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VIRGIN RIVER STUDY

UTAH

MARCH, 1976

TECHNICAL INVESTIGATIONS BRANCH

SURVEILLANCE AND ANALYSIS DIVISION

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION VIII

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ROBERT L. FOX
and
RONALD M. EDDY

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This project was conducted under the direction of C. E. Runas, Chief, Water Quality Investigations Section, EPA, Region VIII. Many additional staff members from the Technical Investigations Branch were involved in the collection and analysis of samples from the study area. Acknowledgement is due each participant for his contribution toward the completion of this report.

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ABSTRACT

The Technical Investigations Branch of the U.S. Environmental Protection Agency, Region VIII, conducted an intensive water quality study in the Virgin River and Kanab Creek drainages in Southwestern Utah in March, 1976. The study was requested by the Five County Association of Governments, the local "208" water quality management planning agency. Water, sediment, and benthic samples were collected at selected locations throughout a total stream reach of 174 km (108 mi). Study results indicated a gradual degradation of water quality downstream from Zion National Park. Violations of recommended criteria/standard levels were most common for the salinity parameters, but concentrations of arsenic, iron, manganese, and mercury also exceeded recommended levels. In addition, high concentrations of suspended solids impaired the quality of water throughout much of the study area.

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CONVERSION FACTORS

Kilometers	X	0.6214	=	miles
Meters	X	3.281	=	feet
Liters	X	0.946	=	quarts
Cubic meters/sec (m^3/s)	X	35.315	=	cubic feet/sec (cfs)
Kilograms	X	2.205	=	pounds
Metric Tons	X	2205	=	pounds

INTRODUCTION

The increasing popularity of the lower Virgin River basin as a retirement setting and the proposed development of large power production facilities requiring water from the Virgin River are two of the factors which led to the designation of the Five County Association of Governments as a water quality management planning "208" agency in Southwestern Utah in 1975. One of the primary responsibilities of the planning agency was to obtain adequate baseline water quality information for use in future planning and management activities. In order to supplement its own efforts, the "208" planning agency requested that the Environmental Protection Agency (EPA), Region VIII, conduct an intensive baseline water quality study. The study involved the collection of water, sediment, and benthic samples from the Virgin River between Alton and St. George, Utah and from Kanab Creek between Alton and Kanab, Utah. Results of that study are presented in this report.

SUMMARY AND CONCLUSIONS

The Five County Association of Governments in Southwestern Utah, a designated "208" area, requested technical assistance from the EPA, Region VIII, in collecting baseline water quality information to be used in future planning and management activities in the area. EPA subsequently conducted an intensive stream survey, including chemical and biological sampling, in the Virgin River and Kanab Creek drainages during March 10-15, 1976.

Stream flows during the study period were generally close to the average flow rates recorded for the month of March during the five year period of 1970-1974. Exceptions to this average condition were noted in the Virgin River at Hurricane, Utah and Littlefield, Arizona where flow rates during the study period averaged approximately 50% below normal.

The chemical data collected during this study has been compared to stream standards developed by the State of Utah and to water quality criteria recommended by EPA. Numerous violations of the standard/criteria concentrations were found in the study area, as outlined below.

1. Salinity is a major water quality problem in the lower Virgin River basin. The La Verkin Hot Springs contribute large quantities of TDS, as reflected by measurements in the Virgin River of 641 mg/l several miles upstream from the springs and 1830 mg/l immediately downstream. Kanab Creek (1188 mg/l) and the Santa Clara River (2050 mg/l) also contained substantial concentrations of TDS. The recommended standard/criteria limit of 500 mg/l for TDS and 250 mg/l for chloride and sulfate was exceeded in the Virgin River at all locations downstream from the La Verkin Hot Springs.

2. The highest average suspended solids concentrations were recorded in Muddy Creek (591 mg/l) and in Kanab Creek (6340 mg/l). All mainstem Virgin River stations downstream from the confluence with Muddy Creek averaged greater than 100 mg/l. Kanab Creek carried three times as much sediment (185 metric tons per day) as the Virgin River carried at St. George.

3. Concentrations of several metals (arsenic, iron, manganese, and mercury) exceeded the standard/criteria levels, particularly in the lower Virgin River drainage. All arsenic concentrations measured downstream from the La Verkin Hot Springs exceeded the EPA criteria limit of 10 μg/l but not the Utah standard of 50 μg/l. Kanab Creek contained the highest arsenic concentration (108 μg/l).

   The recommended total iron criteria of 1000 μg/l was exceeded at 80% of the sampling locations in the Virgin River drainage. The highest total iron concentration was measured in Kanab Creek (115,100 μg/l). Dissolved iron concentrations all averaged less than 100 μg/l.

Total manganese concentrations at four sampling stations averaged above the recommended criteria limit of 200 μg/l. These four stations were the Virgin River downstream from the La Verkin Hot Springs (225 μg/l), Muddy Creek (275 μg/l), Kanab Creek (2130 μg/l), and the Santa Clara River (695 μg/l). The Santa Clara River also contained 235 μg/l dissolved manganese, which greatly exceeds the recommended Utah standard of 50 μg/l.

The recommended criteria for total mercury in drinking water (2.0 μg/l) was exceeded in the North Fork Virgin River (2.4 μg/l), La Verkin Creek (<4.8 μg/l) and the mainstem Virgin River (2.3 and 4.1 μg/l, respectively, at stations VR-7 and VR-12). The effluent ditch from the St. George STP also contained a high mercury concentration (7 μg/l). The recommended mercury criteria for protection of freshwater aquatic life and wildlife (0.05 μg/l) was exceeded at most sampling locations.

Total lead concentrations averaged nearly twice as high as the mandatory Utah limit of 50 μg/l in Kanab Creek near Kanab, Utah (95 μg/l). Most other lead concentrations averaged less than 10 μg/l.

4. Analysis of four water samples for 14 pesticides plus PCB's did not reveal any concentrations in excess of the analytical detection limit of 100 ppt for organochlorides and 500 ppt for organophosphates.

5. Analysis of ten sediment samples for selected metals and PCB's revealed generally low concentrations of trace metals (<20 ppb) and PCB's (13 ppb) at all locations except the St. George STP effluent ditch (24.3 ppb Pb and 73 ppb PCB 1254).

6. Macro-invertebrate benthic samples were collected from 13 mainstem stations and 9 tributary stations. The greatest mean diversity ($\bar{d}$) for samples collected on the mainstem of the Virgin River was recorded at the upstream station (VR-2, 2.63). Mean diversity and number of organisms/m^2 was generally low at all mainstem stations. Diversity was usually less than 2.00, while number of organisms/m^2 was often less than 1076/m^2 (100/ft^2). Mean diversity of samples taken from tributary locations was slightly higher than values recorded for mainstem stations.

DESCRIPTION OF STUDY AREA

The two main forks of the Virgin River originate in the high plateau country of Southwestern Utah.

The East Fork (considered to be part of the mainstem Virgin River for purposes of this report) originates in mountainous terrain just west of the Paunsaugunt Plateau, the location of Bryce Canyon National Park. It flows southward through lightly-cultivated agricultural land in Long Valley before turning westward at Mt. Carmel Junction to flow through wild and rough country, including a portion of Zion National Park. The confluence with the North Fork Virgin River occurs immediately downstream from Zion National Park and approximately 68 km (42 mi) from the East Fork headwaters (Figure 1).

The headwaters of the North Fork lie on the Kolob Terrace, located just south of Cedar Breaks National Monument, in a wild area containing only a few isolated ranches. For 42 km (25mi) the North Fork flows southward through spectacular canyons it has cut in the predominately limestone formations of Zion National Park.

Downstream from the confluence of the North and East Forks, the Virgin River continues to accumulate more sediment via irrigation return flows and natural stream erosion as it flows westward through arid benches and valleys. A severe source of salinity in this reach is the La Verkin Hot Springs, located near Hurricane, Utah (Utah Water Research Laboratory, 1974). Several small streams enter the Virgin River between Hurricane and St. George and agricultural return flows and diversions are common, particularly in the stream reach near St. George. The Santa Clara River, a small 66 km (41mi) stream draining arid, mountainous terrain west of St. George, enters the Virgin River approximately 1.6 km (1mi) downstream from St. George and 21 km (13mi) from the Arizona border.

The study area also included a portion of the Kanab Creek drainage extending for approximately 37 km (23mi) from Alton to Kanab, Utah. Kanab Creek originates on the Paunsaugunt Plateau just east of the East Fork of the Virgin River and flows southward through rough hills and benches which are thought to contain large quantities of coal. The stream bed is composed of highly erodable silt and sand, resulting in very turbid stream flow near Kanab, which is less than 8 km (5mi) from the Arizona border.

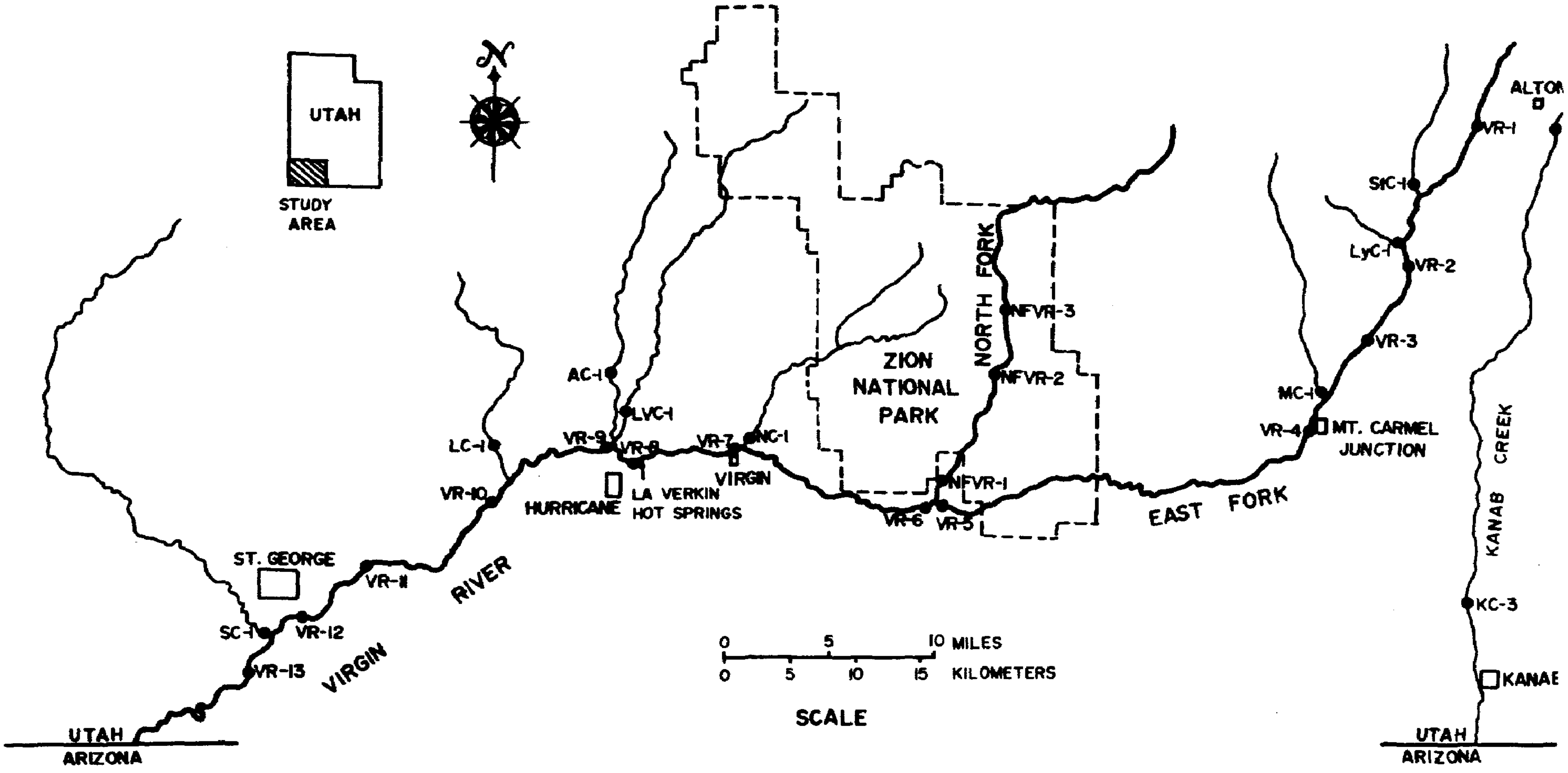

Figure 1. Sampling station locations in the Virgin River and Kanab Creek drainages, Utah.

METHODS AND MATERIALS

Chemical Methods - Field

Water quality samples were collected from 21 stations in the Virgin River and Kanab Creek drainages, covering a total stream reach of approximately 174 km (108mi). Sampling was conducted during two consecutive three-day periods. The first sampling period of March 10-12, 1976 included nine stations on the East Fork Virgin River and its tributaries upstream from Zion National Park and two stations on Kanab Creek. The second sampling period extended from March 13-15, 1976, and included 12 stations in the Virgin River drainage downstream from Zion National Park (Figure 1 and Table 1).

At each sampling site, field measurements were made for temperature, pH, specific conductance (conductivity), and, occasionally, flow (Table 2). Whenever possible USGS stream gaging sites were utilized as water quality sampling sites. Mean daily flow rates at these stations were obtained from the USGS. Until published by the USGS, these values are considered preliminary. The instantaneous flow rates determined by EPA at non-USGS gaging sites were determined by standard stream gaging techniques utilizing a Marsh-McBirney electromagnetic current meter with direct velocity readout.

Water samples for dissolved oxygen (D.O.) and turbidity determinations were collected and analyzed within six hours in the temporary field laboratory. The D.O. samples were "fixed" with appropriate powder reagents in the field and then titrated according to the modified Winkler method. Turbidity measurements were obtained with a Hach Turbidimeter utilizing formazin liquid standards.

Additional water samples were collected in polyethylene cubitainers for analysis for chloride, sulfate, total dissolved solids (TDS), total suspended solids (TSS), and fluoride. These samples were kept refrigerated in ice chests until delivered to the EPA, Region VIII, laboratory in Denver, Colorado. Samples for total metals analysis were also collected in polyethylene cubitainers, preserved with 5mls per liter concentrated HNO_3 and held for analysis following completion of the study. At selected locations samples for dissolved metals analysis were obtained by filtering water through 0.45 micron membrane filter and then preserving with HNO_3.

Water samples for trace organics analysis and sediment samples for metals and PCB analysis were also collected at selected locations. The water samples were collected in 3.8 l (1 gal.) hexane-rinsed glass bottles. Sediment samples were collected from the top several centimeters of stream-side deposits in 0.48 l (1 pt.) glass jars and held without preservation until analysis.

Chemical Methods - Laboratory

All inorganic chemical analyses were conducted in accordance with procedures outlined in the EPA Methods Manual (1974), with the following exceptions:

Table 1. Water quality sampling station descriptions - Virgin River and Kanab Creek drainages, Utah.

Station	River Kilometer	River Mile	Description
KC-1	53.4	33.3	Upstream control station on Kanab Creek at bridge on dirt road approx. 2.4km (1.5 mi) southeast of Alton, Utah.
KC-3	18.7	11.6	Kanab Creek at bridge on Highway 89 approx. 4.8km (3 mi) upstream from Kanab, Utah.
VR-1	307.3	190.9	Upstream control station on the E. Fork Virgin River at the Alton Turnoff from Highway 89.
StC-1	298.6	185.5	Stout Canyon Creek, approx. 30m (100 ft) downstream from the bridge on Highway 89.
LyC-1	294.0	182.6	Lydias Canyon Creek, approx. 30m (100 ft) downstream from the bridge on Highway 89.
VR-2	293.3	182.2	E. Fork Virgin River at the bridge located immediately upstream from Glendale, Utah on Highway 89.
VR-3	284.3	176.6	E. Fork Virgin River at the bridge on Highway 89 in Orderville, Utah.
MC-1	280.5	174.2	Muddy Creek at the bridge on Highway 89.
VR-4	278.8	173.2	E. Fork Virgin River at the Highway 89 bridge crossing located approx. 0.8km (0.5 mi) downstream from Mt. Carmel Junction.
NFVR-1	244.4	151.8	N. Fork Virgin River, approx. 1.6km (1 mi) upstream from confluence with the E. Fork Virgin River. Chemic samples were collected approx. 61m(200 ft) upstream from confluence with the E. Fork Virgin River.
NFVR-2	-	-	N. Fork Virgin River approx. 30m (100 ft) downstream of Zion Lodge foot bridge.
NFVR-3	-	-	N. Fork Virgin River - end point Narrow Trail.
VR-5	244.4	151.8	E. Fork Virgin River, approx. 30m (100 ft) upstream from confluence with the N. Fork Virgin River.
VR-6	244.4	151.8	Virgin River, approx. 30m (100 ft) downstream from confluence with the N. & E. Forks Virgin River.
NC-1	223.0	138.5	North Creek at Highway 15 bridge crossing.

Table 1 (continued)

Station	River Kilometer	River Mile	Description
VR-7	222.5	138.2	Virgin River; North bank, approx. 0.4km (0.25 mi) upstream from Virgin, Utah.
VR-8	212.7	132.1	Virgin River, approx. 150m (500 ft) downstream from "Pah Tempe" (La Verkin) Hot Springs bridge crossing (0.4km (25 mi) upstream from Highway 15 bridge crossing).
LVC-1	210.9	131.0	La Verkin Creek, approx. 0.4km (0.25 mi) upstream from Highway 17 bridge crossing.
AC-1	211.1	131.1	Ash Creek at the concrete "ford" located approx. 0.4 km (0.25 mi) southwest of Toquerville, Utah.
VR-9	211.1	131.1	Virgin River, approx. 60m (200 ft) downstream confluence Ash Creek and Virgin River.
LC-1	198.0	123.0	Leads Creek at the frontage road bridge crossing located approx. 8.0km (5 mi) northeast from the junction of Highway 15 and I-15.
VR-10	195.9	121.7	Virgin River, approx. 60km (200 ft) upstream from the Highway 15 bridge crossing near Harrisburg Junction.
VR-11	181.4	112.7	Virgin River at the new bridge construction site located approx. 0.8km (0.5 mi) south of Washington, Utah.
VR-12	174.2	108.2	Virgin River at the bridge crossing located approx. 1.6km (1 mi) southeast of St. George, Utah.
SC-1	171.0	106.2	Santa Clara River at the old bridge crossing located immediately downstream from the I-15 bridge crossing (upstream from St. George STP effluent ditch).
SC-2	-	-	Effluent from the St. George, Utah STP: sampled approx. 6m (20 ft) upstream from confluence of effluent ditch with the Santa Clara River.
VR-13	167.8	104.2	Virgin River at City of Bloomington, approx. 32m (108 ft) upstream from bridge connecting Bloomington to I-15.

Table 2. Water quality parameters measured during Virgin River, Utah study.

<u>General Parameters</u>

Flow	Turbidity
Temperature	Conductivity
pH	
Dissolved Oxygen	Total Suspended Solids

<u>Salinity Parameters</u>

Chloride	Total Dissolved Solids
Sulfate	

<u>Non-Metals</u>

Fluoride

<u>Metals and Related Elements (Total and Dissolved)</u>

Arsenic	Mercury
Iron	Molybdenum
Lead	Selenium
Manganese	

<u>Sediments</u>

<u>Trace Organics</u>

Aldrin	Heptachlor
Chlordane	Heptachlor Epoxide
PP' DDE	Lindane
PP' DDD	Malathion
PP' DDT	Methyl Parathion
Dieldrin	Parathion (Ethyl)
Endrin	PCB's
	Toxaphene

arsenic and selenium were determined using the graphite furnace technique with the nickel matrix modification as outlined by Ediger (1975); lead was determined in the graphite furnace with the use of ammonium nitrate to volatilize excess sodium chloride (Ediger, 1975); and molyldenum was determined in the graphite furnace with no modifications. Sediment samples underwent hot nitric acid-hydrogen peroxide digestion prior to analysis for metals as indicated above.

The method employed in analyzing water samples for trace organics involved extracting the acidified samples with three 50 ml portions of 80% methylene chloride + 20% hexane. The extract was then concentrated with Kuderna-Danish apparatus and analyzed by gas chromatography (GC). Several "spiked" samples were also carried through the analysis to determine recovery percentages.

The analytical procedures employed for the analysis of PCB's in the sediment samples involved extracting the air-dried sediments with 100 ml of 98% petroleum ether + 2% acetone. The extracts were filtered, concentrated, and elemental mercury was added to precipitate elemental sulfur. The extracts were cleaned-up on a florisil column; 200 ml of petroleum ether were used to elute the PCB's. The solvent was removed and the residues were dissolved in hexane for GC analysis. More mercury was added as needed. Confirmation of the PCB identities was made on GC columns containing 5% OV-210 and 4% SE-30/6% OV-210 stationary phases. Several "spiked" samples were also analyzed.

Biological Methods

Benthic invertebrate samples were collected using Surber samplers. The Surber samplers were modified by replacing the standard mesh bag with a 1.2m long bag constructed with 207 micrometer mesh Nitex net. A large piece of naugahyde was sewn to the bottom of the bag to prevent abrasion by the substrate. The longer length of the bag effectively reduced any backwash incurred due to the smaller mesh size. All quantitative benthic samples were collected from riffle areas.

At the time of sampling, the substrate enclosed within the square foot bottom of the Surber frame was removed from the stream and placed in a large bucket partially filled with water. Each rock was then cleaned using a soft bristle brush and the bag of the Surber sampler inverted and cleaned in the bucket. The contents of the bucket were then poured into a 250 micrometer (#60 mesh) sieve. The collected samples were then placed in pint jars, preserved with 80% formalin, and returned to the laboratory for sorting and identification.

Four Surber samples were collected at each sampling station. The contents of each sample were individually processed and the results from each sample reported separately.

All samples were sorted following procedures outlined by EPA Biological Field and Laboratory Methods (1973). All organisms were identified to the lowest taxonomic level possible using available taxonomic texts (Traver and Hsu, 1935; Ross, 1944; Pennak, 1953; Usinger, 1968; Johannsen, 1969; Gaufin, et al, 1972; EPA, 1973a; Hilsenhoff, 1975).

Mean diversity of collected benthic invertebrates was computed using the machine formula of the Shannon-Weaver function (Lloyd, Zar, and Karr, 1968) as outlined in the EPA Biological and Laboratory Methods Manual (1973). The formula used for computation of mean diversity is as follows:

$$\bar{d} = \frac{C}{N}\left(N \log_{10} N - \sum_{i}^{s} n_i \log_{10} n_i\right)$$

where:

$\bar{d}$ = mean diversity
c = 3.32128 (converts base 10 log to base 2)
N = total number of individuals
n_i = total number of individuals in the i^{th} species
s = total number of taxa

RESULTS AND DISCUSSION

I. Physical and Chemical Data

A complete tabulation of the physical and chemical data collected in the Virgin River and Kanab Creek drainages is presented in Appendix A. The data has been summarized in Table 3 in the form of three-day average values. Many of these values have been plotted on profile maps for the various parameters, as shown on the following pages. River miles are plotted as the horizontal "x" axis while parameter concentration serves as the vertical "y" axis. Scale values may change from one profile to the next, giving the impression of values of greater magnitude upon first viewing than is actually the case. Solid lines connecting the average values should not be interpreted as indicating the parameter concentration at any intermediate point between sampling stations.

In order to evaluate the water quality data collected during this study, it has been compared to Utah stream standards (Utah State Division of Health, 1972) and EPA water quality criteria (NAS, 1973; EPA, 1976) as shown in Table 4. Although the terms "standard" and "criteria" are often used interchangeably, there is an important distinction. "Standards" are legally - enforceable parameter limits adopted to protect unique features of specific water bodies, whereas "criteria" are recommended parameter concentrations which, if not exceeded, will afford reasonable protection to aquatic life or designated uses. A more detailed discussion is presented in Quality Criteria for Water (EPA, 1976). The more restrictive of the stream standards and recommended criteria are shown, where applicable, on the water quality profile maps in the following section. Inclusion of these numerical limits assisted in identifying existing or potential water quality problems in the Virgin River and Kanab Creek drainages.

Flow

The flow profile observed in the Virgin River during March, 1976 is shown in Figure 2. Flow increased from 0.031 m^3/s (1.1 cfs) at the East Fork headwaters to 3.65m^3/s (129 cfs) near St. George, a distance of nearly 134 km (83 mi). Except for the North Fork Virgin River, which contributed a flow nearly equal to the East Fork flow, the tributary streams contained only minor flows (<0.283 m^3/s or <10 cfs). The flow in Kanab Creek actually decreased slightly in the 34.8 km (21.6 mi) reach between Alton and Kanab, Utah as shown in Figure 2. In order to compare measured stream flows with historical flows, Table 5 was prepared for selected stream gaging stations operated by the USGS. This table compares flows measured during this study with 5-year average monthly and annual flows. In general, the stream flows for the different time periods were in fairly close agreement, except for the Virgin River near Hurricane, Utah and at Littlefield, Arizona. During this study, flow at both of these stations averaged only about 50% of the 5-year average flow. There is insufficient data to determine whether this "low flow" condition was present throughout the lower reaches of the Virgin River (from Hurricane to St. George) or to determine the possible causes of the lower flow (irrigation diversions, seepage, etc.).

