AQUATIC HABITAT INVENTORY IN THE HOT DESERT EIS AREA, UTAH

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CENTER FOR HEALTH
AND ENVIRONMENTAL STUDIES
Brigham Young University

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PURPOSE OF STUDY

The purpose of this study was to gather data on aquatic habitat, water quality and macroinvertebrate populations of fourteen streams and approximately fourteen reservoirs within the Hot Desert EIS Area. The streams contain approximately 88 perennial stream miles on U. S. BLM resource lands (Cedar City District) presently under livestock grazing and associated uses. The data assemblage, analysis and recommendations presented as a result of this study will be included in the formation of the area's Allotment Management Plans (AMP's) and the Hot Desert EIS.

Due to budgetary and time restrictions, only one set of samples from each site was possible. With this limitation, it is obvious that observations do not fully take into account seasonal variations, although biotic communities do reflect the sum of conditions for the period of their existence in a particular body of water.

DESCRIPTION OF STUDY AREA

The study area is located in southern Utah with all sampling sites within about a 30 mile radius of St. George (Fig. 1 and 2). This area is unique to Utah in many of its characteristic flora and fauna types since it forms the north eastern edge of the Mohavian region. Such unique plant species as the Soaptree yucca (Yucca elata), Mesquite (Prosopis juliflora) and Palmer Oak (Quercus chrysolepis) are found nowhere else in the state. Some of the common desert trees associated with stream courses are Desert Willow (Chilopsis linearis), Velvet Ash (Frazinus velulina), Fremont cottonwood (Populus fremontii) and New Mexico locust (Robinia neomexicana).

Some of the prominent geologic features of the area include the Navajo and Kayenta sandstone formations of Zion's National Park, the Hurricane fault along the Hurricane cliffs and the relatively recent (Quaternary) volcanic lava beds. Some of the formations which contribute significantly to the degradation of water quality are the shale and limestone deposits of the Moenkopi, Chinle and the Kaibab Formations.

Historically the greatest impacts to water resources of the area have been from: increased siltation due to overgrazing by cattle and sheep; increased water temperatures caused by the removal of riparian vegetation; and flow alteration and dewatering for irrigation.

METHODS AND MATERIALS

Aquatic Habitat

The aquatic habitat was surveyed according to the BLM Manual 6671 entitled Stream Surveys. Both ocular and intensive surveys were made depending on the desired results.

Water Quality

Water temperature and specific conductance were measured in the field using a YSI meter, model 33. Dissolved oxygen was determined using a modified Winkler Method. Narrow range indicators and a Sargent pH meter were used for pH determinations.

One half gallon water samples were collected at each site and taken to the state certified BYU Environmental Analysis Laboratory where routine chemical determinations and basic nutrient analyses were performed.

Bacteria samples were collected and shipped daily in ice to the BYU laboratory for analysis of fecal and total coliform.

Macroinvertebrates

A stratified random method (EPA Biological Field and Laboratory Methods, 1973) was used in sampling benthic macroinvertebrates. This entails selecting against natural variance in sample data by removing some independent field variables such as water depth, velocity, and substrate type. Thus "fewer" samples produced "higher" statistical reliability. At each sampling station, four quantitative benthic samples were taken randomly from the preselected habitat zones. The preferred habitat is coarse gravel-rubble riffles because aquatic invertebrates are found in higher diversity in these substrates than in most other bottom types (Hynes, 1972).

The sampler used was a modified Surber (Reichert, 1975) designed to prevent loss of organisms due to backwash out of the net. Each sample was taken by placing the net frame over one square foot area of stream bottom, removing all coarse materials after scrubbing all organisms off them into the net, and then stirring the remaining fine substrates to a depth of 5-10 cm depending on hardness of substrates. The organisms were washed into the sampler net by the stream current. Samples were placed in saturated salt water which floated all organisms out of the sand and gravel. Organisms were screened off the salt solution and placed in labeled jars and preserved in 10 percent Formalin and 70 percent ethanol.

In the laboratory, invertebrates were separated, identified, and counted. Species lists, population density, total biomass, data reliability, and dominance diversity were calculated for each station.

The dominance diversity indices are highest (most desirable) when the number of species is high and the number of individuals is evenly distributed over several species. With fewer species or when one or two species account for most of the total number, the diversity indices are low (undesirable). For example, when a stream receives a heavy load of sewage effluent, most mayflies, stoneflies, and caddisflies are eliminated; but the numbers of midge larvae and sewage worms become extremely high. In such a condition the diversity index would be low. In clean, cold mountain streams, there are usually numerous species of aquatic insects with moderate numbers of individuals for several species, resulting in high diversity indices. Dominance diversity values used in this report were computed using the formulae:

$$\bar{d} = -\sum_{1}^{s}(Ni/N)\log_2(Ni/N) \qquad \text{(Shannon and Weaver, 1963)}$$

$$H = (i/N)\,(\log N! - \sum_{1}^{s}\log Ni!) \qquad \text{(Brillouin, 1960)}$$

where: $\bar{d}$ and H are dominance diversity indices
Ni = number of the ith species
N = total number of all species

Both indices are very similar and are based upon the information theory. In summary, when several specimens of a sample are examined, more information is gained when the next specimen examined is different from the preceding one than if they were all the same. Thus, these formulas were selected because they are based upon diversity dominance and express the relative importance of each species collected, not merely the relationship between total numbers of species and of individuals. These indices are also independent of sample size.

-- PART I. STREAMS --

RESULTS AND DISCUSSION

Virgin River

Description. The Virgin River has its head waters along the south flank of the Markagunt Plateau and flows some 110 miles emptying into Lake Mead, Nevada. The study area was about 20 miles long with four sampling sites as indicated in Figure 1, Plate I (pictures 1-4) and Plate II (pictures 3 and 4).

Geologically the river originates in the Claron or Cedar Breaks formation and then descends through the Kaiparowits formation; the Iron Springs formation composed of Wahweap sandstone; the Straight Cliffs formation; and finally through the Tropic Shale and Dakota sandstone, all of the Cretaceous Period. The river then cuts through the Carmel formation and Navajo Sandstone which is of the Jurassic Period and composes a large part of Zion's National Park formations. As the river leaves Zion's National Park it cuts through the Kayenta formation and enters the Chinle, Chinarump, and Moenkopi formations.

As the river flows through these last three formations the water quality degrades markedly, becoming quite muddy with a heavy silt load and increased total dissolved solids. This natural degradation coupled with increased man-made impact from agricultural diversion and return flows, grazing impact to riparian vegetation and municipal effluent leads to a rapid decrease in water quality.

Aquatic habitat. Table 1 summarizes the stream habitat survey and analysis. We see that the priority A limiting factors in terms of fisheries habitat are quite poor with the percent of habitat optimum being only 40 percent. Riparian vegetation was sparse and of poor quality with bank cover percent optimum at 38 percent and average stream shade only 8 percent. The dominant substrate was sand with desirable bottom materials composing only 31 percent. Riffle/pool ratio percent optimum was 66 percent with pool quality at only 16 percent.

Water quality. The water quality parameters measured for the Virgin River are summarized in Table 2. The river was characterized as a very hard water, high bicarbonate buffered system. Conductivity as μmhos/cm at 25°C ranged from 783 at S-4 above LaVerkin to 1980 at S-1 below Bloomington. Total dissolved solids showed a similar trend ranging from 483 mg/l at S-1 to 1371 mg/l at S-4. Nitrate levels were quite high, probably due to irrigation return flows and feedlot run-off, averaging 0.57 mg/lN with a range from 0.49 at S-3 to 0.73 at S-1. Phosphate (ortho) averaging 0.02 mg/l is sufficient to allow moderate algal growth but was probably the limiting factor to productivity in the Virgin River. There was however very little periphyton growth due to the sandy substrate and high water turbidity.

The water quality in terms of the bacteria showed fecal contamination with fecal coliform ranging from 9 to 93 MPN/100 ml and total coliform from 93-240 MPN/100 ml (Table 2). This is to be expected with numerous cattle grazing the immediate shore line during the sampling period.

Macroinvertebrates. As seen in Table 3 the macroinvertebrate communities are in quite poor condition below LaVerkin downstream with relatively low diversity indices, low density and biomass. Station S-4 above LaVerkin was in better condition as revealed by a high biomass and density and for a desert sandy stream a good dominance diversity ($\bar{d}$) of 2.24.

The majority of the biomass at S-4 was the result of several large *Corydalus* or Hellgramites, a large predatory insect larva with the ability to burrow into the wet sandy substrates of large desert streams. *Corydalus* larvae can avoid times of severe physical environmental stress by burrowing into the substrate or moving to protected areas of the stream. The require a somewhat stable sandy substrate and perennial water flow.

The Virgin River above LaVerkin has more stable substrates than the lower sites sampled and also has better water quality (Table 2) as shown by conductivity, hardness, sodium, chloride, sulfate, and total dissolved solids. It appears that LaVerkin Springs may be a major contributor to the poor water quality. The macroinvertebrate communities show a direct response to the degradation of the aquatic habitat as show in Tables 3 and 4. The number of taxa drops from 13 at S-4 to only 4 at S-3 and 3 at S-2 and S-1.

Baetis spp. mayflies, simuliid blackflies and oligochaete worms are active downstream drifters. Their presence at S-3, S-2 and S-1 is mainly the result of drift from areas above LaVerkin Springs and probably does not represent permanent resident populations. The shifting sand substrates and extreme flow fluctuations make it highly improbable that these forms could successfully complete a larval cycle and achieve adult reproductive status in these river segments. Simuliid blackflies require stable substrates for attachment and being filter feeders have to filter planktonic matter from the suspended inorganic load making it extremely difficult for them to obtain adequate food in a shifting sand river segment.

Management alternatives. Since the landownership by BLM is quite limited along the Virgin River there is little hope of much restoration of the river system through alteration of habitat on BLM administered sections. Possibly some reseeding could be done to stabilize and beautify small areas. The only real positive impact will have to be accomplished through cooperation with private land owners and this should be mainly aimed at bank stability through establishment and protection of a riparian vegetation zone along both banks with limited cattle access.

Little can be done in the situation where the natural degradation is as severe as it is along the Virgin River as it flows through the Moenkopi and Chinle Formations. Possibly, at best, a status quo could be maintained within the system by regulating future activities along the river on national resource land and soliciting the aid of private land owners to do the same.

Mill Creek

Description. Mill Creek is located near the town of Washington in Washington County, Utah (Fig. 1). It is about 9 miles long, four of which are administered by the BLM. Mill Creek is fed by a series of springs along about a 2.0 mile stream section from Washington upstream. Above the springs it appeared to be intermittent.

Mill Creek has a small drainage area originating in the small mountains to the north of Washington (Plate III, picture 1). Runoff from these mountains is intermittent. As the water progresses downstream to the foothills the stream flows through a narrow, steep-walled canyon which extends to Washington. The majority of BLM administered lands adjoining Mill Creek is in this narrow canyon area. Mean width of the canyon was less than 50 meters, in fact in some areas less than 10 meters.

The land above the canyon walls is dominated by a sage-mesquite-grass community. Geologically the water shed is of the Kayenta Sandstone Formation of the Triassic Period.

Aquatic habitat. As seen from Table 5 the aquatic habitat of Mill Creek is good in some ways with 91 percent bank cover and quite poor in others such as riffle/pool ratio of only 20 percent. The overall percent of habitat optimum was 48 percent. The substrate material was fair at 48 percent desirable material (gravel rubble). Spawning gravels made up 33 percent of the total substrate.

Riparian vegetation consisted of willow, cottonwood and sage. Heavy cattle damage was noted with many cattle trails worn several inches deep along both banks of the stream. Vegetation showed heavy use with no young vegetation present, only mature, partly dead trees and brush (Plate III, pictures 2, 3 and 4).

The average width of the stream was 5 feet with average depth at 0.13. The channel averaged 20 feet wide.

Water quality. Mill Creek is a typical high bicarbonate, hard water system with a pH of 8.15 (Table 6). Specific conductance equaled 873 μmhos/cm at 25°C and total dissolved solids was 522 mg/l. Nitrates and phosphates (ortho) were both quite low at <.05 and 0.011 mg/l respectively, due to the rapid assimilation by the algal communities in the shallow warm waters.

Bacterial examination revealed that total coliform was low equaling 23 MPN/100 ml while fecal coliform was high at 23 MPN/100 ml indicating positive fecal contamination.

Macroinvertebrates. The benthic communities in Mill Creek are in good condition for a small, spring fed, hot desert stream (Tables 7 and 8). It was characterized by the presence of such warm water species as: the damselflies *Heterina* sp., *Amphiagrion abbreviatum*, and *Argia* sp.; the dragonflies *Erpetugomphus compositus*, *Ophiogomphus severus*, and *Progomphus borealis*; the mayfly *Tricorythodes* minutus; the caddisflies Cheumatopsyche sp. and Hydropsyche sp.; the Hellgramite Corydalus sp.; the moth Paragyractis sp.; and the true flies Euparyphus sp. and Psychodidae.

A total of 32 taxa were collected and identified from Mill Creek including 24 from the benthos and 8 from adult collections. This is an exceptionally diverse community for this desert area and quite unique for the state. Population density was high at 22,531 organisms per square meter, with dipterans (true flies) and mayflies composing 59 and 20 percent, respectively. Total biomass which was 5.0 gm/m^2 was quite high for such a small stream. Much of the biomass was due to Corydalus sp. Hellgramites and the larger Hydropsyche sp. caddisflies.

Both diversity indices $\bar{d}$ and H at 2.60 and 2.56 respectively, indicate that the benthic community was in good condition with only moderate dominance by any group.

Management alternatives. Flow regimes and water temperatures in Mill Creek prohibit the development of a cold water trout fishery, but the stream could support a small population of a small size pure strain "coarse" fish. Principle uses of the stream resources are agricultural-livestock and irrigational needs, but the stream has a real value as a unique habitat. Efforts should be made to maintain and improve existing riparian vegetation and thus prevent excessive erosion and siltation.

Leeds Creek

Description. Leeds Creek is a permanent stream flowing some 14 miles off the southeastern slope of the Pine Valley Mountains and joining the Virgin River about 6 miles below LaVerkin in Washington County (Fig. 1). The lower 4 miles of the stream are administered by BLM. One survey station was established on Leeds Creek along a frontage road just below Interstate 15.

Leeds Creek drains a relatively small watershed characterized by Pinõn-Juniper forests with sparse ground cover. In the lower reaches of the drainage, riparian vegetation consists of patches of desert willow, rabbit brush, sage brush and salt cedar but the stream banks are dominated by bare rocks and soil.

Geologically, the stream descends through several formations in its course to the Virgin River. Some of the dominant formations include the Wahweap sandstone, Carmel formation, Navajo Sandstone, and Kayenta, Moenave and Moenkopi formations.

Aquatic habitat. The aquatic habitat was in fair to poor condition as noted on Table 9. The overall percent of habitat optimum was 57 percent. Ungulate damage was quite prevalent, however, receiving a rating of 2 with some sloughing and accelerated erosion of the banks. Bank cover was about 56 percent with stability assessed at 69 percent. Stream shade averaged about 10 percent. Average water width was 9 feet with a stream gradient of 2.5 percent and a flow of 3 cfs. 67 percent of the stream was pool habitat but pool quality was only 33 percent optimum.

Water quality. Leeds Creek appeared to be a typical stream for this region since it was a hard water, high bicarbonate buffered system (Table 6). Total dissolved solids and conductivity were not excessive being 362 mg/l and 550 µmhos/cm respectively. Nutrient levels were quite low with ortho-phosphate at 0.023 mg/l and Nitrate <.05 mg/l. The system could possibly be nitrate limited.

Bacteria counts were also low with total coliform at 9/100 ml but a fecal coliform count of 9/100 ml indicates recent fecal contamination.

Macroinvertebrates. The benthic communities in Leeds Creek appeared to be under environmental stress with 58 percent of the bottom fauna represented by dipterans (true flies) (Table 7). This high dominance contributed to the relatively low $\bar{d}$ and H which registered at 2.24 and 2.17 respectively. There were 14 taxa represented in the benthic collections with 2 additional stonefly species collected as adults. Total density was low at 5,724 organisms per square meter and the biomass was also low at 1 gram dry weight per square meter. The dominant taxa was Simuliid blackfly larvae composing 47 percent of the benthos (Table 10). Stream habitat showed signs of high flows probably caused by thunderstorms which could account for the absence of the more environmentally fragile species of insects and the dominance of those species capable of surviving moderate-severe physical environmental stress.

Management alternatives. Aquatic habitat, especially the riparian vegetation, should be improved. Domestic grazing is heavy along the stream banks with the grasses cropped close to the ground and other vegetation showing heavy use. A limited fishery could possibly be maintained in the lower reaches of Leeds Creek following stabilization of flows and improvement of riparian vegetation. Leeds Creek has limited esthetic and recreational value at present with its main uses being irrigation, grazing and a watering source for livestock and wildlife.

Leap Creek

Description. Leap Creek has its head waters on the eastern slope of Pine Valley Mountains and flows easterly for about 9 miles discharging into Ash Creek approximately 1 mile north of Pintura, Washington County. It drains a rather small watershed with the native vegetation being sparse Piñon-Juniper forest (Plate II, picture 1).

Geologically the upper reach of the watershed is composed of Wahweap Sandstone and the Carmel and Cedar Breaks formations of the Cretaceous and Jurassic Periods. The lower third of the drainage is Quaternary basalt flows.

One sampling site was established on Leap Creek near Interstate 15 about 1 mile north of Pintura (Fig. 1). BLM administered land consists of only the lower 2 miles of Leap Creek.

Aquatic habitat. Leap Creek appears to be an intermittent stream or at least being subject to extreme low and high discharges. This is evidenced by extremely low numbers and biomass of bottom fauna and absence of any visible periphyton. Lack of periphyton indicates extreme high flows with associated scouring of the substrate. The average water width was about 7 feet with a steep gradient of 5-7 percent. The channel was quite wide, capable of carrying greater than 100 cfs. The substrate consisted mainly of boulder, rubble with small amounts of gravel and almost no sand or silt (Table II, Plate II, picture 2).

There was no evidence of ungulate damage in this area due to the rugged nature of the terrain. The channel and banks were very rocky and stable, however the cover was quite sparse. Only about 10 percent of the stream was shaded.

Water Quality. According to the routine chemical analysis shown in Table 6, Leap Creek is a typical high bicarbonate, hard water system with excellent buffering capacity. Its nutrient levels are quite low with ortho-phosphate at 0.019 mg/l and nitrates at <0.05 mg/l. Total dissolved solids and conductivity were well within acceptable limits registering at 213 mg/l and 330 µmhos/cm respectively.

Bacteria counts were extremely low with total coliform at 4/100 ml and fecal at 3/100 ml.

Macroinvertebrates. Eleven taxa were collected in the benthos and two species of stoneflies were collected as adults (Table 12). Total density and biomass were low being 3,314/m^2 and 0.3 g/m^2, respectively. The bottom fauna was composed of 64 percent dipterans (true flies) and 19 percent worms (Table 7). The diversity indices $\bar{d}$ and H were low at 2.11 and 2.02 respectively. Mayflies (Baetidae) and stoneflies (Capniidae) each composed only 6 percent of the benthos and they were all environmentally tolerant forms, at least as far as physical stresses go, such as low and high flows and frequent sediment scouring.

Management alternatives. The limiting factor in this system is the near intermittent nature of the stream. The relatively small watershed in this desert area cannot provide for a sustained runoff. When storms do come they are often violent in nature and the result is flooding with severe environmental stress to aquatic communities. Little can probably be done to improve this system for a fisheries purpose.

Ash Creek

Description. Ash Creek has its headwaters on Timber Mountain west of New Harmony in north Washington County. It flows east and south for about 20 miles discharging into the Virgin River near LaVerkin. Land ownership along the stream is a checker-board with patches alternating between private, state and BLM lands with only about 8 miles being administered by BLM.

Much of the watershed of Ash Creek is vegetated by Piñon pine forest. The stream cuts through two principle geologic formations on its descent to the Virgin River, the Carmel formation of the Jurassic Period and the Quaternary basalt flows.

Three sampling sites were established on Ash Creek, S-1 near Toquerville, S-2 about 2 miles above Pintura, and S-3 below Sawyer Spring south of New Harmony (Figure 1).

Aquatic habitat. Much of Ash Creek is seasonally dried up by irrigation diversions. Below Sawyer Springs the waters run clear most of the year to a point just above the Ash Creek Reservoir where the soils become red clay-sand and turbidity increases. During periods of high runoff heavy loads of sediments are carried from the sedimentary deposits of the upstream geological formations into Ash Creek Reservoir where they are deposited. Deposits are at present above the level of the reservoir outlet and during periods of drawdown Ash Creek below the reservoir runs a thick reddish-brown as these sediments are carried downstream.

As Ash Creek leaves the reservoir it flows through about 3 km of good canyon habitat but then enters an area of recent highway construction activity. Through this zone streamside vegetation has been removed and the stream has been channelized. Aquatic habitat is virtually non-existent through this zone--station S-2 as shown on Figure 1. With periods of zero release from the reservoir, the habitat destruction and periods of heavy silt load, this section of Ash Creek is a biological desert.

Below this area the stream waters, except during high discharge, go underground in a large rocky beach area above Anderson Ranch. These waters may be the source of the springs at Anderson Ranch which flow into the Ash Creek Channel. The area above Anderson Ranch is characterized by sparse vegetation and low grazing use.

The Springs, which are about 1 km above Toquerville, provide culinary and irrigation water for Toquerville and LaVerkin and water quality is high. Ash Creek below Toquerville is periodically dried up by irrigation diversions.

The only sections with any promise as a fisheries resource habitat in Ash Creek under present use would have to be the short reaches below Sawyer Springs and Anderson Ranch Springs and they are of questionable value.

The stream survey summary and analysis is presented in Table 13. A riffle/pool ratio of 90 percent was computed with the other factors such as percent desirable bottom material, bank cover and bank stability not nearly as high, registering at 64 percent, 48 percent and 63 percent respectively. The overall percent of habitat optimum for Ash Creek was 63 percent but this did not take into account periodic dewatering and heavy silt loads.

Water quality. Water quality (Table 13) was similar at all sites, with the main difference being the turbidity levels which were quite high at S-2 below the reservoir as explained above. Sulfate increased significantly down the drainage being 7 mg/l at S-3, 90 mg/l at S-2 and 180 mg/l at S-1. Such parameters as hardness, bicarbonate alkalinity and pH remained quite constant throughout the drainage.

