SELECTED BIOLOGICAL CHARACTERISTICS OF STREAMS IN THE SOUTHEASTERN UINTA BASIN, UTAH AND COLORADO

U.S. GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS

OPEN-FILE REPORT 81-644

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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Salt Lake City, Utah

1981

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CONVERSION FACTORS

Most values in this report are given in inch-pound units. For those readers who may prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below.

Inch pound			Metric	
Unit	Abbreviation		Unit	Abbreviation
Multiply		By	To obtain	
Cubic foot per second	ft^3/s	0.02832	Cubic meter per second	m^3/s
Foot	ft	0.3048	Meter	m
Inch	in.	25.40	Millimeter	mm
		2.540	Centimeter	cm
Mile	mi	1.609	Kilometer	km
Square foot	ft^2	.0929	Square meter	m^2
Square mile	mi^2	2.590	Square kilometer	km^2

National Geodetic Vertical Datum of 1929 (NGVD Of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United and Canada, formerly called "Mean Sea Level."

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ABSTRACT

Biological sampling was carried out during 1976-78 in five streams in the southeastern Uinta Basin, Utah and Colorado, in order to provide baseline water-quality data for an area of potential oil-shale development. The biological activity in the streams sampled generally is limited by physical factors more so than by chemical constituents and plant nutrients. Characteristics of streamflow, such as high turbidity, fluctuating water levels, and moderate to high salinity, limit production of flora and fauna biomass.

Samples were collected for the determination of bacterial and periphyton concentrations and benthic-invertebrate communities. Bacterial concentrations were generally small, with some fecal contamination, primarily from livestock and wildlife. Members of the order Chlorophyta (green algae) were the major periphytic algae present in three of the streams sampled. Bitter Creek was dominated by members of the order Cyanphyta (blue-green algae), and pennate diatoms were the predominant algae in Willow Creek. The benthic-invertebrate communities generally reflect a nonpolluted environment. Shannon-Weiner diversity indices ranged from 1.14 to 3.08.

INTRODUCTION

The proposed accelerated mining of fossil fuels such as coal and oil shale prompted a national concern about the effects of the mining on the quality of the environment. One area of such concern has been the effects of mining and related activites on water quality.

In anticipation of oil-shale development and the desirability of defining baseline-water conditions prior to mining, the U.S. Geological Survey made an evaluation of the hydrologic regime of the southeastern Uinta Basin, Utah and Colorado (fig. 1). The evaluation included the collection and interpretation of data pertaining to climate; vegetation; channel migration; ground-water availability and quality; and the quantity, chemical quality, and sediment and biological characteristics of streamflow. The purpose of this report is to present the results of the biological part of the evaluation and to provide background information on the predevelopment biological conditions in the southeastern Uinta Basin with respect to bacteria, benthic invertebrates, and periphyton. Data evaluated in this report were collected from July 1976 to July 1978.

Two previous reports presented biological information about parts of the study area. Bauman, Gaufin, and Winget (1975) reported on concentrations of benthic macroinvertebrates in the White River. VTN Colorado, Inc. (1977), reported on periphyton, phytoplankton, and benthic macroinvertebrates on the White River and Evacuation Creek in conjunction with studies of prototype oil-shale leases Ua and Ub near Bonanza, Utah.

Figure 1.--Location of biological-sampling stations.

STUDY AREA

The study area (fig. 1) covers about 3,000 mi^2 in the southeastern Uinta Basin, Utah and Colorado. The area is sparsely inhabited, with a population density of approximately one person per 75 mi^2. Industries include cattle ranching, sheep grazing, gilsonite mining (centered around Bonanza, Utah), and oil and gas exploration. Most of the eastern two-thirds of the area is managed by the Federal Government, and most of the western one-third is owned by the Uintah and Ouray Tribal Enterprises, Inc. Small tracts of State and private land are scattered throughout the area.

The major topographic feature in the study area is the north-sloping Roan Plateau, which is highly dissected by steep-walled alluvial valleys (Cashion, 1967). Most of the valleys broaden to the north; and relief between valley bottoms and the plateau increases to the south, with valley walls becoming nearly vertical.

Geology

According to Cashion (1967), who described the geology of the area in detail, exposed bedrock in the study area is of fluvial and lacustrine origin and of Eocene and Oligocene age. The oldest rocks exposed are massive variegated shale and sandstone of the Wasatch Formation of Eocene age. The Wasatch Formation, which is divided into the main body and the Renegade Tongue, interfingers with and is overlain by the Green River Formation, also of Eocene age. The Green River Formation has been divided in ascending order into the Douglas Creek, Garden Gulch, and Parachute Creek Members. The Douglas Creek Member is composed mainly of sandstone, siltstone, and limestone whereas the other members are composed of thin-bedded marlstone, siltstone, and oil shale. Most of the oil shale is in the Parachute Creek Member. The Green River Formation is overlain by the Uinta Formation of Eocene age and the Duchesne River Formation of Eocene and Oligocene age.

Climate

The study area has an arid climate. Temperatures vary with altitude, ranging from over 100°F in the summer to below -20°F in the winter. Precipitation generally occurs as snowfall from November to March and in thunderstorms from April to October. Total precipitation ranges from less than 8 inches at altitudes below 4,500 feet (National Geodetic Vertical Datum of 1929) near Ouray, Utah, to more than 20 inches at altitudes near 9,500 feet at the top of the Roan Plateau. Scattered thunderstorm activity accounts for most of the precipitation at lower altitudes in the area. Thunderstorms are of short duration, yet they can be of such intensity as to cause flash floods which can cause considerable erosion at lower altitudes because of local topography, soil type, and vegetation.

Vegetation

Graham (1937) divided the study area into three zones based on predominant vegetative types. At altitudes between 4,500 and 6,000 feet, sagebrush (*Artemesia* sp.) and rabbitbrush (*Chrysothamnus* sp.) occupy the plateaus, greasewood (*Sarcobatus vermiculatus*) dominates the valleys, and cottonwood (*Populus* sp.) and willow (*Salix* sp.) predominate along perennial streams. At altitudes between 6,000 and 7,500 feet, sagebrush, juniper

(Juniperus sp.), and pinyon (Pinus edulis) communities prevail. Sagebrush dominates the broad valleys, with juniper-pinyon on the sides of valleys and on plateaus. At altitudes above 7,500 feet, sagebrush, aspen (Populus tremuloides), fir (Abies sp.) and serviceberry (Amelanchier sp.) aggregates occupy both plateaus and valleys. The vegetation of the area has been mapped in more detail by Butler and England (1979).

SAMPLING STATIONS

Biological sampling was done at 14 stations (13 sites are shown in figs. 2-14) which were representative of undeveloped drainages in the southeastern Uinta Basin. The stations reflect a wide variety of hydrologic conditions, ranging from ephemeral to perennial streams, and cover a wide range of physiographic features.

White River near Colorado-Utah State line, Utah; station 09306305 (fig. 2).--The station is on the White River, about 2.7 miles downstream from the Colorado-Utah State line and 7.5 miles upstream from Evacuation Creek. The stream is perennial and has an average width of about 100 feet and a depth of about 3.5 feet. The drainage area is 3,680 mi^2. The average discharge, based on record for the 1977-79 water years, is 606 ft^3/s, with a maximum discharge of 4,470 ft^3/s (May 30, 1979) and a minimum discharge of 10 ft^3/s (July 2-4, 1977). The streambed consists of about one-third sand and two-thirds cobble-sized tabular marlstone, 2 to 4 inches in diameter. Riffles are generally formed by the marlstone cobbles.

Evacuation Creek above Missouri Creek, near Dragon, Utah; station 09306410 (fig. 3).--The station is on Evacuation Creek, 0.5 mile upstream from Missouri Creek. The stream is perennial and has an average width of about 2 feet and a depth of about 0.3 foot. The streambed meanders across a 100-foot wide valley. The drainage area is 100 mi^2. The average discharge, based on record for the 1975-79 water years, is 1.04 ft^3/s, with a maximum discharge of 835 ft^3/s (August 13, 1978) and a minimum discharge of 0.04 ft^3/s (February 23, 1979). The streambed consists of fine sand with some gravel and small cobbles.

Evacuation Creek at Watson, Utah; station 09306420 (fig. 4).--The station is on Evacuation Creek at Watson about 1.5 miles upstream from a tributary to Evacuation Creek. The stream is ephemeral, and when flowing it has an average width of about 2 feet and a depth of 0.5 foot. The drainage area is 259 mi^2. The average discharge, based on record for the 1975-76 water years, is 1.36 ft^3/s, with a maximum discharge of 650 ft^3/s (May 9, 1976). There is no flow during several days in most years. The streambed consists mainly of fine sand.

Evacuation Creek near Watson, Utah; station 09306430 (fig. 5).--The station is on Evacuation Creek, 2.2 miles upstream from the mouth and 4.8 miles north of Watson. The stream is perennial in most years and has an average width of about 2 feet and a depth of 0.5 foot. The drainage area is 284 mi^2. The average discharge, based on record for the 1975-79 water years, is 1.11 ft^3/s, with a maximum discharge of 1,980 ft^3/s (September 26, 1979) and no flow for a few days during dry years. Flows generally disappear within 0.2-0.5 mile downstream from the station and only reach the White River during runoff from snowmelt and thunderstorms. The streambed consists of fine to coarse sand.

Figure 2.--White River near Colorado-Utah State line, Utah (09306395).

Figure 3.--Evacuation Creek above Missouri Creek, near Dragon, Utah (09306410).

Figure 4.--Evacuation Creek at Watson, Utah (09306420).

Figure 5.--Evacuation Creek near Watson, Utah (09306430).

White River near Watson, Utah; station 09306500 (fig. 6).--The station is on the White River, 350 feet downstream from the bridge on State Highway 45, 1 mile downstream from Evacuation Creek, and 7 miles north of Watson. The stream is perennial and has an average width of about 105 feet and a depth of about 3.5 feet. The drainage area is 4,020 mi^2. The average discharge, based on record for the 1924-79 water years, is 695 ft^3/s, with a maximum discharge of 8,160 ft^3/s (July 15, 1929) and a mimimum discharge of 11 ft^3/s (December 6, 1972). The streambed consists of marlstone, ranging in size from fine sand to platy cobbles.

White River below Asphalt Wash, near Watson, Utah; station 09306700 (fig. 7).--The station is on the White River, 1.3 miles downstream from Asphalt Wash and 7.8 miles northwest of Watson. The stream is perennial and has as average width of about 100 feet and a depth of about 3.5 feet. The drainage area is 4,130 mi^2. The average discharge, based on record for the 1975-79 water years, is 630 ft^3/s, with a maximum discharge of 4,540 ft^3/s (June 9, 1975) and a minimum discharge of 17 ft^3/s (July 3, 1977). The streambed generally consists of fine sand with shale cropping out at some of the riffles.

Bitter Creek near Bonanza, Utah; station 09306800 (fig. 8).--The station is on Bitter Creek, about 150 feet upstream from a road bridge, 3 miles downstream from Sweetwater Canyon Creek, 17 miles upstream from the mouth, and 18 miles south-southwest of Bonanza. Flow passing this station seldom reaches the lower station site (09306850), Bitter Creek at mouth. The stream is ephemeral and when flowing has an average width of about 2 feet and a depth of about 0.5 foot. The drainage area is 324 mi^2. The average discharge, based on record for the 1971-79 water years, is 1.20 ft^3/s, with a maximum discharge of 1,660 ft^3/s (July 17, 1974). Periods of no flow are common during the summer and autumn. The streambed consists of mainly of fine sand and silt with some cobbles, especially at riffles.

Bitter Creek at mouth, near Bonanza, Utah; station 09306850 (fig. 9).--The station is on Bitter Creek, 0.6 mile upstream from the mouth and 13 miles southwest of Bonanza. The stream is perennial and has an average width of about 2 feet and a depth of about 0.3 foot. The drainage area is 398 mi^2. The average discharge, based on record for the 1975-79 water years, is 0.80 ft^3/s, with a maximum discharge of 117 ft^3/s (August 18, 1977) and a minimum of 0.1 ft^3/s (July 2, 1975). The streambed consists of fine sand and silt.

White River at mouth, near Ouray, Utah; station 09306900 (fig. 10).--The station is on the White River, 2.8 miles southeast of Ouray and 3.9 miles upstream from the mouth. The stream is perennial and has an average width of about 105 feet and a depth of about 3.5 feet. The drainage area is 5,120 mi^2. The average discharge, based on record for the 1974-79 water years, is 644 ft^3/s, with a maximum discharge of 4,260 ft^3/s (March 29, 1976), and a minimum discharge of 1.6 ft^3/s (July 18, 1977). The streambed consists mainly of fine sand, which is subject to scouring during spring runoff, exposing a hard clay.

Willow Creek above diversion, near Ouray, Utah; station number 09307500 (fig. 11).--The station is on Willow Creek, 0.1 mile downstream from Big

Figure 6.--White River near Watson, Utah; (09306500).

Figure 7.--White River below Asphalt Wash, near Watson, Utah; (09306700).

Figure 8.--Bitter Creek near Bonanza, Utah; (09306800).

Figure 9.--Bitter Creek at mouth, near Bonanza, Utah; (09306850).

Figure 10.--White River at mouth, near Ouray, Utah (09306900).

Figure 11.--Willow Creek above diversions, near Ouray, Utah (09307500).