Table 3. Summary of physical and chemical data[1] Virgin River, Utah study.

Parameter	Units	Stations										
		VR-1	StC-1	LyC-1	VR-2	VR-3	MC-1	VR-4	VR-5	NFVR-1	NC-1[3]	VR-7
Temp	C	4.0	0.5	1.0	1.0	3.5	8.0	6.5	2.0	1.0	1.0	2.0
pH[2]	SU	7.6	7.9	7.8	8.0	8.1	8.0	8.2	7.9	8.0	7.7	7.8
Flow	cms	0.031	0.229	0.079	0.507	0.498	0.031	0.586	1.76	1.53	0.130	-
DO	mg/l	9.4	10.5	10.4	10.6	9.2	9.1	9.6	11.2	11.6	11.6	11.5
Cond.	µmhos/cm	540	540	680	570	650	1750	720	630	900	1050	930
Turbidity	FTU	2.5	2.2	25	5.1	12.4	183	53	55	86	25	55
TDS	mg/l	287	339	403	357	378	1320	490	406	476	718	641
TDS	Metric Tons/day	0.8	6.7	2.8	15.6	16.3	3.5	24.8	61.7	62.9	8.1	-
TSS	mg/l	4.6	4.2	41	12.5	33	591	130	117	176	76	124
TSS	Metric Tons/day	0.01	0.1	0.3	0.5	1.4	1.6	6.6	17.8	23.3	0.8	-
Chloride	mg/l	8	5	9	9	10	13	9	23	79	48	71
Tot. Fluoride	mg/l	0.52	0.32	0.60	0.47	0.48	0.33	0.47	0.28	0.18	0.20	0.23
Sulfate	mg/l	4.2	23	52	23	47	679	97	92	100	308	174
Tot. Arsenic	µg/l	<5	<5	<5	<5	<5	≤8	<5	<5	<5	<5	<5
Diss. Arsenic[4]	µg/l	<5	-	-	<5	-	-	<5	<5	<5	-	-
Tot. Iron	µg/l	300	300	1800	700	1100	12100	2800	2700	3400	1400	2500
Diss. Iron[4]	µg/l	10	-	-	20	-	-	10	<10	20	-	-
Tot. Lead	µg/l	<5	≤10	≤10	<5	<5	10	≤10	≤5	<5	5	<5
Diss. Lead[4]	µg/l	<5	-	-	<5	-	-	<5	<5	<5	-	-
Tot. Manganese	µg/l	30	15	185	50	60	275	90	90	95	105	95
Diss. Manganese[4]	µg/l	25	-	-	35	-	-	15	<5	15	-	-
Tot. Mercury	µg/l	0.5	<0.5	0.6	0.6	0.3	1.0	0.4	1.6	2.4	1.9	2.3
Diss. Mercury[4]	µg/l	0.3	-	-	<0.2	-	-	0.3	<0.2	<0.2	-	-
Tot. Molybdenum	µg/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Diss. Molybdenum[4]	µg/l	<10	-	-	<10	-	-	<10	<10	<10	-	-
Tot. Selenium	µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Diss. Selenium[4]	µg/l	<5	-	-	<5	-	-	<5	<5	<5	-	-

[1] All values are three-day arithmetic averages unless otherwise noted.

[2] pH values are median values.

[3] Includes irrigation return flow on 3/14/76 (NC-1).

[4] Dissolved metals were sampled one time only at selected stations as shown.

Table 3. - continued

Parameter	Units	Stations										
		VR-8	LVC-1	AC-1[5]	LC-1	VR-10	VR-11	VR-12	SC-1	SC-2[6]	KC-1	KC-3
Temp	C	7.0	2.5	9.0	7.5	8.0	6.5	9.5	11.0	15	-3.0	7.5
pH[2]	SU	7.0	7.8	8.0	8.1	7.8	8.0	7.9	7.8	7.7	7.6	8.1
Flow	cms	1.98	0.158	0.031	0.023	-[7]	-	3.65	0.082	-	0.108	0.337
DO	mg/l	9.7	11.7	10.2	10.6	10.1	10.5	10.0	12.4	6.4	11.2	9.1
Cond.	µmhos/cm	2750	1180	760	1420	2500	2400	2500	2700	3000	980	970
Turbidity	FTU	95	118	1.0	4.9	108	105	96	6.8	32	159	1290
TDS	mg/l	1830	792	526	928	1670	1069	1311	2050	2120	695	1188
TDS	Metric Tons/day	313	10.8	1.4	1.8	-	-	413	14.5	-	6.5	34.6
TSS	mg/l	213	214	3.2	16.3	246	225	194	39	48	499	6340
TSS	Metric Tons/day	36.4	2.9	0.01	0.03	-	-	61.2	0.3	-	4.6	185
Chloride	mg/l	403	18	22	25	329	329	320	84	168	13	18
Tot. Fluoride	mg/l	0.53	0.22	0.16	0.44	0.47	0.45	0.47	0.40	1.60	0.25	0.31
Sulfate	mg/l	385	436	164	372	367	392	488	900	963	207	325
Tot. Arsenic	µg/l	28	<5	<5	≤6	19	20	15	5	27	≤7	108
Diss. Arsenic[4]	µg/l	26	-	-	-	-	-	14	5	-	<5	<5
Tot. Iron	µg/l	4500	3400	110	300	5200	4500	3800	900	1400	10000	115100
Diss. Iron[4]	µg/l	70	-	-	-	-	-	<10	20	-	20	10
Tot. Lead	µg/l	<5	≤7	<5	<5	<5	<5	<5	<5	<5	12	95
Diss. Lead[4]	µg/l	<5	-	-	-	-	-	<5	<5	-	<5	<5
Tot. Manganese	µg/l	225	85	5	50	130	135	205	695	85	185	2130
Diss. Manganese[4]	µg/l	45	-	-	-	-	-	55	535	-	50	5
Tot. Mercury	µg/l	1.6	≤4.8	0.8	1.4	2.0	1.8	4.1	1.6	7.0	0.7	0.9
Diss. Mercury[4]	µg/l	<0.2	-	-	-	-	-	<0.2	<0.2	-	<0.2	0.3
Tot. Molybdenum	µg/l	<10	<10	<10	≤10	<10	<10	<10	<10	<10	<10	<10
Diss. Molybdenum[4]	µg/l	<10	-	-	-	-	-	<10	10	-	<10	<10
Tot. Selenium	µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Diss. Selenium[4]	µg/l	<5	-	-	-	-	-	<5	<5	-	<5	<5

[2] pH values are median values.

[4] Dissolved metals were sampled one time only at selected stations as shown.

[5] Flow was present in Ash Creek on only two sampling days.

[6] Only one sample was collected from the St. George STP effluent ditch (SC-2).

[7] No USGS flow data at VR-10 because flow measuring equipment and records were stolen from site.

Table 4. Stream standards and recommended water quality criteria.

Parameter	Units	Utah Class "C" Stream Standards[a] Recommended	Utah Class "C" Stream Standards[a] Mandatory	Recommended EPA Criteria (EPA, 1977)
Temperature	C	20, cold	-	-
		26.6, warm	-	-
pH	s.u.	-	6.5-8.5	6.5-9.0
D.O.	mg/l	5.5	5.5	-
TDS	mg/l	500	-	500
Chloride	mg/l	250	-	250
Fluoride[b]	mg/l	1.0	2.0	2.0 (NAS,19
Sulfate	mg/l	250	-	250
Arsenic	μg/l	10	50	50
Iron	μg/l	300[c]	-	300[c], 1000
Lead	μg/l	-	50	50[d]
Manganese	μg/l	50[c]	-	50[c]
Mercury	μg/l	-	-	0.05[e], 2.0[f]
Molydenum	μg/l	-	-	10 (NAS, 197
Selenium	μg/l	-	10	10[d]

a. These standards are contained in the document referenced as Utah, 1968 which utilizes the chemical standards prescribed for drinking water by "Public Health Drinking Water Standards, 1962."
b. Actual fluoride standards and criteria are dependent upon ambient air temperatures at the monitoring site.
c. Dissolved metal.
d. It is recommended that a 96-hour LC_{50} bioassay test be conducted to establish a limit for the particular water body in question.
e. Criteria for freshwater aquatic life and wildlife.
f. Criteria for drinking waters.

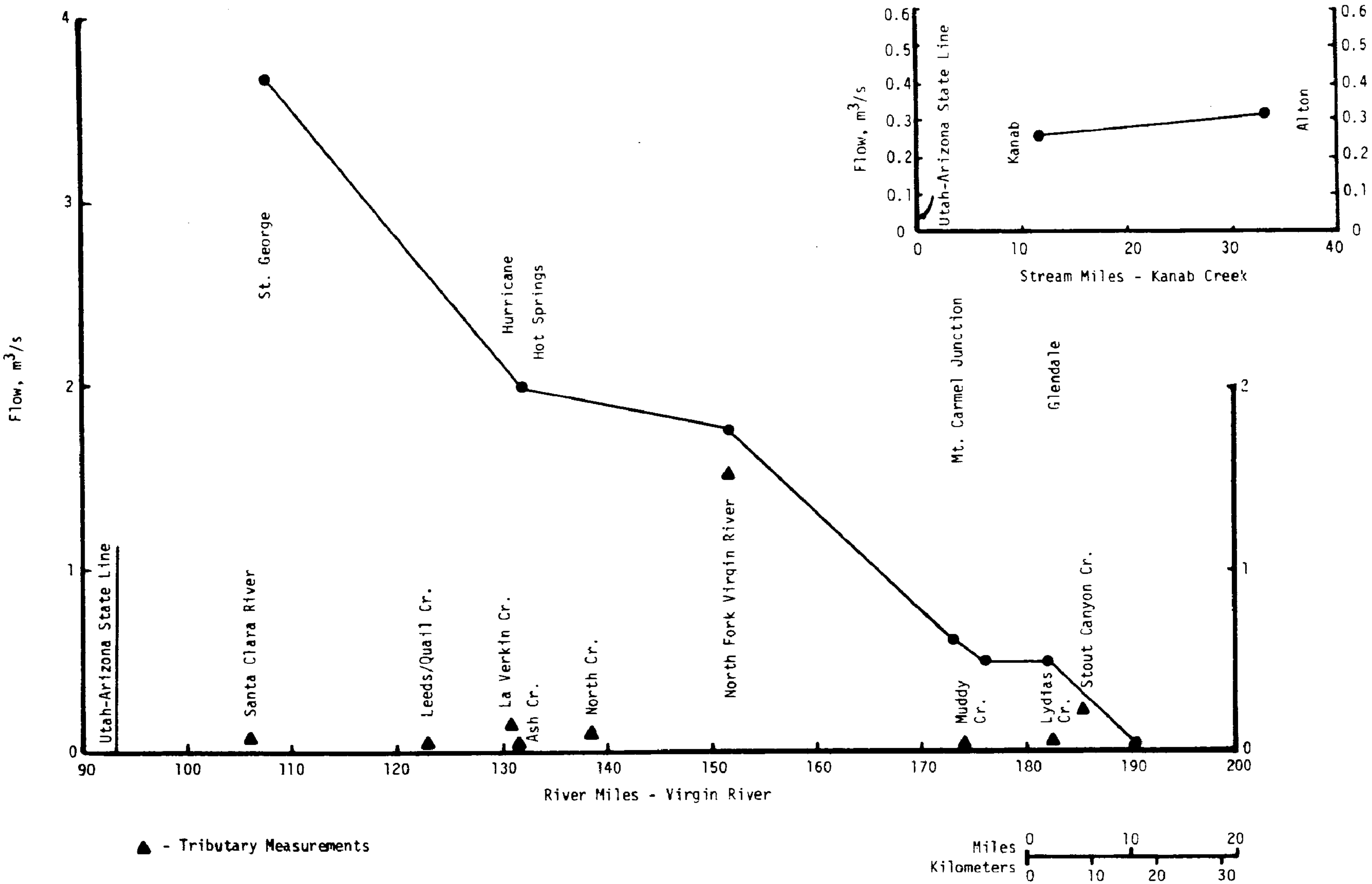

Figure 2. Flow profile, Virgin River and Kanab Creek, Utah.

Table 5. A comparison of streamflows[1] in the Virgin River drainage.

Station Number	Location	Mean Flow During March, 1976 Study[2]	5-Yr. Ave. of Mean Flow for March[3]	5-Yr. Ave. of Mean Annual Flow[3]
9404450	East Fork Virgin River near Glendale	0.501	0.524	0.462
9405500	North Fork Virgin River near Springdale	2.39	2.16	2.51
9406700	South Ash Cr. near Pintura	0.122	0.105	0.153
9408000	Leeds Cr. near Leeds	0.105	0.133	0.150
9408150	Virgin River near Hurricane	2.17[4]	5.92 (4.76[5])	5.24 (4.05[5])
9410100	Santa Clara River below Winsor Dam	0.187	0.232[6]	0.430[6]
9415000	Virgin River at Little-field, Arizona	2.38	6.51 (4.25[5])	5.72 (4.16[5])

1 All flows are in cubic meters per second (m3/s) as converted from USGS flow records.
2 All flows for March, 1976 are provisional and subject to revision by the USGS prior to publication.
3 The 5-year average includes the years 1970-1974 inclusive.
4 The March, 1976 flow in the Virgin River near Hurricane is the sum of flow in the Virgin River at VR-8 (500 feet downstream from the Hot Springs near Hurricane), and flows in Ash Cr., LaVerkin Cr., and Leeds/Quail Cr., all measured by EPA. The difference in flow may be partly due to unidentified irrigation diversior
5 These values represent 4-year averages, omitting high flows from 1973.
6 These values are based on only three years data.

Temperature

As shown in Figure 3 water temperatures fluctuated widely in the Virgin River basin during this study. The snow-melt runoff entering the upper Virgin River from Stout Canyon Creek and Lydias Canyon Creek caused temperatures to drop from 4C near the East Fork Virgin River headwaters to 0.5C near Glendale. Rapid warming occurred during the next 10 miles, resulting in an average water temperature of 6.5C at Mt. Carmel Junction. Measurements at the confluence of the North and East Forks of the Virgin River, immediately downstream from Zion National Park, indicated the water temperature had again decreased to 2C. Stream temperatures remained at this level until warmed by the discharge from the La Verkin Hot Springs located near Hurricane, Utah. This discharge, plus tributary impacts from Ask Creek and Leeds Creek and warmer air temperatures associated with lower elevations, contributed to the higher temperatures observed in the Virgin River near Harrisburg Junction (8C). A general upward trend in water temperatures continued downstream to the lower boundary of the study area below St. George, Utah.

Kanab Creek exhibited the same general trend of coldest water in the upstream reach near Alton (minus 3C-extensive anchor ice) with higher temperatures recorded 34.8 km (21.6 mi) downstream near Kanab (7.5C).

pH

As can be seen from Figure 4, median pH values ranged from 7.0 to 8.2 standard units (S.U.). The lowest median pH value was recorded at station VR-8 (7.0 S.U.), located immediately downstream from the La Verkin Hot Springs near Hurricane, Utah. During this study, no pH measurements exceeded the State limits of 6.5-8.5 S.U.

Dissolved Oxygen

There were no problems with low dissolved oxygen (D.O.) concentrations in the study area, as can be seen from the D.O. profile in Figure 5. Dissolved oxygen concentrations generally averaged between 9 and 12 mg/l at all locations, with the highest concentrations measured in the mid-reach of the Virgin River downstream from Zion National Park. The Santa Clara River contained the highest D.O. concentration of any tributary stream (12.4 mg/l).

Total Suspended Solids

The profile for total suspended solids (TSS) in the Virgin River (Figure 6) indicates several incremental increases in concentration in the downstream direction. The first increase was a result of the impact of Muddy Creek (591 mg/l), which more than doubled the suspended solids load carried by the Virgin River at station VR-3 (1.4 metric tons per day). The second sharp increase in TSS concentrations occurred in the 9.7 km (6 mi) reach of the Virgin River between stations VR-7 and VR-8. Although TSS concentrations increased by 86% in this stream reach, the TSS load at VR-8 (36.4 metric tons per day) remained at approximately the same level as the combined load measured in the North Fork and East Fork (41.1 metric tons per day) approximately 32.2 km (20 mi) further upstream. Irrigation diversions and return

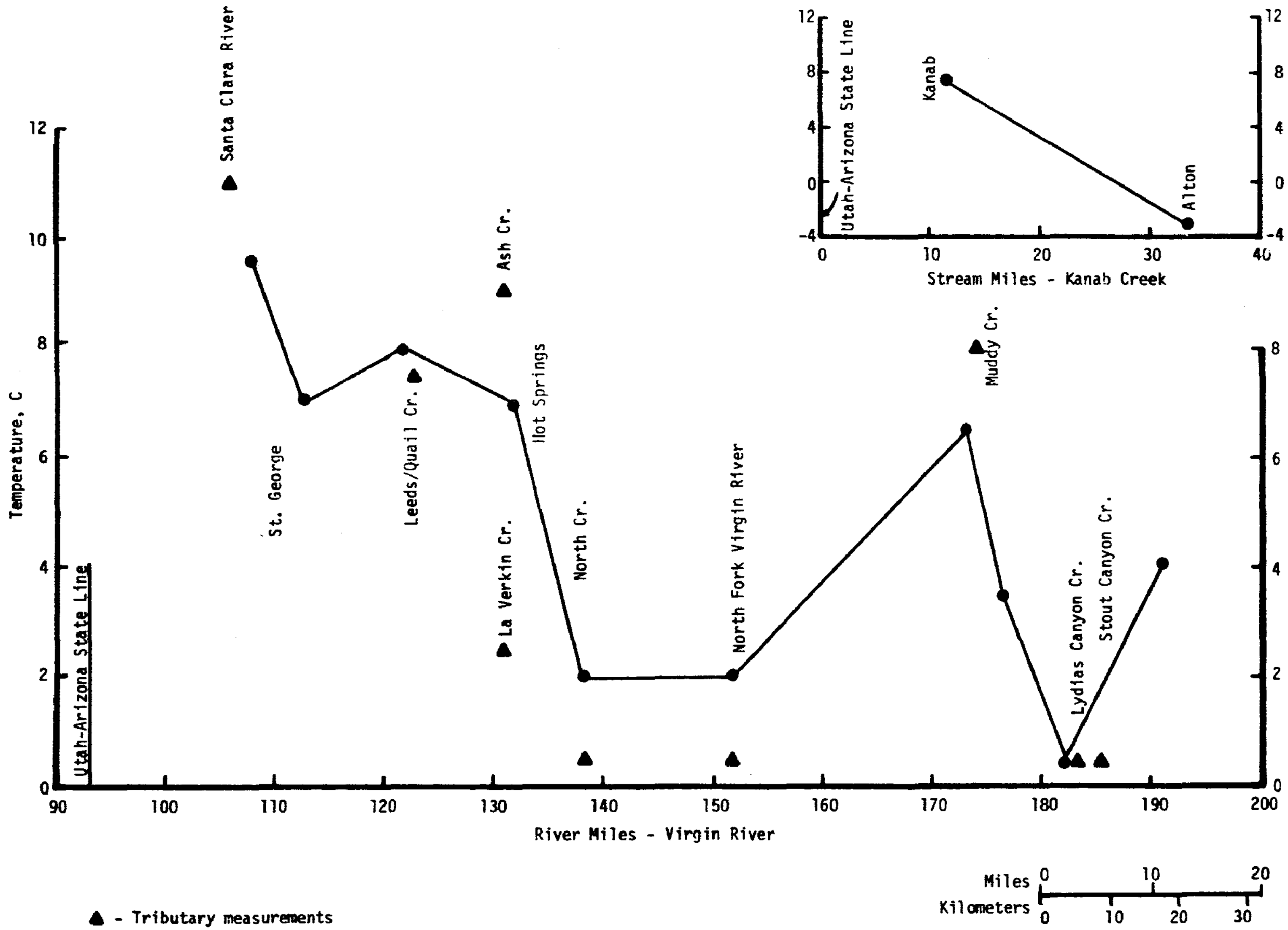

Figure 3. Temperature profile, Virgin River and Kanab Creek, Utah.

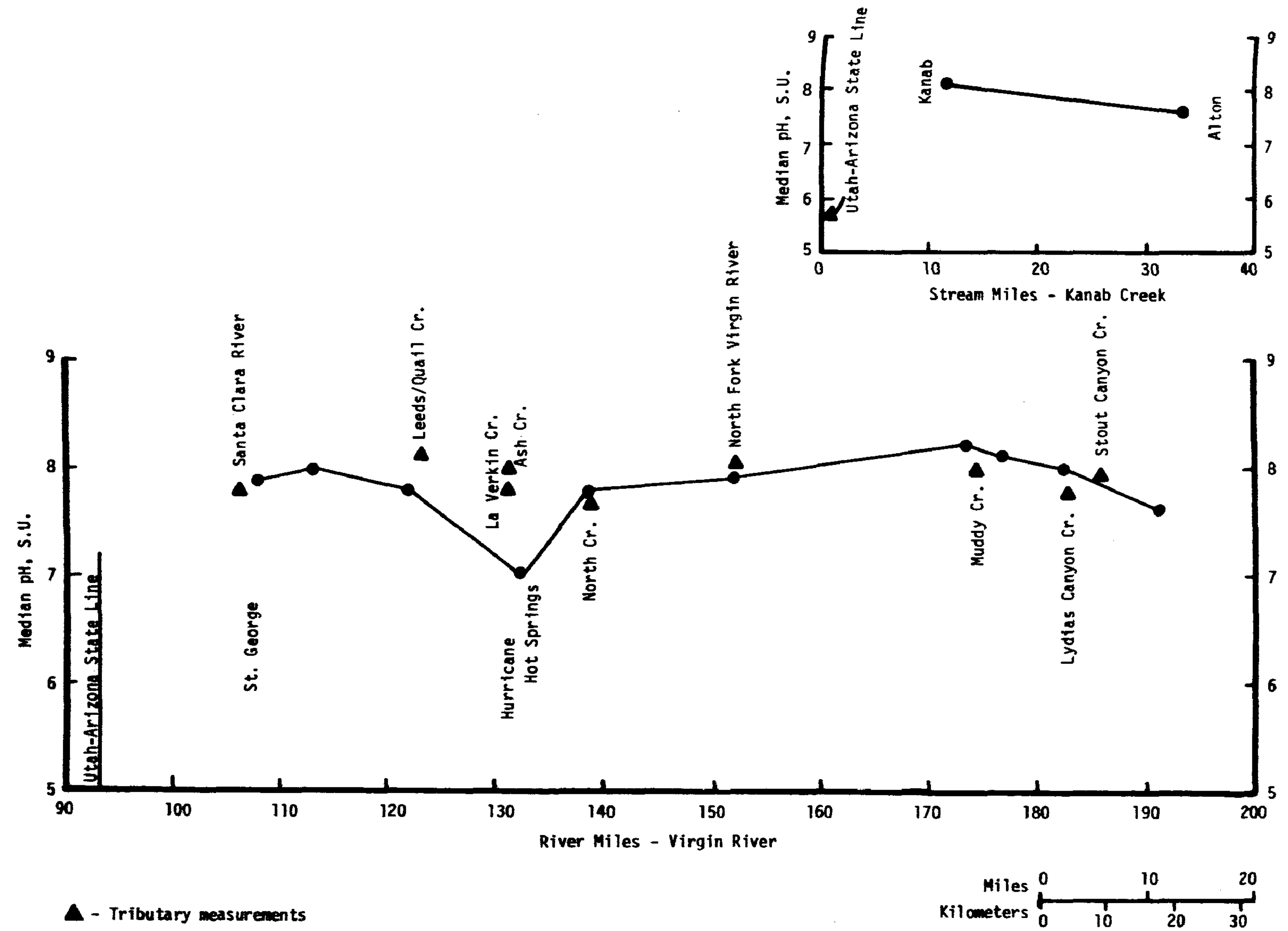

Figure 4. pH profile, Virgin River and Kanab Creek, Utah

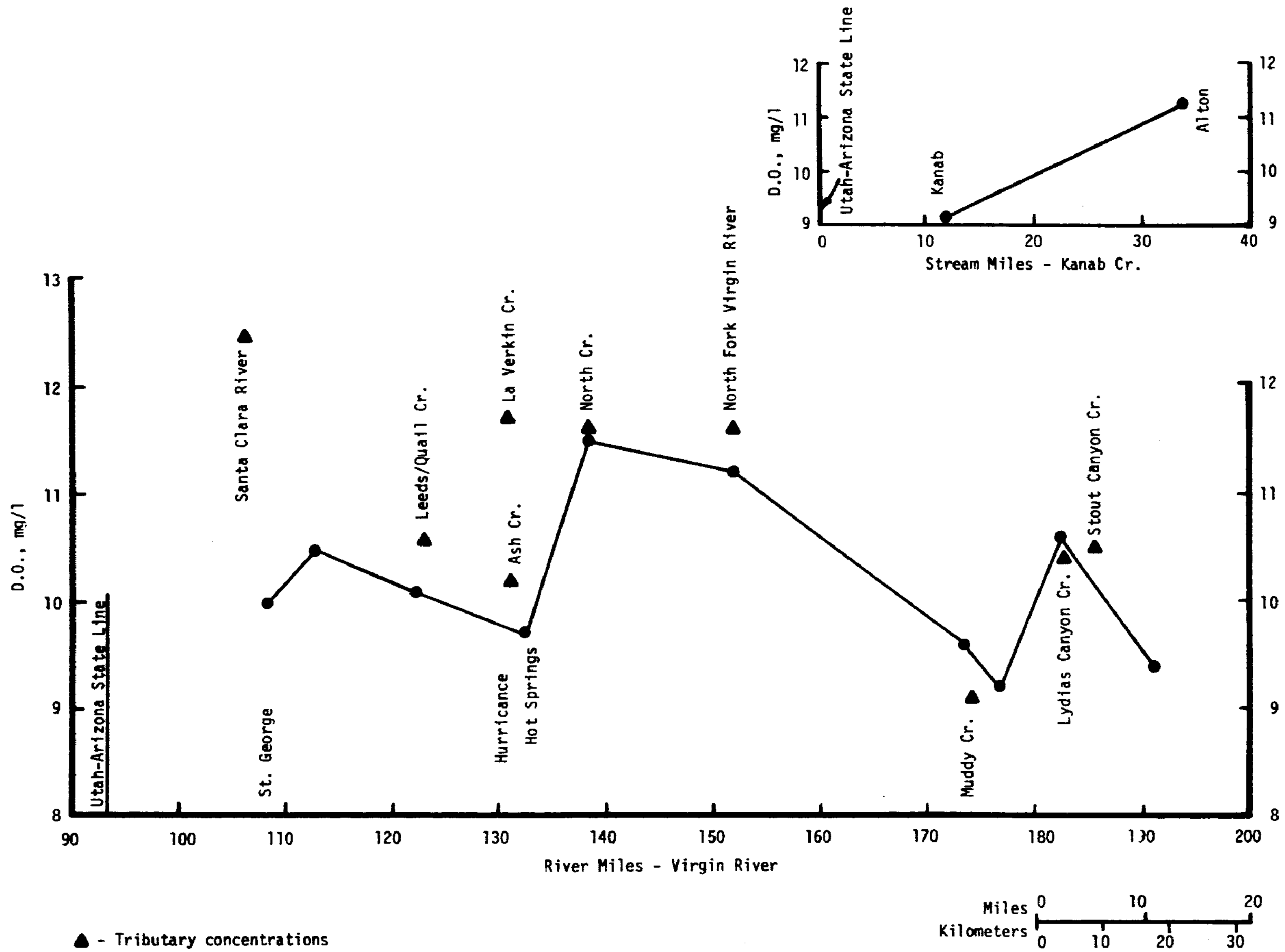

Figure 5. Dissolved oxygen profile, Virgin River and Kanab Creek, Utah.

