UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HYDROLOGIC EVALUATION OF THE ALTON RECLAMATION-STUDY SITE, ALTON COAL FIELD, UTAH

Open-File Report 79-346

Prepared in cooperation with the
U.S. Bureau of Land Management
and the U.S. Bureau of Reclamation

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HYDROLOGIC EVALUATION OF THE ALTON RECLAMATION-STUDY SITE, ALTON COAL FIELD, UTAH

By G. W. Sandberg

Open-File Report 79-346

Prepared in cooperation with the
U.S. Bureau of Land Management
and the U.S. Bureau of Reclamation

Salt Lake City, Utah

1979

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS: INCH-POUND TO METRIC

Most values in this report are given in inch-pound units followed by metric units. The conversion factors are shown to four significant figures. In the text, however, the metric equivalents are shown only to the number of significant figures consistent with the accuracy of the value in inch-pound units.

Inch-pound			Metric	
Unit (Multiply)	Abbreviation	(by)	Unit (to obtain)	Abbreviation
Acre		0.4047	Square hectometer	hm^3
		.004047	Square kilometer	km^3
Acre-foot	acre-ft	.001233	Cubic hectometer	hm^3
		1 233	Cubic meter	m^3
Cubic foot per second	ft^3/s	.02832	Cubic meter per second	m^3/s
Foot	ft	.3048	Meter	m
Inch	in.	25.40	Millimeter	mm
		2.540	Centimeter	cm
Mile	mi	1.609	Kilometer	km
Square mile	mi^2	2.590	Square kilometer	km^2

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

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

HYDROLOGIC EVALUATION OF THE ALTON RECLAMATION-STUDY SITE, ALTON COAL FIELD, UTAH

By G. W. Sandberg

ABSTRACT

This investigation was conducted from July 1974 to September 1977 to define general hydrologic conditions at a reclamation-study site in the Alton coal field near Kanab, Utah. The average annual streamflow through the area was less than 600 acre-feet (0.7 cubic hectometer), and the water carried little sediment except during floods which result from intense local storms. Most of the surface water seeps into the ground or is diverted for irrigation downstream from the study area.

Ground-water data were insufficient to define the potentiometric surface in most of the area. The water level in each of the three observation wells in the study area is above the coal layer in the immediate area of the well. A larger network of wells is needed to define the potentiometric surface throughout the area and to show its relation to surface water and the location of the coal layers.

The short period of this investigation coincided with a drought in southern Utah. Hydrologic data should be collected continuously to establish a hydrologic base before mining begins, and data collection should be continued through the periods of mining and reclamation.

INTRODUCTION

The purpose of this investigation was to define general hydrologic conditions in an area of public land leased for the strip mining of coal. The hydrologic investigation was part of a Federally sponsored rehabilitation study conducted by the U.S. Bureau of Land Management, U.S. Bureau of Reclamation, and U.S. Geological Survey. The study was designed to collect data for use in planning rehabilitation of the land after mining is completed.

The study area, which is about 21 mi (34 km) northeast of Kanab, Utah (fig. 1), includes about 2,600 acres (11 km^2) within approximately 27,000 acres (110 km^2) under mining lease. The approximate area of proposed strip mining in the study area is shown in figure 2.

The collection of hydrologic data was started in the study area on July 1, 1974. The data collected from July to November 1974 were included in a preliminary report by the U.S. Bureau of Land Management (1975).

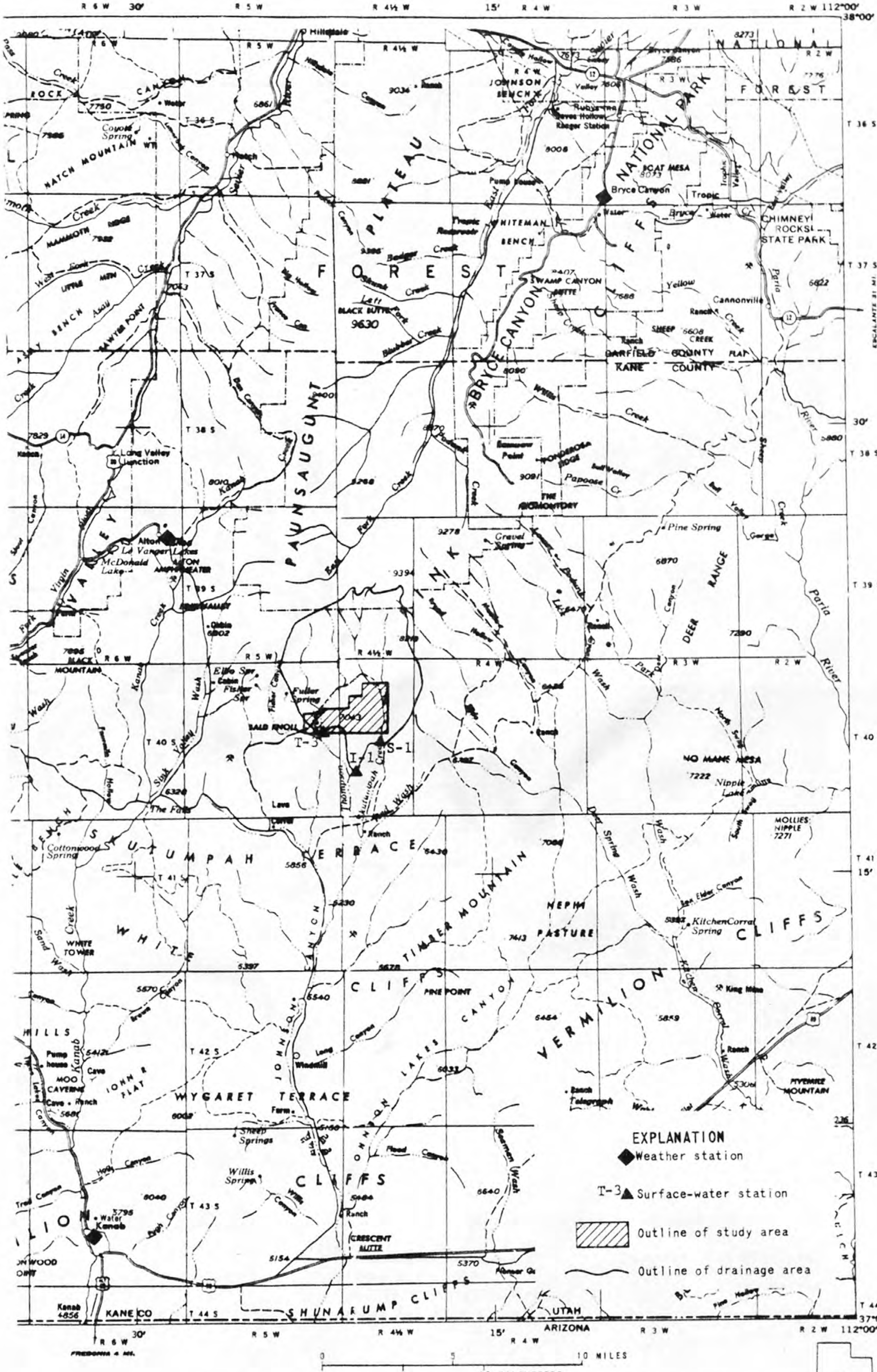
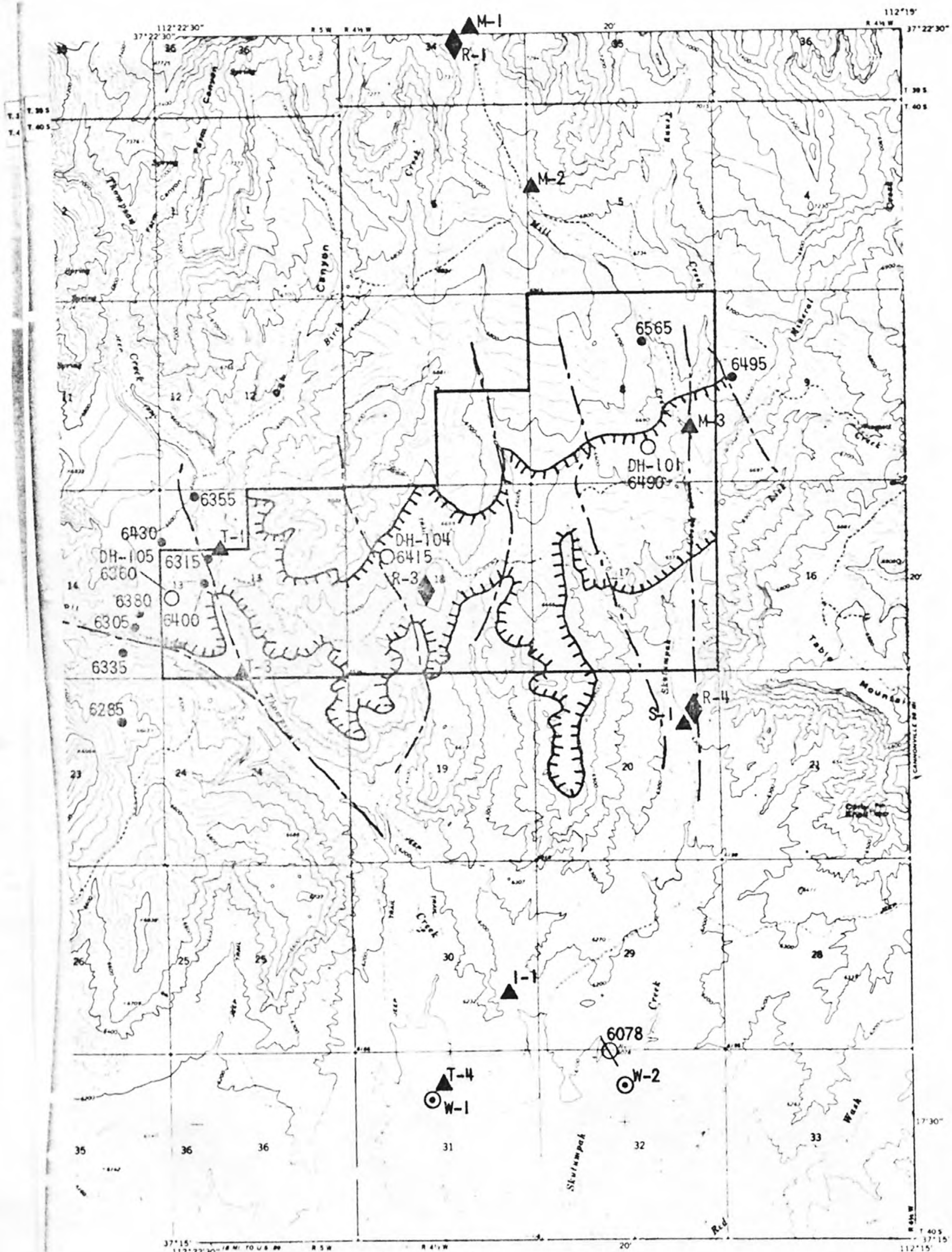


Figure 1.—Map showing location of study area, nearby weather stations, and drainage area of surface-water stations.