Bacteria counts (Table 14) were relatively low for total coliform but fecal coliform counts show significant fecal contamination at sites S-1 and S-3. Cattle were seen grazing close to the stream channel at both of these sites.

Macroinvertebrates. The results of a statistical analysis of the benthic sampling is presented in Table 15. The number of samples taken provides adequate statistical reliability as shown by the percent standard error of the mean being only 16.4 for 4 pooled samples. As stated by Elliott (1971), in order to properly estimate benthic populations enough samples must be taken to yield a percent standard error of the mean of less than 20 percent. In this case four samples were sufficient. The coefficient of variation of 33 percent for the 4 samples lies well within the acceptance range for sampling efficiency as discussed in EPA Biological Field and Laboratory Methods Manual (1973).

There was a significant difference in the benthic fauna at the three sites as shown in Tables 16 and 17. The 'healthiest' station was at S-3 where the total density was 15,332 organisms per square meter, biomass was nearly 10 gram dry weight per square meter and $\bar{d}$ and H registered at 2.52 and 2.48, respectively. The benthic communities at site S-2 reflected the poor quality of the environment with only four taxa present as compared to 27 at S-3 above the reservoir and 13 at S-1 near Toquerville. These 4 taxa at S-2 were all washed down from upstream and were not permanent residents of this site. Population density at S-2 was only 172 per square meter. Sustained heavy sediment loads, high turbidity and periodic dewatering probably account for the demise of most macroinvertebrate species at this station. Site S-1 had the highest density numbering 25,264 per square meter, 69 percent of which were dipterans, mainly blackflies and midge larvae. The diversity indices $\bar{d}$ and H reflected this undesirable dominance by registering at only 1.60 and 1.58 respectively. The benthic fauna at site S-3 was also dominated by midge larvae and worms with only 27 percent of the benthos consisting of mayflies. Stoneflies and caddisflies accounted for only 2 and 4 percent of the total benthos at site S-3 and beetles were absent. The absence, or nearly so, of stoneflies, caddisflies and beetles at all sites on Ash Creek substantiate the existence of extreme environmental conditions and the stress to the aquatic organisms.

Management alternatives. With Ash Creek Reservoir and lower Ash Creek in their present condition, the only section with much recreational or fishery potential is Ash Creek above the reservoir. The existing habitat is in pretty good condition but there was evidence of heavy grazing by cattle and deer and the stream is subject to periods of dewatering or nearly so.

The main management of Ash Creek should be aimed at riparian vegetation protection or improvement as a means to reduce erosion and sedimentation.

LaVerkin Creek

Description. LaVerkin Creek originates along the western edge of Zion's National Park and flows south for about 30 miles discharging into the Virgin River near LaVerkin. The dominant vegetation type in the watershed was Pinõn-Juniper. The stream descends about 1300 feet cutting through several prominent formations including Navajo and Kayenta Sandstone, the Chinle, Shinarump and Moenkopi formations and the Kaibab Limestone.

Three survey stations were established on LaVerkin Creek with S-1 near LaVerkin, S-2 about 4 miles above Toquerville in the mouth of the canyon and S-3 near Zion's Park boundary (Figure 1. Plate IV, pictures 1-4). BLM administered 8 miles along the stream course south of Zion's Park boundary.

Aquatic habitat. The riparian vegetation changed from Pinõn-Juniper -sagebrush to cottonwood and willow as LaVerkin Creek descended the watershed. Consequently, stream bank cover and stability was better along the lower reaches of the stream. Overall bank cover and stability, percent optimum were 44 percent and 62 percent respectively (Table 18).

The substrate was generally quite sandy averaging 38 percent of the total and the sandy substrate was constantly shifting, preventing formation of any sizeable pools and keeping the depth shallow (Plate IV, picture 2). The percent of stream bottom consisting of desirable material such as rubble and gravel was 55 percent. The riffle/pool ratio percent optimum was also less than favorable measuring only 52 percent and pool quality was only 33 percent optimum.

The average channel width was 41 feet indicating the occurrance of flash floods, typical of desert stream ecosystems. The stream gradient averaged 2.7 percent and the flow during the survey was about 3.2 cfs.

In summary the fisheries habitat was quite poor with a total percent of habitat optimum of only 49 percent. Much of the area surveyed appeared to be overgrazed especially at site S-2 near the mouth of the canyon. The average stream shade was only 13 percent due to the lack of riparian vegetation.

Water quality. Table 14 summarizes the water quality parameters for LaVerkin Creek. As noted, the stream is characteristic of the geological formations of the area, being a hard water system with high total dissolved solids and conductivity. The bicarbonate alkalinity and hardness averaged 202 and 461 respectively. Nutrient levels were low with the limiting factors for algal growth probably ortho-phosphate. Dissolved oxygen levels were high enough so that DO is not a limiting factor to aquatic life.

Total coliform bacteria counts (Table 14) were high at S-2 and S-3 but fecal coliform was considerably lower. The 11 fecal/100 ml at S-3 indicates fecal contamination. Most of the fecal coliform counts in LaVerkin Creek are likely from cattle grazing in the area.

Macroinvertebrates. The macroinvertebrate communities of LaVerkin Creek were in poor condition (Tables 16 and 19). The low number and kinds of species are in direct response to the erratic flows and sandy, shifting nature of the substrate. The overgrazed riparian plant communities of the area have resulted in unstable banks, channel and substrate which has eliminated most stream habitat niches and thus prevented establishment of a diverse, abundant macro-invertebrate community. The extremely low $\bar{d}$ and H values at site S-3 were the result of the low diversity and extremely high community dominance of 92 percent by mayflies of the genus *Baetis* which are the first forms to reinvade an area following periods of high stress. Mayflies also dominated the community at site S-2, however at S-1 the dominance shifted with true flies, mainly of blackflies and midges, composing 53 percent of the benthos. At S-1 agricultural activities and high organic loads as evidenced by the presence of blackflies, midges and oligochaete worms (Table 19). The relatively high biomass values at all three sites was made up mainly of larger megalopteran (*Corydalus* sp.) larvae, commonly known as hellgramites.

Management alternatives. LaVerkin Creek above the mouth of the canyon has little fisheries value due to unstable drainage and stream channel, resulting in a wide, shallow exposed stream with poor quality pools and silted riffles. Flows fluctuate excessively, as do water temperatures, thus aquatic forms successfully establishing in the stream will necessarily have to be very resilient to environmental changes. With the prevailing climate and geology, it is doubtful that, even with limited grazing, riparian vegetation will ever be reestablished along most of the stream. The greatest value of the stream is livestock and wildlife watering, irrigation water and esthetics with its colorful drainage. Management should be aimed at channel stabilization and prevention of further degradation of streamside vegetation.

North Creek

Description. The headwaters of North Creek are located in the mountainous back country of central Zion's National Park. It flows southwest for about 13 miles to its confluence with the Virgin River near Virgin, Washington County. Much of North Creek lies within Zion's National Park with the BLM administering only about 3 miles of stream reach. Most of the watershed of North Creek is vegetated by Piñon-Juniper forests. The stream descends some 2400 feet passing through several geologic formations including the Navajo and Kayenta Sandstones, the Chinle, Shinarump and Moenkopi formations and Quaternary basalt flows.

Two sampling sites were established on North Creek with S-1 located about 2 miles above Zion's road and S-2 at Zion's National Park boundary (Figure 1, Plate V, pictures 1 and 2).

Aquatic habitat. The fisheries habitat of North Creek was found to be in relatively poor condition (Table 20). Riffle/pool ratio was only 38 percent optimum with pool quality, at 12 percent optimum. Riparian vegetation consisted mainly of cottonwood, river birch, willow and some juniper and sagebrush. Bank cover was sparse at 33 percent optimum with stability better, registering at 63 percent. There were numerous cattle signs and ungulate damage was quite severe in some areas. Substrate conditions were good with desirable material composing 60 percent of the stream bottom; however, sand at 35 percent constituted a significant portion of the substrate. The overall percent of habitat optimum was only 41 percent.

The average width of the stream was 14 feet with channel width at 55 feet. The wide channel was indicative of periodic high flows generally in the form of flash floods. The mean stream gradient was 2.2 percent with the flow measured at 2 cfs at S-1 and 4.2 cfs at S-2. There was little evidence of periphyton growth on the rocks which is also indicative of flows which had scoured the substrate.

Water quality. North Creek was typical of other streams in the region in terms of water quality parameters (Table 14). Typically the system had hard water with high bicarbonate alkalinity and pH. Conductivity was also moderately high as was total dissolved solids averaging 560 µmhos/cm and 375 mg/l, respectively.

Nutrient levels were high with nitrate nitrogen averaging 0.73 mg/l, ammonia nitrogen 0.21 mg/l and ortho-phosphate at 0.002 mg/l. There should have been dense periphyton growths with nutrients this high--again scouring of substrate is evidenced.

Bacteria counts were low with total coliform at 93 and 23/100 ml at sites S-1 and S-2 respectively. Fecal coliform count was <3/100 ml at both sites.

Macroinvertebrates. The macroinvertebrate communities of North Creek appeared to be in fair condition with station S-2 near Zion's National Park boundary in slightly better condition than S-1

(Tables 16 and 21). Both communities were characterized by such taxa as *Tricorythodes* sp., *Baetis* spp., Capniidae, *Corydalus* sp., *Hydropsyche* spp., *Simulium* spp., *Chironomidae*, Empididae and Oligochaeta.

Most of these taxa are generally indicators of silty, warm water, unstable physical conditions typical of these southern desert stream ecosystems. The dominant taxa at both sites were the *Simulium* spp. blackflies and chironomid midges. They composed 58 percent and 60 percent of the benthos at sites S-1 and S-2, respectively. Number of taxa, population density, and biomass were all higher at S-2 than at S-1 but both diversity indices, $\bar{d}$ and H, were nearly equal for the two stations. This is normal for most mountain streams--higher numbers and diversity at mid-drainage sites than valley sites.

Management alternatives. This stream has good potential as a fisheries habitat. Quality will depend upon reestablishing a good riparian vegetation zone along both banks and limiting livestock access to the stream channel. Some habitat improvement may be required to increase riffle/pool ratio percent optimum along with pool quality percent optimum. Randomized rock placement would probably work without decreasing the esthetic value of the stream. Properly managed grazing of the watershed should not detract from the resource value of this stream.

Santa Clara River

Description. The Santa Clara River originates on the western slopes of Pine Valley Mountain and flows south for about 40 miles joining the Virgin River south of St. George. Approximately 20 miles of streamside lands are administered by BLM with a considerable amount of private land interspersed amongst National Resource lands. The Santa Clara River is an extremely valuable resource to the region providing waters for domestic, agricultural and recreational needs. Man has imposed severe impacts on the system historically and recently in terms of overgrazing, construction of reservoirs and roads, flow manipulations and contamination from agricultural return flows and municipal wastes.

The Santa Clara drainage is composed of several geological formations which have a direct influence on the quality of its waters. Its headwaters on Pine Valley Mountain lie on a tertiary intrustion composed mainly of quartz monzonite and ash-flow tuffs. As the waters descend, they flow through the quaternary alluvial deposits of Pine Valley and enter quaternary basalt until just southwest of Veyo, Utah, where they pass through the following sequence of formations: Wahweap and Straight Cliffs Sandstone, Dakota Sandstone, Carmel formation, Navajo and Kayenta Sandstone and Moenave formation, Chinle formation and the Shinarump Conglomerate. Near the town of Santa Clara, the river enters alluvial deposits which are well drained, with low rock content, suitable for crops.

The watershed of the Santa Clara River is characterized by a wide variety of plant communities, however the Piñon-Juniper forest interspersed with low shrubs is the dominant community. The upper reaches of the watershed are forested by Douglas-fir and Ponderosa Pine mixed with various trees, shrubs and grasses. The lower stream reaches are vegetated mainly be willows, sage and grasses.

Five sampling sites were established on the Santa Clara River (Figure 2) as follows: S-1, 1 mile west of Santa Clara, Utah off Highway 56; S-2, about 1/2 mile below Gunlock Reservoir; S-3, about 2 miles above Gunlock, Utah at road Crossing; S-4, above the riverside resort in Veyo, Utah; S-5, about 2 miles above Baker Dam Reservoir just below bridge crossing and above large spring (Plate V, pictures 3 and 4; Plate VI, pictures 1-4).

Aquatic habitat. Due to the low number of transects at each site (4 or 5), measurements at all sites were combined to generate the data contained in the habitat survey summary (Table 22). These values are rather artifical as they represent average conditions for a very diverse system. For example, percent stream shaded ranged from 10 percent above Gunlock (S-3) to 80 percent in the gorge above Veyo (S-4); but the average value is 47 percent which doesn't represent either site. If the values in the summary table are to be used for future reference the investigators will have to be certain that measurements be taken at a variety of sites.

Site S-5 (Plate V, pictures 3 and 4), about 2 miles upstream from Baker Dam Reservoir. This area was characterized by gently sloping hills covered with piñon-juniper communities. Streamside

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Site S-3 on the Santa Clara River is actually located on Moody Wash approximately 100 yards above the confluence with the Santa Clara River.

Due to similarities in water quality and biotic communities, tables and figures in this report will refer to this site as S-3 on the Santa Clara River.

vegetation was mostly cottonwood trees with most other types destroyed by heavy livestock grazing as evidenced by closely cropped grasses and heavily worn trails. There were no young trees observed indicating a heavy grazing stress with extreme environmental deterioration projected for the future under present use. Stream habitat was good to excellent with good riffle/pool ratio (1:1) and high pool class ratings (I to IV). Stream substrates had a good balance between fine and coarse materials. There was an extensive stretch below this site where the stream entered a narrow steep canyon inaccessible to cattle. In this canyon the cottonwood trees were closely situated creating good stream cover.

Site S-4 (Plate VI, picture 1), below Baker Dam Reservoir and immediately upstream from the riverside resort at Veyo, Utah. Baker Dam Reservoir and other diversions upstream highly limit the stream flow at this site, which was less than 2.0 cfs on 17 February 1976 as compared to 25 cfs at S-5. This stretch of river is in a narrow deep canyon with numerous homes built next to the canyon edge and down into the canyon where the space is available. The stream was heavily shaded (80 percent) by dense stands of cottonwood trees, oak brush and juniper trees with understory growths of willows and grasses. There was little evidence of livestock use in the area. Sixty percent of the stream substrates were fines with 35 percent sand, 20 percent silt and 5 percent organic muck.

Site S-3 (Plate VI, picture 2), two miles above Gunlock, Utah at road crossing, cement bridge. The stream at this site had been subjected to severe flow fluctuations evidenced by wide unstable channel (average width 265 feet) with narrow water width (average 10.5 feet). Banks were largely bare due to overgrazing and stream bank erosion. Only 10 percent of the stream was shaded. Cottonwood trees were sparsely distributed with scattered clumps of willows. Hillsides were mainly vegetated by piñon-juniper and some sagebrush. Stream substrates were composed of mainly sand (36 percent), gravels (32 percent) and rubbles (30 percent). Pool class was poor due to shallow depths and shifting sand substrate. Stream flow was approximately 8 cfs on 19 February 1976 showing some accretion flows from S-4 to this site, probably a combination of irrigation return flows and springs.

Site S-2 (Plate VI, picture 3), 1/2 mile below Gunlock Reservoir. Stream flow in this reach has often neared zero release with most of the water coming from seepage and springs. On 19 February 1976 the flow was less than 0.5 cfs and the stream was more characteristic of spring fed pools than a stream. Rooted vegetation (chara, pondweed and watercress) formed a dense mat completely across the stream in many areas. Stream banks were about 75 percent stable with willows and cottonwood trees providing about 50 percent stream shading. Substrates of the stream were highly dominated by sand, silt and organic muck with only about 10 percent gravel and rubble. Livestock grazing has had considerable impact on the streamside communities of this area.

Site S-1 (Plate VI, picture 4), 1 mile west of Santa Clara, Utah. The Santa Clara River was heavily silted from Gunlock Reservoir downstream to the Virgin River, resulting from geological formations plus poor management of the drainage. At S-1 50 percent of the substrate was sand-silt which explains the poor pool quality (Class IV and V) and poor riffle/pool ratio of 2:1. Bank cover and stability were both low, 25 and 63 percent respectively. Cattle were present and grazing damage was high. There was only approximately 20 percent of the stream shaded, provided mostly by cottonwood trees and willows.

Water quality. Table 23 contains selected water quality parameters determined on 19 February 1976. Santa Clara River waters as they come off Pine Valley Mountain are moderately soft but as they proceed down through the drainage dissolved solids increase. Baker Dam and Gunlock Reservoirs act as catchment basins for nutrients and suspended solids. The high levels of nitrate nitrogen at S-4 almost certainly came from sources below Baker Dam Reservoir, probably livestock and domestic wastes which is supported by the high fecal coliform count of 93/100 ml at S-4 and S-3.

Water quality at sites S-5, S-4 and S-3 were all within acceptable limits except fecal coliform numbers at S-4 and S-3 and nitrate nitrogen at S-4. At site S-1 sulfates were reaching levels of concern for culinary use but still acceptable for agricultural uses. Water quality of the Santa Clara River was well above that of the Virgin River at the point of confluence of the two rivers (Tables 2 and 23).

Macroinvertebrates. An analysis of benthic sampling efficiency at site S-3 reveals that 4 samples were sufficient to estimate the benthic macroinvertebrate populations. The percent standard error of the mean was 16.5 which was within the acceptable limit of 20 percent and the coefficient of variance was only 33.1 (Table 24).

The macroinvertebrate communities of the Santa Clara River (Tables 25 and 26) showed considerable variance in population dominance diversity values, $\bar{d}$ and H.

At site S-5, mayflies were dominant (Ephemeroptera--61 percent) with members of the family Baetidae numbering 6004 per square meter. Baetids are one of the most important grazers of streams, feeding on algae and converting it to animal tissue. A dominance of baetids is common in streams subject to physical stress such as fluctuating flows and shifting substrates. There were a total of 33 macroinvertebrate taxa collected at S-5 with diversity values $\bar{d}$ and H of 2.96 and 2.89 respectively. Density and biomass was high enough to provide an energy base for a moderate fisheries.

Community diversity was good at S-4 near Veyo even though the number of taxa was only 20 (Table 25). The mean number per square meter was nearly the same as at S-5, however the number of individuals were more evenly distributed among the representative taxa. Oligochaetes, chironomids and baetids were dominant reflecting the heavy organic load and fine substrates at S-4 (Table 26).

Community density at S-3 was only $1991/m^2$ and biomass $1g/m^2$ (Table 25). The channel appeared unstable and subject to recent extreme flows which could have caused extensive substrate scouring with a reduction in bottom faunal density. The scouring also caused community diversity to rise to 3.39 ($\bar{d}$) and 3.12 (H) by reducing dominance of the more populus taxa. 29 macroinvertebrate taxa were collected at S-3 with baetid mayflies, blackflies (Simuliidae) and midges (Chironomidae) representing the dominant forms (Table 26). All three of these taxa are active drifters and frequently are among the first groups to repopulate an area following a period of stress.

As described above, S-2 was more of a pond habitat than that of a stream, therefore only qualitative kick samples were taken to evaluate the aquatic insect fauna. The benthos data, therefore, is not truly comparable to that gathered at other sites. Twelve taxa were collected as larval immatures with 9 more species collected as adults for a total of 21 taxa (Table 26) most of which were characteristic of lentic or still waters (Table 26).

The benthic communities at station S-1 just above Santa Clara were characterized by high density and biomass, and reduced dominance diversity (Table 25). There were 20 taxa collected with blackflies (Simulium sp.), midge larvae (Chironomidae) and worms (Oligochaeta) representing the dominant forms at 33 percent, 11 percent and 47 percent respectively (Table 26). Siltation resulting from the sparsely vegetated nature of the surrounding watershed combined with riparian habitat damage caused by livestock and organic enrichment from agriculture and livestock wastes caused the conditions which favored the high number of oligochaete worms. The near absence of stoneflies and caddisflies indicates the severe environmental stresses at this site.

Management alternatives. The best possible areas for potetial cold water fishery appeared to be above Baker Dam Reservoir to the Dixie National Forest Boundary and from Baker Dam Reservoir spillway to where the river emerges from the canyon below Veyo. These stream sections had the best overall aquatic habitat in terms of riparian vegetation and available fish food. Fecal coliform counts were high, at least below the dam, and warrant further investigation. Cattle access along the river should be limited to permit revegetation of overgrazed areas. Dewatering below Baker Dam Reservoir has been a problem to existing fisheries and required minimum flows should be determined.

Beaver Dam Wash

East Fork

Description. Beaver Dam Wash runs in a southerly direction parallel to the Utah-Nevada state line with waters originating along the southern edge of the Dixie national Forest. Headwaters are mainly in Tertiary sedimentary rocks, with the stream then flowing through Calville Limestone, the Muddy Creek formation and then into a large area of alluvium and sandstone of the Quaternary period.

Both East and West Forks are permanent streams for most of the stream reaches but flows in the East Fork become very low during late summer, fall and winter months with periods of zero flow near the confluence with West Fork. The main stream is intermittent in the lower stream reaches due to agricultural water diversions and loss to underground reservoirs. East Fork is about 8 miles in length, most of which is administered by BLM, but some lands along the stream are private ranches and are posted and fenced.

Two sampling sites were established on East Fork with S-1 being about 1 mile below and S-2 about 1 mile above Goldstrike (Fig. 2, Plate VII, pictures 3 and 4). The watershed of East Fork is predominantly Pinõn-Juniper with some Ponderosa Pine in the upper reaches.

Aquatic habitat. Stream habitat is summarized in Table 27. The stream channel was wide averaging 55 feet and highly eroded with evidence of scouring such as lack of periphyton on the rocks. The substrate was also clogged with coarse sand and very little silt which could indicate the existence of hyporheic macroinvertebrate communities. The hyporheic habitat is important in sustaining the benthic fauna by providing a refuge from extremes of current and temperature (Hynes, 1972, p. 407). The benthic communities are indeed subject to high water temperatures and extreme flow variation from dewatering in late summer and fall to spring runoff and summer storm freshets.

The riparian habitat at S-1 below Black Canyon was deteriorated with the total channel being ten times as wide as the watered channel. Limited streamside vegetation consisted of Pinõn-Pine, Palmer Oak and sparse grass cover. Pool/riffle ratio was good at 86 percent; however, pool quality was poor because of the reduced flow, shallowness of the water and lack of cover. Ungulate damage was evident at S-1.

