FINAL REPORT

DOLORES RIVER NATIVE FISH HABITAT SUITABILITY STUDY (UDWR Contract No. 90-2559)

BIO/WEST, Inc.

Resource Management and Problem Solving Services

REPORT NO. TR-272-02
BIO/WEST, Inc.

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(UDWR Contract No. 90-2559)

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EXECUTIVE SUMMARY

BIO/WEST, Inc. conducted an investigation in 1990 and 1991 to determine the suitability of the Dolores River for endangered Colorado River fishes. Physical, chemical, and biological attributes were assessed in six reaches of the lower 177 miles from Bradfield Bridge to the confluence with the Colorado River. The investigation was funded by Utah Division of Wildlife Resources (UDWR) and Bureau of Reclamation (Reclamation) through the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. The study was conducted in cooperation with UDWR, Colorado Division of Wildlife, and U.S. Fish and Wildlife Service.

Nineteen species of fish were captured, including six native species and thirteen non-natives. Native species included Colorado squawfish (Ptychocheilus lucius), roundtail chub (Gila robusta), flannelmouth sucker (Catostomus latipinnis), bluehead sucker (C. discobolus), speckled dace (Rhinichthys osculus), and mottled sculpin (Cottus bairdi). The most common non-native species were red shiner (Cyprinella lutrensis), sand shiner (Notropis stramineus), fathead minnow (Pimephales promelas), carp (Cyprinus carpio), and channel catfish (Ictalurus punctatus). Native species composed 19 percent of total fish numbers, which was four times higher than the adjacent Colorado River, and indicative of a relatively good native fish fauna. No significant changes in species composition were evident when compared to a similar survey in 1981, indicating that the ichthyofaunal community remained relatively stable over the last ten years.

Four Colorado squawfish were captured within 2 km of the confluence with the Colorado River in August and October, 1991. The species was reported in the Dolores River in the 1950's and 1960's, but spills of uranium mill wastes in the lower San Miguel River in mid-1960 killed most of the fish in the lower 60 miles of the Dolores River. Colorado squawfish were not captured in surveys in 1971 and 1981, and seven squawfish reported from the lower 6 miles of the San Miguel River in 1973 were unconfirmed.

Cross-sectional analyses, habitat mapping, and comparisons with the Yampa and White rivers revealed that the Dolores River channel was suitable for all life stages of Colorado squawfish, but low flows during this investigation reduced fish habitat value. Deep pools and adjacent gravel/cobble riffles were judged suitable for holding adults and juveniles, and for staging and spawning. Backwater formation was limited and ephemeral, reducing the value of the Dolores River as a nursery for young Colorado squawfish. However, the Dolores River confluence was located immediately upstream of a major nursery on the Colorado River.

Water quality appeared suitable for Colorado squawfish most of the year. Removal of uranium mill wastes reduced levels of radionucleides and heavy metals. However, during summer flood events associated with high intensity rain storms, copper and iron were released into the system at potentially lethal levels from either instream sediments or tributary input of erodible soils. High water hardness may ameliorate toxic effects of these elements but further study is required to assess potential impacts of heavy metals.

McPhee Dam, constructed in 1984 about 200 miles upstream of the confluence with the Colorado River, has reduced high spring flows and augmented base summer, fall, and winter flows. Base flow releases of 20 to 40 cfs in 1990 and 1991 reduced native fish habitat in the lower 170 miles of the Dolores River through decreased fish holding areas, dewatered nursery backwaters, impeded movement, and enhanced sedimentation. We recommend minimum base flow releases of 50 cfs during dry and normal years, and 78 cfs during wet years.

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The Dolores River is a unique and relatively little studied drainage in the Upper Colorado River Basin. The lack of comprehensive studies or ongoing monitoring in the drainage is reflective of difficulties in sampling this western river. Difficult logistics associated with geographic isolation, low water volumes and limited access made this study both challenging and frustrating. Successful completion of the project would not have been possible without the aid of a group of hardy individuals. The authors would like to acknowledge and thank the following people for their assistance in conducting field work and other contributions to this project.

BIO/WEST biologists that contributed to field work and/or data analysis included Chris Carrier, Bryan Cowdell, Glenn Doster and Penny Trinca.

Mr. Tom Beck of the Colorado Division of Wildlife (CDOW) provided invaluable support throughout the project. Mr. Beck consistently provided personnel and equipment for logistic support of field efforts. He also provided data and insights from a CDOW river otter reintroduction study initiated in 1987. Other CDOW personnel that assisted in field work were Tom Benjamin and Jim White. Mr. Tom Nesler of CDOW, Fort Collins, also provided assistance and insight during field work.

Utah Division of Wildlife (UDWR) provided personnel and logistic support for field trips. UDWR personnel that contributed to field efforts included Tom Chart, Melissa Trammel, Tom McKay, Mike Buntjer and Ira Hickman.

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1.0 INTRODUCTION

This document is the Final Report submitted to Utah Division of Wildlife Resources (UDWR) in fulfillment of Contract No. 90-2559, entitled Dolores River Native Fish Habitat Suitability Study. This investigation was funded through the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. The investigation included three sampling trips each in 1990 and 1991. Four trip reports were submitted, one for each of the first two sampling trips conducted in 1990 and 1991. No trip report were submitted for Trip 3 or 6. Results from Trip 3 were summarized and integrated with the results of the first two trips into the Annual Summary Report for 1990. Results from Trip 6 were summarized and integrated with results of previous trips into this Final Report.

1.1 Objectives

The objectives of this investigation were to:

1. Determine the extent and change in use of the Dolores River by native Colorado River fishes with the advent of consistent flows, reduced pollutant inflow, and reduced salinity occurring in the Dolores River Basin.

2. Assess suitability of physical, chemical, and biological attributes of the Dolores River for endangered fish.

3. Evaluate the feasibility of reintroducing Colorado squawfish into the Dolores River to enhance recovery of the species in the Upper Basin.

4. Issue recommendations on reintroducing Colorado squawfish into the Dolores River.

1.2 Background

The Dolores River once supported unknown numbers of Colorado squawfish (*Ptychocheilus lucius*) and perhaps functioned as a spawning tributary for this species in the upper Colorado River. Seethaler (1978) reported that T.M. Lynch seined small squawfish from Paradox Valley in 1962. Several other collections of Colorado squawfish were reported during the 1950's and 1960's by Lemons (1955), Nolting (1956), and Coon (1965). The most recent collection of Colorado squawfish in the drainage was an unconfirmed report by Horpestad (1973), who captured seven individuals in the San Miguel River, approximately 6 miles above it's confluence with the Dolores River. No Colorado squawfish were captured during a fishery survey of the Dolores River by Holden and Stalnaker (1975) in 1971. More recent surveys by the U.S. Fish and Wildlife Service (Service) in the early 1980's also failed to locate Colorado squawfish in the Dolores River (Valdez et al. 1982).

Operations of uranium processing facilities from the late 1940's through the 1960's caused adverse impacts to the stream biota and may have contributed greatly to the local demise of Colorado squawfish in the Dolores River drainage. These uranium processing facilities included a uranium concentrator at Naturita, Colorado, and a large uranium mill at Uravan, Colorado, both of which were located on the San Miguel River within 15 miles of its confluence with the Dolores River. A uranium concentrator plant was also located on the Dolores River near the town of Slickrock, Colorado, approximately 60 miles above the confluence of the Dolores and San Miguel rivers.

Direct observations of stream impacts associated with effluent and accidental spills of uranium mill wastes from the Uravan mill site on the lower San Miguel River were made by Sigler et al. (1966), and included fish kills, fish avoidance movements, and drastic pH swings (7.6 to 4.3).

A 1989 court order under the EPA Superfund Program to remove tailings from the Uravan site may significantly improve water quality in the Dolores River. Clean up operations were in progress at the Uravan site in 1990 and 1991. Removal of mill tailings and stabilization of riverside ponds were scheduled to be completed in phases by mid-1992. Informal site visits were made during each field trip by BIO/WEST in 1990, to observe progress of clean up operations at the Uravan site. Based on the magnitude of changes that occurred in 1990, it appeared that clean up was proceeding at a significant rate.

Construction and closure of McPhee Dam on the upper Dolores River in 1984 significantly affected the hydrology of the system. Capture and storage of runoff in McPhee Reservoir reduced the magnitude and altered timing of spring peaks below the dam. This effect was attenuated below the confluence of the San Miguel River, which was free flowing and still exhibited a relatively normal hydrograph. Late summer and early fall base flows in the Dolores River have been augmented by more constant base releases from the dam during these periods. Prior to closure of McPhee Dam, in March of 1984, the Dolores River above the confluence of the San Miguel was often dewatered from irrigation diversions. Although the potential impacts of McPhee Dam operations associated with altered timing and magnitude of peak runoff need to be further addressed, augmented late summer flows may represent a beneficial change for native fishes utilizing the Dolores River drainage.

Augmentation of late summer and early fall flows from McPhee Dam may also improve water quality in certain reaches of the Dolores River during base flow periods, particularly in the 10-mile reach between the confluence of the San Miguel River and Paradox Valley. Saline ground water inputs at Paradox Valley are diluted within base flows were augmented by dam releases. Benefits of this dilution are less profound below the confluence of the San Miguel River, where that river generally doubles the flow of the Dolores River. The beneficial effect of dilution occurs only when releases from McPhee Dam exceed normal pre-dam flows.

2.0 STUDY AREA

This investigation was conducted in the Dolores River from Bradfield Bridge (RM 177) to the confluence with the and Colorado River (RM 0.0) (Figure 1). Reconnaissance prior to sampling showed that the Dolores River from Disappointment Creek (RM 124.7) to Bradfield Bridge (RM 177.0) was characteristic of a clear, cool fishery and would be less likely to provide habitat for Colorado squawfish. Consequently this reach was sampled less intensively than the downstream reaches where warmer and more turbid conditions existed. Fishes in the upper reach were sampled by (CDOW) in 1987-89 as part of a river otter reintroduction program. These data were provided to BIO/WEST and incorporated into this Final Report.

The 177-mile study area was divided into six reaches. The four lowest reaches are similar to those established by the Service in 1981 (Valdez et al. 1982). This study extended approximately 125 miles further upstream than the study by the Service, consequently two additional reaches were added. The six reaches used in this study were defined as follows:

Reach I: Dolores-Colorado River Confluence (RM 0.0) to Utah-Colorado Stateline (RM 22.7) (Corresponds to Service's Stratum T)

Reach II: Utah-Colorado Stateline (RM 22.7) to Salt Creek (RM 41.3) (Corresponds to Service's Stratum U)

Reach III: Salt Creek (RM 41.3) to Dolores-San Miguel River Confluence (RM 64.4) (Corresponds to Service's Stratum V)

Reach IV: Dolores-San Miguel River Confluence (RM 64.4) to Paradox Valley at Bedrock (RM 74.8) (Corresponds to Service's Stratum W)

Reach V: Paradox Valley at Bedrock (RM 74.8) to Dolores-Disappointment Creek Confluence (RM 128.7) (No corresponding Service's Stratum)

Reach VI: Dolores-Disappointment Creek Confluence (RM 128.7) to Bradfield Bridge (RM 177) (No corresponding Service's Stratum)

3.0 METHODS

3.1 Sample Collection

Sample collection was conducted during six periods over the course of this study (Table 1). Each period consisted of approximately 10 days afield. Field trips were scheduled so that sampling could be conducted on a seasonal basis, including spring pre-runoff (March/April), summer post-runoff (July/August), and fall (September/October).

3.2 Sample Effort and Techniques

Total sample effort for this project consisted of 107 jon boat electrofishing runs (total current-on-time of 36.4 hours), 150 canoe electrofishing runs (current-on-time of 58.9 hours), 44 experimental gill net sets (142.7 hours), 5 gill net sets (9.1 hours), 37 trammel net sets (63.1 hours), 3 floating trammel net sets (8.2 hours), and 284 seine hauls (Table 2). An attempt was made to expend similar sample effort during each of the trips. However, actual sampling effort varied because of increasing familiarity with the study area, refinement of logistics and variable sampling conditions associated with each trip. Time used to conduct reconnaissance and general habitat surveys also decreased through the study, which allowed for additional sampling time.

Standard gear and techniques were used to sample fish in the Dolores River. The three principal sampling techniques were seining, electrofishing and netting with gill and trammel nets. Various gear types proved more effective in certain areas because of the wide range of flows and channel characteristics encountered.

Seining was used to collect fish in all shallow habitats. Seining was most effective for sampling the early life stages of the larger fish as well as a range of the smaller species. Information documented with each seining effort included: sample size (length and width), maximum depth of sample, primary and secondary substrates, primary and secondary habitats.

Gill and trammel nets were used primarily to sample larger fish in deep habitats such as pools, run and eddies. Information documented for each netting effort included location, temperature, primary and secondary habitat, and duration of net set.

Electrofishing was conducted in all habitats and reaches of the study area. Two types of electrofishing boats were used. These included a 17-foot ABS plastic canoe, equipped with either a 2500-watt generator and a Coffelt 2C control unit or a 3500-watt generator and a VVP-15 control unit; and a Jon boat equipped with a 3500-watt generator and a Coffelt VVP-15 control unit. The canoe was used to electrofish areas where the Jon boat could not be used either because of low water or inadequate launch access for a larger boat. The canoe was controlled by one paddler in the stern, while fish were netted by one person kneeling in the bow of the boat. The Jon boat was powered by a 25-hp Mercury motor, and one or two persons netted fish from a standing position in the bow of the boat. Electrofishing was generally conducted along shorelines, however low flows often necessitated shocking in midchannel. Catch rates for electrofishing were computed as number of fish captured per 10 hours of electrofishing (current-on) for each type of boat.

3.3 Habitat Analysis

Physical, chemical and biological attributes of the Dolores River were assessed to determine habitat suitability of the system for Colorado squawfish. Since little was known about historical or present use of the Dolores River by Colorado squawfish, determinations of habitat suitability were based on data collected from occupied habitat in other Upper Basin drainages. A majority of this information was assimilated and summarized as habitat suitability index (HSI) curves by Valdez et al. (1987). These HSI curves were used as the primary criteria for judging the suitability of physical habitat in the Dolores River. Observations by other researchers including Miller et al. (1982), Lamarra et al. (1985), Archer and Tyus (1984) and Wick et al. (1983) were also considered for determining habitat suitability.

Physical habitat attributes that were evaluated in the Dolores River during the study included flow, velocity, temperature, depth, substrate and habitat structure and complexity. These physical attributes were evaluated using four techniques including: 1) an ocular habitat survey of the entire study reach, with periodic spot measurements of depth and substrate; 2) review of U.S. Geological Survey (USGS) flow data; 3) systematic cross-sectional characterizations within the six reaches and; 4) detailed measurements of physical habitat at specific locales determined to represent important habitat components, i.e. potential spawning and nursery areas.

Chemical attributes of the Dolores River were assessed by collecting and analyzing water quality at six sample sites (Figure 2). Criteria used to determine the suitability of chemical factors with regards to Colorado squawfish were based on EPA water quality standards for aquatic life (EPA 1986). Additional information on the influence of water quality parameters on Colorado squawfish was assimilated from literature where possible.

Biological attributes of the Dolores River used to evaluate the suitability of the system for Colorado squawfish included: 1) food base, including benthic macroinvertebrate and fish composition; and 2) composition and abundance of sympatric fish species, including potential competitors and predators. Overall suitability of the Dolores River as an integration of physical, chemical and biological attributes was also addressed.

Habitat analysis during the study included both qualitative and quantitative approaches. Qualitative habitat analysis involved a general reconnaissance of the entire study reach. The objectives of this generalized qualitative survey were to: 1) determine the range of habitats that existed within the study area; 2) identify significant physical changes to the Dolores River drainage since the 1981 survey (Valdez et al. 1982) i.e. presence of barriers to movement, dewatering, or point pollution sources and; 3) identify habitat features that required additional quantification, i.e. potential spawning area and nursery areas. Quantitative habitat analysis in 1990 included: 1) counting backwaters and potential spawning areas; 2) documenting physical attributes of potential spawning areas, and; 3) compiling and presenting USGS flow data for the Dolores River system. Backwater counts included all backwaters encountered while traversing any portion of the study area during a field trip. Criteria used to delineate a backwater were: 1) the length of the backwater exceeded the width at the mouth and; 2) surface area of the backwater was at least 15 m^2. Density of backwaters was reported as number of backwaters per mile. Physical measurements of backwaters, including water depth, surface area and substrate type were made for all backwaters sampled. Surface area was estimated for all backwaters counted but not sampled.

A count of potential spawning areas was made within the study area in 1990 and 1991. Classification of these sites was based on the presence of deep pools in proximity to, and interspersed with, cobble-riffle habitat (Sensitive Area Document; Biological Subcommittee, 1984). Further refinement of the number of potential spawning areas was made based on spawning sites described in the Yampa River, a system with habitat features similar to the Dolores River (Archer and Tyus 1984). Physical characteristics of these areas included: 1) suitable spawning habitat (gravel/cobble/boulder bars with average depths of 0.3 to 3 m and velocities of 0.3 to 1 m/s), and; 2) suitable resting or staging habitat consisting of pools and eddies with average depth of 2 m and velocities of 0.3 m/s or less. Maps and detailed measurements of the physical attributes of these sites were made on three representative potential spawning areas in 1990 and 1991 under low flow conditions. Scaled maps were produced for each site showing channel configuration, water depths, surface macrohabitat features, substrates, and substrate embeddedness. Corresponding velocity data were provided for each site.

3.4 Water Quality, Macroinvertebrate and Sediment Sampling

Six water quality and macroinvertebrate sampling sites were established within the study area (Figure 2). Twenty-five water quality parameters were measured at each site (Table 3). Water samples represented grab samples taken at one point in time and integrated across the channel at one location. All water samples were stored in coolers at 4°C until processing. Water quality analyses were performed by ChemTech Laboratories of Murray, Utah (State of Utah and EPA Certification # E-56). Additional water quality parameters, including conductivity and salinity were measured afield using a Yellow Springs Instruments (YSI) temperature/conductivity/salinity meter or a Hydrolab Surveyor II.

One sediment sample was collected at each water quality sampling site for analysis of Radium-226. A 5-cm diameter core sampler was used to collect one 8-cm sediment profile from the waters edge at each site. Samples were placed in a sealed container, stored at 4°C, and analyzed by Core Laboratories, Inc., of Casper, Wyoming.

Benthic macroinvertebrates were sampled using a modified Hess sampler (1 $ft.^2$). Similar sample sites were selected where possible to minimize sample variation. Macroinvertebrate sample sites were located in cobble riffles, with velocities ranging from 0.3 to 0.6 m/s and depths of 25 to 36 cm.

Substrate size was 7 to 25-cm rounded cobble, except for the sample site immediately above the San Miguel River, which consisted of 15 to 30-cm angular cobble. Two to four sample replicates were collected within similar habitats at each sample site. Additional qualitative samples were collected in a range of habitats. Macroinvertebrate samples were preserved in 70% ethanol and transported to BIO/WEST laboratories for analysis. A Biotic Condition Index (BCI) was calculated for both the Dolores and San Miguel rivers based on macroinvertebrate collections in 1991, as outlined in the Fisheries Habitat Surveys Handbook (USFWS 1985).

3.5 Bioassays

Three species of fish were collected for bioassays to assess bioaccumulation of seven heavy metals. Liver and kidney tissues were collected from flannelmouth suckers, roundtail chub, and channel catfish in October 1991. Liver and kidney tissue are generally considered good indicators of heavy metals accumulation (Kunkle et al. 1983, Dallinger and Kautzky 1985, Bradley and Morris 1986). Attempts were made to collect ten individuals of each species, however only two roundtail chub and six channel catfish could be obtained. Ten flannelmouth suckers were collected for bioassays. Information collected for each fish included total length, weight, sex and capture location. Liver and kidney tissues were collected and combined into one sample for each fish. Tissue samples were immediately frozen in liquid nitrogen and transported to ChemTech Laboratories in Murray, Utah for analysis.

4.0 RESULTS

4.1 Summary of Fish Collections

A total of 19 species of fish representing seven families were captured in the Dolores River during the study (Table 4). This list was similar to that reported by Holden and Stalnaker (1975) and Valdez et al. (1982) except that black bullhead, bluegill, plains killifish, brown trout, rainbow trout, mottled sculpin, white sucker and Colorado squawfish were not reported in 1975 and bluegill, mottled sculpin and Colorado squawfish were not reported in 1982. White sucker, rainbow trout and brown trout were reported by Valdez et al. (1982) but were not captured by BIO/WEST in 1990. However, all three of these species were captured in 1991.

As a percentage of total catch, the most common species of fish captured during the study were red shiner (33.4), sand shiner (23.1) and fathead minnow (18.4) (Table 5). These three non-native fish comprised 74.9% of the catch. Of the 19 species reported, 13 were non-native and six were native or endemic to the Colorado River system (Tyus et al. 1982). Native species comprised 19% of the total catch and included flannelmouth sucker (9.2), roundtail chub (4.6), bluehead sucker (2.7), speckled dace (2.5), mottled sculpin (<0.1) and Colorado squawfish (<0.1). Four Colorado squawfish were captured during 1991 in the lower 2 km of the Dolores River. These represent the first Colorado squawfish reported in the drainage since unconfirmed reports by Horpestad in 1973 and may be the first record since Coon (1965). No other endangered species including bonytail (*Gila elegans*), humpback chub (*Gila cypha*) or razorback sucker (*Xyrauchen texanus*) were captured in the Dolores River during the study.

Larval and young-of-year (YOY) life stages of 12 species were captured in the Dolores River during this study (Table 6.) Four of these 12 species are native or endemic including flannelmouth sucker, bluehead sucker, roundtail chub and speckled dace. The capture of YOY of these species during both years of the study indicates that the Dolores River provides adequate habitat for successful spawning and rearing for these species. High numbers of YOY red shiners, sand shiners and fathead minnows were also captured, particularly during 1990. High numbers of these species in 1990 may be a result of favorable spawning and rearing conditions created by consistent low flows that year.

Native species were prominent in the middle reaches of the study area (Figure 3). Non-native species may be more common in the lower reaches because of the Colorado River and in the upper reaches because of McPhee Dam. Influxes of non-native species from the Colorado River probably shifted species composition in the lower reaches. In the upper reaches, habitat changes associated with the operation of McPhee Dam may have altered species composition. Stocking and management of non-native salmonid fishes below McPhee have also affected species composition in the upper reaches.

Each of the four major native species exhibited a unique distribution through the study area as a percentage of total species composition. Flannelmouth suckers were the most ubiquitous native species in the drainage, although these were most prevalent in the middle reaches (Figure 4) Bluehead suckers comprised a higher percentage in the lower reaches, but was common throughout the study area (Figure 5). Roundtail chubs were most prevalent in the upper reaches (Figure 6), and percentage of speckled dace was also higher in the upper reaches (Figure 7).

Analyses of seine samples also indicate that natives were more prevalent in the middle and upper of the study area (Figure 8). The relatively high percent composition in Reach 3 during 1991, was difficult to explain. A series of flood events that occurred in 1991 may have reduced the abundance of non-native species in this reach. It is possible that increased composition of native species may be representative of strong year classes of one or more of the native species, however this was not reflected in catch rates for 1991.

During Trip 4, 1991, a Floy-tagged flannelmouth sucker was recaptured at RM 52.8. The fish was originally handled by the Service on May 14, 1981 at RM 39.5 (Valdez et al. 1982), measuring 474 mm total length (TL) and weighing 1120 gms. The fish was recaptured on April 6, 1991, 13 miles upstream measuring 512 mm TL and weighing 993 gms. During a period of approximately 9 years and 11 months the fish grew 38 mm and lost 127 gms. This translates to a growth rate of 3.8 mm/year. The weight loss can be attributed to numerous factors (i.e. condition, observer error, etc.).

4.2 Summary of Fish Collections by Gear Type with CPE Statistics

Results of fish sampling efforts for each gear type are presented in the following sections (Table 2).

4.2.1 Electrofishing

Flannelmouth sucker, roundtail chub, bluehead sucker, carp and channel catfish were the most abundant species in the catch using canoe electrofishing during both years of the study (Table 7). Differences in catch-per-effort (CPE) between the 2 years were difficult to interpret but were probably associated with
one or more factors including: 1) actual changes in density; 2) different conditions (i.e. flow, water quality) between trips and years; 3) differences in timing of sampling between the 2 years of study.

Highest catch rates for canoe electrofishing (Table 7) were for flannelmouth sucker (105.7 fish/10 hours), roundtail chub (52.8), bluehead sucker (30.0) and carp (29.0). Highest catch rates for Jon boat electrofishing (Table 8) were for flannelmouth sucker (294.2), carp (155.5) and bluehead sucker (100.6). Differences in catch rates between the two types of electrofishing boats were related to two factors: 1) catch rates were reflective of actual differences in species composition between the upper Dolores River (above the confluence of the San Miguel River) where the canoe was primarily used and the lower Dolores River (below the confluence of the San Miguel) where the Jon boat was the primary electrofishing craft, and 2) higher catch rates of smaller species with the Jon boat may reflect differences in electrofishing efficiency between the Jon boat and canoe.