Base from U.S. Geological Survey 1:250,000 quadrangle

0 ½ 1 MILE

0 ½ 1 KILOMETER

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

EXPLANATION

M-2 ▲ Surface-water station (discharge, sediment, water quality)

R-3 ♦ Precipitation gage

DH-104 6415 ○ Well drilled by U.S. Bureau of Reclamation

6315 • Well drilled by Utah International, Inc.

W-1 ⊙ Irrigation well

6078 Well equipped with water-level recorder

Letter-number is station, gage, or well designation
Number is altitude of water surface above mean sea level

Outline of study area

Fault, from Utah International, Inc. (written commun., 1975)

Approximate area of proposed strip mining (U.S. Bureau of Land Management, 1975, p. 66)

Figure 2.—Map showing hydrologic-data points, selected geologic faults, and approximate area of proposed strip mining.

This report includes all hydrologic data collected from July 1, 1974, to September 30, 1977. Precipitation and ground-water data were obtained on a monthly basis when the area was accessible. Continuous streamflow data and periodic sediment and water-quality data were obtained at five surface-water stations which were established in 1975 and operated during the 1976 and 1977 water years.[1] The locations of precipitation gages, observations wells, and surface-water stations are shown in figure 2, and the data collected at these sites are included in tables 2-8.

PRECIPITATION

Table 1 shows annual precipitation from 1967 to 1977 at Kanab, Alton, and Bryce Canyon National Park Headquarters, the three long-term weather stations nearest to the study area. The locations of these stations are shown in figure 1. Precipitation at Kanab and Alton was below average during 7 of the 11 years and at Bryce Canyon National Park Headquarters was below average during 6 of the 11 years, reflecting a drought in southern Utah. Precipitation at the three stations for 1977 was lower than for any of the previous 10 years.

---

[1]Water year is the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 1977, is called the "1977 water year."

Table 1.--Precipitation in inches, at Kanab, Alton, and Bryce Canyon National Park Headquarters, 1967-77

(Data from records of U.S. National Weather Service.)

Year	Kanab	Alton	Bryce Canyon National Park Headquarters
1967	14.01	18.74	18.79
1968	9.63	15.87	14.13
1969	20.42	25.82	18.05
1970	10.69	15.79	11.79
1971	10.51	16.79	14.61
1972	10.09	16.33	17.78
1973	11.82	14.56	11.81
1974	10.51	13.17	10.62
1975	13.02	14.45	13.02
1976	9.63	12.24	13.81
1977	7.29	11.53	8.68
1967-77 average	11.60	15.94	13.92

Total precipitation on the study area and its drainage basin is similar during most years to the amounts reported at the nearby weather stations. Variations in the distribution of cloudburst-type storms, however, may result in significant areal variations of precipitation in some years. Such storms, moreover, frequently cause severe local flooding.

Precipitation gages were established in the study area to record local precipitation, which could be correlated with streamflow, sediment, and water-quality records. Locations of the gages are shown in figure 2. The gages were read during the frost-free part of each year, and the data obtained are shown in table 2, together with corresponding data obtained at the three long-term weather stations. The greatest storm intensity recorded was at site R-1 on July 16, 1974, where one-half inch (13 mm) of precipitation was collected in 20 minutes. This amounts to an intensity of 1 1/2 inches (38 mm) per hour.

Table 2.--Precipitation at three sites in the study area and at Kanab, Alton, and Bryce Canyon National Park Headquarters weather stations for selected periods, 1974-77

Date visited	Elapsed time since previous visit (days)	Precipitation (inches): Gages in study area: R-1	R-3	R-4	Long-term weather stations[1]: Kanab	Alton	Bryce Canyon NP Hdq.
1974							
July 16	-	-	-	-	-	-	-
17	1	0.5[2]	-	0.4	Trace	0.04	0.36
19	2	.1	-	0	.02	.09	.06
Aug. 13	24	1.7	1.4	2.1	.47	1.48	2.19
Sept. 18	36	.4	.6	.6	.42	1.49	.57
Oct. 17	29	1.3	1.0	1.3	.48	.90	1.07
Nov. 13	27	3.5	-	-	4.61	3.07	2.25
Total		7.5	-	-	6.00	7.07	6.50
1975							
May 13	-	-	-	-	-	-	-
July 1	49	2.9	-	-	1.42	2.04	1.26
30	29	2.2	2.2	1.9	3.05	3.08	1.45
Aug. 22	23	1.3	1.0	1.5	.47	.81	1.17
Sept. 17	26	1.7	.8	1.0	.22	.56	1.18
Oct. 15	28	.2	.2	.1	.30	.10	.20
Total		8.3	-	-	5.46	6.59	5.26
1976							
July 1	-	-	-	-	-	-	-
Aug. 2	32	1.2	1.1	.9	1.20	2.23	2.17
Sept. 1	30	.1	.2	.2	.16	.11	.26
Oct. 6	35	2.2	2.2	1.9	1.90	1.99	2.10
Total		3.5	3.5	3.0	3.26	4.33	4.53
1977							
Apr. 28	-	-	-	-	-	-	-
May 6	8	0	0	0	-	-	-
25	19	2.5	2.2	2.3	1.06	2.34	2.32
June 18	24	.1	.2	.2	.26	.27	.40
July 22	34	1.3	1.9	1.5	.35	1.43	1.50
Aug. 4	13	.8	.2	.2	.20	1.23	.27
Sept. 6	33	1.2	.7	1.4	.88	1.49	1.95
30	24	.2	.2	.4	.25	.96	.14
Total		6.1	5.4	6.0	3.00	7.72	6.58

[1]Data from records of U.S. National Weather Service.
[2]Recorded in 20 minutes on afternoon of July 16.

SURFACE WATER

Surface-water records were collected at eight sites (fig. 2) during the investigation, and permanent data-collection stations were established at five of the sites at the beginning of the 1976 water year. Continuous streamflow records, monthly water-quality samples, and periodic sediment samples were collected during the 1976 and 1977 water years at the five stations T-1, T-3, M-2, S-1, and I-1. The drainage area upstream from these stations totals about 34 mi^2 (88 km^2), most of which is north of the study area (fig. 1).

Records for water years 1976 and 1977 showed less streamflow than was estimated by channel-geometry measurements, as is shown in the following table:

Station	Average annual streamflow 1976-77 (acre-feet)	Channel-geometry measurements 1974 (acre-feet)
T-1	337	
T-3	340	850[1]
M-2	256	
S-1	250	350[1]
I-1	.86	5

[1]The site was between the two stations.

Continuous streamflow records are more accurate than estimates based on channel-geometry measurements. A more probable explanation of the difference between the two types of measurements, however, is that the channel-geometry method gives a long-term average flow (Moore, 1968), whereas the 1976-77 average shows actual flow. The significantly lower 1976-77 flow shows the effects of drought during those 2 years.

In situ and composite streambed samples were taken after floods in July 1974 at sites T-4 and S-1 (fig. 2). Samples were stored for possible comparison with future streambed samples.

The three drainages in which surface-water data were collected have different flow conditions. Thompson Creek is perennial, with little or no change in channel geometry or flow through the study area; Skutumpah Creek is intermittent, with several tributaries in the study area; and the intermediate drainage is ephemeral, with flow resulting only from summer storms or snowmelt. These conditions, individually or in combination, are probably similar to and representative of surface-water conditions throughout the lease area.

Thompson Creek

Thompson Creek flows in a southerly direction through the western part of the study area. The creek channel is V-shaped along most of its length, and its banks are composed mainly of clay. Lenses of coal crop out in the banks and stream channel near the southern edge of the study area.

Gaging stations were established at sites T-1 and T-3 on Thompson Creek (fig. 2). The drainage area is 9.8 mi^2 (25.4 km^2) for station T-1 and 16.6 mi^2 (43 km^2) for station T-3. Streamflow through the study area showed little change between stations during the 1976 and 1977 water years (tables 3 and 4). Average annual flow was 337 acre-ft (0.416 hm^3) at station T-1 and 340 acre-ft (0.419 hm^3) at station T-3, less than half the amount determined by channel-geometry measurements.

A comparison of sediment at the two sites is shown in tables 3 and 4. The increase in suspended sediment load at site T-3 is primarily caused by erosion of steep, unstable banks in the reach of the channel between sites T-1 and T-3. The large amount of sediment carried during floods is demonstrated by the presence of "mud balls" in the streambed. These balls, which are as large as 2 ft (0.6 m) in diameter, are formed by small rocks or pieces of debris that roll along the streambed and progressively pick up materials from the streambed and sediment-laden flow until they are too heavy to be moved farther. This phenomenon was not observed in the other streams.

The chemical quality of the water changes with variations in the amount of flow. The dissolved solids generally increased with an increase in flow. The greatest changes were observed during floods in 1974 (table 8).

Skutumpah Creek

Skutumpah Creek flows south through the eastern part of the study area. It is formed by the confluence of Mill Creek, a perennial stream, and Tenny Creek, an intermittent stream, in the northern part of the area. Mill Creek and Skutumpah Creek were considered as a single stream in this study and henceforth are referred to as Skutumpah Creek.

The Skutumpah Creek channel is characterized by vertical banks and a wide streambed in which the normally small stream meanders. The streambed north of the study area is mostly composed of gravel washed from the Wasatch Formation of early Tertiary age about 3.5 mi (5.6 km) upstream. The amount of gravel in the streambed decreases progressively downstream and little reaches the southern boundary of the study area. Coal outcrops were not observed in the streambed.

Gaging stations were established at sites M-2 and S-1 (fig. 2). The distance between the two stations is about 3 mi (4.8 km), with several tributaries entering the channel in this reach. These drainages are usually dry except for intermittent seepage or runoff from snowmelt or thunderstorms. The drainage area is 4.8 mi^2 (12.5 km^2) and 14.8 mi^2 (38.3 km^2) for site S-1.

Water flowed past station M-2 throughout the 1976 and 1977 water years, but the channel was dry much of the time at station S-1 (tables 5 and 6). The flow progressed various distances along the channel before completely seeping into the ground, and observations upstream from station M-2 indicate that seepage loss also occurs in much of that part of the channel. Runoff entering the channel from side drainages did not significantly add to the base flow of the main stream but floods from these drainages added significant amounts of water below station M-2, thus offsetting the channel loss between the two stations. The average annual flow was 256 acre-ft (0.316 hm^3) at station M-2 and 250 acre-ft (0.308 hm^3) at station S-1.

Whether or not water flows as far south as station S-1 is determined mainly by floods in the stream. Some floods scour fine particles from the streambed, allowing flow to seep into the ground, whereas other floods deposit fine particles that seal the streambed and permit flow to continue downstream.

Water in Skutumpah Creek is usually used for irrigation about 2 mi (3.2 km) south of the study area when the water flows that far. When the water is not used for irrigation or when it does not seep into the ground, it joins Thompson Creek about 3 mi (4.8 km) south of the study area.