Bank cover and stability were better at S-2 where riparian vegetation was more dense and the channel was not as eroded and widened compared to S-1. Ungulate damage was much less than at S-1 with grasses and forbes providing a fairly dense ground cover in the canyon bottom.

Water quality. East Fork Beaver Dam Wash was typical for streams of this region (Table 28). Hardness, bicarbonate alkalinity and conductivity were relatively high. Nutrient levels were low which resulted in limited algal production which is an important factor in bottom fauna productivity.

The only concern in terms of bacterial contamination was fecal coliform which registered at 9 per 100 ml (MPN). This was probably the result of cattle grazing in the bottom lands.

Macroinvertebrates. The benthic communities (Tables 29 and 30) of the East Fork of Beaver Dam Wash reflected signs of environmental perturbation caused by such factors as dewatering in dry years, scouring and eroded substrate caused by flooding, and elevated water temperature due to the wide, shallow, exposed nature of the stream channel coupled with hot desert climate. The communities at S-1 and S-2 were dominated by black flies and midges (Diptera-true flies) composing 80 percent and 79 percent respectively (Table 30). At site S-2, the blackfly, Simulium sp., composed 67 percent of the bottom fauna which accounts for the relatively low diversity indices of 1.74 ($\bar{d}$) and 1.70 (H) (Table 29). The higher diversity indices at S-1 indicated that no taxa dominated the community as strongly as the blackflies at site S-2. This low dominance at S-1 could have resulted from flash floods which occurred in the region the week before the samples were collected. Such scouring tends to 'even out' the community by partially eliminating those taxa which are most abundant, thus causing an increase in the diversity index. This does not, however, always mean the benthic fauna is in better condition. On the contrary, the aquatic habitat at S-1 appeared to be of lower quality than at S-2. However, the benthos did not reflect this condition. There were 20 taxa collected at S-1 compared to 15 at S-2. Macroinvertebrate taxa which are characteristic of such unstable desert streams and which were present in East Fork Beaver Dam Wash include: Tricorythodes sp., Capnia wanica, Ambrysus woodburyi, Psychomyiidae and Ceratopogonidae (Table 30).

Management recommendations. The upper reaches of Beaver Dam Wash, East Fork could support a limited fishery if there were sufficient waters. Small, non-game fishes would have a better chance of survival than trout or other cold water game fish. Additional studies are recommended to determine the extent of dewatering and the associated impact on the aquatic resource in terms of algal and macrobenthos production. Grazing rights sould be limited especially along the upper reach above Goldstrike in order to preserve the riparian vegetation. Summer high water temperatures may be a limiting factor to many fish species.

Beaver Dam Wash

West Fork

Description. The waters of West Fork Beaver Dam Wash join those of East Fork at the small deserted ranching settlement of Motoqua. West Fork is about 14 miles long, most of which is administered by the BLM. Its waters originate in Nevada and flow in a southeasterly direction entering Utah and continuing south, becoming intermittent and eventually drying up in a valley west of the Beaver Dam Mountains. Waters are diverted for agricultural needs at several small ranches along its course.

Geologically the waters flow through undifferentiated, tertiary volcanic rock, until just south of Sullivan Ranch, where it enters Quaternary colluvium and alluvium deposits.

The watershed was characterized by Pinõn-Pine forest with desert shrub and cactus in the lower elevations.

One sampling site was established about 1 mile above Sullivan Ranch just below the confluence with Slaughter Creek. The survey was conducted on 18 February 1976. Observations were made along most of the stream reach but due to the homogeneity of habitat in the study area only one sampling site was established (Figure 2; Plate VII, pictures 1 and 2).

Aquatic habitat. The stream channel at the survey site was twice as wide as the stream itself and had numerous signs of channel changes. The system was apparently subject to extreme fluctuations in flow, common to this region, which had resulted in moderate bank instability. The riparian vegetation was quite sparse consisting of willow, cottonwood, and associated grasses and forbes. Ungulate damage was less than 50 percent with only limited bank slough as a result of cattle grazing.

At the time of sampling the flow was adequate to sustain a healthy fishery, being one of the better streams surveyed in this study. However, pool/riffle ratio and bank cover percent optimum were quite low at this site, being 40 percent and 41 percent respectively (Table 31). Ocular surveys revealed an improving trend as one proceeded up the canyon but this area was mainly on private lands. The substrate was in good condition with 77 percent being desirable materials and spawning gravels comprised 35 percent of the total.

Water quality. As noted in Table 28, the waters of West Fork Beaver Dam Wash were a little softer than those of East Fork. This was a reflection of the volcanic nature of nearly all the upper drainage of West Fork. Nutrient levels were quite similar with the exception of ortho-phosphate which being extremely low was probably the limiting factor in algal periphyton production.

Total and fecal coliform values of 210 and 4 per 100 ml respectively, were well within acceptable standards and indicated little or no recent contamination from livestock activity.

Macroinvertebrates. The statistical analysis of sampling efficiency for West Fork Beaver Dam Wash was similar to that of Ash Creek (Tables 13 and 32) with the percent standard error of the mean and the coefficient of variation at 17.1 and 34.2 respectively. This substantiates the efficiency of sampling techniques in providing adequate data for describing the benthic macorinvertebrate communities (Table 32).

As noted in Tables 29 and 33, West Fork Beaver Dam Wash had one of the most diverse and healthy benthic faunal communities in the study area. Thirty macroinvertebrate taxa were collected, 27 collected from the stream plus three species of adult stoneflies (Plecoptera). The density was not excessive numbering 6682 organisms per square meter with the numbers of individuals well distributed among the 30 different taxa thus yielding excellent diversity index values of 3.43 ($\bar{d}$) and 3.32 (H). The percent composition by order (Table 29) reflects these distributional patterns. The dominant taxa collected included the mayflies, Baetidae; stoneflies, Capniidae; caddisflies, *Hydropsyche* sp. and *Cheumatopsyche* sp.; true flies (Diptera), *Simulium* sp., Chironomidae and *Euparyphus* sp.; and other invertebrates including Oligochaete worms and Hydracarina watermites (Table 33). Many of these and other species collected are characteristic of southern desert streams. Because of the large size of some of these species (eg. *Corydalus* sp., *Hydropsyche* sp., and *Cheumatopsyche* sp.) biomass was high averaging 5 grams dry weight per square meter. These data indicate ample energy resources within the benthic communities to support a productive trout fishery. The limiting factors would be stream habitat and minimum flows.

Management alternatives. West Fork Beaver Dam Wash has the best potential for sustaining a valuable fishery on BLM lands in this region. Additional surveys would have to be completed to determine minimum flows during late summer and fall. Water quality and the macrobenthic communities appear adequate to support such a fishery resource. The associated riparian habitat is critical in maintaining a productive fishery and should be preserved or improved as part of the management program for both West and East Forks of Beaver Dam Wash.

Pine Park Creek

Description. Pine Park Creek is a small attractive stream located along the western edge of Dixie National Forest. It flows for about 7 miles in a westerly direction into Nevada (Figure 2). Approximately 2 miles of stream reach is administered by BLM. The surrounding watershed is forested by Piñon Pine, Juniper, and Ponderosa Pine. Geologically the watershed consists of undifferentiated tertiary volcanic rocks.

One sampling site was established about 300 meters downstream from Pine Park Campground (Fig. 2; Plate VIII, picture 11).

Aquatic habitat. The riparian habitat was characterized by willow, rabbitbrush, and grasses which together with large rock created a stable bank and provided adequate cover in most areas (Table 34). Grazing was evident in the area, but damage was minimal with good bank grass cover in most places. Riffle/pool ratio was good, with pool quality at 72 percent optimum. The only priority A limiting factor which was of concern was the percent of desirable substrate material which registered at 36 percent most of which was sand. The stream channel appeared to be subject to extreme flow fluctuations with the average width at 29 feet. Average stream gradient was 3 percent and stream width 9 feet. Large rock, willow, Ponderosa and Piñon Pine provided shade for about 45 percent of the stream.

Water quality. The water quality reflected the volcanic or basaltic nature of the watershed's geology (Table 28). The stream was a moderately soft water, low bicarbonate system compared to other streams in that region. Conductivity and total dissolved solids registered at 168 µmhos/cm and 140 mg/l respectively. Nutrient levels were moderate, allowing for adequate growths of periphyton.

Bacteria counts were low with total coliform at 43/100 ml and fecal at <3/100 ml indicating very little cattle or recreational impact.

Macroinvertebrates. Pine Park Creek had one of the best balanced benthic communities in the entire study area (Plate VIII, picture 2). There were 30 taxa present with a mean density of 12,051 organisms per square meter (Tables 29 and 35). The number of individuals were evenly distributed among several taxa thus yielding dominance diversity indices of 3.48 ($\bar{d}$) and 3.41 (H). The largest single percentage composed by one taxa was Baetidae (mayflies) at 27 percent. 16 of the 30 taxa collected were caddisflies and dipterans (true flies) with only 2 taxa of mayflies and 3 of stoneflies. This is a reflection of the extreme flow fluctuations and warm summer temperatures.

Management alternatives. The region appears to have had minimal impact to date from cattle grazing. If this trend could be maintained in the future, the area could probably sustain a limited fishery. Due to the moderately soft water nature of the system, it is quite fragile. Increased nutrients and destruction of riparian vegetation could cause significant perturbation of the resource in the form of excessive algal production and increased erosion and associated siltation. Bank riparian vegetation communities should be protected--this action will do more as far as preserving stream stability and quality than any other management alternative.

Cottonwood Canyon

On our 19 February 1976 sampling day, Cottonwood Creek was dry. Other streams in the area such as Leeds and Leap Creeks were all flowing. From these observations it was deduced that Cottonwood Creek is intermittent with frequent periods of zero flows. Habitat around Cottonwood Creek was very similar to that of Leap Creek so additional survey work was not conducted for this stream.

Grazing impacts will have an impact on the fisheries potential of this stream but streamside vegetation should be protected to prevent extensive channel erosion and added silt loads to the Virgin River.

Bull Canyon and Sheep Canyon

Both of these canyons were inaccessible during sampling trips.

The Sheep Canyon drainage is similar to that of Pine Park Canyon and similar conditions are assumed to exist in both streams, although this will have to be verified through an aquatic habitat survey.

Bull Canyon is a tributary to East Fork Beaver Dam Wash with the confluence about two miles upstream of the higher sampling site (S-2) on East Fork. Due to the low flows of East Fork it is assumed that Bull Canyon Creek also is subject to seasonal low flows, perhaps nearing intermittent status. Water quality was high for the drainage thus Bull Canyon runoff is also assumed to be of high quality. Mr. Neil Armantrout (BLM fisheries biologist, personal communication) reported that Bull Canyon Creek was dry during the summer of 1976.

Bull Canyon's main importance to the fisheries of Beaver Dam Wash would be as a quality water source. Management should be aimed at protection of the vegetation of the drainage to insure low erosion and silt loads.

— PART II. RESERVOIRS —

RESULTS AND DISCUSSION

Little Creek Mountain Reservoirs

Little Creek Mountain is located south-east of Hurricane, Washington County, Utah. It is a large flat plateau with the top mainly of the Triassic Chinle formation intermixed with some Shinarump Conglomerate with associated petrified wood (Fig. 3). Surrounding the plateau are extensive Moenkopi formation deposits. To the east-northeast of the reservoirs are several quaternary volcanic flows and cones, one quite prominent.

The dominant vegetation is piñon-juniper with sagebrush, grasses and sparse herbs. Vegetative growth is highly seasonal with most occurring in the spring associated with warm weather and shower storms. The summers are very hot and dry and most herbaceous plants die off. The plateau is heavily used for fall-winter grazing of livestock.

On the plateau are extensive areas of sandstone slick-rock. The reservoirs are merely a damming up of the lower portion of the drainage off these slick-rocks with no continuous inflow or outflow of water (Plate IX, 1, 2, 3). The reservoirs are heavily silted, shallow and largely void of shoreline vegetation. Summer water temperatures are high as are evaporation rates. It is doubtful that under present conditions any of these reservoirs could support a quality fisheries except for seasonal put-and-take management.

Five reservoirs were sampled and several others observed (Fig. 3). They were all fairly homogeneous as to physical characteristics with the surface area varying from one-tenth acre to one and one-half acres and the maximum depths from one to four meters.

Aquatic macroinvertebrates were scarce in all reservoirs sampled and consisted mainly of zooplankton and midge larvae.

The main factors considered for an environmental evaluation of these reservoirs besides physical features were water quality and algal data.

Reservoir #1. As seen in Table 36 the waters of this reservoir were quite soft and low in total dissolved solids. They were bicarbonate buffered with a pH of 7.8 and total alkalinity of only 50 mg/l as $CaCO_3$. Nutrients were low and the relatively high proportion of ortho-phosphate to nitrate would indicate that nitrate is probably the limiting factor for this reservoir. The presence of coliform bacteria is not surprising considering the extensive cattle grazing near these reservoirs, but the levels of total and fecal coliform bacteria were not high enough to cause concern.

Following is a list of algal species from Reservoir #1 on 13 April 1976.

Chlorophyta and Euglenophyta	Relative abundance
Euglena species	rare
Sphaerellopsis alata	rare
Staurastrum sp.	rare

Diatoms	Percent composition
Asterionella formosa	3
Cocconeis placentula var. lineata	3
Cymbella ventricosa	3
Diatoma vulgare	5
Fragilaria construens var. venter	3
Navicula cryptocephala var. veneta	8
Navicula tripunctata	3
Nitzschia palea	5
Stephanodiscus astrea var. minutula	62
Stephanodiscus niagarae	5

Shannon-Weaver Diversity Index on Diatom Data: 1.474

The 24 liter biomass from Reservoir #1 was lowest of any of those sampled during this study. Phytoplankton biomass was especially low with zooplankton biomass accounting for most of the total biomass. Zooplankton biomass was comparable to that in the previous two samples and in Reservoir #4. Reservoir #1 supported an impoverished green and blue-green algal flora and the diatom dominance diversity was moderate to low due to the dominance of Stephanodiscus astrea var. minutula which is often found in the winter and early spring in reservoirs and lakes with marginal to poor water quality. These factors taken together seem to indicate that on the basis of this single sample, Reservoir #1 is of marginal water quality, perhaps the result of its small size and limited habitat variety.

Reservoir #1 had a maximum depth of 5 feet, length of 213 feet and a surface are less than one-fourth acre. Maximum depth on 13 April 1976 was only 2 feet. There was no inflow or outflow the date of sampling. The shoreline was mostly regular with very little indentations or projections. Limiting factors to biological productivity for this reservoir would be small size, shallowness, evenness of shoreline, summer temperatures, low dissolved oxygen, and seasonal drawdown due to evaporation.

This reservoir was poor in quality and should be managed as a watering hole only.

Reservoir #2. The physical-chemical features of Reservoir #2 were nearly the same as #1 so no biological samples were taken but a water quality analysis was made. Again the water quality reflects the nature of the basin as the waters are merely runoff from sandstone slick-rocks. Waters were moderately soft, pH was 7.6 and total dissolved solids were only 119 mg/1 (Table 36). Sulfates were higher at this reservoir than at #1 as was also nitrate nitrogen. This could indicate a heavier impact from grazing or a different stage in the algal-zooplankton cycle. Algal blooms often follow build-ups of nutrients and cause rapid depletion of one or more of the available nutrients. The amount of the nutrient species that is first depleted is usually the limiting factor to algal productivity and productivity ceases whenever any one of the required chemical species is depleted.

This reservoir is of little biological value under present conditons and has the same limiting factors as Reservoir #1 (Plate IX, 2).

Reservoir #3. This reservoir is located in Ab's Clearing (Fig. 3) and was similar in appearance to the other Little Creek Mountain Reservoirs. It had a length of about 165 feet, a shoreline of approximately 930 feet and a maximum depth of 3 feet. Water had been fairly permanent as attested to be the presence of cattails along one side (Plate IX, 1).

There were dense algal mats on substrate materials around the edges and the water had a greenish-brown cast, probably the result of high numbers of the green alga *Spirogyra weberi* which was listed as abundant. This reservoir would probably be classified as eutrophic and the levels of nitrates and phosphates (Table 36) were not indicative of the total nutrient input. Inside the gelatinous algal strands were numerous chironomid midge larvae, also indicative of high organic loads in the system.

Dissolved oxygen could very well be depleted during periods of decomposition of the large algal biomass. This reservoir, due to shallowness, small size and tendencies towards high temperatures and low dissolved oxygen levels has an extremely low potential for supporting a fisheries.

Following is a list of algal species and their relative densities.

Chlorophyta and Cyanophyta	Relative abundance
Closterium lanceolatum	rare
Spirogyra grevilleana (?)	rare
Spirogyra weberi	abundant
Spirogyra species	rare

Diatoms	Percent composition
Achnanthes minutissima	70
Fragilaria capucina var. *mesolepta*	9
Nitzschia palea	7
Synedra acus	13

Shannon-Weaver Diversity Index on Diatom Data: 0.9178

The 24 liter biomass at this site was the highest of any observed sample. Spirogyra spp. were responsible for this increased biomass. It is difficult to assess water quality according to Spirogyra, except that when biomass reaches extremely high levels it can have bad effects on the aquatic system. It would be necessary to see the duration of the Spirogyra bloom to determine if this is a problem. Diatom dominance diversity was low at this site due to the prominence of Achnanthes minutissima which tends to have a very broad range of occurrence in western waters. More samples are necessary to determine the exact trophic nature of this reservoir.

Reservoir #4. This reservoir was located next to a range improvement project where the piñon and juniper trees have been chained down to allow growth of grasses, herbs, and shrubs. The banks of this reservoir were barren of any vegetation-upland, emergent or submergent. The waters had a brown transparent color possibly as a result of leached materials from the cleared adjoining lands.

Water quality was good (Table 36) evidenced by the high algal diversity and low total biomass. Following is a list of algal species collected. The high numbers of zooplankters may indicate a previous algal bloom which had dissipated the nutrient levels (nitrates and ortho-phosphates) introduced from the cleared watershed. This could explain the brown color of the waters.

Chlorophyta, Euglenophyta and Pyrrhophyta	Relative abundance
Ceratium hirundinella	rare
Closterium lanceolatum	rare
Cosmarium species	rare
Euglena species	rare
Peridinium cinctum	rare
Spirogyra weberi	rare
unknown Chlorophyta	rare-common

Diatoms	Percent composition
Achnanthes lanceolata	2
Achnanthes minutissima	11
Cocconeis placentula var. lineata	1
Diatoma vulgare	3
Fragilaria capucina var. mesolepta	5
Gomphonema angustatum	10
Gomphonema intricatum	1
Gomphonema olivaceum	4
Hantzschia amphioxys	1
Navicula cryptocephala var. veneta	9
Navicula radiosa	1
Navicula tripunctata	1
Nitzschia dissipata	33
Nitzschia frustulum var. perminuta	1
Nitzschia palea	19
Stephanodiscus niagarae	1

Shannon-Weaver Diversity Index on Diatom Data: 2.156

The 24 liter biomass was light at this site and was composed mostly of zooplankton. This reservoir has near zero fisheries potential and should be managed as a livestock and wildlife watering hole. Shoreline vegetation could provide cover, shade and wind protection for the reservoir and enhance its value for wildlife usage.

Reservoir #5. This was the largest of the Little Creek Mountain Reservoirs observed and the only one with a real fisheries potential. There were several areas adjoining the reservoir that showed evidence of ground water - e.g. rushes and reeds, wet ground and recent stream bed flows into the reservoir. There was extensive shoreline irregularities such as rock outcroppings providing good fisheries habitat (Plate IX, 3). Water depth (11 feet on 13 April 1976, Table 36) was adequate to indicate good overwintering possibilities, at least under the mild winter conditions of the area. Several types of macroinvertebrates (beetles, midges, and zooplankton) were observed indicating an adequate basis for energy conversion from algae to organisms suitable for fish consumption.

Reservoir banks were stable with growths of upland vegetation (trees and shrubs) and several clumps of emergent rushes. Grasses were overgrazed and spotty in distribution.

Water quality was good except for the high total coliform counts and the brown color of the water. Cattle use was severe in this area which probably accounted for most of the organic enrichment of the waters and the brown color.

Limiting factors for Reservoir #5 would mainly be related to size which would limit the size of fisheries and the fishing pressures allowed. Organic enrichment could become a severe problem causing possible periods of deoxygenation and undesirable algal species to become dominant.

Red Mountain Lakes

The Red Mountain Lakes are merely depressions in red sandstone slick-rock (Plate X, 1, 2, 3). Many of them are now either entirely filled in with sand and silt or nearly so. Those observed by the author on 30 April 1976 varied from small mudholes with water 1 inch or less in depth to two large ones of approximately the same size--12 feet long by 7 feet wide and maximum depths of eight inches. The preceding months had been exceptionally hot and dry and existing water levels were far below capacity. One had a maximum depth nearing five feet before spillover with the others varying from five feet to only several inches.

Red Mountain is a large sandstone table mountain of Navajo and Kayenta sandstone with sheer cliffs on the south, east and west. At the base, Red Mountain is surrounded by Quaternary alluvium, sand dunes and basalt flows. This topography has resulted in a relatively isolated condition for the wildlife of Red Mountain. Coyotes, rabbits, lizards and numerous birds were observed in the area with signs of small mammals, deer and other wildlife everywhere. The area is a natural refuge and should be managed as such.

The Red Mountain Lakes serve as watering holes for the abundant wildlife which depend heavily on these lakes for their existence.

A water sample was taken from one of the two larger pot holes and analysis results are given in Table 37. Waters were soft, low alkalinity, neutral pH, low total dissolved solids and moderately low nutrients. Total and fecal coliform bacteria were both present in low numbers. The waters were within Class C standards for all parameters measured. With the small size of the lakes and intimate association of wildlife to these waters, they shouldn't be used for human consumption.

There were only seven species of algae found in the samples of 30 April 1976. Following is a list with their relative abundance.

Chlorophyta and Cyanophyta	Relative abundance
Cosmarium species	rare-common
Gomphosphaeria lacustris	rare-common
Oscillatoria species	rare

Diatoms	Percent composition
Achnanthes minutissima	11
Navicula cryptocephala var. *veneta*	7
Pinnularia brebissonii	18
Synedra acus	64

Shannon-Weaver Diversity Index on Diatom Data: 1.0232

Along with the algae there were numerous brine shrimp (*Artemia cinereus*) and ceratopogonid biting midge larvae (*Culicoides* sp.). These forms are common in temporary desert ponds and puddles. The biota was simple in diversity as would be expected from this types of habitat.