Effectiveness of electrofishing from either boat was influenced by conductivity, flow, turbidity and channel morphology. High conductivities associated with particular areas probably had the greatest influence. Electrofishing the Paradox Valley reach (Reach IV) was less effective because of saline groundwater inflow. Conductivities in the other reaches were more suitable for electrofishing. High turbidity associated with tributary runoff from storm events also affected electrofishing efficiency, primarily during Trips 2, 4 and 5 when extremely high turbidities were encountered. This influenced electrofishing success by impairing the netter's ability to see fish, and by possibly reducing fish activity.

Higher catch rates for most species were observed during the second and third trips in 1990 compared to corresponding trips in 1991 (Table 9). Differences in catch rates between similar trips on different years may be associated with differences in flows and timing of sampling. Lower flows during the second trip in 1990 compared to the second trip in 1991 may have concentrated fish and predisposed them to capture. Lower catch rates during the third trip in 1991 compared to the same trip in 1990 were probably associated with behavioral differences of fish between late summer and early fall. During the third trip of 1991 fish were probably in deeper habitats, were less active and therefore less susceptible to capture by electrofishing.

4.2.2 Gill and Trammel Netting

Netting efforts were higher during the first year of the study (1990) because of poor sample conditions in 1991. Factors affecting efficiency of gill and trammel netting included river flow, channel morphology, floating debris and excessive turbidity. Netting was ineffective in shallow habitats and during periods of high debris flow.

Catch rates for experimental gill nets (Table 10), trammel nets (Table 11) and floating trammel nets (Table 12) are presented separately as number of fish/100 feet of net/100 hours. The highest catch rates for experimental gill nets, which were used most frequently, were for flannelmouth sucker (6.4), roundtail chub (1.4) and bluehead sucker (0.8). Trammel nets (both sinking and floating) also produced relatively high catch rates for flannelmouth sucker (1.5 and 43.8, respectively). High catch rates for carp and channel catfish in trammel nets, were probably more indicative of gear effectiveness on spined fishes than actual differences in densities.

Netting with gill and trammel nets was conducive to river reaches with greater flow and deeper channels. Low releases from McPhee Dam above the confluence of the San Miguel River made sampling with nets ineffective. This situation was particularly evident during Trips 1 and 6 when releases from McPhee Dam were 20 and 32 cfs, respectively. Under these conditions nets could be used in few locations where deep pools or runs were found. In reaches where the channel was wide and shallow, netting was impractical and not attempted. Below the confluence of the San Miguel River gill and trammel nets were more effective because of higher water volume. Floating debris associated with tributary runoff from storm events affected netting during Trip 2, 4 and 5.

Gill and trammel net catch rates by species by trip for the 2 years of study show no definitive patterns of fish abundance between trips (Tables 13 and 14). These data reflect lower efforts during 1991.

Netting was not conducted in Reach 6 by BIO/WEST. Electrofishing was the primary sampling method in this reach. Netting was conducted in Reach 6 by CDOW during 1987-1990. CDOW catch rates reported for Reach 6 (RM 129-185) were highest for roundtail chub (7.1 fish/100 feet of net/overnight set), followed by flannelmouth sucker (3.9), trout species (1.8) bluehead sucker (1.0) and channel catfish (0.2). These results were comparable to species composition found by BIO/WEST in Reach 6 (Table 34), indicating that roundtail chub and flannelmouth sucker were the most abundant species in Reach 6.

4.2.3 Seining

Red shiner (98.1 fish/100 m^2), sand shiner (69.6) and fathead minnow (54.0) dominated catch rates when data for all 10 habitat types were combined (Table 15). Catch rates for native species, were 9.2 for roundtail chub, 8.2 for flannelmouth sucker, 6.7 for speckled dace and 2.2 for bluehead sucker. Channel catfish and unidentified suckers represented the only other species with relatively high catch rates of 2.4 and 1.8, respectively. Limited use of a large seine resulted in the capture of three species, all non-natives (Table 16).

Catch rates for red shiners, sand shiners and fathead minnow correspondingly dominated catch rates in eight of ten habitat types (Tables 17-26). Two habitat types not dominated by this species assemblage were riffles and isolated pools. Speckled dace dominated seining catch rates in riffles *(14.1 fish/100 m2) followed by channel catfish (13.5) and red shiners (9.5) (Table 24). In isolated* pools, red shiners were most abundant (51.7 fish/100 m^2) followed by roundtail chub (13.0), and fathead minnows (12.6) (Table 26).

Seining was the most consistent fish sampling technique between reaches. Although sampling effort was not always consistent between trips or reaches, factors affecting seining catch rates were not as variable as with other sampling techniques. Still, seining catch rates varied substantially between the 2 years of study (Table 27). Catch rates were much higher in 1990 than 1991 with the exception of the first trip (pre-runoff). It is hypothesized that low flows during 1990 created conditions more conducive to seining and may have concentrated fish and increased catch rates. However, higher catch rates in Trip 1 of 1991 compared to Trip 1 of 1990, indicated high spawning success of most species with a strong cohort the following spring.

Of the 14 species captured by seining, five were from backwaters, three from riffles, three from isolated pools, two from embayments and one each from trickle-fed backwaters, eddies and pools (Table 28). The three native species, flannelmouth sucker, bluehead sucker and roundtail chub, were in backwaters. The affinity of these species for backwaters was shared by red shiners and fathead minnows. Speckled dace was the only native species captured most frequently in riffles, although catch rates were also relatively high in backwaters.

4.2.4 Fish Species Composition - Past and Present

In order to address Objective 1 of this study, a comparison was made between the 1981 study (Valdez et al. 1982) and the 1990-1991 BIO/WEST investigation. Comparisons of catch rates for trips conducted within the same season of the year are presented in Tables 29 and 30. Species composition by reach was compared between the two studies in Tables 31 and 32. These comparisons are presented as a means of indicating possible changes that have occurred in the Dolores River in the last 9-10 years. Based on differences in catch rates and species composition between BIO/WEST's 1990 and 1991 data, the potential for a high variability in catch data is apparent. Differences between the two studies were expected especially with differences in gear types, efficiency and methods. Since these differences could not be evaluated, comparisons between catch data from the two studies focused on gross differences in composition and catch rates.

Catch rates for netting and electrofishing combined (Table 29) showed little differences between the two studies. No unusual discrepancies or patterns were identified between the two data sets. Catch rates for seining also showed no major differences between the two studies (Table 30). One minor difference was the high catch rates for red shiners and roundtail chubs by the Service in April followed by a decline in July. BIO/WEST's data suggests an opposite pattern, low catch rates in April followed by higher catch rates in July as individuals from the current year class became prominent in the catch. Differences may have reflected a poor year class of these two species during the Service's study in 1981.

No major changes in fish species composition captured in gill nets, trammel nets and by electrofishing were evident between the two studies (Table 31). Several trends were noteworthy and suggested subtle changes in species composition. Except for Reach 1, consistently lower catch rates of roundtail chub by BIO/WEST suggest a decrease in abundance of this species. Conversely, consistently higher catch rates of flannelmouth suckers in all reaches except Reach 1 indicate an increased abundance of this species, particularly higher in the drainage.

With the exception of compositional shifts between sand shiners, red shiners and fathead minnows, seining data showed very few changes in species composition of fish captured seining since 1981 (Table 32). The shift in composition between red shiners, sand shiners and fathead minnows probably represents natural variation in populations of these prolific species.

4.3 Summary of Colorado Squawfish Habitat Assessment

Habitat suitability assessment of the Dolores River for Colorado squawfish was divided into three components including: 1) physical attributes; 2) chemical attributes, and 3) biological attributes. Each of these components is address in the following sections.

4.3.1 Physical Attributes

Habitat suitability of the Dolores River was influenced by physical attributes such as flow, temperature, substrate characteristics, habitat structure, and channel morphology. Measuring these physical attributes was generally not difficult, but determining the combination of attributes most suitable to a species like the Colorado squawfish is not well defined, particularly since the fish cannot be observed directly. For the purposes of this study, it was necessary to use information collected on physical habitat for Colorado squawfish from other upper basin rivers. We assumed that physical habitat of the Dolores River was suitable and not limiting if its physical attributes were within the range in areas of other rivers used by the species.

Criteria for physical habitat suitability were based on HSI curves developed by Valdez et al. (1987), for endangered fish of the Upper Colorado River Basin. These HSI curves were developed using data collected on various life stages of Colorado squawfish between 1964 and 1985. Studies of Colorado squawfish in other upper basin drainages were also used. Information collected from the Yampa and White rivers was used to describe habitat requirements, since these systems may be functionally comparable to the Dolores River in the life of the Colorado squawfish. Habitat suitability of the Dolores River for different life stages of Colorado squawfish is summarized in Table 33. Physical factors that affect the suitability of five parameters listed in Table 33 are discussed below.

4.3.1.1 Flows. The Dolores River drainage exhibits a hydrograph that is typical of most upper Colorado River basin drainages. Beginning in mid to late March, flows increase dramatically from melting of mid-elevation snowpack. This early runoff can peak quickly and subside in mid to late April, when flows increase again with melting of higher elevation snowpack. Following spring runoff, flows gradually subside until mid to late July. From late July through September, the climate in the Dolores River drainage is often dominated by moisture-laden Pacific air masses transported by a southwesterly flow of air. The result of this "summer monsoon season" is frequent high intensity storms that result in short term flow of relatively large magnitude.

For purposes of assessing flows of the Dolores River, the study area was divided into two regions, each with a distinct hydrograph. These regions included: 1) the Dolores River above the confluence of the San Miguel River (above RM 64.4), and 2) the Dolores River below the confluence of the San Miguel River (below RM 64.4).

RM 0.0 to 64.4. Below the confluence of the Dolores and San Miguel rivers, flow increased substantially. The San Miguel River was a free flowing river with a relatively normal hydrograph, and an average annual flow of 410 cfs. Peak flows from the San Miguel River generally occurred in late April and early May and ranged from below 1000 to above 8000 cfs for the period of record. Base flows generally occurred in late fall and winter and averaged 80 to 200 cfs. Irrigation withdrawals from the San Miguel above Uravan affected flows during the summer months. Peak instantaneous flow and peak daily discharge at the gage near Cisco on the Dolores River in 1990 were 1,340 cfs (on July 18) and 997 cfs (on June 12), respectively. In 1991, peak daily discharge at the same location was 2,130 cfs on May 22. During 1990, flows from the San Miguel River contributed more to the system than flows from the Dolores River below McPhee Dam. Flows encountered in the Dolores River near its confluence with the Colorado River during the study period ranged from 107 to 1400 cfs (Table 34).

Drought conditions persisted for both years of the study. Figure 10 presents a post-dam hydrograph of mean monthly flows of the Dolores River near its confluence with the Colorado River. Also presented are mean daily flows for the 2 years of study. Low flows during the study were a result of below normal snow pack in both the Dolores and San Miguel rivers. McPhee Dam captured runoff during both years and compounded low flow conditions. These conditions probably impeded fish movement between reaches and habitats. Numerous cobble bars were encountered with only 5-7 cm of water. Colorado squawfish captured in the lower 2 km of the Dolores River may have been prevented from moving higher in the drainage by such conditions just upstream of the confluence with the Colorado River.

Mean monthly flows of the Dolores, White and Yampa rivers were compared in Figure 11 to provide a prospective on the relative size of the Dolores River after McPhee Dam. The White River is a tributary of the Green River very similar in size and sediment characteristics to the Dolores River, and supports adult Colorado squawfish. The Dolores River averaged higher spring peak flows than the White River, but base flows in the White were consistently higher. Spring runoff in the White River generally peaked in June compared to May for the Dolores River. The Yampa River is the major tributary of the Green River and is known to provide both holding and spawning habitat for Colorado squawfish. Although flows of the Yampa River were nearly an order of magnitude larger than those of the Dolores River, the pattern of the hydrograph for both systems was similar.

RM 64.4 to 177.0. Flows in the Dolores River above the confluence of the San Miguel River were dominated by releases from McPhee Dam. Although seasonal inputs from ephemeral and perennial tributaries contributed significant flows, the operation of McPhee Dam had the greatest influence on the hydrograph. Flows encountered in the Dolores River above the confluence of the San Miguel River ranged from 21 to 730 cfs (Table 34). A comparison of mean monthly flows from two USGS gages (the Dolores gage immediately above McPhee Reservoir, and the Bedrock gage 120 miles below McPhee dam) indicates that the operation of McPhee affects both the timing and magnitude of flows below the dam to some degree (Figure 9). Similarities between the two hydrographs, particularly associated with peak flows, was the result of several high flow years since the closure of the dam (1984, 1985 and 1987). Differences between mean monthly flows for the study period (1990 and 1991) and overall mean monthly flows indicate that in low to medium water years McPhee Dam drastically affects the hydrograph.

Before 1990, releases from McPhee Dam were based on runoff predictions from snowpack and reservoir level on March 1 and April 24, respectively. Annual releases were based on criteria for dry, normal or wet years with base flows of 20, 50 and 78 cfs, respectively. A series of wet years (1985-87) following closure of McPhee Dam in 1984 continued to affect reservoir levels and base flows were maintained at about 78 cfs.

Persistent drought from 1988 through 1991 greatly reduced water availability in the Dolores River drainage and the operation of McPhee Dam was modified in 1990. On March 5, 1990 (first day of Trip 1), releases from McPhee Dam were reduced to 20 cfs because of low reservoir level and predicted of low runoff from high elevation snow-pack. Low flows from McPhee Dam continued in 1990, ranging from 20 to 50 cfs. Flows increased to 50 cfs during July 1990, as a result of an informal agreement between Reclamation, water users and CDOW (personal communication with Tom Beck, CDOW). Increased summer flows were intended to maintain cooler temperatures for the tailwater trout fishery. Low flows, ranging between 20 and 50 cfs were continued through 1991. One short release in 1991 provided flows for rafters for approximately 10 days during the Memorial Day weekend.

4.3.1.2 Temperature. To evaluate main channel water temperatures in the Dolores River and factors that influence temperatures, the study area was divided into two regions, including 1) the Dolores River below the confluence of the San Miguel River (RM 0.0-64.4), and 2) the Dolores River above the confluence of the San Miguel River to Bradfield Bridge (RM 64.5-177).

RM 0.0 to 64.4. Temperature in this region was influenced primarily by the San Miguel River. Main channel temperatures recorded in the Dolores River during the study ranged from a low of 3.5°C (March 13, 1990) to a high of 28.5°C (August 12, 1991) (Table 35). USGS temperature data at Bedrock (RM 75) ranged from a high of 30 °C in July to O°C during many days in winter. Maximum temperature recorded at the Bedrock gage was 33.5°C on July 10, 1981. Temperatures in the lower Dolores River, below the confluence of the San Miguel, were moderated by larger volumes of water and ranged from 29°C in July and August to O°C during the winter. Maximum temperature recorded at the USGS gage near Cisco (approximately 9.5 miles above the Colorado/Dolores River confluence) was 29°C on August 14, 1958.

Analysis of mean monthly temperatures from the USGS gages near Cisco for both the Colorado and Dolores Rivers indicate that lower volume and early runoff in the Dolores River resulted in earlier warming when compared to the Colorado River (Figure 12). The Colorado River generally reached comparable temperatures 10 to 20 days after the Dolores River. Temperatures in the Dolores were consistently higher than in the Colorado River except during November - January. The effect of differences in warming of the Colorado and Dolores rivers on migration and spawning cues of Colorado squawfish is unknown.

<u>RM 64.5-177.0</u>. Temperatures in this reach ranged from O to 30 °C, with highs occurring in July and August and lows in winter months. Releases from McPhee Dam had a profound effect on temperatures in this region. Effects were seen in both diel and annual temperature patterns. Diel temperature patterns were primarily affected by low volume releases during summer months. During this time, diel temperature swings were extreme because of the small thermal mass in stream flow. This problem was particularly acute in low velocity habitats such as pools and backwaters where warm temperatures were often accompanied by depressed oxygen levels. From April through July, 1991, the monthly extreme diel temperature ranges in the mainstem Dolores River, just above the San Miguel River confluence, were 3.2-8.9, 5.9-12.3, 13.6-19.4, and 13.9-20.1°C, respectively (T. Beck, CDOW, unpublished data).

Changes to annual temperature patterns related to the operation of McPhee Dam were potentially deleterious to native species. Premature warming during low flows in April and May initiated gonadal maturation and spawning by native fish species including roundtail chub, flannelmouth sucker and bluehead sucker. Warm temperatures followed by cold releases probably killed large numbers of eggs and larvae. Data provided by CDOW indicate that water temperatures during low flows (20 cfs) in 1990 reached 16°C by mid April and 18°C by the first week in May. Large aggregations of flannelmouth suckers were observed during the same time period in the upper Dolores River and individuals showing signs of spawning readiness were captured (T. Beck CDOW, pers. comm.).

A distinct temperature break occurred at the confluence of Disappointment Creek (RM 128.7). Above this point, under normal flow conditions, the Dolores River was relatively cool. The river flowed through extensive canyon areas which delayed warming. Below Disappointment Creek the channel became more open and the river warmed as it traversed a broad flood plain. During the summer, main channel temperatures above and below Disappointment Creek differed by as much as 4°C and turbidity increased significantly below (Beck 1989). Higher turbidity below Disappointment Creek was the result of highly erodible shales and sandstones. Disappointment Creek represented a distinct geomorphic transition in the Dolores River system where the river changed from a cool, clear stream to a warm, turbid system.

<u>4.3.1.3 Habitat Availability/Channel Morphology.</u> A general description of channel morphology and gross habitat structure of the Dolores River was presented by Valdez et al. (1982). This description included maximum and average depths, channel width and a description of floodplain and channel characteristics. The present study indicated that few changes in gross physical habitat occurred in the Dolores River since 1981, except for sedimentation. Observations and communications (Personal communication with T. Beck, CDOW) indicate that fine sediments accumulated in the Dolores River channel. This problem was most acute above the confluence of the San Miguel River where McPhee Dam greatly reduced or eliminated spring runoff flushing flows. Below the confluence of the San Miguel River, sediment was less evident. Additional studies would be required to evaluate sedimentation and channel armoring. A description of habitat and channel morphology for each reach of the study area is presented below.

Reach I (RM 0.0 - 22.7) This reach included a wide variety of substrates, channel configuration and habitat types. From the confluence (RM 0.0) to approximately RM 12.0, the river was relatively shallow, with numerous runs interspersed with cobble riffles, small rapids and pools at the mouths of ephemeral tributaries. Substrate at tributary mouths was large boulder and rubble fans, while cobble and gravel dominated riffle areas, and finer sands and silt were in slow runs and other low velocity habitat. Above RM 12.0 to Stateline Rapid (RM 22.7) the river flowed through a narrow canyon. The gradient was slightly higher with more rapid and pool habitat. Maximum depth was 13 feet in a pool at RM 15.9. Approximate depths observed for various habitats at low flows ranged from 6 to 8 feet in pools, 2 to 4 feet in runs and 0.5 to 3 feet in riffles. Channel widths of 33 to 100 feet reported by Valdez et al. (1982) were consistent with our observations in 1990.

Reach II (RM 22.7 - RM 41.3) This reach was characterized by a relatively wide floodplain and braided channel, with a diversity of habitats and substrates. Areas of long slow runs were prevalent, interspersed with cobble riffles and small alluvial rapids associated with mouths of side canyons. Channel widths of 82 to 100 feet and a mean depth of 3.3 feet with a maximum depth of 11 feet were reported by Valdez et al. (1982). In 1991, at flows of approximately 200 cfs, mean channel width was 127.2 feet, mean depth was 2.7 feet and a maximum depth was 13.2 feet. One perennial tributary, West Creek, flowed into the Dolores River from the east at RM 31.2.

Reach III (RM 41.3 - RM 64.4) The floodplain became more constricted in this reach as the river flowed through narrow deep canyons. Several small rapids occurred at mouths of side canyons, but the reach was characterized by a series of riffles, pools and long slow runs. Numerous pools with depths greater than 10 feet were identified in this reach. Valdez et al. (1982) reported 6.5 and 33 feet as the mean and maximum depths, respectively, for this reach, and channel widths of 82 to 115 feet. In 1991, at flows of approximately 200 cfs, mean channel width was 98.5 feet, a mean depth was 2.7 feet and a max depth was 10.5 feet. Perennial tributaries in this reach included Blue Creek (RM 44.3), Roc Creek (RM 54.7) and the San Miguel River (RM 64.4).

Reach IV (RM 64.4 - RM 74.8) This reach was composed of two distinct areas including a short narrow canyon above the San Miguel confluence and a reach where the Dolores River traversed Paradox Valley. The canyon reach was composed of a continuous series of shallow riffles and runs. With the exception of a large deep pool immediately above the confluence of the San Miguel River, pool habitat was sparse in this reach. Rubble, cobble and boulders were the predominant substrates. Where the Dolores River traversed Paradox Valley, the river was characterized by a wide floodplain, low velocities and fine substrates. Average depth in this reach was approximately 1 to 2 feet. River widths of 80 to 100 feet were reported by the Valdez et al. (1982). In 1991, at flows of approximately 40 cfs, mean channel width was 63.6 feet, mean depth was 0.83 feet and a maximum depth was 3.3 feet.

Reach V (RM 74.8 - 128.7) This reach encompassed several narrow canyon reaches, including one canyon 32 miles long. The river also traversed several small valleys. In the canyons the river was generally characterized by series of riffles, pools and slow runs. Several small rapids were located at tributary mouths. Silt was the predominant substrate in areas with low velocities, with cobble more prevalent in riffles and rapids. Rubble and boulder substrates were associated with alluvial fans of tributaries. Maximum depth measured in this reach was 11 feet in 1990. In 1991, at approximately 40 cfs, mean channel width was 52.9 feet, mean depth was 1.7 feet and a maximum depth was 5.3 feet. La Sal Creek, which flowed perennially, entered the Dolores River from the west at RM 79.5.

Reach VI (RM 128.7 - 177.0) This reach traversed a large canyon through its entirety. The channel was primarily pool-drop in native, interspersed with short sections of riffle-run habitat. Data collected by CDOW showed that cobble was the dominant substrate followed by boulder, silt and sand, with finer substrates occurring in pools and other slow velocity areas. CDOW data showed that channel widths range from less than 30 feet to more than 90 feet.

4.3.1.4 Potential Spawning Habitat. Thirteen potential spawning sites for Colorado squawfish were identified on the Dolores River during the study. Classification of these sites was based on criteria previously described including the presence of deep pools and eddies in proximity to and interspersed with cobble riffles and run habitat. Three of these sites were selected as representative of potential spawning sites in the Dolores River. Detailed maps of these sites are presented in Figures 13-15. All mapping was conducted during low flows and emphasis was placed on characterizing substrate sizes and embeddedness. Data collected from each of the three potential spawning areas are presented in Appendix A.

4.3.1.5 Nursery Habitat. Backwater densities on the Dolores River ranged from 0.2 to 0.8 backwaters per mile at flows observed during the study. Backwaters ranged in size from 150 ft^2 to 32,000 ft^2. Maximum depths of backwaters ranged from 6 inches to 4 feet. Substrates were generally composed of organic fines, silt, sand and cobble. The majority of backwaters were formed in dewatered side channels. Highest backwater densities were found in Reaches II and III at flows of approximately 200 - 300 cfs. It was noted during the study that the stochostic nature of the hydrograph during the summer months frequently inundated and desiccated backwater habitats. This ephemeral character of backwaters reduced the value of the system as a nursery. However, the Dolores River confluence was located immediately upstream of the Professor Valley nursery area on the Colorado River, where dispersing larvae and age-0 fish find ample habitat. A similar situation exists on the Yampa River, where larval Colorado squawfish drift into nursery areas in the Green River downstream of their confluence.

Other potential nursery habitats included ephemeral isolated pools and trickle fed side channels. Ephemeral isolated pools were uncommon in the Dolores River, although several large isolated pools were located with an array of both native and non-native species. Trickle fed side channels were also identified as potential nursery habitat. This habitat was characterized by a side channel isolated from inflow except for a small trickle of water flowing through cobbles. Current was generally not perceptible and temperature was similar to that observed in backwaters. This habitat type was common in much of the study area.

4.3.2 Chemical Attributes

Water quality of the Dolores River was represented by grab samples collected at points in time. Because of the variable nature of the river, these water samples were not necessarily representative of the full range of water quality. Flood events or spates, particularly those associated with runoff of high intensity summer storms, greatly influenced water quality. Water quality data for Trips 1 through 6 are presented in Tables 36-41.

In addition to water quality samples for laboratory analysis, field measurements were taken for conductivity, salinity, pH, alkalinity and dissolved oxygen. Water quality data collected afield are presented in Table 35. A historical comparison of water quality is presented in Table 42.