Water in Skutumpah Creek is usually clear except during rain storms or periods of snowmelt when it contains moderate to large amounts of sediment (tables 5 and 6). When runoff occurs from the tributaries, flow past station S-1 usually contains more sediment than does flow past station M-2.

The quality of water at stations M-2 and S-1 is similar during periods of low flow, but it differs during periods of higher flow. The quality at each station also varies with the amount of flow. This variation is most evident by comparing analyses of samples taken during floods in 1974 with analyses obtained during periods of low flow (table 8).

Tenny Creek contributes more water to the main stream during periods of low flow than does any other tributary. This intermittent flow, originating mostly from seepage, carries a relatively large amount of sediment and differs in chemical quality from flow in the main channel. Instability of the Tenny Creek channel, fineness of sediment, and quality of the seepage water mainly account for these differences. Low flow in the main channel is usually clear above Tenny Creek, but it is turbid below the mouth of Tenny Creek when the latter is flowing. Comparison of dissolved solids during low flow shows 346 mg/L at station M-2, 1,740 mg/L at the mouth of Tenny Creek, and 413 mg/L at station S-1. Two analyses of water from Tenny Creek are shown in table 8.

Intermediate drainage

A relatively large ephemeral drainage in which no flow occurs except during periods of snowmelt or rainstorms lies between Thompson Creek and Skutumpah Creek. Gaging station I-1 (fig. 2) was established on this drainage, at a site chosen for accessibility, nearly 2 mi (3.2 km) south of the study area. Drainage area of this station is 2.5 mi^2 (6.4 km^2). The average annual flow for the period of record was 0.86 acre-ft (0.0011 hm^3).

When flow does occur in this drainage, it carries a significant amount of sediment. There were several periods of flow past station I-1 (table 7) during the 1976 and 1977 water years (table 7), but observers were not present during those periods to collect water samples and determine the actual sediment load in the runoff.

Combined drainage

Skutumpah Creek and the intermediate drainage join Thompson Creek about 3 mi (4.8 km) south of the study area. Flow from the combined drainage is directed thence into Johnson Wash, Kanab Creek, and the Colorado River. Low flow from the combined drainage seeps into the ground or is used for irrigation south of the study area, and it seldom reaches far past the confluence of the three drainages. Floodflow, however, has been observed by local residents more than 20 mi (32.2 km) south of the study area. Based on precipitation records, channel-geometry measurements, and streamflow records of other streams in southern Utah, it was assumed that flow during 1976 and 1977 was below average. During years of average or above-average flow, water from the combined drainage may reach the Colorado River. Increased sediment loads or concentrations of dissolved solids resulting from mining operations, therefore, could affect irrigation-water supplies downstream from the study area and eventually the Colorado River.

Data are not available for the study area concerning possible increases in sediment loads or concentrations of dissolved solids that might result from mining. Studies in strip-mined areas of Kentucky, however, show that chemical degradation was about 12 times faster and sediment loads were as much as 1,000 times larger in stripped areas than in unstripped areas (Collier and others, 1970, p. C30, C45, and C46). Mining operations in the study area should be designed to prevent such increased stream loads from leaving mined areas. Leaving the main streambeds free of mining operations would alleviate much of the effects of mining.

GROUND WATER

Characteristics of ground water occurring in and near the study area remain mostly unknown because of insufficient data. Loss in streamflow in Skutumpah Creek between stations M-2 and S-1 suggests that a close relationship may exist between surface water and ground water in this drainage. Little loss occurs between the two stations on Thompson Creek; consequently, it is likely that little ground-water recharge occurs within the study area from this stream.

The only springs in the Thompson Creek and Skutumpah Creek drainages are north of the study area (Goode, 1966, p. 17, 18).

Observation wells

Three of five core holes drilled by the Bureau of Reclamation in 1974 were cased with 2-in. (5.1 cm) pipe for use as observation wells. These wells, designated DH-101, DH-104, and DH-105 (fig. 2), were the only ones in the study area. Wells DH-101 and DH-105 were drilled only through the top layer of coal; well DH-104 was drilled through a second coal layer approximately 160 ft (48.8 m) below the top layer. Figure 3 shows hydrographs of water-level fluctuations in these wells and the relation of the water surface to the coal layers. The water surface is above the top of the coal in wells DH-101 and DH-105, and above the bottom layer of coal in well DH-104. Fluctuations were small during the period of record.

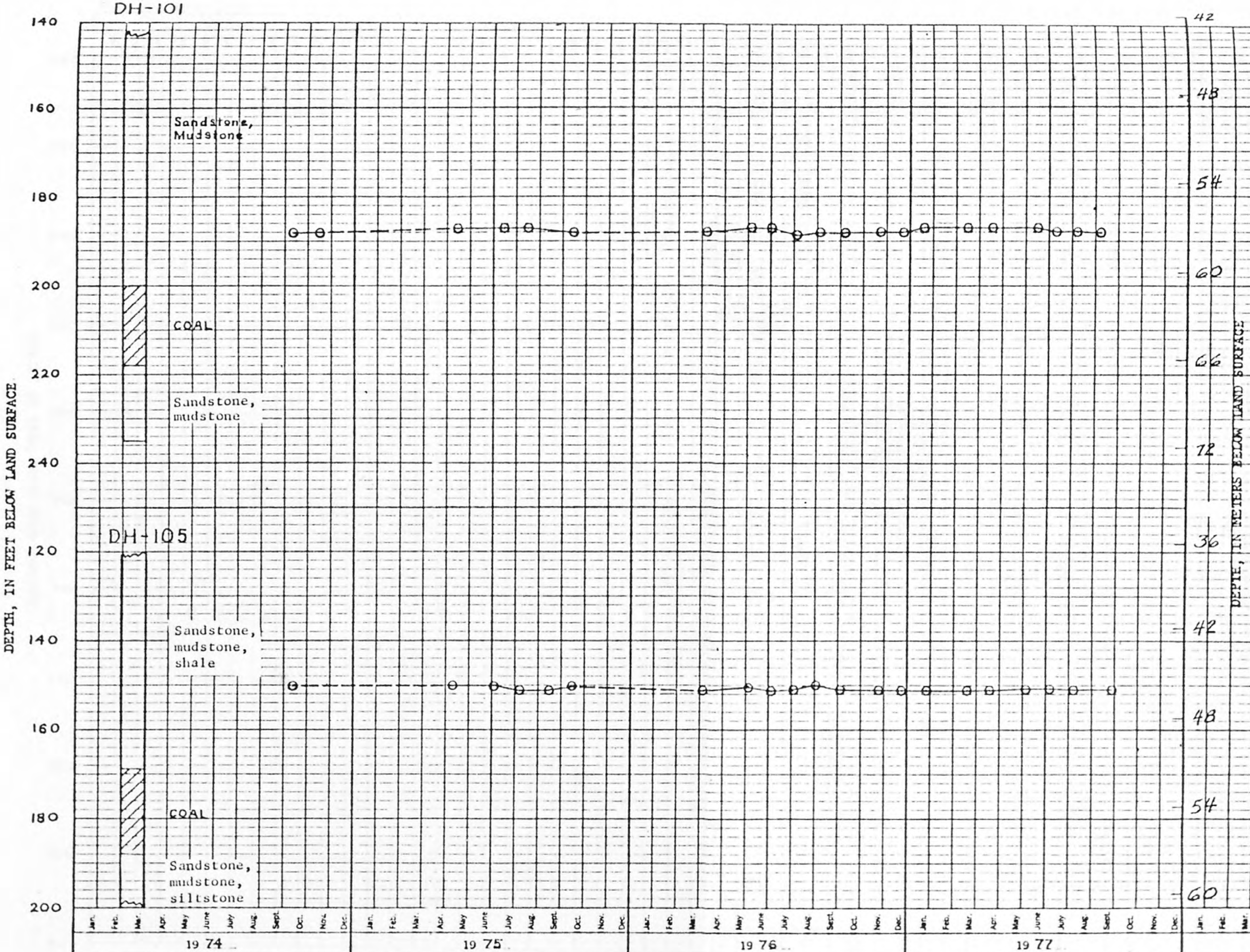


Figure 3.--Water levels and partial logs for wells DH-101, DH-104, and DH-105.