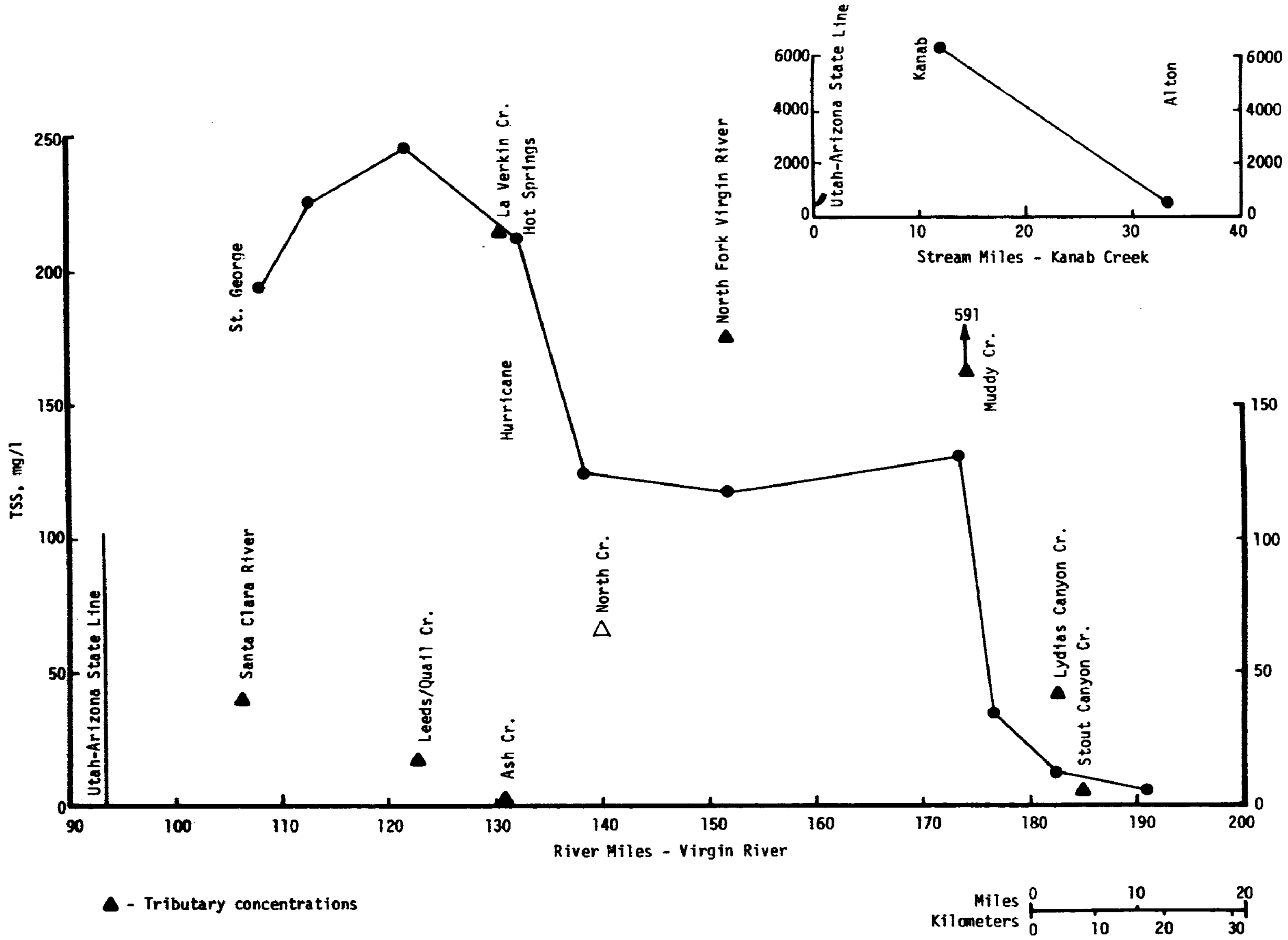

Figure 6. TSS profile, Virgin River and Kanab Creek, Utah

flows, as well as the presence of highly erodable soils throughout the region, contributed to the variability of TSS concentrations in the Virgin River drainage.

In Kanab Creek, TSS concentrations showed a tremendous increase, ranging from 499 mg/l near Alton to 6340 mg/l near Kanab. The solids load in Kanab Creek at Kanab (185 metric tons per day) was three times greater than the maximum load carried by the Virgin River at St. George (61.2 metric tons per day) during this study. As would be expected, a very good correlation existed between TSS concentrations and turbidity measurements (r = 0.99).

Salinity

For purposes of this report, total dissolved solids (TDS), chloride, and sulfate are discussed under the general heading of "salinity". Profiles for these three parameters are shown in Figures 7 through 9. From the TDS profile (Figure 7), it is readily apparent that excessive TDS concentrations pose a severe problem in the lower Virgin River basin downstream from Zion National Park. The recommended Utah maximum limit of 500 mg/l TDS was exceeded at all main stem and tributary sampling locations downstream from the confluence of the North and East Forks of the Virgin River. It appears that one of the most significant sources of TDS in this stream reach is the La Verkin Hot Springs located near the town of Hurricane. TDS concentrations in the Virgin River nearly tripled in the 9.7 km (6 mi) stream reach between Virgin (VR-7, 641 mg/l) and Hurricane (VR-8, 1830 mg/l), Utah. TDS loads could not be computed at VR-7 because no flow measurement was possible, but comparison of the TDS load at VR-8 with the combined load measured upstream in the North Fork (NFVR-1) and East Fork (VR-5) Virgin River indicated a 250% increase in this 32.2 km (20mi) stream reach. Although no TDS measurements were made on the hot springs discharge itself, previous investigations have reported concentrations in excess of 9000 mg/l (Utah Water Research Laboratory, 1974). Another significant source of salinity in the lower Virgin River drainage is the Santa Clara River which enters the Virgin River approximately 2 km (1.2 mi) downstream from George, Utah. Figure 7 shows that the average TDS concentration of 2050 mg/l, measured at the mouth of the Santa Clara River, was the highest value observed in the entire Virgin River drainage. Although containing very high concentrations of TDS, flow from the Santa Clara River increased the salinity load in the Virgin River by only approximately 3%. Figure 7 also shows that the Kanab Creek drainage exhibited the same pattern of increasing TDS concentrations in the downstream direction (695 mg/l near Alton to 1188 mg/l near Kanab). TDS loads likewise increased in the same direction from 6.5 to 34.6 metric tons per day, respectively (Table 3).

Average concentrations of chloride and sulfate exceeded the recommended limit of 250 mg/l throughout the lower Virgin River drainage (Figures 8 and 9). As noted previously in the discussion of TDS, the major source of the high chloride and sulfate concentrations appeared to be La Verkin Hot Springs. Chloride concentrations increased by more than 400% in the Virgin River

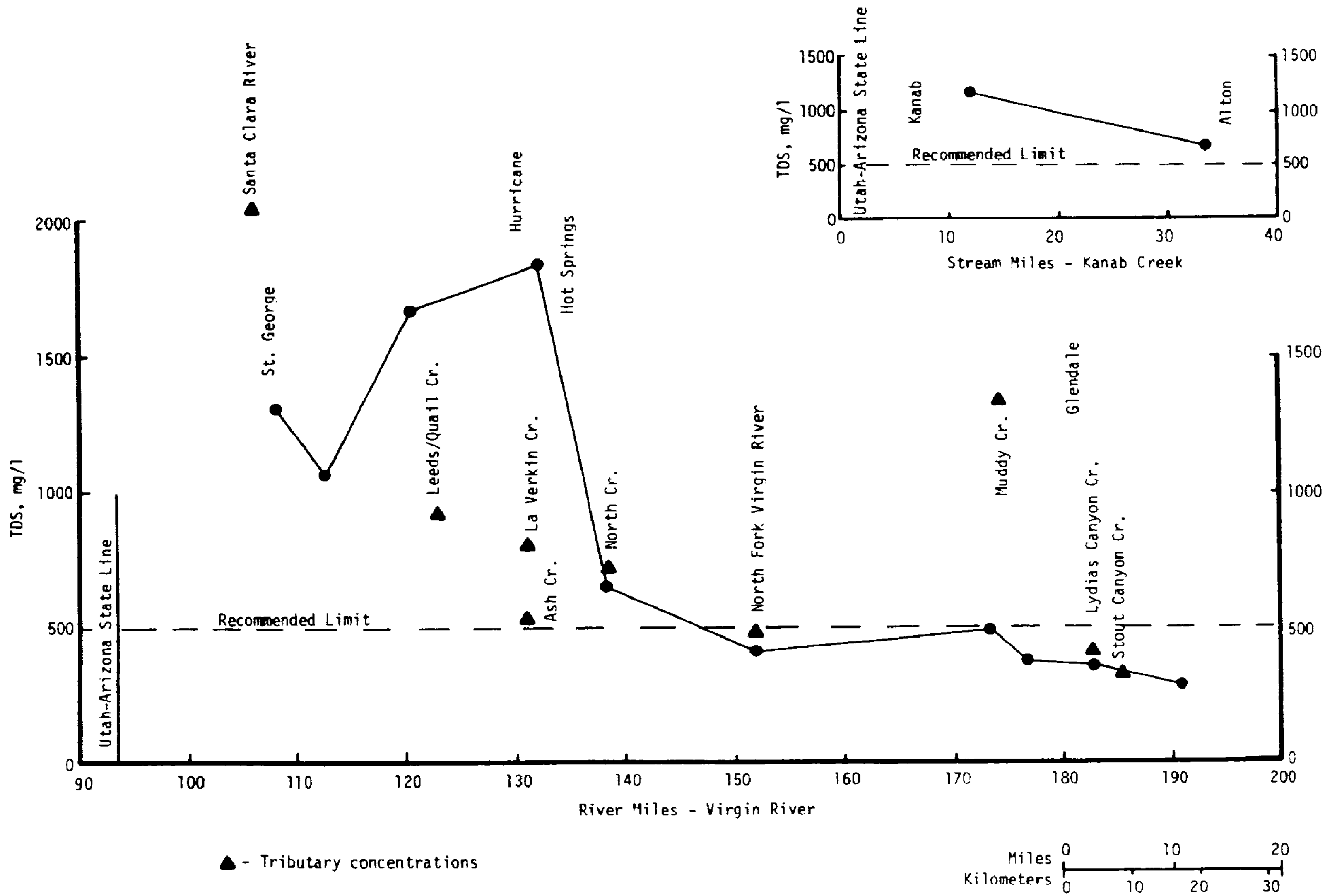

Figure 7. TDS profile, Virgin River and Kanab Creek, Utah.

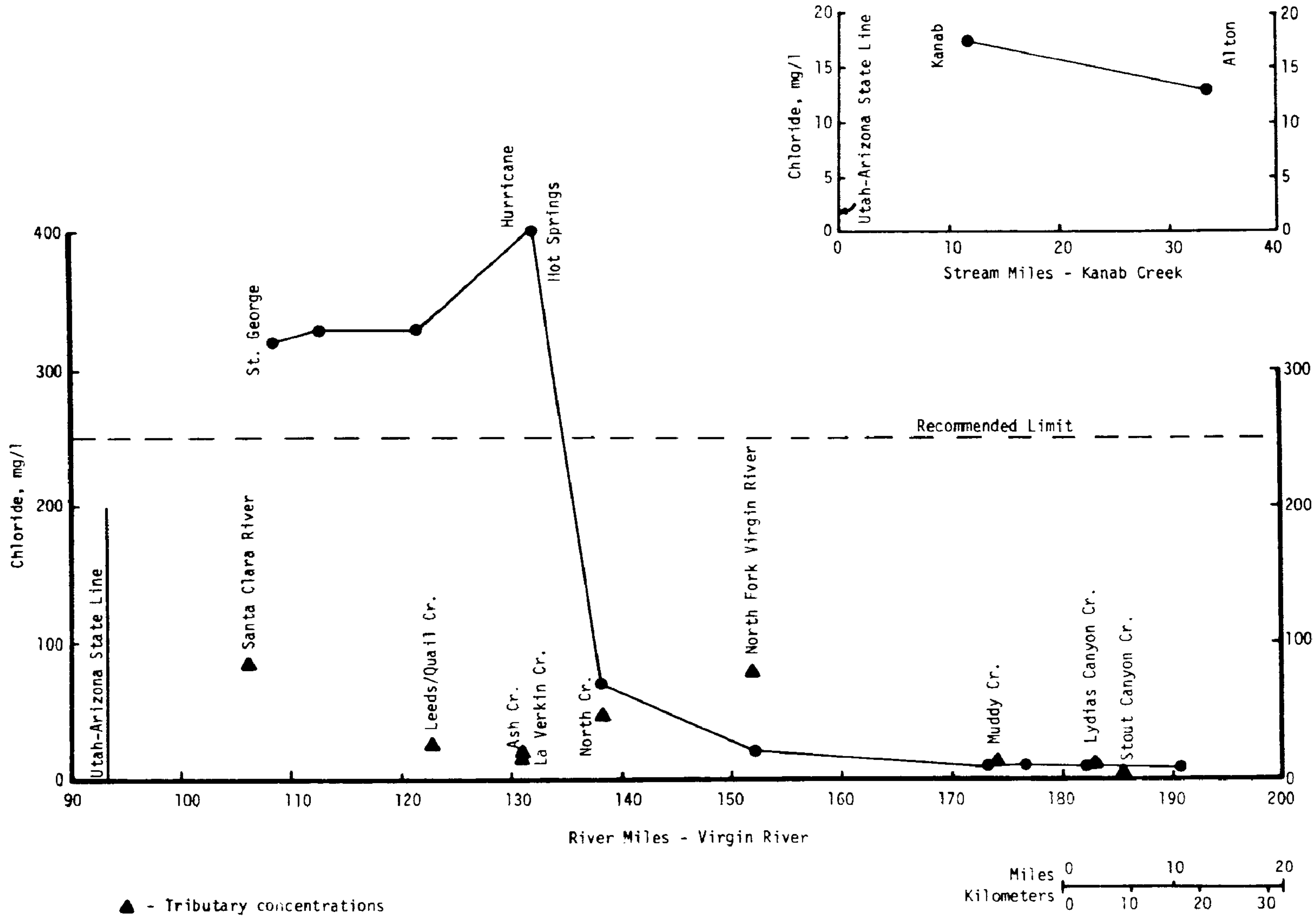

Figure 8. Chloride profile, Virgin River and Kanab Creek, Utah.

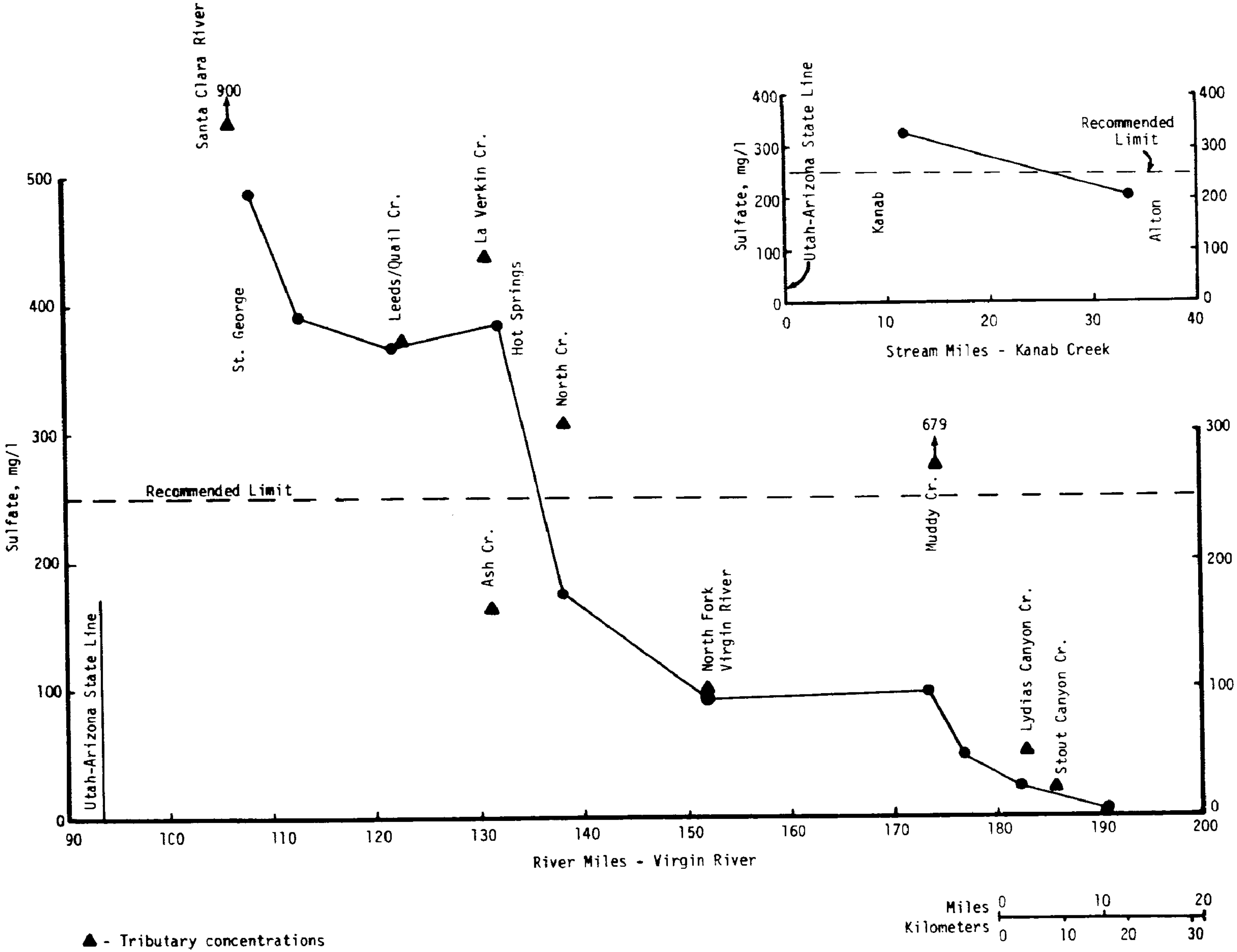

Figure 9. Sulfate profile, Virgin River and Kanab Creek, Utah.

between Virgin (VR-7) and Hurricane (VR-8), Utah, while sulfate concentrations increased by 121% in the same stream reach. Although the Santa Clara River contained relatively little chloride (84 mg/l), it was extremely high in sulfate (900 mg/l). The lower Kanab Creek station (KC-3) also contained high concentrations of sulfate (325 mg/l).

Fluoride

Concentrations of fluoride ranged between 0.1 and 0.6 mg/l at all sampling stations in the Virgin River and Kanab Creek drainages. As shown in the profile in Figure 10, fluoride concentrations decreased from the headwaters downstream to the La Verkin Hot Springs. Downstream from the Hot Springs, the fluoride concentration in the Virgin River increased by approximately 100%, as measured at the Hurricane sampling station (VR-8). Concentrations remained near the same level (0.5 mg/l) from this point downstream to St. George Based on this data, fluoride was not a problem in either drainages at the time of this study.

Metals

A total of seven different metals were measured during this study, including arsenic, iron, lead, manganese, mercury, molybdenum and selenium. Table 3 lists the average total metal concentrations obtained from three samples collected at each location. The table also shows the dissolved metal concentrations obtained from a single sample collected at selected locations as shown on the data sheets in Appendix A.

As shown in Table 3 and Figure 11 concentrations of total arsenic averaged less than 5 μg/l at all sampling locations on the Virgin River upstream from the La Verkin Hot Springs. However, below the Hot Springs, average total arsenic concentrations ranged from 15 to 28 μg/l. Although these concentrations do not exceed the mandatory Utah limit of 50 μg/l, they do exceed the recommended Utah limit of 10 μg/l. The most significant arsenic problem was found in Kanab Creek, where the average total concentration near Kanab was 108 μg/l. Although 80% of the dissolved arsenic measurements were below the analytical detection limit (reported in Table 3 as <5 μg/l), two measurements were above the recommended Utah limit of 10 μg/l (VR-8, 26 μg/l and VR-12, 14 μg/l).

The profile of total iron concentrations shown in Figure 12 indicates the highly variable but generally upward trend of iron concentrations in the downstream direction. Total iron concentrations, as might be expected, were directly related to TSS concentrations (correlation coefficient, r = 0.99). Average total iron concentrations ranged as high as 5200 μg/l in the main stem Virgin River (VR-10), 12,100 μg/l in one of its tributaries (Muddy Creek-MC-1), and 115, 100 μg/l in Kanab Creek near Kanab (KC-3). Although there is no applicable Utah stream standard for total iron, the recommended EPA criterion of 1000 μg/l was greatly exceeded at many locations. However, the recommended Utah standard of 300 μg/l for dissolved iron was not exceeded at any location. The highest average dissolved iron concentration measured was 70 μg/l at VR-8, located immediately downstream from the La Verkin Hot Springs (Table 3).