4.3.2.1 Alkalinity. Alkalinity is a measure of the buffering capacity of water. Buffering capacity is important to water quality (EPA 1986) since pH has a direct effect on organisms as well as an indirect effect on the toxicity of pollutants. Total alkalinity in the Dolores River ranged from 92.1 mg $CaCO_3$/l on Trip 3 to 3,424 mg/l on Trip 5. Dissolved alkalinity was measured only during Trips 5 and 6, and ranged from 62.7 to 146 mg/l. There were no consistent differences in alkalinity, total or dissolved, between study reaches. Historically, the range of alkalinity measured in the Dolores River in 1960 (82-850 mg/l) was lower than measured by BIO/WEST in 1991 (165-3,424 mg/l). A similar comparison for the San Miguel River showed little difference in total alkalinity. The EPA criteria for freshwater aquatic life for alkalinity is a minimum of 20 mg $CaCO_3$/l except where natural concentrations are less.

__4.3.2.2 Hardness.__ Water hardness in the Dolores River varied from 138.5 (Trip 2) to 912 mg $CaCO^3$/l (Trips 2 and 4). Although hardness varied substantially between reaches, no distinct trends were apparent. In 1991, hardness in the San Miguel River was lower than any Dolores River reach for all trips, ranging from 129 - 165 mg/l. High values during Trip 2 probably reflected a high noncarbonate hardness fraction, since alkalinity was relatively low for the same samples. Dolores River water was classified as moderately hard to very hard based on the classification used by Sawyer (1960). The effect of hardness on freshwater fish and other aquatic life is often related to the ionic concentration rather than carbonate, therefore no EPA criteria exist (EPA 1986).

__4.3.2.3 pH Units.__ pH varied from 7.7 during Trips 2 and 4 to 8.5 during Trip 3. No distinct trends or differences were apparent between trips or study reaches, except for slightly lower values in all reaches for Trip 5. In 1960, measurements of pH in the Slick Rock area and near Gateway did not exceed 8.0 and were as low as 7.5 (USPHS 1961). The pH of the San Miguel River near the confluence ranged from 7.6 to 8.5 in 1990-1991, compared to 7.6 in 1960. pH as low as 4.3 was measured in the main channel several miles below Uravan (Sigler et al. 1966) while effluent with a pH as low as 2.3 was being discharged into the San Miguel River from a uranium mill in 1960 (USPHS 1961). A pH of 5 to 9 is not directly lethal to freshwater fish (European Inland Fisheries Advisory Commission 1969), however, the toxicity of several common pollutants is markedly affected by pH changes within this range, and increasing acidity or alkalinity may make these poisons more toxic (EPA 1986). The EPA criteria is set at 6.5 -9.0 for freshwater aquatic life.

__4.3.2.4 TDS.__ Levels of total dissolved solids (TDS) in the Dolores River ranged from 220 (Trip 4) - 6,320 mg/l (Trip 1) during 1990-1991. TDS were generally higher on Trip 1 because of low flows which concentrated dissolved solids. TDS decreased below the confluence of the San Miguel on Trip 1, because to dilution by flows from the San Miguel River. High TDS above the confluence of the San Miguel River where related to saline groundwater inflow into the Dolores River across Paradox Valley. The San Miguel River had a noticeable diluting effect on TDS throughout the study. Maximum levels of TDS recorded below the confluence of the San Miguel were 2,595 mg/l on Trip 1 in 1990, compared to 3,822 mg/l in 1975 and 3,020 mg/l in 1960 (Miller 1976, USPHS 1961). Thus, TDS levels have decreased in the Dolores River since the 1960's and 70's (Table 42). Rawson and Moore (1944) found that several common freshwater fish species survived exposure to 10,000 mg/l TDS. Pimentel and Bulkley (1983) determined that Colorado squawfish avoided TDS concentrations greater than 4,400 mg/l. No criteria have been set for TDS by the EPA.

__4.3.2.5 Ammonia.__ Ammonia varied from 0.10 mg NH^3-N/l on Trip 2 to 0.963 on Trip 1. High values associated with Trip 1 were probably related to extremely low flows during this period. No pattern was found between study reaches. Ammonia in the San Miguel River ranged from <0.2 to 0.44 mg/l. Levels of ammonia declined in the Dolores River in the last 15 years from a high of 9.0 mg NH^3/l below the San Miguel confluence (Miller 1976) in 1975 to <0.2 to 0.963 mg/l during 1990-1991 (Table 42). Ammonia levels of up to 23.5 mg NH^3/l were observed in the San Miguel River below Uravan in 1975. Ammonia is acutely toxic to freshwater organisms at concentrations ranging from 0.53 to 22.8 mg/l for 19 invertebrate species representing 14 families and 16 genera, and from 0.083 to 1.09 mg/l for 29 fish species from 9 families and 18 genera (EPA 1986). Among fish species, 96-hr LC50 ranged from 0.083 to 1.09 mg/l for salmonids and from 0.14 to 4.60 mg/l for non-salmonids. Ammonia toxicity varies with temperature and pH. Based on conditions in the Dolores River in 1990, EPA Water Quality Criteria for a 1-hour average concentration of ammonia would range from about 2.3 to 11.4 mg/l.

4.3.2.6 Nitrate. Nitrate values ranged from <0.01 (Trip 5) to 1.26 (Trip 2) mg NO^3-N/l in the Dolores River during 1990-1991. Consistently high levels of nitrates above the confluence of the San Miguel suggest that nitrates were entering the system in Paradox Valley. High nitrates during Trip 1 were probably associated with poor dilution during low base flows. The highest nitrate concentration in 1960 was 3.6 mg near Slickrock (USPHS 1961). Nitrate in the San Miguel River near the confluence was 0.70 mg/l in 1960 and 0.02 - 0.16 mg/l in 1990-1991. The 7-day LC50 for fingerling rainbow trout was 1,060 mg/l (Westin 1974), and Knepp and Arkin (1973) concluded that levels of nitrate nitrogen at or below 90 mg/l had no adverse effects on warmwater fish. No EPA criteria have been established for nitrate concentrations.

4.3.2.7 Phosphate. Concentrations ranged from <0.01 - 11.5 mg PO^4-P/l on trips 6 and 5, respectively. Phosphate was lowest near Slickrock and highest at the station above the confluence of the San Miguel River, indicating inputs from Paradox Valley. Phosphate values were similar between trips although variance was high within trips. Phosphate in the San Miguel River ranged from 0.022 (Trip 4) to 0.31 (Trip 5). High levels of phosphate may lead to proliferation of nuisance plant and animal pests. Mackenthun (1973) set the desired goal for the prevention of plant nuisances at 0.1 mg/l for flowing waters not directly discharging into lakes or impoundments. There are no criteria for phosphate set by the EPA.

4.3.2.8 Ortho-Phosphate. Ortho-phosphate was consistently low, ranging from <0.01 to 0.044 mg PO^4-P/l on Trip 2. Levels ranged from <0.01 - 0.025 mg/l in the San Miguel River. There were no discernable trends between study reaches. No EPA criteria have been established for ortho-phosphates.

4.3.2.9 Heavy Metals. Copper, iron, lead, and zinc were measured as total concentrations during Trips 1 and 2. Because of high levels of these metals, analysis for Trips 3, 5, and 6 was expanded to include a measurement of dissolved concentrations. During Trips 5 and 6, water analysis included total and dissolved forms of aluminum, cadmium, and silver. The significance of total versus dissolved metals in water depends largely on the elemental species. All forms of zinc are potentially toxic if absorbed or bound by biological tissues, which generally will not happen unless zinc is dissolved. On the other hand, water criteria for other metals (e.g., silver, cadmium) are best stated in terms of total recoverable fractions because of the variety of forms that may exist and the various chemical and toxicological properties of these forms (EPA 1986). Measurements of both total and dissolved forms were taken for the third trip in 1990 and all trips in 1991 to facilitate comparison with EPA standards and historical measurements. It should be noted that historical comparison of metal concentrations should be viewed cautiously because of inherent differences in sample sites, collecting and measurement techniques, and variability in related physical parameters such as flow, pH, and water hardness.

The toxicity of copper, like many other heavy metals, is inversely proportional to water hardness (EPA 1986). In nature, copper usually occurs as sulfides and oxides and occasionally as metallic copper (EPA 1980a). Weathering and solution of these natural minerals results in background levels of copper in natural surface waters at concentrations generally well below 0.020 mg/l. Major industrial sources of copper pollution include smelting and refining (EPA 1980a). Copper may enter natural waters directly as effluent or by atmospheric fallout of pollutants produced by industry. Precipitation of atmospheric fallout may be a significant source of copper to the aquatic environment in industrial and mining areas (EPA 1980a). Total copper concentrations in the Dolores River ranged from <0.01 - 0.32 mg/l. Based on the range of water hardness in the Dolores River the EPA criteria states that freshwater aquatic organisms should not be affected unacceptably if the 1-hour average concentration does not exceed 0.024 - 0.142 mg/l more than once every 3 years on the average (depending on hardness). However, these values do not apply to situations where a locally important species is sensitive. When 41 genera of freshwater species were tested for sensitivity to copper, *Ptychocheilus* was found to be most sensitive. Copper became acutely toxic to squawfish at concentrations of 0.016 mg/l at a hardness of 50 mg/l. In the Dolores River in 1990-1991, the upper limit for preservation of aquatic life was exceeded five-fold. Although high levels of water hardness temper its toxicity, copper may still be present in high enough levels to adversely affect native fish species, especially Colorado squawfish. Concentrations of copper in the Dolores River in 1990-1991 were substantially higher than reported in 1960 (Table 42). Total copper measured just above the San Miguel confluence in 1960 peaked at 0.010 mg/l (USPHS 1961), compared to a high of 0.32 near this location in 1991. Copper levels in the San Miguel were similar in both studies (<0.2 mg/l).

Concentrations of iron in the Dolores River in 1990-1991 ranged from 0.2 - 267 mg/l. The EPA has set 1.0 mg/l as the maximum acceptable level of iron for freshwater aquatic life (EPA 1986). This value was exceeded in 25 of 28 water samples taken on the Dolores River in 1990-1991. The highest concentration of iron was found on Trip 5 above the confluence of the San Miguel River, and was 267 times the maximum value set by the EPA for protection of freshwater aquatic life. Iron concentrations in both the Dolores and San Miguel rivers measured in 1990-1991 were higher than levels recorded in 1960 (USPHS 1961), as well as 1986 (ERI 1986) (Table 42). In 1960, total iron was 0.08 mg/l in the Dolores River just above the San Miguel confluence, compared to a high of 267 mg/l for the same area in 1991. Although specific criteria were set by EPA, they do not state possible adverse effects of unacceptable iron levels on fish.

Lead may reach the aquatic environment through precipitation, fallout of lead dust, roadway runoff, and industrial and municipal wastewater discharges (EPA 1980b). The solubility of lead compounds in water is inversely related to pH. Concentrations of <0.01 - 0.36 mg/l were measured in the Dolores River in 1990-1991. Based on the Dolores River water hardness, freshwater species should not be affected unacceptably if 1-hour average concentration does not exceed 0.124 - 1.36 mg/l (depending on water hardness) more than once every 3 years on average (EPA 1986). Lead concentrations in the Dolores River never exceeded the upper limit and, based on these criteria, lead in this system did not appear to be problematic. Total lead in the Dolores and San Miguel rivers (ERI 1986) were similarly low (Table 42).

Zinc is not found free in nature, but occurs as sulfide, oxide, or carbonate complexes (EPA 1980c). Zinc is readily transported in most natural waters. Variables affecting its mobility include concentration and composition of suspended and bed sediments, concentrations of dissolved and particulate iron and manganese, pH, salinity, and concentrations of zinc. Total zinc in the Dolores River in 1990-1991 was 0.01 - 1.20 mg/l. EPA criteria for zinc specifies that concentrations should not exceed 0.421 - 2.012 mg/l (based on water hardness) at any time (EPA 1986). Like lead, zinc in the Dolores River appeared to be at acceptable levels. ERI (1986) also reported low levels of zinc in the Dolores and San Miguel rivers in 1986 (Table 42).

Aluminum in the Dolores River ranged from 6.2 - 57 mg/l in 1991. No EPA criteria for freshwater life are established for aluminum. Concentrations of this element exceeding 1.5 mg/l constitute a hazard in the marine environment, and levels less than 0.2 mg/l present minimal risk of deleterious effects (Van der Leeden et al. 1990). ERI (1986) reported 0.55 and 1.28 mg/l aluminum in the Dolores and San Miguel rivers, respectively, compared to 6.2 - 57 mg/l and 2.8 - 5.0 mg/l in the respective rivers in 1991 (Table 42).

Cadmium may reach the aquatic environment through atmospheric fallout and in effluents from pigments, plastics, alloys, and other manufacturing operations as well as from municipal effluents (EPA 1980d). Total cadmium in the Dolores River in 1991 ranged from <0.01 - 0.015 mg/l. Based on the range of water hardness in the Dolores River in 1990-1991, a maximum 1 hour average concentration of 0.005 - 0.047 mg/l is not to be exceeded more than once every 3 years on average (EPA 1986). Concentrations in the Dolores River never exceeded the upper EPA limit, although cadmium was analyzed only during the last two trips. Cadmium in the Dolores and San Miguel rivers reported by ERI (1986) was similarly low compared to levels recorded in 1991 (Table 42). Smith (1977) reported cadmium levels as high as 2.0 mg/l in the San Miguel River in 1977 (Table 42).

Silver is usually found in extremely low concentrations in the aquatic environment because of its low crustal abundance and its limited mobility in water (EPA 1980e). Silver in the Dolores River never exceeded <0.01 mg/l in 1991. For preservation of freshwater aquatic life, total silver should never exceed 0.007 - 0.182 (based on hardness) at any time (EPA 1986). ERI (1986) also found low levels of silver in the Dolores and San Miguel rivers in 1986 (Table 42).

<u>4.3.2.10 Oil and Grease.</u> Oil and grease in the Dolores River were less than 0.5 mg/l, with the exception of slightly higher concentrations detected during Trip 6. Because of a wide range of compounds included in the category of oil, it is impossible to establish meaningful 96-hour LC50 values for oil and grease without specifying the product involved (EPA 1986). No numerical criteria has been established by the EPA.

<u>4.3.2.11 TSS.</u> Total suspended solids (TSS) ranged from 14 to 18,600 mg/l on Trips 1 and 5, respectively. High TSS were usually associated with turbidity from runoff of high intensity storms. High levels of TSS may affect fish and fish food populations in four ways (EIFAC 1969): 1) reduced growth rate and resistance to diseases that may lead to death; 2) impeded development of fish eggs and larvae; 3) altered movements and migrations and; 4) reduced abundance of food. Given the high tolerance to turbidity of native fish species in the Dolores River, it is difficult to postulate any adverse effects of current TSS levels.

<u>4.3.2.12 Sulfate.</u> Sulfate was measured only on Trips 5 and 6, and ranged from 100 - 424 mg SO_4/l on the Dolores River, and 76.5 - 88 mg/l on the San Miguel River. Sulfate levels in the San Miguel River in 1991 were substantially lower than reported by ERI in 1986 (Table 42). No EPA criteria exist for sulfates.

<u>4.3.2.13 Salinity.</u> Salinity of the Dolores River in 1990-1991 was generally at or below 1 part per thousand (ppt), with the exception of Reach IV where the Dolores River traversed Paradox Valley. This persisted to the confluence of the San Miguel, where dilution from increased flow reduced the concentration of salts. Highest salinity reading were recorded during Trip 1, when flows were lowest. During this trip salinity increased from less than 1 ppt to 7 ppt in a 7.2 mile reach, from RM 75.4 to RM 68.2. This extreme salinity gradient was not observed during other trips when flows were higher.

<u>4.3.2.14 Specific Conductance.</u> Conductance of the Dolores River ranged from 154 to 7500 umhos/cm. Highest conductivities were observed during Trip 1 in Reach IV and were probably related to low flows and saline groundwater inflow in Paradox Valley. On Trip 6, conductivity increased across Paradox Valley, from 784 umhos/cm at RM 74.0 to 1820 umhos/cm at RM 68.5.

4.3.2.15 Dissolved Oxygen. Dissolved oxygen in the Dolores River was measured during five of six trips in 1990-1991, and generally ranged from 7 to 10 mg/l. EPA's standards for non-salmonid fisheries are 6.5 mg/l for early life stages and 6.0 mg/l for all other life stages.

4.3.3 Fish Tissue and Sediment Analysis

4.3.3.1 Sediment Analysis. Radium (R-226) may be introduced into stream sediments when uranium mill wastes are released into a stream, either by direct discharge or seepage (Tsivoglou et al. 1960). Stream sediments act as radium reservoirs, collecting and storing this element. Where concentrations of most elements decrease with increased stream flow, the release of dissolved radium from sediments is stimulated by increased velocities and turbulence.

Radium in sediments from the Dolores and San Miguel rivers ranged from 6.2 to 8.0 pCi/g, except for a concentration of 20.4 pCi/g at RM 59.7, just below the confluence of the San Miguel River (Table 42). Historically, fluctuating but similar levels of radium were recorded in Dolores River sediment for four study areas from 1960-63 (Table 44). Measurements by BIO/WEST in 1991 showed similar concentrations in three areas, and somewhat higher concentrations in the three remaining areas. Radium concentrations at RM 0.1 of the San Miguel increased greatly in 1960-63, but levels in 1991 were substantially lower. In 1960, radium concentrations were measured in sediments from the Dolores River, above Slickrock, and from the San Miguel River above Naturita. These concentrations were used as "background levels" of radioactivity in river sediments located upstream of sources of man-made contamination (PHS 1961). Based on these results, sediment from three sites on the Dolores River contained from 3 to 3.3 times the amount of background radiation. The remaining site on the Dolores River measured 9.3 times greater than background levels. Sediments from the single study site in the San Miguel River were 5.6 times greater than background. In 1956, Tsivoglou reported concentrations as high as 2,100 pCi/g in the San Miguel River below the Naturita uranium mill, or 2,100 times background levels (Tsivoglou et al. in Sigler et al. 1966).

Radium concentrations in sediments of the Dolores and San Miguel rivers appeared in a state of improvement since peak uranium operations in the 1950's. The closure of the Uravan Mill in 1970, and the subsequent Super Fund clean-up program initiated in 1988, were probably the main reasons for this improvement. In the 1960's, radium in Dolores River sediments appeared to increase with distance downstream (Table 41), possibly because of decreased radium inputs (i.e. closure of the mill in 1970) and gradual movement of existing radium in downstream sediments. No longitudinal trends were apparent for radium measured in 1991.

Although analysis of heavy metals was not included in the Dolores River sediment analysis, it is likely that high concentrations of at least certain metals were present since stream sediments may serve as storage reservoirs and primary sources of bioconcentration (Van Hassel et al. 1980). Mathis et al. (1979) reported concentrations of cadmium in sediments of an experimental power plant pond of about 450 times the amount found in the water; lead in sediments was concentrated about 4,000 times that in water.

4.3.3.2 Fish Tissue Analysis. Eighteen individual fish representing three species were collected during Trip 6 for tissue analysis (Table 42). Although variance between samples can be high, maximum metal concentrations within fish species is a good indicator of potential bioaccumulation problems in the system. Maximum levels of metals (mg/kg) in liver and kidney tissue from three fish species sampled in the Dolores River were as follows: 32.6 of aluminum, 2,100 of cadmium, 534 of copper, 613 of iron, 2.9 of lead, 2.4 of silver, and 177 of zinc (Table 45). All maximum values were from the same fish, a roundtail chub, which was captured at RM 109.6. ChemTech Laboratories were called to verify the high levels of metals observed in the one roundtail chub. Although the results were verified by ChemTech, it is suspected that the high values are an error and may be an order of magnitude high. Cadmium levels of 2,100 mg/kg in liver and kidney tissues would certainly be fatal for an individual fish (Pers. comm. L. Crist, BOR, from L. Crist pers. comm. S. Hamilton USFWS, April, 1992). The fish in question appeared robust and healthy.

The availability of a metal to a fish depends on such physio-chemical factors as the chemical species involved, the chemistry of the water itself, and the structure and chemistry of the sediment. Biological factors such as organism feeding behavior, feeding preference, and the physiology of the organism also regulate metal accumulation (Dallinger et al. 1987). Metals may enter the body of a fish in three ways: through their skin, gills, or more commonly, through their alimentary tract (i.e., from feeding on contaminated material) (Dallinger et al. 1987). Bioaccumulation occurs when metals gradually buildup in target organs of final deposition. Sub-lethal metal contamination has been correlated with reduced spawning success, reduced larval and egg survival, smaller egg size, reduced longevity, and inferior mechanical properties of bones in white suckers (McFarlane and Franzin 1978, Hamilton and Haines 1989).

Metal accumulation and concentration can increase along a given food chain (biomagnification). In the Dolores River, channel catfish were probably the primary top-level carnivore, feeding mainly on fish and large invertebrates (Coon 1965, Minckley 1973). Roundtail chubs are somewhat piscivorous, but rely on insects and flannelmouth suckers feed mainly on benthic insects and detritus (Minckley 1973). Based on the principle of biomagnification, channel catfish should accumulate the most metals, followed by roundtail chubs, and finally, flannelmouth suckers. However, roundtail chubs had the highest average concentrations for every metal except iron (Table 46), although the sample size was only two fish, and average metal levels in flannelmouth suckers were higher than channel catfish for all metals. Dallinger et al. (1987) reported that fish do not necessarily adhere to the principle of biomagnification for three reasons: 1) heavy metals are more available to organisms of lower trophic levels than to those of higher trophic levels, 2) fish seem to be able to reject large amounts of heavy metals ingested, and 3) comparison of concentration factors along a food chain may give an inaccurate description of the actual metal transfer, since fish concentrate heavy metals in certain organs which make a small contribution to total body weight.

No historical data for fish tissue analysis could be found for the Dolores River, however Kunkle et al. (1983) performed bioassays on four species collected from the Gunnison River in October, 1981. Average metal content in kidneys and livers of two roundtail chubs collected in the Dolores River in 1991 were substantially higher (up to 1,106 times higher in the case of cadmium) than equivalent metal concentrations in the same organs of rainbow trout and white suckers collected in the Gunnison River (Table 47). Flannelmouth suckers captured in the Dolores River had substantially higher concentrations of four of five metals compared to white suckers from the Gunnison River. Kunkle et al. (1983) concluded that metal concentrations in fish from the Gunnison River were probably not high enough to cause concern about human health, but they failed to address concerns about the health of fish. Hamilton and Haines (1989) reported whole-fish concentrations of cadmium and lead in white suckers ranging from 0.7 - 1.2 mg/kg and 15.5 - 23.2 mg/kg, respectively, and postulated that accumulation of these metals may have contributed to altered bone development observed in the fish.

Since analysis of fish muscle tissue was not performed on samples from the Dolores River, it is not known if consumption of these fish represent a human health hazard.

4.3.4 Biological Attributes

4.3.4.1 Macroinvertebrates. Eleven orders of macroinvertebrates were collected in the Dolores River during the study (Tables 48-53). In 1990, 47.7% of all macroinvertebrates sampled were Diptera, mostly from the family Simuliidae. Ephemeroptera and Trichoptera comprised 22.4% and 20.5% of all invertebrates, respectively. In 1991 invertebrate composition was more evenly distributed among Ephemeroptera (28.7%), Diptera (28.4%), and Trichoptera (28.4%). Invertebrate composition in the San Miguel River in 1990 was dominated by Diptera (92.6%), most of which were Simuliidae collected from one sample on Trip 1. Invertebrates sampled in the San Miguel in 1991 were primarily Diptera (46.8%), Ephemeroptera (25.5%), and Trichoptera (15%).

Longitudinal composition of macroinvertebrates in the Dolores River in 1990-1991 was fairly consistent. In 1990, there was a gradual shift in composition downstream as Trichoptera increased from 2.2% at RM 122.5 to 37.8% at RM 1.3. Conversely, Diptera declined downstream, from 70.4% at RM 122.5 to 32.3% at RM 1.3. The same trend was not evident in 1991 samples.

A summary of invertebrate collections prior to this study is presented in Table 54. It was difficult to make meaningful comparisons of historical macroinvertebrate data because of inherent differences in techniques, season, flows, etc. Little information on macroinvertebrates in the Dolores and San Miguel rivers was available before 1980, but what does exist indicates very low species diversity in both systems in the 1970's and 80's. Some insight may be gained by examining the presence or absence of "indicator species", that is specific macroinvertebrate taxa that are known to be pollution tolerant or intolerant. In 1960, pollution intolerant Plecoptera were absent from samples collected in the San Miguel River, but this taxa was present in samples collected in the 1980's and 90's. This evidence supports water chemistry and sediment analysis which indicate a substantial improvement in water quality of the San Miguel River since the 1960's. Pollution-intolerant Trichopterans (i.e., *Glossosomatidae*) were present in both the Dolores and San Miguel rivers in 1990, but were not found historically in samples prior to our study.