Canyon and 36 miles southeast of Ouray. The stream is perennial and subject to frequent flash floods during summer thunderstorms. The stream has an average width of about 12 feet and a depth of 1 foot. The drainage area is 297 mi^2. The average discharge, based on record for the 1951-55, 1958-70, and 1975-79 water years, is 20.1 ft^3/s, with a maximum discharge of 2,240 ft^3/s (July 19, 1977) and a minimum of 0.3 ft^3/s (August 21-23, 1960). The streambed consists mainly of fine sand.

Hill Creek above Towave Reservoir, near Ouray, Utah; station 09307800 (fig. 12).--The station is on Hill Creek, 0.5 mile upstream from Lower Wagon Canyon, 3.5 miles south of Towave Reservoir, and 39 miles south of Ouray. The stream is perennial and has an average width of about 8 feet and a depth of about 1 foot. The drainage area is 89.7 mi^2. The average discharge, based on record for the 1975-79 water years, is 8.54 ft^3/s, with a maximum discharge of 106 ft^3/s (May 28, 1979) and a minimum discharge of 0.07 ft^3/s (August 10, 1977). The streambed consisted mainly of gravel with some sand.

Hill Creek near mouth, near Ouray, Utah; station 09307900 (fig. 13).-- The station is on Hill Creek, 5.9 miles upstream from the mouth and 15 miles southeast of Ouray. The stream is ephemeral and has an average width of about 5 feet and a depth of less than 1 foot. The drainage area is 288 mi^2. The average discharge, based on record for the 1975-79 water years, is 3.98 ft^3/s, with a maximum discharge of 201 ft^3/s (August 1, 1976). For most years, there are many days of no flow during July through January. The streambed consists of fractured marlstone, ranging in size from coarse sand to cobbles.

Willow Creek near Ouray, Utah; station 09308000 (fig. 14).-- The station is on Willow Creek, 1.6 miles downstream from Hill Creek and 10 miles south of Ouray. The stream ceases to flow during late summer because of irrigation diversions. The stream has an average width of about 15 feet and a depth of about 0.7 foot. The drainage area is 897 mi^2. The average discharge, based on record for the 1948-55 and 1975-79 water years, is 24.2 ft^3/s, with a maximum discharge of 11,000 ft^3/s (February 1962). The streambed consists of fine sand mixed with platy cobbles of marlstone.

Willow Creek at mouth, near Ouray, Utah; station 09308010.--The station is on Willow Creek, 0.6 mile upstream from the mouth and 5.2 miles southwest of Ouray. The stream is ephemeral. It is dry most of the year, flowing periodically during thunderstorms and periods of snowmelt. It has an average width of about 20 feet with a depth of about 1 foot. The drainage area is 951 mi^2. This is a partial-record site. Flows are generally equivalent to those measured at station 09308000, and the channel is similar to that shown in figure 14.

DATA COLLECTION

Methods

The methods used for the collection and analysis of biological data are described by Greeson and others (1977). The membrane filtration technique was used for the analysis of total coliform, fecal coliform, and fecal streptococci bacteria. Water samples were filtered in the field immediately after collection. Filters were then placed on agar media specifically designed to promote the growth of each type of bacteria. The colonies of bacteria were counted after a specific incubation period to determine the

Figure 12.--Hill Creek above Towave Reservoir, near Ouray, Utah (09307800).

Figure 13.--Hill Creek near mouth, Near Ouray, Utah (09307900).

Figure 14.--Willow Creek near Ouray, Utah; (09308000).

number of colonies per 100 mL (milliliter). At each site, samples were filtered from three volumes of water. If two or more filters of a series produced colony counts within the recommended counting range (Greeson and others, 1977, p. 29-55 and p. 53-62), averaging was used to report results. The determination of the origin of fecal contamination by using colony concentrations can be cumbersome and misleading, but the FC/FS ratio can be useful in inferring the possible origin of the contamination. If human wastes are involved, the primary inference to be drawn from the bulk of the FC/FS ratios, which are less than 1.0, is that the source of the fecal coliform bacteria and streptococci are animal rather than human wastes.

Benthic invertebrates were collected by taking samples on the right side, middle, and left side of the streams. The samples were composited for analysis. Samples were generally taken from riffles where possible. All samples were taken with a Surber sampler (1 ft^2) using the U.S. Standard Sieve No. 70 mesh (210-micrometer mesh opening), except at the White River at mouth (09306900) where the streambed consists of shifting sand and silt. Samples were taken at this site from 10 rocks which were removed from the streambed and held above a net to catch the organisms dislodged from each rock.

In order to summarize the benthic-invertebrate data, the Shannon-Weiner diversity index (Krebs, 1972, p. 506) was calculated for each sample taken. This diversity index is used as an indicator of the health of a stream's benthic-invertebrate community. Diversities less than 1 indicate a physically stressed or polluted environment, whereas diversities approaching or exceeding 3 generally indicate a well-balanced, nonpolluted environment. The index is most useful in evalulating environments in which there has been a large influx of organic material.

The diversity index, D.I., is calculated as:

$$D.I. = -\sum_{i=1}^{s} (P_i)(\log_2 P_i)$$

where D.I. = information content of the sample or diversity,
s = number of species, and
P_i = proportion of total sample belonging to the ith species.

In this diversity index, a community made up of one species would have a diversity of zero, whereas a community having more than one species would have a diversity greater than zero. The more evenly the individuals in a community are divided among the species present, the higher the diversity index. For purposes of computing the diversity index in this study, the term species is used to mean the lowest taxonomic level to which the organisms were identified. Greater diversities would be found if all organisms had been identified to the species level. Diversity depends on both the number of species in a community and on the evenness with which they are represented. The evenness, V, is calculated as:

$$V = \frac{D.I.}{\log_2 s}$$

where D.I. and s are same as defined above. Evenness values are between one and zero. A community in which the majority of the individuals belong to only

one or two species will have a low evenness value while a community in which all species are equally represented will have an evenness value close to one.

Periphyton samples were collected at first by using floating-type artificial sampling devices, with mylar strips used as colonization substrate. Results were poor because of flooding and silting of channels. The sampling procedure was then changed to the collection of periphyton by scraping a natural substrate of measured area. Using a Sedgwick-Rafter counting cell, the total number of periphyton cells was counted in 20 random fields and recorded as the number of cells per square millimeter (mm^2) of surface scraped. The calculations for periphyton data are as follows:

(1) Calibration factor

$$= \frac{1{,}000\ mm^2}{\text{Area of Whipple disk at 100 magnification } (mm^2)}$$

(2) Periphyton cells/mL of suspended scraping

$$= \frac{\text{Total cell count x calibration factor}}{\text{Number of random fields x 1 mL}}$$

(3) Total periphyton cells/mm^2 of surface

$$= \frac{\text{Cells/mL of suspended scraping x total volume pf scraping (mL)}}{\text{Area of scraped surface } (mm^2)}$$

In addition to the biological sampling, the following field measurements were made periodically at each site: dissolved oxygen, pH, specific conductance, water discharge, and air and water temperature. Samples of bed material were also obtained in order to help explain variances in biological characteristics. The results of these measurements are reported by Conroy and Fields (1977), and Conroy (1979, 1980).

White River

Biological samples were collected at four stations on the White River. (See fig. 1 for locations.) The range in bacterial concentrations at the stations are shown in figures 15-18 and in table 1. Bacterial concentrations at all the stations are small.

Benthic invertebrates were sampled at the White River near Colorado-Utah State line, Utah, and at the White River at mouth, near Ouray, Utah (tables 2 and 3). The data available reflect a well-balanced community with many different organisms present, yet with no group dominating. The water at the sites is of moderate specific conductance and well oxygenated with a pH in the optimum range for aquatic organisms; thus, it is not surprising to find such relatively high diversities.

Periphyton samples were collected at the White River near Colorado-Utah State line, Utah, and at the White River at mouth, near Ouray, Utah. Green algae (order Chlorophyta) were the dominant algae present (table 4). Periphyton concentrations at the State-line site were generally smaller than at the mouth site.

Figure 15.--Bacterial concentration at White River near Colorado-Utah State line, Utah (09306395).

Figure 16.--Bacterial concentrations at White River near Watson, Utah (09306500).

Figure 17.--Baterial concentrations at White River below Asphalt Wash, near Watson, Utah (09306700).

Figure 18.--Bacterial concentration at White River at mouth, near Ouray, Utah (09306900).

Table 1.--Summary of bacterial concentrations
[All bacteria analyses were made with 100 milliliters of water]

Station number and name	Date of collection	Colonies per 100 milliliters: Total coliform bacteria	Fecal coliform bacteria	Fecal streptococci	Ratio of fecal coliform bacteria to fecal streptococci (FC/FS)
09306395, White River near Colorado-Utah State line, Utah	2-15-77	62	--	40	--
	4-25-77	50	30	40	0.75
	7-25-77	50	40	60	.67
	8-25-77	45	40	56	.71
	2-20-78	40	40	52	.77
	4-24-78	64	22	46	.48
09306410, Evacuation Creek above Missouri Creek, near Dragon, Utah	8-20-76	20	15	60	.25
	9-23-76	30	20	50	.40
	12-28-76	<1	<1	1	--
	2-15-77	30	<1	12	--
	4-25-77	40	<1	20	--
	7-25-77	20	10	40	.25
	10-26-77	52	40	60	.67
	2-20-78	240	140	220	.64
	4-24-78	60	4	120	.03
09306420, Evacuation Creek at Watson, Utah	7-14-76	100	20	25	.80
	8-20-76	20	15	60	.25
	9-23-76	70	40	60	.67
	12-28-76	60	30	60	.50
	2-15-77	40	<1	87	--
09306430, Evacuation Creek at mouth, near Watson, Utah	7-14-76	100	20	25	.80
	8-20-76	140	50	240	.21
	9-23-76	200	100	500	.20
	12-28-76	<1	<1	1	--
	2-15-77	<1	<1	<1	--
	4-25-77	150	80	300	.27
	7-25-77	2	1	60	.02
	10-26-77	94	80	220	.36
	2-20-78	140	100	240	.42
	4-24-78	220	100	420	.24
09306500, White River near Watson, Utah	7-14-76	40	30	25	1.20
	4-23-77	80	25	25	1.00
09306700, White River below Asphalt Wash, near Watson, Utah	7-14-77	20	10	30	.33
	7-25-77	45	20	30	.67
	10-26-77	20	14	22	.64
	2-20-78	88	32	48	.67
	4-24-78	42	14	22	.64

Table 1.--Summary of bacterial concentrations--Continued

Station number and name	Date of collection	Colonies per 100 milliliters: Total coliform bacteria	Fecal coliform bacteria	Fecal streptococci	Ratio of fecal coliform bacteria to fecal streptococci (FC/FS)
09306800, Bitter Creek near Bonanza, Utah	7-15-76	88	50	60	0.83
	8-18-76	(1)	--	--	--
	9-24-76	(1)	--	--	--
	12-30-76	40	30	2	15.00
	2-16-77	60	40	<1	--
	4-26-77	10	<1	<1	--
	7-27-77	80	60	80	.75
	10-24-77	60	44	50	.88
	2-22-78	14	1	1	1.00
09306850, Bitter Creek at mouth, near Bonanza, Utah	7-15-76	40	20	100	.20
	8-18-76	40	20	60	.33
	9-24-76	40	1	100	.01
	12-29-76	1	<1	<1	--
	2-16-77	100	60	30	2.00
	4-26-77	20	10	60	.17
	7-27-77	60	40	120	.33
	10-24-77	80	60	62	.97
	2-22-78	30	30	42	.71
09306900, White River at mouth, near Ouray, Utah	7-15-76	10	<1	<1	--
	8-19-76	10	<1	<1	--
	9-24-76	<1	<1	<1	--
	12-30-76	10	5	1	5.00
	2-16-77	<1	<1	<1	--
	4-26-77	<1	<1	3	--
	7-26-77	12	4	10	.40
	10-25-77	2	2	<1	--
	2-21-78	10	4	10	.40
	4-25-78	28	28	40	.70
09307500, Willow Creek above diversions, near Ouray, Utah	4-29-77	4	4	1	4.00
	7-26-77	40	30	50	.60
	10-25-77	44	44	62	.71
	2-21-78	1	1	4	.25
	4-25-78	44	30	34	.88
09307800, Hill Creek above Towave Reservoir, near Ouray, Utah	4-28-77	1	1	1	1.00
	10-25-77	50	26	42	.62
	2-22-78	4	--	--	--
	4-25-78	60	24	32	.75

Table 1.--Summary of bacterial concentrations--Continued

Station number and name	Date of collection	Colonies per 100 milliliters: Total coliform bacteria	Fecal coliform bacteria	Fecal streptococci	Ratio of fecal coliform bacteria to fecal streptococci (FC/FS)
09307900, Hill Creek near mouth, near Ouray, Utah	7-15-76	([1])	--	--	--
	8-19-76	([1])	--	--	--
	9-24-76	([1])	--	--	--
	12-30-76	([1])	--	--	--
	4-27-77	10	<1	15	--
	7-26-77	([1])	--	--	--
	10-24-77	([1])	--	--	--
	4-25-78	60	44	80	0.55
09308000, Willow Creek near Ouray, Utah	7-15-76	20	15	60	.25
	8-19-76	20	10	60	.17
	9-24-76	20	10	80	.12
	12-30-76	1	1	4	.25
	4-27-77	80	15	60	.25
	7-26-77	([1])	--	--	--
	10-24-77	([1])	--	--	--
	2-22-78	140	100	120	.83
	4-25-78	160	80	120	.67
09308010, Willow Creek at mouth, near Ouray, Utah	7-15-76	([1])	--	--	--
	8-19-76	([1])	--	--	--
	9-24-76	([1])	--	--	--
	12-30-76	<1	<1	10	--
	4-27-77	45	30	15	2.00

[1] No flow in stream.