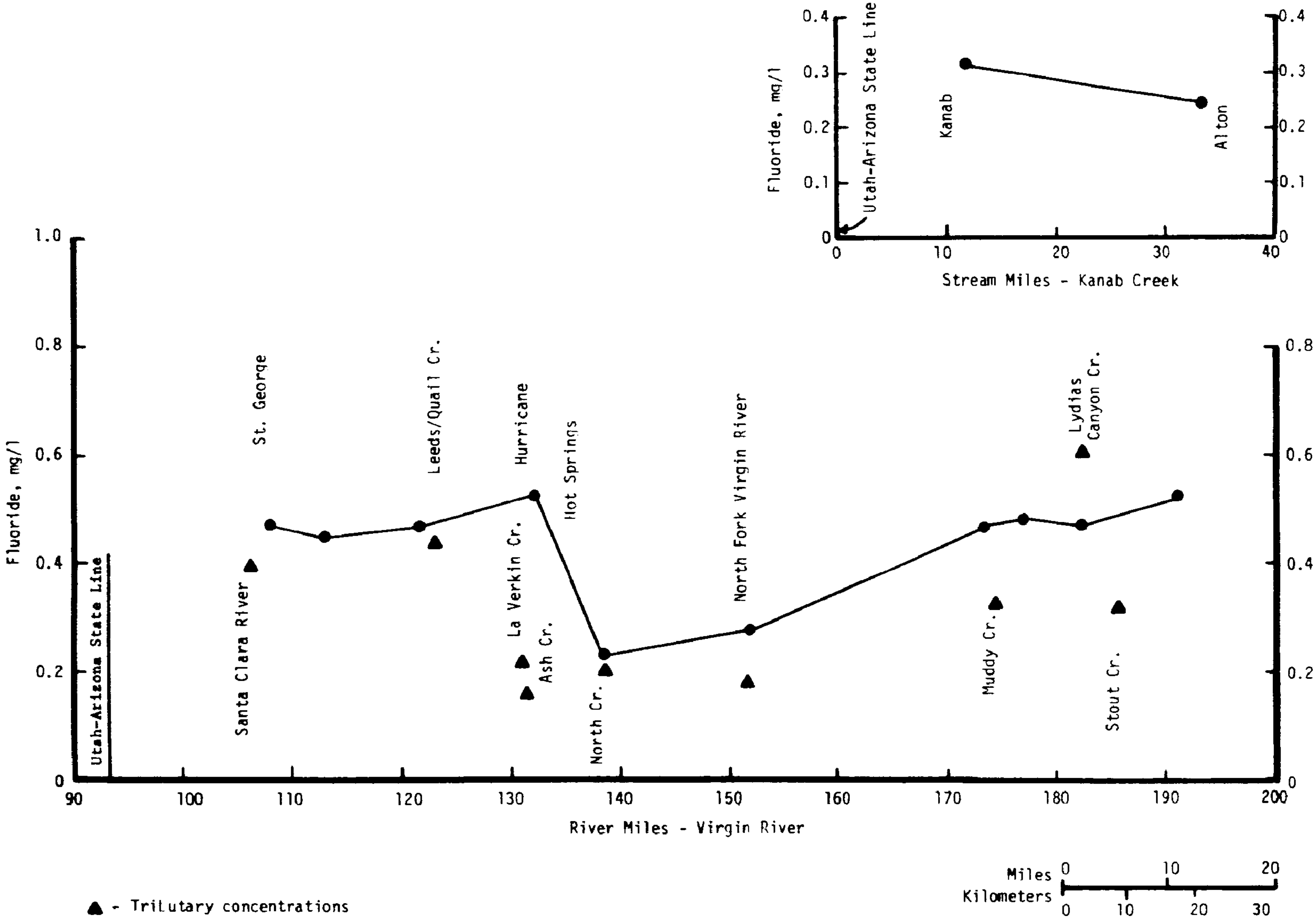

Figure 10. Fluoride profile, Virgin River and Kanab Creek, Utah.

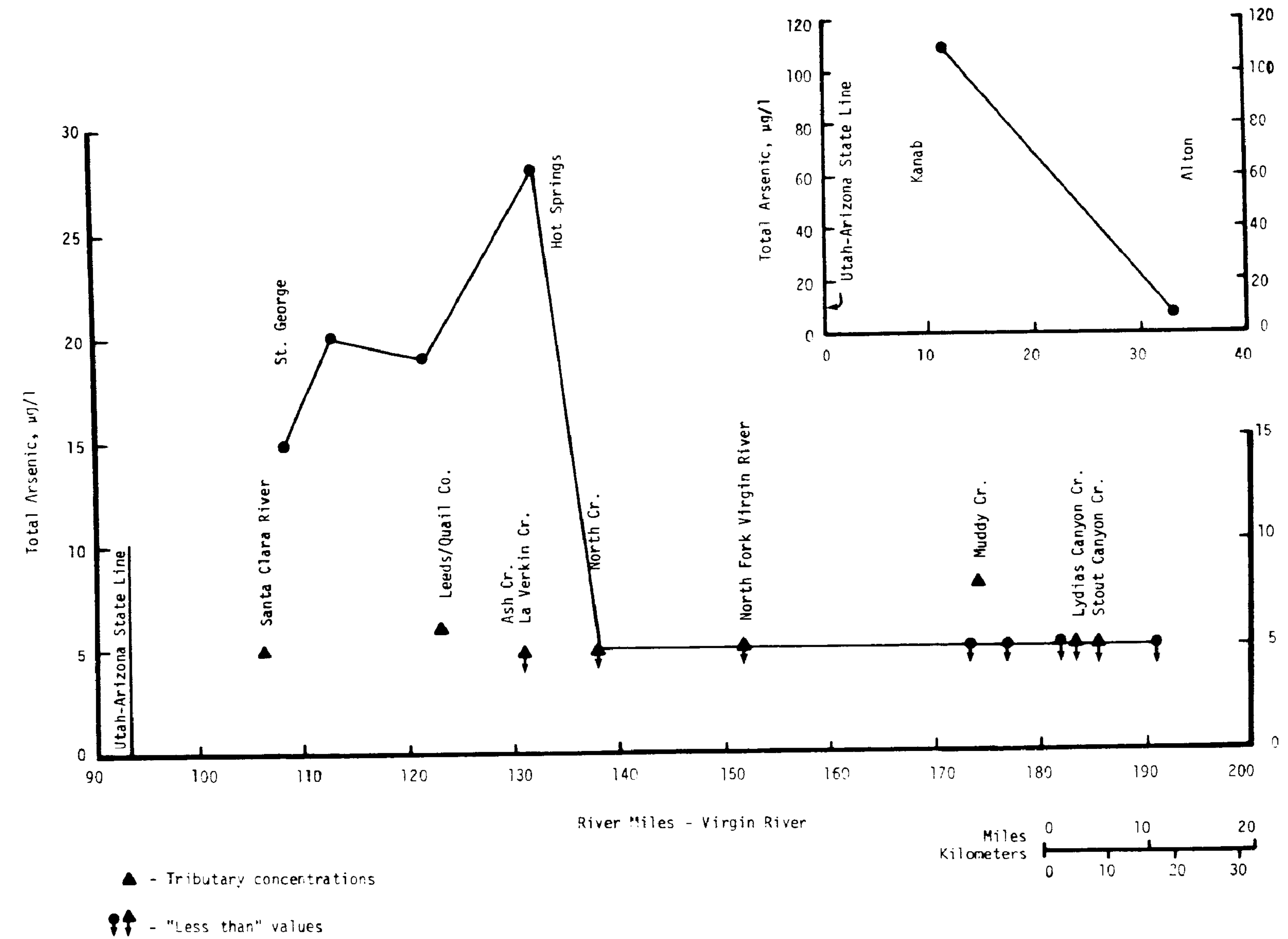

Figure 11. Total arseric profile, Virgin River and Kanab Creek, Utah

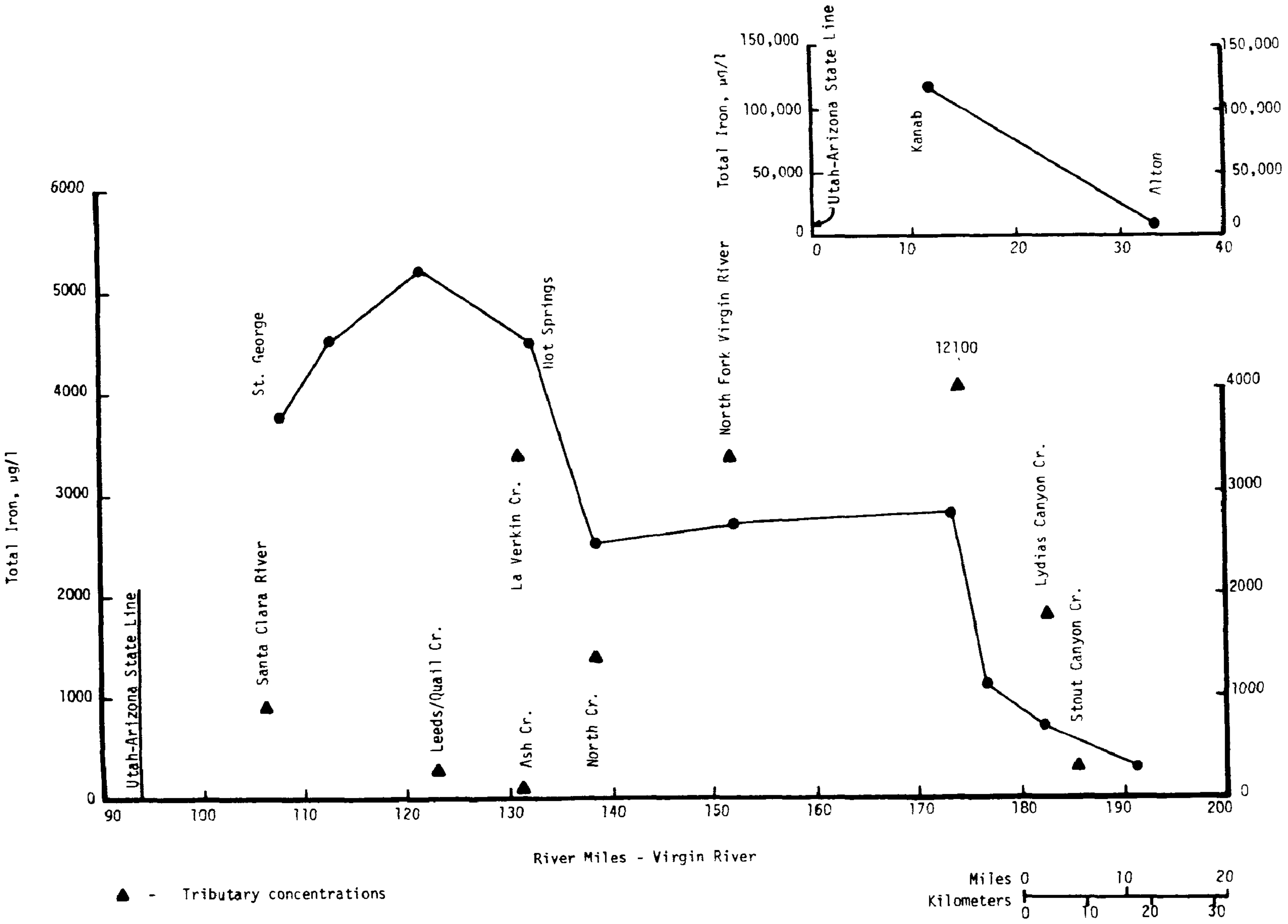

Figure 12. Total iron profile, Virgin River and Kanab Creek, Utah.

Total lead concentrations averaged less than 10 μg/l throughout the Virgin River drainage and were, therefore, not plotted graphically in a concentration profile. However, the Kanab Creek drainage exhibited much higher total lead concentrations, ranging from 12 μg/l near the headwaters (KC-1) to 95 μg/l near Kanab. The concentration of 95 μg/l exceeds the mandatory Utah limit of 50 μg/l as well as the recommended EPA criterion of 30 μg/l (EPA, 1973). Dissolved lead concentrations averaged less than 5 μg/l at all locations.

The profile of total manganese concentrations measured in the Virgin River basin is shown in Figure 13. The highest concentrations were measured at station VR-8, located immediately downstream from the La Verkin Hot Springs (225 μg/l), Muddy Creek at MC-1 (275 μg/l), Kanab Creek at KC-3 (2130 μg/l), and the Santa Clara River at SC-1 (695 μg/l). All of these concentrations exceed the recommended EPA criterion for total manganese of 200 μg/l (Table 4). Dissolved manganese concentrations were generally less than 50% of the total concentrations except for the upper Virgin River at VR-1 and VR-2 and the Santa Clara River near the mount (SC-1). The Santa Clara River contained the highest concentration of dissolved manganese (535 μg/l), far exceeding the recommended Utah limit of 50 μg/l. The Virgin River near St. George (VR-12, 55 μg/l) also contained dissolved manganese concentrations slightly in excess of the recommended Utah limit.

Total mercury concentrations at most sampling locations in the Virgin River and Kanab Creek Drainages exceeded the recommended EPA criterion of 0.05 μg/l for the protection of freshwater aquatic life and wildlife. As shown in Figure 14, even the more liberal criterion of 2.0 μg/l for drinking water supplies was exceeded at four locations: NFVR-1 (2.4 μg/l), VR-7 (2.3 μg/l), LVC-1 (≤ 4.8 μg/l), and VR-12 (4.1 μg/l). The mercury concentrations in La Verkin Creek (LVC-1) showed considerable variation, ranging from <0.2 to 11 μg/l over the three-day sampling period. In North Creek (NC-1) an increase in stream flow of 63% due to irrigation return flow on 3/14/76 produced an increase in total mercury concentrations of 680% or 3.4 μg/l. Another high concentration of total mercury was found in the single grab sample collected from the St. George wastewater treatment plant effluent ditch at SC-2 (7.0 μg/l, Table 3). Also of interest is the fact that, for some unknown reason, all sampling locations downstream from Zion National Park exhibited significantly higher concentrations of total mercury (by a factor of from 3 to 10) on the second two days of sampling (3/14-15/76) than on the first day (3/13/76) This phenomenon could not be related to changes in flow or any other measured or observed stream characteristic. Of the dissolved mercury measurements, 70% were less than the detection limit of 0.2 μg/l. While these dissolved mercury concentration may or may not have exceeded the recommended EPA criterion of 0.05 μg/l for the protection of freshwater aquatic life and wildlife, the remaining 30% (three samples) of the samples did exceed the recommended criterion

All concentrations of molybdenum, both total and dissolved, were reported as less than or equal to 10 μg/l - the minimum detection limit achieved during this study. These values are less than the recommended criterion of 10 μg/l for total molybdenum in irrigation water (NAS, 1973).

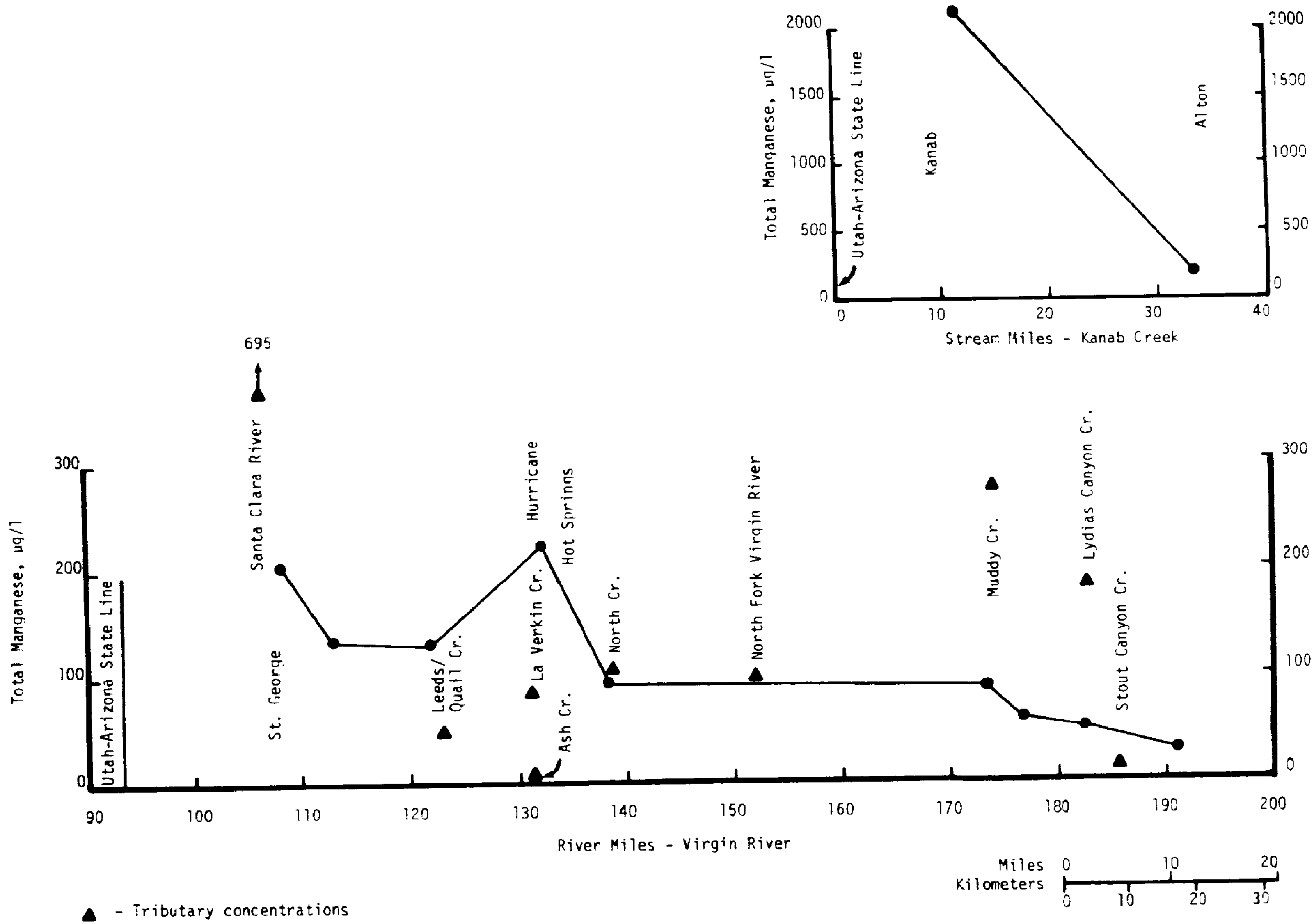

Figure 13. Total manganese profile, Virgin River and Kanab Creek, Utah.

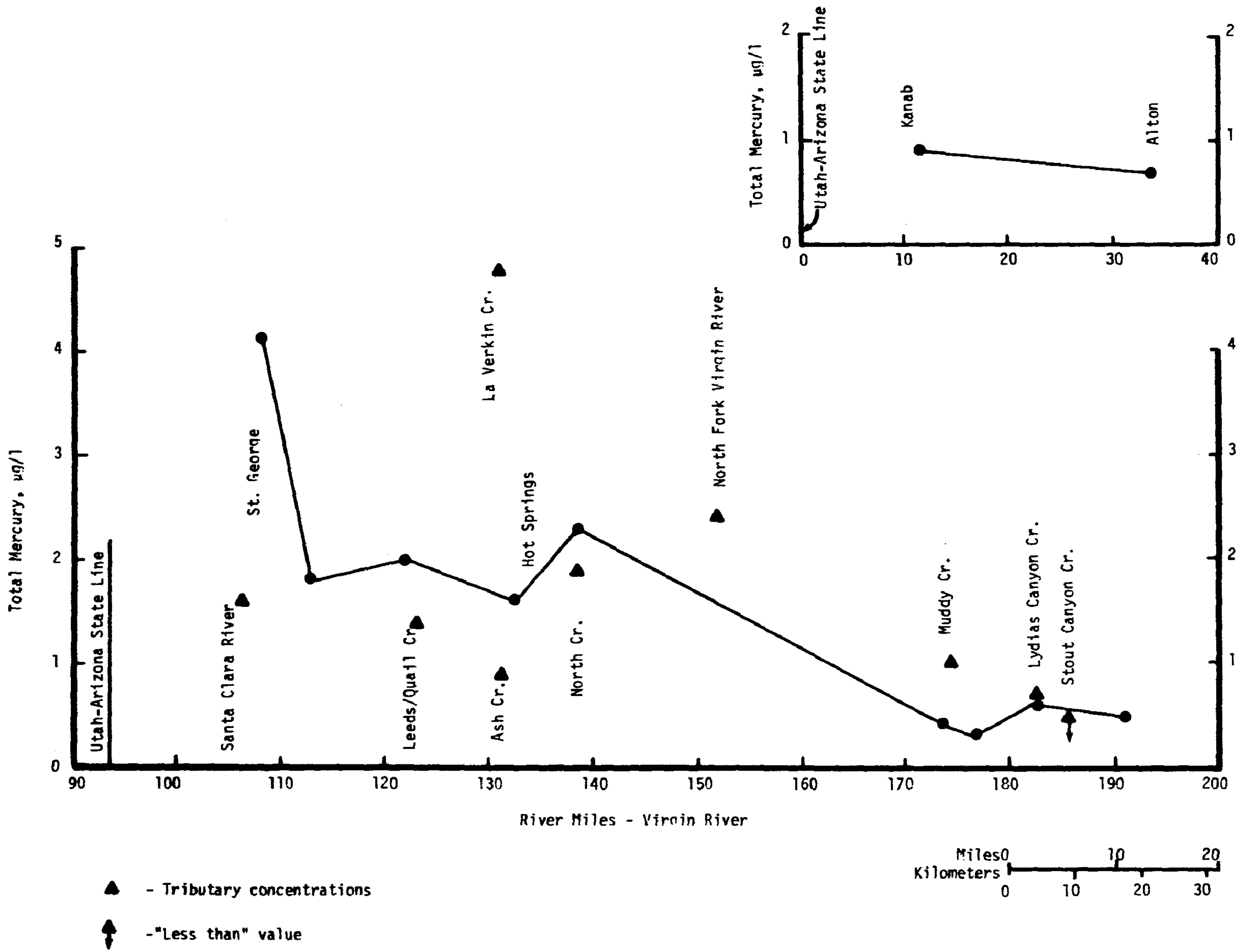

Figure 14. Total mercury profile, Virgin River and Kanab Creek, Utah.

Selenium concentrations at all sampling locations were reported as <5 μg/l, the minimum detection limit (Table 3). No differences were observed between total and dissolved selenium concentrations, and all concentrations were less than the mandatory Utah limit (10 μg/l) and the recommended EPA criterion (10 μg/l).

Sediments

A total of ten sediment samples from the Virgin River and Kanab Creek drainages were analyzed forseven different metals and PBC's. The results are shown in Table 6. Maximum concentrations of each metal parameter were found in sediments in the following areas: arsenic - 12.7 μg/gm in the East Fork Virgin River headwaters near Alton (VR-1); iron - 5800 μg/gm in the East Fork Virgin River near Glendale (VR-2); lead - 19.1 μg/gm and manganese - 670 μg/gm in the Santa Clara River near St. George (SC-1); mercury and molybdenum concentrations were below the detection limits of 0.1 and 1.0 μg/gm, respectively, at all stream locations, while selenium was found above the detection limit of 5 μg/gm only in the East Fork Virgin River near Mt. Carmel Junction (5.7 μg/gm). The only stream sampling location which exhibited measurable concentrations of PCB's was Kanab Creek near Kanab (KC-3), which contained 13 parts per billion (ppb) PCB 1260. Of the ten sediment samples collected, the sample from the St. George STP effluent ditch (SC-2) contained the highest concentrations of lead (24.3 μg/gm), mercury (1.1 μg/gm) and PCB's (73 ppb PCB 1254).

The concentrations shown in Table 6 basically represent baseline sediment characteristics existing at the time of this study. The sediment concentrations do not appear to be related to any existing water quality problems in the study area except for manganese in the Santa Clara River (SC-1).

Trace Organics

As a part of the intensive baseline stream survey, water samples were collected from several locations in the Virgin River basin for trace organics analysis. Table 7 lists 14 commonly occurring pesticides which, along with PCB's, were measured at three locations on the Virgin River (VR-1, VR-4, VR-12) and one location on the Santa Clara River (SC-1). The reported concentrations, in parts per trillion (ppt), ranged from <10 to <500. In each case these values are the limits of detection for each organic parameter. This trace organics data will serve as reference values against which future concentrations may be compared.

II. Biological Data

The complete tabulation of kinds and number of benthic macroinvertebrate collected in each sample at each station is given in Appendix B. Table 8 is a summary of the data presented in Appendix B.

As expected, in view of the high sediment load in the Virgin River the macroinvertebrate population was poor throughout most of the mainstem of the Virgin River. Aside from station VR-1, which averaged 17,665 organisms/m^2

Table 6. Sediment analysis, Virgin River and Kanab Creek drainages, March 12-13, 1976

Station	Total Metals, μgm/gm (ppb) Dry Weight							
	As	Fe	Pb	Mn	Hg	Mo	Se	PCB's*
VR-1	12.7	4760	13.5	216	<0.1	<1.0	<5	<8
VR-2	4.2	5800	8.5	143	<0.1	<1.0	<5	<8
VR-4	1.2	4000	7.1	122	<0.1	<1.0	5.7	<8
NFVR-1	1.3	1940	3.7	64	<0.1	<1.0	<5	<8
VR-5	0.86	2180	5.8	66	<0.1	<1.0	<5	<8
VR-8	1.7	2230	3.9	64	<0.1	<1.0	<5	<8
VR-12	4.6	3.42	5.1	78	<0.1	<1.0	<5	<8
KC-3	0.95	1740	2.4	79	<0.1	<1.0	<5	13(PCB 1260)
SC-1	10.8	9.72	19.1	670	<0.1	<1.0	<5	<8
SC-2	5.9	6.27	24.3	217	1.1	<1.0	<5	73 (PCB 1254

* ppb, calculated as PCB 1254. Recovery was $\geq$ 92%.

Table 7. Trace organic analysis of water samples from the Virgin River drainage - March 12-13, 1976

Parameter	Concentration, ppt[1]	Recovery (ppt)[2]
Aldrin	<10	
Chlordane	<100	
PP' DDE	<23	
PP' DDD	<10	
PP' DDT	<60	480
Dieldrin	<20	240
Endrin	<53	
Heptachlor	<25	
Heptachlor Epoxide	<25	
Lindane	<25	
Malathion	<500	1200
Methyl Parathion	<500	
Parathion (Ethyl)	<500	
Toxaphene	<100	
PCB's	<100	

1 Each of the four water samples (VR-1, VR-4, VR-12, SC-1) contained pesticide and PCB concentrations as shown.

2 Recovery was ≥89% for sample VR-1 which was spiked with three different pesticides as indicated above.

able 8. A compilation of results of the benthic macroinvertebrate survey, Virgin River, Utah 1976.