Biotic Condition Index (BCI) values were calculated for the Dolores and San Miguel rivers in 1991. The BCI is based on mean community tolerance, and is a composite of tolerance of individual taxa which varies in response to intensity of perturbations in the ecosystem. Parameters analyzed in calculating BCI include stream gradient and substrate, total alkalinity, sulfate concentration, and tolerance quotients (TQ) for each macroinvertebrate taxon (USFS 1985). Relative to their own potential, the Dolores (BCI=108) and San Miguel (BCI=56) rivers were rated excellent and fair to poor, respectively.

Crayfish (*Orceonectes virilis*) were abundant in the Dolores River. Crayfish densities increased in upper portions of the study. Beck (1989) reported mean catch rates of 3.3 crayfish/trap day (24 hours) from RM 76 to RM 101, 20.1 crayfish/trap day from RM 102 to RM 128 below the confluence of Disappointment Creek and 41.5 crayfish/trap day from RM 129 at the confluence to Disappointment Creek to RM 173 near Bradfield Bridge. Data from a similar survey done in 1991 resulted in 5.5, 13.1 and 58.3 crayfish/trap day respectively for the same reaches discussed above (T. Beck Pers. Comm. April 1992).

<u>4.3.4.2 Forage, Competition, and Predation.</u> Colorado squawfish can become piscivorous in their first year of life, and retain a nearly exclusive fish diet throughout life (Valdez 1990). Non-native cyprinids (i.e. red shiner, sand shiner, and fathead minnow) can probably provide an ample forage base for juvenile squawfish. An ample forage base of both native and non-native fish is available for adult squawfish in the system.

Non-native cyprinids in the Dolores River appear to be no greater a potential threat to Colorado squawfish than in other rivers in the Upper Colorado River Basin. These non-natives may be a source of competition to larval squawfish, but their abundance in nursery habitat (backwaters) is no higher than other areas on the Colorado and Green rivers which consistently harbor young squawfish. The diet of these non-natives is probably adult and immature insects, small crustaceans, and plant material (Pflieger 1975), although recent data from the Yampa River suggest that red shiners may be piscivorous on larval native species (J. Ruppert, CSU, Pers. Comm. Feb. 1992). Effects of predation by these species on Colorado squawfish are not known (Valdez 1990). Green sunfish are highly piscivorous and represent a potential threat, but these fish are found in small numbers in the Dolores River, mostly near the Colorado River confluence. Other centrarchids (e.g., bluegill, largemouth bass) were rare in the Dolores River. Ictalurids probably represent the most significant potential threat to squawfish in the Dolores River. Black bullheads are probably indiscriminate feeders, and even small numbers may constitute a threat to small fish. Only 48 bullheads were captured in 1990-1991. These were found mostly along shorelines, rather than in backwaters, perhaps tempering their threat to young squawfish. Channel catfish are also piscivorous, and juvenile and adults have been found in sympatry with chubs in Cataract Canyon (Valdez 1990). Channel catfish in the Dolores River were collected in greater numbers from eddies and shorelines than from backwaters, possibly reducing the potential for larval squawfish predation. Predation by large adult catfish on juvenile and small adult squawfish is a potential problem, although relatively few large adult catfish were captured in 1990-1991. Trout are rare in the Dolores River below Disappointment Creek and probably have little effect on squawfish.

4.4 Feasibility of Reintroducing Colorado Squawfish

Data collected on physical, chemical and biological attributes of the Dolores River during this study suggest that reintroduction of Colorado squawfish into the Dolores River system is possible. However, since the status of the species in the Upper Colorado River is not fully understood and further study is required to determine the extent that Colorado squawfish use the Dolores River, reintroduction of squawfish for purposes of augmenting populations is not recommended. Based on results of this study, it is recommended that the Dolores River drainage be considered as a site for experimental stocking of Colorado squawfish and possibly razorback sucker associated with future research. With low numbers of squawfish currently in the drainage and few predators relative to other upper basin drainages, the Dolores would be suitable for experimental stocking. Potential research includes studies on survival, dispersal and homing of various life stages of the species. BIO/WEST recognizes three potential experimental scenarios that would be feasible in the Dolores River drainage. These include: 1) incubation of eggs in situ; 2) release of PIT-tagged juveniles, and; 3) chemoreception studies with adults.

4.4.1 Incubation of Eggs in Situ

Reintroduction via incubation of eggs in situ has not been attempted for endangered species in the upper basin of the Colorado River. The possibility of strong homing tendencies by these species, especially Colorado squawfish, suggests that this type of reintroduction may be suitable for re-establishing drainage-specific stocks. A well conceived study that would allow the incubation and hatching of eggs and holding of larvae in an off stream facility would be required so that offspring could be transported to a hatchery for rearing to size suitable for PIT-tagging. Ultimately the fish could be released into the Dolores River to test chemoreception and homing hypotheses.

4.4.2 Release of Juveniles

Experimental stocking of juvenile Colorado squawfish has been attempted numerous times in the lower basin of the Colorado River with limited success. Unsuccessful attempts to recapture tagged fish has limited the ability of researchers to evaluate survival and dispersal of stocked individuals. It has been hypothesized that high levels of predation on stocked fish are the reason for limited recaptures. The relatively low predator density in the Dolores River is conducive to stocking juvenile Colorado squawfish for purposes of assessing survival and dispersal. PIT-tagging the juveniles before releases would allow for accurate recapture information on growth and distribution of individual squawfish. Biologically, the Dolores River appears suitable to provide needs for early life stages of this species.

4.4.3 Chemoreception studies with adults

Chemoreception studies recently proposed in the Upper Basin could be conducted in the Dolores River. Hatchery-reared individuals imprinted to a scent marker (i.e. morpholine) could be introduced into the Dolores River to test chemoreception and homing hypotheses. Suitability of the Dolores River for this type of research is increased by low numbers of squawfish that are currently present in the drainage.

5.0 SUMMARY OF FINDINGS

1. Four Colorado squawfish were captured in the lower 2 km of the Dolores River in August and October, 1991.

2. Physical habitat of the Dolores River was suitable for adult and juvenile Colorado squawfish, although extremely low flows observed during the study may have restricted fish access from the Colorado River and impaired movement within the Dolores River drainage.

3. Water quality of the Dolores River was suitable for Colorado squawfish and other native species, although high levels of copper and iron were found during spring runoff and rain spates.

4. Macroinvertebrate densities and high numbers of native and non-native forage fish species indicate that the Dolores River is biologically suitable for Colorado squawfish.

5. Non-native fish represented 87% and 68% of the catch in 1990 and 1991 respectively, indicating a potential for predation and competition with native species. Since the percentage composition of non-natives in the Dolores River was relatively lower than other upper basin rivers, predation and competition by non-natives was not considered a limiting factor for native fish species.

6. No major changes in fish composition and numbers occurred as compared to the USFWS survey in 1981.

7. The percentage of native fish species in the Dolores River was relatively high when compared to other upper basin systems; 13% in 1990, 32% in 1991, 19% for the study.

8. Native fish species including flannelmouth sucker, bluehead sucker, roundtail chub and speckled dace were found with evidence of successful reproduction in the Dolores River.

6.0 RECOMMENDATIONS

1. The operation of McPhee Dam should consider enhancing the suitability of the Dolores River for Colorado squawfish and protecting existing native fisheries. Flows observed in the Dolores River during this study indicate that the operation of McPhee Dam has the potential to adversely or beneficially impact native fisheries by altering timing and magnitude of flows. Extremely low flows (20-50 cfs) released on a year round basis are potentially devastating to aquatic resources as well as other aspects of the rivers corridor (i.e. productive cobble riffles, riparian vegetation). Potential impacts include: 1) reduced survival and recruitment of early year classes caused by unnatural temperature regimes, 2) winter kills due to inadequate water volume, 3) lack of access and disruption of fish movement because of inadequate water volume, and 4) increased stress associated with water quality problems at extremely low flow. Specific flow recommendations include:

   a. Increase minimum base flows to 78 cfs during wet and normal years and 50 cfs (or equal to reservoir inflow in less than 50 cfs) during dry years.

   b. Spring and summer flows should simulate the shape of the natural hydrograph. Peak flow should approximate peak inflow to McPhee Reservoir. Ramping up should commence as soon reservoir inflow increases to avoid early warming in the Dolores River below McPhee Dam. Following peak flow, a period of at least 30 days should be utilized for gradual down ramping to a base flow. Ideally ramping of flows to base conditions should be done in a manner to approximate relative magnitude of decreasing inflow into the reservoir.

   c. Downstream flow releases should prioritize maintaining aquatic systems. The release of large volumes of water to provide short term downstream benefits should not be allowed if it results in loss of flexibility in managing flows for the system during the course of the year.

2. Additional research should be conducted to better understand use of the Dolores River by Colorado squawfish. This should include additional sampling during spring runoff and during a high flow year.

3. Monitoring should be continued in the Dolores River to assess biological recovery associated with ongoing changes in the system. These changes include the continued clean up of the Uravan mill site, Reclamation's desalinization project in Paradox Valley, and potential changes in the operation of McPhee Dam.

4. An efficiency evaluation of Reclamation's Dolores River project should be conducted. Since much of the water withdrawn for the Dolores Project is used to irrigate agricultural land in the San Juan River Basin, return flows associated with overwatering and other inefficient water use practices provide no benefit to aquatic resources in the Dolores River drainage. The cost of inefficient irrigation practices is high for the Dolores River ecosystem and should be evaluated

5. The Dolores River system should be considered as a site for experimental stocking of Colorado squawfish and razorback suckers if deemed necessary or appropriate.

6. The Dolores River provides habitat for a large population of reproducing roundtail chubs and should be considered for additional studies considering potential status changes for this species.

Table 1. Trip schedule for Dolores River Study.

Trip	Primary Purpose	Dates
1	RECON/CS/WQ/HAB[a]	March 5 - 14, 1990
2	CS/WQ/HAB	July 7 - 15, 1990
3	CS/WQ/HAB	August 27 - September 3, 1990
4	CS/WQ/HAB	April 4 - 12, 1991
5	CS/WQ/HAB	August 5 - 15, 1991
6	CS/WQ/HAB	September 29 - October 12, 1991

[a]CS/WQ/HAB = Determine the presence or absence of Colorado squawfish, sample water quality and quantify habitat in terms of Colorado squawfish.

Table 2. Summary of fish sampling efforts for six field trips on the Dolores River, 1990-1991.

GEAR (code)	1	2	3	4	5	6	TOTAL
Electrofishing - Jon Boat - EL (220-v DC, 5-10 A)	10[a] (1.6)[b]	15 (2.8)	13 (1.8)	22 (7.4)	24 (12.3)	23 (10.5)	107 (36.4)
Electrofishing - Canoe - EC (220-v DC, 5-10 A)	18 (2.8)	24 (4.3)	17 (4.8)	15 (5.5)	42 (12.5)	34 (29.0)	150 (58.9)
Experimental Gill Net - GQ (80' x 5'; 1/2, 1, 1½, 2)	12 (65.4)	4 (6.6)	26 (67.7)	2 (3.0)	-	-	44 (142.7)
Seine (10' x 3'; 1/16") - SE	23	54	56	22	56	73	284
Large Seine (30' x 5' x 1/2")	?	?	?	?	?	?	?
Trammel Net - TI (50' x 5' x 1.5" x 10")	0	22 (36.1)	5 (10.8)	1 (1.4)	9 (14.8)	-	37 (63.1)
Trammel Net, Floating - TD (50' x 5' x 1.5" x 10")	0	0	3 (8.2)	-	-	-	3 (8.2)
Gill Net - GN (100' x 5' x 2")	-	-	-	-	5 (9.1)	-	5 (9.1)

[a]number of sample efforts
[b]total sample time in hours

Table 3. Water quality parameters analyzed for Dolores River Native Fish Habitat Suitability Study.

PARAMETER	METHOD REFERENCE
Alkalinity as $CaCO_3$, mg/l	EPA 130.2
Hardness as $CaCO_3$, mg/l	EPA 314A
pH Units	EPA 150.1
TDS, mg/l	EPA 160.1
Ammonia as NH_3-N, mg/l	EPA 350.3
Nitrate as NO_3-N, mg/l	EPA 352.1
Phosphorus as PO_4-P, mg/l	EPA 365.2
Otho-Phosphate as PO_4-P, mg/l	EPA 365.2
Sulfate as SO_4, mg/1	EPA 375.4
Oil & Grease, mg/l	EPA 413.1
TSS, mg/l	EPA 160.2
Copper as Cu (T), mg/l	EPA 200.7
Iron as Fe (T), mg/l	EPA 236.1
Lead as Pb (T), mg/l	EPA 200.7
Zinc as Zn (T), mg/l	EPA 200.7
Aluminum as AL (T), mg/1	EPA 202.1
Cadmium as Cd (T), mg/1	EPA 200.7
Silver as Ag (T), mg/1	EPA 200.7
Copper as Cu (D), mg/l	EPA 220.1
Iron as Fe (D), mg/l	EPA 236.1
Lead as Pb (D), mg/l	EPA 239.1
Zinc as Zn (D), mg/l	EPA 289.1
Aluminum as AL (D), mg/1	EPA 202.1
Cadmium as CD (D), mg/1	EPA 200.7
Silver as Ag (D), mg/1	EPA 200.7

Table 4. List of fish species captured in the Dolores River, 1990-1991.

Common and Scientific Name (Species Code)		Status[a]
Family:	*Catostomidae* (suckers)	
BH	bluehead sucker (*Catostomus discobolus*)	NA
FM	flannelmouth sucker (*C. latipinnis*)	EN
WS	white sucker (*C. commersoni*)	NN
SU	sucker sp.	NA
Family:	*Centrarchidae* (sunfishes)	
BG	bluegill (*Lepomis macrochirus*)	NN
GS	green sunfish (*L. cyanellus*)	NN
LG	largemouth bass (*Micropterus salmoides*)	NN
Family:	*Cottidae*	
MS	mottled sculpin (*Cottus bairdi*)	NA
Family:	*Cyprinidae* (minnows)	
CP	common carp (*Cyprinus carpio*)	EX
FH	fathead minnow (*Pimephales promelas*)	NN
RT	roundtail chub (*Gila robusta*)	EN
RS	red shiner (*Cyprinella lutrensis*)	NN
SS	sand shiner (*Notropis stramineus*)	NN
SD	speckled dace (*Rhinichthys osculus*)	NA
CS	Colorado squawfish (*Ptychocheilus lucius*)	EN
SH	shiner sp.	NN
Family:	*Cyprinodontidae* (killifishes)	
PK	plains killifish (*Fundulus zebrinus*)	NN
Family:	*Ictaluridae* (catfishes, bullheads)	
BB	black bullhead (*Ameiurus melas*)	NN
CC	channel catfish (*Ictalurus punctatus*)	NN
Family:	*Salmonidae*	
BR	brown trout (*Salmo trutta*)	EX
RB	rainbow trout (*Oncorhynchus mykiss*)	NN

[a] NA = native to the Colorado River drainage
EN = endemic to the Colorado River drainage
NN = non-native, not native to the Colorado River drainage but from North America
EX = exotic, introduced from another continent

Table 5. A summary of fish species captured in the Dolores River during six sample trips, 1990-1991.

	TRIP								
Species[a]	**1**	**2**	**3**	**4**	**5**	**6**	**TOTAL 90**	**TOTAL 91**	**TOTAL**
RS	223 (18.1%)	1109 (25.0%)	4548 (45.4%)	229(10%)	444(20.2%)	1389(38.6%)	5880(37.5%)	2062(25.5%)	7942(33.4)
FH	384 (31.2)	1037 (23.4)	2276 (22.7)	369(16.1)	131(6.0)	174(4.8)	3697(23.6)	674(8.3)	4371(18.4)
SS	301 (24.5)	747 (16.8)	2508 (25.0)	1144(50)	138(6.3)	663(18.4)	3556(22.7)	1945(24.1)	5501(23.1)
FM	130 (10.6)	629 (14.2)	334 (3.3)	306(13.4)	283(12.9)	501(13.9)	1093(7.0)	1090(13.5)	2183(9.2)
RT	118 (9.6)	305 (6.9)	49 (0.5)	25(1.1)	423(19.3)	162(4.5)	472(3.0)	610(7.6)	1082(4.6)
CP	20 (1.6)	170 (3.8)	78 (0.8)	135(5.9)	121(5.5)	105(2.9)	268(1.7)	361(4.5)	629(2.6)
BH	21 (1.7)	157 (3.5)	62 (0.6)	33(1.4)	98(4.5)	262(7.3)	240(1.5)	393(4.9)	633(2.7)
SD	12 (1.0)	155 (3.5)	66 (0.7)	18(0.8)	244(11.1)	108(3.0)	233(1.5)	370(4.6)	603(2.5)
CC	15 (1.2)	74 (1.7)	39 (0.4)	17(0.7)	139(6.3)	196(5.4)	128(0.8)	352(4.4)	480(2.0)
SH	0 (0)	5 (1.1)	0 (0)	0(0)	14(0.6)	0(0)	50(0.3)	14(0.2)	64(0.3)
GS	1 (-)	5 (0.1)	33 (0.3)	7(0.3)	11(0.5)	10(0.3)	39(0.2)	28(0.3)	67(0.3)
BB	2 (0.2)	1 (-)	29 (0.3)	1(0.1)	5(0.2)	10(0.3)	32(0.2)	16(0.2)	48(0.2)
PK	2 (0.2)	1 (-)	0 (0)	0(0)	0(0)	0(0)	3(-)	0(0)	3(-)
BG	0 (0)	0 (0)	1 (-)	0(0)	0(0)	0(0)	1(-)	0(0)	1(-)
LG	0 (0)	0 (0)	1 (-)	0(0)	0(0)	0(0)	1(-)	0(0)	1(-)
SU	0 (0)	1 (-)	0 (0)	0(0)	139(6.3)	4(0.1)	1(-)	143(1.8)	144(0.6)
BR				1(0.1)	0(0)	6(0.2)	0	7(0.1)	7(-)
RB				0(0)	0(0)	2(0.1)	0	2(0.1)	2(-)
WS				2(0.1)	0(0)	1(0.1)	0	3(0.1)	3(-)
MS				0(0)	0(0)	1(0.1)	0	1(0.1)	1(-)

Table 5 continued

	TRIP								
Species[a]	**1**	**2**	**3**	**4**	**5**	**6**	**TOTAL 90**	**TOTAL 91**	**TOTAL**
CS				0(0)	1(0.1)	3(0.1)	0	4(0.1)	4(-)
UNK				0(0)	2(0)	0(0)	0	2(0.1)	2(-)
TOTAL	**1,229**	**4,441**	**10,024**	**2287**	**2193**	**3597**	**15694**	**8077**	**23771**

[a] See Table 4 for definition of species codes.

Table 6. A summary fish species by life stages captured in the Dolores River during six sample trips, in 1990-1991.

N[a]	Species[b]	LAR		YOY		JUV		ADU		TOTAL
		1990	1991	1990	1991	1990	1991	1990	1991	
225	RS	7	0	2351	45	2220	962	1302	1055	7,942
180	SS	3	0	771	5	2050	1584	732	356	5,501
152	FH	0	0	605	0	2025	370	1067	304	4,371
312	FM	0	0	498	135	189	200	406	755	2,183
238	RT	22	0	204	367	203	148	43	95	1,082
178	BH	1	0	67	103	80	66	92	224	633
186	CP	0	0	5	0	11	21	252	340	629
128	SD	8	0	72	5	105	281	48	84	603
190	CC	0	0	51	136	42	86	35	132	482
16	SU	0	0	0	142	1	0	0	0	143
42	GS	0	0	7	0	24	2	8	26	67
6	SH	0	0	0	13	0	1	50	0	64
25	BB	0	0	24	1	3	3	5	12	48
5	BR	0	0	0	0	0	1	0	6	7
3	CS	0	0	0	0	0	0	0	4	4
3	PK	0	0	1	0	1	0	1	0	3
3	WS	0	0	0	0	0	2	0	1	3
2	RB	0	0	0	0	0	2	0	0	2
1	LG	0	0	0	0	1	0	0	0	1
1	BG	0	0	0	0	1	0	0	0	1

Table 6 continued

N[a]	Species[b]	LAR		YOY		JUV		ADU		TOTAL
		1990	1991	1990	1991	1990	1991	1990	1991	
1	MS	0	0	0	0	0	0	0	1	1

[a] Number of samples.
[b] See Table 4 for definition of species codes.

Table 7. Numbers and catch per unit effort (CPE) by species with canoe electrofishing in the Dolores River, 1990-1991.

Species*	LAR		YOY		JUV		ADU		TOTAL	#/10 hrs		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
FM	0	0	3	1	67	138	74	281	564	50.9	167.8	105.7
RT	2	0	13	3	103	79	13	69	282	46.3	60.3	52.8
BH	0	0	0	1	25	37	20	77	160	15.9	45.9	30.0
CP	0	0	0	0	7	9	49	90	155	19.8	39.6	29.0
CC	0	0	1	0	19	33	12	67	132	11.3	40.0	24.7
SD	0	0	0	0	9	12	9	32	62	6.4	17.6	11.6
RS	0	0	0	0	0	1	17	14	32	6.0	6.0	6.0
SH	0	0	0	0	0	0	30	0	30	10.6	0	5.6
GS	0	0	0	0	11	1	2	15	29	4.6	6.4	5.4
BB	0	0	0	0	1	1	3	4	9	1.4	2.0	1.7
BR	0	0	0	0	0	1	0	5	6	0	2.4	1.1
FH	0	0	0	0	0	0	1	2	3	0.4	0.8	0.6
RB	0	0	0	0	0	2	0	0	2	0	0.8	0.4
SS	0	0	0	0	0	0	0	2	2	0	0.8	0.4
BG	0	0	0	0	1	0	0	0	1	0.4	0	0.2
LG	0	0	0	0	1	0	0	0	1	0.4	0	0.2
WS	0	0	0	0	0	0	0	1	1	0	0.4	0.2
MS	0	0	0	0	0	0	0	1	1	0	0.4	0.2

* See Table 4 for definition of species codes.

Table 8. Number and catch per unit effort (CPE) by species with Jon boat electrofishing in the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/10 hrs		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
FM	0	0	0	1	102	58	209	472	842	478.5	240.2	294.2
CP	0	0	0	0	3	12	188	242	445	293.8	114.9	155.5
BH	0	0	0	1	49	27	64	147	288	173.8	79.2	100.6
RS	0	0	0	0	40	2	133	7	181	266.2	4.1	63.6
CC	0	0	0	1	18	48	17	62	148	53.8	50.2	51.0
FH	0	0	0	0	41	0	73	4	118	175.4	1.8	41.2
RT	0	0	0	1	17	10	7	20	55	36.9	14.0	19.2
SH	0	0	0	0	0	0	20	0	20	30.8	0	7.0
SS	0	0	0	0	0	0	17	0	17	26.2	0	5.9
SD	0	0	0	0	0	0	7	10	17	10.8	4.5	5.9
GS	0	0	0	0	1	1	5	10	17	9.2	5.0	5.9
BB	0	0	0	0	0	1	2	7	10	3.2	3.6	3.5
CS	0	0	0	0	0	0	0	4	4	0	1.8	1.4
WS	0	0	0	0	0	2	0	0	2	0	0.9	0.7
BR	0	0	0	0	0	0	0	1	1	0	0.5	0.3

[a] See Table 4 for definition of species codes.

Table 9. Electrofishing catch per unit effort (fish/10hr) for species sampled in the Dolores River, 1990-1991

Species[a]	TRIP #1		TRIP #2		TRIP #3	
	March 1990	April 1991	July 1990	August 1991	Aug-Sept 1990	Sept-Oct 1991
BB	4.5	0.8	0	2.0	6.1	1.8
BG	0	0	0	0	1.5	0
BH	38.6	25.6	125.4	32.3	78.8	44.9
BR	0	0.8	0	0	0	1.5
CC	29.5	13.2	38.0	33.5	40.9	28.6
CP	43.2	104.7	219.7	46.8	109.1	25.8
CS	0	0	0	0.4	0	0.8
FH	213.6	0	29.6	1.2	0	0.8
FM	188.6	236.4	160.6	73.0	390.9	117.8
GS	0	5.4	4.2	4.4	24.2	2.3
LG	0	0	0	0	1.5	0
MS	0	0	0	0	0	0.3
RB	0	0	0	0	0	0.5
RS	181.8	3.1	142.3	6.9	12.1	0.8
RT	250.0	16.3	45.1	28.6	19.7	22.8
SD	27.3	2.3	8.5	7.3	10.6	8.4
SH	0	0	70.4	0	0	0
SS	0	0	22.5	0.4	1.5	0.3
WS	0	1.6	0	0	0	0.3

[a]See Table 4 for definition of species codes.

Table 10. Number and catch per unit effort (CPE) by species with experimental gill net in the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100 ft/10 hrs		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
FM	0	0	0	0	5	0	86	0	91	6.5	0	6.4
RT	0	0	0	0	7	0	13	0	20	1.4	0	1.4
BH	0	0	1	0	2	0	8	0	11	0.8	0	0.8
CC	0	0	0	0	5	0	1	0	6	0.4	0	0.4
CP	0	0	0	0	0	0	2	0	2	0.1	0	0.1
CR	0	0	0	0	0	0	2	0	0	0.1	0	0.1

[a]See Table 4 for definition of species codes.