Table 2.--Benthic-invertebrate identifications and distribution

[A, indicates adult; L, indicates larva; and P, indicates pupa]

Station. 09306395, White River near Colorado-Utah State line, Utah
Sampling method: Four Surber samples, 4 square feet sampled.

Order	Family	Genus	Species	Date			
				4-25-77	7-27-77	5-25-78	7-25-78
				Number of organisms per 4 square feet			
Ephemeroptera	Siphlonuridae	*Isonychia*	*sp.*	2	--	--	1
	Heptageniidae	*Heptagenia*	*sp.*	1	3	--	1
	Baetidae	*Baetis*	*sp.*	1	--	1	2
	Tricorythidae	*Tricorythodes*	*sp.*	--	--	--	1
Odonata	Gomphidae	*Ophiogomphus*	*severus*	--	1	--	--
Plecoptera	Nemouridae	*Malenka*	*sp.*	1	--	--	--
	Perlodidae	*Isoperla*	*mormona*	2	18	14	--
Hemiptera	Corixidae	*Corisella*	*tarsalis*	--	4	--	1
	Naucoridae	*Ambrysus*	*sp.*	--	1	--	--
	Veliidae	*Rhagovelia*	*sp.*	3	--	--	11
Coleoptera	Hydraenidae	*Ochthebius*	*sp. A*	--	1	--	--
	Elmidae	*Optioservus*	*sp. L*	1	14	5	--
Trichoptera	Hydropsychidae	*Hydropsyche*	*sp.*	2	10	2	1
	Leptoceridae	*Nectopsyche*	*minuta*	--	--	--	1
	Brachycentridae	*Brachycentrus*	*americanus*	--	1	1	--
Diptera	Tipulidae	*Hexatoma*	*sp.*	--	6	1	--
	Simuliidae	*Simulium*	*sp.*	3	--	1	4
	Chironomidae	*Ablabesmyia*	*sp. P*	--	--	--	1
		Eukiefferiella	*sp.*	--	--	1	--
	Ceratopogonidae	*Bezzia*	*sp. P*	--	--	2	--
	Stratiomyidae	*Euparyphus*	*sp.*	--	--	1	--

Station: 09306410, Evacuation Creek above Missouri Creek,near Dragon, Utah
Sampling method: Four Surber samples, 4 square feet sampled.

				10-28-77	5-27-78	7-27-78
Ephemeroptera	Heptageniidae	*Heptagenia*	*sp.*	--	2	--
	Baetidae	*Baetis*	*sp.*	2	1	1
Odonata	Gomphidae	*Ophiogomphus*	*severus*	--	--	1
	Coenagrionidae	*Argia*	*emma*	--	1	2
Hemiptera	Corixidae	*Hesperocorixa*	*sp.*	--	--	1
Coleoptera	Dytiscidae	*Agabus*	*sp. A*	1	--	--
		Deronectes	*sp. A*	--	--	1
	Hydrophilidae	*Laccobius*	*sp. A*	--	2	1
	Hydraeridae	*Ochthebius*	*sp. A*	1	--	--
Trichoptera	Hydropsychidae	*Hydropsyche*	*sp.*	--	1	--

Table 2.--Benthic-invertebrate identifications and distribution--Continued

Station. 09306410, Evacuation Creek above Missouri Creek, near Dragon, Utah--Continued

Order	Family	Genus	Species	Date 10-28-77	5-27-78	7-27-78
				Number of organisms per 4 square feet		
Diptera	Tipulidae	*Tipula*	*sp.*	4	--	--
	Dixidae	*Unidentified*	*P*	1	--	--
	Simuliidae	*Simulium*	*sp.*	4	22	12
	Chironomidae	*Conchapelopia*	--	--	--	--
		Arctopelopia	--	--	--	--
		Rheopelopia	*sp.*	--	--	1
		Eukiefferiella	*sp.*	--	--	1
	Muscidae	*Limnophora*	*sp.*	--	--	1

Station: 09306850, Bitter Creek at mouth, near Bonanza, Utah
Sampling method. Four Surber samples, 4 square feet sampled.

				7-25-77	10-25-77	5-24-77	7-27-78
Ephemeroptera	Heptageniidae	*Heptagenia*	*sp.*	--	--	--	2
Odonata	Coenagrionidae	*Argia*	*emma*	6	4	8	9
Plecoptera	Perlodidae	*Isoperla*	*mormona*	2	--	--	--
Hemiptera	Corixidae	*Corisella*	*tarsalis*	5	1	--	1
Trichoptera	Hydropsychidae	*Hydropsyche*	*sp.*	3	1	--	4
Diptera	Tipulidae	*Hexatoma*	*sp.*	2	--	--	--
	Chironomidae	*Cricotopus*	*sp. L/P*	--	--	7/1	2/0
	Tabanidae	*Tabanus*	*sp.*	--	--	2	--
	Ephydridae	*Ephydra*	*riparia*	--	--	2	--

Station: 09306900, White River at mouth, near Ouray, Utah
Sampling method: Organisms removed from 10 rocks because shifting sand channel and deep water precluded the use of a Surber sample.

				7-25-77	10-25-77	7-27-78
Ephemeroptera	Heptageniidae	*Heptagenia*	*sp.*	1	6	4
	Oligoneuriidae	*Lachania*	*powelli*	--	--	1
	Leptophlebiidae	*Choroterpes*	*sp.*	--	--	2
		Traverella	*sp.*	--	--	1
	Baetidae	*Baetis*	*sp.*	3	4	8
	Tricorythidae	*Tricorythodes*	*sp.*	9	4	14
Odonata	Agrionidae	*Hetaerina*	*americana*	1	--	1
Plecoptera	Perlidae	*Acroneuria*	*abnormis*	1	--	3
Hemiptera	Naucoridae	*Ambrysus*	*sp.*	--	--	1
Coleoptera	Dryopidae	*Helichus*	*suturalis*	--	2	--
	Elmidae	*Microcyllopus*	*sp. A*	1	--	--
Trichoptera	Hydropsychidae	*Hydropsyche*	*sp. L/P*	32/1	4/0	44/0

Table 2.--Benthic-invertebrate identifications and distribution--Continued

Station: 09306900, White River at mouth, near Ouray, Utah--Continued

Order	Family	Genus	Species	Date 7-25-77	10-25-77	7-27-78
				Number of organisms per 4 square feet		
Diptera	Simuliidae	*Simulium*	*sp.*	10	4	36
	Chironomidae	*Zavrelimyia*	*sp.*	1	--	1
		Cladotanytarsus	*sp.*	--	1	--
		Polypedilum	*sp.*	1	1	--
		Orthocladius	*dorenus*	--	2	5
		Corynoneura	*sp.*	--	1	--
		Thienemanniella	*sp.*	5	--	--

Station: 09307500, Willow Creek above diversions, near Ouray, Utah
Sampling method: Four Surber samples, 4 square feet sampled.

				7-26-77	5-23-78	7-28-78
Ephemeroptera	Heptageniidae	*Heptagenia*	*sp.*	1	13	17
	Leptophlebiidae	*Choroterpes*	*sp.*	3	--	4
		Traverella	*sp.*	1	2	--
	Baetidae	*Baetis*	*sp.*	--	17	--
	Tricorythidae	*Tricorythodes*	*sp.*	28	8	26
Odonata	Gomphidae	*Ophiogomphus*	*severus*	--	--	3
Plecoptera	Nemouridae	*Amphinemura*	*sp.*	--	--	--
Coleoptera	Dytiscidae	*Deronectes*	*sp. A*	--	--	--
	Dryopidae	*Helichus*	*suturalis*	--	2	--
Trichoptera	Hydropsychidae	*Hydropsyche*	*sp. L/P*	2/1	9/1	2/0
	Limnephilidae	*Hesperophylax*	*sp.*	--	--	--
Diptera	Tipulidae	*Hexatoma*	*sp.*	--	--	--
		Tipula	*sp.*	--	--	--
	Simuliidae	*Simulium*	*sp.*	6	8	9
	Chironomidae	*Concha-, Arcto-Rheopelopia*	*sp.*	--	--	1
		Zavrelimyia	*sp.*	--	3	--
		Phaenopsectra	*sp.*	--	--	--
		Polypedilum	*sp.*	--	1	--
		Cricotopus	*sp.*	--	3	--
		Thienemanniella	*sp.*	--	1	--

Station: 09307800, Hill Creek above Towave Reservoir, near Ouray, Utah
Sampling method: Four Surber samples, 4 square feet sampled.

				4-28-77	7-26-77	10-26-77	5-23-78	7-28-78
Ephemeroptera	Heptageniidae	*Heptagenia*	*sp.*	--	--	--	--	--
	Leptophlebiidae	*Choroterpes*	*sp.*	--	--	--	--	--
	Baetidae	*Baetis*	*sp.*	9	1	2	--	--
	Tricorythidae	*Tricorythodes*	*sp.*	--	--	--	--	--
Odonata	Gomphidae	*Ophiogomphus*	*severus*	--	3	1	3	--
Plecoptera	Perlodidae	*Isoperla*	*mormona*	9	--	--	2	1

Table 2.--Benthic-invertebrate identifications and distribution--Continued

Station: 09307800, Hill Creek above Towave Reservoir, near Ouray, Utah--Continued

Order	Family	Genus	Species	Date 4-28-77	7-26-77	10-26-77	5-23-78	7-28-78
				Number of organisms per 4 square feet				
Hemiptera	Notonectidae	*Notonecta*	*sp.*	--	--	--	1	--
Coleoptera	Hydrophilidae	*Laccobius*	*sp. A*	1	--	--	--	--
	Dryopidae	*Helichus*	*suturalis*	2	--	--	--	--
	Elmidae	*Optioservus*	*sp. L/A*	1/1	--	1/8	0/2	1/0
Trichoptera	Hydropsychidae	*Hydropsyche*	*sp.*	58	9	--	10	3
Diptera	Tipulidae	*Hexatoma*	*sp.*	4	--	2	3	--
		Tipula	*sp.*	1	--	--	--	--
	Simuliidae	*Simulium*	*sp.*	4	--	--	--	--
	Chironomidae	*Diamesa*	*sp.*	28	--	--	--	--
		Pseudodiamesa	*sp.*	--	--	--	--	1
		Orthocladius	*dorenus*	1	--	--	--	--
		Smittia	*sp.*	3	--	--	--	--
Decapoda	Astacidae	*Pacifastacus*	*sp.*	--	--	--	2	1

Station: 09308000, Willow Creek near Ouray, Utah
Sampling method: Four Surber samples, 4 square feet sampled.

				5-23-78
Ephemeroptera	Heptageniidae	*Heptagenia*	*sp.*	18
	Leptophlebiidae	*Choroterpes*	*sp.*	--
		Traverella	*sp.*	--
	Baetidae	*Baetis*	*sp.*	9
	Tricorythidae	*Tricorythodes*	*sp.*	--
Odonata	Gomphidae	*Ophiogomphus*	*severus*	--
Plecoptera	Nemouridae	*Amphinemura*	*sp.*	3
Coleoptera	Dytiscidae	*Deronectes*	*sp. A*	8
	Dryopidae	*Helichus*	*suturalis*	--
Trichoptera	Hydropsychidae	*Hydropsyche*	*sp.*	--
	Limnephilidae	*Hesperophylax*	*sp.*	1
Diptera	Tipulidae	*Hexatoma*	*sp.*	1
		Tipula	*sp.*	1
	Simuliidae	*Simulium*	*sp.*	--
	Chironomidae	*Concha-, Arcto-Rheopelopia*	*sp.*	--
		Zavrelimyia	*sp.*	--
		Phaenopsectra	*sp.*	1
		Polypedilum	*sp.*	--
		Cricotopus	*sp.*	1
		Thienemanniella	*sp.*	--

Table 3.--Benthic-invertebrate statistics and environmental factors

Station number and name	Date	Number of species	Number of individuals per square meter	Diversity index (D. L)	Evenness	Specific conductance (micromhos per centimeter at 25°C)	Dissolved oxygen (milligrams per liter)	pH (units)
09306395, White River near Colorado-Utah State line, Utah	4-25-77	9	43	3.03	0.96	800	11.4	7.8
	7-27-77	10	159	2.66	.80	780	9.6	7.4
	5-25-78	10	78	2.48	.75	365	11.6	7.6
	7-25-78	10	65	2.58	.78	540	9.4	7.4
09306410, Evacuation Creek above Missouri Creek, near Dragon, Utah	10-28-77	6	35	2.32	.90	4,000	9.0	7.8
	5-27-78	6	78	1.34	.52	4,000	8.6	8.2
	7-27-78	10	59	2.41	.73	4,200	8.2	7.9
09306850, Bitter Creek at mouth, near Bonanza, Utah	7-27-77	5	48	2.18	.94	14,700	7.8	8.0
	10-25-77	3	16	1.25	.79	15,500	7.6	8.2
	5-24-78	4	54	1.72	.86	15,500	9.2	7.8
	7-27-78	5	48	1.92	.83	14,000	9.4	8.2
09306900, White River at mouth, near Ouray, Utah	7-25-77	11	178	2.34	.67	950	7.6	8.4
	10-25-77	10	78	3.08	.93	840	8.0	8.6
	7-27-78	13	326	2.54	.69	680	9.6	7.4
09307500, Willow Creek above diversions, near Ouray, Utah	7-26-77	6	113	1.59	.62	850	9.8	8.2
	5-23-78	11	183	2.97	.86	740	10.6	7.6
	7-28-78	7	167	2.16	.77	700	9.6	7.8
09307800, Hill Creek above Towave Reservoir, near Ouray, Utah	4-28-77	12	328	2.37	.66	610	10.4	8.1
	7-26-77	3	35	1.14	.72	780	9.6	8.2
	10-25-77	4	38	1.48	.74	460	9.0	8.1
	5-23-78	7	62	2.40	.86	720	9.6	8.0
	7-28-78	10	54	2.92	.88	560	9.8	8.2
09308000, Willow Creek near Ouray, Utah	5-23-78	9	116	2.35	.74	1,200	11.0	8.5