Station	No/ft^2/Sample	Mean No/ft^2	St. Dev.	Range No/ft^2	Taxa/ Station	Range Taxa/Sample	No. Taxa/ Sample	No/m^2/Sample	Mean No/m^2	Diversity ($\bar{d}$) Sample 1	2	3	4	Ave. d
VR-1	1105/1225 2214/2021	1641.25	557.70	1105- 2214	35	17- 24	17-24- 21-23	11893-13185 23829-21752	17665	1.977	1.539	1.967	1.820	1.83
VR-2	248/ 82 164/ 493	246.75	177.61	82- 493	30	11- 20	16-11- 17-20	2669- 883 1765- 5306	2656	2.895	2.362	2.720	2.553	2.63
VR-3	179/ 242 103/ 239	190.75	65.3	103- 242	18	5- 12	12- 5- 9- 9	1927-2605 1109-2572	2053	1.260	1.427	0.997	1.214	1.22
VR-4	52/ 28 12/ 12	26.00	18.90	12- 52	11	2- 7	7- 5- 2- 5	560- 301 129- 129	280	1.637	1.370	0.413	1.950	1.34
VR-5	149/ 179 181/ 131	160.00	24.25	131- 181	17	8- 9	8- 8- 9- 8	1604-1927 1948-1410	1722	0.771	0.796	0.616	0.730	0.73
VR-6	107/ 12 98/ 300	129.25	121.62	12- 300	19	2- 12	9- 2- 9-12	1152- 129 1055-3229	1391	1.146	0.650	0.976	1.205	0.99
VR-7	307/ 126 159/ 389	245.25	124.01	126- 389	23	6- 16	6- 6- 16- 9	3304-1356 1711-4187	2640	0.810	0.518	1.607	0.668	0.90
VR-8	151/ 312 86/ 142	172.75	97.18	86- 312	16	8- 11	11-10- 8-10	1625-3358 926-1528	1859	2.460	1.623	2.138	2.082	2.08
VR-9	542/ 42 153/ 128	216.25	222.31	42- 542	20	7- 10	7-10- 10-10	5834- 452 1647-1378	2328	0.191	1.726	1.056	1.060	1.01
VR-10	27/ 31 144/ 326	132.00	140.25	27- 326	17	5- 10	6- 5- 10- 8	291- 334 1550-3509	1421	1.708	0.812	1.540	1.016	1.27
VR-11	93/ 335 82/ 204	178.50	117.99	82- 335	19	5- 11	5-10- 9-11	1001-3606 883-2196	1922	1.155	1.369	1.570	1.611	1.43
VR-12	40/ 41 66/ 48	48.75	12.04	40- 66	11*	4- 7	4- 5- 7- 6	431- 441 710- 517	525	0.934	1.572	1.333	1.719	1.39

Table 8. continued

Station	No/ft²/Sample	Mean No/ft²	St. Dev.	Range No/ft²	Taxa/ Station	Range Taxa/Sample	No. Taxa/ Sample	No/m²/Sample	Mean No/m²	Diversity ($\bar{d}$) Sample 1	2	3	4	Ave. $\bar{d}$
VR-13	Qual. Sample Only -													
StC-1	285/ 712 563/ 708	567.00	200.37	285- 712	41	19- 29	29-24- 26-19	3067-7664 6060-7620	6103	3.632	3.363	3.710	3.522	3.56
MC-1	27/ 1 3/ 11	10.50	11.82	1- 27	8	1- 4	4- 1- 2- 4	291- 11 32- 118	113	1.293	0.000	0.918	1.789	1.00
NFVR-1	62/ 78 101/ 412	163.25	166.60	62- 412	20	9- 14	9-10- 11-14	667- 840 1087-4434	1757	2.656	2.304	1.659	1.361	2.00
NFVR-2	1303/1083 995/1423	1201.00	196.68	995- 1423	33	19- 22	21-19- 19-22	14024-11656 10709-15316	12926	2.768	1.950	2.783	2.896	2.60
NFVR-3	Qual. Sample Only -													
NC-1	66/ 22	47.25	20.61	22- 66	19	5- 11	11- 8- 5- 6	710- 237 420- 667	509	2.735	2.460	1.398	1.789	2.10
LVC-1	50/ 71 88/ 117	81.50	28.31	50- 117	21	8- 13	8- 9- 13-11	538- 764 947- 1259	877	1.621	1.486	1.772	1.138	1.50
AC-1	2045/1304 4907/1733	2497.25	1634.97	1304- 4907	40	14- 32	23-14 32-10	22010-14035 52814-18652	26878	2.019	1.670	2.003	1.760	1.86
LC-1	362/ 614 527/ 743	561.50	159.88	362- 743	33	14- 28	14-26 28-23	3896-6608 5672-7997	6043	2.358	3.261	3.519	3.062	3.05
SC-1	542/ 426 526/ 948	610.50	230.78	426- 948	26	13- 20	13-15- 15-20	5834-4586 5662-10204	6572	1.383	1.445	1.778	2.158	1.69

* Does not include qualitative sample collected.

(558/ft^2), total number of organisms was generally less than 3230/m^2 (300.ft^2) with samples frequently containing less than 1076 organisms/m^2 (100/ft^2). The greatest number of genera noted during the survey was at station VR-1, Figure 15. No apparent trends were observed for either number of organisms/m^2 or total number of genera versus river mile. The extremely low number of organisms and genera reported at VR-4 is thought to be due to lack of suitable sampling substrate rather than any marked changes in the water quality.

Figures 15-18 show the reported number of organisms/m^2 and the total number of genera per station recorded for sampling locations on tributaries to the Virgin River. Total number of organisms per m^2 varied from 113 at Station MC-1 to 26,878 at AC-1, while total number of genera per sample varied from 8 at Station MC-1 to 41 at Station StC-1.

Although the value of mean diversities ($\bar{d}$) computed for samples containing less than 1076 organisms/m^2 (100/ft^2) is questionable, mean diversity was calculated for all samples, regardless of total number, for means of comparison. As can be seen from Figure 19, the highest mean diversities were reported for the upstream Stations VR-1 (1.83) and VR-2 (2.63), while the lowest mean diversity $\bar{d}$ was noted at VR-5 (0.73). Recorded mean diversities were generally higher in the tributaries than in the mainstem of the Virgin River (Fig. 20). The highest mean diversity (3.56) was recorded at Station StC-1 while the lowest (1.00) was recorded at MC-1. Recorded mean diversities were, in general less than 2.00 throughout the sampling area.

Although numerous taxa were often recorded at various sampling stations, usually one taxa was markedly dominant. At all stations sampled, with the exception of VR-8, the Ephemoptera (mayflies) were the dominant benthic macroinvertebrates, the dominant genera being Baetis sp. At Station VR-8, located immediately downstream from the La Verkin Hot Springs (Figure 1 and Table 1), the Chironomidae (midges) were the dominant organisms. The Ephemoptera, which averaged 1862/m^2 (173/ft^2) at VR-7, averaged only 118/m^2 (11/ft^2), at VR-8, while the Chironimidae increased from an average of 54/m^2 (5/ft^2) at VR-7 to 1604/m^2 (149/m^2) at VR-8. At Station VR-9, the next downstream station, the Ephemoptera were, once again, the dominant macroinvertebrates, averaging 2153/m^2 (200/ft^2). A discussion of the significant physical and chemical effects of the La Verkin Hot Springs on the Virgin River water quality appeared in a previous section of the report.

Table 9 shows the comparison of results from this study with reported findings of the Utah Water Research Laboratory (1974). An attempt was made to match stations reported in the previous study with EPA stations in as close proximity as possible. In general, the results of the benthic invertebrate surveys for the two studies are similar. A breakdown of percent of various taxa recorded per station is not given in the UWRL report. However, both studies show a benthic population low in number and diversity throughout much of the drainage. The highest number of organisms per unit area and the highest mean diversity were recorded, for both studies, at the furthest upstream stations.

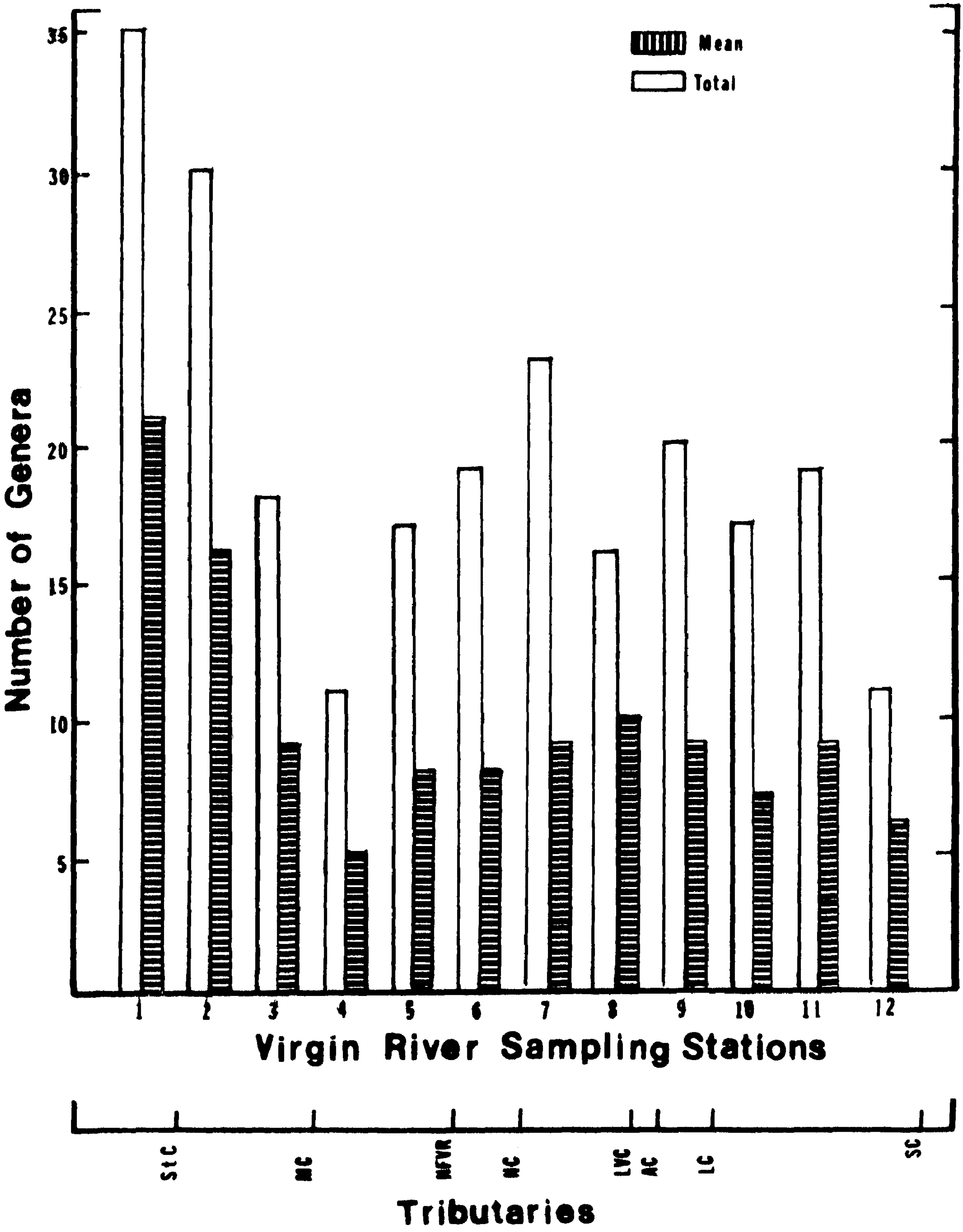

Fig. 15 Total and mean number of genera recorded at each Virgin River sampling station, Alton to St. George, Utah.

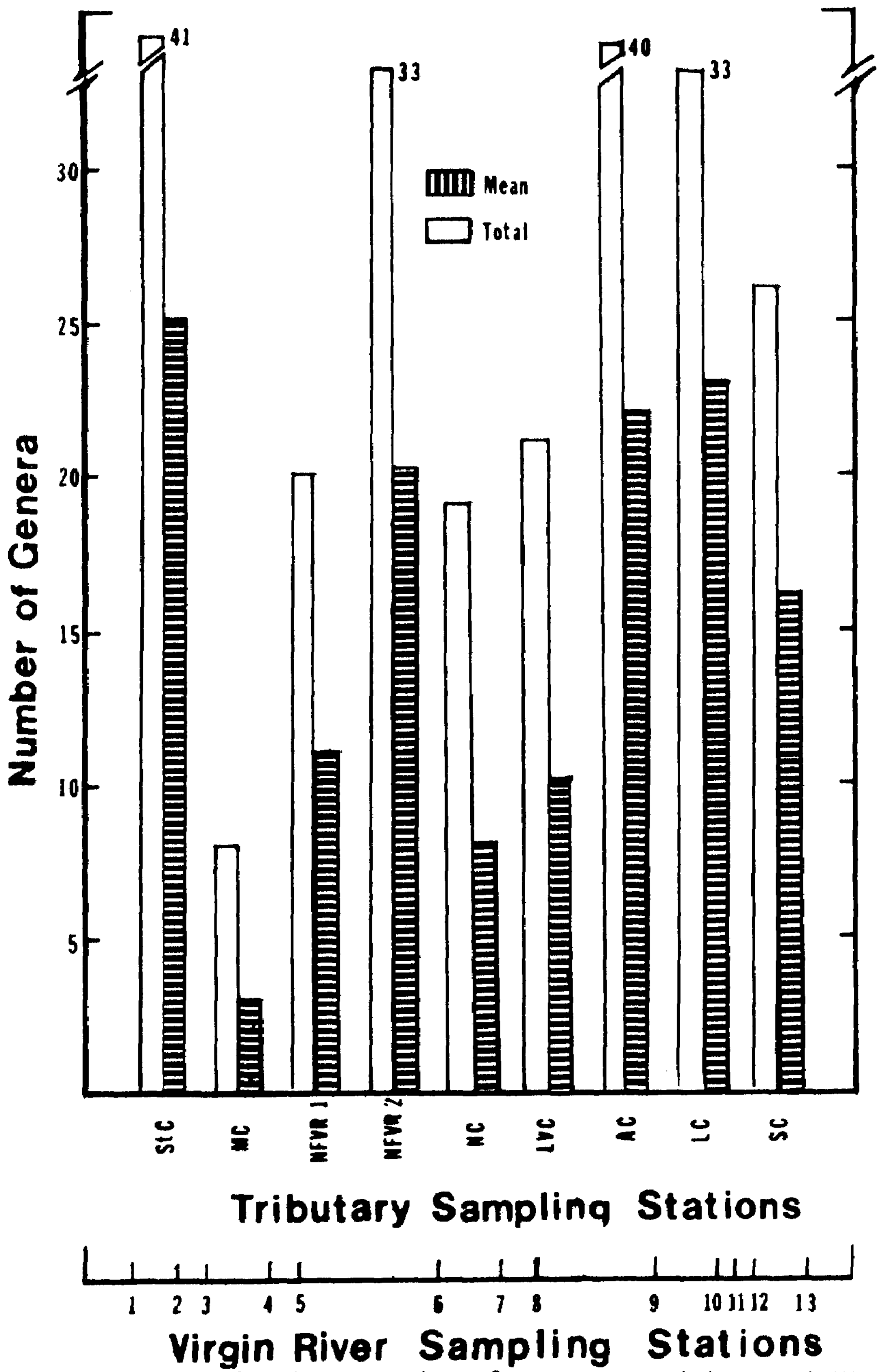

Fig. 16 Total and mean number of genera recorded at each Virgin River tributary sampling station, Alton to St. George, Utah.

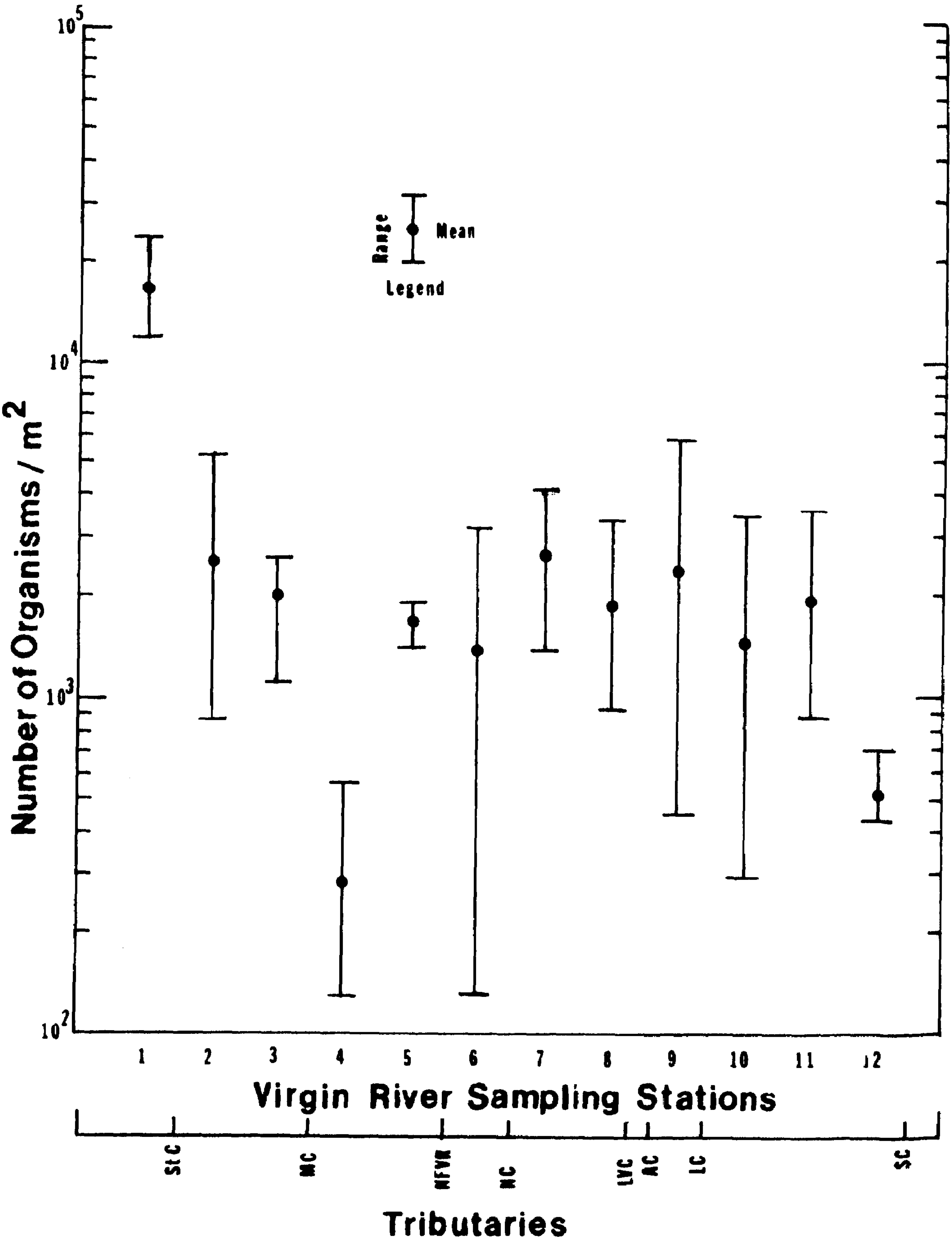

Fig. 17 Mean number of organisms per square meter and range at mainstem Virgin River sampling locations, Alton to St. George, Utah.

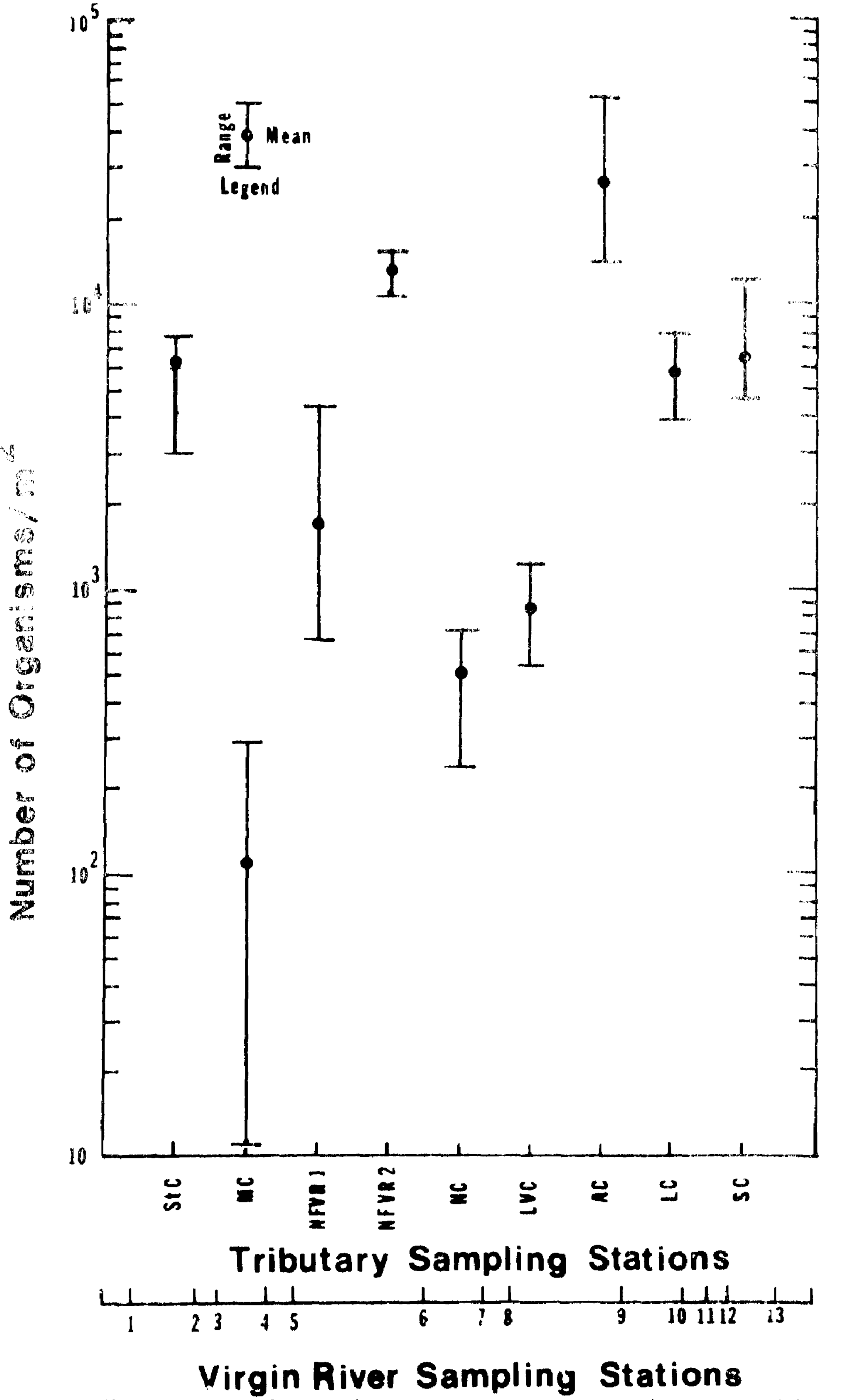

Fig. 18 Mean number of organisms per square meter and range at Virgin River tributary sampling stations, Alton to St. George, Utah.