Table 11. Number and catch per unit effort (CPE) by species with trammel nets in the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100 ft/10 hr		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
CP	0	0	0	0	0	0	10	4	14	1.9	2.5	2.1
FM	0	0	0	0	1	0	9	0	10	1.9	0	1.5
CC	0	0	0	0	0	0	5	1	6	1.0	0.6	0.9

[a]See Table 4 for definition of species codes.

Table 12. Number and catch per unit effort (CPE) by species with floating trammel nets in the Dolores River, 1990.

Species[a]	LAR	YOY	JUV	ADU	TOTAL	#/100ft/10 hr
FM	0	0	0	14	14	43.8
CP	0	0	0	1	1	3.1

[a]See Table 4 for definition of species codes.

Table 13. Gill netting catch per unit effort (fish/100ft/100hr) by species in the Dolores River, 1990-1991.

Species[a]	TRIP #1		TRIP #2		TRIP #3	
	March 1990	April 1991	July 1990	August 1991	Aug-Sept 1990	Sept-Oct 1991
BH	8.2	0	18.9	0	11.1	0
CC	4.1	0	37.9	13.5	3.7	0
CP	0	0	18.9	54.1	1.8	0
FM	95.8	0	18.9	0	79.4	0
RT	14.3	0	18.9	0	22.2	0

[a]See Table 4 for definition of species code.

Table 14. Trammel netting catch per unit effort (fish/100ft/100hr) by species in the Dolores River, 1990-1991.

Species[a]	TRIP #1		TRIP #2		TRIP #3	
	March 1990	April 1991	July 1990	August 1991	Aug-Sept 1990	Sept-Oct 1991
CC	0	0	27.7	1.6	0	0
CP	0	0	38.8	1.6	38.0	0
FM	0	0	33.2	0	50.6	0

[a]See Table 4 for definition of species codes.

Table 15. Number and catch per unit effort (CPE) by species with seines in all habitats of the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100m²		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
RS	7	0	2351	45	2180	959	1152	1034	7728	164.7	46.1	98.1
SS	3	0	771	5	2050	1584	715	354	5482	102.4	44.0	69.6
FH	0	0	605	0	1984	370	993	298	4250	103.7	15.1	54.0
RT	20	0	191	363	76	59	10	6	725	8.6	9.7	9.2
FM	0	0	495	133	14	4	0	2	648	14.7	3.1	8.2
SD	8	0	72	5	96	269	32	42	524	6.0	7.2	6.7
CC	0	0	50	134	0	4	0	1	189	1.4	3.1	2.4
BH	1	0	66	101	4	2	0	0	174	2.1	2.3	2.2
SU	0	0	0	143	1	0	0	0	144	0	3.2	1.8
BB	0	0	24	1	2	1	0	1	29	0.8	0.01	0.4
GS	0	0	7	0	12	0	1	1	21	0.6	0	0.3
SH	0	0	0	13	0	1	0	0	14	0	0.3	0.2
CP	0	0	5	0	1	0	2	3	11	0.2	0.01	0.1
PK	0	0	1	0	1	0	1	0	3	0.01	0	0.0

[a]See Table 4 for definition of species codes.

Table 16. Number and catch per unit effort (CPE) by species with large seines in all habitats of the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100 m^2		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
SS	0	0	0	0	0	144	0	84	228	0	228	228
FH	0	0	0	0	0	36	0	96	132	0	132	132
RS	0	0	0	0	0	45	0	24	69	0	69	69

[a]See Table 4 for definition of species codes.

Table 17. Number and catch per unit effort (CPE) by species with seines in backwaters of the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100m²		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
RS	7	0	2006	19	1843	534	910	286	5605	292.8	90.8	219.6
FH	0	0	563	0	1722	192	916	116	3509	196.6	33.3	137.5
SS	2	0	624	4	1587	422	608	131	3378	173.3	60.3	132.4
FM	0	0	384	99	13	0	0	0	493	24.4	10.7	19.4
RT	20	0	161	210	49	4	10	0	454	14.7	23.2	17.8
SD	8	0	64	2	50	129	4	1	258	7.7	14.3	10.1
BH	1	0	56	67	0	0	0	0	124	3.5	7.3	4.9
CC	0	0	7	27	0	0	0	0	34	0.4	2.9	1.3
SU	0	0	0	29	0	0	0	0	29	0	3.1	1.1
GS	0	0	3	0	8	0	1	0	12	0.7	0	0.5
CP	0	0	4	0	1	0	1	2	8	0.4	0.2	0.3
BB	0	0	5	0	2	0	0	0	7	0.4	0	0.3
PK	0	0	1	0	1	0	0	0	2	0.1	0	0.1
SH	0	0	0	2	0	0	0	0	2	0	0.2	0.1

[a] See Table 4 for definition of species codes.

Table 18. Number and catch per unit effort (CPE) by species with seines in trickle-fed backwaters of the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100m²		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
SS	0	0	0	0	0	683	0	30	713	0	248.4	191.1
RS	0	0	0	0	0	103	0	6	109	0	38.0	29.2
FH	0	0	0	0	1	41	8	7	57	10.5	16.7	15.3
SU	0	0	0	39	0	0	0	0	39	0	13.6	10.5
RT	0	0	0	34	0	1	0	0	35	0	12.2	9.4
CC	0	0	6	1	0	1	0	0	8	7.0	0.70	2.1
SD	0	0	0	0	0	3	0	1	4	0	1.4	1.1
FM	0	0	0	1	0	2	0	0	3	0	1.0	0.8
BH	0	0	3	0	0	0	0	0	3	3.5	0	0.8
CP	0	0	1	0	0	0	0	0	1	1.2	0	0.3

[a]See Table 4 for definition of species codes.

Table 19. Number and per unit effort (CPE) by species with seines in eddies of the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100 m²		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
RS	0	0	0	0	11	3	16	132	162	18.6	112.5	61.1
SS	0	0	1	0	19	1	3	13	37	15.9	11.7	14.0
FH	0	0	0	0	8	0	10	3	21	12.4	2.5	7.9
CC	0	0	9	3	0	0	0	0	12	6.2	2.5	4.5
RT	0	0	0	2	0	3	0	1	6	0	5.0	2.3
SD	0	0	0	0	0	0	1	0	1	0.7	0	0.4
CP	0	0	0	0	0	0	1	0	1	0.7	0	0.4

[a]See Table 4 for definition of species codes.

Table 20. Number and catch per unit effort (CPE) by species with seines in embayments of the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100m²		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
SS	0	0	58	1	215	207	12	2	495	164.7	304.3	204.5
RS	0	0	135	9	140	47	69	2	402	198.8	84.1	166.1
FH	0	0	9	0	164	75	15	4	267	108.7	114.5	110.3
RT	0	0	15	19	1	6	0	1	42	9.2	37.7	17.4
SD	0	0	0	0	0	16	0	0	16	0	23.2	6.6
FM	0	0	5	0	0	0	0	0	5	2.9	0	2.1
CC	0	0	3	0	0	0	0	0	3	1.7	0	1.2
GS	0	0	2	0	0	0	0	0	2	1.2	0	0.8
SU	0	0	0	1	0	0	0	0	1	0	1.4	0.4

[a]See Table 4 for defininition of species codes.

Table 21. Number and catch per unit effort (CPE) by species with seines in shorelines of the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100m²		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
RS	0	0	106	0	31	0	19	13	169	71.2	10.8	49.9
SS	0	0	35	0	45	0	5	2	87	38.8	1.7	25.7
FH	0	0	14	0	30	0	3	1	48	21.5	0.83	14.2
CC	0	0	22	1	0	0	0	0	23	10.0	0.83	6.8
SD	0	0	0	0	4	8	0	0	12	1.8	6.7	3.5
RT	0	0	3	2	3	1	0	0	9	2.7	2.5	2.7
FM	0	0	5	0	0	0	0	0	5	2.3	0	1.5
BB	0	0	4	0	0	0	0	0	4	1.8	0	1.2
SH	0	0	0	0	0	1	0	0	1	0	0.83	0.3
GS	0	0	1	0	0	0	0	0	1	0.46	0	0.3

[a]See Table 4 for definition of species codes.

Table 22. Number and catch per unit effort (CPE) by species with seines in side channels of the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100m^2		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
RS	0	0	146	1	268	240	128	546	1329	74.9	45.3	54.0
SS	0	0	64	0	278	256	71	168	837	57.0	24.4	34.0
FH	0	0	17	0	239	62	48	154	520	42.0	12.4	21.1
SD	0	0	0	1	1	722	2	16	192	0.4	10.9	7.8
RT	0	0	3	76	8	30	0	3	120	1.5	6.3	4.9
SU	0	0	0	61	0	0	0	0	61	0	3.5	2.5
FM	0	0	64	25	0	1	0	2	92	14.0	8.8	1.6
BH	0	0	0	26	3	1	0	0	30	0.4	1.6	1.2
CC	0	0	3	20	0	2	0	1	26	0.4	1.3	1.0
BB	0	0	15	1	0	1	0	1	18	2.1	0.17	0.8
SH	0	7	0	0	0	0	0	0	7	0	0.4	0.3
GS	0	0	1	0	4	0	0	1	6	0.7	0.06	0.2

[a]See Table 4 for definition of species codes.

Table 23. Number and catch per unit effort (CPE) by species with seines in runs of the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100m^2		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
RS	0	0	52	1	100	99	94	293	639	57.2	20.3	27.0
SS	0	0	42	0	83	248	31	136	540	36.3	19.8	22.8
FH	0	0	12	0	33	47	13	133	238	13.5	9.3	10.0
SD	0	0	0	2	30	62	9	16	119	9.1	4.1	5.0
RT	0	0	2	47	7	25	0	2	83	2.1	3.8	3.5
FM	0	0	62	19	1	1	0	1	84	14.7	1.1	3.5
SU	0	0	0	48	0	0	0	0	48	0	2.5	2.0
BH	0	0	0	23	4	0	0	0	27	0.9	1.2	1.1
CC	0	0	3	18	0	1	0	0	22	0.7	1.0	0.9
SH	0	0	0	7	0	0	0	0	7	0	0.4	0.3
BB	0	0	0	0	0	1	0	0	1	0	0.1	0.0

[a]See Table 4 for definition of species codes.

Table 24. Number and catch per unit effort (CPE) by species with seines in riffles of the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100m²		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
SD	0	0	0	0	3	48	13	22	86	15.2	13.9	14.1
CC	0	0	0	81	0	1	0	0	82	0	16.3	13.5
RS	0	0	0	0	0	11	1	46	58	1.0	11.3	9.5
SS	0	0	0	0	1	14	0	11	26	1.0	5.0	4.3
RT	0	0	0	20	1	4	0	0	25	1.0	4.8	4.1
BH	0	0	0	8	0	2	0	0	10	0	2.0	1.6
FM	0	0	0	5	0	1	0	0	6	0	1.2	1.0
FH	0	0	0	0	0	0	0	1	1	0	0.2	0.7
SH	0	0	0	4	0	0	0	O	4	0	0.8	0.2

[a]See Table 4 for definition of species codes.

Table 25. Number and catch per unit effort (CPE) by species with seine in pools of the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100m²		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
RS	0	0	50	0	54	81	28	233	446	31.4	91.5	58.5
SS	0	0	0	0	94	8	2	27	131	22.9	10.2	17.2
FH	0	0	5	0	17	15	8	21	66	7.1	10.5	8.7
RT	0	0	2	21	5	1	0	2	31	1.7	7.0	4.1
SD	0	0	0	0	2	3	1	1	7	0.7	1.2	2.1
CC	0	0	0	3	0	1	0	1	5	0	1.5	0.9
BB	0	0	15	1	0	0	0	0	16	3.6	0.3	0.9
GS	0	0	0	0	4	0	0	0	4	1.0	0	0.9
SU	0	0	0	6	1	0	0	0	7	0.2	1.7	0.7
BH	0	0	0	2	0	0	0	0	2	0	0.6	0.5
FM	0	0	0	6	0	0	0	1	7	0	2.0	0.3

[a]See Table 4 for definition of species codes.

Table 26. Number and catch per unit effort (CPE) by species with seines in isolated pools of the Dolores River, 1990-1991.

Species[a]	LAR		YOY		JUV		ADU		TOTAL	#/100m²		
	1990	1991	1990	1991	1990	1991	1990	1991		1990	1991	Total
RS	0	0	0	16	0	81	3	23	123	2.4	107.1	51.7
RT	0	0	7	8	2	14	0	0	31	7.1	19.6	13.0
FH	0	0	0	0	4	0	14	12	30	14.3	10.7	12.6
FM	0	0	27	3	0	0	0	0	30	21.4	2.7	12.6
SU	0	0	0	20	0	0	0	0	20	0	17.9	8.4
SD	0	0	8	1	2	0	1	1	13	8.7	1.8	5.4
SS	0	0	2	0	2	1	2	2	9	4.8	2.7	3.8
BH	0	0	5	1	0	0	0	0	6	4.0	0.9	2.5
GS	0	0	1	0	0	0	0	1	2	0.8	0.9	0.8
CP	0	0	0	0	0	0	0	1	1	0	0.9	0.4
BB	0	0	0	0	0	0	0	1	1	0	0.9	0.4
PK	0	0	0	0	0	0	1	0	1	0.8	0	0.4

[a]See Table 4 for definition of species codes.

Table 27. Seining catch per unit effort (fish/100m^2) for species sampled in the Dolores River, 1990-1991.

Species[a]	TRIP #1		TRIP #2		TRIP #3	
	March 1990	April 1991	July 1990	August 1991	Aug-Sept 1990	Sept-Oct 1991
BB	0	0	0	0	1.8	0.1
BH	0	0	5.0	0.4	0.29	4.0
CC	0	0	3.0	1.3	0.73	4.0
CP	0.13	0	0.45	0	0.07	0.1
FH	38.3	38.4	76.3	3.0	166.6	8.0
FM	0	0.1	38.2	2.4	0.07	1.7
GS	0.13	0	0.15	0	1.2	0.05
PK	0.26	0	0.08	0	0	0
RS	18.7	23.4	75.7	9.9	332.4	64.4
RT	0.13	4.2	20.4	8.2	1.8	3.3
SD	0	15.6	11.2	5.3	4.3	3.5
SH	0	0	0	0.3	0	0
SS	39.7	119.2	54.9	3.2	183.5	30.8
SU	0	0	0.08	3.2	0	0.1

[a]See Table 4 for definition of species codes.

Table 28. Comparison of seining catch rates ($fish/100m^2$) by species between habitat types[a] in the Dolores River, 1990-1991.

Species[b]	BA	TFBA	ED	EM	SH	SC	RU	RI	PO	IP
BB	0.3	0	0	0	1.2	0.7	>0.1	0	2.1	0.4
BH	4.9	0.8	0	0	0	1.2	1.1	1.6	0.3	2.5
CC	1.3	2.1	4.5	1.2	6.8	1.0	0.9	13.5	0.7	0
CP	0.3	0.3	0.4	0	0	0	0	0	0	0.4
FH	137.5	15.3	7.9	110.3	14.2	21.1	10.0	0.2	8.7	12.6
FM	19.4	0.8	0	2.1	1.5	3.7	3.5	1.0	0.9	12.6
GS	0.5	0	0	0.8	0.3	0.2	0	0	0.5	0.8
PK	0.1	0	0	0	0	0	0	0	0	0.4
RS	219.6	29.2	61.1	166.1	49.9	54.0	27.0	9.5	58.5	51.7
RT	17.8	9.4	2.3	17.4	2.7	4.9	3.5	4.1	4.1	13.0
SD	10.1	1.1	0.4	6.6	3.5	7.8	5.0	14.1	0.9	5.4
SH	0.1	0	0	0	0.3	0.3	0.3	0.7	0	0
SS	132.4	191.1	14.0	204.5	25.7	34.0	22.8	4.3	17.2	3.8
SU	1.1	10.5	0	0.4	0	2.5	2.0	0	0.9	8.4

[a]BA=backwater TFBA=trickle-fed backwater
ED=eddy EM=embayment
SH=shoreline SC=side channel
RU=run RI=riffle
PO=pool IP=isolated pool

[b]See Table 4 for definition of species codes.

Table 29. Catch per 10 hours of effort for fish species captured by gill nets, trammel nets, and electrofishing in the Dolores River sampled by USFWS, 1981, and by BIO/WEST, 1990-1991.

	B/W	B/W	USFWS	B/W	B/W	USFWS
SPECIES[a]	MARCH 90	APRIL 91	APRIL 81	JULY 90	AUGUST 91	JULY 81
BB	O.3	0.5	0.3	0	1.0	0.6
BH	3.0	19.1	3.8	18.1	16.4	11.3
CC	2.2	9.8	2.1	6.8	17.5	6.8
CP	2.7	78.0	4.5	32.9	24.8	9.0
FH	13.5	0	0.3	4.2	0.6	0
FM	18.6	176.3	15.5	24.3	37.2	43.5
GS	0	4.0	0	0.6	2.3	0
RB	0	0	0	0	0	0.6
RS	11.5	2.3	0	20.3	3.5	1.1
RT	16.8	12.1	2.8	6.6	14.6	6.2
SD	1.7	1.7	0	1.2	3.7	2.3
SH	0	0	0	10.0	0	0
SS	0	0	1.0	3.2	0.2	1.1
WS	0	1.2	0.3	0	0	0

[a]See Table 4 for definition of species codes.

Table 30. Catch per 100 m^2 of area for fish species collected by seine in the Dolores River by USFWS, 1981, and by BIO/WEST, 1990-1991.

	SAMPLE MONTH					
	B/W	B/W	USFWS	B/W	B/W	USFWS
SPECIES[a]	MARCH 90	APRIL 91	APRIL 81	JULY 90	AUGUST 91	JULY 81
BB	0	0	0.20	0	0	0
BH	0	0	5.70	5.00	0.1	0.90
CC	0	0	0	3.00	1.3	0.10
CP	0.13	0	0	0.45	0	0
FH	38.30	38.4	19.50	76.30	3.0	14.10
FM	0	0.1	6.60	38.20	2.4	1.20
GS	0.13	0	0.20	0.15	0	0
PK	0.26	0	0	0.08	0	0
RS	18.70	23.4	224.50	75.70	9.9	4.00
RT	0.13	4.2	59.80	20.40	8.2	2.80
SD	0	15.6	0	11.20	5.3	2.70
SS	39.70	119.2	134.00	54.90	0.3	25.00
WS	0	0	0.90	0	0	0

[a]See Table 4 for definition of species codes.

Table 31. Compostion of fish species captured by gill nets, trammel nets, and electrofishing in six reaches of the Dolores River sampled by USFWS, 1981, and BIO/WEST 1990 and 1991.

	REACH/SAMPLE																			
	1				2				3				4				5			6
RANK	USFWS	B/W 1990	B/W 1991	B/W COMBINED	USFWS	B/W 1990	B/W 1991	B/W COMBINED	USFWS	B/W 1990	B/W 1991	B/W COMBINED	USFWS	B/W 1990	B/W 1991	B/W COMBINED	B/W 1990	B/W 1991	B/W COMBINED	B/W 1991
1	CC (33.5)	RS (27.1)	CP (40.0)	CP (27.7)	FM (24.1)	FM (30.8)	FM (54.2)	FM (41.5)	FM (49.3)	FM (63.8)	FM (52.8)	FM (57.6)	FM (33.3)	CP (38.5)	FM (59.5)	FM (55.3)	RT (48.3)	FM (50.5)	FM (45.2)	RT (27.0)
2	FM (23.6)	FH (19.7)	CC (20.6)	RS (16.0)	CP (22.0)	CP (26.5)	CP (19.8)	CP (23.4)	BH (16.2)	BH (12.4)	BH (22.1)	BH (17.9)	RT (33.3)	RS (30.8)	CP (10.8)	CP (13.0)	FM (34.8)	RT (19.9)	RT (29.5)	SD (23.5)
3	CP (21.1)	CP (18.5)	FM (18.2)	FM (15.6)	BH (16.8)	SH (12.7)	BH (14.7)	BH (13.1)	CP (11.8)	CP (7.6)	CP (11.7)	CP (9.9)	CP (22.2)	CC (15.4)	RT (8.8)	RS (8.7)	SD (5.6)	BH (10.4)	BH (7.8)	FM (21.7)
4	RS (8.3)	FM (13.6)	BH (10.3)	FH (11.6)	CC (13.3)	BH (11.7)	CC (7.5)	CC (5.4)	RT (7.9)	CC (7.4)	CC (7.2)	CC (7.3)	BH (11.1)	FM (7.7)	RS (6.8)	RT (8.7)	CP (4.9)	CC (9.5)	CC (7.3)	BR (5.2)
5	BH (7.0)	BH (10.6)	RT (3.8)	CC (10.9)	RT (10.8)	RS (6.6)	RT (1.5)	RS (3.6)	CC (5.9)	RT (4.8)	RT (2.0)	RT (3.2)		RT (7.7)	BH (4.7)	CC (5.0)	CC (3.0)	CP (6.5)	CP (5.9)	CC (4.3)
6	RT (2.1)	CC (3.6)	GS (1.9)	BH (10.5)	RS (6.0)	RT (4.1)	GS (1.2)	RT (2.9)	FH (3.1)	RS (1.7)	SD (1.8)	SD (1.4)			CC (4.1)	BH (4.3)	BH (2.6)	SD (1.9)	SD (3.1)	CP (4.3)
7	SS (1.7)	GS (2.0)	BB (1.4)	RT (2.4)	LG (3.0)	CC (3.6)	BB (0.3)	GS (1.2)	SS (1.7)	SD (0.9)	GS (1.0)	RS (1.1)			SD (2.0)	SD (1.9)	RS (0.4)	GS (0.8)	GS (0.5)	BH (3.5)
8	BB (1.7)	SS (2.3)	RS (1.2)	GS (2.0)	BB (1.3)	GS (1.3)	BR (0.3)	FH (0.7)	RS (1.4)	GS (0.7)	BB (0.7)	GS (0.9)			SS (1.4)	SS (1.2)	BB (0.4)	RS (0.4)	RS (0.4)	GS (3.5)
9	LG (0.4)	RT (1.3)	CS (1.0)	SS (1.3)	BN (0.9)	FH (1.0)	FH (0.3)	SD (0.6)	SD (1.4)	BB (0.4)	RS (0.7)	BB (0.6)			BB (0.7)	BB (0.6)		BB (0.2)	BB (0.3)	RS (2.6)
10	SD (0.4)	BB (0.5)	FH (0.7)	BB (0.9)	SD (0.9)	SS (1.0)	SD (0.3)	SS (0.6)	BB (1.0)	FH (0.2)		FH (0.1)			GS (0.7)	GS (0.6)				FH (1.7)
11	WS (0.4)	SD (0.5)	SD (0.5)	SD (0.5)	FH (0.4)	SD (0.8)		BB (0.1)	RB (0.3)						WS (0.7)	WS (0.6)				RB (1.7)
12		LG (0.2)	WS (0.5)	CS (0.4)	GS (0.4)			BR (0.1)												MS (0.9)
13		BG (0.2)		WS (0.2)																

Table 32. Composition of fish species captured by seining in five reaches of the Dolores River sampled by USFWS, 1981, and BIO/WEST, 1990 and 1991.