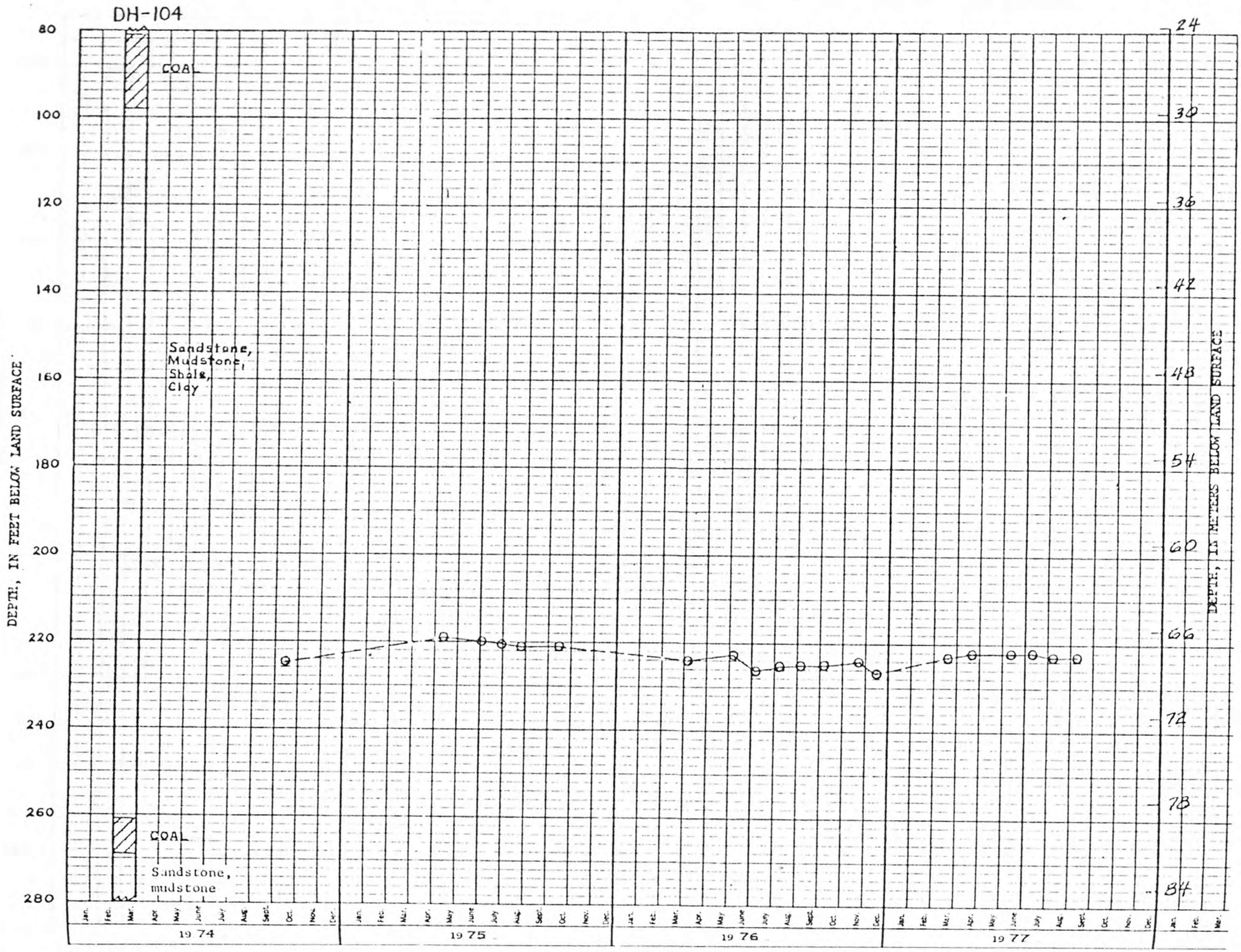
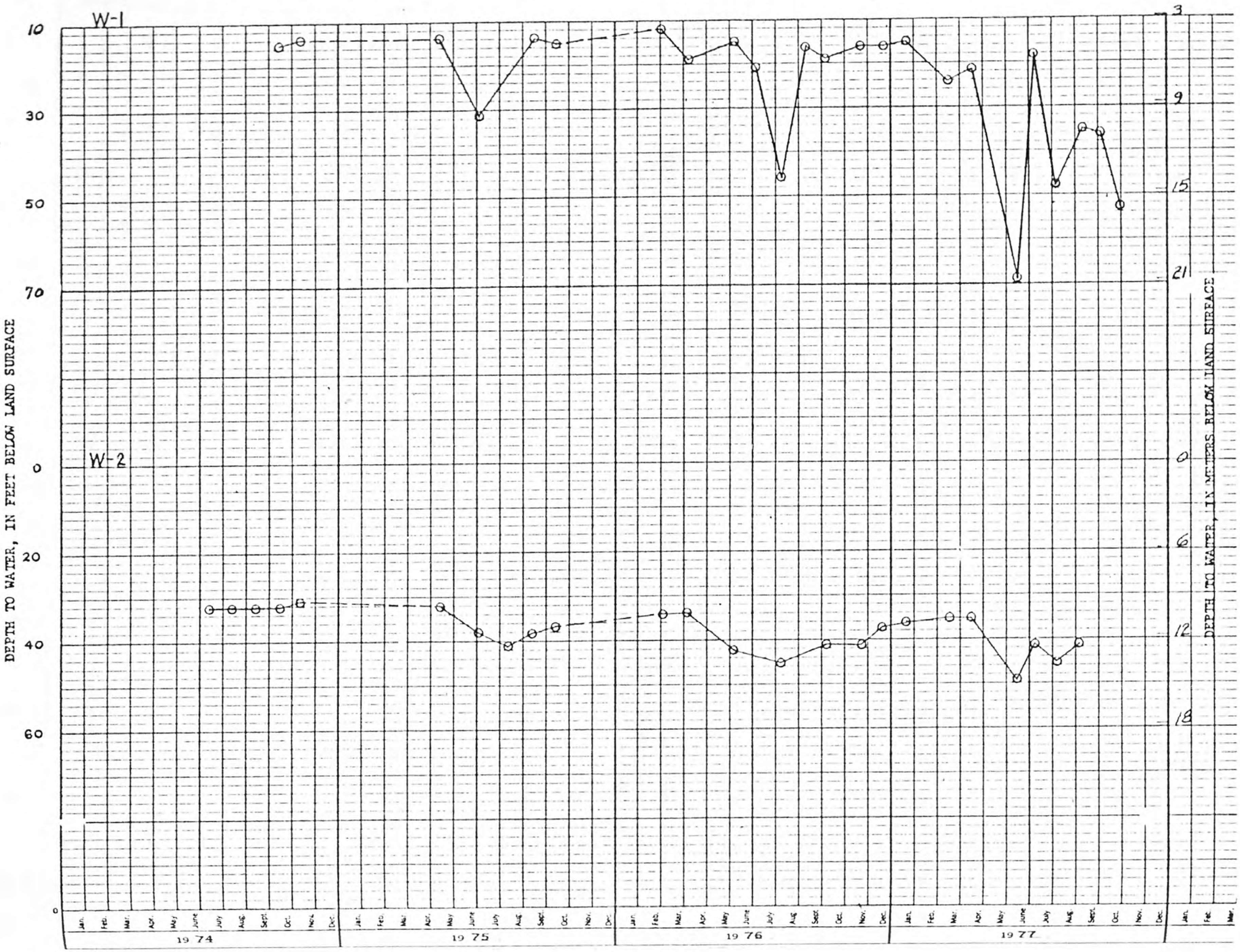


Figure 3.--Water levels and partial logs for wells DH-101, DH-104, and DH-105.--Continued.

Irrigation wells

Two irrigation wells, W-1 in the Thompson Creek drainage and W-2 in the Skutumpah Creek drainage, are about 2 mi (3.2 km) south of the study area (fig. 2). Hydrographs of these wells are shown in figure 4. Water levels in both wells declined significantly during the pumping seasons and had a much larger net decline during the investigation than did wells in the study area. The seasonal declines reflect effects of pumping, whereas, the net declines probably reflect effects of drought and consequent insignificant recharge from surface streams. Both Thompson and Skutumpah Creeks are losing streams and probably contribute to the recharge of the aquifers tapped by these wells.

Water levels in wells W-1 and W-2 are readily affected by pumping and recharge, although they are the only irrigation wells in area. This sensitivity suggests that change in recharge characteristics caused by mining would be likely to affect ground-water storage in the area.



W-1
W-2
DEPTH TO WATER, IN FEET BELOW LAND SURFACE
DEPTH TO WATER, IN METERS BELOW LAND SURFACE
10
30
50
70
0
20
40
60
3
9
15
21
0
6
12
18
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
1974
1975
1976
1977

A water-level recorder was installed on an abandoned irrigation well about one-quarter of a mile (0.40 km) north of well W-2 (fig. 2). Little water-level fluctuation occurred in this well, even when well W-2 was being pumped, thus indicating that the well was either partly plugged or that the two wells tap different aquifers.

Potentiometric surface

An accurate potentiometric-surface map could not be drawn because of complications due to block faulting in and around the study area (Goode, 1973a, b), and because too few ground-water control points were available. Water levels in and near the study area were available from wells DH-101, DH-104, and DH-105, and from 10 uncased wells drilled by Utah International, Inc. Water levels in the uncased wells, however, were only approximate because of a short stabilization period following drilling and possible caving in the wells before the water levels stabilized.

The water-surface altitudes obtained at all wells when they were drilled in 1974 are shown in figure 2. These altitudes indicate that the direction of ground-water movement is generally toward the southwest and that the gradient is steep. Comparison of water-level altitudes in wells DH-101 and DH-105 (fig. 3) with the altitudes of Skutumpah and Thompson Creeks indicates that the potentiometric surface is at least several feet below the surface of the streambeds.

The potentiometric surface overlies coal layers in wells DH-101, DH-104, and DH-105, and the coal probably forms part of the aquifers in these areas. The coal layers rise about 2 percent toward the south, whereas the land surface drops sharply toward the south, resulting in a coal outcrop near the south boundary of the study area. No springs or seeps discharge along this outcrop, indicating that the coal rises above the aquifer between the wells and the outcrop. It is likely that the coal layer dips progressively deeper beneath the potentiometric surface farther toward the north. (See fig. 5.)

A network of observation wells in and near the study area would define the potentiometric surface and its relation to the coal layers. Such a network would also define the continuity, if any, between the potentiometric surface in the study area and in the irrigated area to the south, indicating potential problems that might be incurred if the aquifer were disturbed during mining. Such a network, if maintained during and following mining, could also serve to keep track of the effects of reclamation on the aquifer. It is unlikely that during reclamation a material with the same recharge characteristics would replace the mined part of the present aquifer. The new part of the aquifer, therefore, would have different effects on the patterns of ground-water flow and water-level fluctuations than would the undisturbed aquifer to the north and south of the mined area.

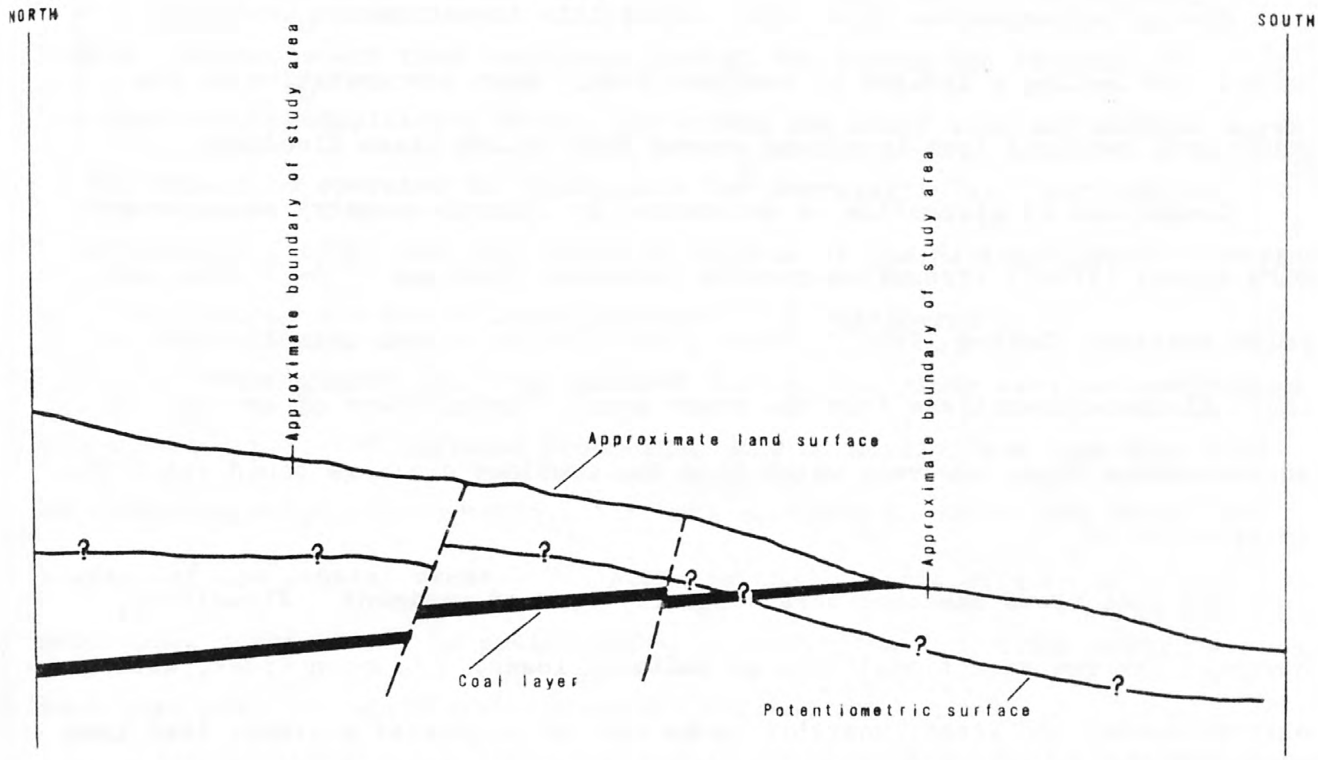


Figure 5.— Diagram showing probable relation of potentiometric surface to coal and topography.