Table 4.--Concentrations of periphyton cells

Station number and name	Date	Time	Cells per square millimeter	Dominant genera and species
09306395, White River near Colorado-Utah State line, Utah	8-26-77	1230	480	*Cladophora glomerata*
	4-24-78	1325	640	*Do.*
	7-25-78	1030	150	*Do.*
09306410, Evacuation Creek above Missouri Creek, near Dragon, Utah	10-26-77	1310	310	*Oedogonium*
	5-27-78	1540	200	*Zygnema*
	7-27-78	1600	240	*Ulothrix*
09306850, Bitter Creek near mouth, near Bonanza, Utah	10-24-77	1420	8,600	*Anabaena*
	5-24-78	0930	7,400	*Oscillatoria*
	7-27-78	1025	4,200	*Nostoc*
09306900, White River at mouth, near Ouray, Utah	7-26-77	1210	1,200	*Cladophora glomerata*
	10-25-77	1530	3,600	*Do.*
	7-27-78	1925	2,400	*Do.*
09307500, Willow Creek above diversions, near Ouray, Utah	7-28-77	1125	120	*Pennate diatoms*
	5-23-78	1340	80	*Do.*
	7-28-78	1670	240	*Do.*
09307800, Hill Creek above Towave Reservoir, near Ouray, Utah	7-26-77	1410	420	*Oedogonium*
	10-25-77	1520	2,200	*Ulothrix*
	5-23-78	1430	1,400	*Do.*

Evacuation Creek

Biological samples were collected at three sites on Evacuation Creek (fig. 1). Bacterial concentrations are compiled in table 1 and shown graphically in figures 19-21. Bacterial concentrations were generally lowest in winter and highest in early spring and summer, with the exception of the samples obtained in February 1978, which were anomalously high. These data suggest that some fecal contamination is present periodically. Fecal streptococci counts were the highest of the three bacterial groups sampled, with the highest concentrations occurring during the winter when the country near Evacuation Creek is used for livestock grazing. The ratio of fecal coliform to fecal streptococci bacteria (FC/FS) can be used as an indicator of the source of fecal pollution. FC/FS ratios greater than 4.0 are indicative of human waste whereas ratios less than 1.0 are indicative of feces from farm animals, dogs, cats, and rodents (Geldriech and Kenner, 1969, p. R349). The data from Evacuation Creek show FC/FS ratios of less than 1.0, which indicates that the contribution is of livestock origin rather than human origin.

Benthic invertebrates were sampled only at Evacuation Creek above Missouri Creek, near Dragon, Utah (table 2). The diversity of the benthic community is moderately low (table 3) because of the large Diptera population. The latter may be due to the size of the streambed material, which ranges from very fine sand to very coarse gravel, because dipterans show the highest colonization rate for this type of bed material. Another reason for the low diversity could be the shifting channel and the high summer water temperatures, which can exceed 35°C.

Periphyton samples were collected at Evacuation Creek above Missouri Creek, near Dragon, Utah, where green algae (order Chlorophyta) were the dominant algae present. The results of the periphyton sampling are recorded in table 4.

Bitter Creek

Biological samples were collected at two sites on Bitter Creek (fig. 1). Bacterial concentrations are shown in table 1 and figures 22 and 23. Total coliform and fecal coliform bacteria concentrations were relatively low, whereas fecal streptococci concentrations were as high as 120 colonies/100 mL. This area is used for livestock grazing in the winter, and deer are known to concentrate there also in winter.

Benthic invertebrates were sampled only at Bitter Creek at mouth, near Ouray, Utah (table 2). The dominant species present in all samples was Argia emma, a damselfly. Few organisms were found on all sampling dates, and diversity was generally low (table 3). If organisms only inhabit a few habitats and fill a small number of trophic levels, water may be judged to be of poor biological quality (Patrick, 1949). Specific conductance of the water at this station ranges from about 2,000 to 19,000 micromhos/cm at 25°C, dissolved solids average about 15,000 mg/L, and water temperatures reach 32°C in late summer. Only a few species are capable of surviving under these environmental conditions.

Periphyton samples were also collected at the lower Bitter Creek station, where blue-green algae (order Cyanophyta) were the dominant algae present. Algal mats were observed to occur throughout the year. The results of the sampling are shown in table 4.

Figure 19.--Bacterial concentrations at Evacuation Creek above Missouri Creek, near Dragon, Utah (09306410).

Figure 20.--Bacterial concentrations at Evacuation Creek at Watson, Utah (09306420).

Figure 21.--Bacterial concentrations at Evacuation Creek at mouth, near Watson, Utah (09306430).

Figure 22.--Bacterial concentrations at Bitter Creek near Bonanza, Utah (09306800).

Figure 23.--Bacterial concentrations at Bitter Creek at mouth, near Bonanza, Utah (09306850).

Hill Creek

Biological samples were collected at two sites on Hill Creek (fig. 1). The streambed is dry at the lower Hill Creek station, except for short periods in the winter and spring; thus, only two bacterial samples were collected. These samples and those collected at the upper site showed low bacterial concentrations. The FC/FS ratios were all low, indicating that fecal wastes present are of other than human origin. This seems reasonable because horses and cattle are known to range in bottom lands throughout the Hill Creek drainage.

Benthic invertebrates were sampled at the upper Hill Creek station (table 2). The diversity was generally low, reflecting the domination of trichopterans (caddisflies) in three of the samples.

Periphyton samples were also collected at the upper Hill Creek station, where green algae (order Chlorophyta) were the dominant algae present. The results of the sampling are shown in table 4.

Willow Creek

Biological samples were collected at three stations on Willow Creek (fig. 1). All samples collected showed low bacterial concentrations with little fecal contamination present (table 1 and figs. 24-26). The few colonies present probably resulted from overland runoff washing the feces from livestock into the creek. The FC/FS ratios tend to validate the belief that cattle are the source of fecal contamination.

Benthic invertebrates were sampled at the middle and upper stations on Willow Creek (table 2). In all samples, mayflies (order Ephemeroptera) were found to be the dominant form. The diversity was moderately low (table 3). The reach of Willow Creek at the middle station is susceptible to flash floods which scour the streambed, remove most organisms, and then deposit silt during recessions that inhibits repopulation. The biological community is thus unstable at this station.

Periphyton samples were collected at the upper station on Willow Creek. Pennate diatoms were the dominate algae present. The results of the sampling are shown in table 4.

CONCLUSIONS

Bacterial concentrations, periphyton, and benthic-invertebrate populations in streams in the southeastern Uinta Basin were sampled during a 2-year period to establish baseline conditions prior to oil-shale development. The concentrations of total coliform bacteria were moderate to low, mostly having been introduced from nonfecal sources. The highest numbers occurred during periods of high water (spring snowmelt and summer thunderstorms), suggesting that the introduction of nonfecal coliform bacteria (predominantly soil bacteria) may result from erosional processes caused by overland flooding and runoff.

Concentrations of fecal coliform bacteria also increased during high-water periods. Animal feces from livestock and wildlife are washed into the streams by the same processes that introduce soil bacteria to the streams, and

Figure 24.--Bacterial concentrations at Willow Creek above diversions, near Ouray, Utah (09307500).

Figure 25.--Bacterial concentrations at Willow Creek near Ouray, Utah (09308000).

Figure 26.--Bacterial concentrations at Willow Creek at mouth, near Ouray, Utah (09308010).

large numbers of animal feces were observed in the water and on debris jams during high-water periods. Concentrations of fecal streptococci also increased at the same time but generally at higher rates than did the concentrations of fecal coliform bacteria. Only three FC/FS values were 4.0 or greater (table 1), and these anomalies are attributed to very low non-ideal bacteria counts.

The periphyton sampling resulted in poor data mainly because of difficulties in sampling procedures. Even if these difficulties were overcome, however, it would take a comprehensive and lengthy study to collect statistically accurate data. Periphyton productivity and the standing crop in an area, such as the Uinta Basin, are variable because of seasonal changes in environmental conditions. Periphyton may be removed by high water, low water, and high concentrations of suspended sediment during different seasons of the year. Thus, concentrations of periphyton may go through rapid changes within a short time. A comprehensive study would include increased sampling frequency and identification of periphyton to the species level where feasible. This is essential if periphyton are to be used to monitor pre- and post-development water-quality conditions. Changes in species diversity thus could be used as an indicator of impacts associated with oil-shale development. Changes in diversity would have to be monitored over a long period so that natural changes could be differentiated from cultural changes, such as might result from oil-shale development.

Benthic-invertebrate sampling was successful in determining species present and their relative diversity and density. Due to physical factors outside of their control, populations vary from season to season, even from flood to flood. The benthic invertebrates have the capability of repopulation, often from upstream drift as well as flying adult stages. Of the three groups of organisms sampled, however, the benthic invertebrates are the most stable, easiest to identify, and are readily available for collection during all seasons. The diversity indices are parameters that can be used to determine the effects of industrial activity, thus in a monitoring program of the biological aspects of streamflow, major emphasis should be placed on benthic invertebrates. If future monitoring programs are established, increased statistical accuracy would be obtained by a greater sampling frequency than that used in this study.

REFERENCES CITED

Bauman, R. W., Gaufin, A. H., and Winget, R. N., 1975, Aquatic habitat evaluation of the White River, Uintah County, Utah: Prepared for the Utah Division of Wildlife Resources, Salt Lake City, Utah, draft only.

Butler, J. R., and England, J. L., 1979, Vegetation map of southeastern Uinta Basin, Utah and Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-1141, scale 1:126,720.

Cashion, W. B., 1967, Geology and fuel resources of the Green River Formation, southeastern Uinta Basin, Utah and Colorado: U.S. Geological Survey Professional Paper 548, 48 p.

Conroy, L. S., 1979, Hydrologic and climatologic data, southeastern Uinta Basin, Utah and Colorado, water year 1977: U.S. Geological Survey Open-File Report 79-1493 (also duplicated as Utah Hydrologic-Data Report 33), 193 p.

_____ 1980, Hydrologic and climatologic data, southeastern Uinta Basin, Utah and Colorado, water year 1978: U.S. Geological Survey Open-File Report 80-1025 (also duplicated as Utah Hydrologic-Data Report 34).

Conroy, L. S., and Fields, F. K., 1977, Climatologic and hydrologic data, southeastern Uinta Basin, Utah and Colorado, water years 1975 and 1976: U.S. Geological Survey open-file report (duplicated as Utah Basic-Data Release 29), 244 p.

Geldriech, E. E., and Kenner, B. A., 1969, Concepts of fecal streptococci in stream pollution: Journal of the Water Pollution Control Federation, v. 41, no. 8, part 2, p. R336-352.

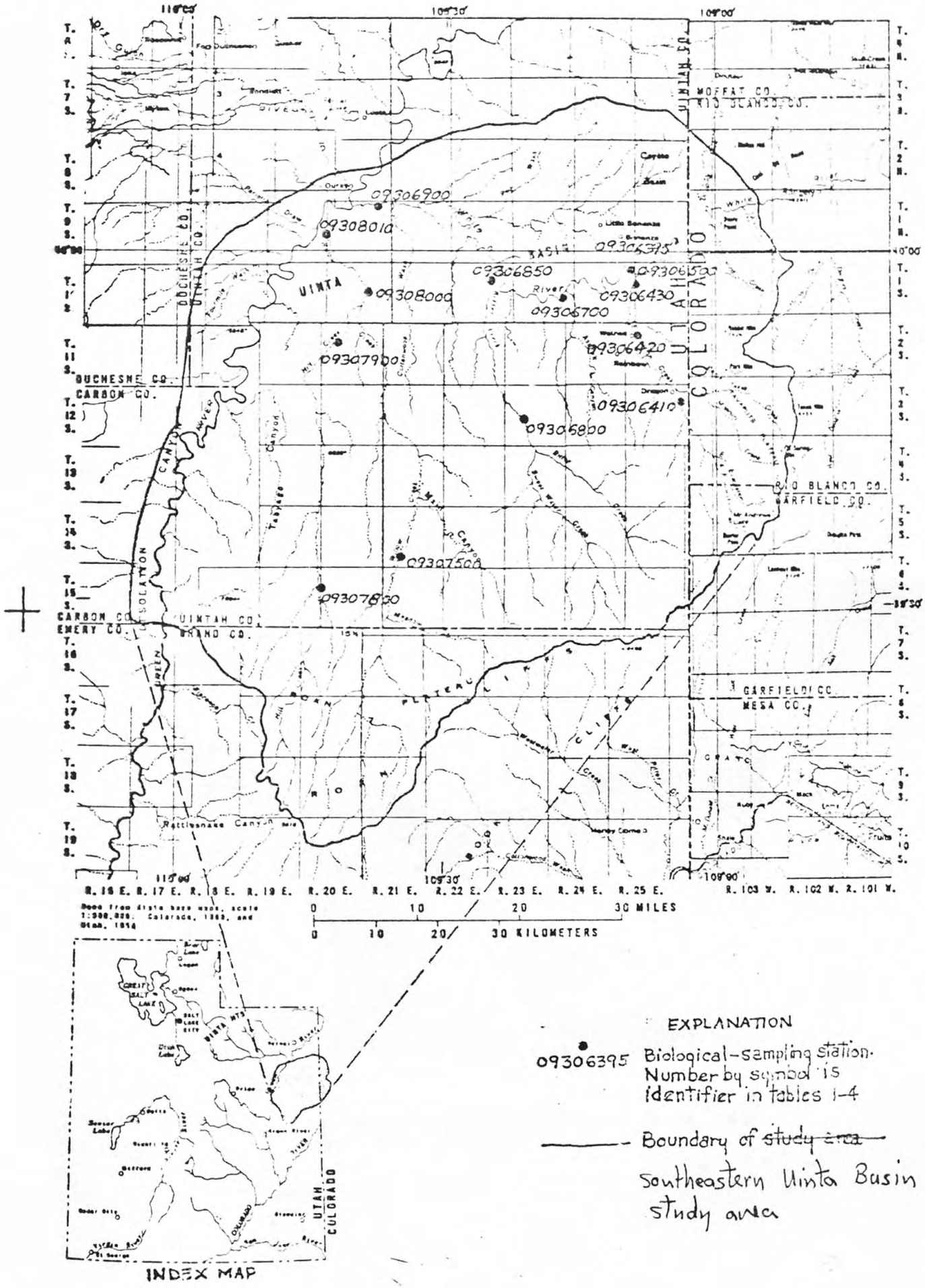
Graham, E. H., 1937, Botanical studies in the Uinta Basin of Utah and Colorado: Pittsburg, Carnegie Museum Annals, v. 26, 432 p.