It is recommended that Red Mountain be closed to domesticated animals and the area be preserved for wildlife only. There should be no improvement to roads entering the area and the only management of Red Mountain Lakes recommended from this study would be: 1) the removal of sand from some of the pot holes thus increasing their storage capacity; and 2) blockage of the drainage of others allowing them to capture a greater percentage of the natural runoff.

Baker Dam Reservoir

Baker Dam Reservoir is located on the Santa Clara River north of Veyo, Utah (Figure 2; Plate VIII, pictures 3 and 4). Inflow comes from the Santa Clara River plus several small springs. The only outflow is the Santa Clara River. The reservoir is used for irrigation storage and recreation.

Baker Dam Reservoir is located below agricultural lands with nutrient and bacteria input from cattle grazing and feed yards and possibly human dwellings. This becomes evident from the water quality data presented in Table 38. At the inlet both total and fecal coliform bacteria levels were high, 460 and 93/100 ml respectively, compared to the open reservoir waters which had only 4 and 4 respectively. Inlet waters had significantly higher nutrient concentrations than the open water areas. The high pH indicates removal of most of the free CO_2 by phytoplankton, especially in the surface layers of the reservoir. The reservoir was not thermally stratified as evidenced by uniformity of waters between surface and bottom samples, probably in the middle of spring turn over.

There were some blue-green algae present in the algal samples (see the following list) but overall diversity was fairly high ($\bar{d}$=1.913). From these measurements it appears that Baker Dam Reservoir is bordering on mesotrophic to lightly eutrophic. It will require additional sampling to determine if there are problems of overproductivity.

Following is a list of algae collected from Baker Dam Reservoir on 14 April 1976.

Chlorophyta and Cyanophyta	Relative abundance
Closterium acerosum var. *elongatum*	rare
Lyngbya aerugineo-caerulea	common
Sphaerocystis schroeteri	common
Spirogyra weberi	rare
Spirogyra species	rare
unknown Chlorophyta	rare
(possibly *Oocystis* species)	rare

Diatoms	Percent composition
Achnanthes lanceolata	3
Achnanthes minutissima	1
Amphora ovalis var. *pediculus*	3
Asterionella formosa	3
Caloneis ventricosa var. *subundulata*	1
Cocconeis placentula var. *lineata*	1
Fragilaria capucina var. *mesolepta*	25
Hannaea arcus	7
Melosira varians	4
Navicula cryptocephala var. *veneta*	2
Nitzschia palea	18

Diatoms (con't.)	Percent Composition
Nitzschia sinuata var. *tabellaria*	1
Stephanodiscus astrea var. *minutula*	32

Shannon-Weaver Dominance Diversity Index ($\bar{d}$) on Diatom Data: 1.913

The 14 liter biomass was second to the the highest of reservoirs sampled during this study. The majority of algal biomass was composed of diatoms. Dominance diversity was higher than in many northern Utah reservoirs at this time of year, but this is to be expected with the mild winters and early spring warming in southern Utah.

The Bureau of Land Management has jurisdiction over such a small portion of the shore line of Baker Dam Reservoir and the upstream banks of the Santa Clara River that impacts to the reservoir from grazing practices on their lands would be insignificant compared to the total. The major benefit from good grazing management on BLM lands would be "education by example" for private land owners in the area.

Baker Dam Reservoir should be able to assimilate moderate nutrient loads without going highly eutrophic. Under present conditions Baker Dam Reservoir should maintain its present quality; but with significant increases in nutrient or bacteria inputs the reservoir water quality could deteriorate drastically in a short period of time.

Gunlock Reservoir

Gunlock Reservoir is a new reservoir with high recreational use pressures. A Utah State Park has been established at the south end of this reservoir with associated boat launch, parking, picnic tables and restroom facilities. Boating, water skiing, swimming and fishing are all common activities on the reservoir with lakeside camping also common.

The Santa Clara River is the only major inflow and outflow. The shoreline was stable and consisted mainly of sand and sandstone with some Carmel formation sand-clay. There was no rooted aquatic vegetation and shoreline vegetation was sparse.

There was no evidence of cattle grazing near the reservoir, mainly as a result of the topography--e.g. steep hillsides and sparse vegetation (Plate IX, picture 4). The Bureau of Land Management has jurisdiction over about 10 percent of the shoreline which is largely inaccessible to cattle and thus is not subject to grazing impacts. The greatest impact from grazing comes from private lands along the Santa Clara River above the reservoir. This, plus the city of Gunlock, pose the greatest threats to water quality in this reservoir.

Table 39 presents a summary of water quality on 14 April 1976. The data are from a surface sample taken in the middle of the reservoir at the north end--depth approximately 12 feet and about 300 feet from the mouth of the Santa Clara River. Both nutrient (NO_3 and P) levels and bacterial counts indicate organic enrichment from upstream on the Santa Clara River. The pH values indicated moderate phytoplankton activity. There was no appreciable stratification with the reservoir in spring turn over.

Following is a list of algal species from 14 April 1976 samples.

Chlorophyta and Cyanophyta	Relative abundance
Cosmarium species	common
Pandorina morum	rare-common
Sphaerellopsis alata	rare
Sphaerocystis schroeteri	rare
Spirogyra weberi	rare

Diatoms	Percent composition
Achnanthes minutissima	4
Asterionella formosa	9
Cocconeis placentula var. lineata	22
Cymatopleura elliptica	1
Cymbella affinis	2
Fragilaria capucina var. mesolepta	57
Hantzschia amphioxys	1
Navicula cryptocephala var. veneta	2
Nitzschia palea	3
Synedra ulna	1

Gunlock Reservoir is probably mesotrophic with good water quality. Lakeside vegetation should be encouraged and upstream organic loading should be kept from increasing significantly. Algal growths at the present are not excessive, but with the warm temperature of the area the potential for nuisance blooms is high if the required nutrients are present in high enough concentrations. With the heavy recreational use, bacterial levels should be monitored regularly and levels kept within state standards. The main threat to the quality of this reservoir is from upstream water use rather than activities around the reservoir itself.

REFERENCES CITED

Brillouin, L. 1960. Science and Information Theory. 2nd Ed. Academic Press, New York. Cited by Wilhm, J. L., and T. C. Dorris. 1968. Biological parameters of water quality. BioScience 18:477-481.

Duff, Donald A. 1975. BLM manual supplement 6671 - stream surveys. Bureau of Land Management, Utah State Office.

Elliott, J. M. 1971. Some methods for the statistical analysis of samples of benthic invertebrates. Freshwater Biol. Assoc. Sci. Publ. 25. 144pp.

Hynes, H. B. N. 1972. The Ecology of Running Waters. University of Toronto Press. 555pp.

Reichert, M. K. 1975. Use of selected macroinvertebrates as indicators of sedimentation effects on Huntington River, Utah. Unpublished Masters Thesis, Brigham Young University. 284pp.

Shannon, C. E., and W. Weaver. 1963. The Mathematical Theory of Communication. University of Illinois Press.

Weber, C. I., ed. 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. National Environmental Research Center, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio. 176pp.

APPENDIX A

FIGURES

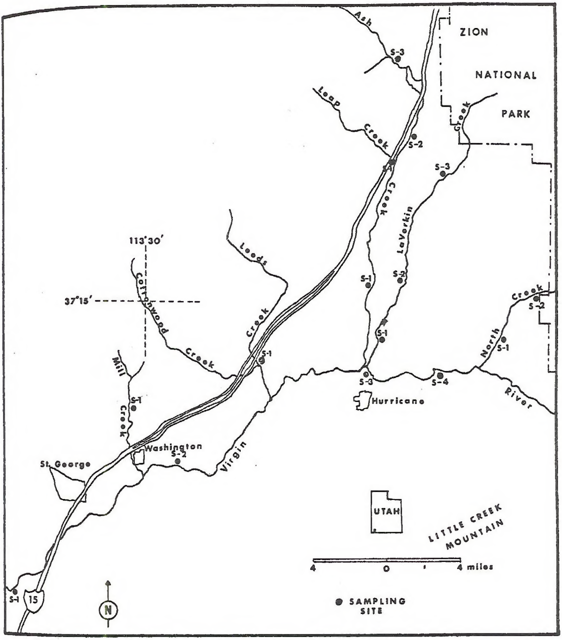


Figure 1. Study area within the Hurricane Planning Unit, Cedar City District, BLM.

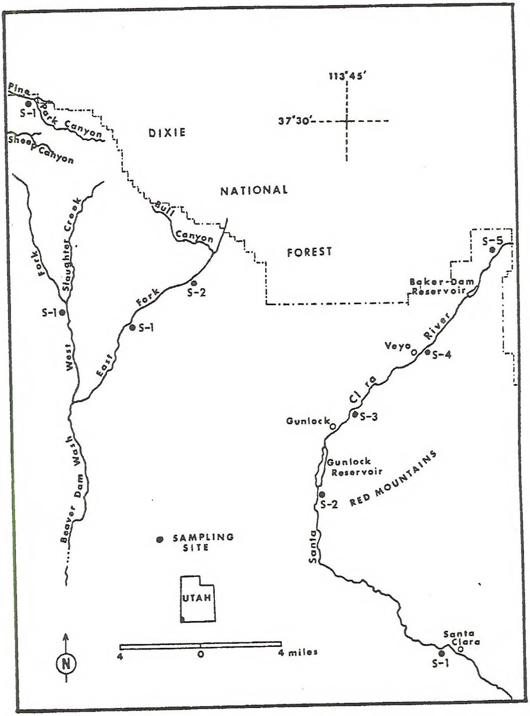


Figure 2. Study area within the Beaver Dam Planning Unit, Cedar City District, BLM.

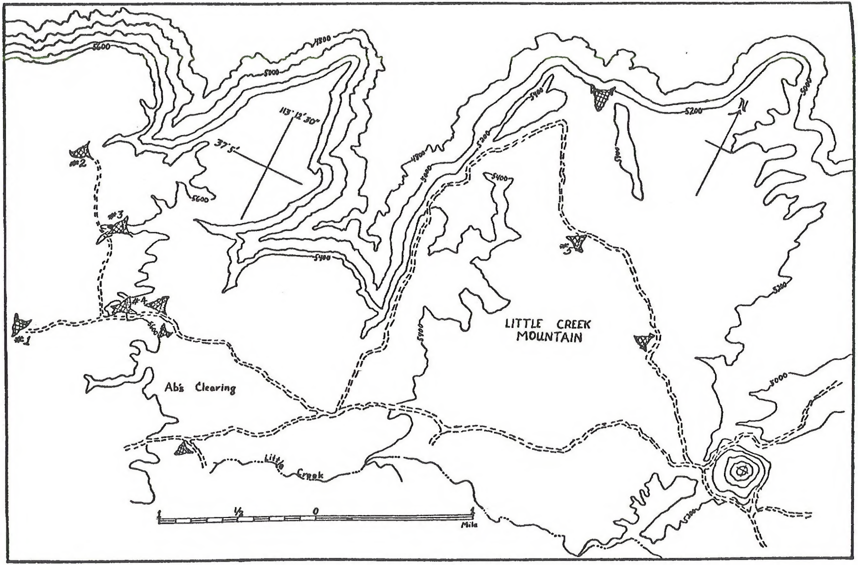


Figure 3. Little Creek Mountain with livestock watering reservoirs.

APPENDIX B

TABLES

Table 1. Stream habitat survey summary and analysis for the Virgin River on February 16, 1976.

1. State, County Utah, Washington	2. District Cedar City	3. Resource Area--P.U. Beaver Dam, Hurricane
4. Drainage Colorado River	5. Stream Unit Virgin River	6. Location T. 43S R. 17W Sect. 36
7. Investigators Winget, Baumann and (Reichert)		8. Date 16 Feb 76

General Data

9. Total length of stream (mi.)	42
10. Total length of stream surveyed (mi.)	
a. BLM	6
b. Public	-
c. Private	15
11. Total No. sample stations:	
a. BLM	4
b. Public	-
c. Private	-
12. Total of all stream width measurements (ft.)	367
13. Total channel width (ft.)	880
14. Total width--all pools (ft.)	122
15. Total width of all pools classed 1, 2, and 3 (ft.)	30
16. Total footage of desirable bottom materials (ft.)	112
17. Total spawning gravels (ft.)	25
18. Sum of cover ratings	12
19. Sum of stability ratings	16
20. Elevation: (MSL)	
a. Lowest	2800
b. Highest	6200
21. Multiple use zones	Agricultural Recreation
22. Number of camera points	
23. Total cost	
a. Planning	
b. Salaries	
c. Equipment	
d. Analysis of data	
24. Cost per station	

Priority A Limiting Factora

25. Percent of total stream width in poola	33%
26. Pool-riffle ratio, % optimum	66%
27. Pool quality, % optimum	16%
28. Percent of stream bottom with desirable materials	31%
29. Percent spawning gravels	7%
30. Bank cover, % optimum	38%
31. Bank stability, % optimum	50%
32. Percent of habitat optimum	40%

Priority B Limiting Factors

33. Average depth of stream (ft.)	0.9
34. Average width of stream (ft.)	92
35. Average width of channel (ft.)	220
36. Percent of bottom with clinging vegetation (ft.)	5%
37. Percent of bottom with rooted vegetation (ft.)	<1%
38. Percent stream shade	8%
39. Average stream gradient (%)	2.6%
40. Average stream velocity (f/s)	1.2
41. Stream discharge (cfs)	62
42. Average water temperature: (°F or °C)	10
43. Average Air Temperature (°F or °C)	13
44. Turbidity description muddy	83 JTU
45. Access (mi.):	
a. Remote	-
b. Low standard trails	-
c. Improved trails	-
d. Low standard roads	-
e. Improved roads	30
46. Water quality analysis:	
a. Hach kit	✓
b. Chemical (BYU)	✓
c. Coli (BYU)	✓

Table 2. Water quality analysis for the Virgin River during January and February 1976.

Test	Sampling Site S-1 below Bloomington	S-2 above Washington	S-3 below LaVerkin	S-4 above LaVerkin
Date	19 Feb 76	16 Feb 76	16 Feb 76	15 Jan 76
Time	1415	1715	1525	1520
Field Tests				
Dissolved Oxygen as O_2, mg/l	—	9	—	9
pH	—	7.8	7.3	—
Salinity, ppt	—	1	1.2	—
Turbidity, JTU	75	90	140	27
Water Temperature, °C	13	10	8	8
Air Temperature, °C	20	10	11	10
Laboratory Tests				
Alkalinity, total as $CaCO_3$, mg/l	240	199	223	189
Bicarbonate as HCO_3, mg/l	293	240	272	226
Boron as B, µg/l	410	320	350	—
Calcium as Ca, mg/l	160	122	127	74
Carbonate as CO_3, mg/l	<1	2	<1	3
Chloride as Cl, mg/l	279	191	246	55
Conductivity, µmhos/cm (25°C)	1980	1320	1520	783
Hardness as $CaCO_3$, mg/l	658	446	469	314
Hydroxide as OH, mg/l	<0.1	<0.1	<0.1	<0.1
Magnesium as Mg, mg/l	63	34	37	31
pH	8.3	8.4	8.05	8.4
Potassium as K, mg/l	17.4	12.7	1.3	3.8
Silica as SiO_2, mg/l	—	—	—	8
Sodium as Na, mg/l	230	155	190	52
Sulfate as SO_4, mg/l	470	276	286	140
Total Dissolved Solids mg/l @ 180°C	1371	903	1001	483
Ammonia as N, mg/l	0.078	0.054	0.069	0.12
Nitrate as N, mg/l	0.73	0.53	0.49	0.52
Phosphate (ortho) as P, mg/l	0.053	0.014	0.016	0.003
Total Coliform, MPN/100ml	93	120	—	240
Fecal Coliform, MPN/100ml	93	23	—	9

Table 3. Summary of macroinvertebrate community analysis for Virgin River during January - February 1976.

Sampling Site	No. of Taxa	Mean #/m^2	Mean Biomass g/m^2	% Ephemeroptera	% Plecoptera	% Trichoptera	% Coleoptera	% Diptera	% Other Invertebrates	$\bar{d}$	H
S-1 At Bloomington	3	129	1.0	33	0	0	0	67	0	1.46	1.15
S-2 Above Washington	3	215	0.3	40	0	0	0	40	20	1.85	1.59
S-3 At LaVerkin	4	538	0.2	96	0	4	0	0	0	0.72	0.61
S-4 Above LaVerkin	13	13,116	52.0	63	2	1	2	28	5	2.24	2.20

Table 4. Number per square meter of macroinvertebrate taxa collected from the Virgin River during January and February 1976.

	Sampling Sites			
	S-1 below Bloomington	S-2 above Washington	S-3 below LaVerkin	S-4 above LaVerkin
PHYLUM ANNELIDA				
Class Oligochaeta	--	43	--	258
PHYLUM ARTHROPODA				
Class Arachnida				
Order Acarina				
Suborder Hydracarina	--	--	--	344
Class Insecta				
Order Ephemeroptera				
Family Baetidae				
Baetis spp.	43	86	473	624
Baetis sp.		A*		
Family Leptophlebiidae				
Paraleptophlebia sp.	--	--	--	22
Family Ephemerellidae				
Ephemerella inermis	--	--	22	1011
Family Tricorythidae				
Tricorythodes sp.	--	--	22	581
Order Plecoptera				
Family Capniidae				
Capnia wanica	--	--	--	A
Family Taeniopterygidae				
Taenionema sp.	--	--	--	237
Order Megaloptera				
Family Corydalidae				
Corydalus sp.	--	--	--	53
Order Trichoptera				
Family Hydropsychidae				
Hydropsyche sp.	--	--	22	65
Order Coleoptera				
Family Elmidae	--	--	--	215
Order Diptera				
Family Simuliidae	--	86	--	2927
Family Chironomidae	65	--	--	646
Family Tabanidae	22	--	--	--
Family Empididae	--	--	--	43

*A Adult

Table 5. Stream habitat survey summary and analysis for Mill Creek on February 20, 1976.

1. State, County Utah, Washington	2. District Cedar City	3. Resource Area--P.U. Hurricane
4. Drainage Virgin River	5. Stream Unit Mill Creek	6. Location T. 42S R. 15W Sect. 23
7. Investigators Winget, Baumann, and (Reichert)		8. Date 20 Feb 76

General Data

9. Total length of stream (mi.)	9
10. Total length of stream surveyed (mi.)	
a. BLM	4
b. Public	-
c. Private	-
11. Total No. sample stations:	
a. BLM	1
b. Public	-
c. Private	-
12. Total of all stream width measurements (ft.)	21
13. Total channel width (ft.)	81
14. Total width--all pools (ft.)	2
15. Total width of all pools classed 1, 2, and 3 (ft.)	0
16. Total footage of desirable bottom materials (ft.)	10
17. Total spawning gravels (ft.)	7
18. Sum of cover ratings	31
19. Sum of stability ratings	26
20. Elevation: (MSL)	
a. Lowest	2600
b. Highest	5200
21. Multiple use zones	Agricultural
22. Number of camera points	
23. Total cost	
a. Planning	
b. Salaries	
c. Equipment	
d. Analysis of data	
24. Cost per station	

Priority A Limiting Factors

25. Percent of total stream width in pools	10%
26. Pool-riffle ratio, % optimum	20%
27. Pool quality, % optimum	0%
28. Percent of stream bottom with desirable materials	48%
29. Percent spawning gravels	33%
30. Bank cover, % optimum	91%
31. Bank stability, % optimum	81%
32. Percent of habitat optimum	48%

Priority B Limiting Factors

33. Average depth of stream (ft.)	0.13
34. Average width of stream (ft.)	5
35. Average width of channel (ft.)	20
36. Percent of bottom with clinging vegetation (ft.)	10%
37. Percent of bottom with rooted vegetation (ft.)	20%
38. Percent stream shade	75%
39. Average stream gradient (%)	2.3
40. Average stream velocity (f/s)	0.7
41. Stream discharge (cfs)	0.4
42. Average water temperature: (°F or °C)	12
43. Average Air Temperature (°F or °C)	18
44. Turbidity description clear	3 JTU
45. Access (mi.):	
a. Remote	-
b. Low standard trails	-
c. Improved trails	-
d. Low standard roads	3
e. Improved roads	-
46. Water quality analysis:	✓
a. Hach kit	✓
b. Chemical (BYU)	✓
c. Coli (BYU)	

Table 6. Water quality analysis of Mill Creek, Leeds Creek, and Leap Creek on February 20, 1976.

Test	Sampling Site		
	MILL CREEK S-1 above Washington	LEEDS CREEK S-1 near I-15	LEAP CREEK S-1 above Pintura
Time	1100	1620	1330
Field Tests			
Dissolved Oxygen as O_2, mg/l	9	10	11
pH	7.8	8.1	8.0
Salinity, ppt	0.5	0.2	0
Turbidity, JTU	3	8	10
Water Temperature, °C	12	11	5
Air Temperature, °C	18	13	7
Laboratory Tests			
Alkalinity, total as $CaCO_3$, mg/l	181	172	166
Bicarbonate as HCO_3, mg/l	221	205	200
Boron as B, µg/l	80	90	<50
Calcium as Ca, mg/l	70	65	46
Carbonate as CO_3, mg/l	<1	4	2
Chloride as Cl, mg/l	100	7	4
Conductivity, µmhos/cm (25°C)	875	550	330
Hardness as $CaCO_3$, mg/l	254	284	170
Hydroxide as OH, mg/l	<0.1	<0.1	<0.1
Magnesium as Mg, mg/l	19	29	14
pH	8.15	8.4	8.45
Potassium as K, mg/l	12.7	1.9	0.9
Silica as SiO_2, mg/l	---	---	---
Sodium as Na, mg/l	95	20	7.9
Sulfate as SO_4, mg/l	120	125	10
Total Dissolved Solids mg/l @ 180°C	522	362	213
Ammonia as N, mg/l	.011	<.01	<.01
Nitrate as N, mg/l	<.05	<.05	<.05
Phosphate (ortho) as P, mg/l	.011	.023	.019
Total Coliform, MPN/100ml	23	9	4
Fecal Coliform, MPN/100ml	23	9	<3

Table 7. Summary of macroinvertebrate community analysis for Mill Creek, Leeds Creek, and Leap Creek on 20 Feb 1976.