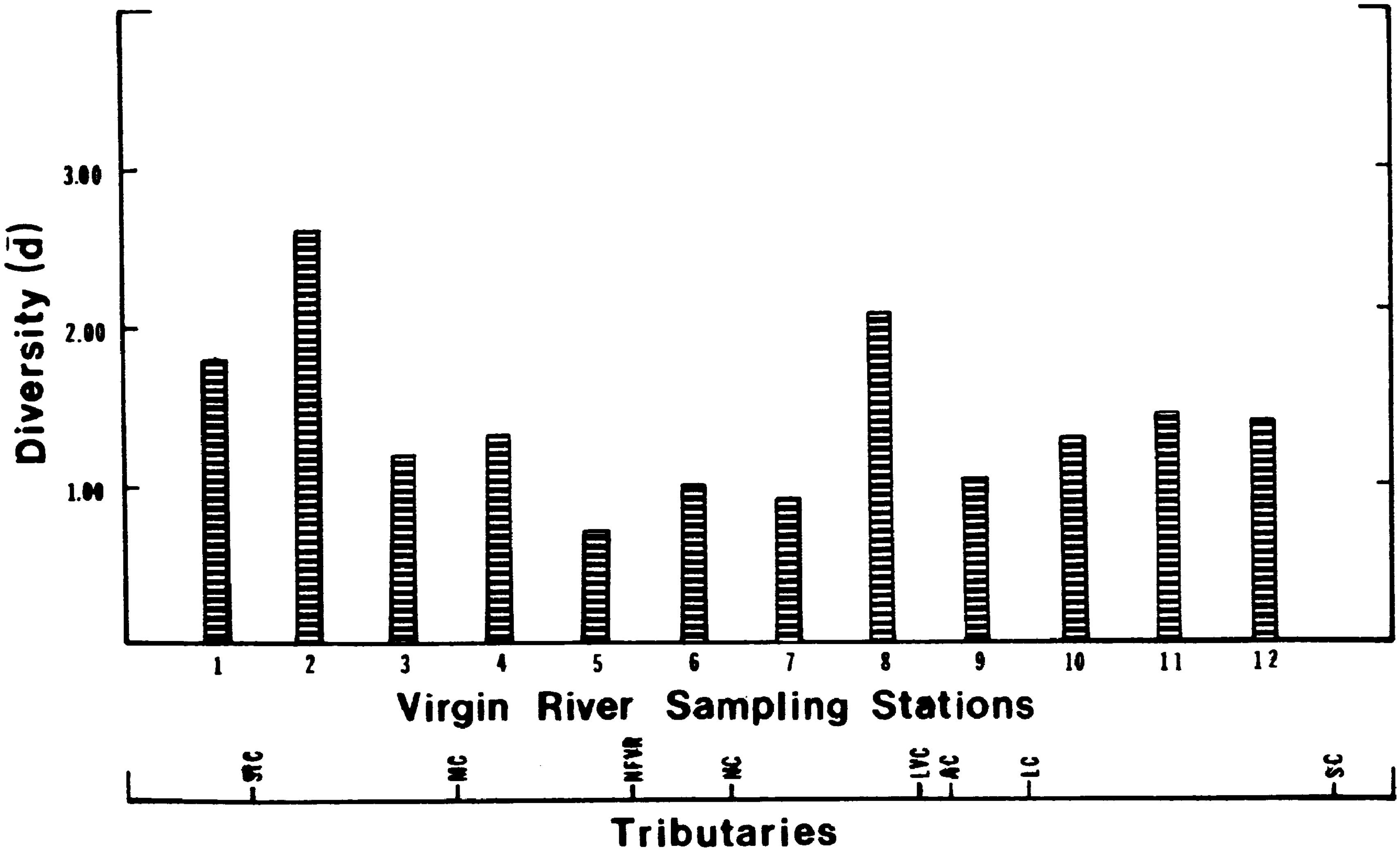

Fig. 19 Mean diversity of benthic invertebrates collected at sampling stations on the Virgin River, Alton to St. George, Utah.

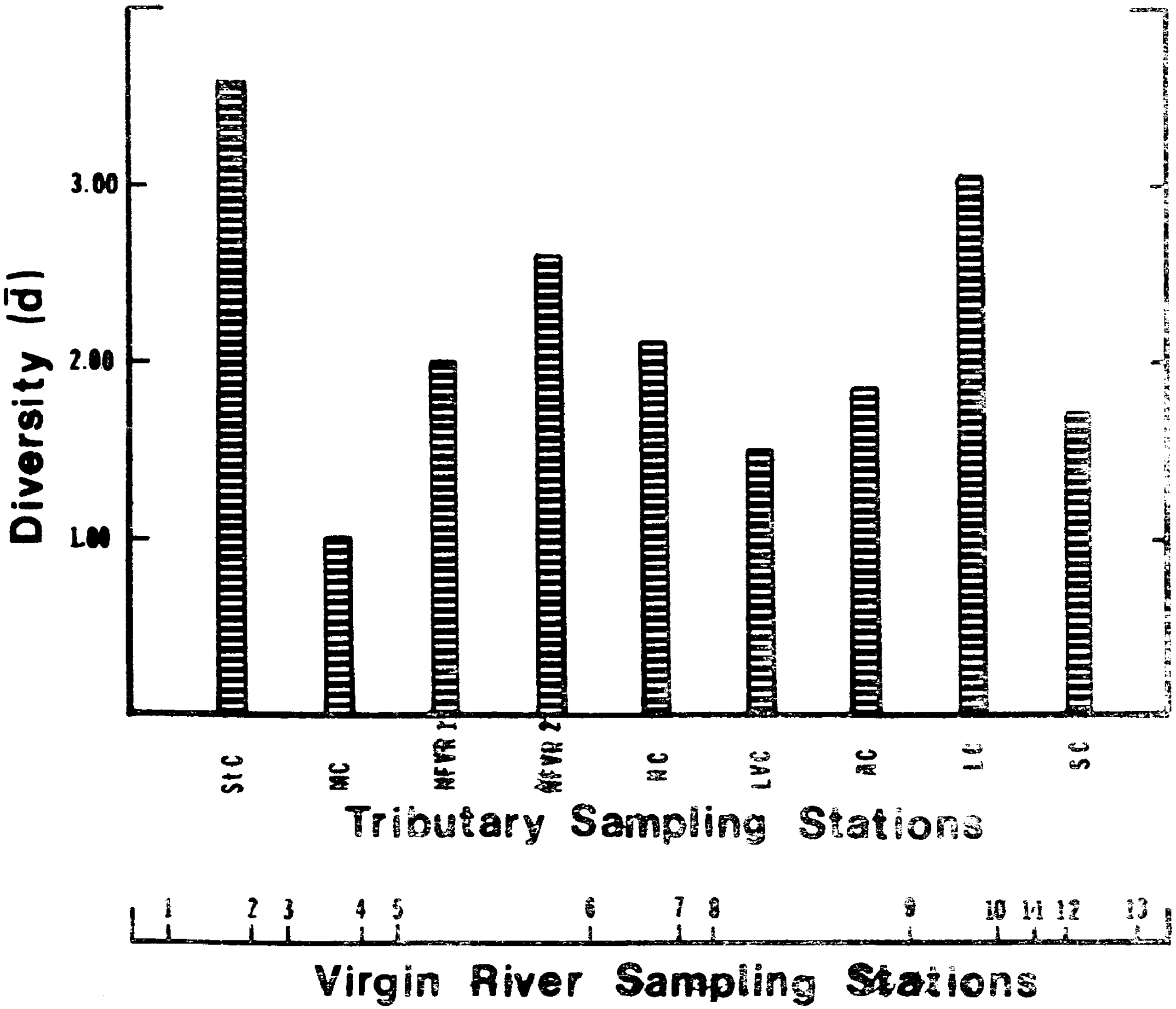

Fig. 20 Mean diversity of benthic invertebrates collected at sampling stations on tributaries to the Virgin River, Alton to St. George, Utah.

Table 9 A comparison of the results of benthic macroinvertebrate surveys on the Virgin River conducted by the Utah Water Research Laboratory and EPA, Region VIII

Comparative Stations[1]		# Organisms/ft^2		Diversity		# Taxa	
EPA	Utah	EPA	Utah	EPA	Utah	EPA	Utah
VR1/VR2	201	1630/246	1365	1.83/2.65	2.47	35/30	32
NFVR-1	204	163	313	2.00	1.91	19	11
NFVR-2	206	1201	287	2.60	1.17	32	12
VR-5	206B	160	421	0.73	0.96	17	13
VR-8	209	173	30	2.08	0.84	16	4
VR-7	209A	245	9	0.90	1.28	24	4
VR-10	210	132	105	1.27	1.60	18	14
VR-13[2]	212	Q	1128	Q	1.32	6	23

1 EPA Station VR-7 and Utah WRL Station 209A are not as close in geographical proximity as desired but represent best match available. Also, EPA/VR-13 is approximately 4-5 miles downstream from corresponding Station Utah/212.

2 Only qualitative samples were collected at Station VR-13.

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Appendix A

Physical and Chemical Water Quality Data

VIRGIN RIVER STUDY

Station No. KC-1

Parameter	Units	3/10/76	3/11/76	3/12/76
Time	Mtly	0950	0940	0930
Temperature	Cent	-3	-3.0	-4
pH	SU	7.6	7.6	7.85
Flow	cms	*	0.108	**
DO	mg/l	11.1	11.0	11.4
Conductivity	µmhos/cm	900	850	1200
Turbidity	FTU	175	230	71
TDS	mg/l	596	616	874
TSS	mg/l	650	662	186
Chloride	mg/l	15	10	14
Tot. Fluoride	mg/l	0.24	0.26	0.26
Sulfate	mg/l	163	188	269
Tot. Arsenic	µg/l	5	10	<5
Diss. Arsenic	µg/l	-	-	<5
Tot. Iron	µg/l	11400	15300	3200
Diss. Iron	µg/l	-	-	20
Tot. Lead	µg/l	15	15	5
Diss. Lead	µg/l	-	-	<5
Tot. Manganese	µg/l	205	255	90
Diss. Manganese	µg/l	-	-	50
Tot. Mercury	µg/l	1.6	0.4	0.2
Diss. Mercury	µg/l	-	-	<0.2
Tot. Molydenum	µg/l	<10	<10	<10
Diss. Molybdenum	µg/l	-	-	<10
Tot. Selenium	µg/l	<5	5	<5
Diss. Selenium	µg/l	-	-	<5

* Similar to flow on 3/11/76 as determined by water level measurement.
** Flow measurement impossible due to ice condition.

VIRGIN RIVER STUDY

Station No. KC-3

Parameter	Units	3/10/76	3/11/76	3/12/76
Time	Mtly	1425	1450	1410
Temperature	Cent	7.0	8.0	8
pH	SU	8.3	8.1	8.05
Flow	cms	*	0.388	0.238
DO	mg/l	9.7	8.7	9.0
Conductivity	µmhos/cm	1000	1050	860
Turbidity	FTU	1480	1440	960
TDS	mg/l	708	766	2090
TSS	mg/l	8820	8270	1920
Chloride	mg/l	28	14	12
Tot. Fluoride	mg/l	0.33	0.31	0.30
Sulfate	mg/l	338	400	238
Tot. Arsenic	µg/l	160	120	45
Diss. Arsenic	µg/l	-	-	<5
Tot. Iron	µg/l	149000	145000	51300
Diss. Iron	µg/l	-	-	10
Tot. Lead	µg/l	125	110	50
Diss. Lead	µg/l	-	-	<5
Tot. Manganese	µg/l	2700	2700	980
Diss. Manganese	µg/l	-	-	5
Tot. Mercury	µg/l	0.9	0.8	1.0
Diss. Mercury	µg/l	-	-	0.3
Tot. Molydenum	µg/l	10	10	<10
Diss. Molybdenum	µg/l	-	-	<10
Tot. Selenium	µg/l	<5	5	<5
Diss. Selenium	µg/l	-	-	<5

* Similar to flow on 3/11/76 as determined by water level measurement.

VIRGIN RIVER STUDY

Station No. VR-1

Parameter	Units	3/10/76	3/11/76	3/12/76
Time	Mtly	1017	1025	1010
Temperature	Cent	5.5	3	4
pH	SU	7.6	7.3	7.65
Flow	cms	*	0.034	0.028
DO	mg/l	9.5	9.3	9.4
Conductivity	μmhos/cm	540	530	540
Turbidity	FTU	1.9	2.0	3.5
TDS	mg/l	274	282	306
TSS	mg/l	4.0	2.5	5.6
Chloride	mg/l	9	8	7
Tot. Fluoride	mg/l	0.50	0.53	0.53
Sulfate	mg/l	5	2.5	5
Tot. Arsenic	μg/l	<5	6	5
Diss. Arsenic	μg/l	-	-	<5
Tot. Iron	μg/l	200	300	400
Diss. Iron	μg/l	-	-	10
Tot. Lead	μg/l	5	<5	<5
Diss. Lead	μg/l	-	-	<5
Tot. Manganese	μg/l	30	30	30 (25)**
Diss. Manganese	μg/l	-	-	30 (20)**
Tot. Mercury	μg/l	0.7	0.5	0.3
Diss. Mercury	μg/l	-	-	0.3
Tot. Molybdenum	μg/l	<10	<10	<10
Diss. Molybdenum	μg/l	-	-	<10
Tot. Selenium	μg/l	<5	<5	<5
Diss. Selenium	μg/l	-	-	<5

* Similar to flow on 3/11/76 as determined by water level measurement.
** Duplicate analysis

Station No. StC-1

Parameter	Units	3/10/76	3/11/76	3/12/76
Time	Mtly	1035	1055	1050
Temperature	Cent	2.0	-0.5	0.5
pH	SU	7.85	7.8	8.0
Flow	cms	*	0.258	0.173
DO	mg/l	10.4	10.4	10.8
Conductivity	μmhos/cm	550	530	530
Turbidity	FTU	2.2	2.6	1.9
TDS	mg/l	314	336	368
TSS	mg/l	1.5	4.5	6.5
Chloride	mg/l	7	6	4
Tot. Fluoride	mg/l	0.28	0.35	0.32
Sulfate	mg/l	20	23	25
Tot. Arsenic	μg/l	<5	5	<5
Tot. Iron	μg/l	200	300	300
Tot. Lead	μg/l	10	10	<5
Tot. Manganes	μg/l	15	15	10
Tot. Mercury	μg/l	0.5	0.7	<0.2
Tot. Molybdenum	μg/l	<10	<10	10
Tot. Selenium	μg/l	<5	<5	<5

* Similar to flow on 3/11/76 as determined by water level measurement.

Station No. LyC-1

Parameter	Units	3/10/76	3/11/76	3/12/76
Time	Mtly	1055	1120	1110
Temperature	Cent	2.0	0.0	1.0
pH	SU	7.85	7.7	7.85
Flow	cms	*	0.093	0.048
DO	mg/l	10.0	10.6	10.5
Conductivity	µmhos/cm	700	640	710
Turbidity	FTU	26	26	22
TDS	mg/l	384	416	408
TSS	mg/l	46	42	35
Chloride	mg/l	11	6	11
Tot. Fluoride	mg/l	0.62	0.52	0.67
Sulfate	mg/l	51	50	55
Tot. Arsenic	µg/l	<5	<5	<5
Tot. Iron	µg/l	2000	1800	1600
Tot. Lead	µg/l	<5	15	<5
Tot. Manganese	µg/l	175	160	225
Tot. Mercury	µg/l	0.6	1.0	0.3
Tot. Molybdenum	µg/l	<10	<10	<10
Tot. Selenium	µg/l	<5	<5	<5

* Similar to flow on 3/11/76 as determined by water level measurement.

VIRGIN RIVER STUDY

Station No. VR-2

Parameter	Units	3/10/76	3/11/76	3/12/76
Time	Mtly	1110	1150	1125
Temperature	Cent	2.0	1.0	0
pH	SU	8.1	7.8	8.0
Flow	cms	*	0.549	0.419
DO	mg/l	10.3	10.5	10.9
Conductivity	μmhos/cm	580	560	580
Turbidity	FTU	5.2	5.7	4.4
TDS	mg/l	318	378	376
TSS	mg/l	12	16	9.5
Chloride	mg/l	8	9	9
Tot. Fluoride	mg/l	0.46	0.47	0.49
Sulfate	mg/l	24	25	21
Tot. Arsenic	μg/l	<5	<5	<5
Diss. Arsenic	μg/l	-	-	<5
Tot. Iron	μg/l	700	700	600
Diss. Iron	μg/l	-	-	20
Tot. Lead	μg/l	<5	<5	<5
Diss. Lead	μg/l	-	-	<5
Tot. Manganese	μg/l	45	45	60
Diss. Manganese	μg/l	-	-	35
Tot. Mercury	μg/l	0.4	1.3	0.2
Diss. Mercury	μg/l	-	-	<0.2
Tot. Molydenum	μg/l	<10	<10	<10
Diss. Molybdenum	μg/l	-	-	<10
Tot. Selenium	μg/l	<5	<5	<5
Diss. Selenium	μg/l	-	-	<5

* Similar to flow on 3/11/76 as determined by water level measurement.

VIRGIN RIVER STUDY

Station No. VR-3

Parameter	Units	3/10/76	3/11/76	3/12/76
Time	Mtly	1205	1315	1245
Temperature	Cent	4.5	2.5	3
pH	SU	8.15	8.1	8
Flow	cms	*	0.538	0.42
DO	mg/l	10.0	10.4	7.3
Conductivity	µmhos/cm	650	625	680
Turbidity	FTU	18	9.5	9.6
TDS	mg/l	308	394	432
TSS	mg/l	30	28	41
Chloride	mg/l	9	6	14
Tot. Fluoride	mg/l	0.50	0.46	0.49
Sulfate	mg/l	45	40	56
Tot. Arsenic	µg/l	<5	<5	<5
Tot. Iron	µg/l	1000	1200	1200
Tot. Lead	µg/l	<5	<5	<5
Tot. Manganese	µg/l	60	60	60
Tot. Mercury	µg/l	0.3	0.3	0.2
Tot. Molybdenum	µg/l	<10	<10	<10
Tot. Selenium	µg/l	<5	5	<5

* Similar to flow on 3/11/76 as determined by water level measurements.

VIRGIN RIVER STUDY

Station No. MC-1

Parameter	Units	3/10/76	3/11/76	3/12/76
Time	Mtly	1255	1340	1310
Temperature	Cent	10.0	5.5	8
pH	SU	8.1	8.05	7.9
Flow	cms	-	0.051	0.011
DO	mg/l	8.6	9.7	9.1
Conductivity	μmhos/cm	1600	1400	2200
Turbidity	FTU	240	240	68
TDS	mg/l	1150	1050	1760
TSS	mg/l	715	210	849
Chloride	mg/l	15	14	11
Tot. Fluoride	mg/l	0.37	0.33	0.30
Sulfate	mg/l	575	513	950
Tot. Arsenic	μg/l	7	12	<5
Tot. Iron	μg/l	15400	18000	2800
Tot. Lead	μg/l	15	15	5
Tot. Manganese	μg/l	335	385	110
Tot. Mercury	μg/l	1.0	1.1	0.9
Tot. Molybdenum	μg/l	<10	<10	<10
Tot. Selenium	μg/l	<5	<5	<5

VIRGIN RIVER STUDY

Station No. VR-4

Parameter	Units	3/10/76	3/11/76	3/12/76
Time	Mtly	1310	1415	1330
Temperature	Cent	7.5	6.0	6
pH	SU	8.25	8.2	8
Flow	cms	*	0.612	0.575
DO	mg/l	9.0	9.8	10.0
Conductivity	μmhos/cm	750	700	725
Turbidity	FTU	46	70	44
TDS	mg/l	514	496	460
TSS	mg/l	94	150	145
Chloride	mg/l	7	11	10
Tot. Fluoride	mg/l	0.46	0.46	0.48
Sulfate	mg/l	103	113	75
Tot. Arsenic	μg/l	<5	<5	<5
Diss. Arsenic	μg/l	-	-	<5
Tot. Iron	μg/l	2300	3500	2500
Diss. Iron	μg/l	-	-	10
Tot. Lead	μg/l	<5	10	20
Diss. Lead	μg/l	-	-	<5
Tot. Manganese	μg/l	75	110	85
Diss. Manganese	μg/l	-	-	15
Tot. Mercury	μg/l	0.3	0.7	0.3
Diss. Mercury	μg/l	-	-	0.3
Tot. Molydenum	μg/l	<10	<10	<10
Diss. Molybdenum	μg/l	-	-	<10
Tot. Selenium	μg/l	<5	<5	<5
Diss. Selenium	μg/l	-	-	<5

* Similar to flow on 3/12/76 as determined by water level measurements.

VIRGIN RIVER STUDY

Station No. NFVR-1

Parameter	Units	3/13/76	3/14/76	3/15/76
Time	Mtly	0820	0810	0830
Temperature	Cent	0	1.0	2
pH	SU	7.9	8.05	8.0
Flow **	cms	1.58	1.50	*
DO	mg/ℓ	11.9	11.4	11.4
Conductivity	µmhos/cm	900	900	950
Turbidity	FTU	110	115	34
TDS	mg/ℓ	528	518	382
TSS	mg/ℓ	234	226	69
Chloride	mg/ℓ	86	69	83
Tot. Fluoride	mg/ℓ	0.18	0.19	0.18
Sulfate	mg/ℓ	93	98	110
Tot. Arsenic	µg/ℓ	<5	<5	<5
Diss. Arsenic	µg/ℓ	<5	-	-
Tot. Iron	µg/ℓ	4200	4400	1500
Diss. Iron	µg/ℓ	20	-	-
Tot. Lead	µg/ℓ	<5	<5	<5
Diss. Lead	µg/ℓ	<5	-	-
Tot. Manganese	µg/ℓ	120	110	55
Diss. Manganese	µg/ℓ	15	-	-
Tot. Mercury	µg/ℓ	0.3	4.4	2.6
Diss. Mercury	µg/ℓ	<0.2	-	-
Tot. Molybdenum	µg/ℓ	<10	<10	<10
Diss. Molybdenum	µg/ℓ	<10	-	-
Tot. Selenium	µg/ℓ	<5	< 5	<5
Diss. Selenium	µg/ℓ	<5	-	-

* Similar to flow on 3/14/76 as determined by water level measurements.

** These flows are approximately 0.85 CMS (30 cfs) less than the USGS preliminary flows reported at Station 9405500 near Springdale because the USGS flow rates include the flow in the Springdale Canal whereas the EPA flow rates do not.

VIRGIN RIVER STUDY

Station No. VR-5

Parameter	Units	3/13/76	3/14/76	3/15/76
Time	Mtly	0840	0825	0840
Temperature	Cent	1.0	1.5	3
pH	SU	7.9	7.8	7.95
Flow	cms	1.56	*	2.15
DO	mg/ℓ	11.5	11.3	10.8
Conductivity	µmhos/cm	620	630	650
Turbidity	FTU	53	62	51
TDS	mg/ℓ	416	422	380
TSS	mg/ℓ	82	139	130
Chloride	mg/ℓ	22	24	22
Tot. Flouride	mg/ℓ	0.28	0.28	0.29
Sulfate	mg/ℓ	95	105	75
Tot. Arsenic	µg/ℓ	<5	<5	<5
Diss. Arsenic	µg/ℓ	<5	-	-
Tot. Iron	µg/ℓ	2600	2900	2700
Diss. Iron	µg/ℓ	<10	-	-
Tot. Lead	µg/ℓ	<5	<5	10
Diss. Lead	µg/ℓ	<5	-	-
Tot. Manganese	µg/ℓ	115	95	65
Diss. Manganese	µg/ℓ	<5	-	-
Tot. Mercury	µg/ℓ	0.3	2.5	2.0
Diss. Mercury	µg/ℓ	<0.2	-	-
Tot. Molybdenum	µg/ℓ	<10	<10	<10
Diss. Molybdenum	µg/ℓ	<10	-	-
Tot. Selenium	µg/ℓ	<5	<5	<5
Diss. Selenium	µg/ℓ	<5	-	-

* Similar to flow on 3/13/76 as determined by water level measurements.

VIRGIN RIVER STUDY

Station No. NC-1

Parameter	Units	3/13/76	3/14/76	3/15/76
Time	Mtly	0930	0850	0920
Temperature	Cent	0	1.0	2
pH	SU	7.65	7.8	7.75
Flow	cms	0.108	0.176	0.105
DO	mg/ℓ	12.1	11.4	11.3
Conductivity	µmhos/cm	1050	950	1200
Turbidity	FTU	0.9	72	1.1
TDS	mg/ℓ	732	592	830
TSS	mg/ℓ	2.8	208	18
Chloride	mg/ℓ	42	61	41
Tot. Flouride	mg/ℓ	0.15	0.28	0.17
Sulfate	mg/ℓ	344	190	390
Tot. Arsenic	µg/ℓ	<5	<5	<5
Tot. Iron	µg/ℓ	170	3800	240
Tot. Lead	µg/ℓ	5	5	5
Tot. Manganese	µg/ℓ	60	190	70
Tot. Mercury	µg/ℓ	0.5	3.9	1.4
Tot. Molybdenum	µg/ℓ	<10	<10	<10
Tot. Selenium	µg/ℓ	< 5	<5	<5

* Includes 0.068 cms (2.4 cfs) irrigation return flow on 3/14/76 only.

VIRGIN RIVER STUDY

Station No. VR-7

Parameter	Units	3/13/76	3/14/76	3/15/76
Time	Mtly	1010	0910	0940
Temperature	Cent	1.5	1.5	3
pH	SU	7.85	7.85	7.85
Flow	cms	*	*	*
DO	mg/ℓ	11.8	11.5	11.1
Conductivity	μmhos/cm	920	960	900
Turbidity	FTU	52	67	46
TDS	mg/ℓ	496	576	850
TSS	mg/ℓ	92	147	134
Chloride	mg/ℓ	72	80	60
Tot. Flouride	mg/ℓ	0.22	0.23	0.23
Sulfate	mg/ℓ	153	194	175
Tot. Arsenic	μg/ℓ	<5	<5	5
Tot. Iron	μg/ℓ	2100	3200	2200
Tot. Lead	μg/ℓ	<5	<5	<5
Tot. Manganese	μg/ℓ	95	115	70
Tot. Mercury	μg/ℓ	0.8	3.4	2.6
Tot. Molybdenum	μg/ℓ	<10	<10	<10
Tot. Selenium	μg/ℓ	<5	<5	<5

* No flow measurement possible at this location.
USGS gaging station located approximately ¼ mile downstream has been discontinued.

