurements below 160 cfs and by slope-area measurement at 1,400 cfs.

Maxima. December 1966: Discharge, 1,810 cfs Dec. 6 (gage height, 9.75 ft).
1954 to November 1966: Discharge, 1,400 cfs Sept. 17, 1961 (gage height, 8.60 ft).

Mean discharge, in cubic feet per second, December 1966

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1	0.13	9	25	17	2.5	25	2.1
2	.13	10	18	18	2.5	26	2.1
3	.33	11	13	19	2.4	27	2.0
4	.26	12	9.0	20	2.4	28	2.0
5	87	13	7.0	21	2.3	29	1.9
6	720	14	5.0	22	2.3	30	1.9
7	120	15	4.0	23	2.2	31	1.8
8	45	16	3.0	24	2.2		

Monthly mean discharge, in cubic feet per second	35.1
Runoff, in acre-feet	2,160

Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1966

Hour	Gage height	Discharge	Hour	Gage height	Discharge	Hour	Gage height	Discharge
Dec. 2			*Dec. 4*			*Dec. 6*—Con.		
2400	1.58	0.15	2000	1.61	0.21	0400	5.30	456
Dec. 3			2300	1.65	.32	0500	4.59	316
0100	1.60	.15	2400	1.68	.42	0600	4.86	366
0300	1.60	.19	*Dec. 5*			0800	4.48	297
0500	1.63	.26	0330	1.75	.83	0900	4.80	355
1330	1.61	.21	0800	1.75	.83	1000	5.70	546
1400	1.62	.23	1115	1.83	1.8	1030	5.87	587
1900	1.61	.21	1130	2.08	9.4	1130	5.62	528
1930	1.92	3.7	1500	2.59	52	1230	5.96	605
2000	1.75	.83	1700	3.22	119	1300	5.76	560
2100	1.68	.42	2100	4.27	262	1500	6.80	830
2300	1.65	.32	2400	5.20	435	1700	9.75	1,810
2400	1.64	.29	*Dec. 6*			1800	8.30	1,280
			0100	5.36	469	2100	7.15	930
			0200	5.74	556	2400	6.50	748
			0300	5.67	539			

19. SANTA CLARA RIVER AT BAKER DAM, NEAR CENTRAL, UTAH

[Miscellaneous site]

Location. Lat 37°22'35", long 113°38'25", in sec. 22, T. 39 S., R. 16 W., at Baker Dam 1.5 miles downstream from Kane Spring Canyon and 2.5 miles south of Central.

Drainage area. 108 sq mi, approximately.

Discharge record. Peak discharge by flow over dam measurement.

Maximum. December 1966: Discharge, 2,080 cfs Dec. 6.

20. (4100) SANTA CLARA RIVER ABOVE WINSOR DAM, NEAR SANTA CLARA, UTAH

[Gaging station]

Location. Lat 37°13′, long 113°47′, near center of sec. 17, T. 41 S., R. 17 W., on right bank 2 miles upstream from Winsor Dam, 2½ miles downstream from Sandy Wash, 8 miles downstream from Magotsu Creek, and 9 miles northwest of Santa Clara.

Drainage area. 338 sq mi, approximately.

Gage-height record. Water-stage recorder graph except Dec. 8–31. Altitude of gage is 3,340 ft (by barometer).

Discharge record. Stage-discharge relation defined by current-meter measurements below 1,560 cfs and by slope-area measurement at 5,930 cfs.

Maxima. December 1966: 5,930 cfs Dec. 6 (gage height, 10.88 ft, from floodmarks).

1942 to November 1966: Discharge, 6,190 cfs Aug. 24, 1955 (gage height, 10.25 ft).

Remarks. Many diversions for irrigation above station.