STREAM Sampling Site	No. of Taxa	Mean #/m^2	Mean Biomass g/m^2	% Ephemeroptera	% Plecoptera	% Trichoptera	% Coleoptera	% Diptera	% Other Invertebrates	$\bar{d}$	H
MILL CREEK											
S-1 Above Washington	32	22,531	5	20	0	7	12	59	3	2.60	2.56
LEEDS CREEK											
S-1 Near I-15	16	5,724	1	10	0	0	0	58	32	2.24	2.17
LEAP CREEK											
S-1 Above Pintura	13	3,314	0.3	6	6	4	2	64	19	2.11	2.02

Table 8. Number per square meter of macroinvertebrate taxa collected from Mill Creek on February 20, 1976.

	Sampling Site S-1 above Washington
PHYLUM ARTHROPODA	
Class Insecta	
Order Odonata	
Suborder Anisoptera	
Family Gomphidae	
Erpetogomphus compositus	258
Ophiogomphus severus	ks*
Progomphus borealis	ks
Family Libellulidae	
Somatochlora sp.	22
Suborder Zygoptera	
Family Agrionidae	
Hetaerina sp.	22
Family Coenagrionidae	
Amphiagrion abbreviatum	322
Argia sp.	22
Order Ephemeroptera	
Family Baetidae	3852
Family Tricorythidae	
Tricorythodes minutus	538
T. minutus	A*
Order Hemiptera	
Family Veliidae	
Microvelia americana	43
Rhagovelia distincta	A
Order Megaloptera	
Family Corydalidae	
Corydalus sp.	22
Order Trichoptera	
Family Leptoceridae	
Nectopsyche sp.	A
Family Philopotamidae	
Chimarra sp.	1205
Chimarra sp.	A
Family Hydropsychidae	
Hydropsyche sp.	151
Hydropsyche occidentalis	A
Cheumatopsyche sp.	43
Cheumatopsyche arizonensis	A
Family Hydroptilidae	
Leucoptrichia sp.	A
Others	151
Family Helicopsychidae	
Helicopsyche borealis	A

*ks kick sample
*A Adults

Table 8. Continued.

	Sampling Site S-1 above Washington
Order Lepidoptera	
Family Pyralidae	
Parargyractis spp.	22
Order Coleoptera	
Family Elmidae	2410
Family Dryopidae	258
Order Diptera	
Family Psychodidae	22
Family Simuliidae	
Prosimulium sp.	1635
Family Chironomidae	10502
Family Ceratopogonidae	796
Family Stratiomyidae	
Euparyphys sp.	172
Family Empididae	64

Table 9. Stream habitat survey summary and analysis for Leeds Creek on February 19, 1976.

1. State, County	2. District	3. Resource Area--P.U.
Utah, Washington	Cedar City	Hurricane
4. Drainage	5. Stream Unit	6. Location
Virgin River	Leeds Creek	T. 41S R. 14W Sect. 36
7. Investigators		8. Date
Winget, Baumann and (Reichert)		19 Feb 76

General Data	
9. Total length of stream (mi.)	14
10. Total length of stream surveyed (mi.)	
a. BLM	4
b. Public	-
c. Private	-
11. Total No. sample stations:	
a. BLM	1
b. Public	-
c. Private	-
12. Total of all stream width measurements (ft.)	35
13. Total channel width (ft.)	78
14. Total width--all pools (ft.)	10
15. Total width of all pools classed 1, 2, and 3 (ft.)	5
16. Total footage of desirable bottom materials (ft.)	22
17. Total spawning gravels (ft.)	14
18. Sum of cover ratings	18
19. Sum of stability ratings	22
20. Elevation: (MSL)	
a. Lowest	2800
b. Highest	6000
21. Multiple use zones	Recreation Agricultural
22. Number of camera points	
23. Total cost	
a. Planning	
b. Salaries	
c. Equipment	
d. Analysis of data	
24. Cost per station	

Priority A Limiting Factors	
25. Percent of total stream width in pools	67%
26. Pool-riffle ratio, % optimum	66%
27. Pool quality, % optimum	33%
28. Percent of stream bottom with desirable materials	63%
29. Percent spawning gravels	40%
30. Bank cover, % optimum	56%
31. Bank stability, % optimum	69%
32. Percent of habitat optimum	57%

Priority B Limiting Factors	
33. Average depth of stream (ft.)	0.35
34. Average width of stream (ft.)	9
35. Average width of channel (ft.)	20
36. Percent of bottom with clinging vegetation (ft.)	2
37. Percent of bottom with rooted vegetation (ft.)	<1
38. Percent stream shade	10
39. Average stream gradient (%)	2.5
40. Average stream velocity (f/s)	1.2
41. Stream discharge (cfs)	3
42. Average water temperature: (°F or °C)	11
43. Average Air Temperature (°F or °C)	13
44. Turbidity description clear	5 JTU
45. Access (mi.):	
a. Remote	-
b. Low standard trails	-
c. Improved trails	-
d. Low standard roads	-
e. Improved roads	2
46. Water quality analysis:	
a. Hach kit	✓
b. Chemical (BYU)	✓
c. Coli (BYU)	✓

Table 10. Number per square meter of macroinvertebrate taxa collected from Leeds Creek on February 19, 1976.

	Sampling Site S-1 below I-15
PHYLUM ASCHELMINTHES	
Class Nematoda	108
PHYLUM ANNELIDA	
Class Oligochaeta	1592
PHYLUM ARTHROPODA	
Class Arachnida	
Order Acarina	
Suborder Hydracarina	43
Class Insecta	
Order Odonata	
Suborder Zygoptera	
Family Coeagrionidae	
Argia sp.	65
Order Ephemeroptera	
Family Baetidae	430
Family Ephemerellidae	
Ephemerella inermis	129
Order Plecoptera	
Family Capniidae	
Mesocapnia frisoni	A*
Family Taeniopterygidae	
Taenionema pacificum	A
Order Trichoptera	
Family Limnephilidae	11
Order Coleoptera	
Family Dytiscidae	22
Order Diptera	
Family Tipulidae	
Dicranota sp.	43
Family Simuliidae	
Simulium sp.	2690
Prosimulium sp.	238
Family Chironomidae	301
Family Ceratopogonidae	43
Family Stratiomyidae	
Euparyphus sp.	22

*A Adults

Table 11. Stream habitat survey summary and analysis for Leap Creek on February 20, 1976.

1. State, County Utah, Washington	2. District Cedar City	3. Resource Area--P.U. Hurricane
4. Drainage Virgin River	5. Stream Unit Leap Creek	6. Location T. 39S R. 13W Sect. 36
7. Investigators Winget, Buamann and (Reichert)		8. Date 20 Feb 76

General Data

9.	Total length of stream (mi.)	9
10.	Total length of stream surveyed (mi.)	
	a. BLM	.2
	b. Public	-
	c. Private	-
11.	Total No. sample stations:	
	a. BLM	1
	b. Public	-
	c. Private	-
12.	Total of all stream width measurements (ft.)	27
13.	Total channel width (ft.)	93
14.	Total width--all pools (ft.)	10
15.	Total width of all pools classed 1, 2, and 3 (ft.)	8
16.	Total footage of desirable bottom materials (ft.)	15
17.	Total spawning gravels (ft.)	8
18.	Sum of cover ratings	14
19.	Sum of stability ratings	22
20.	Elevation: (MSL)	
	a. Lowest	4200
	b. Highest	6600
21.	Multiple use zones	Recreation
22.	Number of camera points	
23.	Total cost	
	a. Planning	
	b. Salaries	
	c. Equipment	
	d. Analysis of data	
24.	Cost per station	

Priority A Limiting Factors

25.	Percent of total stream width in pools	37%
26.	Pool-riffle ratio, % optimum	80%
27.	Pool quality, % optimum	51%
28.	Percent of stream bottom with desirable materials	55%
29.	Percent spawning gravels	30%
30.	Bank cover, % optimum	44%
31.	Bank stability, % optimum	69%
32.	Percent of habitat optimum	60%

Priority B Limiting Factors

33.	Average depth of stream (ft.)	0.4
34.	Average width of stream (ft.)	7
35.	Average width of channel (ft.)	23
36.	Percent of bottom with clinging vegetation (ft.)	<1%
37.	Percent of bottom with rooted vegetation (ft.)	<1%
38.	Percent stream shade	10%
39.	Average stream gradient (%)	6%
40.	Average stream velocity (f/s)	1.2
41.	Stream discharge (cfs)	3
42.	Average water temperature: (°F or °C)	5
43.	Average Air Temperature (°F or °C)	7
44.	Turbidity description clear	12 JTU
45.	Access (mi.):	
	a. Remote	-
	b. Low standard trails	-
	c. Improved trails	-
	d. Low standard roads	2
	e. Improved roads	-
46.	Water quality analysis:	
	a. Hach kit	✓
	b. Chemical (BYU)	✓
	c. Coli (BYU)	✓

Table 12. Number per square meter of macroinvertebrate taxa collected from Leap Creek on February 20, 1976.

	Sampling Site S-1 above Pintura
PHYLUM ANNELIDA	
Class Oligochaeta	613
PHYLUM ARTHROPODA	
Class Insecta	
Order Ephemeroptera	
Family Baetidae	194
Order Plecoptera	
Family Capniidae	
Capnia wanica	A*
Capnia utahensis	A
Others	215
Order Trichoptera	
Family Philopotamidae	
Chimarra sp.	11
Family Psychomyiidae	
Tinodes sp.	11
Family Hydropsychidae	
Hydropsyche sp.	108
Order Coleoptera	
Family Elmidae	11
Order Diptera	
Family Tipulidae	
Antocha monticola	11
Dicranota sp.	11
Family Simuliidae	1797
Family Chironomidae	290

*A Adults

Table 13. Stream habitat survey summary and analysis for Ash Creek on January 14, 1976.

1. State, County Utah, Washington	2. District Cedar City	3. Resource Area--P.U. Hurricane
4. Drainage Virgin River	5. Stream Unit Ash Creek	6. Location T. 41S R. 13W Sect. 23
7. Investigators Winget, Baumann, and (Reichert)		8. Date 14 Jan 76

General Data

9. Total length of stream (mi.)	20
10. Total length of stream surveyed (mi.)	
a. BLM	8
b. Public	-
c. Private	-
11. Total No. sample stations:	
a. BLM	3
b. Public	0
c. Private	0
12. Total of all stream width measurements (ft.)	58
13. Total channel width (ft.)	129
14. Total width--all pools (ft.)	26
15. Total width of all pools classed 1, 2, and 3 (ft.)	14
16. Total footage of desirable bottom materials (ft.)	37
17. Total spawning gravels (ft.)	11
18. Sum of cover ratings	23
19. Sum of stability ratings	30
20. Elevation: (MSL)	
a. Lowest	3400
b. Highest	4900
21. Multiple use zones	Grazing Agricultural
22. Number of camera points	
23. Total cost	
a. Planning	
b. Salaries	
c. Equipment	
d. Analysis of data	
24. Cost per station	

Priority A Limiting Factors

25. Percent of total stream width in pools	45%
26. Pool-riffle ratio, % optimum	90%
27. Pool quality, % optimum	48%
28. Percent of stream bottom with desirable materials	64%
29. Percent spawning gravels	20%
30. Bank cover, % optimum	48%
31. Bank stability, % optimum	63%
32. Percent of habitat optimum	63%

Priority B Limiting Factors

33. Average depth of stream (ft.)	0.34
34. Average width of stream (ft.)	10
35. Average width of channel (ft.)	22
36. Percent of bottom with clinging vegetation (ft.)	<1%
37. Percent of bottom with rooted vegetation (ft.)	5%
38. Percent stream shade	28%
39. Average stream gradient (%)	2.5%
40. Average stream velocity (f/s)	1.0
41. Stream discharge (cfs)	2.7
42. Average water temperature: (°F or °C)	8°C
43. Average Air Temperature (°F or °C)	14°C
44. Turbidity description	$\bar{x}$ JTU = 101
45. Access (mi.):	
a. Remote	-
b. Low standard trails	-
c. Improved trails	-
d. Low standard roads	4
e. Improved roads	16
46. Water quality analysis:	
a. Hach kit	✓
b. Chemical (BYU)	✓
c. Coli (BYU)	✓

Table 14. Water quality analysis for Ash Creek, LaVerkin Creek and North Creek on January 15, 1976.

Test	Sampling Site							
	ASH CREEK			LAVERKIN CREEK			NORTH CREEK	
	S-1 near Toquerville	S-2 above Pintura	S-3 above Ash Creek Reservoir	S-1 at Ut. 17	S-2 mouth of Canyon	S-3 near Zion's Boundary	S-1 above Virgin, Ut.	S-2 Zion's Boundary
Time	1600	1445	1250	1545	1035	1230	1220	1130
Field Tests								
Dissolved Oxygen as O_2, mg/l	6	7	8	8	--	8	9	10
pH	--	--	--	--	--	--	--	--
Salinity, ppt	--	--	--	--	--	--	--	--
Turbidity, JTU	18	270	15	23	17	20	5	5
Water Temperature, °C	17	1	7	12	6	8	7	6
Air Temperature, °C	17	15	10	20	17	17	14	11
Laboratory Tests								
Alkalinity, total as $CaCO_3$, mg/l	173	164	208	174	158	166	160	191
Bicarbonate as HCO_3, mg/l	206	200	254	121	193	202	195	228
Boron as B, µg/l	--	--	--	--	--	--	--	--
Calcium as Ca, mg/l	81	74	49	150	121	105	91	53
Carbonate as CO_3, mg/l	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3
Chloride as Cl, mg/l	17	11	11	14	12	11	14	7
Conductivity, µmhos/cm (25°C)	655	605	445	997	874	756	655	466
Hardness as $CaCO_3$, mg/l	334	260	199	544	442	398	322	209
Hydroxide as OH, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Magnesium as Mg, mg/l	32	18	16	41	34	33	23	18
pH	8.4	8.3	8.3	8.2	8.3	8.3	8.3	8.4
Potassium as K, mg/l	2.7	2.8	2.3	3.3	3.2	3.2	3.1	2.9
Silica as SiO_2, mg/l	47	26	31	13	8	10	12	13
Sodium as Na, mg/l	21	15	15	28	24	21	21	17
Sulfate as SO_4, mg/l	180	90	7	380	300	235	175	70
Total Dissolved Solids mg/l @ 180°C	472	366	264	762	600	539	466	283
Ammonia as N, mg/l	0.12	0.76	<.01	<.01	<.01	0.15	0.15	0.26
Nitrate as N, mg/l	0.65	0.15	0.24	0.25	0.06	0.08	0.7	0.75
Phosphate (ortho) as P, mg/l	.016	.038	.012	<.001	<.004	.002	.003	.002
Total Coliform, MPN/100ml	93	11	23	75	150	240	93	23
Fecal Coliform, MPN/100ml	93	7	23	<3	3	11	<3	<3

Table 15. Statistical analysis for stepwise pooled samples from Ash Creek site S-3 on 16 Jan 1976.

Step*	Total No. of Taxa	Mean No./ft ^{2}	80% Confidence Limits LL	80% Confidence Limits UL	Standard Deviation	Percent SE of Mean	Coefficient of Variation	$\bar{d}$	H
1	8	undefined	undefined	undefined	undefined	undefined	undefined	2.28	2.24
2	15	1,178	-96.3	2,452.3	585.5	35.14	49.7	2.43	2.41
3	24	1,280	789.9	1,770.1	450.1	20.3	35.2	2.57	2.55
4	24	1,424	1,041.6	1,806.4	466.9	16.4	32.8	2.52	2.51

*Step 1 consists of only one sample; Step 2 is the results from 2 pooled samples; Step 3 is the results from 3 pooled samples, etc.

Table 16. Summary of macroinvertebrate community analysis for Ash Creek, LaVerkin Creek and North Creek on 15-17 Jan 1976.

STREAM Sampling Site	No. of Taxa	Mean $\#/m^2$	Mean Biomass g/m^2	% Ephemeroptera	% Plecoptera	% Trichoptera	% Coleoptera	% Diptera	% Other Invertebrates	$\bar{d}$	$\bar{H}$
ASH CREEK											
S-1 Near Toquerville	13	25,264	2.5	27	0	1	0	69	3	1.60	1.58
S-2 Above Pintura	4	172	0.2	19	0	0	0	31	50	1.95	1.58
S-3 Above Ash Creek Reservoir	27	15,322	9.6	27	2	4	0	51	16	2.52	2.48
LAVERKIN CREEK											
S-1 At Ut. 17	10	818	8	11	26	3	3	53	5	2.52	2.29
S-2 Mouth of Canyon	10	753	5	60	6	3	3	29	0	2.04	1.81
S-3 Near Zion's Boundary	6	1,528	24	92	1	4	2	1	0	0.53	0.48
NORTH CREEK											
S-1 Above Virgin	14	5,897	2	12	7	0	1	58	23	2.51	2.45
S-2 Zion's Boundary	18	13,192	30	11	2	3	1	60	23	2.47	2.43

Table 17. Number per square meter of macroinvertebrate taxa collected from Ash Creek on January 16, 1976.

	Sampling Sites		
	S-1 near Toquerville	S-2 above Pintura	S-3 above Ash Creek Reservoir
PHYLUM ASCHELMINTHES			
Class Nematoda	--	--	43
PHYLUM ANNELIDA			
Class Oligochaeta	646	32	2334
PHYLUM ARTHROPODA			
Class Arachnida			
Order Acarina			
Suborder Hydracarina	43	--	--
Class Insecta			
Order Odonata			
Suborder Zygoptera			
Family Coenagrionidae			
Argia sp.	--	--	11
Order Ephemeroptera			
Family Baetidae			
Baetis sp.	6757	32	4173
Baetis sp.	A*	--	--
Family Ephemerellidae			
Ephemerella sp.	--	--	11
Family Tricorythidae			
Tricorythodes sp.	43	--	--
Order Plecoptera			
Family Capniidae			
Capnia utahensis	--	--	A
Mesocapnia frisoni	A	--	A
Others	--	--	355
Family Perlodidae			
Isoperla ebria	--	--	11
Order Hemiptera			
Family Corixidae	--	54	--
Family Gerridae			
Gerrus sp.	A	--	--
Family Saldidae	--	--	A
Order Trichoptera			
Family Rhyacophilidae			
Rhyacophila sp.	--	--	11
Family Glossosomatidae			
Agapetus sp.	--	--	11
Others	--	--	11
Family Hydropsychidae			
Hydropsyche sp.	215	--	118

*A adult collection

Table 17. Continued.

	Sampling Sites S-1 near Toquerville	S-2 above Pintura	S-3 above Ash Creek Reservoir
Order Trichoptera (continued)			
Family Limnephilidae	--	--	97
Family Brachycentridae			
Micrasema sp.	--	--	355
Family Helicopsychidae			
Helicopsyche borealis	A	--	--
Family Leptoceridae			
Nectopsyche sp.	A	--	--
Order Coleoptera			
Family Elmidae	43	--	--
Family Dryopidae	--	--	11
Family Dytiscidae	--	--	11
Family Hydrophilidae	--	--	11
Order Diptera			
Family Tipulidae			
Antocha monticola	--	--	129
Holorusia grandis	--	--	11
Dicranota sp.	--	--	151
Family Simuliidae			
Simulium sp.	14246	--	3583
Family Chironomidae	3271	54	3820
Family Ceratopogonidae	--	--	11
Family Empididae	--	--	11
Family Muscidae			
Limnophora	--	--	32

Table 18. Stream habitat survey summary and analysis for LaVerkin Creek on January 16, 1976.

1. State, County	2. District	3. Resource Area--P.U.
Utah, Washington	Cedar City	Hurricane
4. Drainage Virgin River	5. Stream Unit LaVerkin Creek	6. Location T. 41S R. 13W Sect. 23
7. Investigators Winget, Baumann and (Reichert)		8. Date 16 Jan 76

General Data

9.	Total length of stream (mi.)	30
10.	Total length of stream surveyed (mi.)	
	a. BLM	8
	b. Public	-
	c. Private	-
11.	Total No. sample stations:	
	a. BLM	3
	b. Public	-
	c. Private	-
12.	Total of all stream width measurements (ft.)	114
13.	Total channel width (ft.)	287
14.	Total width--all pools (ft.)	30
15.	Total width of all pools classed 1, 2, and 3 (ft.)	19
16.	Total footage of desirable bottom materials (ft.)	63
17.	Total spawning gravels (ft.)	40
18.	Sum of cover ratings	23
19.	Sum of stability ratings	32
20.	Elevation: (MSL)	
	a. Lowest	3300
	b. Highest	4600
21.	Multiple use zones	People Agricultural Grazing
22.	Number of camera points	
23.	Total cost	
	a. Planning	
	b. Salaries	
	c. Equipment	
	d. Analysis of data	
24.	Cost per station	

Priority A Limiting Factors

25.	Percent of total stream width in pools	26%
26.	Pool-riffle ratio, % optimum	52%
27.	Pool quality, % optimum	33%
28.	Percent of stream bottom with desirable materials	55%
29.	Percent spawning gravels	35%
30.	Bank cover, % optimum	44%
31.	Bank stability, % optimum	62%
32.	Percent of habitat optimum	49%

Priority B Limiting Factors

33.	Average depth of stream (ft.)	0.26
34.	Average width of stream (ft.)	14
35.	Average width of channel (ft.)	41
36.	Percent of bottom with clinging vegetation (ft.)	<1%
37.	Percent of bottom with rooted vegetation (ft.)	<1%
38.	Percent stream shade	13%
39.	Average stream gradient (%)	2.7%
40.	Average stream velocity (f/s)	1.0
41.	Stream discharge (cfs)	3.2
42.	Average water temperature: (°F or °C)	9°C
43.	Average Air Temperature (°F or °C)	18°C
44.	Turbidity description $\bar{x}$ =	20 JTU
45.	Access (mi.):	
	a. Remote	-
	b. Low standard trails	-
	c. Improved trails	-
	d. Low standard roads	10
	e. Improved roads	-
46.	Water quality analysis:	
	a. Hach kit	✓
	b. Chemical (BYU)	✓
	c. Coli (BYU)	✓

Table 19. Number per square meter of macroinvertebrate taxa collected from LaVerkin Creek on January 16, 1976.