Greeson, P. E., and others, 1977, Methods for collection and analysis of aquatic biological and microbiological samples: Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 5, Chapter A4, 332 p.

Krebs, C. J., 1972, Ecology; the experimental analysis of distribution and abundance: New York, Harper and Row, 694 p.

Patrick, Ruth, 1949, A proposed biological measure of stream conditions based on a survey of the Conestoga Basin, Lancaster County, Pennsylvania: Academy Natural Science, Philadelphia, Proceedings, v. 101, p. 277-341.

VTN Colorado, Inc., 1977, Final environmental baseline report: Federal prototype Oil-Shale Leasing Program, Tracts Ua and Ub, Utah: White River Shale Project, Vernal, Utah.



EXPLANATION

09306395 Biological-sampling station. Number by symbol is identifier in tables 1-4

——— Boundary of ~~study area~~ southeastern Uinta Basin study area

Figure 1.--Location of biological-sampling stations.

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Figure 2.--White River near Colorado-Utah State line, Utah (09306395)

Figure 3.--Evacuation Creek above Missouri Creek, near Dragon, Utah (09306410)

APPROVED IN RESTON

Figure 4.--Evacuation Creek at Watson, Utah (09306420)

Figure 5.--Evacuation Creek near Watson, Utah (09306430)

APPROVED IN RESTON

Figure 6.--White River below Asphalt Wash, near Watson, Utah (09306700)

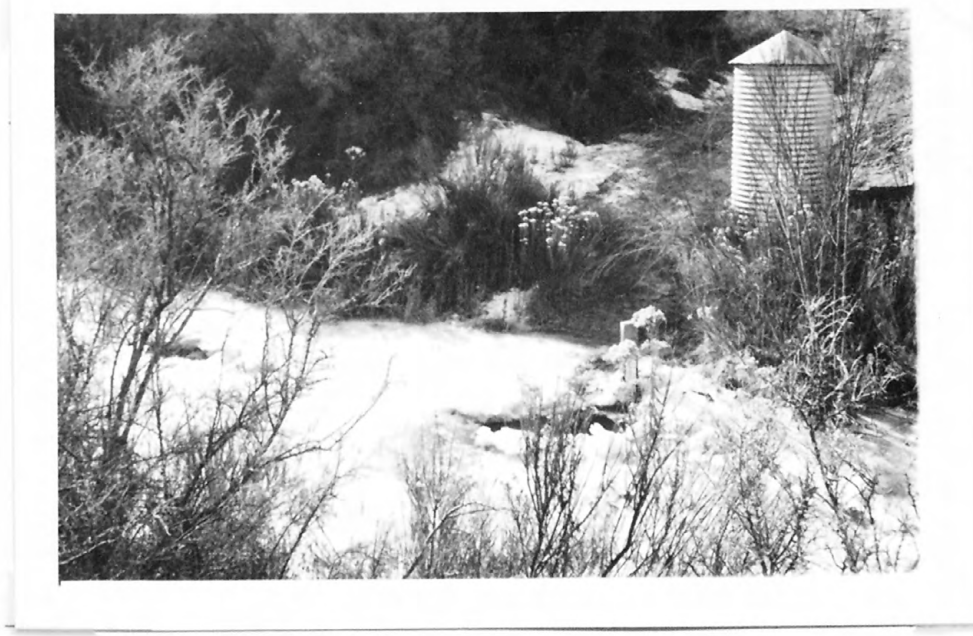

Figure 7.--Bitter Creek near Bonanza, Utah (09306800).

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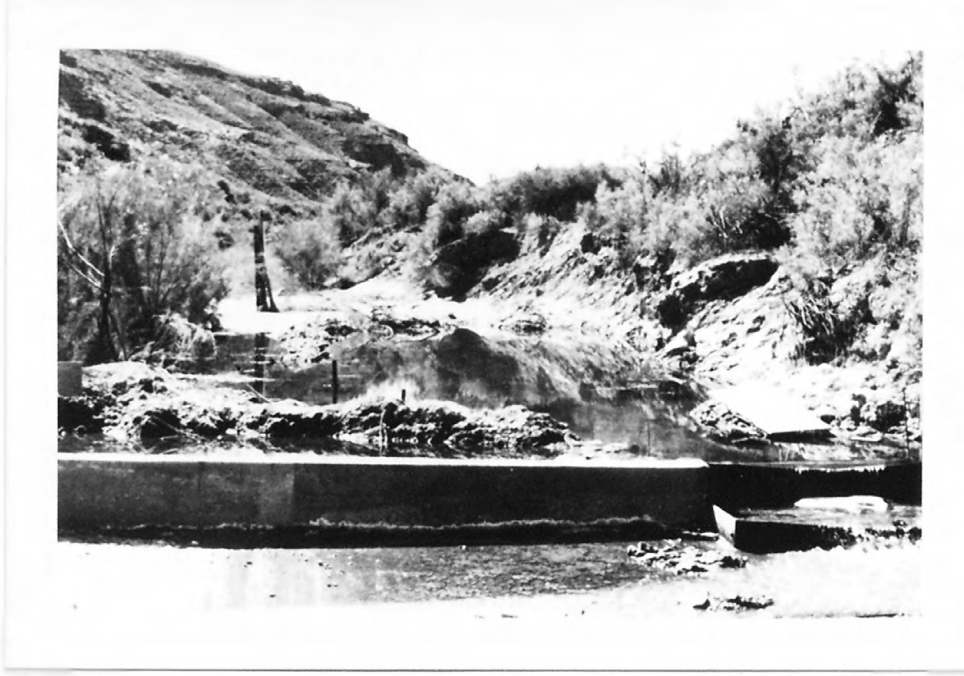

Figure 8.--Bitter Creek at mouth, near Bonanza, Utah (09306850)

Figure 9.--White River at mouth, near Ouray, Utah (09306900)

Figure 10.--Hill Creek near mouth, near Ouray, Utah (09307900)

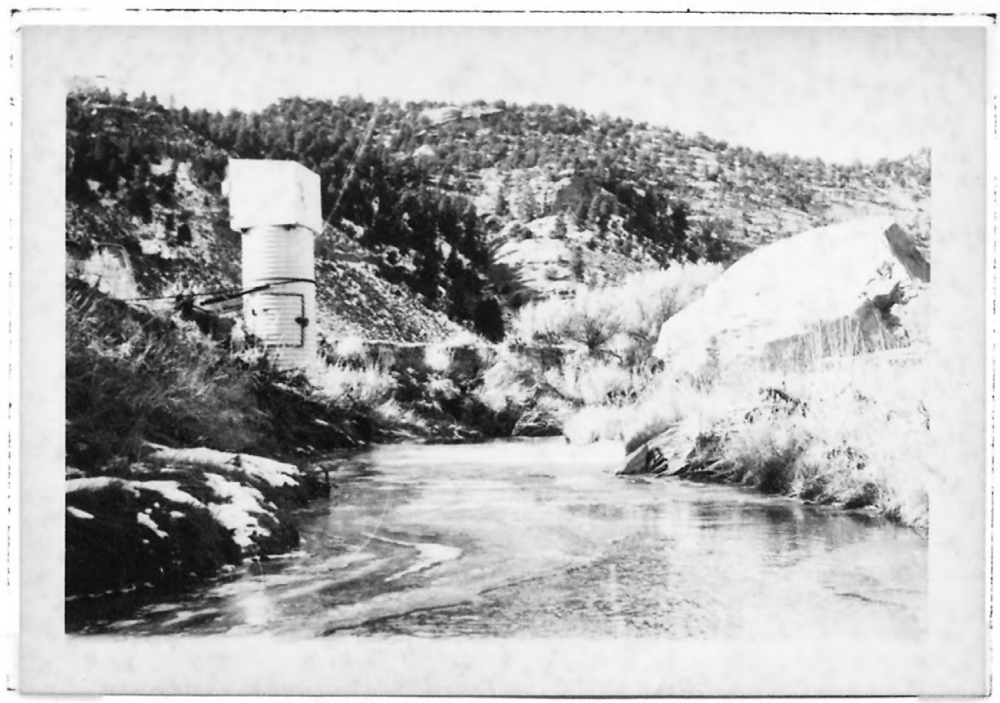

Figure 11.--Hill Creek above Towave Reservoir, near Ouray, Utah (09307800)

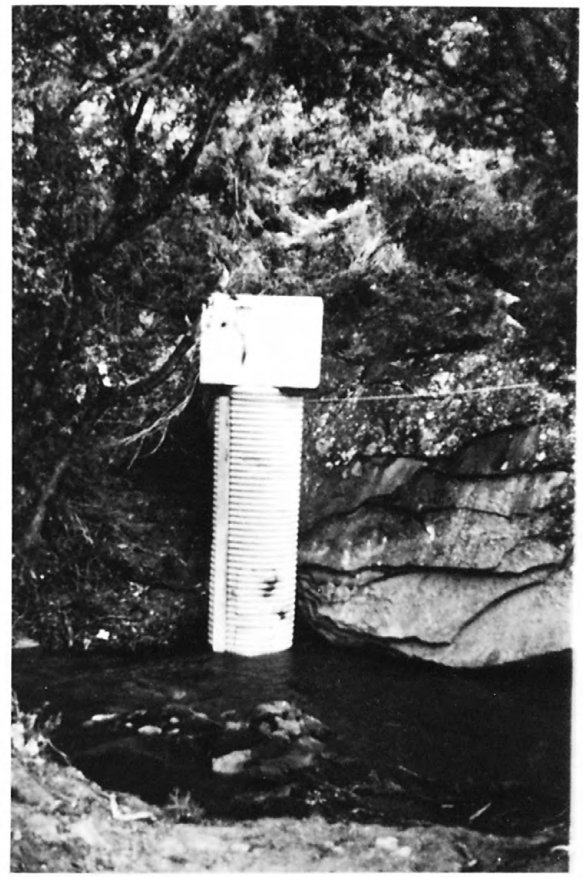

Figure 12.--Willow Creek above diversions, near Ouray, Utah (09307500)

Figure 13.--Willow Creek near Ouray, Utah (09308000)

Figure 14.--White River near Watson, Utah (09306500)