Mean discharge, in cubic feet per second, December 1966

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1	6.6	9	100	17	27	25	16
2	6.9	10	60	18	25	26	14
3	8.9	11	45	19	24	27	17
4	9.9	12	38	20	23	28	14
5	97	13	35	21	22	29	17
6	1,680	14	32	22	21	30	14
7	1,750	15	30	23	20	31	12
8	170	16	28	24	18		

Monthly mean discharge, in cubic feet per second	141
Runoff, in acre-feet	8,690

Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1966

Hour	Gage height	Discharge	Hour	Gage height	Discharge	Hour	Gage height	Discharge
Dec. 2			*Dec. 5*—Con.			*Dec. 6*—Con.		
2400	1.65	7.1	1430	2.18	31	1930	8.58	2,870
Dec. 3			1630	1.90	16	2100	8.10	2,410
0500	1.68	8.0	1930	1.85	14	2130	8.35	2,640
1200	1.67	7.7	2000	3.50	186	2200	9.99	4,440
1800	1.68	8.0	2100	4.25	348	2300	10.88	5,930
2000	1.68	8.0	2230	4.97	574	2400	10.10	4,570
2200	1.78	11	2400	5.68	852	*Dec. 7*		
2300	2.10	26	*Dec. 6*			0015	9.95	4,390
2400	1.88	15	0230	6.11	1,060	0130	9.11	3,420
Dec. 4			0300	5.98	995	0230	9.33	3,650
0200	1.75	10	0430	6.51	1,270	0300	9.23	3,540
0300	1.74	9.7	0530	6.49	1,250	0400	8.93	3,220
0330	1.77	11	0600	6.33	1,170	0600	7.81	2,180
1200	1.72	9.1	0630	6.63	1,340	1100	6.58	1,310
1500	1.73	9.4	0930	5.68	852	1700	5.97	995
2000	1.72	9.1	1100	5.43	752	2400	5.51	788
2400	1.73	9.4	1300	5.36	724			
Dec. 5			1400	5.73	872			
1100	1.75	10	1500	6.38	1,200			
1400	1.82	13	1700	6.83	1,460			

21. (4104) SANTA CLARA RIVER NEAR SANTA CLARA, UTAH

[Gaging station]

Location. Lat 37°08'20", long 113°41'30", in SW¼ sec. 7, T. 42 S., R. 16 W., on left bank 1 mile downstream from Whitmore Canyon, and 2 miles west of Santa Clara.

Drainage area. 410 sq mi, approximately.

Gage-height record. Water-stage recorder graph except Dec. 11–31. Altitude of gage is 2,850 ft (from topographic map).

Discharge record. Stage-discharge relation defined by current-meter measurements below 453 cfs and by slope-area measurement at 6,390 cfs.

Maxima. December 1966: Discharge, 6,390 cfs Dec. 7 (gage height, 12.30 ft, from inside floodmark, 12.60 ft, from outside floodmark).

May 1965 to November 1966: Discharge, 1,260 cfs Dec. 30, 1965 (gage height, 6.87 ft).

Remarks. Many diversions for irrigation above station.

Mean discharge, in cubic feet per second, December 1966

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1	7.8	9	103	17	25	25	14
2	7.8	10	68	18	24	26	12
3	9.0	11	50	19	23	27	8.0
4	13	12	40	20	22	28	12
5	24	13	35	21	21	29	15
6	1,320	14	32	22	20	30	13
7	1,980	15	30	23	18	31	7.2
8	237	16	28	24	16		