	REACH/SAMPLE																	
	1				2				3				4			5		
RANK	USFWS	B/W 1990	B/W 1991	B/W COMBINED	USFWS	B/W 1990	B/W 1991	B/W COMBINED	USFWS	B/W 1990	B/W 1991	B/W COMBINED	B/W 1990	B/W 1991	B/W COMBINED	B/W 1990	B/W 1991	B/W COMBINED
1	SS (43.3)	RS (53.2)	RS (78.4)	RS (56.8)	SS (51.7)	FH (29.1)	SS (41.1)	SS (28.5)	SS (33.6%)	SS (36.9%)	RS (30.3)	SS (27.3)	RS (40.5%)	SS (61.5)	SS (27.2)	SS (30.2 %)	SS (37.4)	SS (23.9)
2	RS (40.5)	FH (30.0)	FH (9.6)	FH (27.1)	RS (32.6)	RS (28.8)	RS (25.8)	RS (24.1)	FH (27.0)	RS (32.7)	RT (24.5)	RS (24.1)	FM (26.6)	CC (13.3)	RS (19.5)	RS (23.5)	RS (32.6)	RS (20.1)
3	FH (12.1)	SS (15.9)	SS (6.6)	SS (14.6)	FH (11.7)	SS (28.5)	FH (18.8)	FH (15.0)	RS (18.2)	FH (22.3)	FM (12.0)	FM (14.5)	RT (9.5)	SD (12.9)	FM (15.4)	FH (15.0)	SD (15.2)	RT (17.0)
4	RT (2.2)	BB (0.3)	RT (3.0)	RT (0.5)	RT (2.6)	FM (7.6)	BH (4.1)	FM (12.9)	RT (14.1)	FM (3.8)	SS (9.2)	FH (12.1)	SS (9.2)	RS (5.5)	RT (13.8)	RT (13.1)	RT (10.5)	FM (14.8)
5	FM (0.6)	GS (0.2)	CC (1.5)	BB (0.3)	FM (0.7)	RT (2.7)	SU (3.5)	RT (6.5)	SD (2.6)	SD (1.8)	FH (7.2)	RT (8.3)	CC (8.5)	FH (3.6)	SD (9.9)	SD (10.0)	FH (3.5)	SD (10.7)
6	CC (0.6)	FM (0.2)	SD (0.3)	CC (0.2)	BH (0.4)	BH (1.7)	RT (3.3)	SD (3.8)	FM (2.3)	RT (1.7)	SU (7.0)	SD (5.3)	FH (3.0)	RT (2.4)	FH (5.2)	FM (6.3)	CC (0.3)	FH (6.1)
7	BH (0.3)	RT (0.1)	FM (0.2)	FM (0.2)	SD (0.1)	SD (1.0)	FM (1.8)	BH (3.4)	BH (1.8)	BH (0.4)	SD (5.9)	BH (2.8)	SD (2.7)	FM (0.6)	CC (4.5)	BH (1.5)	SU (0.3)	BH (2.7)
8	SD (0.2)	SD (>0.2)	SH (0.2)	GS (0.2)	BB (>0.1)	CC (0.3)	CC (0.8)	CC (2.3)	CC (0.1)	CC (0.2)	CC (2.5)	CC (2.8)		SU (0.2)	BH (2.1)	CP (0.4)	BB (0.2)	CC (2.2)
9	WS (0.1)	PK (>0.1)	BH (0.1)	SD (0.1)	CP (>0.1)	BB (0.2)	SD (0.6)	CP (2.3)	CP (0.1)	BB (0.1)	SH (0.7)	CP (1.8)			CP (1.8)	SU (0.1)	BH (0.2)	CP (1.9)
10	BB (0.1)	BH (>0.1)		BH (>0.1)	GS (>0.1)	GS (0.2)	SH (0.3)	SU (0.9)	GS (0.1)	GS (0.1)	CP (0.4)	SU (0.6)			GS (0.2)		GS (0.1)	GS (0.3)
11	CP (0.1)	CP (>0.1)		CP (>0.1)		CP (>0.1)		GS (0.2)		CP (>0.1)	BB (0.1)	GS (0.2)			BB (0.1)			SU (0.2)
12	GS (>0.1)							BB (0.1)			BH (0.1)	BB (0.1)			SU (0.1)			BB (0.1)
13	PK (>0.1)																	

Table 33. Summary of Dolores River habitat suitability for different life history stages of Colorado squawfish. Habitat requirements based on HSI curves developed by the USFWS (Valdez et al. 1987).

LIFE STAGE	PARAMETER	HABITAT REQUIREMENTS[1]	DOLORES HABITAT	SUITABILITY OF DOLORES[2]	COMMENTS
EGG	DEPTH	0.5-4.0 FT.	0.05-6.5 FT. X=1.67	+	Below the Dolores/San Miguel confluence
	VELOCITY	0.61-4.9 F/S	0-4.6 F/S X=0.95	0	Insufficient data
	SUBSTRATE	RU,GR,BO	CO,BO,GR,SI,SA	+	May be sedimentation problem
	HABITAT	RU,RI	RU,RI	0	Insufficient data
	TEMP	20-22 °C	16-20 °C	0	Insufficient data
LARVAE	DEPTH	0.3-7.9 FT.	0.5-4.0 FT.	+	Below the Dolores/San Miguel confluence
	VELOCITY	0-0.25 F/S	0-0.5 F/S	+	
	SUBSTRATE	SI,SA	SI,SA,CO	+	
	HABITAT	BA,EM,SH	BA,TFSC	0	May be ephemeral in nature
	TEMP	20-22 °C	22-33 °C	+	Data collected during July (Post-runoff)
JUVENILE	DEPTH	0.1-4.2 FT.	0-7.4 FT.	+	
	VELOCITY	0-2.9 F/S	0-3.7 F/S	+	
	SUBSTRATE	SI,SA,RU	SI,SA,BO,GR,CO,BE	+	
	HABITAT	BA,ED,RU,SH,PO	BA,ED,RU,PO	0	May be ephemeral in nature
	TEMP	5-32 °C	16-20 °C	+	
ADULT (HOLDING - APR. - NOV.)	DEPTH	1.0-6.3 FT.	0.1-7.4 FT. X=2.01	0	Possible access problems at low flows
	VELOCITY	0-4.4 F/S	0-4.6 F/S X=0.80	+	
	SUBSTRATE	SA,SI,RU,GR,BE,CL	SA,SI,BO,GR,CO,BE	+	
	HABITAT	ED,RU,SH,RI,PO	ED,RU,PO,RI,SW	+	
	TEMP	0-32 °C	0-29 °C	+	
ADULT (STAGING)	DEPTH	1.2-18.2 FT.	0.1-7.4 FT. X=2.60	+	Below the Dolores/San Miguel confluence
	VELOCITY	0-4.1 F/S	0-3.7F/S X=0.64	0	Insufficient data
	SUBSTRATE	RU,SA,BO,GR,SI,BE	SA,SI,BO,GR,CO,BE	+	
	HABITAT	ED,PO,RU	ED,RU,PO	0	Insufficient data
	TEMP	19-22 °C	16-20 °C	0	Insufficient data
ADULT (SPAWNING)	DEPTH	1.0-4.1 FT.	0.05-6.5 FT. X=1.67	+	Below the Dolores/San Miguel confluence
	VELOCITY	0.61-4.9 F/S	0-4.6 F/S X=0.95	0	Insufficient data
	SUBSTRATE	RU,GR,BO	CO,BO,GR,SI,SA	+	May be sedimentation problem
	HABITAT	RU,RI	RU,RI	0	Insufficient data
	TEMP	19-22 °C	16-20 °C	0	Insufficient data

1. Substrate: RU=rubble, GR=gravel, BO=boulder, SI=silt, SA=sand, BE=bedrock, CL=clay
Habitat: BA=backwater, EM=embayment, SH=shoreline, RU=run, RI=riffle, ED=eddy, PO=pool, SW=slackwater, TFSC=trickle-fed sidechannel
2. (+) = suitable, (O) = undetermined, (-) = unsuitable

Table 34. A summary of average daily flows (cfs) of the Dolores River during the field trips of the 1990 Dolores River study.

Trip	Dates	Releases from McPhee	Dolores below McPhee	Dolores at Bedrock	Dolores near Cisco
1	March 5	80-20	40	97	195
	6	20	21	82	219
	7	20	18	64	229
	8	20	18	58	209
	9	20	18	57	186
	10	20	18	50	173
	11	20	18	44	169
	12	20	18	42	177
	13	20	18	42	186
2	July 7	50	50	30	300
	8	50	50	40	300
	9	50	50	35	475
	10	50	50	50	500
	11	50	50	250	620
	12	50	50	70	550
	13	50	50	40	370
	14	50	50	40	270
	15	50	50	35	250
3	Sept 24	32	32	32	132
	25	32	32	28	148
	26	32	32	23	128
	27	32	32	21	169
	28	32	32	23	111
	29	32	32	33	107
	30	31	32	135	141
	Oct 1	31	32	50	245
	2	31	32	54	209
4	April 4	30	30	55	130
	5	30	30	70	150
	6	30	30	70	440
	7	30	30	130	750
	8	30	30	530	1100
	9	30	30	830	1400
	10	37	37	600	930
	11	41	41	730	1000
	12	-	-	500	875

Table 34 continued

Trip	Dates	Releases from McPhee	Dolores below McPhee	Dolores at Bedrock	Dolores near Cisco
5	August 5	70	70	100	300
	6	70	70	120	258
	7	70	70	100	290
	8	70	70	210	220
	9	70	70	110	270
	10	70	70	90	170
	11	70	70	80	130
	12	70	70	60	100
	13	70	70	120	100
	14	70	70	120	190
	15	70	70	90	140
6	Sept 29	33	33	25	105
	30	33	33	25	113
	Oct 1	33	33	25(E[a])	106
	2	34	34	25(E[a])	106
	3	36	36	25(E[a])	152
	4	36	36	25(E[a])	145
	5	36	36	25(E[a])	139
	6	36	36	25(E[a])	134
	7	36	36	25(E[a])	142
	8	36	36	25(E[a])	137
	9	36	36	25(E[a])	143
	10	36	36	25(E[a])	132
	11	36	36	25(E[a])	135

[a]Estimated

Table 35. Temperature and water quality data[a] recorded for three Dolores River field trips, 1990, and three Dolores River field trips, 1991.

Location	Date/Time (ymd)	Temp. (°C)	Conductivity (umhos)	Salinity (ppt)	D.O. (mg/L)	Alkalinity (mg $CaCO^3$/L)	pH	Secchi (ft)
Trip 1								
RM 23.4	900306/1100	6.5	1600	<1.0				
RM 1.4	900310/0930	9.5	1975	1.5				
RM 110.5	900311/1030	8.0	375	<1.0				
RM 122.7	900312/1500	5.0	355	<1.0				
RM 75.4	900313/0940	3.5	600	<1.0				
RM 71.2	900313/1000	5.0	4600	4.5				
RM 63.0	900313/1020	5.0	7500	7.0				
RM 68.2	900313/1035	5.0	7500	7.0				
RM 65.5	900313/1126	5.0	7000	6.5				
RM 64.3	900313/1300	4.5	3100	3.0				
RM 0.1[b]	900313/1300	4.0	625	<1.0				
RM 59.7	900313/1445	6.5	2875	4.0				
Trip 2								
RM 119.6	900707/1026	21.0	330	<1.0				
RM 122.7	900707/1215	23.0	350	<1.0				
RM 108.0	900708/0900	18.0	340	<1.0				
RM 106.7	900708/1115	18.0	370	<1.0				
RM 93.2	900709/1300	22.0	850	----				
RM 87.0	900710/0900	20.0	1400	----				
RM 75.6	900711/1000	21.5	1000	<1.0				
RM 71.2	900711/1030	22.0	1490	1.0				
RM 69.4	900711/1040	21.5	2300	1.75				
RM 68.4	900711/1050	22.0	2400	1.5				
RM 64.5	900711/1200	22.0	2400	2.0				
RM 0.1[2]	900711/1625	25.0	700	<1.0				
RM 64.4	900711/1635	25.0	750	<1.0				

Table 35 continued

Location	Date/Time (ymd)	Temp. (°C)	Conductivity (umhos)	Salinity (ppt)	D.O. (mg/L)	Alkalinity (mg $CaCO^3/L$)	pH	Secchi (ft)
RM 59.7	900711/1800	25.0	1100	<1.0				
RM 54.7	900712/0900	23.0	1000	<1.0				
RM 41.4	900713/1225	23.5	1050	<1.0				
RM 38.7	900713/1550	27.5	1150	<1.0				
RM 30.9	900714/0930	21.0	1100	<1.0				
RM 11.3	900715/1035	23.0	1175	1.0				
RM 8.5	900715/1350	25.5	1250	1.0				
RM 1.3	900715/1700	26.0	1250	1.				
Trip 3								
RM 64.4	900925/1136	18.0	3600	3.5				
RM 59.7	900925/1305	21.0	2000	1.0	7.3	200	7.97	
RM 64.4	900925/1755	20.0	4200	2.8	7.6	160	8.20	
RM 42.7	900926/1020	21.0	1800	1.0	6.5	220	8.08	
RM 52.3	900926/1640	20.0	2000	1.0	7.5	220	8.07	0.4
RM 52.7	900927/1040	18.0	2275	1.25				
RM 122.6	900930/0955	13.0	300	0.25	8.0	160	8.12	0.8
RM 74.9	900930/1500	18.0	510	0.25	7.8	275	7.87	0.1
RM 71.3	900930/1608	19.5	625	0.25				
RM 69.3	900930/1617	19.5	1000	0.5				
RM 64.6	900930/1638	17.0	700	0.25	7.4	280	7.78	<0.1
RM 59.7	900930/1805	17.5	1350	0.9	7.2	300	7.88	0.1
RM 4.5	901001/1003	15.0	2250	1.75				
RM 1.3	901001/1638	18.5	2220	1.6	8.1	260	8.17	0.3
RM 0.1[b]	900925/1140	17.0	1200	0.75				
RM 0.1[b]	900930/1716	18.0	800	0.25	7.2	170	8.10	0.4
Trip 4								

Table 35 continued

Location	Date/Time (ymd)	Temp. (°C)	Conductivity (umhos)	Salinity (ppt)	D.O. (mg/L)	Alkalinity (mg $CaCO^3/L$)	pH	Secchi (ft)
RM 59.6	910406/1622	9.0	725	23.5	0.75	150	7.2	0.1
RM 53.7	910407/0918	8.0	725	14.0	0.6	320	7.7	<0.1
RM 0.1[b]	910407/1041	5.2	154	22.0	0.2	120	7.9	0.15
RM 65.5	910407/1050	9.2	2870	22.0	2.5	260	8.2	0.3
RM 74.8	910407/1148	12.5	1050	24.0	0.9	490	8.0	0.3
RM 71.3	910407/1700	13.8	1640	15.0	1.5	530	8.0	0.1
RM 69.3	910407/1811	18.5	2200	15.0	1.5	630	8.0	0.1
RM 68.5	910407/1835	13.5	2210	14.0	1.8	620	7.9	0.1
RM 110.2	910408/1416	8.7	317	19.5	0.25	1640	8.1	0.1
RM 119.7	910409/1501	8.0	225	21.0	0.2	480	7.5	0.1
RM 122.5	910409/1558	7.7	230	21.0	0.15	260	7.9	<0.1
RM 74.9	910409/1834	11.5	400	16.0	0.2	800	7.6	<0.1
RM 64.7	910409/1919	11.8	600	17.0	0.5	1380	7.6	<0.1
RM 0.1[b]	910409/1932	7.6	200	10.0	0.1	-	7.4	0.5
RM 59.7	910410/0913	5.4	239	8.0	0.1	-	7.5	<0.1
RM 1.4	910411/1142	7.5	300	-	0.05	-	7.2	0.1
Trip 5								
RM 1.4	910805/1519	22.0	1300	0.8	7.66	5	7.0	
RM 1.3	910806/1510	20.5	980	0.8	-	2	7.0	
RM 27.0	910807/1238	23.0	2050	1.1	-	<2	6.0	
RM 41.9	910808/1006	20.2	1080	0.8	-	3	7.8	
RM 41.9	910810/0930	19.2	1030	0.8	-	3	8.1	
RM 0.1[b]	910811/1600	25.0	1000	0.5	8.06	19	8.0	
RM 64.6	910811/1610	25.0	3525	2.3	7.79	<1	7.0	
RM 75.3	910812/1211	23.0	850	0.5	-	-	-	
RM 74.5	910812/1242	23.5	990	0.8	-	-	-	

Table 35 continued

Location	Date/Time (ymd)	Temp. (°C)	Conductivity (umhos)	Salinity (ppt)	D.O. (mg/L)	Alkalinity (mg $CaCO^3$/L)	pH	Secchi (ft)
RM 73.5	910812/1351	25.0	1100	1.0	-	-	-	
RM 72.5	910812/1439	27.5	1100	0.8	-	-	-	
RM 71.5	910812/1515	27.5	1150	0.6	-	-	-	
RM 70.5	910812/1601	28.0	1300	0.7	-	-	-	
RM 69.5	910812/1646	28.5	2600	1.5	-	-	-	
RM 69.0	910812/1702	28.0	2890	1.8	-	-	-	
RM 68.5	910812/1726	27.5	2890	1.8	-	-	-	
RM 113.5	910813/1300	21.0	910	0.5	7.88	<1	8.3	
RM 122.8	910814/1010	20.5	420	0.25	-	5	8.1	
RM 119.8	910815/0930	21.0	390	0.1	-	12.5	7.3	
RM 129.0	910815/1155	23.5	325	0.15	-	30	6.9	
RM 0.1[b]	910815/1739	24.0	1010	0.55	-	9	6.9	
RM 64.6	910815/1754	24.3	2200	1.5	-	3	7.0	
RM 74.9	910815/1817	24.0	910	0.5	-	3	7.2	
RM 59.7	910815/1926	23.5	1400	0.95	-	3	7.0	
Trip 6								
RM 4.7	910930/1058	17.77	2240	0.1	8.83		8.37	
Dewey Bridge CO River	910930/1930	18.74	1130		8.40		8.74	
RM 1.4	910930/1955	20.41	2250		9.35		8.55	
RM 1.4	/0939	17.09	2330		8.55		8.35	**.15 m**
RM 11.4	911001/1118	17.38	2390	0.1	9.45		8.28	
RM 9.0	/1553	21.23	2360	0.1	9.43		8.44	
RM 1.3	/1747	22.06	2380	0.1	10.16		8.51	
RM 0.2	911001/1900	21.14	2390	0.1	9.5		Broken	
Colorado **River**	911001/1907	18.54	1060.9	0.0	9.15			
RM 32.0	911002/1307	17.78	2700	0.1	8.80			

Table 35 continued

Location	Date/Time (ymd)	Temp. (°C)	Conductivity (umhos)	Salinity (ppt)	D.O. (mg/L)	Alkalinity (mg $CaCO^3/L$)	pH	Secchi (ft)
RM 30.0	911002/1614	20.2	2630	0.1	8.64			
RM 42.5	911003/0859	14.58	2070	0.1	8.84			
RM 57.5	911003/115	16.04	1670	0.1	9.35			
RM 55.0	911003/1443	17.86	1670	0.1	9.43			
Bedrock Boat Launch	911004/1453	15.00	772	0.0	10.5			
RM 74.5	911005/1614	16.12	785	0.0	9.93			
RM 74.0	911005/1658	16.44	784	0.0	10.13			
RM 73.5	911005/1723	17.06	796	0.0	9.56			
RM 72.3	911005/1808	16.91	797	0.0	9.70			
RM 71.2	911005/1827	16.9	885	0.0	9.46			
RM 70.7	911005/1871	16.80	948	0.0	9.60			
RM 70.5	911005/1851	16.82	1244	0.1	9.36			
Takeout	911005/1918	16.17	1820	0.1	9.25			
Big Gypsum Valley	911006/1107	14.06	422	0.0	9.83			
RM 99.5	911007/1914	15.91	437	0.0	9.12			
RM 99.5	/0900	11.57	438	0.0	9.73			
RM 86.2	/1005	11.90	679	0.0	9.88			
RM 122.5	911011/0806	10.44	382	0.0	9.87			
RM 129.1	911011/1113	11.39	381	0.0	9.96			
RM 75.0	911011/1359	15.42	732	0.0	10.27			
RM 64.5	911011/1442	16.41	3660	0.2	10.57			
RM 0.1 San Miguel	911011/1504	15.60	885	0.0	9.96			
RM 59.7	911011/1555	16.17	1800	0.1	10.17			
RM 1.4	911011/	16.13	1870	0.1	8.66			

[a]Recorded with YSI temperature/conductivity/salinity meter
[b]Taken in San Miguel River

Table 36. Summary of water quality data for Field Trip 1 of the 1990 Dolores River study.

Location:		Above confluence w/San Miguel River (RM 65.5)			Below confluence w/San Miguel River (RM 60.3)			Near confluence w/Colorado River (RM 1.4)		
		Rep #1	Rep #2	$\bar{x}$	Rep #1	Rep #2	$\bar{x}$	Rep #1	Rep #2	$\bar{x}$
Sample I.D:		1-WQ02	1-WQ04		1-WQ03	1-WQ05		1-WQ01	1-WQ06	
Trip 1	Parameter									
Mar. 5-14, 1990	Alkalinity as $CaCO_3$ (T), mg/l	164	167	**165.5**	154	148	**151**	163	168	**165.5**
	Hardness as $CaCO_3$, mg/l	474	465	**469.5**	439	400	**419.5**	314	293	**303.5**
	pH Unit	8.22	8.24	**8.23**	8.19	8.24	**8.22**	7.60	8.16	**7.88**
	TDS, mg/l	6,240	6,400	**6,320**	2,640	2,550	**2,595**	1,550	1,610	**1,580**
	Ammonia as NH_3-N, mg/l	0.697	0.535	**0.616**	0.988	0.938	**0.963**	0.805	0.518	**0.662**
	Nitrate as NO_3-N, mg/l	0.502	0.362	**0.432**	0.487	0.487	**0.487**	0.649	0.502	**0.576**
	Phosphate as PO_4-P (T), mg/l	0.013	0.038	**0.026**	0.011	<.01	**0.01**	0.387	0.102	**0.245**
	Ortho Phosphate as PO_4-P, mg/l	<.01	<.01	**<.01**	<.01	<.01	**<.01**	<.01	<.01	**<.01**
	Copper as Cu (T), mg/l	0.047	0.062	**0.055**	0.047	0.065	**0.056**	0.042	0.057	**0.050**
	Iron as Fe (T), mg/l	0.35	0.34	**0.345**	0.18	0.22	**0.20**	1.98	2.06	**2.02**
	Lead as Pb (T), mg/l	0.055	0.052	**0.054**	0.065	0.058	**0.062**	0.055	0.062	**0.059**
	Zinc as Zn (T), mg/l	0.080	0.235	**0.158**	0.110	0.130	**0.12**	0.092	0.105	**0.099**
	Oil & Grease, mg/l	<.5	<.5	**<.5**	<.5	<.5	**<.5**	<.5	<.5	**<.5**
	TSS, mg/l	21	22	**21.5**	13	15	**14**	105	109	**107**

Table 37. Summary of water quality for Field Trip 2 of the 1990 Dolores River Study.

LOCATION		Near Slickrock (RM 122.7)			Above confluence w/San Miguel River (RM 64.5)	Below confluence w/San Miguel River (RM 59.7)	Near confluence w/Colorado River (RM 1.3)		
Sample ID:		Rep #1	Rep #2				Rep #1	Rep #2	
Trip 2	Parameter	2-WQ2	2-WQ4	$\bar{x}$	2-WQ1	2-WQ6	2-WQ3	2-WQ5	$\bar{x}$
Sep. 24-Oct. 2, 1990	Alkalinity as $CaCO^3$ (T), mg/l	122	120	**121**	92.6	107	120	122	**121**
	Hardness as $CaCO^3$, mg/l	138	139	**138.5**	912	407	378	372	**375**
	pH Unit	8.29	8.33	**8.31**	7.67	8.00	8.27	8.25	**8.26**
	TDS, mg/l	232	220	**226**	2,030	752	741	761	**751**
	Ammonia as NH^3-N, mg/l	<.2	<.2	**<.2**	0.61	0.26	<.2	0.28	**0.24**
	Nitrate as NO^3-N, mg/l	0.02	0.04	**0.03**	1.26	0.27	0.36	0.44	**0.40**
	Phosphate as PO^4-P (T), mg/l	0.022	0.022	**0.022**	0.456	0.420	0.050	0.075	**0.063**
	Ortho Phosphate as PO^4-P, mg/l	<.01	<.01	**<.01**	0.044	0.020	0.018	0.020	**0.019**
	Copper as Cu (T), mg/l	<.01	<.01	**<.01**	0.282	0.030	<.01	<.01	**<.01**
	Iron as Fe (T), mg/l	1.80	1.80	**1.80**	27.0	27.6	12.8	10.1	**11.5**
	Lead as Pb (T), mg/l	<.01	<.01	**<.01**	0.180	<.01	<.01	<.01	**<.01**
	Zinc as Zn (T), mg/l	<.01	<.015	**0.012**	1.20	0.140	0.058	0.058	**0.058**
	Oil & Grease, mg/l	<.5	<.5	**<.5**	<.5	<.5	<.5	<.5	**<.5**
	TSS, mg/l	65	66	**65.5**	9,050	2,080	480	496	**488**

Table 38. Summary of water quality for Field Trip 3 of the 1990 Dolores River Study.

LOCATION		Near Slickrock (RM (122.6)	Near Bedrock (RM 74.9)	Above confluence w/San Miguel River (RM 64.6)	Below confluence w/San Miguel River (RM 59.7)	Near confluence w/Colorado River (RM 1.3)	San Miguel River above Dolores Confluence (RM 0.1)
Sample ID:		3-WQ1	3-WQ4	3-WQ2	3-WQ3	3-WQ6A	3-WQ5
Trip 3	Parameter						
Sep. 24-Oct. 2, 1990	Alkalinity as $CaCO^3$ (T), mg/l	122	124	92.1	127	114	132
	Hardness as $CaCO^3$, mg/l	150	189	141	326	678	528
	pH Unit	8.33	8.35	8.27	8.45	8.37	8.45
	TDS, mg/l	270	439	518	592	1.620	666
	Ammonia as NH^3-N, mg/l	0.28	0.13	0.25	0.34	0.10	0.44
	Nitrate as NO^3-N, mg/l	0.06	0.14	0.45	0.43	0.69	0.16
	Phosphate as PO^4-P (T), mg/l	0.013	1.23	3.19	2.03	0.75	0.042
	Ortho Phosphate as PO^4-P, mg/l	0.015	0.024	0.010	0.016	0.016	<.01
	Copper as Cu (T), mg/l	<.01	0.030	0.148	0.060	0.015	<.01
	Iron as Fe (T), mg/l	0.67	24.2	32.8	29.6	14.5	4.45
	Lead as Pb (T), mg/l	<.01	0.055	0.098	0.098	0.035	0.045
	Zinc as Zn (T), mg/l	0.020	0.083	0.148	0.133	0.058	0.040
	Copper as Cu (D), mg/l	<.01	<.01	<.01	<.01	<.01	<.01
	Iron as Fe (D), mg/l	0.52	3.42	0.21	0.31	3.08	1.62
	Lead as Pb (D), mg/l	<.01	0.020	0.080	0.080	<.01	<.01
	Zinc as Zn (D), mg/l	<.01	<.01	<.01	<.01	<.01	<.01
	Oil & Grease, mg/l	<.5	<.5	<.5	<.5	<.5	<.5
	TSS, mg/l	32	1,730	4,610	3,800	1,020	275

Table 39. Summary of water quality for Field Trip 4 of the 1991 Dolores River Study.