	Sampling Sites		
	S-1 at Ut. 17	S-2 near Canyon mouth	S-3* near Zion Boundary
PHYLUM ANNELIDA			
Class Oligochaeta	43	--	--
PHYLUM ARTHROPODA			
Class Insecta			
Order Ephemeroptera			
Family Baetidae			
Baetis spp.	86	430	131
Family Tricorythidae			
Tricorythodes sp.	--	22	--
Order Plecoptera			
Family Capniidae	215	22	1
Capnia wanica	A*	A	A
Mesocapnia frisoni	A	--	--
Family Taeniopterygidae			
Taenionema sp.	--	22	--
Order Megaloptera			
Family Corydalidae			
Corydalus sp.	22	22	5
Order Trichoptera			
Family Hydropsychidae			
Hydropsyche sp.	22	22	3
Order Diptera			
Family Simuliidae	258	151	2
Family Chironomidae	129	43	--
Family Empididae	43	22	--

*S-3 Qualitative sample *A adult collection

Table 20. Stream habitat survey summary and analysis for North Creek on January 15, 1976.

1. State, County Utah, Washington	2. District Cedar City	3. Resource Area--P.U. Hurricane
4. Drainage Virgin River	5. Stream Unit North Creek	6. Location T. 41S R. 12W Sect. 23
7. Investigators Winget, Baumann and (Reichert)		8. Date 15 Jan 76

General Data

9. Total length of stream (mi.)	13
10. Total length of stream surveyed (mi.)	
a. BLM	3
b. Public	-
c. Private	2
11. Total No. sample stations:	
a. BLM	2
b. Public	-
c. Private	-
12. Total of all stream width measurements (ft.)	83
13. Total channel width (ft.)	330
14. Total width--all pools (ft.)	16
15. Total width of all pools classed 1, 2, and 3 (ft.)	5
16. Total footage of desirable bottom materials (ft.)	50
17. Total spawning gravels (ft.)	33
18. Sum of cover ratings	16
19. Sum of stability ratings	30
20. Elevation: (MSL)	
a. Lowest	3600
b. Highest	6000
21. Multiple use zones	Agriculture Recreation
22. Number of camera points	
23. Total cost	
a. Planning	
b. Salaries	
c. Equipment	
d. Analysis of data	
24. Cost per station	

Priority A Limiting Factors

25. Percent of total stream width in pools	19%
26. Pool-riffle ratio, % optimum	38%
27. Pool quality, % optimum	12%
28. Percent of stream bottom with desirable materials	60%
29. Percent spawning gravels	40%
30. Bank cover, % optimum	33%
31. Bank stability, % optimum	63%
32. Percent of habitat optimum	41%

Priority B Limiting Factors

33. Average depth of stream (ft.)	0.3
34. Average width of stream (ft.)	14
35. Average width of channel (ft.)	55
36. Percent of bottom with clinging vegetation (ft.)	<1%
37. Percent of bottom with rooted vegetation (ft.)	<1%
38. Percent stream shade	18%
39. Average stream gradient (%)	2.2
40. Average stream velocity (f/s)	0.9
41. Stream discharge (cfs) 2.0 at S-1	4.2 at s-2
42. Average water temperature: (°F or °C)	6.5
43. Average Air Temperature (°F or °C)	12.5
44. Turbidity description clear	5 JTU
45. Access (mi.):	
a. Remote	-
b. Low standard trails	-
c. Improved trails	-
d. Low standard roads	-
e. Improved roads	5
46. Water quality analysis:	
a. Hach kit	✓
b. Chemical (BYU)	✓
c. Coli (BYU)	✓

Table 21. Number per square meter of macroinvertebrate taxa collected from North Creek on January 15, 1976.

	Sampling Sites	
	S-1 above oil fields	S-2 near Zion Park
PHYLUM ANNELIDA		
Class Oligochaeta	1270	3013
PHYLUM ARTHROPODA		
Class Arachnida		
Order Acarina		
Suborder Hydracarina	65	65
Class Insecta		
Order Odonata		
Suborder Zygoptera	--	43
Order Ephemeroptera		
Family Baetidae		
Baetis spp.	581	689
Family Leptophlebiidae		
Paraleptophlebia sp.	--	452
Family Tricorythidae		
Tricorythodes sp.	108	215
Order Plecoptera		
Family Capniidae	387	194
Capnia wanica	A*	A
Order Megaloptera		
Family Corydalidae		
Corydalus sp.	22	43
Order Trichoptera		
Family Philopotamidae	--	43
Family Hydropsychidae		
Hydropsyche sp.	22	258
Family Brachycentridae		
Micrasema sp.	--	22
Order Coleoptera		
Family Elmidae	22	194
Family Dryopidae	22	--
Order Diptera		
Family Simuliidae		
Simulium sp.	775	2346
Family Chironomidae	2367	5423
Family Ceratopogonidae	151	65
Family Stratiomyidae	--	22
Family Empididae	108	86

*A adult collection

Table 22. Stream habitat survey summary and analysis for Santa Clara River on February 17 and 19, 1976.

1. State, County Utah, Washington	2. District Cedar City	3. Resource Area--P.U. Beaver Dam
4. Drainage Virgin River	5. Stream Unit Santa Clara River	6. Location T. 43S. R. 15W. Sect. 6
7. Investigators Winget, Baumann and (Reichert)		8. Date 17 and 19 Feb 76

General Data

9. Total length of stream (mi.)	40
10. Total length of stream surveyed (mi.)	
a. BLM	20
b. Public	-
c. Private	-
11. Total No. sample stations:	
a. BLM	5
b. Public	-
c. Private	-
12. Total of all stream width measurements (ft.)	178
13. Total channel width (ft.)	1523
14. Total width--all pools (ft.)	82
15. Total width of all pools classed 1, 2, and 3 (ft.)	60
16. Total footage of desirable bottom materials (ft.)	114
17. Total spawning gravels (ft.)	52
18. Sum of cover ratings	61
19. Sum of stability ratings	77
20. Elevation: (MSL)	
a. Lowest	2800
b. Highest	5200
21. Multiple use zones	Recreation Agricultural
22. Number of camera points	
23. Total cost	
a. Planning	
b. Salaries	
c. Equipment	
d. Analysis of data	
24. Cost per station	

Priority A Limiting Factors

25. Percent of total stream width in pools	46%
26. Pool-riffle ratio, % optimum	92%
27. Pool quality, % optimum	67%
28. Percent of stream bottom with desirable materials	64%
29. Percent spawning gravels	29%
30. Bank cover, % optimum	54%
31. Bank stability, % optimum	69%
32. Percent of habitat optimum	69%

Priority B Limiting Factors

33. Average depth of stream (ft.)	0.57
34. Average width of stream (ft.)	13
35. Average width of channel (ft.)	109
36. Percent of bottom with clinging vegetation (ft.)	10%
37. Percent of bottom with rooted vegetation (ft.)	5%
38. Percent stream shade	47%
39. Average stream gradient (%)	2.6%
40. Average stream velocity (f/s)	1.2
41. Stream discharge (cfs)	3
42. Average water temperature: (°F or °C)	11°C
43. Average Air Temperature (°F or °C)	14°C
44. Turbidity description clear	5JTU
45. Access (mi.):	
a. Remote	-
b. Low standard trails	-
c. Improved trails	-
d. Low standard roads	-
e. Improved roads	20
46. Water quality analysis:	
a. Hach kit	✓
b. Chemical (BYU)	✓
c. Coli (BYU)	✓

Table 23. Water quality analysis for Santa Clara River on February 19, 1976.

Test	Sampling Site				
	S-1 above Santa Clara	S-2 below Gunlock Reservoir	S-3 above Gunlock, Ut.	S-4 at Veyo, Ut.	S-5 above Baker Reservoir
Time	1230	1110	0945	1615	1425
Field Tests					
Dissolved Oxygen as O_2, mg/l	9	--	10	7	--
pH	8.0	--	7.9	--	7.8
Salinity, ppt	0.5	--	0.2	0	0
Turbidity, JTU	5	0	5	15	0
Water Temperature, °C	11	12	6.5	14	9
Air Temperature, °C	18	14	13	11	12
Laboratory Tests					
Alkalinity, total as $CaCO_3$, mg/l	223	--	227	207	101
Bicarbonate as HCO_3, mg/l	272	--	273	252	123
Boron as B, µg/l	110	--	<50	70	80
Calcium as Ca, mg/l	102	--	66	58	26
Carbonate as CO_3, mg/l	<1	--	3	<1	<1
Chloride as Cl, mg/l	31	--	28	22	5
Conductivity, µmhos/cm (25°C)	840	--	540	490	228
Hardness as $CaCO_3$, mg/l	401	--	210	230	104
Hydroxide as OH, mg/l	<.1	--	<.1	<.1	<.1
Magnesium as Mg, mg/l	36	--	11	21	10
pH	8.3	--	8.45	8.3	8.2
Potassium as K, mg/l	3.2	--	2.8	4.7	1.4
Silica as SiO_2, mg/l	--	--	--	--	--
Sodium as Na, mg/l	35	--	25	18.5	8.5
Sulfate as SO_4, mg/l	190	--	22	25	3
Total Dissolved Solids mg/l @ 180°C	560	--	324	293	124
Ammonia as N, mg/l	<.01	--	.011	.016	<.01
Nitrate as N, mg/l	<.05	--	.09	.49	.21
Phosphate (ortho) as P, mg/l	.006	--	.011	.006	.036
Total Coliform, MPN/100ml	9	--	93	240	39
Fecal Coliform, MPN/100ml	9	--	93	93	4

Table 24. Statistical analysis for stepwise pooled samples from Santa Clara River site S-3 on 19 Feb 1976.

Step*	Total No. of Taxa	Mean No./ft^2	80% Confidence Limits LL	80% Confidence Limits UL	Standard Deviation	Percent SE of Mean	Coefficient of Variation	$\bar{d}$	H
1	19	undefined	undefined	undefined	undefined	undefined	undefined	3.26	2.98
2	22	141.0	128.7	153.3	5.7	2.8	4.0	3.29	3.12
3	25	182.7	104.0	261.4	72.3	22.9	39.6	3.26	3.15
4	26	179.5	130.8	228.1	59.4	16.5	33.1	3.25	3.16

*Step 1 consists of only one sample; Step 2 is the results from 2 pooled samples; Step 3 is the results from 3 pooled samples, etc.

Table 25. Summary of macroinvertebrate community analysis for Santa Clara River on 17 Feb 1976.

Sampling Site	No. of Taxa	Mean #/m^2	Mean Biomass g/m^2	% Ephemeroptera	% Plecoptera	% Trichoptera	% Colecptera	% Diptera	% Other Invertebrates	$\bar{d}$	$\bar{H}$
S-1 Above Santa Clara	20	13,536	14	2	1	1	4	45	47	1.98	1.94
S-2* Below Gunlock Reservoir	21	49	2	4	0	6	2	29	59	3.07	2.64
S-3 Above Gunlock	29	1,991	1	20	1	9	3	52	14	3.39	3.12
S-4 Veyo, Utah	20	12,030	11	36	1	9	5	26	23	3.03	2.97
S-5 Above Baker Reservoir	33	12,482	20	61	4	8	7	11	10	2.96	2.89

* S-2 was a qualitative sample - the values 49 and 2 were sample totals and not values per square meter.

Table 26. Number per square meter of macroinvertebrate taxa collected from the Santa Clara River on February 17, 1976.

	Sampling Sites				
	S-1 above Santa Clara	S-2* below Gunlock Reservoir	S-3 above Gunlock, Ut.	S-4 at Veyo, Ut.	S-5 above Baker Reservoir
PHYLUM ASCHELMINTHES					
Class Nematoda	--	4	--	22	366
PHYLUM MOLLUSCA					
Class Gastropoda	--	8	--	--	--
Class Pelecypoda	--	--	--	--	108
PHYLUM ANNELIDA					
Class Oligochaeta	6327	7	194	2087	689
Class Hirudinea	--	2	--	--	--
PHYLUM ARTHROPODA					
Class Arachnida					
Order Acarina					
Suborder Hydracarina	65	--	22	387	22
Class Crustacea					
Order Amphipoda	22	8	--	--	22
Class Insecta					
Order Collembola					
Family Poduridae	--	--	22	--	--
Order Odonata					
Suborder Anisoptera					
Family Gomphidae					
Ophiogomphus severus	22	--	--	22	--
Family Libellulidae	--	--	--	86	--
Suborder Zygoptera					
Family Coenagrionidae					
Argia sp.	--	- -	11	22	--
Order Ephemeroptera					
Family Baetidae	151	1	387	3400	6004
Family Heptageniidae					
Heptagenia sp.	--	--	--	--	43
Epeorus sp.	--	--	--	--	22
Family Leptophlebiidae					
Paraleptophlebia sp.	--	--	--	904	344
Family Ephemerellidae					
Ephemerella inermis	--	--	--	--	1162
Family Tricorythidae					
Tricorythodes minutus	--	A*	--	--	--
Tricorythodes sp.	86	1	22	22	22

*S-2 Qualitative sample *A adult collection

Table 26. Continued.

	Sampling Sites				
	S-1 above Santa Clara	S-2 below Gunlock Reservoir	S-3 above Gunlock, Ut.	S-4 at Veyu, Ut.	S-5 above Baker Reservoir
Order Plecoptera					
Family Capniidae					
Capnia wanica	--	--	A	--	--
Capnia utahensis	--	--	--	--	A
Mesocapnia frisoni	A	--	A	--	--
Others	108	--	11	--	--
Family Pteronarcyidae					
Pteronarcella badia	--	--	--	--	22
Pteronarcys californica	--	--	--	--	86
Family Perlodidae					
Isoperla sp.	22	--	--	86	409
Others	--	--	--	--	22
Family Perlidae					
Hesperoperla pacifica	--	--	--	--	22
Order Hemiptera					
Family Corixidae	--	A	--	--	--
Family Gelastocoridae	--	A	--	--	--
Family Naucoridae					
Ambrysus mormon	--	A	A	--	--
Ambrysus woodburyi	--	A	--	--	--
Family Notonectidae					
Notonecta sp.	--	A	--	--	--
Family Veliidae					
Microvelia sp.	--	A	--	--	--
Family Saldidae	--	A	--	--	--
Order Megaloptera					
Family Corydalidae					
Corydalus sp.	22	--	11	65	--
Order Trichoptera					
Family Rhyacophilidae					
Rhyacophila sp.	--	--	--	--	22
Family Glossosomatidae					
Glossosoma ventrale	--	--	--	--	A
Agapetus sp.	--	--	--	22	--
Others	--	--	--	--	65
Family Philopotamidae	--	--	--	--	43
Family Psychomyiidae	--	1	22	--	--
Family Hydropsychidae					
Hydropsyche sp.	22	--	43	--	452
Cheumatopsyche sp.	43	--	108	775	86
Family Hydroptilidae					
Leucotrichia sp.	--	--	--	--	A
Others	--	--	--	270	--

Table 26. Continued.

	Sampling Sites				
	S-1 above Santa Clara	S-2 below Gunlock Reservoir	S-3 above Gunlock, Ut.	S-4 at Veyu, Ut.	S-5 above Baker Reservoir
Order Plecoptera					
Family Capniidae					
Capnia wanica	--	--	A	--	--
Capnia utahensis	--	--	--	--	A
Mesocapnia frisoni	A	--	A	--	--
Others	108	--	11	--	--
Family Pteronarcyidae					
Pteronarcella badia	--	--	--	--	22
Pteronarcys californica	--	--	--	--	86
Family Perlodidae					
Isoperla sp.	22	--	--	86	409
Others	--	--	--	--	22
Family Perlidae					
Hesperoperla pacifica	--	--	--	--	22
Order Hemiptera					
Family Corixidae	--	A	--	--	--
Family Gelastoceridae	--	A	--	--	--
Family Naucoridae					
Ambrysus mormon	--	A	A	--	--
Ambrysus woodburyi	--	A	--	--	--
Family Notonectidae					
Notonecta sp.	--	A	--	--	--
Family Veliidae					
Microvelia sp.	--	A	--	--	--
Family Saldidae	--	A	--	--	--
Order Megaloptera					
Family Corydalidae					
Corydalus sp.	22	--	11	65	--
Order Trichoptera					
Family Rhyacophilidae					
Rhyacophila sp.	--	--	--	--	22
Family Glossosomatidae					
Glossosoma ventrale	--	--	--	--	A
Agapetus sp.	--	--	--	22	--
Others	--	--	--	--	65
Family Philopotamidae	--	--	--	--	43
Family Psychomyiidae	--	1	22	--	--
Family Hydropsychidae					
Hydropsyche sp.	22	--	43	--	452
Cheumatopsyche sp.	43	--	108	775	86
Family Hydroptilidae					
Leucotrichia sp.	--	--	--	--	A
Others	--	--	--	270	--

Table 26. Continued.

	Sampling Sites S-1 above Santa Clara	S-2 below Gunlock Reservoir	S-3 above Gunlock, Ut.	S-4 at Veyo, Ut.	S-5 above Baker Reservoir
Order Trichoptera (continued)					
Family Leptoceridae	--	--	11	--	22
Family Brachycentridae					
Micrasema sp.	--	--	--	--	280
Family Helicopsychidae					
Helicopsyche borealis	--	2	--	--	--
Order Lepidoptera					
Family Pyralidae					
Parargyractis kearfottalis	--	--	32	43	--
Order Coleoptera					
Family Elmidae	538	--	43	646	796
Family Dryopidae	22	1	11	--	22
Family Haliplidae	--	A	--	--	--
Family Dytiscidae	--	A	--	--	--
Order Diptera					
Family Tipulidae					
Antocha monticola	--	--	11	--	43
Dicranota sp.	22	--	--	--	43
Limonia sp.	--	--	11	--	--
Family Deuterophlebiidae	--	--	--	--	108
Family Simuliidae					
Simulium sp.	4476	--	43	--	947
Prosimulium sp.	43	--	11	517	--
Others	--	--	377	--	--
Order Diptera (continued)					
Family Chironomidae	1484	12	463	2453	194
Family Ceratopogonidae	43	--	75	--	--
Family Stratiomyidae					
Euparyphus sp.	--	2	11	--	--
Family Tabanidae	--	--	11	65	--
Family Empididae	22	--	22	129	--
Family Sciomyzidae	--	--	11	--	--

Table 27. Stream habitat survey summary and analysis for Beaver Dam Wash, East Fork on February 18, 1976.

1. State, County Utah, Washington	2. District Cedar City	3. Resource Area--P.U. Beaver Dam
4. Drainage Beaver Dam Wash	5. Stream Unit Beaver Dam Wash, East Fork	6. Location T.40S. R.19W. Sect. 17
7. Investigators Winget, Sherwood and (Reichert)		8. Date 18 Feb 76

General Data		Priority A Limiting Factors	
9. Total length of stream (mi.)	5	25. Percent of total stream width in pools	43%
10. Total length of stream surveyed (mi.)		26. Pool-riffle ratio, % optimum	86%
a. BLM	5	27. Pool quality, % optimum	43%
b. Public	-	28. Percent of stream bottom with desirable materials	57%
c. Private	-	29. Percent spawning gravels	29%
11. Total No. sample stations:		30. Bank cover, % optimum	63%
a. BLM	2	31. Bank stability, % optimum	63%
b. Public	-	32. Percent of habitat optimum	62%
c. Private	-		

General Data		Priority B Limiting Factors	
12. Total of all stream width measurements (ft.)	14	33. Average depth of stream (ft.)	0.13
13. Total channel width (ft.)	110	34. Average width of stream (ft.)	7
14. Total width--all pools (ft.)	6	35. Average width of channel (ft.)	55
15. Total width of all pools classed 1, 2, and 3 (ft.)	3	36. Percent of bottom with clinging vegetation (ft.)	0
16. Total footage of desirable bottom materials (ft.)	8	37. Percent of bottom with rooted vegetation (ft.)	0
17. Total spawning gravels (ft.)	4	38. Percent stream shade	30%
18. Sum of cover ratings	10	39. Average stream gradient (%)	3%
19. Sum of stability ratings	10	40. Average stream velocity (f/s)	1.0
20. Elevation: (MSL)		41. Stream discharge (cfs)	1.0
a. Lowest	3600	42. Average water temperature: (°F or °C)	13
b. Highest	4800	43. Average Air Temperature (°F or °C)	15
21. Multiple use zones	Recreation Agricultural	44. Turbidity description clear	3JTU
22. Number of camera points		45. Access (mi.):	
23. Total cost		a. Remote	-
a. Planning		b. Low standard trails	-
b. Salaries		c. Improved trails	-
c. Equipment		d. Low standard roads	5
d. Analysis of data		e. Improved roads	-
24. Cost per station		46. Water quality analysis:	
		a. Hach kit	✓
		b. Chemical (BYU)	✓
		c. Coli (BYU)	✓

Table 28. Water quality analysis for East and West Fork Beaver Dam Wash and Pine Park Canyon on February 18, 1976.

Test	Sampling Site: EAST FORK BEAVER DAM WASH S-1 1 mile below Goldstrike	EAST FORK BEAVER DAM WASH S-2 1 mi. above Goldstrike	WEST FORK BEAVER DAM WASH S-1 below Slaughter Creek	PINE PARK CANYON S-1 below Pine Park Campground
Time	1400	1700	1025	1110
Field Tests				
Dissolved Oxygen as O_2, mg/l	7	10	10	11
pH	8.0	8.0	8.0	7.5
Salinity, ppt	0.2	0	0	0
Turbidity, JTU	0	5	5	3
Water Temperature, °C	14	12	12	3
Air Temperature, °C	15	14	16	6
Laboratory Tests				
Alkalinity, total as $CaCO_3$, mg/l	194	206	131	56
Bicarbonate as HCO_3, mg/l	232	246	160	68
Boron as B, µg/l	100	<50	<50	120
Calcium as Ca, mg/l	54	54	42	17
Carbonate as CO_3, mg/l	4	4	<1	<1
Chloride as Cl, mg/l	23	24	13	8
Conductivity, µmhos/cm (25°C)	475	460	350	168
Hardness as $CaCO_3$, mg/l	206	206	159	63
Hydroxide as OH, mg/l	<.1	<.1	<.1	<.1
Magnesium as Mg, mg/l	17	17	13	5
pH	8.5	8.45	8.12	7.8
Potassium as K, mg/l	1.6	1.3	2.9	2.6
Silica as SiO_2, mg/l	--	--	--	--
Sodium as Na, mg/l	28	29	17.4	7.8
Sulfate as SO_4, mg/l	31	17	26	8
Total Dissolved Solids mg/l @ 180°C	294	295	227	140
Ammonia as N, mg/l	<.01	<.01	<.01	<.01
Nitrate as N, mg/l	0.01	<.05	<.05	0.13
Phosphate (ortho) as P, mg/l	.05	.042	.005	.024
Total Coliform, MPN/100ml	9	150	210	43
Fecal Coliform, MPN/100ml	9	<3	4	<3

Table 28. Water quality analysis for East and West Fork Beaver Dam Wash and Pine Park Canyon on February 18, 1976.