Aquifer tests

Aquifer tests were attempted at wells DH-101, DH-104, and DH-105 shortly after completion of drilling. All water was pumped from the casing within seconds but inflow was not sufficient to allow additional water to be pumped. Later, a slug test after the method of Ferris and others (1962, p. 104, 105) was made at each well, but the results were inconclusive. All attempts suggest that the transmissivity of the aquifer is low.

Several aquifer tests are needed to determine the hydraulic relations between faulted areas and to obtain as much information as possible about the hydraulic characteristics of the aquifer.

SUMMARY

Precipitation on the study area during this investigation was below normal, reflecting a drought in southern Utah. Most precipitation on the study area resulted from localized storms that caused flash flooding.

Comparison of streamflow as determined by channel-geometry measurements with actual 1976-77 streamflow records indicates that the 1976-77 flow was below average. During 1976-77, water flowed in the stream channels only a short distance downstream from the study area. During years of average or above-average flow, however, water from the combined drainage could reach the Colorado River.

The base flows measured were virtually free of sediment. Floodflows, however, carried exceptionally large sediment loads. Thompson Creek, with a narrow channel and steep, unstable banks carried a greater sediment load than did Skutumpah Creek with a wider, more stable channel. If sediment loads are increased by mining, recharge to ground-water aquifers could decrease in all drainages.

Most surface water flowing through the study area originates north of the area. Thus, if the main drainage channels through the mined area are left undisturbed during mining, the sediment loads and concentrations of dissolved solids during floods or periods of high streamflow would be minimized.

Records of three wells in the study area indicate that much of the coal is below the potentiometric surface. More observation wells and a longer period of record are needed to determine the relationship of the ground water to the surface water and to the coal layers.

RECOMMENDATIONS

Hydrologic data should be collected continuously until the beginning of mining operations and then continued through the mining and reclamation periods. Two recording precipitation gages, one within the study area and another north of it, should be operated to obtain data for correlation with streamflow (particularly floods) and precipitation records of the National Weather Service at Kanab, Alton, and Bryce Canyon National Park Headquarters.

The stream-gaging stations operated during this study were not positioned to measure runoff and sediment production only or mostly from land that will be disturbed during strip-mining, but were adequate to define the water resources of the general areas. To determine the specific effects of mining, additional gages should be positioned so that the drainage areas upstream from each gage will include a high percentage of land that will be disturbed by mining.

Gaging stations should be maintained at stations M-2, S-1, and T-3. These stations adequately characterize streamflow through the study area. It would not be necessary to maintain stations T-1 and I-1. Sediment and water-quality samples should be taken during floods or periods of above-average flow.

The collection of water-level records should be continued in the three observation wells in the study area and the two irrigation wells south of the study area. A larger network of observation wells in and around the study area is needed to adequately define the potentiometric surface and its relation to coal beds, irrigated areas, the effects of faulting on the potentiometric surface, and the position of the potentiometric surface relative to surface drainages.

The observation-well network should include at least three wells suitable for aquifer testing. Data from the tests are needed to determine if ground-water disposal will be a problem during mining and if sufficient ground water of suitable quality exists for irrigation of reclaimed areas or for use in the mining process.

A skeleton form of this program should be established throughout the remainder of the lease area to relate conditions over the entire area to the study of the smaller control area. Mining operations should be designed so that surface flow in the major drainages is essentially undisturbed. Provisions should be made in major drainages for allowing flow, especially during floods, to pass through the mined area without eroding significant amounts of sediment.

REFERENCES CITED

Collier, C. R., Pickering, R. J. and Musser, J. J., eds., 1970, Influences of strip mining on the hydrologic environment of parts of Beaver Creek basin, Kentucky, 1955-66: U.S. Geological Survey Professional Paper 427-C, p. C1-C80.

Ferris, J. G., Knowles, D. B., Brown, R. H., and Stallman, R. W., 1962, Theory of aquifer tests: U.S. Geological Survey Water-Supply Paper 1536-E, p. 69-174.

Goode, H. D., 1966, Second reconnaissance of water resources in western Kane County, Utah: Utah Geological and Mineralogical Survey Water-Resources Bulletin 8, 44 p.

__________1973a [1974], Preliminary geologic maps of the Bald Knoll Quadrangle, Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-520, scale 1:24,000.

__________1973b [1974], Preliminary geologic map of the Skutumpah Quadrangle, Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-521, scale 1:24,000.

Moore, D. O., 1968, Estimating mean runoff in ungaged semiarid areas: Nevada Department Conservation and Natural Resources Water-Resources Bulletin 36, 39 p.

U. S. Bureau of Land Management, 1975, Resource and potential reclamation evaluation, Alton study site, Alton coal Field, [Utah]: EMRIA Report No. 4 - 1975, 130 p.

Table 3.—Summary of water and sediment discharges for station T-1, Thompson Creek, October 1975 to September 1977

Month	Water discharge			Suspended sediment				
	Total (cfs-days)	Maximum daily (ft^3/s)	Minimum daily (ft^3/s)	Load (tons)	Daily load (tons)		Concentration (mg/L)	
					Maximum	Minimum	Maximum observed	Minimum observed
1975								
October	9.10	0.41	0.25	–	–	–	–	–
November	10.42	.49	.30	–	–	–	–	–
December	12.35	.50	.33	–	–	–	–	–
1976								
January	12.93	.59	.36	–	–	–	–	–
February	17.79	2.0	.44	–	–	–	–	–
March	16.92	.72	.46	–	–	–	–	–
April	60.87	4.5	.67	–	–	–	–	–
May	32.90	1.8	.52	119	10	1.0	–	720
June	12.63	.50	.37	59	6.5	.91	5,460	606
July	12.66	.75	.34	46	3.0	1.0	1,800	986
August	6.03	.29	.18	17	1.1	.40	2,400	880
September	7.02	.40	.18	27	3.0	.40	4,100	788
October	9.11	.62	.22	48	2.0	.48	2,920	563
November	11.45	.42	.33	59	5.9	.50	5,490	597
December	10.18	.36	.31	16	1.1	.15	1,350	216
1977								
January	9.82	.35	.29	22	3.0	.10	2,290	329
February	9.20	.36	.29	627	40	5.0	39,000	16,800
March	16.90	.75	.32	1,100	70	12	49,800	10,400
April	12.95	.70	.29	195	36	.74	19,000	782
May	10.60	.94	.20	271	70	.81	7,650	1,010
June	8.36	.68	.16	44	8.0	.30	5,320	278
July	9.33	1.8	.10	1,930	900	.03	243,000	182
August	16.08	7.4	.09	1,880	1,600	.04	1,970	196
September	4.16	.17	.10	2.8	.3	.04	396	141
Water-year totals								
1976	211.62	4.5	.18	–	–	–	–	–
1977	128.14	7.4	.09	6,194.8	1,600	.03	243,000	141

Table 4.—Summary of water and sediment discharges for station T-3, Thompson Creek, October 1975 to September 1977

Month	Water discharge			Suspended sediment				
	Total (cfs-days)	Maximum daily (ft^3/s)	Minimum daily (ft^3/s)	Load (tons)	Daily load (tons)		Concentration (mg/L)	
					Maximum	Minimum	Maximum observed	Minimum observed
1975								
October	10.96	0.47	0.26	—	—	—	—	—
November	15.14	1.4	.31	—	—	—	—	—
December	20.48	.80	.30	—	—	—	—	—
1976								
January	22.15	1.0	.45	—	—	—	—	—
February	18.87	2.0	.45	—	—	—	—	—
March	16.08	.85	.44	—	—	—	—	—
April	41.72	2.9	.62	—	—	—	—	—
May	35.67	2.5	.53	366	50	1.3	3,630	914
June	11.27	.51	.28	77	6.2	.95	7,950	1,040
July	11.02	.80	.22	54	5.0	.50	4,530	1,060
August	4.51	.40	.12	15	1.5	.20	3,220	890
September	6.31	.40	.12	34	3.0	.40	4,140	1,060
October	8.73	.60	.21	41	5.0	.60	5,860	668
November	10.98	.39	.32	66	15	.30	14,300	352
December	9.86	.35	.30	19	2.0	.20	2,310	314
1977								
January	9.48	.33	.28	10	.90	.20	1,020	—
February	8.91	.34	.28	697	80	.90	80,800	7,240
March	16.21	.72	.31	1,440	75	35	63,400	21,200
April	11.85	.64	.29	248	84	.88	48,600	618
May	11.45	1.3	.15	119	20	.43	12,100	470
June	8.95	1.1	.08	352	295	.20	99,200	914
July	11.92	3.6	.07	6,830	3,800	.02	372,000	118
August	19.41	11	.06	13,500	11,000	.04	—	210
September	2.67	.14	.06	1.7	.20	.01	536	30
Water-year totals								
1976	214.18	2.9	.12	—	—	—	—	—
1977	130.42	11	.06	23,323.7	11,000	.01	372,000	30

Table 5.—Summary of water and sediment discharges for station M-2, Mill Creek, October 1975 to September 1977

Month	Water discharge			Suspended sediment				
	Total (cfs-days)	Maximum daily (ft³/s)	Minimum daily (ft³/s)	Load (tons)	Daily load (tons)		Concentration (mg/L)	
					Maximum	Minimum	Maximum observed	Minimum observed
1975								
October	6.32	0.34	0.19	–	–	–	–	–
November	5.65	.19	.18	–	–	–	–	–
December	6.59	.28	.18	–	–	–	–	–
1976								
January	6.11	.24	.18	–	–	–	–	–
February	16.37	2.2	.20	–	–	–	–	–
March	17.52	.94	.34	–	–	–	–	–
April	21.64	4.0	.28	–	–	–	–	–
May	15.27	.79	.26	11	2.5	0	350	2
June	12.54	.50	.38	.3	.04	0	44	1
July	14.44	.85	.35	.2	.02	0	11	1
August	11.48	.57	.26	1.0	.30	0	200	1
September	12.34	.57	.31	2.1	.30	0	204	2
October	9.25	2.9	.12	.3	.06	0	82	1
November	3.68	.16	.10	.6	.10	0	252	2
December	2.74	.13	.06	3.0	.27	.01	978	43
1977								
January	2.48	.08	.08	.5	.05	.01	232	88
February	2.02	.08	.06	4.0	.42	.10	1,960	450
March	3.40	.13	.08	11.0	1.0	.02	2,780	101
April	8.22	.51	.12	7.1	1.8	.03	2,520	38
May	21.05	1.2	.54	2,190	650	0	206,000	2
June	23.27	1.0	.67	53	30	.05	6,150	46
July	15.98	1.4	.26	171	80	0	3,860	1
August	15.90	4.5	.18	2,600	1,500	0	16,400	0
September	7.15	.30	.20	.1	.07	0	105	0
Water-year totals								
1976	146.27	4.0	.18	–	–	–	–	–
1977	115.14	4.5	.06	5,040.6	1,500	0	106,000	0