	Near Slickrock (RM 122.7)	Near Bedrock (RM 74.9)	Above confluence w/San Miguel River (RM 64.5)	Below confluence w/San Miguel River (RM 59.7)	Near confluence w/Colorado River (RM 1.3)	San Miguel River above Dolores Confluence (RM 0.1)
Parameter	2-WQ-4	2-WQ-3	2-WQ-1	2-WQ-6	2-WQ-5	2-WQ-2
Alkalinity as $CaCO_3$(T), mg/1	120	120	92.6	107	122	122
Hardness as $CaCO_3$, mg/1	139	378	912	407	372	138
pH Unit	8.33	8.27	7.67	8.00	8.25	8.29
TDS, mg/1	220	711	2,030	752	761	232
Ammonia as NH_3-N, mg/1	<.2	<.2	0.61	0.26	0.28	<.2
Nitrate as NO_3-N, mg/1	0.04	0.36	1.26	0.27	0.44	0.02
Phosphate as PO_4-P(T), mg/1	0.022	0.050	0.456	0.420	0.075	0.022
Ortho Phosphate as PO_4-P,mg/1	<.01	<.01	0.044	0.020	0.020	<.01
Copper as Cu (T), mg/1	<.01	0.018	0.282	0.030	<.01	<.01
Iron as Fe (T), mg/1	1.80	12.8	27.0	27.6	10.1	1.80
Lead as Pb (T), mg/1	<.01	<.01	0.180	<.01	<.01	<.01
Zinc as Zn (T), mg/1	0.015	0.058	1.20	0.140	0.058	<.01
Oil & Grease, mg/1	<.5	<.5	<.5	<.5	<.5	<.5
TSS, mg/1	66	480	9,050	2,080	496	65
Hardness as CaCo, (Diss), mg/1			158			

Table 40. Summary of water quality for Field Trip 5 of the 1991 Dolores River Study.

	Near Slickrock (RM 122.7)	**Near Bedrock (RM 74.9)**	**Above confluence w/San Miguel River (RM 64.5)**	**Below confluence w/San Miguel River (RM 59.7)**	**Near confluence w/Colorado River (RM 1.3)**	**San Miguel River above Dolores Confluence (RM 0.1)**
Parameter	WQ-4	WQ-3	WQ-1	WQ-6	WQ-5	WQ-2
Alkalinity as $CaCO_3$(T), mg/l	746	1,790	3,424	694	602	94.6
Alkalinity as $CaCO_3$ (Diss), mg/l	62.7	75.1	106	77.1	78.1	75.1
Hardness as $CaCO_3$, (Diss) mg/l	139	185	216	140	143	129
pH Unit	7.68	7.53	7.56	7.69	7.82	7.57
TDS, mg/l	236	442	501	368	336	279
Ammonia as NH_3-N, mg/l	<.2	0.24	0.34	<.2	<.2	<.2
Nitrate as NO_3-N, mg/l	0.03	<.01	<.01	0.01	0.08	0.13
Phosphate as PO_4-P(T), mg/l	2.41	7.25	11.5	1.99	2.25	0.31
Ortho Phosphate as PO_4-P, mg/l	0.013	0.022	0.023	0.013	0.012	0.025
Sulfate as SO_4, mg/l	113	162	178	100	104	88
Oil & Grease, mg/l	<.5	<.5	<.5	<.5	<.5	<.5
TSS, mg/l	2,630	10,980	18,600	1,120	3,350	314
Aluminum as Al (T), mg/l	13.9	36.9	54	14.4	21.5	2.8
Cadmium as Cd (T), mg/l	<.01	<.01	0.015	<.01	<.01	<.01
Copper as Cu (T), mg/l	0.058	0.195	0.320	0.065	0.070	0.012
Iron as Fe (T), mg/l	43.2	174	267	44.7	49.4	3.21
Lead as Pb (T), mg/l	0.030	0.147	0.36	0.070	0.045	<.01
Silver as Ag (T), mg/l	<.01	<.01	<.01	<.01	<.01	<.01
Zinc as Zn (T), mg/l	0.185	0.745	1.18	0.270	0.290	0.080

Table 40 continued

Parameter	Near Slickrock (RM 122.7) WQ-4	Near Bedrock (RM 74.9) WQ-3	Above confluence w/San Miguel River (RM 64.5) WQ-1	Below confluence w/San Miguel River (RM 59.7) WQ-6	Near confluence w/Colorado River (RM 1.3) WQ-5	San Miguel River above Dolores Confluence (RM 0.1) WQ-2
Aluminum as Al (Diss), mg/1	<.1	<.1	<.1	<.1	<.1	<.1
Cadmium as Cd (Diss), mg/1	<.01	<.01	<.01	<.01	<.01	<.01
Copper as Cu (Diss), mg/1	<.01	<.01	<.01	<.01	<.01	<.01
Iron as Fe (Diss), mg/1	10.96	8.31	0.28	6.55	12.69	1.05
Lead as Pb (Diss), mg/1	<.01	<.01	<.01	<.01	<.01	<.01
Silver as Ag (Diss), mg/1	<.01	<.01	<.01	<.01	<.01	<.01
Zinc as Zn (Diss), mg/1	0.080	0.170	<.01	0.120	0.160	0.065

Table 41. Summary of water quality for Field Trip 6 of the 1991 Dolores River Study.

	Near Slickrock (RM 122.5)	Near Bedrock (RM 75.0)	Above confluence w/San Miguel River (RM 64.5)	Below confluence w/San Miguel River (RM 59.7)	Near Confluence w/Colorado River (RM 1.4)	San Miguel River above Dolores Confluence (RM 0.1)
Parameter	WQ-1	WQ-2	WQ-3	WQ-5	WQ-6	WQ-4
Alkalinity as $CaCO_3$ (T), mg/l	423	165	295	354	201	138
Alkalinity as $CaCO_3$ (Diss), mg/l	111	146	120	114	140	105
Hardness as $CaCO_3$, (Diss) mg/l	303	534	279	300	408	165
pH Unit	7.95	8.41	8.23	8.26	8.20	8.35
TDS, mg/l	630	914	1,318	568	936	274
Ammonia as NH_3-N, mg/l	0.306	0.606	<.2	<.2	0.274	<.2
Nitrate as NO_3-N, mg/l	0.31	0.24	0.24	0.053	0.22	<.05
Phosphate as PO_4-P, (Ortho), mg/l	0.014	<.01	0.011	<.01	<.01	<.01
Phosphate as PO_4-P, (Total), mg/l	1.64	0.16	0.99	1.46	0.44	0.25
Sulfate as SO_4, mg/l	211	424	164	179	268	76.5
Oil & Grease, mg/l	<.5	1.4	0.5	1.8	0.7	0.6
TSS, mg/l	2,240	306	1,156	1,980	550	315
Aluminum as Al (T), mg/l	57	6.2	29	24	12	5.0
Cadmium as Cd (T), mg/l	<.01	<.01	<.01	<.01	<.01	<.01
Copper as Cu (T), mg/l	0.052	<.01	0.031	0.059	0.018	0.011
Iron as Fe (T), mg/l	47.5	2.72	21.5	32.5	7.62	6.18
Lead as Pb (T), mg/l	0.060	<.01	0.024	0.033	0.015	<.01
Silver as Ag (T), mg/l	<.01	<.01	<.01	<.01	<.01	<.01
Zinc as Zn (T), mg/l	0.241	0.061	0.248	0.184	0.072	0.068

Table 41 continued

	Near Slickrock (RM 122.5)	Near Bedrock (RM 75.0)	Above confluence w/San Miguel River (RM 64.5)	Below confluence w/San Miguel River (RM 59.7)	Near Confluence w/Colorado River (RM 1.4)	San Miguel River above Dolores Confluence (RM 0.1)
Parameter	WQ-1	WQ-2	WQ-3	WQ-5	WQ-6	WQ-4
Aluminum as Al (Diss), mg/1	<.1	<.1	<.1	<.1	<.1	<.1
Cadmium as Cd (Diss), mg/1	<0.1	<.01	<.01	<.01	<.01	<.01
Copper as Cu (Diss), mg/1	0.032	<.01	<.01	<.01	<.01	<.01
Iron as Fe (Diss), mg/1	10.51	0.85	9.20	16.2	4.42	2.92
Lead as Pb (Diss), mg/1	0.060	<.01	0.022	<.01	<.01	<.01
Silver as Ag (Diss), mg/1	<.01	<.01	<.01	<.01	<.01	<.01
Zinc as Zn (Diss), mg/1	0.06	<.01	0.04	0.07	0.03	<.01

Table 42. Historical summary of water chemistry in the Dolores (DO) and San Miguel (SM) Rivers.

PARAMETER	USPHS 1960		Sigler et al 1960-63	Horpested 1973		Miller 1974-75		Storet Data 1970-78 in ERI doc AM/PH	Smith 1977	ERI 1986		BIO/WEST 1990		BIO/WEST 1991		USGS 1969-1990
	DO	SM	SM	DO	SM	DO	SM	DO	SM	DO	SM	DO	SM	DO	SM	DO
Alkalinity as $CaCO_3$ (T), mg/l	82-850	82-130										92.1-165.5	132	165-3424	94.6-138	
Alkalinity as $CaCO_3$ (Diss), mg/l														62.7-146	105-314	
Hardness as $CaCO_3$ (Diss), mg/l														139-534	129-165	
pH Units	7.5-8.0	7.6-7.9	4.7-8.8					7.4-8.8	7.4-9.1			7.67-8.45	8.45	7.53-8.41	7.57-8.35	7.0-8.5
TDS, mg/l	2240-5350	1030-2320		1800-2000	1200	150-9750	148-2400		423-1137			226-6320	666	2.030-1318	232-279	153-5390
Ammonia as NH_3-N, mg/l						<1.0-18.6	<1.0-48.2	0.0-41.0		<0.1-0.8	<.01-1.2	0.10-0.963	0.44	<.2-0.61	<.2	<0.01-6.8
Nitrate as NO_3-N, mg/l	0.12-3.6	0.12-0.7							0.2-11		0.2-1.0	0.03-1.26	0.16	<0.1-1.26	0.02-0.13	
Phosphate as PO_4-P (Ortho), mg/l												<.01-0.044	<.01	<.01-0.044	<.01-0.025	0-0.21
Phosphate as PO_4-P (Total), mg/l									0-0.3			0.01-3.19	0.042	0.022-11.5	0.022-0.31	
Sulfate as SO_4, mg/l	680-3160	550-1330							112-745		274.0-377.0			100-424	76.5-88	41-810
Oil & Grease, mg/l												<.5	<.5	<.5-1.8	<.5-0.6	
TSS, mg/l												14-9050	275	2.080-18600	65-315	153-5390
Aluminum as AL (T), mg/l										0.55	1.28			6.2-57	2.8-5.0	
Cadmium as Cd (T), mg/l									0-2	<0.0005	0.0006			<.01-0.015	<.01	
Copper as Cu (T), mg/l	0.007-0.017	0.006-0.018									0.014	<.01-0.282	<.01	<.01-0.320	<.01	
Iron as Fe (T), mg/l	0.06-0.11	0.07-0.08								0.73	1.84	0.2-32.8	4.45	1.8-267	1.8-6.18	
Lead as Pb (T), mg/l										<0.005	0.014	<.01-0.098	0.045	<.01-0.36	<.01	
Silver as Ag (T), mg/l										<0.0005	<0.0005			<.01	<.01	
Zinc as Zn (T), mg/l										<0.02	0.056	0.02-1.2	0.04	0.015-1.2	<.01-0.08	
Aluminum as AL (D), mg/l														<.1	<.1	1-200
Cadmium as Cd (D), mg/l														<.01	<.01	0-4
Copper as Cu (D), mg/l									0			<.01	<.01	<.01-0.032	<.01	0-5

Table 42 continued

PARAMETER	USPHS 1960		Sigler et al 1960-63	Horpested 1973		Miller 1974-75		Storet Data 1970-78 in ERI doc AM/PH	Smith 1977	ERI 1986		BIO/WEST 1990		BIO/WEST 1991		USGS 1969-1990
	DO	SM	SM	DO	SM	DO	SM	DO	SM	DO	SM	DO	SM	DO	SM	DO
Iron as Fe (D), mg/l												0.21-3.42	1.62	0.28-16.2	1.05-2.92	0-98
Lead as Pb (D), mg/l												<.01-0.08	<.01	<.01-0.06	<.01	0-16
Silver as Ag (D), mg/l														<.01	<.01	0-50
Zinc as Zn (D), mg/l												<.01	<.01	<.01-0.17	<.01-0.065	0-210

Table 43. Radium - 226 in Dolores and San Miguel River bottom sediments, 1991. LLD = Lower Limit of Detection.

Site Location/ Description	Radium 226, total (pCi/g)	Radium 226, total, error, =/- (pCi/g)	Radium 226, total, LLD (pCi/g)
RMI 1.4 Near confluence with Colorado River	7.3	1.2	0.2
RMI 59.7 Below confluence with San Miguel River	20.4	2.0	0.2
RMI 64.5 Above confluence with San Miguel River	6.5	1.2	0.2
RMI 75.0 Near Bedrock, CO	8.0	1.3	0.2
RMI 122.5 Near Slickrock, CO	7.6	1.2	0.2
RMI 0.1 San Miguel River	6.2	1.1	0.2

Table 44. Historical comparison of Radium-226 in Dolores and San Miguel River bottom sediments at five sample sites. Values represent ranges of measurements per sample period.

Site Location/ Description	YEAR					
	Jun - Nov[a] 1960	**Aug[b] 1960**	**Jan - Oct[a] 1961**	**Jan - Sept[a] 1962**	**Feb - July[a] 1963**	**Oct[c] 1991**
RMI 0.1 - 1.4 Above confluence with Colorado River	-	7.5 - 8.9	-	-	-	7.3
RMI 50 - 60 Below confluence with San Miguel River	4.2 - 16	4.3 - 5.2	2.5 - 18	4.7 - 38	4.9 - 17	20.4
RMI 64.5 - 64.7 Above confluence with San Miguel River	2.1 - 17	<1 - 11	1.7 - 5	0.7 - 2.2	1.9	6.5
≈RMI 122.5 Near Slickrock, CO	1.3 - 1.9	2 - 2.8	0.9 - 1.8	1.3	-	7.6
RMI 0.1 San Miguel River	2.4 - 15	4.9 - 33	3.8 - 27	5.9 - 41	31	6.2

[a] Sigler et al, 1966
[b] Public Health Service, 1961
[c] BIO/WEST, 1991

Table 45. Heavy metal analysis of tissue (liver and kidney combined, wet weight) from three fish species sampled in the Dolores River, 1991.

	RM	Date	Parameter mg/kg						
			Aluminum (Al)	Cadmium (Cd)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Silver (Ag)	Zinc (Zn)
Channel catfish									
CC-1	155.9	911003	10.8	0.90	5.6	539	0.52	<.1	27.4
CC-2	157.6	911003	6.9	0.88	3.2	322	0.44	<.1	30.1
CC-3	157.1	911003	8.9	0.79	2.6	207	<.1	<.1	24.2
CC-4	155.0	911003	9.7	0.73	3.2	149	0.16	<.1	24.0
CC-5	155.9	911003	6.2	0.78	5.8	463	<.1	<.1	24.3
CC-6	110.8	911006	22.4	2.3	1.2	162	0.15	<.1	23.6
Flannelmouth sucker									
FM-1	157.6	911003	20.2	2.1	20.3	312	0.67	<.1	75.2
FM-2	157.1	911003	3.4	1.1	29.5	435	0.32	<.1	77.1
FM-3	57.1	911003	7.8	2.5	31.0	560	0.62	0.3	71.8
FM-4	57.6	911003	3.6	1.1	32.8	314	0.20	<.1	78.5
FM-5	55.0	911003	16.7	1.7	19.8	448	1.2	<.1	111
FM-6	110.8	911006	23.1	1.1	9.6	568	1.4	<.1	57.7
FM-7	110.8	911006	10.0	53.5	7.8	382	0.66	<.1	41.3
FM-8	110.2	911006	7.4	0.62	7.0	488	<.1	<.1	40.4
FM-9	110.2	911006	7.1	1.0	20.9	231	0.39	0.24	74.0
FM-10	110.2	911006	28.8	0.54	6.2	552	0.41	0.12	36.9
Roundtail chub									
RT-1	109.6	911006	32.6	2,100	534	613	2.9	2.4	177
RT-2	109.6	911006	7.6	1.6	50.0	137	0.72	<.1	44.6

Table 46. Summary of heavy metal analysis of tissue (liver and kidney combined, wet weight) from three fish species sampled in the Dolores River, 1991.

Species	#	Parameter (mg/kg) mean/std. deviation						
		Al	Cd	Cu	Fe	Pb	Ag	Zn
Channel catfish	6	10.8 (5.9)	1.06 (0.61)	3.6 (1.7)	307.0 (163.9)	0.24 (0.19)	0.09 (0)	25.6 (2.6)
Flannelmouth sucker	10	12.8 (8.8)	54.7 (168.8)	18.5 (10.4)	429.0 (117.3)	0.60 (0.42)	0.13 (0.08)	66.4 (22.8)
Roundtail Chub	2	20.1 (17.7)	1,050.8 (1,483.8)	292.0 (342.2)	375.0 (336.6)	1.8 (1.5)	1.2 (1.6)	110.8 (93.6)

Table 47. Comparison of average metal content of liver or kidney tissue (highest value is used) of two species of fish collected in the Gunnison River, 1981 (Kunkle et al, 1983) with average metal content of liver and kidney tissue of three fish species collected in the Dolores River, 1991.

	Al	Cd	Cu	Pb	Zn
Rainbow Trout Gunnison River	3.31	1.61	13.81	<0.75	12.35
White Sucker Gunnison River	1.87	0.95	3.68	1.04	14.23
Channel Catfish Dolores River	10.8	1.06	3.6	0.24	25.6
Flannelmouth Sucker Dolores River	12.8	54.7	18.5	0.6	66.4
Roundtail Chub Dolores River	20.1	1,050.8	292	1.8	110.8

Table 48. Summary of invertebrate collections during Trip 1 in the Dolores River, 1990.

	Location														
	RM 1.3			RM 59.7			RM 64.5			RM 122.7			S.M. RM 0.1		
TAXA	R 1	R 2	X	R 1	R 2	X	R 1	R 2	X	R 1	R 2	X	R 1	R 2	X
PLECOPTERA															
Perlodidae	12	25	18.5		4	2				4	16	10	16	64	40
Isogenoides	2		1					2	1						
Isoperla				4		2									
Taemopterigydae							112		56						
Taenionema	4	25	14.5	4	4	4		20	10					48	24
Leuctridae													16		8
EPHEMEROPTERA															
Baetis	1	7	4	6		3				492	928	710			
Heptageniadae				2	12	7									
Heptagenia				10		5								16	8
Rithrogena	7	7	7	14		7		2	1						
Tricorythodes		5	2.5	60	212	136	24	8	16	4	16	10			
TRICHOPTERA					4	2									
Hydropsychidae	15	53	34	136	172	154	160	20	90	28	16	22	128	64	96
Polycentropus														16	8
Glossosomatidae		13	6.5		8	4		2	1						
DIPTERA															
Simuliidae	51	113	82	220	30	125	1888	706	1297	768	3152	1960	4992	8512	6752
Chironomidae	5	50	27.5	152	112	132	80	16	48	44	112	78	128	156	142
Empididae		9	4.5	4	10	7	24	6	15	12	16	14	16	32	24
Ceratogonidae				4	14	9		2	1	16	64	40	32	16	24
COLEOPTERA															
mostly Elmidae	1	1	1	28	68	48	48	16	32	20	16	18	48	112	80
MEGALOPTERA															
Undefined Megaloptera				3		1.5									
Corydalidae		1	0.5		4	2				1	1	1		3	1.5

Table 48 continued

Location	RM 1.3			RM 59.7			RM 64.5			RM 122.7			S.M. RM 0.1		
TAXA	R 1	R 2	X	R 1	R 2	X	R 1	R 2	X	R 1	R 2	X	R 1	R 2	X
ODONATA															
Zygoptera		2	1												
Anisoptera					1	0.5									
Hydracarina				2	6	4	8	2	5	8		4	16		8
Annelida	2	1	1.5	2		1				8	80	44		64	32
Prionoxystus		1	0.5							4		2			

Table 49. Summary of invertebrate collections during Trip 2 in the Dolores River, 1990.

	Location																													
	RM 1.3					RM 59.7					RM 64.4					RM 64.5					RM 122.7					S.M. RM 0.1				
TAXA	R 1	R 2	R 3	R 4	X	R 1	R 2	R 3	R 4	X	R 1	R 2	R 3	R 4	X	R 1	R 2	R 3	R 4	X	R 1	R 2	R 3	R 4	X	R 1	R 2	R 3	R 4	X
PLECOPTERA																														
Perlodidae			4		1																							3	3	1.5
Leuctridae							4		4	2																				
Pteronarcella																										1				0.25
Perlidae																										5		4		2.25
EPHEMEROPTERA																														
Baetis	13	32	140	54	59.75	124	100	100	212	134	136	44	76	19	68.75	18		1		4.75	18	9	14	2	10.75	120	104	133	113	117.5
Heptageniidae						8		4	4	4																			5	1.25
Arthroplea																													4	1
Heptagenia																												2		0.5
Rithrogena														1	0.25											11	10	13	4	9.5
Leptophlebiidae									4	1																4			1	1.25
Traverella	243	156	220	64	170.8		4			1																				
Tricorythodes		16	40	42	24.5	28	32	104	152	79	476	348	332	174	332.5	8	1			2.25	5		3	7	3.75	24	9	24	24	20.25
TRICHOPTERA																														
Undef. Trichoptera			4		1									4	1								1		0.25			1		0.25
Hydropsychidae	211	356	576	274	354.3	76	152	88	148	116	16	16	36	4	18		1			0.25	47	27	25	24	30.75	8	5	5	19	9.25
Hydroptilidae			4		1			4		1		40			10											4				1
Hydroptila		4		4	2						12		8	1	5.25															
Mayatrichia											12		4		4															
Polycentropodidae									8	2																				
Glossosomatidae			16	2	4.5	44	8		4	14	4		4		2						2		2	1	1.25					
DIPTERA																														
Simuliidae	61	40	80	24	51.25				4	1	4			1	1.25											5	1	2	4	3
Chironomidae	13	4	12	8	9.25	36	40	80	84	60	72	52	72	62	64.5	9	36	47	52	36	78	102	49	64	73.25	25	20	12	19	19
Empididae						4	4			2				3	0.75						1	3	3	1	2				1	0.25
Ceratogonidae																					1				0.25					

Table 49 continued

	Location																													
	RM 1.3					RM 59.7					RM 64.4					RM 64.5					RM 122.7					S.M. RM 0.1				
TAXA	R 1	R 2	R 3	R 4	X	R 1	R 2	R 3	R 4	X	R 1	R 2	R 3	R 4	X	R 1	R 2	R 3	R 4	X	R 1	R 2	R 3	R 4	X	R 1	R 2	R 3	R 4	X
Tipulidae																					1				0.25					
COLEOPTERA																														
Mostly Elmidae	19	44	36	14	28.25	20	20	4		11	36	20	32	3	22.75	1		2	1	1	32	40	25	39	34	3		2	2	1.75
MEGALOPTERA																														
Corydalidae	3	9	5	1	4.5	3	1	1		1.25			1		0.25															
ODONATA																														
Undef. Odonata																					1				0.25					
Anisoptera				2	0.5																									
Hydracarina	3			8	2.75	8	12		4	6	8	4		1	3.25						1			2	0.75	1	1		1	0.75
Nematoda											24	8		3	8.75															
Annelida											16		4	29	12.25				3	0.75	7	5	1	8	5.25	52	1		1	13.5
Ostracod									4	1		4			1	1	2	1	1	1.25										
Misc. Adults						4			4	2						1			1	0.5										

Table 50. Summary of invertebrate collection during Trip 3 in the Dolores River, 1990.