Monthly mean discharge, in cubic feet per second 137
Runoff, in acre-feet 8,400

Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1966

Hour	Gage height	Discharge	Hour	Gage height	Discharge	Hour	Gage height	Discharge
Dec. 2			*Dec. 6*—Con.			*Dec. 7*—Con.		
2400	1.33	8.0	0500	6.17	928	1000	7.52	1,600
Dec. 3			0700	6.12	908	1400	5.79	792
0700	1.36	8.9	0730	6.77	1,200	1730	5.05	603
2000	1.37	9.2	1030	7.11	1,380	2100	4.40	460
2400	1.43	11	1100	6.77	1,200	2300	4.12	400
Dec. 4			1200	6.70	1,170	2400	4.05	385
0300	1.40	10	1230	6.13	912	*Dec. 8*		
0330	1.75	24	1330	5.76	783	0500	3.70	315
0800	1.48	13	1500	5.65	750	0530	3.60	296
0930	1.48	13	1600	5.89	826	1000	3.30	239
1900	1.43	11	1700	6.42	1,030	1500	3.07	201
2400	1.45	12	1800	7.57	1,630	1700	2.91	174
Dec. 5			1830	7.69	1,700	2000	2.85	165
0400	1.47	12	1900	7.55	1,620	2400	2.68	138
1100	1.47	12	2000	7.69	1,700	*Dec. 9*		
1530	1.52	14	2100	8.22	2,020	1500	2.35	90
1600	1.80	27	2200	9.74	3,170	1800	2.30	83
1830	1.58	17	2230	10.24	3,640	2000	2.28	81
1900	1.84	29	2300	9.99	3,390	2130	2.34	89
2300	1.65	19	2400	10.26	3,660	2230	2.28	81
2300	2.70	134	*Dec. 7*			2400	2.26	78
2400	3.65	306	0015	9.99	3,390	*Dec. 10*		
Dec. 6			0100	12.60	6,390	1000	2.20	70
0100	4.35	449	0400	10.31	3,710	1930	2.13	61
0200	5.00	592	0515	10.65	4,050	2000	2.17	66
0300	5.52	715	0615	9.99	3,390	2030	2.13	61
0400	6.12	908	0700	9.27	2,800	2400	2.10	57

22. (4150) VIRGIN RIVER AT LITTLEFIELD, ARIZONA

[Gaging station]

Location. Lat 36°53′, long 113°56′, in SW¼SW¼ sec. 4, T. 40 N., R. 15 W., on right bank three-eighths of a mile downstream from Beaver Dam Wash, three-eighths of a mile upstream from Littlefield, and 36 miles upstream from water line of Lake Mead at elevation 1,221 ft above mean sea level.

Drainage area. 5,090 sq mi, approximately.

Gage-height record. Water-stage recorder graph except Dec. 8–12. Datum of gage is 1,763.68 ft above mean sea level, datum of 1929.

Discharge record. Stage-discharge relation defined by current-meter measurements below 15,500 cfs and by slope-area measurement at 35,200 cfs.

Maxima. December 1966: Discharge, 35,200 cfs Dec. 6 (gage height, 15.66 ft). 1929 to November 1966: Discharge, 22,000 cfs Mar. 3, 1938 (gage height, 13.60 ft).

Mean discharge, in cubic feet per second, December 1966

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1	121	9	681	17	247	25	207
2	113	10	600	18	230	26	207
3	117	11	500	19	225	27	204
4	538	12	450	20	233	28	204
5	380	13	340	21	225	29	197
6	14,200	14	334	22	212	30	202
7	15,200	15	291	23	212	31	204
8	1,460	16	267	24	209		

Monthly mean discharge, in cubic feet per second	1,252
Runoff, in acre-feet	76,980

Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1966

Hour	Gage height	Discharge	Hour	Gage height	Discharge	Hour	Gage height	Discharge
Dec. 3			*Dec. 5*—Con.			*Dec. 7*—Con.		
2400	2.32	131	1700	2.69	223	0200	14.00	23,300
Dec. 4			2000	2.68	221	0400	14.18	24,400
0200	2.31	129	2100	3.65	585	0730	15.20	31,500
0300	3.17	378	2400	4.65	1,180	1000	13.65	21,200
0400	3.30	430	*Dec. 6*			1200	11.20	11,100
1000	2.92	289	0300	7.08	3,320	1500	9.50	6,550
1100	4.05	790	0500	8.55	6,180	1900	8.32	3,980
1230	4.39	1,000	0700	8.91	6,580	2400	7.50	2,500
1700	3.97	745	1000	11.00	11,700	*Dec. 8*		
2400	3.24	406	1400	12.50	16,800	0600	7.00	1,800
Dec. 5			1600	12.35	16,200	1700	6.20	1,030
0300	3.10	350	1900	13.25	19,200	2100	6.07	929
0800	3.05	332	2200	15.15	31,100	2400	6.00	880
1030	2.87	274	2300	15.66	35,200	*Dec. 9*		
1200	3.34	446	2400	15.00	30,000	0500	5.94	838
1300	2.90	283	*Dec. 7*			1700	5.48	555
1400	2.65	212	0100	14.98	29,900	2400	5.37	502

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