Test	Sampling Site: EAST FORK BEAVER DAM WASH S-1 1 mile below Goldstrike	EAST FORK BEAVER DAM WASH S-2 1 mi. above Goldstrike	WEST FORK BEAVER DAM WASH S-1 below Slaughter Creek	PINE PARK CANYON S-1 below Pine Park Campground
Time	1400	1700	1025	1110
Field Tests				
Dissolved Oxygen as O_2, mg/l	7	10	10	11
pH	8.0	8.0	8.0	7.5
Salinity, ppt	0.2	0	0	0
Turbidity, JTU	0	5	5	3
Water Temperature, °C	14	12	12	3
Air Temperature, °C	15	14	16	6
Laboratory Tests				
Alkalinity, total as $CaCO_3$, mg/l	194	206	131	56
Bicarbonate as HCO_3, mg/l	232	246	160	68
Boron as B, µg/l	100	<50	<50	120
Calcium as Ca, mg/l	54	54	42	17
Carbonate as CO_3, mg/l	4	4	<1	<1
Chloride as Cl, mg/l	23	24	13	8
Conductivity, µmhos/cm (25°C)	475	460	350	168
Hardness as $CaCO_3$, mg/l	206	206	159	63
Hydroxide as OH, mg/l	<.1	<.1	<.1	<.1
Magnesium as Mg, mg/l	17	17	13	5
pH	8.5	8.45	8.12	7.8
Potassium as K, mg/l	1.6	1.3	2.9	2.6
Silica as SiO_2, mg/l	--	--	--	--
Sodium as Na, mg/l	28	29	17.4	7.8
Sulfate as SO_4, mg/l	31	17	26	8
Total Dissolved Solids mg/l @ 180°C	294	295	227	140
Ammonia as N, mg/l	<.01	<.01	<.01	<.01
Nitrate as N, mg/l	0.01	<.05	<.05	0.13
Phosphate (ortho) as P, mg/l	.05	.042	.005	.024
Total Coliform, MPN/100ml	9	150	210	43
Fecal Coliform, MPN/100ml	9	<3	4	<3

Table 29. Summary of macroinvertebrate community analysis for East and West Fork Beaver Dam Wash and Pine Park Canyon on February 18, 1976.

STREAM Sampling Site	No. of Taxa	Mean $\#/m^2$	Mean Biomass g/m^2	% Ephemeroptera	% Plecoptera	% Trichoptera	% Coleoptera	% Diptera	% Other Invertebrates	$\bar{d}$	H
EAST FORK BEAVER DAM WASH											
S-1 2 mi. below Goldstrike	20	8,005	0.4	3	3	1	0	80	13	2.44	2.38
S-2 1 mi. above Goldstrike	15	8,952	1.0	3	11	2	0	79	5	1.74	1.70
WEST FORK BEAVER DAM WASH											
S-1 Below Slaughter Creek	30	6,682	5	22	12	7	1	37	21	3.43	3.32
PINE PARK CREEK											
S-1 Below Pine Park Campground	30	12,051	3	30	7	23	0	24	17	3.48	3.41

Table 29. Summary of macroinvertebrate community analysis for East and West Fork Beaver Dam Wash and Pine Park Canyon on February 18, 1976.

STREAM Sampling Site	No. of Taxa	Mean $\#/m^2$	Mean Biomass g/m^2	% Ephemeroptera	% Plecoptera	% Trichoptera	% Coleoptera	% Diptera	% Other Invertebrates	$\bar{d}$	H
EAST FORK BEAVER DAM WASH S-1 2 mi. below Goldstrike	20	8,005	0.4	3	3	1	0	80	13	2.44	2.38
S-2 1 mi. above Goldstrike	15	8,952	1.0	3	11	2	0	79	5	1.74	1.70
WEST FORK BEAVER DAM WASH S-1 Below Slaughter Creek	30	6,682	5	22	12	7	1	37	21	3.43	3.32
PINE PARK CREEK S-1 Below Pine Park Campground	30	12,051	3	30	7	23	0	24	17	3.48	3.41

Table 30. Number per square meter of macroinvertebrate taxa collected from Beaver Dam Wash East Fork on February 18, 1976.

	Sampling Sites	
	S-1 1 mile below Goldstrike	S-2 1 mile above Goldstrike
PHYLUM ASCHELMINTHES		
Class Nematoda	--	86
PHYLUM ANNELIDA		
Class Oligochaeta	861	344
PHYLUM ARTHROPODA		
Class Arachnida		
Order Acarina		
Suborder Hydracarina	11	--
Class Insecta		
Order Collembola		
Family Poduridae	86	--
Family Sminthuridae	11	--
Family Entomobryidae	32	--
Order Ephemeroptera		
Family Baetidae	172	237
Family Ephemerellidae		
Ephemerella inermis	11	--
Family Tricorythidae		
Tricorythodes sp.	22	--
Order Plecoptera		
Family Capniidae		
Capnia wanica	A*	A
Others	248	1011
Order Hemiptera		
Family Gerridae		
Gerrus sp.	A	A
Family Naucoridae		
Ambrysus woodburyi	A	A
Order Trichoptera		
Family Psychomyiidae	65	129
Family Hydropsychidae		
Hydropsyche sp.	--	11
Family Hydroptilidae	32	--
Family Limnephilidae	22	22
Order Coleoptera		
Family Dryopidae	--	22
Order Diptera		
Family Simuliidae		
Simulium sp.	1754	5983
Prosimulium sp.	3196	215
Family Chironomidae	1377	882
Family Ceratopogonidae	65	22
Family Stratiomyidae		
Euparyphus sp.	43	--

*A adult collection

Table 31. Stream habitat survey summary and analysis for Beaver Dam Wash, West Fork on February 18, 1976.

1. State, County	2. District	3. Resource Area--P.U.
Utah, Washington	Cedar City	Beaver Dam
4. Drainage	5. Stream Unit	6. Location
Beaver Dam Wash	Beaver Dam Wash, West Fork	T.41S. R.19W. Sect. 20
7. Investigators		8. Date
Winget, Sherwood and (Reichert)		18 Feb 76

General Data

9.	Total length of stream (mi.)	14
10.	Total length of stream surveyed (mi.)	
	a. BLM	14
	b. Public	-
	c. Private	-
11.	Total No. sample stations:	
	a. BLM	1
	b. Public	-
	c. Private	-
12.	Total of all stream width measurements (ft.)	101
13.	Total channel width (ft.)	215
14.	Total width--all pools (ft.)	20
15.	Total width of all pools classed 1, 2, and 3 (ft.)	16
16.	Total footage of desirable bottom materials (ft.)	78
17.	Total spawning gravels (ft.)	35
18.	Sum of cover ratings	32
19.	Sum of stability ratings	20
20.	Elevation: (MSL)	
	a. Lowest	3000
	b. Highest	5000
21.	Multiple use zones	
22.	Number of camera points	
23.	Total cost	
	a. Planning	
	b. Salaries	
	c. Equipment	
	d. Analysis of data	
24.	Cost per station	

Priority A Limiting Factors

25.	Percent of total stream width in pools	20%
26.	Pool-riffle ratio, % optimum	40%
27.	Pool quality, % optimum	32%
28.	Percent of stream bottom with desirable materials	77%
29.	Percent spawning gravels	35%
30.	Bank cover, % optimum	41%
31.	Bank stability, % optimum	63%
32.	Percent of habitat optimum	51%

Priority B Limiting Factors

33.	Average depth of stream (ft.)	0.6
34.	Average width of stream (ft.)	25
35.	Average width of channel (ft.)	54
36.	Percent of bottom with clinging vegetation (ft.)	5%
37.	Percent of bottom with rooted vegetation (ft.)	<1%
38.	Percent stream shade	20
39.	Average stream gradient (%)	2.3
40.	Average stream velocity (f/s)	1.6
41.	Stream discharge (cfs)	19
42.	Average water temperature: (°F or °C)	10
43.	Average Air Temperature (°F or °C)	12
44.	Turbidity description clear	5JTU
45.	Access (mi.):	
	a. Remote	-
	b. Low standard trails	-
	c. Improved trails	-
	d. Low standard roads	15
	e. Improved roads	-
46.	Water quality analysis:	
	a. Hach kit	✓
	b. Chemical (BYU)	✓
	c. Coli (BYU)	✓

Table 32. Statistical analysis for stepwise pooled samples from Beaver Dam Wash, West Fork site S-1 on 18 Feb 1976.

Step*	Total No. of Taxa	Mean No./ft^2	80% Confidence Limits LL	80% Confidence Limits UL	Standard Deviation	Percent SE of Mean	Coefficient of Variation	$\bar{d}$	H
1	16	undefined	undefined	undefined	undefined	undefined	undefined	3.09	2.97
2	20	471.5	165.2	777.8	140.7	21.1	29.8	3.01	2.95
3	22	609.0	328.0	890.1	258.1	24.5	42.4	3.23	3.19
4	27	617.8	444.6	790.9	211.5	17.1	34.2	3.41	3.37

*Step 1 consists of only one sample; Step 2 is the results from 2 pooled samples; Step 3 is the results from 3 pooled samples, etc.

Table 33. Number per square meter of macroinvertebrate taxa collected from Beaver Dam Wash West Fork on February 18, 1976.

	Sampling Site S-1 below Slaughter Creek
PHYLUM ASCHELMINTHES	
Class Nematoda	65
PHYLUM MOLLUSCA	
Class Gastropoda	65
PHYLUM ANNELIDA	
Class Oligochaeta	839
PHYLUM ARTHROPODA	
Class Arachnida	
Order Acarina	
Suborder Hydracarina	194
Class Insecta	
Order Odonata	
Suborder Zygoptera	
Family Coenagrionidae	
Argia sp.	172
Order Ephemeroptera	
Family Baetidae	1399
Family Ephemerellidae	
Ephemerella inermis	22
Family Tricorythidae	
Tricorythodes sp.	54
Order Plecoptera	
Family Capniidae	
Capnia utahensis	A*
Capnia wanica	A
Mesocapnia frisoni	A
Others	775
Family Perlodidae	
Isoperla sp.	11
Order Megaloptera	
Family Corydalidae	
Corydalus sp.	11
Order Trichoptera	
Family Psychomyiidae	
Polycentropus sp.	11
Others	11
Family Hydropsychidae	
Hydropsyche sp.	215
Cheumatopsyche sp.	204
Family Hydroptilidae	11
Family Limnephilidae	11

*A adult collection

Table 33. Continued.

	Sampling Site S-1 below Slaughter Creek
Order Lepidoptera	
Family Pyralidae	
Parargyractis sp.	75
Order Coleoptera	
Family Elmidae	43
Family Dryopidae	32
Order Diptera	
Family Tipulidae	11
Family Simuliidae	
Simulium sp.	979
Prosimulium sp.	151
Family Chironomidae	1065
Family Ceratopogonidae	11
Family Stratiomyidae	
Euparyphus sp.	237
Family Empididae	11

Table 34. Stream habitat survey summary and analysis for Pine Park Creek on February 17, 1976.

1. State, County Utah, Washington	2. District Cedar City	3. Resource Area--P.U. Beaver Dam
4. Drainage	5. Stream Unit Pine Park Creek	6. Location T. 37S. R. 19W. Sect. 31
7. Investigators Winget, Sherwood and (Reichert)		8. Date 17 Feb 76

General Data

9.	Total length of stream (mi.)	7
10.	Total length of stream surveyed (mi.)	
	a. BLM	2
	b. Public	-
	c. Private	-
11.	Total No. sample stations:	
	a. BLM	1
	b. Public	-
	c. Private	-
12.	Total of all stream width measurements (ft.)	28
13.	Total channel width (ft.)	88
14.	Total width--all pools (ft.)	10
15.	Total width of all pools classed 1, 2, and 3 (ft.)	10
16.	Total footage of desirable bottom materials (ft.)	10
17.	Total spawning gravels (ft.)	5
18.	Sum of cover ratings	17
19.	Sum of stability ratings	21
20.	Elevation: (MSL)	
	a. Lowest	--
	b. Highest	5400
21.	Multiple use zones	Recreation
		Mining
		Grazing
22.	Number of camera points	
23.	Total cost	
	a. Planning	
	b. Salaries	
	c. Equipment	
	d. Analysis of data	
24.	Cost per station	

Priority A Limiting Factors

25.	Percent of total stream width in pools	36%
26.	Pool-riffle ratio, % optimum	72%
27.	Pool quality, % optimum	72%
28.	Percent of stream bottom with desirable materials	36%
29.	Percent spawning gravels	18%
30.	Bank cover, % optimum	71%
31.	Bank stability, % optimum	88%
32.	Percent of habitat optimum	68%

Priority B Limiting Factors

33.	Average depth of stream (ft.)	0.3
34.	Average width of stream (ft.)	9
35.	Average width of channel (ft.)	29
36.	Percent of bottom with clinging vegetation (ft.)	<5%
37.	Percent of bottom with rooted vegetation (ft.)	<1%
38.	Percent stream shade	45%
39.	Average stream gradient (%)	3%
40.	Average stream velocity (f/s)	0.9
41.	Stream discharge (cfs)	2.0
42.	Average water temperature: (°F or °C)	3
43.	Average Air Temperature (°F or °C)	6
44.	Turbidity description clear	3JTU
45.	Access (mi.):	
	a. Remote	.5
	b. Low standard trails	-
	c. Improved trails	-
	d. Low standard roads	10
	e. Improved roads	-
46.	Water quality analysis:	
	a. Hach kit	✓
	b. Chemical (BYU)	✓
	c. Coli (BYU)	✓

Table 35. Number per square meter of macroinvertebrate taxa collected from Pine Park Creek on February 17, 1976.

	Sampling Site S-1 below Pine Park Campground
PHYLUM MOLLUSCA	
Class Gastropoda	22
PHYLUM ANNELIDA	
Class Oligochaeta	732
PHYLUM ARTHROPODA	
Class Arachnida	
Order Acarina	
Suborder Hydracarina	387
Class Insecta	
Order Collembola	
Family Poduridae	645
Family Entomobryidae	43
Order Odonata	
Suborder Zygoptera	
Family Coenagrionidae	
Argia sp.	65
Order Ephemeroptera	
Family Baetidae	3271
Family Tricorythidae	
Tricorythodes sp.	301
Order Plecoptera	
Family Nemouridae	
Prostoia sp.	279
Family Capniidae	
Capnia utahensis	A*
Capnia wanica	A
Others	581
Order Hemiptera	
Family Naucoridae	
Ambrysus woodburyi	22
Order Megaloptera	
Family Corydalidae	
Corydalus sp.	11
Order Trichoptera	
Family Philopotamidae	
Chimarra sp.	861
Family Psychomyidae	43
Family Hydropsychidae	
Cheumatopsyche sp.	1571
Family Hydroptilidae	22
Family Limnephilidae	65
Family Leptoceridae	86

*A adult collection

Table 35. Continued.

	Sampling Site S-1 below Pine Park Campground
Order Trichoptera (continued)	
Family Helicopsychidae	
Helicopsyche borealis	151
Order Diptera	
Family Tipulidae	
Dicranota sp.	43
Hexatoma sp.	43
Others	22
Family Simuliidae	
Simulium sp.	689
Family Chironomidae	1786
Family Ceratopogonidae	22
Family Stratiomyidae	
Euparyphus sp.	237
Family Tabanidae	32
Family Muscidae	
Limnophora sp.	22

Table 36. Water quality analysis results for Little Creek Mountain Reservoirs, 13 April 1976.

	#1	#2	#3	#4	#5
Time, Daylight Savings	1015	1135	1300	1410	1600
*Water Temperature, °C	10.5	11.0	11.0	12.0	13.0
Alkalinity (total as $CaCO_3$) mg/l	50	39	82	76	112
Bicarbonate (as HCO_3) mg/l	61	48	100	93	137
Calcium (as Ca) mg/l	17.6	13	27	26	34
Carbonate (as CO_3) mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Hardness (as $CaCO_3$) mg/l	56	42	83	78	110
Magnesium (as Mg) mg/l	3	2	4	3	7
*pH	6.8	7.2	6.8	7.9	8.1
Sulfate (as SO_4) mg/l	5	80	3	2	60
Total Dissolved Solids mg/l	91	119	124	111	181
*Surface Dissolved Oxygen mg/l	7	7	8	7	7
Nitrate (as N) mg/l	0.08	0.24	0.14	0.12	0.14
Phosphate-ortho (as P) mg/l	0.025	0.03	0.013	0.013	0.01
*Specific Conductance, µmhos/cm, 25°C	110	154	207	239	217
MPN Total Coliform/100ml	23	<3	<3	<3	240
MPN Fecal Coliform/100ml	<3	<3	<3	<3	<3
Algal taxa, number	13	--	8	22	--
Diatom dominance diversity ($\bar{d}$)	1.474	--	0.918	2.156	--
Length (feet)	231	60	165	560	900
Depth at capacity (feet)	5	4	6	10.5	14
**Depth fluctuation (feet)	4	3	2	5	5
Shoreline at capacity (feet)	760	210	930	1643	3200
Maximum depth (feet) at existing level	2	2	3	8.5	11

*Surface and bottom measurements were made but there were no significant differences indicating a lack of stratification as is to be expected in such small shallow reservoirs.

**Fluctuation was derived from existing conditions and educated guesses. Drawdown could be greater during an extended dry period.

Table 37. Water quality analysis of Red Mountain Lakes, 30 April 1976.

Alkalinity (total as $CaCO_3$) mg/l	17
Bicarbonate (as HCO_3) mg/l	21
Calcium (as Ca)	6
Carbonate (as CO_3) mg/l	<1
Chloride (as Cl) mg/l	3
Conductivity (25°C) µmhos/cm	55
Hardness (as $CaCO_3$) mg/l	18
Hydroxide (as OH) mg/l	<0.1
Magnesium (as Mg) mg/l	<1
pH	7.30
Potassium (as K) mg/l	1.1
Sodium (as Na) mg/l	2.3
Sulfate (as SO_4) mg/l	8
Total Dissolved Solids mg/l	58
Turbidity FTU	6.6
Nitrogen (total Kjeldahl as N) mg/l	.59
Ammonia (as N) mg/l	0.12
Nitrate (as N) mg/l	<.05
Phosphate-ortho (as P) mg/l	.003
MPN Total Coliform/100ml	4
MPN Fecal Coliform/100ml	<3

Table 38. Water quality analysis of waters from Baker Dam Reservoir, 14 April 1976

	Surface near Inlet	Center of Reservoir*		
		Surface	Middle	Bottom
Time	1030	1120	1120	1120
Water Temperature, °C	11.0	11.0	12.0	12.0
Alkalinity (total as $CaCO_3$) mg/l	118	134	--	119
Bicarbonate (as HCO_3) mg/l	144	162	--	145
Calcium (as Ca) mg/l	32	35	--	35
Carbonate (as CO_3) mg/l	<0.1	0.9	--	<0.1
Hardness (as $CaCO_3$) mg/l	95	133	--	134
Magnesium (as Mg) mg/l	4	11	--	11
Specific Conductance, µmhos/cm, 25°C	453	403	441	441
Dissolved Oxygen mg/l	8	9	--	7
pH	8.1	8.0	7.9	7.8
Sulfate (as SO_4) mg/l	7	9	--	8
Total Dissolved Solids mg/l	165	181	--	185
Nitrate (as N) mg/l	0.11	<.05	--	<.05
Phosphate - ortho (as P) mg/l	0.04	0.016	--	.025
MPN Total Coliform/100ml	460	4	--	--
MPN Fecal Coliform/100ml	93	4	--	--
Secchi Disk Depth (feet)	--	--	12	--

*no evidence of stratification, probably during spring turn over.

Table 39. Water quality analysis of waters from Gunlock Reservoir, 14 April 1976, 1390 hour.