Table 6.—Summary of water and sediment discharges for station S-1, Skutumpah Creek, October 1975 to September 1977

Month	Water discharge: Total (cfs-days)	Water discharge: Maximum daily (ft³/s)	Water discharge: Minimum daily (ft³/s)	Suspended sediment: Load (tons)	Suspended sediment: Daily load (tons) Maximum	Suspended sediment: Daily load (tons) Minimum	Suspended sediment: Concentration (mg/L) Maximum observed	Suspended sediment: Concentration (mg/L) Minimum observed
1975								
October	1.60	0.20	0.01	–	–	–	–	–
November	.40	.04	0	–	–	–	–	–
December	1.78	.17	.01	–	–	–	–	–
1976								
January	1.65	.21	0	–	–	–	–	–
February	16.68	2.5	.07	–	–	–	–	–
March	6.89	1.2	.01	–	–	–	–	–
April	27.28	5.3	.03	–	–	–	–	–
May	31.83	1.8	.66	104	18	0	–	1
June	17.56	.68	.49	.1	.03	0	24	1
July	14.35	.82	.33	.4	.20	0	25	1
August	9.41	.49	.23	.2	.08	0	66	2
September	11.44	.50	.26	3.9	.50	0	320	1
October	6.75	3.5	.02	1.5	1.0	0	953	0
November	.53	.05	.01	.11	.02	0	898	–
December	0	–	–	–	–	–	–	–
1977								
January	0	–	–	–	–	–	–	–
February	0	–	–	–	–	–	–	–
March	.33	.02	0	13.4	1.0	0	16,000	–
April	7.02	.51	.02	11.9	1.5	.03	12,700	102
May	27.46	2.2	.54	313	60	.25	12,000	115
June	19.01	3.0	.19	97	25	.10	2,880	224
July	31.23	4.9	0	1,370	1,090	0	176,000	1
August	22.25	8.5	0	3,860	3,000	0	–	5
September	4.24	.74	0	1.0	.65	0	326	2
Water-year totals								
1976	140.87	5.3	0	–	–	–	–	–
1977	118.82	8.5	0	–	–	–	–	–

Table 7.--Recorded streamflow at station I-1, intermediate drainage, October 1, 1975 to Septamber 30, 1977

Date	Mean daily discharge (ft^3/s)	Date	Mean daily discharge (ft^3/s)
Feb. 10, 1976	0.01	July 21, 1977	0.01
Sept. 25	.80	July 24	.01
June 25, 1977	.01	Aug. 18	.02
July 4	.01		

Table 8.--Chemical analyses of ground and surface waters

DATE	TIME	AIR TEMPER-ATURE (DEG C)	DIS-CHARGE (FT^3/S)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)	CARBON DIOXIDE (CO2) (MG/L)	HARD-NESS (CA+MG) (MG/L)	NON-CAR-BONATE HARD-NESS (MG/L)	DIS-SOLVED CAL-CIUM (CA) (MG/L)
WELL W-1 (LAT 37 17 40 LONG 112 21 06)										
SEP , 1974 19...	--	--	--	2800	7.4	13.5	31	1400	980	240
WELL W-2 (LAT 37 17 49 LONG 112 20 04)										
AUG , 1974 13...	--	--	1.8	1050	7.3	10.0	29	560	260	100
SEP , 1976 02...	1110	--	--	1050	7.5	13.0	18	590	290	120
WELL DH-105 (LAT 37 19 58 LONG 112 22 37)										
SEP , 1974 19...	1210	--	--	900	8.1	14.5	7.3	24	0	6.5
JUL , 1977 06...	--	--	--	4000	10.0	13.0	.0	76	0	5.8
WELL DH-104 (LAT 37 20 02 LONG 112 21 23)										
JUL , 1977 06...	--	--	--	750	9.2	14.0	.2	100	0	12
WELL DH-101 (LAT 37 20 35 LONG 112 19 48)										
SEP , 1974 19...	0845	--	--	3000	8.0	15.0	5.2	140	0	35
JUL , 1977 06...	--	--	--	2080	8.5	14.0	3.1	200	0	40

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	SODIUM AD-SORP-TION RATIO	PERCENT SODIUM	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)
WELL W-1 (LAT 37 17 40 LONG 112 21 06)										
SEP , 1974 19...	190	180	2.1	22	11	487	--	399	1300	34
WELL W-2 (LAT 37 17 49 LONG 112 20 04)										
AUG , 1974 13...	75	35	.6	12	6.9	367	--	301	310	8.6
SEP , 1976 02...	70	38	.7	12	7.4	363	0	298	350	9.3
WELL DH-105 (LAT 37 19 58 LONG 112 22 37)										
SEP , 1974 19...	1.9	230	20	94	6.5	572	--	469	72	11
JUL , 1977 06...	15	880	44	96	7.3	140	65	223	1700	13
WELL DH-104 (LAT 37 20 02 LONG 112 21 23)										
JUL , 1977 06...	18	120	5.1	70	4.9	150	0	123	190	21
WELL DH-101 (LAT 37 20 35 LONG 112 19 48)										
SEP , 1974 19...	12	600	22	90	8.8	326	--	267	970	68
JUL , 1977 06...	23	550	17	85	7.8	610	0	500	780	18

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	DIS-SOLVED NITRITE PLUS NITRATE (N) (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PO4) (MG/L)	DIS-SOLVED ORTHO. PHOS-PHORUS (P) (MG/L)	DIS-SOLVED BORON (B) (UG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	DIS-SOLVED SOLIDS (TONS PER DAY)	DIS-SOLVED SOLIDS (TONS PER AC-FT)
WELL W-1 (LAT 37 17 40 LONG 112 21 06)									
SEP , 1974 19...	.01	.09	.03	250	.6	18	2210	--	3.01
WELL W-2 (LAT 37 17 49 LONG 112 20 04)									
AUG , 1974 13...	.00	.00	.00	120	.5	9.9	727	3.53	.99
SEP , 1976 02...	.35	.00	.00	120	.5	10	786	--	1.07
WELL DH-105 (LAT 37 19 58 LONG 112 22 37)									
SEP , 1974 19...	4.3	.03	.01	120	.5	11	641	--	.87
JUL , 1977 06...	--	--	--	940	.7	.9	2760	--	--
WELL DH-104 (LAT 37 20 02 LONG 112 21 23)									
JUL , 1977 06...	--	--	--	280	3.4	.9	444	--	--
WELL DH-101 (LAT 37 20 35 LONG 112 19 48)									
SEP , 1974 19...	34	.03	.01	360	1.1	3.8	2010	--	2.73
JUL , 1977 06...	--	--	--	1400	.6	7.3	1730	--	--

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	TIME	AIR TEMPER- ATURE (DEG C)	DIS- CHARGE (CFS)	SPE- CIFIC CON- DUCT- ANCE (MICRO- MHOS)	PH (UNITS)	TEMPER- ATURE (DEG C)	CARBON DIOXIDE (CO2) (MG/L)	HARD- NESS (CA,MG) (MG/L)	NON- CAR- BONATE HARD- NESS (MG/L)	DIS- SOLVED CAL- CIUM (CA) (MG/L)
MILL CR ABV STUDY AREA SITE M-2 (LAT 37 21 49 LONG 112 20 30)										
AUG , 1974										
13...	1330	--	.11	620	7.7	23.0	8.5	340	130	44
NOV										
13...	1100	--	--	630	7.3	3.0	23	320	77	58
MAY , 1975										
13...	1430	--	1.0	625	7.7	18.5	9.4	330	88	54
APR , 1976										
27...	1500	10.0	.57	695	8.2	12.5	2.9	310	72	57
JUN										
04...	1000	26.0	.41	570	7.7	24.0	8.4	320	100	51
JUL										
01...	1500	26.0	.40	660	8.3	25.5	2.3	330	95	52
AUG										
03...	--	19.0	.39	540	7.9	17.5	5.4	320	95	57
SEP										
01...	1445	30.5	.27	525	8.4	26.0	1.7	300	86	48
OCT										
06...	--	20.5	.05	580	8.0	15.0	3.6	280	95	37
NOV										
23...	0900	5.0	.10	700	8.0	.0	.7	370	130	65
DEC										
21...	--	.0	.06	825	7.2	.5	34	450	170	79
JAN , 1977										
26...	1430	5.0	.09	630	7.8	1.0	8.0	340	85	62
MAR										
22...	0920	15.0	.10	700	7.8	2.0	9.4	400	98	72
APR										
26...	1030	19.0	.42	590	7.1	6.0	37	330	96	58
JUN										
09...	1835	18.0	1.2	490	8.2	10.0	2.6	290	80	53
JUL										
06...	--	31.0	.39	560	8.4	25.0	1.4	280	100	39
AUG										
04...	--	--	.20	560	8.8	25.0	.6	300	110	38

Table 8.--Chemical analyses of ground and surface waters--Continued

MILL CR ABV STUDY AREA SITE M-2 (LAT 37 21 49 LONG 112 20 30)

DATE	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	SODIUM AD-SORP-TION RATIO	PERCENT SODIUM	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)
AUG , 1974										
13...	57	11	.3	6	6.8	265	--	--	130	4.4
NOV										
13...	42	7.5	.2	5	4.6	293	--	240	90	3.4
MAY , 1975										
13...	47	7.2	.2	4	4.3	293	0	240	94	3.0
APR , 1976										
27...	41	5.8	.1	4	3.8	291	0	239	92	4.7
JUN										
04...	46	7.4	.2	5	4.4	263	0	216	96	3.5
JUL										
01...	49	7.9	.2	5	4.5	288	0	236	110	3.0
AUG										
03...	42	7.3	.2	5	4.1	269	0	221	89	3.2
SEP										
01...	44	8.1	.2	5	4.5	262	0	215	100	3.1
OCT										
06...	46	8.9	.2	6	4.5	228	0	187	95	3.1
NOV										
23...	50	10	.2	6	5.1	295	0	242	130	3.1
DEC										
21...	62	11	.2	5	6.2	340	0	279	160	4.1
JAN , 1977										
26...	46	8.6	.2	5	4.6	316	0	259	100	2.9
MAR										
22...	54	15	.3	7	5.7	371	0	304	120	4.1
APR										
26...	46	7.4	.2	5	4.5	290	0	240	93	3.1
JUN										
09...	39	5.0	.1	4	3.5	260	0	210	77	2.7
JUL										
06...	45	7.6	.2	5	4.4	220	0	180	98	3.1
AUG										
04...	51	10	.3	7	5.5	240	0	200	130	3.6