VIRGIN RIVER STUDY

Station No. VR-8

Parameter	Units	3/13/76	3/14/76	3/15/76
Time	Mtly	1115	1005	1030
Temperature	Cent	6	7	7
pH	SU	6.95	6.95	7.05
Flow	cms	1.76	1.78	2.44
DO	mg/ℓ	9.8	9.5	9.9
Conductivity	μmhos/cm	3000	3000	2300
Turbidity	FTU	86	83	115
TDS	mg/ℓ	1670	1750	2080
TSS	mg/ℓ	140	204	294
Chloride	mg/ℓ	454	438	316
Tot. Flouride	mg/ℓ	0.54	0.59	0.46
Sulfate	mg/ℓ	381	450	325
Tot. Arsenic	μg/ℓ	28	34	22
Diss. Arsenic	μg/ℓ	26	-	-
Tot. Iron	μg/ℓ	2200	4200	7100
Diss. Iron	μg/ℓ	70	-	-
Tot. Lead	μg/ℓ	5	<5	<5
Diss. Lead	μg/ℓ	<5	-	-
Tot. Manganese	μg/ℓ	260	160	255
Diss. Manganese	μg/ℓ	45	-	-
Tot. Mercury	μg/ℓ	0.3	2.4	2.0
Diss. Mercury	μg/ℓ	<0.2	-	-
Tot. Molybdenum	μg/ℓ	<10	<10	<10
Diss. Molybdenum	μg/ℓ	<10	-	-
Tot. Selenium	μg/ℓ	< 5	<5	<5
Diss. Selenium	μg/ℓ	< 5	-	-

VIRGIN RIVER STUDY

Station No. LVC-1

Parameter	Units	3/13/76	3/14/76	3/15/76
Time	Mtly	1030	0930	1000
Temperature	Cent	1.5	1.5	4
pH	SU	7.75	7.75	7.75
Flow	cms	0.133	0.187	0.158
DO	mg/ℓ	12.1	11.6	11.3
Conductivity	μmhos/cm	1150	1200	1200
Turbidity	FTU	68	110	175
TDS	mg/ℓ	790	816	770
TSS	mg/ℓ	119	198	326
Chloride	mg/ℓ	17	17	20
Tot. Flouride	mg/ℓ	0.24	0.20	0.22
Sulfate	mg/ℓ	394	432	481
Tot. Arsenic	μg/ℓ	<5	<5	<5
Tot. Iron	μg/ℓ	3100	4600	2500
Tot. Lead	μg/ℓ	<5	10	5
Tot. Manganese	μg/ℓ	65	85	110
Tot. Mercury	μg/ℓ	<0.2	11	3.2
Tot. Molybdenum	μg/ℓ	<10	<10	<10
Tot. Selenium	μg/ℓ	<5	<5	<5

VIRGIN RIVER STUDY

Station No. AC-1

Parameter	Units	3/13/76	3/14/76	3/15/76
Time	Mtly	1050	0945	1015
Temperature	Cent	10	8	No Flow
pH	SU	8.05	7.95	
Flow	cms	0.031	*	
DO	mg/ℓ	10.0	10.4	
Conductivity	μmhos/cm	760	750	
Turbidity	FTU	1.0	1.0	
TDS	mg/ℓ	512	540	
TSS	mg/ℓ	3.6	2.8	
Chloride	mg/ℓ	24	20	
Tot. Flouride	mg/ℓ	0.17	0.16	
Sulfate	mg/ℓ	172	156	
Tot. Arsenic	μg/ℓ	<5	<5	
Tot. Iron	μg/ℓ	100	120	
Tot. Lead	μg/ℓ	<5	5	
Tot. Manganese	μg/ℓ	5	5	
Tot. Mercury	μg/ℓ	0.2	1.5	
Tot. Molybdenum	μg/ℓ	<10	<10	
Tot. Selenium	μg/ℓ	<5	<5	

*Similar to flow on 3/13/76 as determined by water level measurements.

Station No. LC-1

Parameter	Units	3/13/76	3/14/76	3/15/76
Time	Mtly	1300	1105	1145
Temperature	Cent	8	6.5	8.5
pH	SU	8.25	8.05	8.15
Flow	cms	0.020	0.023	*
DO	mg/ℓ	10.6	10.9	10.3
Conductivity	μmhos/cm	1400	1450	1400
Turbidity	FTU	3.2	2.9	8.6
TDS	mg/ℓ	958	1030	796
TSS	mg/ℓ	8.8	10	30
Chloride	mg/ℓ	27	25	23
Tot. Flouride	mg/ℓ	-	0.42	0.45
Sulfate	mg/ℓ	413	438	265
Tot. Arsenic	μg/ℓ	<5	5	7
Tot. Iron	μg/ℓ	200	200	400
Tot. Lead	μg/ℓ	<5	<5	<5
Tot. Manganese	μg/ℓ	60	60	35
Tot. Mercury	μg/ℓ	0.3	1.9	2.1
Tot. Molybdenum	μg/ℓ	10	<10	10
Tot. Selenium	μg/ℓ	<5	<5	<5

*Similar to flow on 3/14/76 as determined by water level measurements.

Station No. VR-10

Parameter	Units	3/13/76	3/14/76	3/15/76
Time	Mtly	1235	1045	1130
Temperature	Cent	9	7	8.5
pH	SU	7.9	7.85	7.7
Flow	cms	*	*	*
DO	mg/ℓ	10.1	10.2	10.0
Conductivity	μmhos/cm	2300	2700	2500
Turbidity	FTU	73	125	125
TDS	mg/ℓ	1380	1590	2040
TSS	mg/ℓ	226	216	296
Chloride	mg/ℓ	308	338	342
Tot. Flouride	mg/ℓ	0.41	0.52	0.47
Sulfate	mg/ℓ	344	413	344
Tot. Arsenic	μg/ℓ	15	23	20
Tot. Iron	μg/ℓ	3300	5400	6800
Tot. Lead	μg/ℓ	<5	<5	<5
Tot. Manganese	μg/ℓ	125	140	125
Tot. Mercury	μg/ℓ	0.3	2.1	3.7
Tot. Molybdenum	μg/ℓ	<10	<10	<10
Tot. Selenium	μg/ℓ	<5	<5	<5

* No data - USGS stream flow data and gaging equipment stolen from site.

VIRGIN RIVER STUDY

Station No. VR-11

Parameter	Units	3/13/76	3/14/76	3/15/76
Time	Mtly	1345	1135	0735
Temperature	Cent	9	8	3
pH	SU	8.05	7.75	8.05
Flow	cms	*	*	*
DO	mg/ℓ	10.2	10.5	10.7
Conductivity	μmhos/cm	2200	2500	2500
Turbidity	FTU	98	140	77
TDS	mg/ℓ	1280	1510	418
TSS	mg/ℓ	208	290	177
Chloride	mg/ℓ	286	313	389
Tot. Flouride	mg/ℓ	0.42	0.47	0.46
Sulfate	mg/ℓ	363	413	400
Totl Arsenic	μg/ℓ	17	22	20
Tot. Iron	μg/ℓ	3700	6800	3100
Tot. Lead	μg/ℓ	<5	<5	<5
Tot. Manganese	μg/ℓ	135	175	95
Tot. Mercury	μg/ℓ	0.3	2.6	2.4
Tot. Molybdenum	μg/ℓ	<10	<10	<10
Tot. Selenium	μg/ℓ	<5	<5	<5

* Flow measurement impossible at this location.

VIRGIN RIVER STUDY

Station No. VR-12

Parameter	Units	3/13/76	3/14/76	3/15/76
Time	Mtly	1415	1200	1220
Temperature	Cent	10	8.5	10
pH	SU	8.0	7.8	7.85
Flow	cms	4.39	3.28	*
DO	mg/ℓ	9.9	10.3	9.8
Conductivity	μmhos/cm	2300	2700	2500
Turbidity	FTU	99	95	93
TDS	mg/ℓ	1470	1610	852
TSS	mg/ℓ	190	194	198
Chloride	mg/ℓ	289	351	320
Tot. Flouride	mg/ℓ	0.46	0.48	0.48
Sulfate	mg/ℓ	488	500	475
Tot. Arsenic	μg/ℓ	15	14	17
Diss. Arsenic	μg/ℓ	14	-	-
Tot. Iron	μg/ℓ	4600	3400	3500
Diss. Iron	μg/ℓ	<10	-	-
Tot. Lead	μg/ℓ	<5	<5	<5
Diss. Lead	μg/ℓ	< 5	-	-
Tot. Manganese	μg/ℓ	245	205	170
Diss. Manganese	μg/ℓ	55	-	-
Tot. Mercury	μg/ℓ	0.4	8.9	3.0
Diss. Mercury	μg/ℓ	<0.2	-	-
Tot. Molybdenum	μg/ℓ	<10	<10	<10
Diss. Molybdenum	μg/ℓ	<10	-	-
Tot. Selenium	μg/ℓ	<5	<5	<5
Diss. Selenium	μg/ℓ	<5	-	-

*Similar to flow on 3/14/76 as determined by water level measurements.

VIRGIN RIVER STUDY

Station No. SC-1

Parameter	Units	3/13/76	3/14/76	3/15/76
Time	Mtly	1450	1230	1235
Temperature	Cent	12	9.5	11
pH	SU	7.85	7.8	7.75
Flow	cms	0.082	*	*
DO	mg/ℓ	12.1	12.5	12.6
Conductivity	μmhos/cm	2600	2800	2800
Turbidity	FTU	9.1	6.1	5.1
TDS	mg/ℓ	2080	2120	1950
TSS	mg/ℓ	50	36	31
Chloride	mg/ℓ	90	83	78
Tot. Flouride	mg/ℓ	0.44	0.40	0.35
Sulfate	mg/ℓ	863	963	875
Tot. Arsenic	μg/ℓ	5	5	5
Diss. Arsenic	μg/ℓ	5	-	-
Tot. Iron	μg/ℓ	1100	700	800
Diss. Iron	μg/ℓ	20	-	-
Tot. Lead	μg/ℓ	<5	<5	<5
Diss. Lead	μg/ℓ	<5	-	-
Tot. Manganese	μg/ℓ	665	725	690
Diss. Manganese	μg/ℓ	535	-	-
Tot. Mercury	μg/ℓ	0.3	2.9	1.6
Diss. Mercury	μg/ℓ	<0.2	-	-
Tot. Molybdenum	μg/ℓ	<10	<10	<10
Diss. Molybdenum	μg/ℓ	10	-	-
Tot. Selenium	μg/ℓ	<5	<5	<5
Diss. Selenium	μg/ℓ	<5	-	-

*Similar to flow on 3/13/76 as determined by water level measurements.

Station No. SC-2

Parameter	Units	3/13/76	3/14/76	3/15/76
Time	Mtly	1510	No Sample	No Sample
Temperature	Cent	15		
pH	SU	7.7		
Flow	cms	*		
DO	mg/ℓ	6.4		
Conductivity	μmhos/cm	3000		
Turbidity	FTU	32		
TDS	mg/ℓ	2120		
TSS	mg/ℓ	48		
Chloride	mg/ℓ	168		
Tot. Flouride	mg/ℓ	1.60		
Sulfate	mg/ℓ	963		
Tot. Arsenic	μg/ℓ	27		
Tot. Iron	μg/ℓ	1400		
Tot. Lead	μg/ℓ	<5		
Tot. Manganese	μg/ℓ	85		
Tot. Mercury	μg/ℓ	7.0		
Tot. Molybdenum	μg/ℓ	<10		
Tot. Selenium	μg/ℓ	<5		

* No flow measurement made.

Appendix B

Benthic Data

Virgin River, Utah Study

Benthic Data - Number per ft[2]

	VR-1	VR-2	VR-3	VR-4
Trichoptera				
Hydropsychidae				
Hydropsyche sp.	10/ 0/ 13/ 7	18/ 5/ 11/ 23	0/ 0/ 1/ 1	
Hydroptilidae	0/ 0/ 1/ 0			
Agraylea sp.	4/ 5/ 2/ 7			
Orthotrichia sp.				
Ochrotrichia sp.				
Leptoceridae				
Oecetis sp.				
Leptocella sp.	1/ 0/ 0/ 0			
Leptocerus sp.				
Limnophilidae				
Limnophilus sp.	2/ 1/ 0/ 7			
Brachycentridae				
Brachycentrus sp.	4/ 3/ 6/ 10	21/ 3/ 2/ 87	0/ 0/ 1/ 0	
Micrasema sp.				
Philoptomaidae				
Chimarra sp.				
Helicopsychidae				
Helicopsyche sp.				
Plecoptera				
Chloroperlidae				
Alloperla sp.			1/ 0/ 0/ 0	
Nemouridae				
Eucapnopsis sp.				
Brachyptera sp.				
Perlodidae				
Isogenus sp.				
Pteronarcidae				
Pteronarcella sp.				
Ephemoptera				
Baetidae				
Tricorythodes sp.		4/ 0/ 0/ 5		
Paraleptophlebia sp.	0/ 3/ 10/ 6	2/ 1/ 0/ 0		
Baetis sp.	532/ 912/1023/1012	78/ 37/ 65/ 188	136/ 150/ 88/ 166	11/ 19/ 11/ 5
Ephemerella sp.	1/ 1/ 1/ 1	67/ 22/ 40/ 128	1/ 0/ 0/ 4	
Heptagenidae				
Heptagenia sp.		4/ 0/ 3/ 0		
Iron sp.		2/ 0/ 1/ 3		
Ironodes sp.		0/ 0/ 0/ 1		
Megaloptera				
Corydaldae				
Corydalus sp.				

Note: Slash lines (/) are used only to separate numbers.

Virgin River, Utah, Study
Benthic Data - Number per ft^2

	VR-1	VR-2	VR-3	VR-4
Diptera				
Chironomidae				
Chironominae				
Parachironomus sp.				3/ 0/ 0/ 0
Cryptochironomus sp.		0/ 0/ 0/ 12		
Pseudochironomus sp.				
Glyptotendipes sp.				
Micropsectra sp.	5/ 5/ 0/ 10	0/ 0/ 0/ 14		
Paratendipes sp.				
Polypedilum sp.	0/ 2/ 0/ 10			
Rheotanytarsus sp.				
Tribelos sp.			1/ 2/ 0/ 1	1/ 1/ 0/ 0
Tanytarsus sp.	0/ 2/ 10/ 10	15/ 3/ 4/ 0		
Paratanytarsus sp.				
Phaenopsectra sp.				
Tanypodinae				
Clinotanypus sp.				
Psectrotanypus sp.				
Nilotanypus sp.				
Ablabesmyia sp.	0/ 0/ 0/ 5			
Procladius sp.	0/ 2/ 0/ 0			
Conchapelopia sp.	5/ 7/ 25/ 0	0/ 0/ 0/ 1	1/ 0/ 0/ 1	
Diamesinae				
Diamesa sp.				
Pseudodiamesa sp.	122/ 0/ 46/ 35			
Orthocladiinae				
Orthocladius sp.	0/ 3/ 0/ 5	0/ 0/ 2/ 0		1/ 1/ 0/ 1
Cardiocladius sp.	0/ 0/ 0/ 5			
Cricotopus sp.	5/ 2/ 0/ 0			
Eukiefferiella sp.	25/ 0/ 80/ 35	2/ 5/ 2/ 4	1/ 0/ 3/	2/ 0/ 0/ 0
Heterotrissocladius sp.	0/ 0/ 1/ 0		0/ 0/ 1/ 0	
Metriocnemus sp.				
Parametriochnemus sp.		0/ 0/ 0/ 1	1/ 2/ 0/ 0	0/ 0/ 0/ 1
Pseudosmittia sp.		2/ 0/ 0/ 0		
Smittia sp.	0/ 0/ 5/ 0	9/ 2/ 2/ 7	0/ 0/ 0/ 2	
Thienemanniella sp.	1/ 5/ 0/ 0	1/ 1/ 0/ 0	0/ 0/ 1/ 0	
Trichlocladius sp.	0/ 5/ 3/ 0		1/ 0/ 0/ 0	
Brillia sp.				
Trissocladius sp.			1/ 0/ 0/ 0	
Ceratopogonidae				
Bezzia sp.		0/ 0/ 0/1	0/ 0/ 1/ 0	
Heleidae				
Forcypomyia sp.				
Tipulidae				
Tipula sp.	0/ 3/ 4/ 8	1/ 1/ 0/ 3		
Dicronota sp.	0/ 7/ 16/ 9	16/ 2/ 6/ 4		0/ 1/ 0/ 0
Limnophila sp.		0/ 0/ 2/ 4		
Antocha sp.		0/ 0/ 3/ 1		
Rhagionidae				
Atherix sp.				
Dixidae				
Paradixa sp.	0/ 0/ 0/ 1			
Tabanidae				
Muscidae				
Simuliidae				
Simulium sp.	348/ 148/ 843/ 778	0/ 0/ 1/ 0	28/ 36/ 3/ 61	0/ 0/ 1/ 0
Stratiomyiidae				1/ 0/ 0/ 0
Empididae				
Psychodidae				
Psychoda sp.				
Ephydridae				

Note: Slash lines (/) are used only to separate numbers

Virgin River, Utah, Study
Benthic Data - Number per ft^2

	VR-1	VR-2	VR-3	VR-4
Coleoptera				
Elmidae				
Microcylloepus sp.				
Optioservus sp.	34/ 26/ 83/ 44			
Zaitzevia sp.	4/ 1/ 0/ 1			
Heterelmis sp.				
Stenelmis sp.				
Curculionidae				
Dyticidae				
Agabus sp.				
Rhantus sp.				
Amphipoda				
Hyalella sp.				
Ostracoda				
Hemiptera				
Naucoridae				
Ambrysus sp.				
Lepidoptera				
Collembola	0/ 0/ 2/ 0	0/ 0/ 1/ 0	1/ 0/ 0/ 0	0/ 0/ 0/ 1
Hydracarina	2/ 5/ 3/ 5			
Zygoptera				
Coenagrionidae		0/ 0/ 1/ 0		
Anisoptera				
Gomphidae				
Octogomphus sp.				
Isopoda				
Annelida				
Oligochaeta	0/ 6/ 37/ 0	6/ 0/ 18/ 0	6/ 52/ 4/ 0	33/ 6/ 0/ 4
Gastropoda	0/ 15/ 0/ 0	0/ 0/ 0/ 3		
Pelecypoda	0/ 56/ 0/ 10	0/ 0/ 0/ 3		

Note: Slash lines (/) are used only to separate numbers.

Virgin River, Utah, Study
Benthic Data - Number per ft^2

	VR-5	VR-6	VR-7	VR-8
Trichoptera				
Hydropsychidae				
Hydropsyche sp.	3/ 5/ 1/ 2	4/ 0/ 0/ 4	1/ 0/ 2/ 0	1/ 1/ 0/ 0
Hydroptilidae				
Agraylea sp.	0/ 0/ 1/ 0			
Orthotrichia sp.			0/ 0/ 0/ 1	
Ochrotrichia sp.				
Leptoceridae				
Oecetis sp.				
Leptocella sp.				
Leptocerus sp.				
Limnophilidae				
Limnophilus sp.				
Brachycentridae				
Brachycentrus sp.				
Micrasema sp.				
Philoptomaidae				
Chimarra sp.				
Helicopsychidae				
Helicopsyche sp.				
Plecoptera				
Chloroperlidae				
Alloperla sp.				
Nemouridae				
Eucapnopsis sp.				
Brachyptera sp.	0/ 0/ 1/ 0	0/ 0/ 0/ 1		
Perlodidae				
Isogenus sp.		0/ 0/ 0/ 1		
Pteronarcidae				
Pteronarcella sp.				
Ephemoptera				
Baetidae				
Tricroythodes sp.		0/ 0/ 0/ 2	0/ 2/ 9/ 8	0/ 2/ 3/ 1
Paraleptophlebia sp.			0/ 0/ 2/ 0	
Baetis sp.	133/ 159/ 166/ 118	86/ 10/ 84/ 235	47/ 117/ 122/ 350	11/ 13/ 1/ 11
Ephemerella sp.	5/ 4/ 0/ 0	0/ 0/ 0/ 4	2/ 4/ 3/ 22	
Heptageniidae				
Heptagenia sp.			0/ 0/ 1/ 0	
Iron sp.				
Ironodes sp.				
Megaloptera				
Corydaldae				
Corydalus sp.			1/ 0/ 0/ 0	

Note: Slash lines (/) are used only to separate numbers.

Virgin River, Utah Study
Benthic Data - Number per ft^2

	VR-5	VR-6	VR-7	VR-8
Diptera				
Chironomidae				
Chironominae				
Parachironomus sp.		0/ 0/ 1/ 3		
Cryptochironomus sp.				
Pseudochironomus sp.				
Glyptotendipes sp.				
Micropsectra sp.				
Paratendipes sp.			0/ 0/ 2/ 0	
Polypedilum sp.		1/ 0/ 0/ 0	0/ 0/ 1/ 0	1/ 0/ 0/ 0
Rheotanytarsus sp.	0/ 0/ 1/ 0	0/ 0/ 0/ 2	0/ 1/ 0/ 0	5/ 0/ 0/ 0
Tribelos sp.			0/ 1/ 0/ 0	
Tanytarsus sp.				
Paratanytarsus sp.				
Phaenopsectra sp.				
Tanypodinae				
Clinotanypus sp.				
Psectrotanypus sp.				
Nilotanypus sp.				
Ablabesmyia sp.	0/ 3/ 0/ 1		0/ 0/ 2/ 1	
Procladius sp.				
Conchapelopia sp.				
Diamesinae				
Diamesa sp.				
Pseudodiamesa sp.				
Orthocladiinae				
Orthocladius sp.	2/ 0/ 1/ 3	1/ 2/ 5/ 0	0/ 0/ 3/ 3	50/ 145/ 20/ 32
Cardiocladius sp.	1/ 2/ 0/ 1	1/ 0/ 2/ 0	0/ 1/ 1/ 0	40/ 135/ 5/ 70
Cricotopus sp.	0/ 0/ 2/ 3	1/ 0/ 0/ 0	0/ 0/ 0/ 1	5/ 5/ 20/ 20
Eukiefferiella sp.			0/ 0/ 1/ 0	5/ 0/ 0/ 2
Heterotrissocladius sp.	1/ 0/ 0/ 0			
Metriocnemus sp.				
Parametriochnemus sp.			0/ 0/ 0/ 1	
Pseudosmittia sp.				
Smittia sp.		1/ 0/ 1/ 5		0/ 0/ 35/ 0
Thienemanniella sp.	0/ 0/ 0/ 2		0/ 0/ 0/ 2	0/ 0/ 0/ 1
Trichocladius sp.	0/ 0/ 0/ 1			
Brillia sp.				
Trissocladius sp.				
Ceratopogonidae				
Bezzia sp.				1/ 1/ 0/ 0
Heleidae				
Forcypomyia sp.				
Tipulidae				
Tipula sp.				
Dicronota sp.				
Limnophila sp.				
Antocha sp.				
Rhagionidae				
Atherix sp.				
Dixidae				
Paradixa sp.				
Tabanidae				
Muscidae				
Simulidae				
Simulium sp.	2/ 4/ 7/ 0	11/ 0/ 2/ 41	253/ 0/ 2/ 0	31/ 6/ 1/ 2
Stratiomyiidae				
Empididae	0/ 0/ 1/ 0	0/ 0/ 0/ 1		1/ 3/ 0/ 2
Psychodidae				
Psychoda sp.				
Ephydridae				

Note: Slash lines (/) are used only to separate numbers.

Virgin River, Utah Study
Benthic Data - Number per ft^2

	VR-5	VR-6	VR-7	VR-8
Coleoptera				
Elmidae				
Microcylloepus sp.				
Optioservus sp.	0/ 1/ 0/ 0			
Zaitzevia sp.				
Heterelmis sp.				
Stenelmis sp.				
Curculionidae				
Dyticidae				
Agabus sp.				
Rhantus sp.				
Amphipoda				
Hyalella sp.				
Ostracoda				
Hemiptera				
Naucoridae				
Ambrysus sp.				
Lepidoptera		0/ 0/ 1/ 0		
Collembola				
Hydracarina		1/ 0/ 1/ 0	0/ 0/ 5/ 0	0/ 1/ 0/ 0
Zygoptera				
Coenagrionidae			0/ 0/ 1/ 0	
Anisoptera				
Gomphidae				
Octogomphus sp.				
Isopoda		0/ 0/ 1/ 0		
Annelida				
Oligochaeta	2/ 1/ 0/ 0	0/ 0/ 0/ 1	3/ 0/ 2/ 0	0/ 0/ 1/ 1
Gastropoda				
Pelecypoda				

Note: Slash lines (/) are used only to separate numbers.