	Surface	Middle	Bottom
Water Temperature, °C	12.0	13.0	11.5
Dissolved Oxygen mg/l	9.0	--	7.0
pH	8.0	8.0	8.0
Specific Conductance, µmhos/cm, 25°C	378	403	400
Alkalinity (total as $CaCO_3$) mg/l	158	--	--
Bicarbonate (as HCO_3) mg/l	186	--	--
Calcium (as Ca) mg/l	48	--	--
Carbonate (as CO_3) mg/l	3.1	--	--
Hardness (as $CaCO_3$) mg/l	189	--	--
Magnesium (as Mg) mg/l	8.45	--	--
Sulfate (as SO_4) mg/l	23	--	--
Total Dissolved Solids mg/l	274	--	--
Turbidity, FTU	8	--	--
Nitrate (as N) mg/l	0.09	--	--
Phosphate - ortho (as P) mg/l	0.01		
MPN Total Coliform/100ml	23	--	--
MPN Fecal Coliform/100ml	9	--	--
Secchi Disk Depth (feet)	9	--	--

APPENDIX C

PLATES

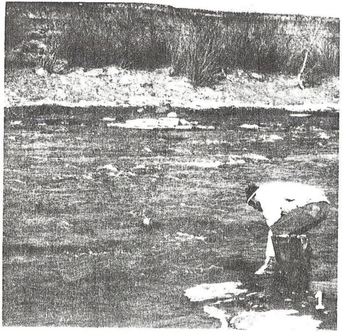
PLATE I

Picture 1. Virgin River above LaVerkin and below North Creek (See S-4, Fig. 1). Rocky substrate, sandy stream banks, high grazing impacts. 15 January, 1976

Picture 2. Virgin River above Washington, Utah (See S-2, Fig 1). Stream channelized, heavy growths of tamarisk along banks, substrate mostly sand with some small gravel. Heavy cattle use of stream-side lands. 16 January, 1976

Picture 3. Virgin River below Bloomington, Utah (See S-1, Fig 1). Stream channel wide, meandering, banks unstable sand, substrate mostly shifting sand. 16 January, 1976

Picture 4. Virgin River below Bloomington, Utah. View looking NNW across the channel. 16 January, 1976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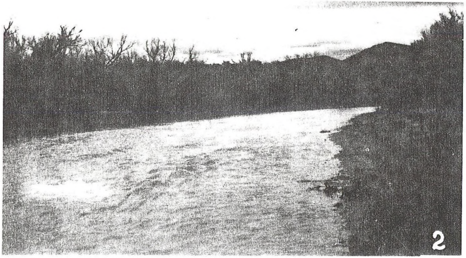
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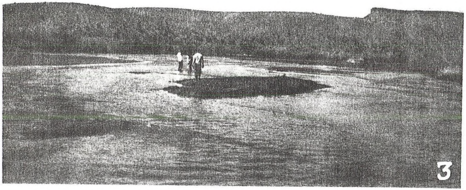
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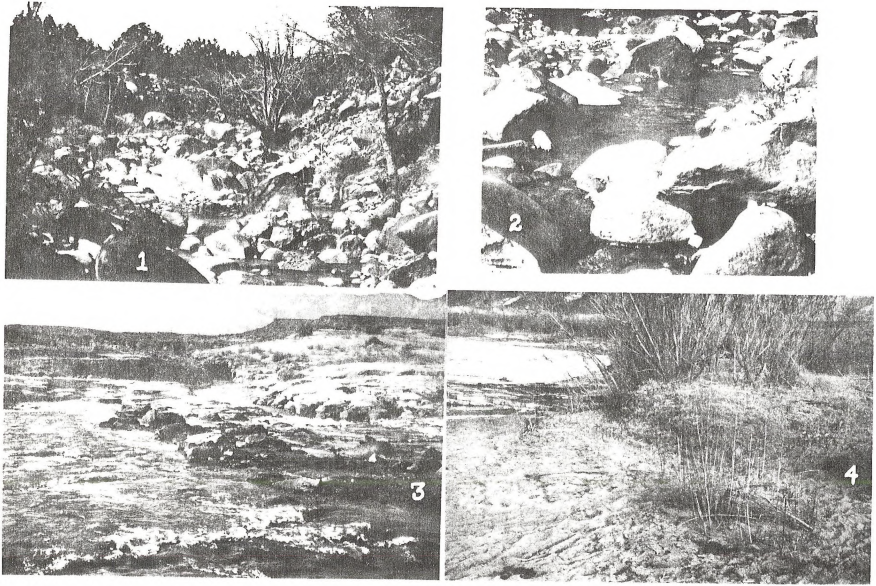
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PLATE II

Picture 1. Leap Creek 100 meters above I-15, 20 February, 1976. Large rock strewn channel, heavily scoured, sparse periphyton on rocks indicate high spring and summer storm runoff. Piñon-juniper trees dominate streamside vegetation.

Picture 2. Leap Creek, same as picture 1 but close-up of stream bed showing rocky substrate.

Picture 3. Virgin River above LaVerkin and below North Creek (Fig. 1, S-4) 15 January, 1976. Rocky outcrop is shown with a waterfall in the upper-center of picture. This habitat is good for macroinvertebrates, especially in a predominantly sandy substrate river.

Picture 4. Virgin River--same as Picture 3. Cattle tracks and croppings plus heavily grazed vegetation give visual evidence to heavy grazing pressures on streamside vegetation in desert situations.

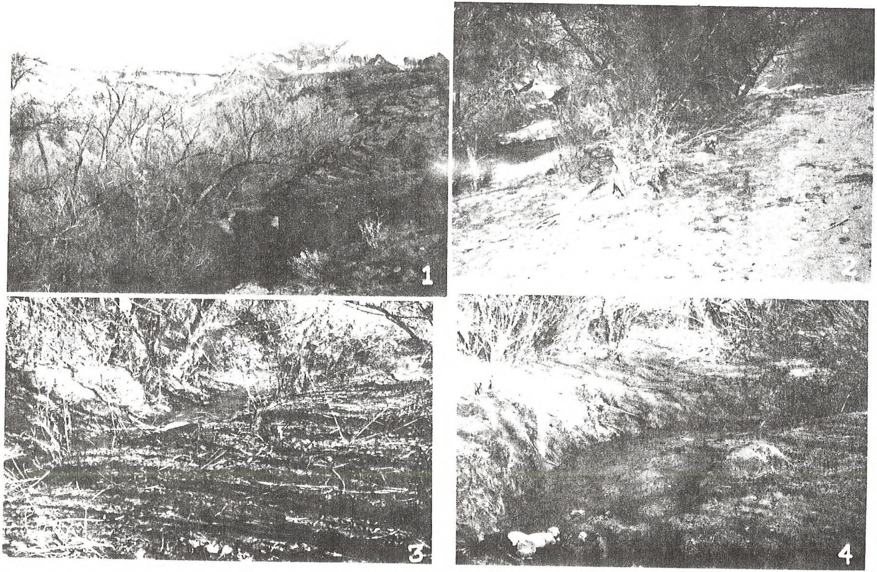
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PLATE III

Mill Creek from mouth of Gorge to I-15 crossing, 20 February 1976 (Figure 1).

Picture 1. Mill Creek Gorge showing dense growths of mature cottonwood trees, sparsity of vegetation on adjoining lands and snow capped mountains where waters arise which feed the stream.

Picture 2. Heavy cattle use is illustrated by well worn trails, droppings and cropped vegetation.

Picture 3. Vegetation trampled down by cattle passage.

Picture 4. Stream showing bare banks and worn cattle trails.

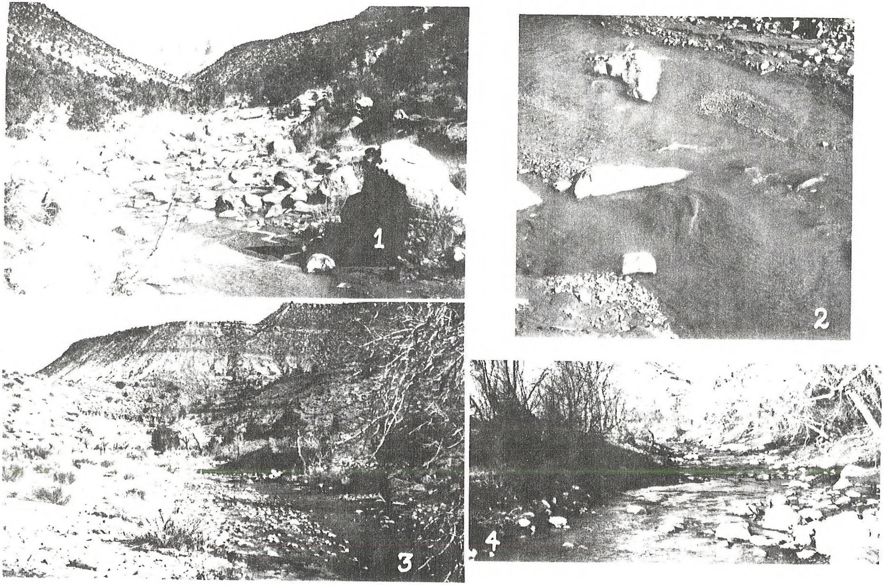
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PLATE IV

Picture 1. LaVerkin Creek, S-3, below Zion's Park boundary, 16 January 1976. Pinõn-juniper forest, sparsely vegetated.

Picture 2. LaVerkin Creek, S-3, 16 January 1976. Close-up of stream substrate--shifting sand dominating, shallow, no deep pools.

Picture 3. LaVerkin Creek, S-2, above canyon mouth, 16 January 1976. Sparse streamside vegetation and wide, shallow channel are the prominent features of this photograph.

Picture 4. LaVerkin Creek, S-1, above LaVerkin, Utah, 16 January 1976. Streamside vegetation mainly cottonwood trees and willows. Area under intensive agricultural use.

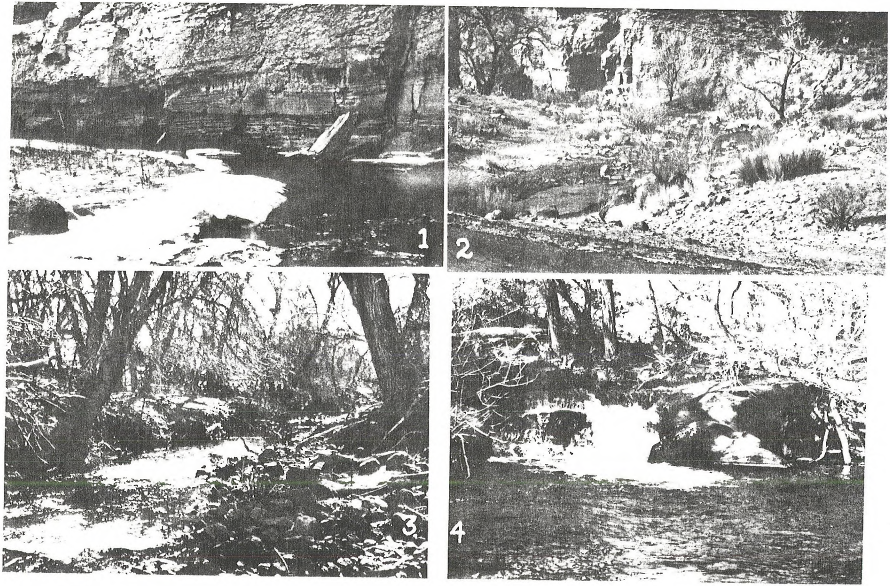
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PLATE V

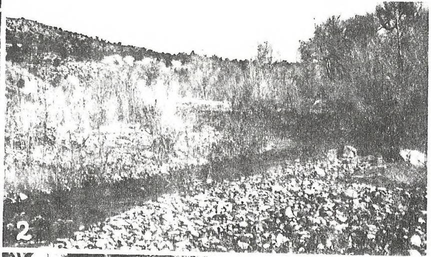
Picture 1. North Creek, below Zion's Park boundary, 15 January 1976. Note bare rock stream side with wide shallow stream channel.

Picture 2. North Creek, below Zion's Park boundary, 15 January 1976. Note naturally sparse vegetation. Area not presently subject to heavy grazing pressures but historically this was probably not the case.

Picture 3. Santa Clara River, S-5, two miles above Baker Dam Reservoir, 17 February 1976. Note the mature trees, dead branches, lack of new young trees. Streamside heavily grazed.

Picture 4. Santa Clara River, S-5, 17 February 1976. Frequent rock outcrops have allowed creation of quality pool and riffle habitat.


1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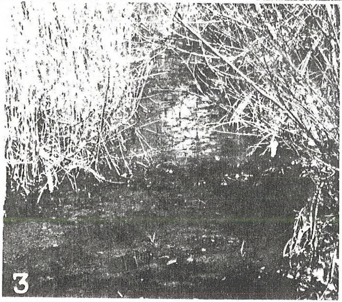
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PLATE VI

Picture 1. Santa Clara River, S-4, at Veyo, Utah above Veyo Resort, 17 February 1976. Stream is at the bottom of a narrow gorge with steep volcanic rocks. Water flow is slow, water temperature is high due to numerous springs, and streamside vegetation is dense.

Picture 2. Santa Clara River, S-3, two miles above Gunlock, Utah at road crossing, 19 February 1976. Wide channel reveals effects of high flows--shallow water, low quality pools.

Picture 3. Santa Clara River, S-2, one-half mile below Gunlock Reservoir, 19 February 1976. Stream largely spring fed as reservoir outflow was near zero. Heavy algal growths indicated high CO_2 and nutrient levels. Habitat stream-like.

Picture 4. Santa Clara River, S-1, one mile west of Santa Clara, Utah, 19 February, 1976. Stream sides heavily grazed, stream shallow with poor quality pool habitat.

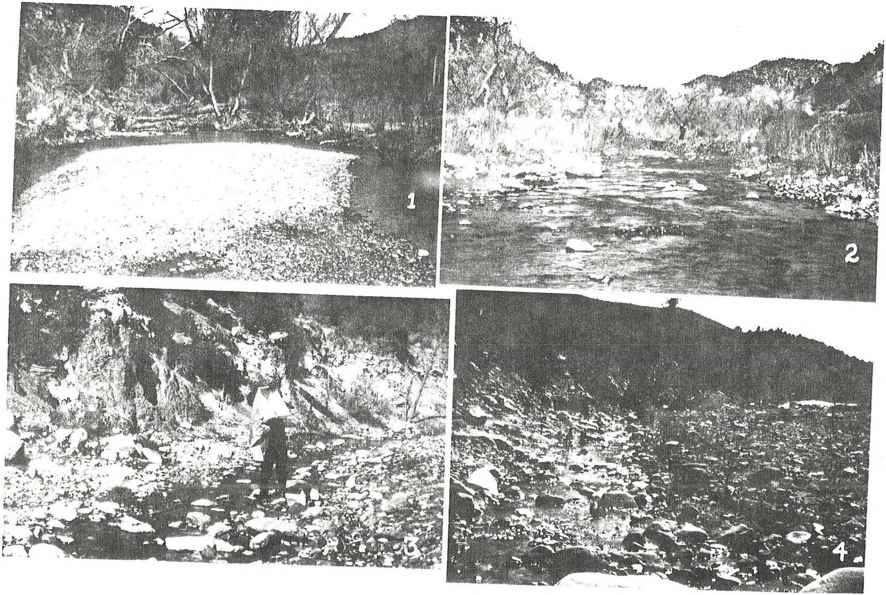
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PLATE VII

Picture 1. West Fork Beaver Dam Wash at fork with Slaughter Creek, 18 February 1976. West Fork left of center with Slaughter Creek coming in on right of gravel bar. Wide channel indicates severity of periodic high flows.

Picture 2. West Fork Beaver Dam Wash, 50 meters below confluence with Slaughter Creek, 18 February 1976. Note stable banks with dense vegetative growth.

Picture 3. East Fork Beaver Dam Wash, S-1, one mile below Goldstrike, Utah and below Black Canyon, 18 February, 1976. Note small discharge but wide rocky channel and unstable right bank.

Picture 4. East Fork Beaver Dam Wash, S-1, 18 February 1976. View looking downstream showing wide rocky channel, lack of large pools, unstable banks.

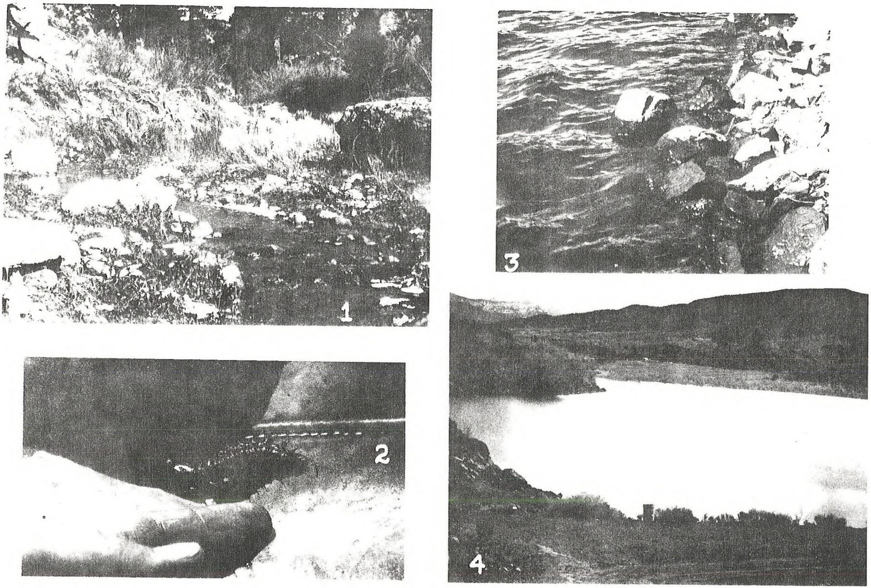

PLATE VIII

Picture 1. Pine Park Creek below U. S. Forest Service campground, 17 February 1976. View looking upstream, note leaves and debris on weeds indicating recent flood level flows. Habitat generally stable with low grazing impacts.

Picture 2. *Corydalus* sp. (dobsinfly) from Pine Park Creek, 17 February 1976. Over two inches long, this larvae is over two years old indicating perennial flow for the period of its existence.

Picture 3. Baker Dam Reservoir, West shore, 14 April 1976. Note rocky shore line with dense periphyton growths.

Picture 4. Baker Dam Reservoir, looking north from Dam, 14 April 1976. Inlet on left around shore line outcropping.

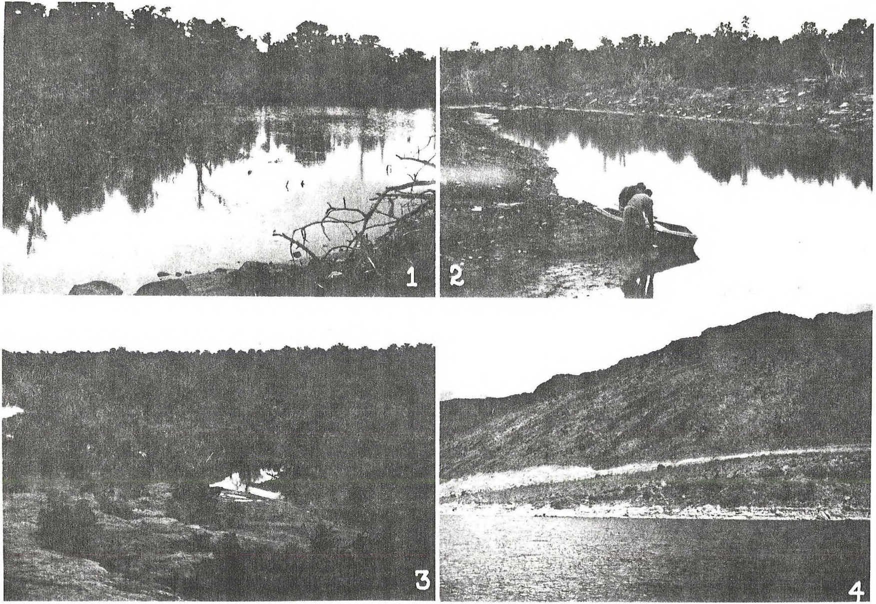
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PLATE IX

Picture 1. Little Creek Mountain Reservoir number 3, 13 April 1976.

Picture 2. Little Creek Mountain Reservoir number 2, 13 April 1976.

Picture 3. Little Creek Mountain Reservoir number 5, 13 April 1976.

Picture 4. Gunlock Reservoir, northeast side of reservoir, 14 April 1976.

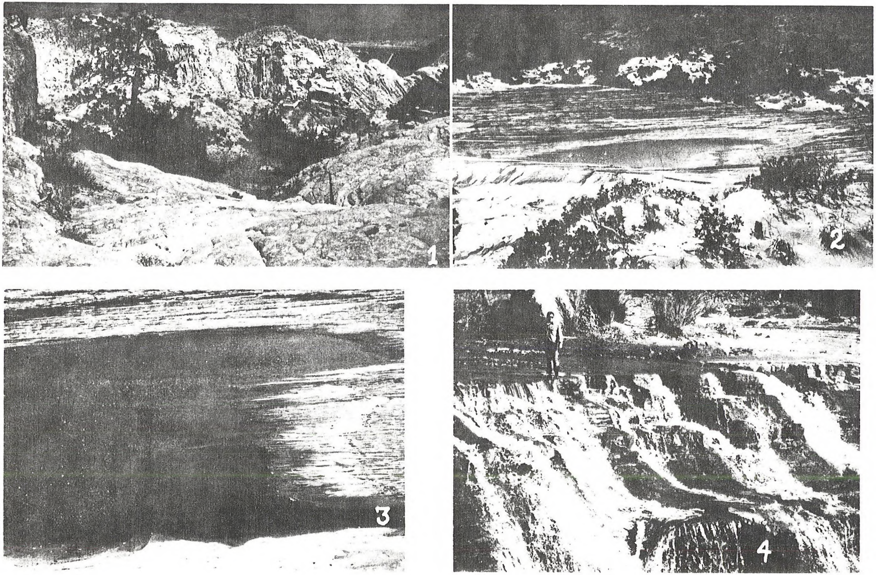
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PLATE X

Picture 1. Red Mountain, dry lake basin, 30 April 1976. Note slick rock in fore ground with depression in center of picture. During rainy season this basin would probably be full of water.

Picture 2. Red Mountain Lake, 30 April 1976. Maximum depth at present 8-10 inches, at capacity near two feet.

Picture 3. Red Mountain Lake, 30 April 1976. Close-up of lake shown in picture 2.

Picture 4. LaVerkin Creek Falls, between S-3 and S-2, 16 January 1976. Falls have approximately a forty foot drop. Banks highly unstable.

APPENDIX D

ABSTRACT

SELECTED WATER RESOURCES ABSTRACTS

INPUT TRANSACTION FORM

1. Report No.	
2.	
3. Accession No.	W
4. Title	AQUATIC HABITAT INVENTORY IN THE HOT DESERT EIS AREA, UTAH
5. Report Date	
6.	
7. Author(s)	Winget, R. N., and Reichert, M. K.
8. Performing Organization Report No.	
9. Organization	Brigham Young University, Center for Health and Environmental Studies, Provo, Utah 84602
10. Project No.	
11. Contract/Grant No.	YA-512-CT6-77
12. Sponsoring Organization	
13. Type of Report and Period Covered	
15. Supplementary Notes	Funded by Bureau of Land Management, unpublished final report, 117 pp., vi, 39 Tables, 3 Figures, 10 Plates.

16. Abstract

These surveys were to provide aquatic habitat and water quality baseline data to be ueed in evaluating quality of aquatic resources in relation to grazing use of national resource lands. This study covered 14 streams and 14 reservoirs in the Hot Desert EIS designated area of southwestern Utah.

Included in the analyses are: descriptions of existing aquatic habitats; characterizations of macroinvertebrate communities; and water quality for the date of sampling.

Preliminary analyses indicate that riparian vegetation comprises one of the most critical components of quality aquatic habitat in hot desert streams and reservoirs. Due to sparsity of vegetation on most desert lands, stream riparian communities are highly desirable to grazing animals and thus are often highly impacted. Extreme flows are the next most serious environmental perturbation but one which generally has little chance of being controlled.

17a. Descriptors *Watershed management, *Macrobenthos, *Stream improvement, *Water quality, *Coliforms, Bank stability, Land management, Grazing, Cutthroat trout.

17b. Identifiers Environmental Impact Evaluation, National Resource Lands, Critical Aquatic Habitat, Pure Strain Cutthroat Trout, Grazing Impacts, BLM administered streams

17c. COWRR Field & Group 06G, 05C

18. Availability	
19. Security Class. (Report)	
20. Security Class. (Page)	
21. No. of Pages	
22. Price	

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