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	DIS-SOLVED NITRITE PLUS NITRATE (N) (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PO4) (MG/L)	DIS-SOLVED ORTHO. PHOS-PHORUS (P) (MG/L)	DIS-SOLVED BORON (B) (UG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	DIS-SOLVED SOLIDS (TONS PER DAY)	DIS-SOLVED SOLIDS (TONS PER AC-FT)
MILL CR ABV STUDY AREA SITE M-2 (LAT 37 21 49 LONG 112 20 30)									
AUG , 1974									
13...	.00	.00	.00	100	.4	11	395	.12	.54
NOV									
13...	.16	.06	.02	80	.4	6.7	358	--	.49
MAY , 1975									
13...	.22	.06	.02	50	.3	7.1	362	1.03	.49
APR , 1976									
27...	.19	.00	.00	40	.4	6.0	355	.55	.48
JUN									
04...	.11	.03	.01	60	.3	7.0	346	.38	.47
JUL									
01...	.10	.03	.01	60	.4	7.2	377	.41	.51
AUG									
03...	.04	.03	.01	60	.4	7.3	343	.36	.47
SEP									
01...	.04	.00	.00	60	.3	7.9	345	.25	.47
OCT									
06...	.08	.03	.01	60	.3	7.6	315	.21	.43
NOV									
23...	.17	.00	.00	70	.3	7.2	417	.11	.57
DEC									
21...	.12	.31	.10	80	.4	9.7	501	.08	.68
JAN , 1977									
26...	.25	.03	.01	60	.3	6.5	388	.10	.53
MAR									
22...	.14	.06	.02	70	.4	8.4	463	.13	.63
APR									
26...	.18	.06	.02	60	.4	7.7	364	.41	.50
JUN									
09...	.28	.00	.00	50	.4	7.0	317	.01	.43
JUL									
06...	--	--	--	60	.3	8.7	315	.33	.43
AUG									
04...	--	--	--	80	.3	8.0	365	.20	.50

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	TIME	AIR TEMPER- ATURE (DEG C)	DIS- CHARGE (FT^3/S)	SPE- CIFIC CON- DUCT- ANCE (MICRO- MHOS)	PH (UNITS)	TEMPER- ATURE (DEG C)	CARBON DIOXIDE (CO2) (MG/L)	HARD- NESS (CA,MG) (MG/L)	NON- CAR- BONATE HARD- NESS (MG/L)	DIS- SOLVED CAL- CIUM (CA) (MG/L)
				TENNY CREEK SITE M-3 (LAT 37 20 42 LONG 112 19 34)						
JUN , 1977										
09...	--	--	--	2000	8.2	10.0	4.6	1100	730	99
JUL										
06...	--	--	--	750	9.2	14.0	.2	--	0	12

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	SODIUM AD-SORP-TION RATIO	PERCENT SODIUM	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)
TENNY CREEK SITE M-3 (LAT 37 20 42 LONG 112 19 34)										
JUN , 1977										
09...	210	140	1.8	21	30	460	0	380	1000	29
JUL										
06...	18	120	5.1	70	4.9	150	0	123	190	21

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	DIS-SOLVED NITRITE PLUS NITRATE (N) (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PO4) (MG/L)	DIS-SOLVED ORTHO. PHOS-PHORUS (P) (MG/L)	DIS-SOLVED BORON (B) (UG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	DIS-SOLVED SOLIDS (TONS PER DAY)	DIS-SOLVED SOLIDS (TONS PER AC-FT)
TENNY CREEK SITE M-3 (LAT 37 20 42 LONG 112 19 34)									
JUN , 1977									
09...	.42	.12	.04	550	.8	6.3	1740	--	2.37
JUL									
06...	--	.12	--	280	3.4	.9	444	--	.60

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	TIME	AIR TEMPER- ATURE (DEG C)	DIS- CHARGE (FT³/S)	SPE- CIFIC CON- DUCT- ANCE (MICRO- MHOS)	PH (UNITS)	TEMPER- ATURE (DEG C)	CARBON DIOXIDE (CO2) (MG/L)	HARD- NESS (CA,MG) (MG/L)	NON- CAR- BONATE HARD- NESS (MG/L)	DIS- SOLVED CAL- CIUM (CA) (MG/L)
SKUTUMPAH CR BLW STUDY AREA SITE S-1 (LAT 37 19 18 LONG 112 19 37.01)										
JUL , 1974										
15...	1530	--	16	1250	7.0	19.5	80	600	180	110
17...	1855	--	.32	608	6.6	23.0	107	310	87	40
NOV										
13...	1030	--	--	650	7.7	--	8.8	330	110	58
MAY , 1975										
13...	--	--	1.1	725	7.9	22.0	5.4	350	130	46
MAR , 1976										
02...	1445	-1.5	.53	820	8.0	.0	4.7	390	160	69
APR										
27...	1400	--	1.4	950	8.1	13.0	4.1	470	210	70
JUN										
04...	--	26.0	.41	700	8.2	24.0	2.6	330	120	24
JUL										
01...	1540	27.5	.71	600	8.2	22.5	2.9	320	88	41
AUG										
04...	0845	19.5	.46	470	8.2	9.0	2.8	340	110	57
SEP										
02...	1020	26.0	.32	560	8.2	16.0	2.6	330	120	53
OCT										
06...	--	19.0	.08	620	8.2	15.0	2.5	310	110	41
APR , 1977										
26...	0935	18.0	.44	725	7.4	7.5	20	400	150	57
JUN										
09...	1940	12.5	.13	640	8.3	10.0	2.2	350	130	53
JUL										
06...	--	30.0	.22	575	8.5	26.0	1.2	280	94	34
AUG										
04...	--	--	.12	590	8.9	25.0	.5	280	70	36

Table 8.--Chemical analyses of ground and surface waters--Continued

SKUTUMPAH CR BLW STUDY AREA SITE S-1 (LAT 37 19 18 LONG 112 19 37.01)

DATE	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	SODIUM AD-SORP-TION RATIO	PERCENT SODIUM	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)
JUL , 1974										
15...	78	31	.6	10	14	501	--	--	270	13
17...	50	12	.3	8	6.4	267	--	--	120	4.1
NOV										
13...	46	12	.3	7	5.1	275	--	226	110	4.0
MAY , 1975										
13...	57	19	.4	10	5.7	270	0	221	160	6.5
MAR , 1976										
02...	54	31	.7	14	7.5	291	0	239	220	6.8
APR										
27...	71	28	.6	11	8.4	319	0	262	270	13
JUN										
04...	65	19	.5	11	6.5	254	0	208	160	5.3
JUL										
01...	53	13	.3	8	5.4	283	0	232	120	4.0
AUG										
04...	48	12	.3	7	4.5	279	0	229	110	3.8
SEP										
02...	48	12	.3	7	4.5	259	0	212	110	3.7
OCT										
06...	50	13	.3	8	4.8	247	0	203	130	4.3
APR , 1977										
26...	63	19	.4	9	6.6	310	0	250	150	6.6
JUN										
09...	53	18	.4	10	6.1	270	0	220	160	5.0
JUL										
06...	48	9.3	.2	7	4.6	230	0	189	100	3.5
AUG										
04...	45	12	.3	8	5.7	250	0	210	110	3.8

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	DIS-SOLVED NITRITE PLUS NITRATE (N) (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PO4) (MG/L)	DIS-SOLVED ORTHO. PHOS-PHORUS (P) (MG/L)	DIS-SOLVED BORON (B) (UG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	DIS-SOLVED SOLIDS (TONS PER DAY)	DIS-SOLVED SOLIDS (TONS PER AC-FT)
SKUTUMPAH CR BLW STUDY AREA SITE S-1 (LAT 37 19 18 LONG 112 19 37.01)									
JUL , 1974									
15...	.03	.12	.04	310	.5	18	782	33.8	1.06
17...	.07	.03	.01	100	.4	9.9	375	.32	.51
NOV									
13...	.21	.03	.01	80	.4	6.2	378	--	.51
MAY , 1975									
13...	.03	.03	.01	90	.4	7.7	436	1.25	.59
MAR , 1976									
02...	.32	.00	.00	80	.4	5.8	539	.77	.73
APR									
27...	.21	.00	.00	110	.4	7.0	626	2.30	.85
JUN									
04...	.03	.03	.01	90	.4	7.5	413	.46	.56
JUL									
01...	.04	.03	.01	70	.4	7.8	384	.74	.52
AUG									
04...	.02	.00	.00	60	.3	7.5	381	.47	.52
SEP									
02...	.01	.00	.00	60	.3	7.8	367	.32	.50
OCT									
06...	.09	.06	.02	60	.3	7.8	373	.08	.51
APR , 1977									
26...	.07	.03	.01	90	.4	8.0	464	.55	.63
JUN									
09...	.57	.03	.01	110	.4	7.1	438	1.54	.60
JUL									
06...	--	--	--	70	.4	8.7	322	.19	.44
AUG									
04...	--	--	--	80	.3	7.6	344	.11	.47

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	TIME	AIR TEMPER-ATURE (DEG C)	DIS-CHARGE (FT³/S)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)	CARBON DIOXIDE (CO2) (MG/L)	HARD-NESS (CA,MG) (MG/L)	NON-CAR-BONATE HARD-NESS (MG/L)	DIS-SOLVED CAL-CIUM (CA) (MG/L)
THOMPSON CR ABV STUDY AREA SITE T-1 (LAT 37 20 11 LONG 112 22 19)										
APR , 1976										
27...	1125	4.0	3.3	1110	7.7	1.0	11	610	320	120
JUN										
03...	1100	28.0	.45	1100	8.0	22.5	--	590	330	81
JUL										
01...	1120	25.0	.32	1190	8.0	21.0	5.2	660	390	83
AUG										
02...	1230	28.5	.19	1300	7.4	23.5	19	710	460	87
SEP										
01...	1220	30.0	.17	1550	8.0	24.0	5.2	850	590	110
OCT										
06...	--	21.5	.24	1300	7.6	14.0	14	730	440	110
NOV										
22...	1235	17.0	.51	1010	8.6	4.5	.9	550	370	91
DEC										
20...	--	2.0	.10	1650	6.8	.5	118	930	550	140
JAN , 1977										
27...	1100	1.0	.43	1300	7.9	1.5	8.6	710	360	120
MAR										
21...	1230	18.0	2.1	1180	7.9	5.0	7.0	660	380	130
APR										
25...	--	27.0	.36	1050	7.9	16.0	7.0	620	330	93
JUN										
17...	--	33.0	.19	1175	8.3	25.0	2.4	650	400	77
JUL										
07...	--	28.0	.31	2025	7.6	16.0	8.0	700	540	100
AUG										
04...	--	--	.12	1750	8.5	25.0	1.5	1000	790	150
SEP										
30...	--	28.0	--	1500	8.4	--	1.8	790	550	100