APPROVED IN RESTON

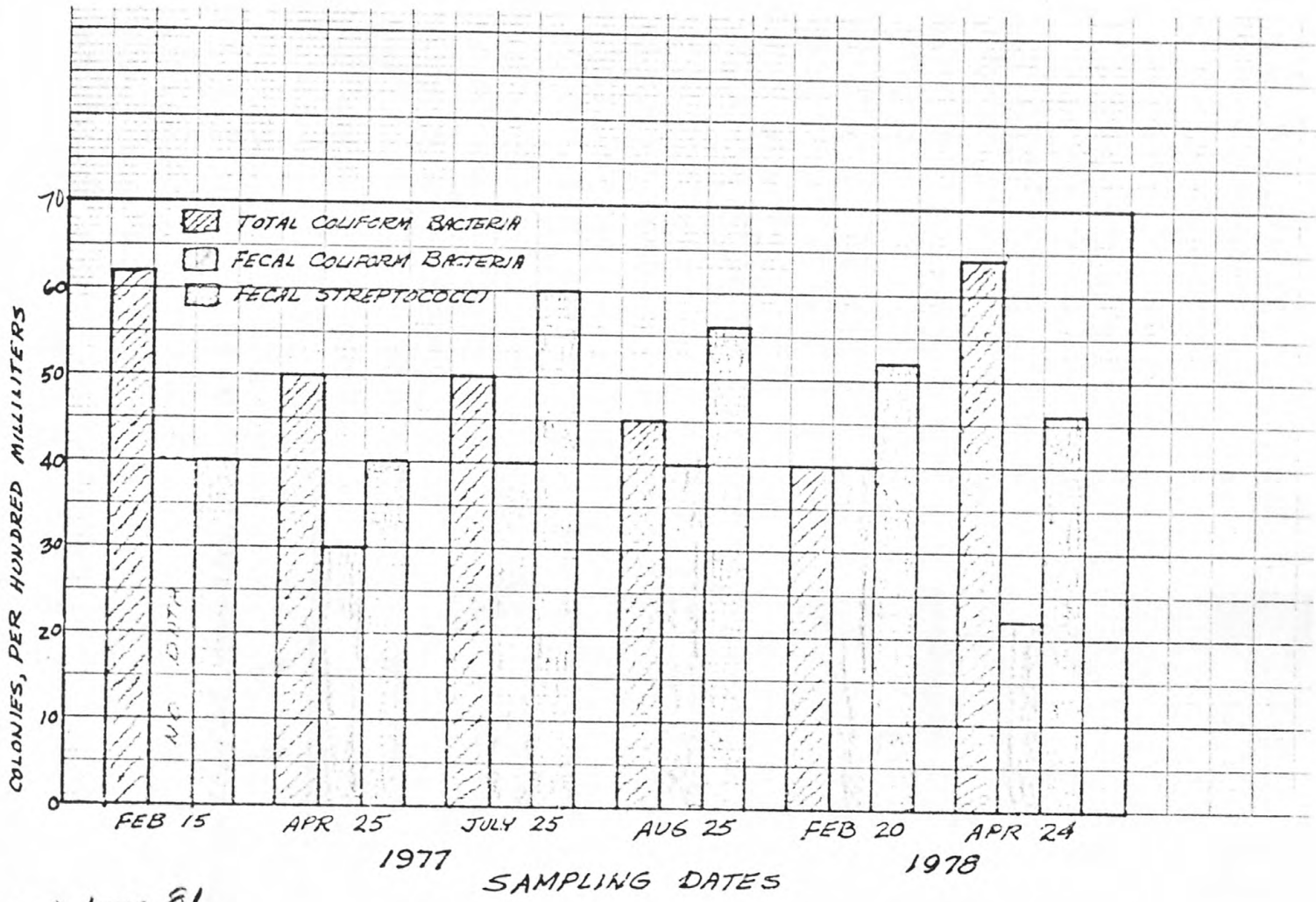

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Figure 16.--Bacterial concentrations at White River near Colorado-Utah State line, Utah, (09306395).

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Note to reviewer
Fig 15-26 will be changed to this type graph when final drafted

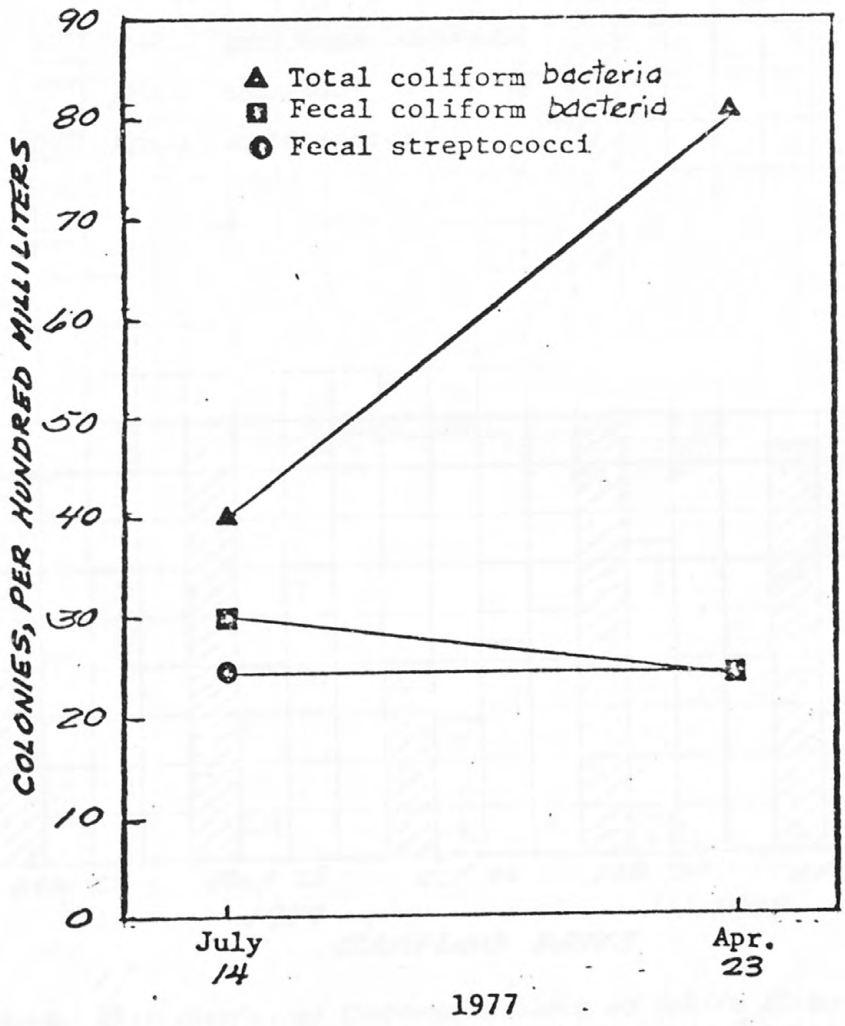

Figure ~~17.~~ 16.--Bacterial concentrations at White River near Watson, Utah, (09306500).

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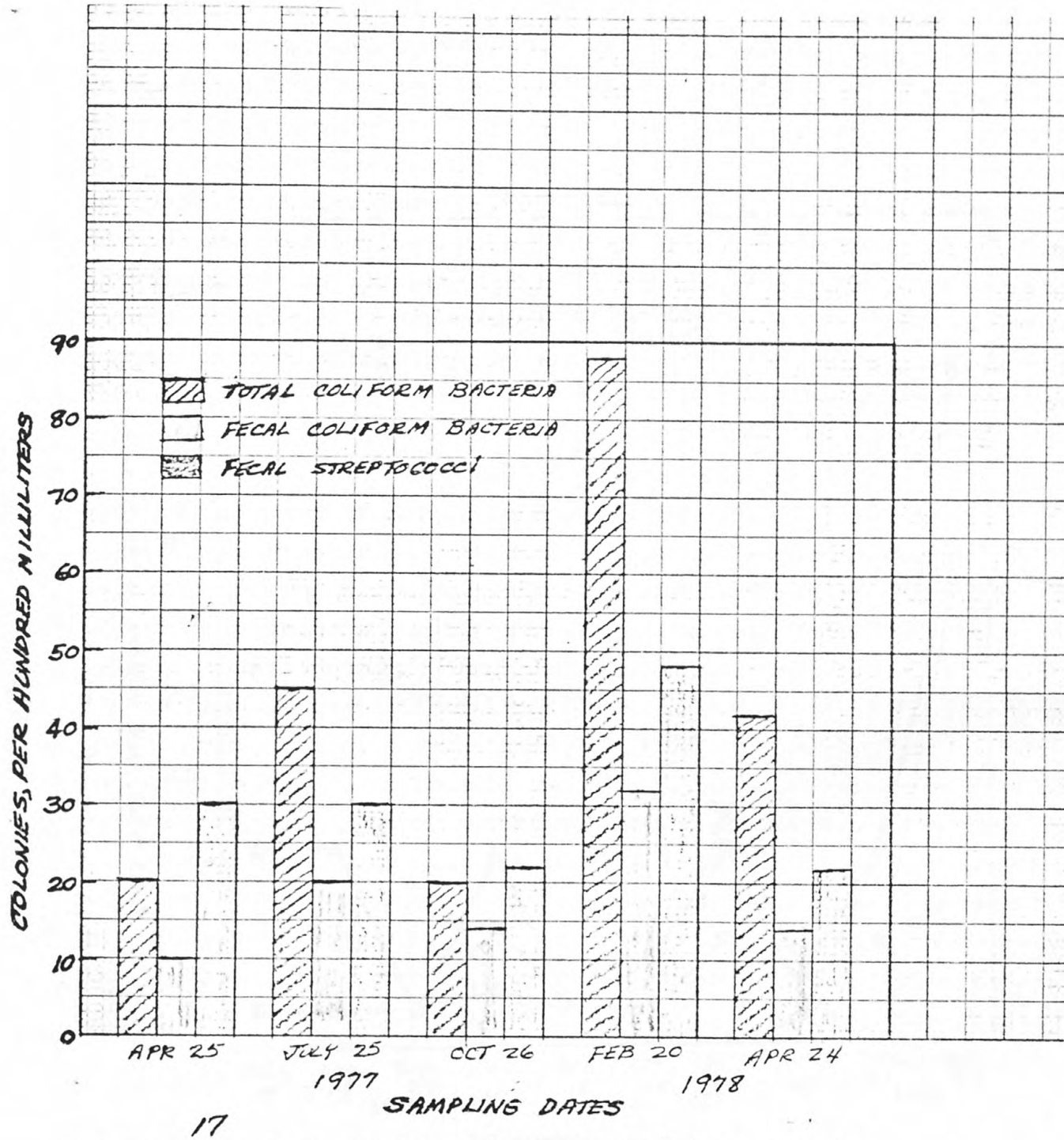

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Figure 18— Bacterial concentrations at White River below Asphalt Wash, near Watson, Utah, (09306700).

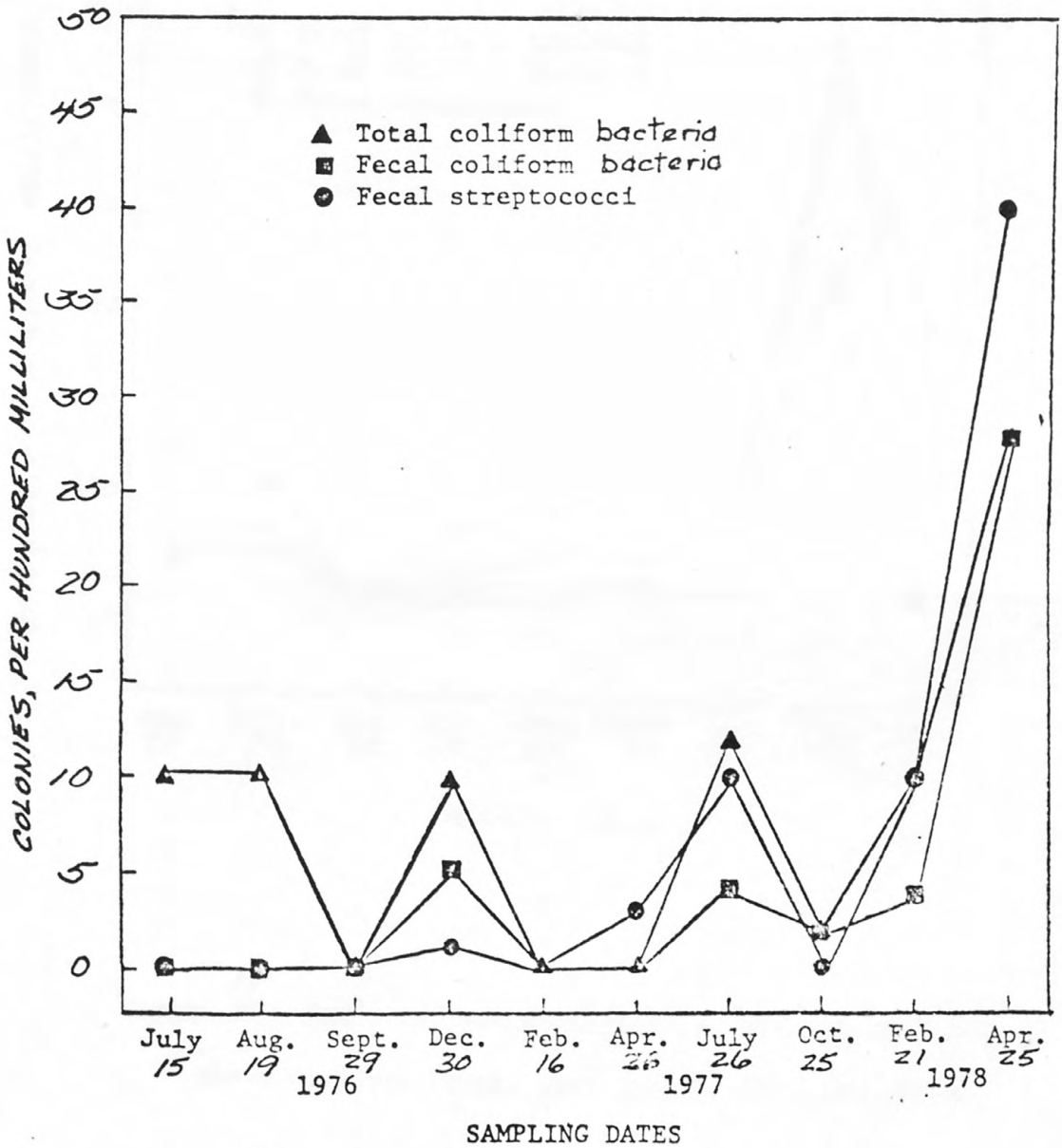

Figure ~~19~~ 18.--Bacterial concentrations at White River at mouth, near Ouray, Utah, (09306900).