Virgin River, Utah Study
Benthic Data - Number per ft^2

	VR-9	VR-10	VR-11	VR-12
Trichoptera				
Hydropsychidae				
Hydropsyche sp.	0/ 0/ 0/ 1			0/ 0/ 0/ 2/Q
Hydroptilidae				
Agraylea sp.				
Orthotrichia sp.				
Ochrotrichia sp.				
Leptoceridae				0/ 0/ 1/ 2/Q
Oecetis sp.				
Leptocella sp.				
Leptocerus sp.				
Limnophilidae				
Limnophilus sp.				
Brachycentridae				
Brachycentrus sp.				
Micrasema sp.				
Philoptomaidae				
Chimarra sp.				
Helicopsychidae				
Helicopsyche sp.				
Plecoptera				
Chloroperlidae				
Alloperla sp.				
Nemouridae				
Eucapnopsis sp.				
Brachyptera sp.	0/ 0/ 0/ 1			
Perlodidae				
Isogenus sp.				
Pteronarcidae				
Pteronarcella sp.				
Ephemoptera				
Baetidae				
Tricorythodes sp.		0/ 0/ 2/ 2	0/ 3/ 2/ 4	Q
Paraleptophlebia sp.				
Baetis sp.	531/ 30/ 130/ 105	4/ 27/ 94/ 60	31/ 119/ 56/ 124	32/ 20/ 48/ 17/Q
Ephemerella sp.	2/ 0/ 3/ 1	0/ 1/ 1/ 0	0/ 4/ 1/ 2	Q
Heptageniidae				
Heptagenia sp.				
Iron sp.				
Ironodes sp.				
Megaloptera				
Corydaldae				
Corydalus sp.				

Note: Slash lines (/) are used only to separate numbers.
"Q" indicates qualitative sample only.

Virgin River, Utah Study
Benthic Data - Number per ft^2

	VR-9				VR-10				VR-11				VR-12			
Diptera																
Chironomidae					1/	0/	0/	0								
Chironominae																
Parachironomus sp.	0/	0/	0/	1					0/	0/	3/	0				
Cryptochironomus sp.																
Pseudochironomus sp.													1/	1/	0/	0/Q
Glyptotendipes sp.									0/	0/	1/	0				
Micropsectra sp.																
Paratendipes sp.																
Polypedilum sp.	0/	0/	2/	2					0/	0/	0/	1				
Rheotanytarsus sp.									0/	1/	0/	0				
Tribelos sp.					0/	1/	0/	1	0/	1/	0/	0				
Tanytarsus sp.	0/	0/	0/	1	0/	0/	1/	0								
Paratanytarsus sp.									1/	5/	0/	4				
Phaenopsectra sp.																
Tanypodinae																
Clinotanypus sp.																
Psectrotanypus sp.																
Nilotanypus sp.																
Ablabesmyia sp.													0/	0/	1/	0/Q
Procladius sp.																
Conchapelopia sp.					0/	0/	1/	0								
Diamesinae																
Diamesa sp.																
Pseudodiamesa sp.																
Orthocladiinae																
Orthocladius sp.	4/	3/	5/	1	0/	1/	1/	0	0/	1/	1/	5	0/	3/	3/	1/Q
Cardiocladius sp.					3/	0/	0/	3					0/	0/	0/	2/Q
Cricotopus sp.	2/	2/	0/	0	0/	0/	1/	0	0/	0/	2/	0				
Eukiefferiella sp.	1/	1/	3/	0	0/	1/	0/	0	0/	1/	0/	0	0/	0/	1/	0/Q
Heterotrissocladius sp.	0/	1/	0/	0					1/	0/	0/	0				
Metriocnemus sp.	0/	1/	0/	0												
Parametriochnemus sp.	1/	0/	0/	0					0/	0/	0/	1				
Pseudosmittia sp.																
Smittia sp.	0/	1/	1/	0	1/	0/	8/	0	0/	0/	0/	3	1/	1/	0/	0/Q
Thienemanniella sp.	1/	0/	1/	1	1/	0/	2/	0	0/	0/	1/	1				
Trichlocladius sp.																
Brillia sp.																
Trissocladius sp.																
Ceratopogonidae																
Bezzia sp.																
Heleidae																
Forcypomyia sp.																
Tipulidae																
Tipula sp.																
Dicronota sp.	0/	0/	1/	0	0/	0/	0/	1								
Limnophila sp.																
Antocha sp.																
Rhagionidae																
Atherix sp.	0/	1/	0/	0												
Dixidae																
Paradixa sp.																
Tabanidae																
Muscidae																
Simulidae																
Simulium sp.	0/	1/	4/	14	17/	0/	0/	253	59/	197/	15/	58	6/	16/	11/	24/Q
Stratiomyiidae																
Empididae																
Psychodidae																
Psychoda sp.																
Ephydridae																

Note: Slash lines (/) are used only to separate numbers.
"Q" indicates qualitative sample only.

Virgin River, Utah Study
Benthic Data - Number per ft^2

	VR-9	VR-10	VR-11	VR-12
Coleoptera				
Elmidae				
Microcylloepus sp.				
Optioservus sp.				
Zaitzevia sp.				
Heterelmis sp.				
Stenelmis sp.				
Curculionidae				
Dyticidae				
Agabus sp.				
Rhantus sp.				
Amphipoda				
Hyalella sp.				
Ostracoda				
Hemiptera				
Naucoridae				
Ambrysus sp.				Q
Lepidoptera				0/ 0/ 1/ 0
Collembola				
Hydracarina	0/ 1/ 0/ 0	0/ 0/ 33/ 3		
Zygoptera				
Coenagrionidae				
Anisoptera				
Gomphidae				
Octogomphus sp.			0/ 0/ 0/ 1	
Isopoda				
Annelida				
Oligochaeta	0/ 0/ 3/ 0	0/ 0/ 0/ 3	1/ 3/ 0/ 0	
Gastropoda				
Pelecypoda				

Note: Slash lines (/) are used only to separate numbers.
"Q" indicates qualitative sample only.

Virgin River, Utah Study
Benthic Data - Number per ft^2

	VR-13	NFVR-1	NFVR-2	NFVR-3
Trichoptera				
Hydropsychidae				
Hydropsyche sp.		11/ 3/ 8/ 4	239/ 137/ 201/ 378	Q
Hydroptilidae				
Agraylea sp.				
Orthotrichia sp.				
Ochrotrichia sp.				
Leptoceridae			0/ 0/ 0/ 1	
Oecetis sp.				
Leptocella sp.				
Leptocerus sp.				
Limnophilidae				
Limnophilus sp.				
Brachycentridae				
Brachycentrus sp.				
Micrasema sp.				
Philoptomaidae				
Chimarra sp.				
Helicopsychidae				
Helicopsyche sp.				
Plecoptera				
Chloroperlidae				
Alloperla sp.				
Nemouridae				
Eucapnopsis sp.				
Brachyptera sp.	Q			
Perlodidae				
Isogenus sp.		0/ 0/ 0/ 1	2/ 0/ 7/ 7	Q
Pteronarcidae				
Pteronarcella sp.			1/ 0/ 0/ 0	
Ephemoptera				
Baetidae				
Tricorythodes sp.	Q	6/ 13/ 3/ 5	71/ 56/ 91/ 157	Q
Paraleptophlebia sp.				
Baetis sp.	Q	17/ 40/ 73/ 318	435/ 687/ 307/ 198	Q
Ephemerella sp.		13/ 4/ 2/ 35	247/ 94/ 174/ 225	Q
Heptageniidae				
Heptagenia sp.		0/ 0/ 0/ 1	3/ 2/ 28/ 0	Q
Iron sp.			2/ 0/ 0/ 0	
Ironodes sp.				
Megaloptera				
Corydaldae				
Corydalus sp.			0/ 1/ 0/ 0	

Note: Slash lines (/) are used only to separate numbers.
"Q" indicates qualitative sample only.

Virgin River, Utah Study
Benthic Data - Number per ft^2

	VR-13	NFVR-1	NFVR-2	NFVR-3
Diptera				
Chironomidae		0/ 0/ 0/ 1	0/ 0/ 2/ 0	
Chironominae				
Parachironomus sp.				
Cryptochironomus sp.				
Pseudochironomus sp.			0/ 0/ 1/ 0	
Glyptotendipes sp.				
Micropsectra sp.				
Paratendipes sp.				
Polypedilum sp.			0/ 1/ 0/ 0	
Rheotanytarsus sp.			10/ 41/ 47/ 220	
Tribelos sp.		1/ 0/ 0/ 0		
Tanytarsus sp.				
Paratanytarsus sp.				
Phaenopsectra sp.				
Tanypodinae				
Clinotanypus sp.				
Psectrotanypus sp.				
Nilotanypus sp.		0/ 0/ 1/ 0		
Ablabesmyia sp.		1/ 0/ 0/ 0	10/ 6/ 5/ 4	Q
Procladius sp.				
Conchapelopia sp.			0/ 0/ 0/ 1	
Diamesinae				
Diamesa sp.				
Pseudodiamesa sp.				
Orthocladiinae				
Orthocladius sp.		9/ 8/ 6/ 4	60/ 21/ 98/ 150	
Cardiocladius sp.		3/ 4/ 3/ 0	25/ 5/ 0/ 20	Q
Cricotopus sp.		0/ 1/ 0/ 0		
Eukiefferiella sp.			10/ 0/ 0/ 0	
Heterotrissocladius sp.				
Metriocnemus sp.				
Parametriocnemus sp.			0/ 5/ 0/ 5	
Pseudosmittia sp.				
Smittia sp.		0/ 0/ 1/ 9	0/ 5/ 18/ 30	
Thienemanniella sp.		0/ 1/ 1/ 2	0/ 0/ 1/ 1	Q
Trichocladius sp.		0/ 0/ 0/ 1		
Brillia sp.				
Trissocladius sp.				
Ceratopogonidae				
Bezzia sp.		0/ 0/ 1/ 1	0/ 0/ 0/ 3	
Heleidae				
Forcypomyia sp.				
Tipulidae				
Tipula sp.				
Dicranota sp.			3/ 0/ 2/ 1	
Limnophila sp.				
Antocha sp.				
Rhagionidae				
Atherix sp.			2/ 0/ 4/ 1	
Dixidae				
Paradixa sp.				
Tabanidae				
Muscidae				
Simuliidae				
Simulium sp.		0/ 3/ 2/ 28	23/ 9/ 0/ 5	
Stratiomyiidae				
Empididae		1/ 1/ 0/ 0	6/ 7/ 6/ 13	
Psychodidae				
Psychoda sp.			1/ 0/ 0/ 0	
Ephydridae				

Note: Slash lines (/) are used only to separate numbers.
"Q" indicates qualitative sample only.

Virgin River, Utah Study
Benthic Data - Number per ft^2

	VR-13	NFVR-1	NFVR-2	NFVR-3
Coleoptera				
Elmidae				
Microcylloepus sp.				
Optioservus sp.			1/ 1/ 1/ 1	
Zaitzevia sp.				
Heterlmis sp.			5/ 1/ 1/ 1	
Stenelmis sp.				
Curculionidae				
Dyticidae				
Agabus sp.				
Rhantus sp.				
Amphipoda				
Hyalella sp.				
Ostracoda				
Hemiptera				
Naucoridae				
Ambrysus sp.				
Lepidoptera			0/ 2/ 1/ 0	
Collembola				
Hydracarina	Q	0/ 0/ 0/ 2	0/ 2/ 0/ 1	
Zygoptera				
Coenagrionidae				
Anisoptera				
Gomphidae				
Octogomphus sp.				
Isopoda				
Annelida				
Oligochaeta	Q		147/ 0/ 0/ 0	
Gastropoda				
Pelecypoda				

Note: Slash lines (/) are used only to separate numbers.
"Q" indicates qualitative sample only.

Virgin River, Utah Study
Benthic Data - Number per ft^2

	LVC-1	StC-1	SC-1	MC-1
Trichoptera				
Hydropsychidae				
Hydropsyche sp.	5/ 1/ 1/ 0	5/ 20/ 31/ 22		
Hydroptilidae			0/ 2/ 0/ 0	
Agraylea sp.		2/ 0/ 0/ 0		
Orthotrichia sp.				
Ochrotrichia sp.		0/ 0/ 3/ 0		
Leptoceridae		1/ 0/ 0/ 0		
Oecetis sp.		0/ 2/ 0/ 0		
Leptocella sp.				
Leptocerus sp.				
Limnophilidae				
Limnophilus sp.				
Brachycentridae				
Brachycentrus sp.		6/ 2/ 4/ 0		
Micrasema sp.				
Philoptomaidae				
Chimarra sp.				
Helicopsychidae				
Helicopsyche sp.				
Plecoptera				
Chloroperlidae				
Alloperla sp.				
Nemouridae sp.				
Eucapnopsis sp.	0/ 0/ 1/ 0			
Brachyptera sp.	0/ 0/ 1/ 1			
Perlodidae				
Isogenus sp.		3/ 2/ 0/ 0		
Pteronarcidae				
Pteronarcella sp.				
Ephemoptera				
Baetidae				
Tricorythodes sp.	0/ 2/ 0/ 0			
Paraleptophlebia sp.		18/ 14/ 70/ 124		
Baetis sp.	35/ 53/ 59/ 98	51/ 158/ 81/ 102	8/ 24/ 12/ 28	19/ 0/ 0/ 3
Ephemerella sp.	0/ 0/ 0/ 2	15/ 26/ 31/ 44		
Heptageniidae				
Heptagenis sp.	0/ 1/ 0/ 0			
Iron sp.		2/ 16/ 12/ 4		
Ironodes sp.				
Megaloptera				
Corydaldae				
Corydalus sp.				

Note: Slash lines (/) are used only to separate numbers.

Benthic Data - Number per ft^2

	LVC-1				StC-1				SC-1				MC-1			
ptera																
Chironomidae																
Chironominae																
Parachironomus sp.																
Cryptochironomus sp.																
Pseudochironomus sp.																
Glyptotendipes sp.																
Micropsectra ps.					5/	0/	0/	10	0/	0/	0/	8				
Paratendipes sp.																
Polypedilum sp.																
Rheotanytarsus sp.					1/	100/	42/	80	10/	0/	0/	0				
Tribelos sp.	1/	0/	0/	0												
Tanytarsus sp.					55/	150/	88/	100	6/	0/	4/	18	0/	0/	2/	2
Paratanytarsus sp.																
Phaenopsectra sp.																
Tanypodinae																
Clinotanypus sp.					1/	0/	0/	0								
Psectrotanypus sp.									0/	0/	0/	2				
Nilotanypus sp.																
Ablabesmyia sp.					4/	0/	15/	50	0/	0/	0/	4				
Procladius sp.					1/	0/	0/	0								
Conchapelopia sp.																
Diamesinae																
Diamesa sp.																
Pseudodiamesa sp.					0/	0/	1/	0								
Orthocladiinae																
Orthocladius sp.	0/	4/	3/	2	10/	50/	11/	10	430/	336/	370/	572	4/	0/	1/	0
Cardiocladius sp.	0/	0/	2/	0	11/	0/	0/	10								
Cricotopus sp.	1/	0/	0/	1	0/	2/	0/	0	10/	2/	0/	160	0/	1/	0/	0
Eukiefferiella sp.	2/	0/	0/	3	56/	92/	96/	50	14/	12/	20/	24	0/	0/	0/	1
Heterotrissocladius sp.	1/	1/	1/	1	1/	0/	0/	0								
Metricnemus sp.	0/	0/	1/	0												
Parametriochnemus sp.					0/	0/	5/	0	0/	0/	0/	10				
Pseudosmittia sp.																
Smittia sp.	0/	2/	1/	2	1/	12/	16/	0	2/	2/	20/	0	3/	0/	0/	0
Thienemanniella sp.	0/	1/	0/	0	0/	0/	1/	0	0/	2/	2/	12				
Trichlocladius sp.	0/	0/	1/	1	1/	0/	0/	0								
Brillia sp.	0/	0/	1/	0												
Trissocladius sp.																
Ceratopogonidae																
Bezzia sp.					2/	6/	4/	0	0/	6/	16/	0				
Heleidae																
Forcypomyia sp.																
Tipulidae																
Tipula sp.					0/	0/	0/	2								
Dicronota sp.					5/	8/	8/	0	0/	0/	2/	0				
Limnophila sp.																
Antocha sp.					0/	8/	5/	0								
Rhagionidae																
Atherix sp.					1/	2/	0/	0								
Dixidae																
Paradixa sp.																
Tabanidae									2/	0/	0/	0	1/	0/	0/	[illegible]
Muscidae																
Simulidae																
Simulium sp.	4/	6/	15/	5	1/	8/	12/	8	30/	10/	54/	54				
Stratiomyiidae																
Empididae					5/	12/	5/		18/	6/	8/	18	0/	0/	0/	[illegible]
Psychodidae																
Psychoda sp.																
Ephydridae																

Note: Slash lines (/) are used only to separate numbers.

Virgin River, Utah Study
Benthic Data - Number per ft^2

	LVC-1	StC-1	SC-1	MC-1
Coleoptera				
Elmidae				
Microcylloepus sp.				
Optioservus sp.		3/ 6/ 6/ 0		
Zaitzevia sp.		0/ 6/ 3/ 0		
Heterlmis sp.				
Stenelmis sp.			0/ 2/ 0/ 4	
Curculionidae	1/ 0/ 0/ 1			
Dyticidae				
Agabus sp.			2/ 0/ 2/ 2	
Rhantus sp.				
Amphipoda				
Hyalella sp.			4/ 8/ 2/ 2	
Ostracoda			0/ 8/ 0/ 2	
Hemiptera				
Naucoridae				
Ambrysus sp.				
Lepidoptera	0/ 0/ 1/ 0			
Collembola			0/ 0/ 6/ 4	
Hydracarina		2/ 8/ 4/ 0	0/ 2/ 0/ 2	
Zygoptera				
Coenagrionidae		0/ 2/ 8/ 26	0/ 0/ 4/ 4	
Anisoptera				
Gomphidae				
Octogomphus sp.				
Isopoda				
Annelida				
Oligochaeta		16/ 0/ 0/ 52		
Gastropoda		0/ 0/ 1/ 0	6/ 4/ 4/ 16	
Pelecypoda		0/ 0/ 0/ 10		

Note: Slash lines (/) are used only to separate numbers.

Virgin River, Utah Study
Benthic Data - Number per ft^2

	LC-1				AC-1				NC-1			
Trichoptera												
Hydropsychidae												
Hydropsyche sp.	1/	6/	3/	12	11/	8/	8/	0	0/	0/	1/	3
Hydroptilidae	0/	1/	2/	1	0/	0/	0/	4				
Agraylea sp.	0/	0/	5/	1	0/	2/	22/	13				
Orthotrichia sp.												
Ochrotrichia sp.												
Leptoceridae												
Oecetis sp.												
Leptocella sp.												
Leptocerus sp.					0/	0/	1/	0				
Limnophilidae												
Limnophilus sp.	0/	2/	1/	4								
Brachycentridae												
Brachycentrus sp.												
Micrasema sp.					1/	1/	0/	2	1/	0/	0/	0
Philoptomaidae												
Chimarra sp.									1/	0/	0/	0
Helicopsychidae												
Helicopsyche sp.					1/	0/	1/	1				
Plecoptera												
Chloroperlidae												
Alloperla sp.												
Nemouridae												
Eucapnopsis sp.												
Brachyptera sp.									0/	1/	0/	0
Perlodidae												
Isogenus sp.					0/	0/	1/	0				
Pteronarcidae												
Pteronarcella sp.												
Ephemoptera												
Baetidae												
Tricorythodes sp.	0/	0/	1/	0	12/	0/	4/	14	0/	0/	0/	2
Paraleptophlebia sp.												
Baetis sp.	35/	74/	59/	91	825/	665/	2399/	134	20/	3/	27/	33
Ephemerella sp.	3/	17/	16/	18	0/	0/	76/	0	0/	1/	0/	0
Heptageniidae												
Heptagenia sp.												
Iron sp.												
Ironodes sp.												
Megaloptera												
Corydaldae												
Corydalus sp.									1/	0/	0/	0

Note: Slash lines (/) are used only to separate numbers.

	LC-1				AC-1				NC-1			
Diptera												
Chironomidae												
Chironominae												
Parachironomus sp.					3/	0/	0/	0				
Cryptochironomus sp.	0/	0/	1/	0								
Pseudochironomus sp.												
Glyptotendipes sp.												
Micropsectra sp.	0/	1/	0/	10	0/	1/	5/	0				
Paratendipes sp.												
Polypedilum sp.												
Rheotanytarsus sp.	7/	6/	15/	5	27/	0/	22/	20				
Tribelos sp.									10/	0/	0/	0
Tanytarsus sp.	1/	6/	6/	0	5/	1/	46/	7	2/	0/	0/	1
Paratenytarsus sp.												
Phaenopsectra sp.	0/	25/	17/	9								
Tanypodinae												
Clinotanypus sp.												
Psectrotanypus sp.												
Nilotanypus sp.												
Ablabesmyia sp.	0/	7/	5/	5					0/	1/	0/	0
Procladius sp.												
Conchapelopia sp.									0/	0/	1/	0
Diamesinae												
Diamesa sp.												
Pseudodiamesa sp.												
Orthocladiinae												
Orthocladius sp.	144/	145/	120/	95	111/	40/	54/	38	0/	10/	5/	17
Cardiocladius sp.					0/	5/	65/	0				
Cricotopus sp.	21/	145/	45/	130	11/	5/	90/	0				
Eukiefferiella sp.	10/	75/	40/	100	78/	10/	239/	150	17/	0/	0/	0
Heterotrissocladius sp.	0/	8/	5/	0	1/	0/	11/	0				
Metriocnemus sp.												
Parametriocnemus sp.												
Pseudosmittia sp.					11/	0/	0/	0				
Smittia sp.	11/	10/	10/	5	80/	80/	74/	181	5/	2/	5/	0
Thienemanniella sp.	7/	6/	6/	11	1/	0/	6/	0	5/	2/	0/	0
Trichocladius sp.	0/	2/	0/	10	0/	0/	25/	0				
Brillia sp.					0/	0/	1/	0				
Trissocaldius sp.	0/	0/	1/	0								
Ceratopogonidae												
Bezzia sp.	1/	8/	6/	0	0/	0/	0/	3	2/	0/	0/	0
Heleidae												
Forcypomyia sp.					1/	0/	0/	0				
Tipulidae												
Tipula sp.												
Dicronota sp.	0/	1/	4/	1	3/	2/	9/	4				
Limnophila sp.												
Antocha sp.	0/	2/	0/	1	1/	0/	0/	1				
Rhagionidae												
Atherix sp.												
Dixidae												
Paradixa sp.												
Tabanidae	0/	4/	0/	1	0/	0/	2/	0				
Muscidea					3/	0/	0/	0				
Simulidae												
Simulium sp.	116/	52/	26/	217	852/	478/	1726/	1157	0/	0/	0/	6
Stratiomyiidae					0/	0/	2/	0				
Empididae	4/	2/	5/	6	0/	6/	7/	0				
Psychodidae												
Psychoda sp.	0/	4/	4/	5	0/	0/	1/	0				
Ephydridae					5/	0/	2/	0				

Note: Slash lines (/) are used only to separte numbers.

Virgin River, Utah Study
Benthic Data - Number per ft^2

	LC-1	AC-1	NC-1
Coleoptera			
Elmidae			
Microcylloepus sp.		0/ 0/ 3/ 0	
Optioservus sp.		0/ 0/ 1/ 0	
Zaitzevia sp.			
Heterelmis sp.		1/ 0/ 1/ 1	
Stenelmis sp.			
Curculionidae			
Dyticidae			
Agabus sp.	0/ 3/ 6/ 5		
Rhantus sp.	1/ 0/ 0/ 0		
Amphipoda			
Hyalella sp.		0/ 0/ 1/ 1	
Ostracoda			
Hemiptera			
Naucoridae			
Ambrysus sp.			
Lepidoptera			
Collembola			
Hydracarina	0/ 0/ 1/ 0	1/ 0/ 2/ 2	2/ 2/ 0/ 0
Zygoptera			
Coenagrionidae			
Anisoptera			
Gomphidae			
Octogomphus sp.			
Isopoda			
Annelida			
Oligochaeta	0/ 0/ 116/ 0	*P/ *P/ 0/ 0	*P/ P/ 0/ 0
Gastropoda	0/ 2/ 1/ 0		
Pelecypoda			

Note: Slash lines (/) are used only to separate numbers.
*P - Present in sample but not observed during counting of subsample.

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1. REPORT NO. EPA-908/2-77-005	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Virgin River Study - Utah: March, 1976		5. REPORT DATE December, 1977 6. PERFORMING ORGANIZATION CODE
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15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Technical Investigations Branch of the U.S. Environmental Protection Agency, Region VIII, conducted an intensive water quality study in the Virgin River and Kanab Creek drainages in Southwestern Utah in March, 1976. The study was requested by the Five County Association of Governments, the local "208" water quality management planning agency. Water, sediment, and benthic samples were collected at selected locations throughout a total stream reach of 174 km (108 mi). Study results indicated a gradual degradation of water quality downstream from Zion National Park. Violations of recommended criteria/standard levels were most common for the salinity parameters, but concentrations of arsenic, iron, manganese, and mercury also exceeded recommended levels. In addition, high concentrations of suspended solids impaired the quality of water throughout much of the study area.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Water Quality, Monitoring, Criteria, Standards, Parameters	Virgin River Kanab Creek	

18. DISTRIBUTION STATEMENT Release to the Public	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES
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