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	SODIUM AD-SORP-TION RATIO	PERCENT SODIUM	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)
THOMPSON CR ABV STUDY AREA SITE T-1 (LAT 37 20 11 LONG 112 22 19)										
APR , 1976										
27...	76	33	.6	10	6.7	355	0	291	390	15
JUN										
03...	95	34	.6	11	6.3	316	0	259	360	11
JUL										
01...	110	47	.8	13	7.6	325	0	267	470	13
AUG										
02...	120	57	.9	15	9.5	305	0	250	540	18
SEP										
01...	140	86	1.3	18	10	322	0	264	710	22
OCT										
06...	110	44	.7	12	7.7	346	0	284	480	14
NOV										
22...	79	27	.5	10	5.7	226	0	185	330	8.4
DEC										
20...	140	75	1.1	15	7.9	464	0	381	630	22
JAN , 1977										
27...	100	41	.7	11	6.6	425	0	349	430	12
MAR										
21...	82	31	.5	9	7.8	350	0	287	450	9.4
APR										
25...	93	34	.6	11	6.3	350	0	290	360	11
JUN										
17...	110	52	.9	15	7.3	300	0	250	480	15
JUL										
07...	110	57	.9	15	8.1	200	0	164	540	16
AUG										
04...	160	100	1.4	17	12	290	3	240	940	19
SEP										
30...	130	74	1.2	17	8.5	290	0	240	620	16

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	DIS-SOLVED NITRITE PLUS NITRATE (N) (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PO4) (MG/L)	DIS-SOLVED ORTHO. PHOS-PHORUS (P) (MG/L)	DIS-SOLVED BORON (B) (UG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	DIS-SOLVED SOLIDS (TONS PER DAY)	DIS-SOLVED SOLIDS (TONS PER AC-FT)
THOMPSON CR ABV STUDY AREA SITE T-1 (LAT 37 20 11 LONG 112 22 19)									
APR , 1976									
27...	.51	.00	.00	50	.4	6.8	825	7.31	1.12
JUN									
03...	.15	.03	.01	70	.3	9.0	753	.91	1.02
JUL									
01...	.14	.00	.00	90	.4	8.8	901	.78	1.23
AUG									
02...	.09	.00	.00	100	.3	9.1	992	.51	1.35
SEP									
01...	.15	.00	.00	130	.4	9.5	1250	.57	1.70
OCT									
06...	.15	.03	.01	90	.3	8.6	946	.61	1.29
NOV									
22...	.22	.00	.00	60	.3	6.9	661	.91	.90
DEC									
20...	.30	.09	.03	100	.4	9.7	1260	.34	1.71
JAN , 1977									
27...	.21	.03	.01	70	.3	8.2	929	1.08	1.26
MAR									
21...	.64	.06	.02	80	.4	7.9	894	5.21	1.22
APR									
25...	.24	.06	.02	70	.4	8.9	780	.76	1.06
JUN									
17...	.06	.03	.01	90	.4	11	901	.46	1.23
JUL									
07...	--	--	--	100	.3	10	940	.79	1.28
AUG									
04...	--	--	--	150	.4	9.2	1540	.50	2.09
SEP									
30...	.04	.03	.01	100	.3	7.8	1100	--	1.50

Table 8.--Chemical analyses of ground and surface waters--Continued

THOMPSON CR BLW STUDY AREA SITE T-3 (LAT 37 19 31 LONG 112 22 12.01)

DATE	TIME	AIR TEMPER- ATURE (DEG C)	DIS- CHARGE (FT^3/S)	SPE- CIFIC CON- DUCT- ANCE (MICRO- MHOS)	PH (UNITS)	TEMPER- ATURE (DEG C)	CARBON DIOXIDE (CO2) (MG/L)	HARD- NESS (CA,MG) (MG/L)	NON- CAR- BONATE HARD- NESS (MG/L)	DIS- SOLVED CAL- CIUM (CA) (MG/L)
MAY , 1975										
13...	--	--	.65	1100	7.8	18.0	8.7	580	300	94
APR , 1976										
28...	1010	5.0	2.1	960	8.0	.0	5.7	580	280	110
JUN										
04...	1400	22.0	.46	1125	8.1	25.0	3.6	610	380	84
JUL										
01...	1320	27.5	.31	1210	8.0	25.0	4.8	690	450	80
AUG										
03...	1230	19.0	.15	1300	7.1	12.0	42	790	520	100
SEP										
01...	1310	31.5	.12	1700	8.0	25.0	4.9	920	660	120
OCT										
06...	--	23.0	.25	1400	8.1	17.0	4.2	730	460	110
NOV										
22...	1200	10.0	.72	1050	8.2	.5	3.4	580	310	92
DEC										
20...	--	2.0	.10	1600	6.8	.5	--	930	540	140
JAN , 1977										
27...	1000	-3.0	.17	1700	7.9	1.0	8.8	880	530	140
MAR										
21...	1550	16.0	.72	1250	7.9	10.0	6.0	710	470	140
APR										
25...	1300	24.0	.27	1125	8.0	17.0	5.3	640	370	93
JUN										
17...	--	33.0	.12	1250	8.2	25.0	2.9	690	450	79
JUL										
07...	--	31.0	.21	1450	8.1	16.0	3.9	730	470	110
AUG										
04...	--	--	.19	1700	8.4	25.0	1.7	980	760	160
SEP										
30...	--	31.0	--	1600	--	--	--	600	470	110

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	SODIUM AD-SORP-TION RATIO	PERCENT SODIUM	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)
THOMPSON CR BLW STUDY AREA SITE T-3 (LAT 37 19 31 LONG 112 22 12.01)										
MAY , 1975										
13...	83	29	.5	10	5.3	343	0	281	330	11
APR , 1976										
28...	73	31	.6	10	5.2	357	0	293	340	15
JUN										
04...	97	40	.7	12	6.3	285	0	234	380	16
JUL										
01...	120	62	1.0	16	8.7	300	0	246	550	15
AUG										
03...	130	71	1.1	16	8.6	327	0	268	620	19
SEP										
01...	150	100	1.4	19	12	309	0	253	810	21
OCT										
06...	110	59	1.0	15	8.6	329	0	270	550	17
NOV										
22...	85	28	.5	9	6.2	332	0	272	330	8.2
DEC										
20...	140	81	1.2	16	8.1	472	0	387	660	20
JAN , 1977										
27...	130	77	1.1	16	7.2	437	0	358	640	18
MAR										
21...	88	47	.8	12	8.7	298	0	244	530	14
APR										
25...	100	45	.8	13	7.1	330	0	270	440	12
JUN										
17...	120	64	1.1	17	8.0	290	0	240	550	15
JUL										
07...	110	66	1.1	16	8.2	310	0	254	580	15
AUG										
04...	140	95	1.3	17	12	250	5	210	940	18
SEP										
30...	80	89	1.6	24	9.0	160	--	130	660	17

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	DIS-SOLVED NITRITE PLUS NITRATE (N) (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PO4) (MG/L)	DIS-SOLVED ORTHO. PHOS-PHORUS (P) (MG/L)	DIS-SOLVED BORON (B) (UG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	DIS-SOLVED SOLIDS (TONS PER DAY)	DIS-SOLVED SOLIDS (TONS PER AC-FT)
THOMPSON CR BLW STUDY AREA SITE T-3 (LAT 37 19 31 LONG 112 22 12.01)									
MAY , 1975									
13...	.19	.03	.01	100	.3	8.8	731	1.28	.99
APR , 1976									
28...	.28	.00	.00	50	.4	7.1	759	4.24	1.03
JUN									
04...	.18	.03	.01	80	.3	8.9	774	.96	1.05
JUL									
01...	.32	.03	.01	110	.4	9.3	995	.83	1.35
AUG									
03...	.13	.00	.00	100	.3	8.8	1120	.45	1.52
SEP									
01...	.26	.03	.01	150	.4	9.8	1380	.45	1.88
OCT									
06...	.42	.15	.05	100	.3	8.7	1030	.70	1.40
NOV									
22...	.24	.00	.00	70	.3	7.3	722	1.40	.98
DEC									
20...	.16	.06	.02	100	.4	9.5	1290	.35	1.75
JAN , 1977									
27...	.24	.03	.01	90	.4	8.6	1240	.57	1.69
MAR									
21...	.81	.06	.02	90	.5	7.5	986	1.92	1.34
APR									
25...	.20	.03	.01	90	.4	9.1	870	.63	1.18
JUN									
17...	.14	.49	.16	110	.3	2.7	983	.32	1.34
JUL									
07...	--	--	--	100	.3	9.8	1050	.60	1.43
AUG									
04...	--	--	--	140	.3	8.4	1500	.77	2.04
SEP									
30...	.10	.03	.01	110	.4	7.5	1050	--	1.43

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	TIME	AIR TEMPER-ATURE (DEG C)	DIS-CHARGE (FT^3/S)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)	CARBON DIOXIDE (CO_2) (MG/L)	HARD-NESS (CA,MG) (MG/L)	NON-CAR-BONATE HARD-NESS (MG/L)	DIS-SOLVED CAL-CIUM (CA) (MG/L)
THOMPSON CR BLW STUDY AREA SITE T-4 (LAT 37 17 41 LONG 112 21 04)										
JUL , 1974										
15...	1700	--	40	1790	6.6	--	113	870	640	220
17...	1120	--	.67	2160	6.5	25.0	119	1100	950	260
AUG										
13...	1030	--	.19	1900	7.7	13.0	8.5	1000	790	140
NOV										
13...	0900	--	--	1800	7.7	1.0	12	840	540	140

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	SODIUM AD-SORP-TION RATIO	PERCENT SODIUM	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)
THOMPSON CR BLW STUDY AREA SITE T-4 (LAT 37 17 41 LONG 112 21 04)										
JUL , 1974										
15...	78	55	.8	12	18	280	--	230	720	11
17...	120	85	1.1	14	23	236	--	194	1100	18
AUG										
13...	160	110	1.5	19	12	266	--	218	910	23
NOV										
13...	120	84	1.3	18	7.1	371	--	304	690	19

Table 8.--Chemical analyses of ground and surface waters--Continued

DATE	DIS- SOLVED NITRITE PLUS NITRATE (N) (MG/L)	DIS- SOLVED ORTHO PHOS- PHATE (PO4) (MG/L)	DIS- SOLVED ORTHO. PHOS- PHORUS (P) (MG/L)	DIS- SOLVED BORON (B) (UG/L)	DIS- SOLVED FLUO- RIDE (F) (MG/L)	DIS- SOLVED SILICA (SIO2) (MG/L)	DIS- SOLVED SOLIDS (SUM OF CONSTI- TUENTS) (MG/L)	DIS- SOLVED SOLIDS (TONS PER DAY)	DIS- SOLVED SOLIDS (TONS PER AC-FT)
THOMPSON CR BLW STUDY AREA SITE T-4 (LAT 37 17 41 LONG 112 21 04)									
JUL , 1974									
15...	.18	.12	.04	300	.4	18	1260	136	1.71
17...	.51	.03	.01	240	.5	11	1740	3.15	2.37
AUG									
13...	.03	.00	.00	170	.4	10	1500	.77	2.04
NOV									
13...	.15	.06	.02	130	.5	9.8	1250	--	1.70