APPROVED IN RESTON

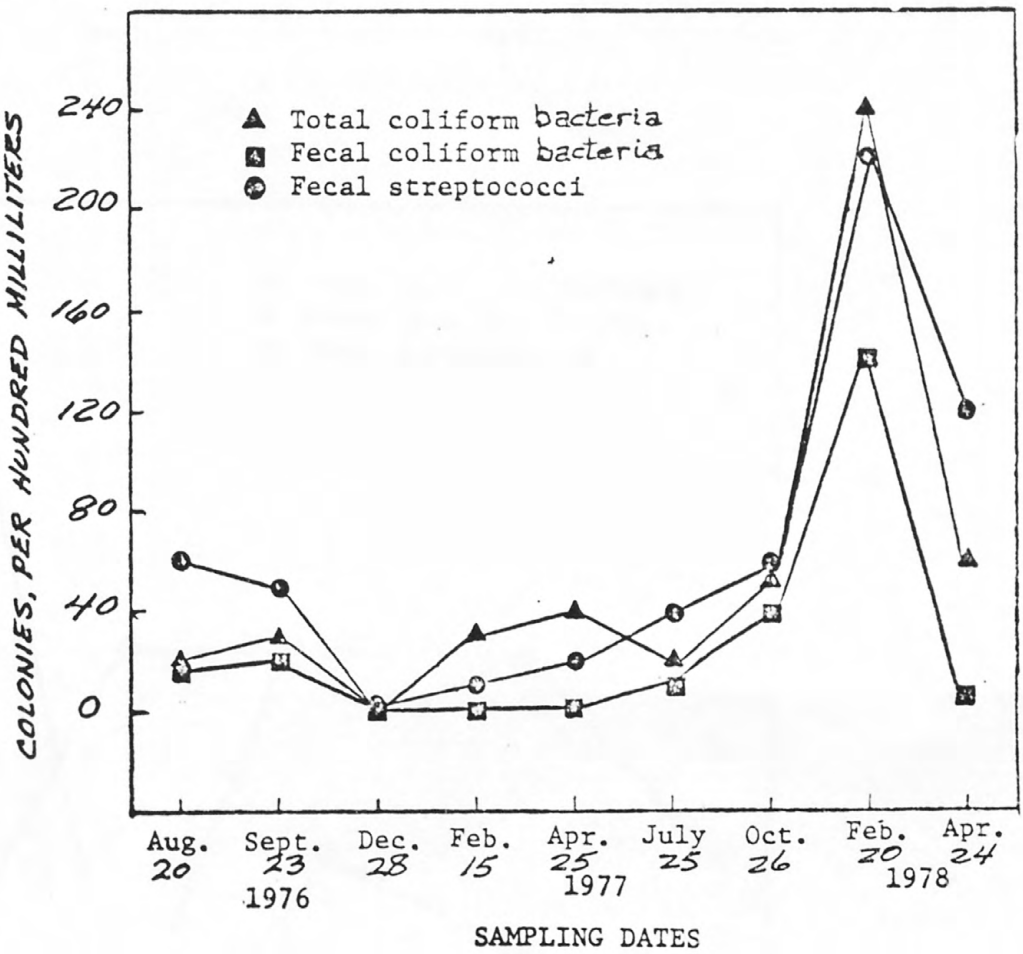

Figure ~~20.~~ A--Bacterial concentrations at Evacuation Creek above Missouri Creek, near Dragon, Utah, (09306410).

APPROVED IN RESTON

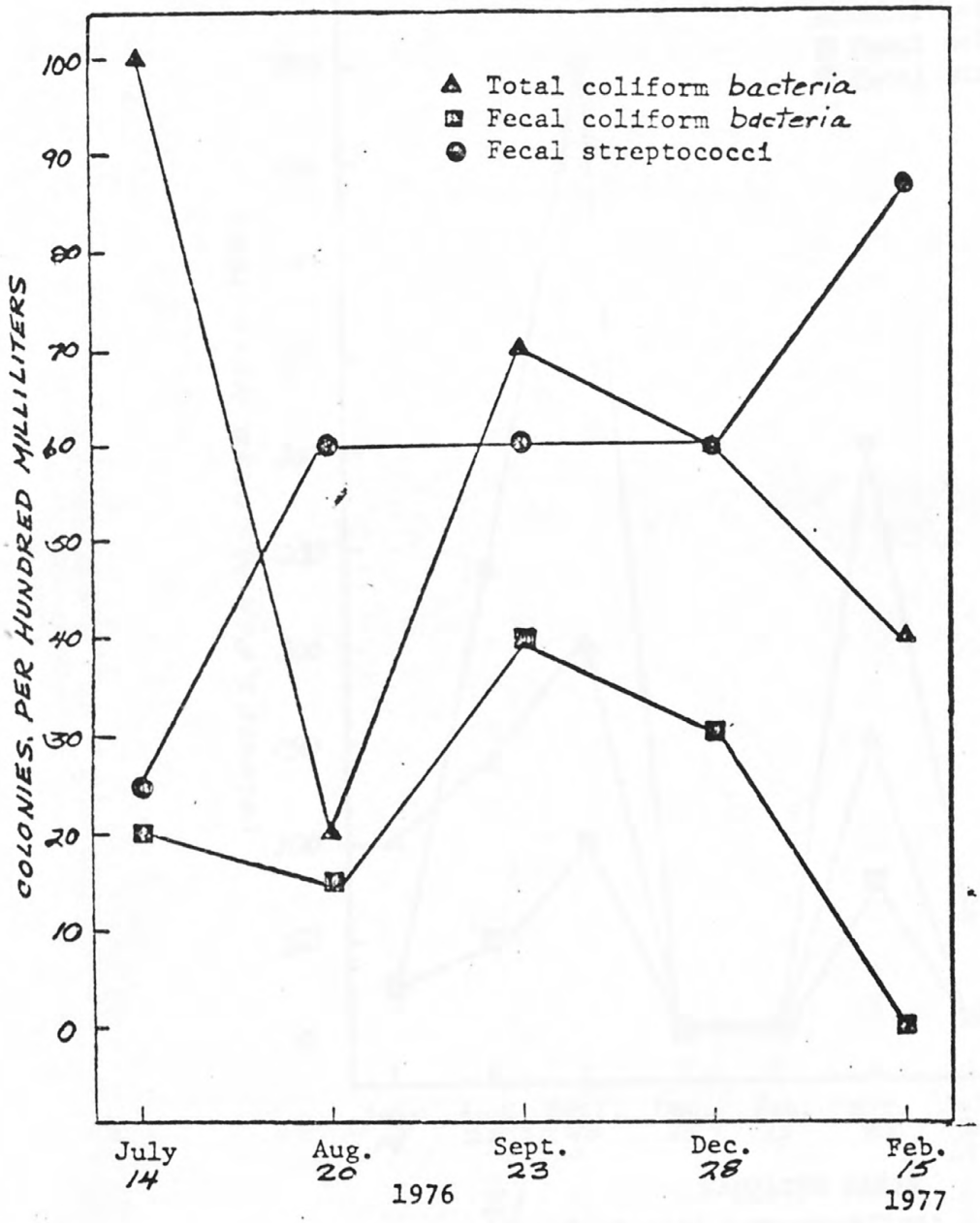

Figure ~~21~~ 20.--Bacterial concentrations at Evacuation Creek at Watson, Utah, (09306420).

APPROVED IN RESTON

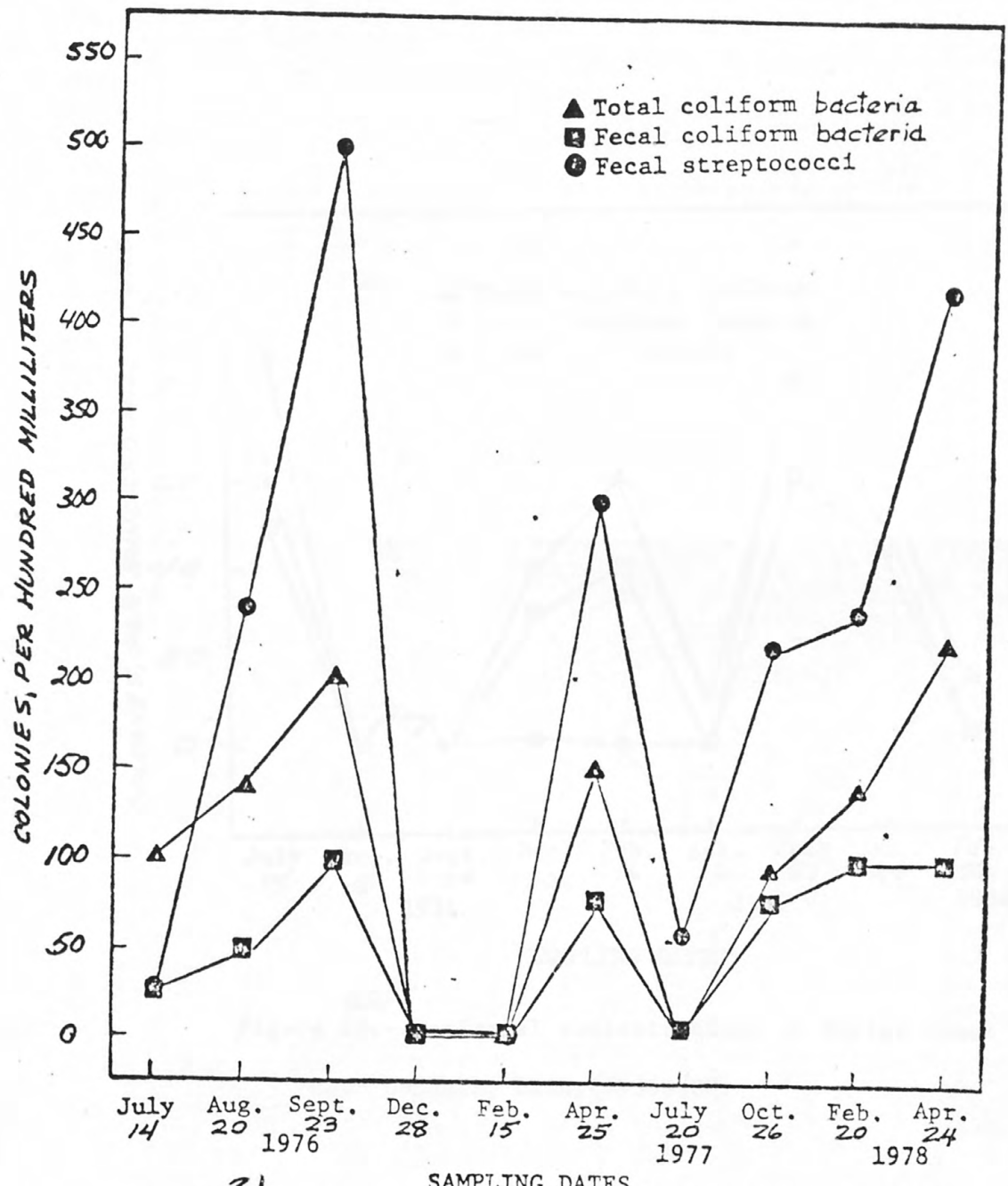

Figure ~~22.~~ 21.--Bacterial concentrations at Evacuation Creek at mouth, near Watson, Utah, (09306430).

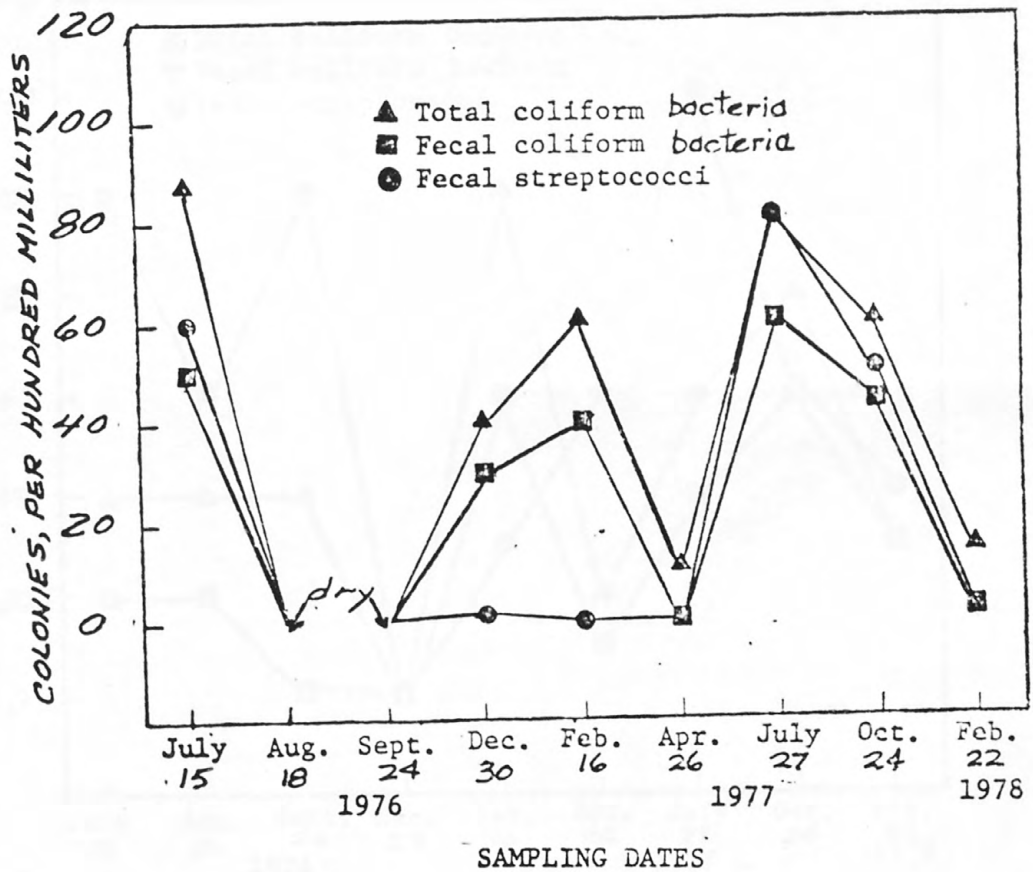

Figure ~~23.~~ 22.--Bacterial concentrations at Bitter Creek near Bonanza, Utah, (09306800).

APPROVED IN RESTON

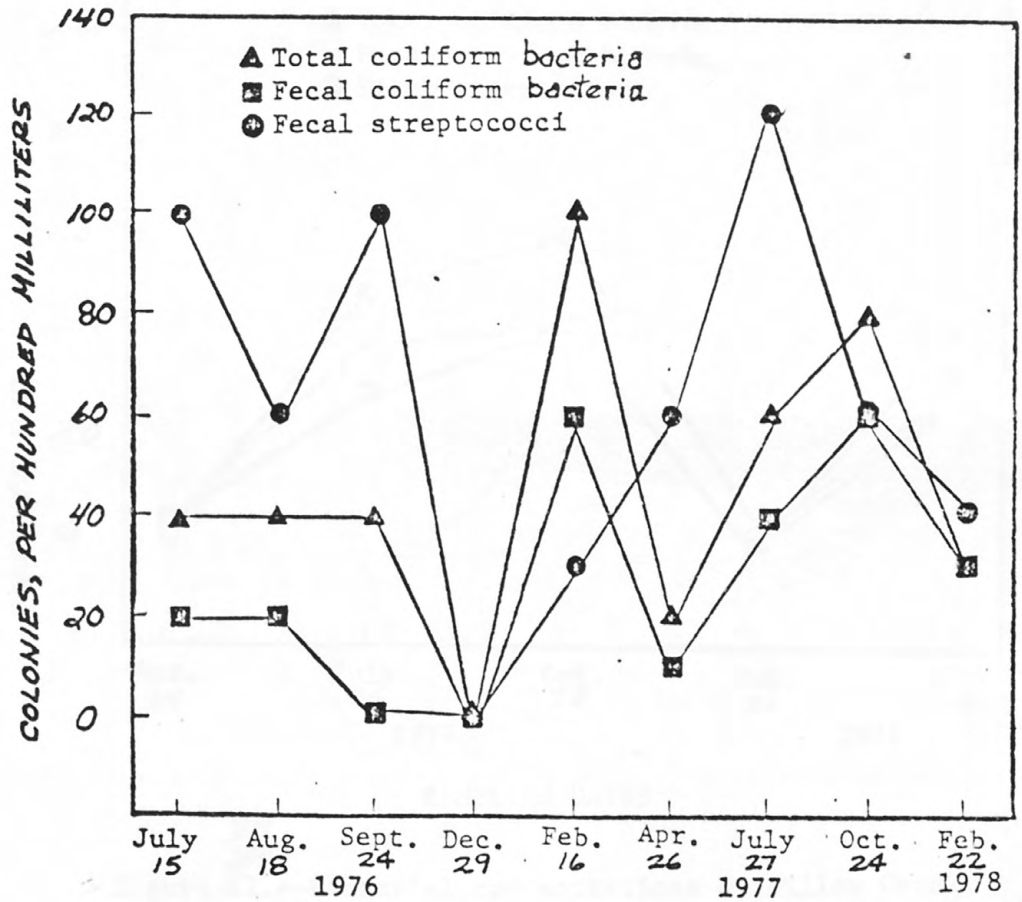

Figure ~~24~~ 23.--Bacterial concentrations at Bitter Creek at mouth, near Bonanza, Utah, (09306850).

APPROVED IN RESTON

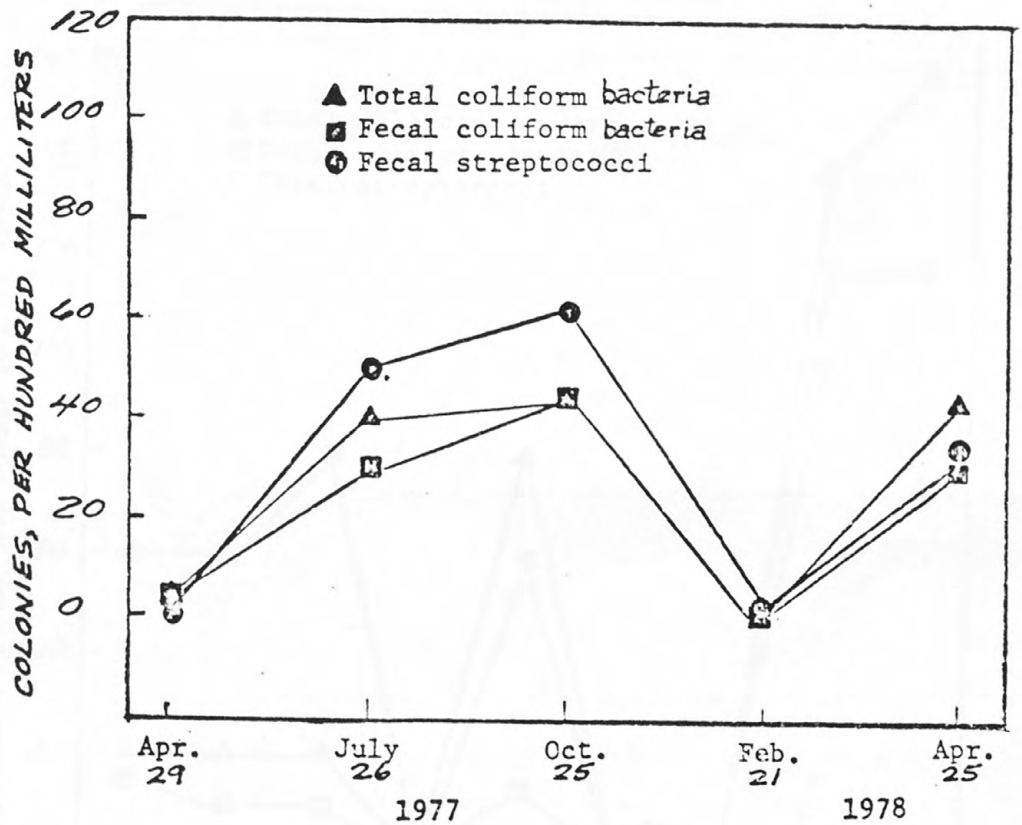

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Figure 27.--Bacterial concentrations at Willow Creek above diversions, near Ouray, Utah, (09307500).

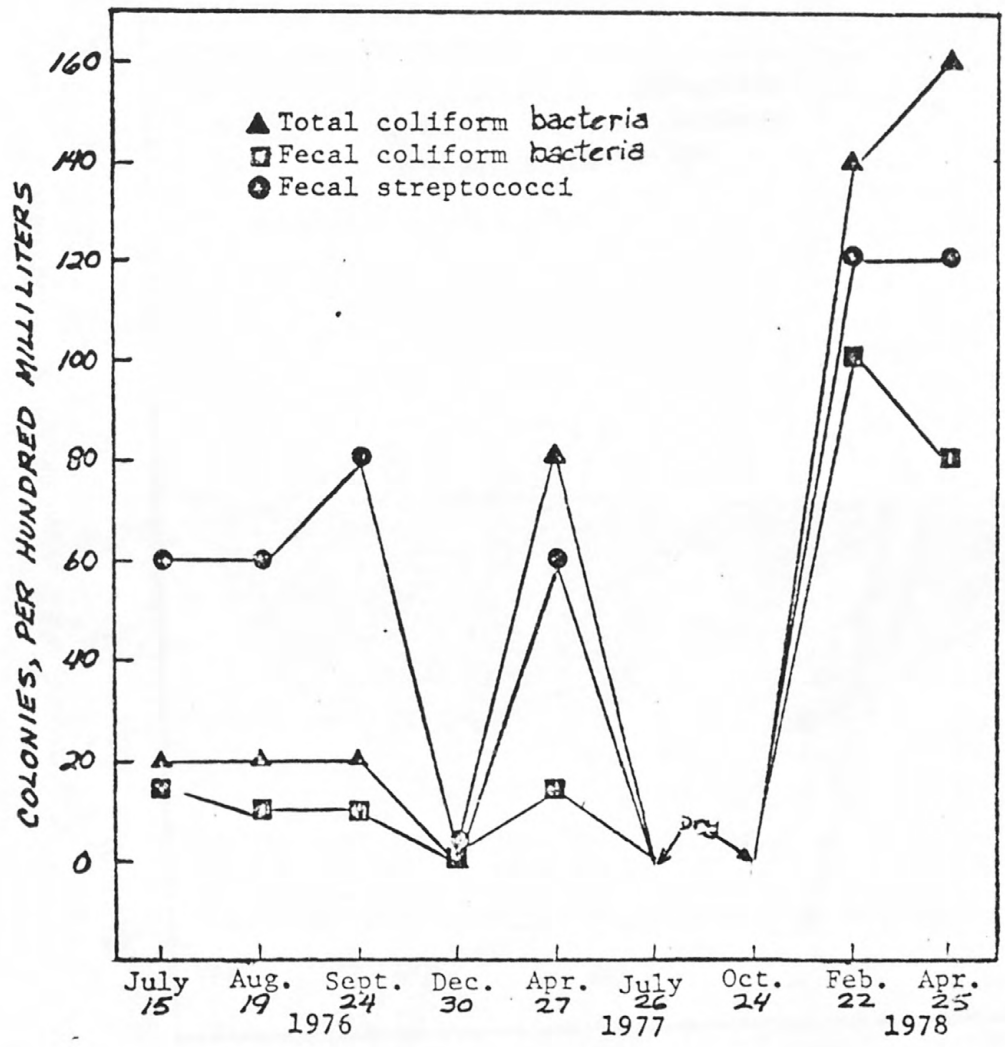

Figure 25.--Bacterial concentrations at Willow Creek near Ouray, Utah, (09308000).

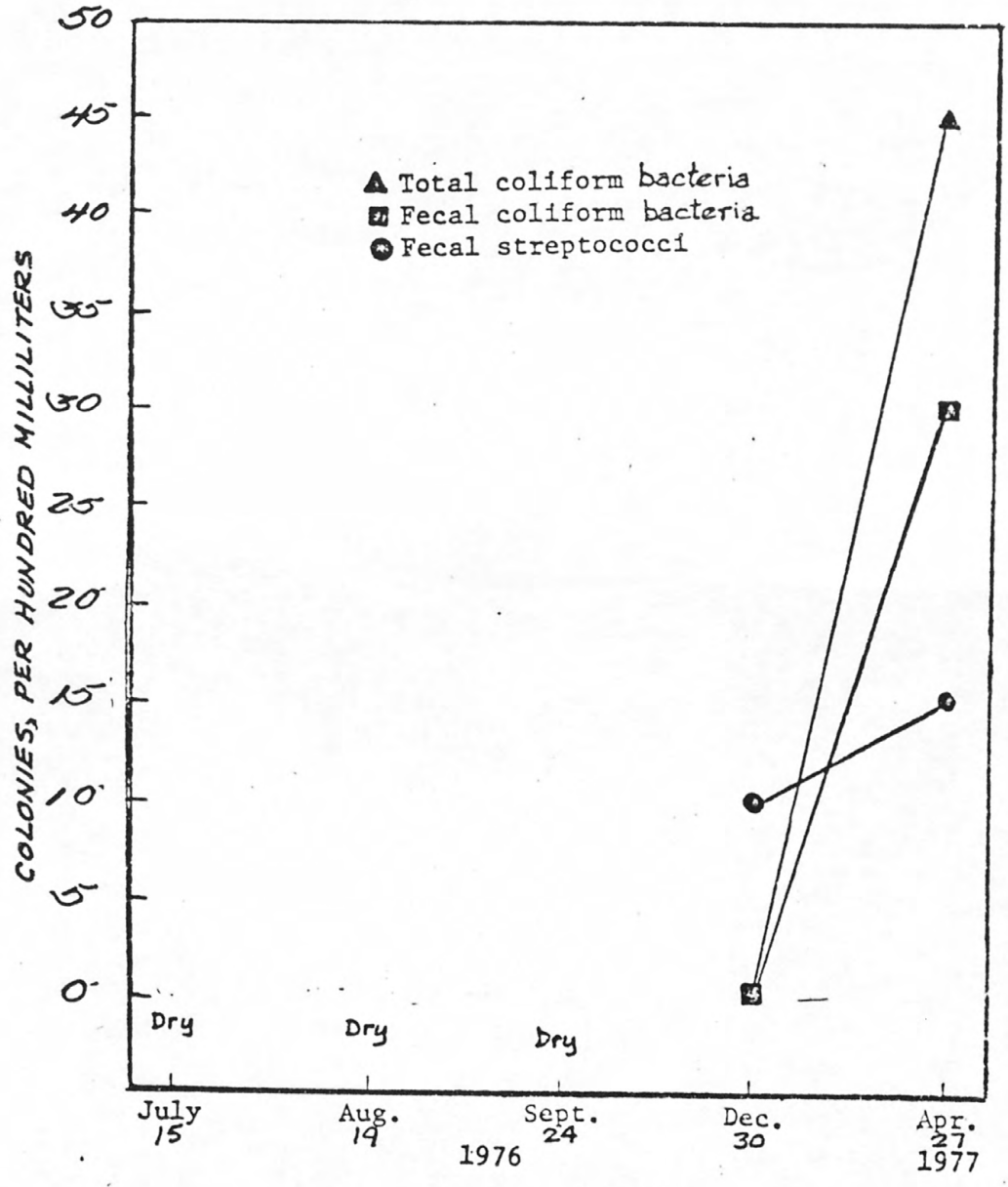

Figure 26.--Bacterial concentrations at Willow Creek at mouth, near Ouray, Utah, (09308010).