	Location																							
	Rm 1.3				Rm 59.7				RM 64.6				RM 74.9				RM 122.6				S.M. RM 0.1			
TAXA	R 1	R 2	R 3	X	R 1	R 2	R 3	X	R 1	R 2	R 3	X	R 1	R 2	R 3	X	R 1	R 2	R 3	X	R 1	R 2	R 3	X
EPHEMEROPTERA																								
Baetis	4	8	32	14.67	12	8	20	13.33	4			1.33	24	28	32	28	4	3	4	3.67	4	4	16	8
Heptageniadae						4		1.33					4	20	12	12								
Leptophlebiidae														4		1.33								
Traverella																	6			2				
Tricorythodes					8	12		6.67	8			2.67	12	12	12	12	8	2	8	6	8	20	20	16
TRICHOPTERA																								
Hydropsychidae					8	8	8	8	20			6.67	16	276	268	186.7	10	2	24	12	24	4	36	21.33
Hydroptilidae																	12			4				
Glossosomatidae											4	1.33											4	1.33
DIPTERA																								
Unident. Diptera	12	44	72	42.67		16	20	12	28			9.33	4	76	12	30.67	1			0.33	4			1.33
Simuliidae	108	80	188	125.3	36	52	16	34.67	60		80	46.67	120	216	60	132	19	10	8	12.33	56	220	64	113.33
Chironomidae					4			1.33			4	1.33	8	40		16	7	3	28	12.67	8	24	24	18.67
Empididae		4		1.33			8	2.67						4		1.33	1	4		1.67	4	4	4	4
COLEOPTERA																								
Unident. Coleoptera					16	24		13.33	4			1.33	4	76	20	33.33	18	7	32	19	32	28	20	26.67
Mostly Elmidae																								
MEGALOPTERA																								
Corydalidae		1		0.33	4			1.33						8	1	3			5	1.67			4	1.33
ODONATA																								
Zygoptera															4	1.33								
Anisoptera					4			1.33													8			2.67
Nematoda	4	4		2.67	4	4	28	12	4			1.33	12	4	4	6.67		2		0.67		4	4	2.67
Ostracod					4			1.33																
Arachnida						4		1.33													1			0.33

Table 50 continued

	Location																							
	Rm 1.3				Rm 59.7				RM 64.6				RM 74.9				RM 122.6				S.M. RM 0.1			
TAXA	R 1	R 2	R 3	X	R 1	R 2	R 3	X	R 1	R 2	R 3	X	R 1	R 2	R 3	X	R 1	R 2	R 3	X	R 1	R 2	R 3	X
EPHEMEROPTERA																								
Prionoxystus													2			0.67								
Decapoda									8			2.67					1	1		0.67			4	1.33
Misc. Adults					4	4		2.67			4	1.33					1			0.33				
Terrestrials			4	1.33																				

Table 51. Summary of invertebrates collected during Trip 4 in the Dolores River, 1991.

TAXA	RM 122.5				RM 74.9				RM 0.1 (SM)			
	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x
DIPTERA												
Chironomidac	2	0	4	3	12	0	0	4	22	26	56	34.67
Ceratopagondae	2	0	0	0.67	4	4	0	2.67	0	0	4	1.33
Simuliidae					8	0	4	4	22	74	48	48
Empididae									1	0	8	3
EPHEMEROPTERA												
Baetiddae									2	0	10	4
Bactis	2	0	0	0.67								
Ephemerella									1	0	2	1
Tricorythodes									5	4	8	5.67
TRICHOPTERA												
Hydropsychidae					8	1	4	4	0	2	4	2
Limncphilidae									1	0	0	0.33
PLECOPTERA												
Perlodidae									1	0	0	0.33
COLEOPTERA												
Elmidae									4	0	10	4.67
Oligochete	8	4	0	4	4	8	0	4	2	2	2	2
Gastropoda	4	0	0	1.33					1	0	0	0.33
Isopoda									1	0	0	0.33
Hydracarina									0	0	2	0.67

Table 52. Summary of invertebrates collection during Trip 5 in the Dolores River, 1991.

TAXA	RM 129				RM 1.3				RM 0.1 (SM)				RM 64.5				RM 122.5				RM 74.9				RM 59.7			
	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x
DIPTERA																												
Chironomidae	56	45		50.5	36	4		20	152	46	76	91.3	6	6	5	5.67	3	1	1	1.67	4	3	2	3·	16	14	25	21.67
Ceratopagondae																												
Simuliidae	46	7		17.67	36	18		24	12	18	12	14	1	6	1	2.67					37	5	7	16.33	2	3	14	6.33
Empididae	0	2		1	20	1		10.5	4			1.3	0	0	1	.33	0	0	1	.33					1	0	0	.33
EPHEMEROPTERA																												
Psychodidae					4	0		2																				
Baetisdae	130	81		105.5	76	10		43	12	42	24	26	10	2	1	4.33	0	2	1	1	9	0	2	3.67	29	23	53	35
Traverella	2	1		1.5	164	91		127.5	4			1.3					0	0	1	.33	3	0	0	1	0	2	9	6
Cynigmula	8	8		8																	1	1	0	.67	1	1	2	1.33
Tricorythodes					48	11		29.5	92	30	60	60.7	4	5	0	3	0	0	2	.67	1	1	1	1	10	5	16	10.33
Ephemerella					4	0		2	16	2		6	2	0	0	.67	1	0	0	.33								
Hexagenia					4	0	2																					
PLECOPTERA																												
Alloperla	2	5		3.5							4	1.3					0	0	2	.67					4	0	0	1.33
Perlodidaae	2	2		2					8	4	8	6.7									1	1	1	1	0	0	1	.33
TRICHOPTERA																												
Brachycentrus					4	0		2	4			1.3																
Hydropsychidae	96	153		124.5	140	18		79	80	28	20	42.7	5	10	4	6.33	3	2	0	1.67	20	6	4	10	26	24	32	27.33
Hydroptilidae	0	2		1	20	8		14	36	12	28	25.3	1	1	0	.67					2	1	1	1.33	3	0	5	2.67
Limnephilidae																	1	0	1	.67	3	0	0	1				
COLEOPTERA																												

Table 52 continued

TAXA	RM 129				RM 1.3				RM 0.1 (SM)				RM 64.5				RM 122.5				RM 74.9				RM 59.7			
	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x
Elmidae	4	15		9.5	52	13		32.5	24			8	1	5	1	2.33	0	4	5	3	8	6	6	6.67	4	7	9	6.67
Dytisccidae	12	6		9	12.	0		6					0	1	0	.33	1	1	0	.67	3	0	2	1.67	1	0	1	.67
MEGALOPTERA																												
Corydalus	5	3		4	12	8		10	4			1.3	0	0	2	.67	0	1	0	.33	1	0	0	.33	2	2	1	1.67
Hydracarina					4	2		3	8			2.7									1	1	0	.67	1	1	0	.67
Oligochete	5	43		24							4	1.3	2	0	0	.67					3	0	0	1	0	4	4	2.67
Petecypoda																	0	0	1	.33								
Gactropoda																												
Lepidoptera	0	3		1.5																								
Rhyacophilidae													0	0	1	.33									0	0	1	.33
Perlidae																									1	0	0	.33

Table 53. Summary of Invertebrate collection during Trip 6 in the Dolores River, 1991.

TAXA	RM 122.5				RM 75.0				RM 64.5				RM .01 (SM)				RM 59.7				RM 1.4			
	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x
DIPTERA																								
Chironomidae	4	1	0	1.67	2	16	36	18	2	16	4	7.33	76	28	200	101.33	24	10	14	16	12	10	16	12.67
Simuliidae	11	1	3	5	2	304	100	135.33	13	2	5	6.67	136	6	112	84.67	44	24	52	40	9	63	25	32.33
Ceratopagondae																					0	0	1	.33
Empididae	7	4	8	6.33	2	0	0	1.33					20	36	48	34.67	8	0	8	5.3	6	4	2	4
EPHEMEROPTERA																								
Baetisdae	27	9	18	18	9	24	12	15	3	4	3	3.33	32	5	104	47	16	6	10	10.67	1	23	16	13.33
Traverella					0	0	12	4													5	0	0	1.67
Cynigmula					0	0	10	3.33													1	0	0	.67
Tricorythodes					0	0	10	3.33					0	10	104	38	32	18	16	22	3	0	0	1
Ephemerella																	0	2	0	.67	1	0	0	.67
PLECOPTERA																								
Alloperla					0	0	6	2	3	0	0	1												
Perlodidaae					0	4	0	1.33					0	0	16	5.33					17	18	27	20.67
TRICHOPTERA																								
Brachycentrus																	0	4	0	1.33	4	0	0	1.33
Hydropsychidae	16	6	2	8	14	148	174	112	21	10	6	12.33	48	5	48	33.67	64	62	40	55.33	7	18	7	10.67
Hydroptilidae	0	1	0	.33					6	0	4	3.33	8	0	0	2.67	8	2	0	3.33	0	1	0	.33
Limnephilidae					4	0	0	1.33									0	0	2	.67	0	0	1	.33
COLEOPTERA																								
Elmidae	15	9	12	12	4	8	22	11.33	3	14	0	5.67	36	8	40	28	36	4	2	14	4	5	0	3
Dytiscidae	2	1	3	2	1	0	2	1									0	2	0	.67	0	5	1	2

Table 53 continued

TAXA	RM 122.5				RM 75.0				RM 64.5				RM .01 (SM)				RM 59.7				RM 1.4			
	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x	R1	R2	R3	x
MEGALOPTERA																								
Corydalus	0	0	2	.67	1	2	2	1.67	2	0	0	.67	1	4	0	1.67	0	2	0	.67	0	1	1	.67
Hydracarina	2	0	0	.67									8	0	8	5.33	8	2	4	4.67	1	0	0	.33
Oligochete	0	0	3	1									0	8	0	2.67	8	0	10	6				
Pelecypoda	0	1	0	.33																				
Rithrogena	0	0	1	.33					3	0	0	1					8	0	0	2.67	3	0	0	1
Heptaganiidae					2	28	0	10	0	6	3	3					0	0	2	.67	0	12	6	18
Lepidoptera									0	0	2	.67	8	0	8	5.33								
ANISOPTERA																					0	1	3	1.33
Hetaerina																								

Table 54. Historical summary of invertebrate collections from two sections of the Dolores River and one section of the San Miguel River. Invertebrate taxa are listed in ranked order of abundance. All samples were taken with either Hess or kick samplers.

TAXA	RMI 59.7 - 60.0										RMI 64.5 - 65.0 Just above San Miguel Con.								San Miguel RMI 0.1 - 1.5							
	Aug 1960	Aug 1973	Nov 1975	Apr 1980	Aug 1980	Mar 1981	Aug 1981	Jan 1986	Aug 1990	Aug 1991	Aug 1973	Nov 1975	Aug 1980	Mar 1981	Aug 1981	Jan 1986	Aug 1990	Aug 1991	Aug 1960	Nov 1975	Apr 1980	Aug 1980	Mar 1981	Aug 1981	Aug 1990	Aug 1991
EPHEMEROPTERA	3																		3							
Baetis					5				2	1							5	2				3		5	6	1
Heptageniadae					3		7	x	7	5						x						6	9	8		4
Leptophlebiidae					8					5												7				
Traveralla					9																					8
Tricorythodes					2		4		5	2					2		4	3				4	9	2	5	2
Ephemerella						7	5	x																4		
TRICHOPTERA	1																		1							
Hydropsychidae		1		4	1	3	1	x	4	3			2	3		x	3	6			2	1	1	1	3	3
Hydroptilidae							5																4	6		
Glossosomatidae																	5								9	
Brachycentridae		2																				8	7	13		
Psychomyiidae							7																6	10		
DIPTERA	2																		2							
Unid. Diptera				5					3								2				3				9	
Simuliidae		4		2		1	7	x	1	5				1		x	1					6	2		1	5
Chironomidae				1	4	2	3	x	7	4				2	1	x	5	1			1	2	3	3	4	3
Empididae					11		3		6													7		9	7	8
Tendipedidae		3									2															
Ephydridae				3		9					1		2													
Tipulidae					6	4	7	x													4	6	5	12		
COLEOPTERA																										

Table 54 continued

TAXA	RMI 59.7 - 60.0										RMI 64.5 - 65.0 Just above San Miguel Con.								San Miguel RMI 0.1 - 1.5							
	Aug 1960	Aug 1973	Nov 1975	Apr 1980	Aug 1980	Mar 1981	Aug 1981	Jan 1986	Aug 1990	Aug 1991	Aug 1973	Nov 1975	Aug 1980	Mar 1981	Aug 1981	Jan 1986	Aug 1990	Aug 1991	Aug 1960	Nov 1975	Apr 1980	Aug 1980	Mar 1981	Aug 1981	Aug 1990	Aug 1991
Unid. Coleoptera									2								5								2	
Mostly Elmidae		5				8	6	x								x		5					5	13		7
Dytiscidae																										
MEGALOPTERA																										
Corydalidae		5			7	5	2	x	7							x					7	7	5	7	9	
ODONATA																										
Zygoptera																										
Anisoptera		6							7												6	7	8	11	8	
LEPIDOPTERA																										
Pyralidae																		4								
ANNALIDA													3	4												
Oligochaeta									3												5		6	13	8	
NEMATODA																										
PLECOPTERA	4												1													
Perlodidae		5			10	6															7	5	9			6
Perlidae		6																				8				8
Chloroperlidae						9										x										
Taeniopterygidae						8		x								x										

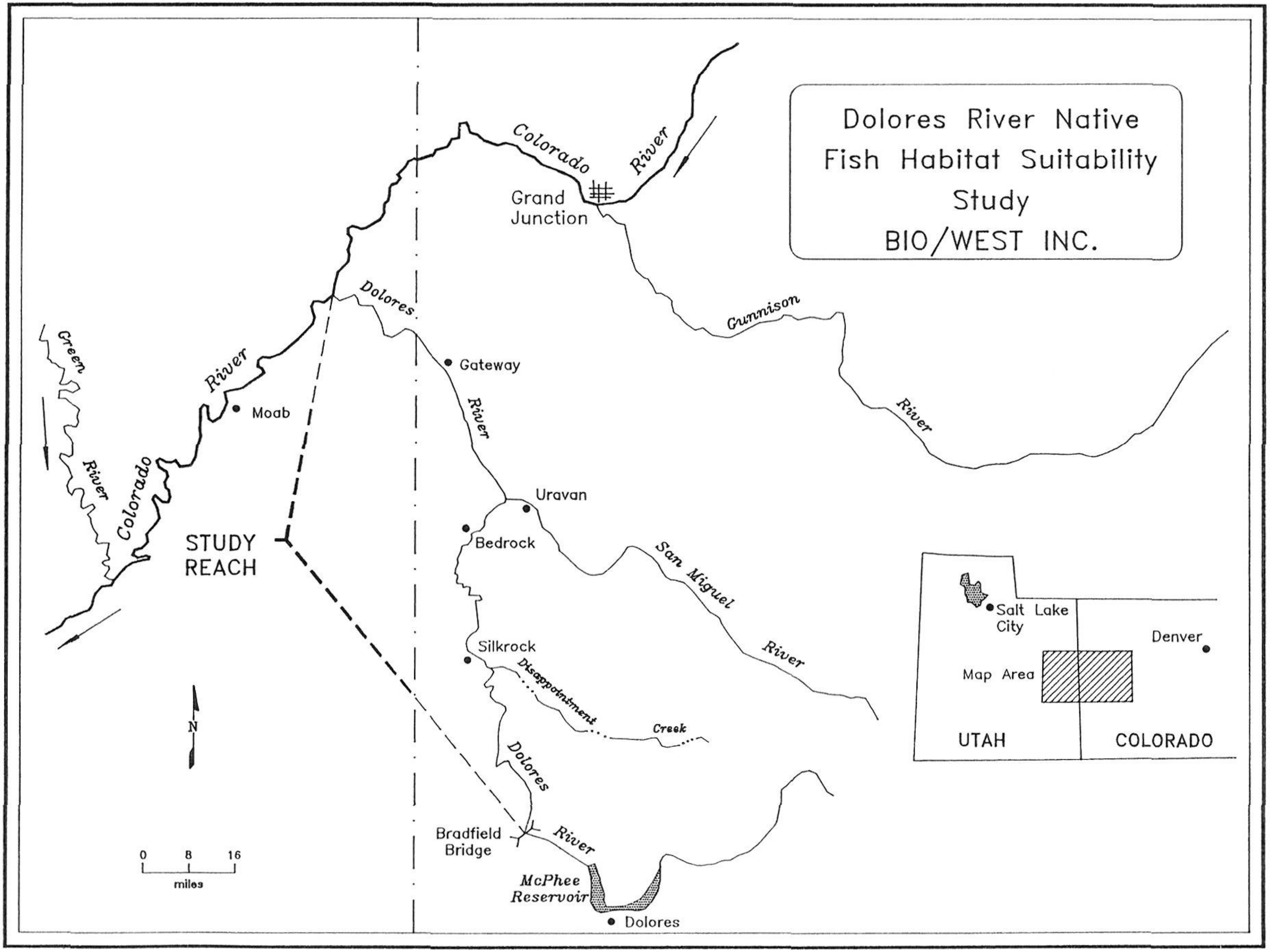

Figure 1. Study area for Dolores River Native Fish Habitat Suitability Study, 1990-1991.

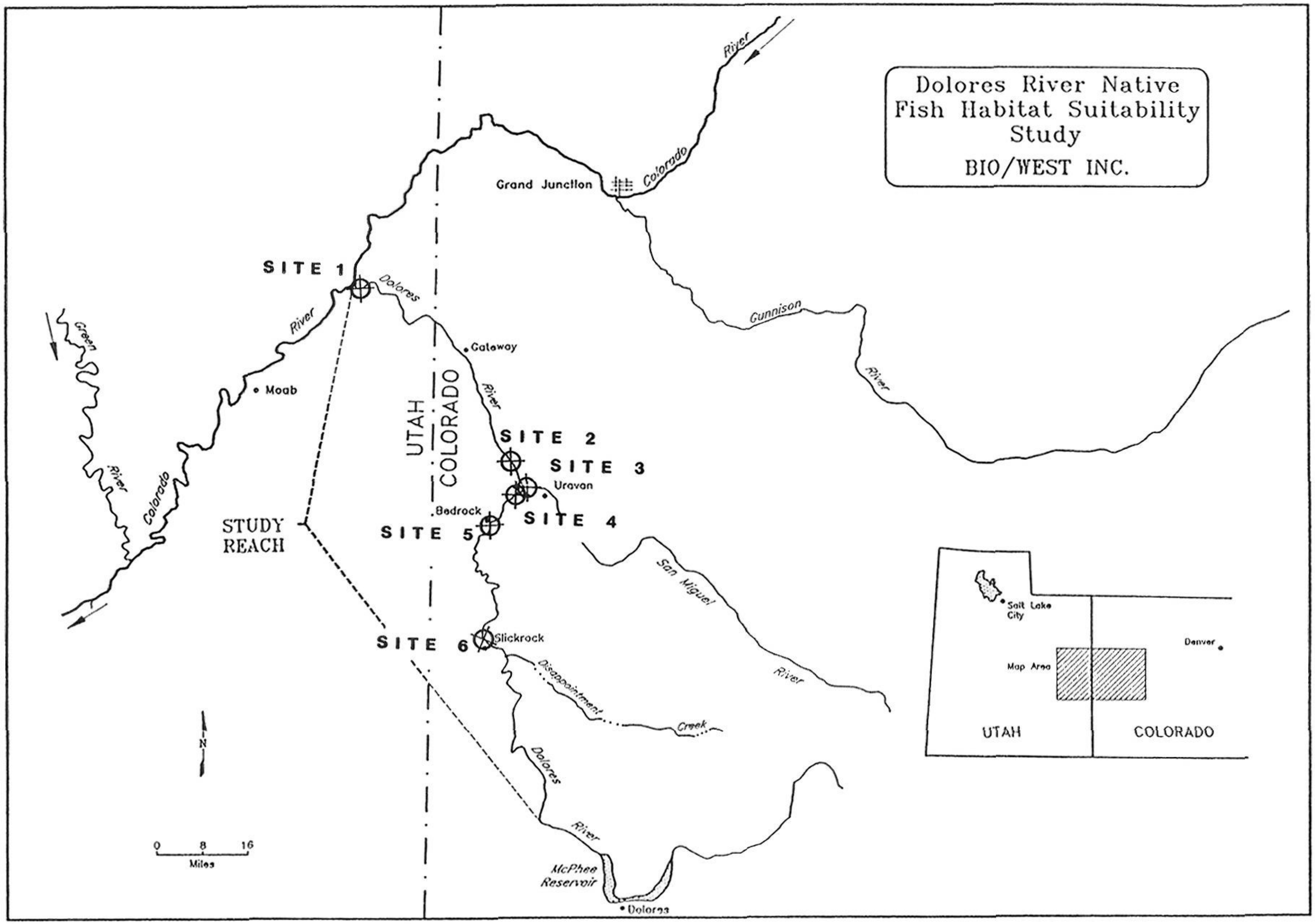

Figure 2. Locations of water quality and invertebrate sampling sites for Dolores River Native Fish Habitat Suitability Study, 1990-1991.

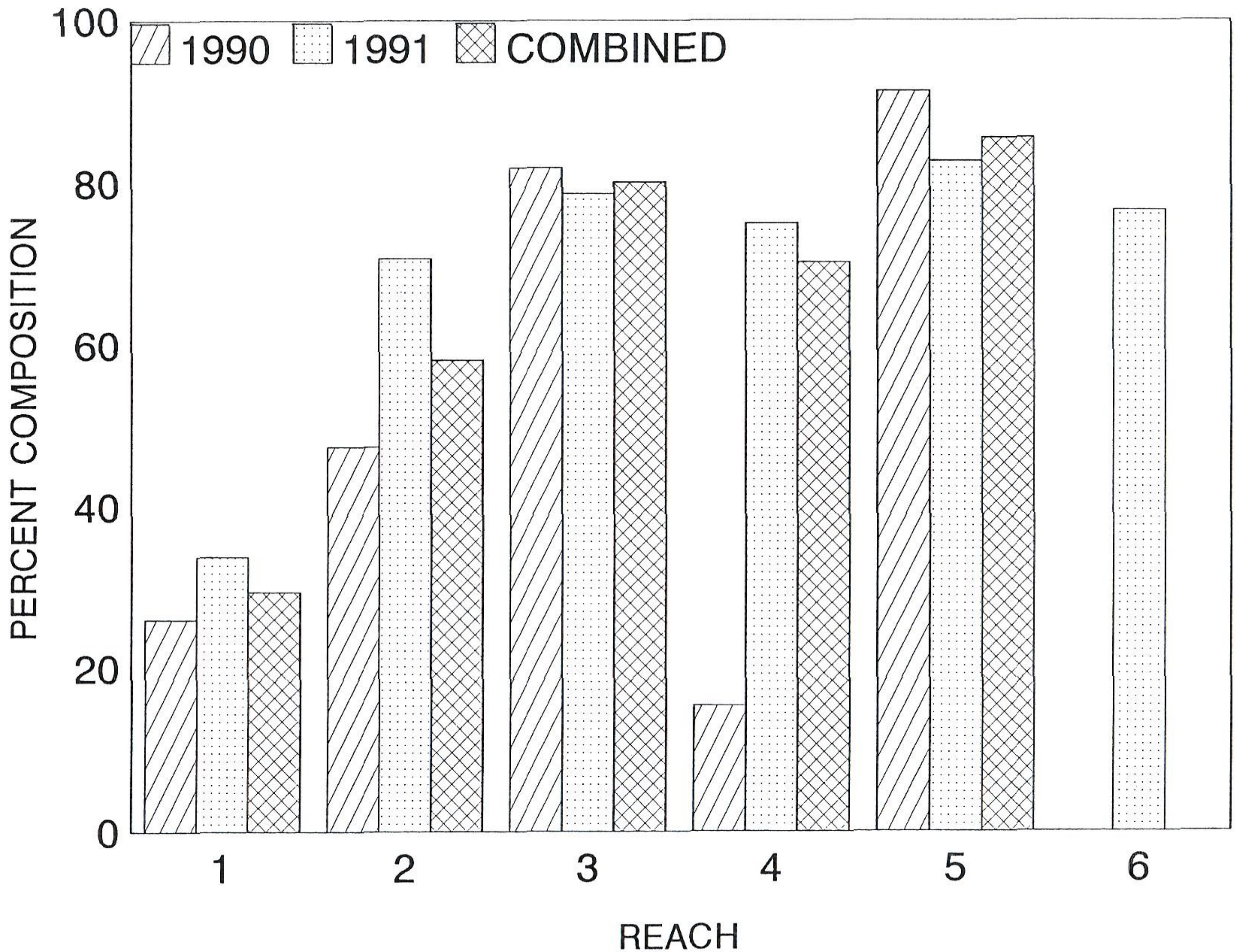

Figure 3. Composition of native fish species captured by netting and electrofishing in six reaches of the Dolores River by BIO/WEST, 1990-91.

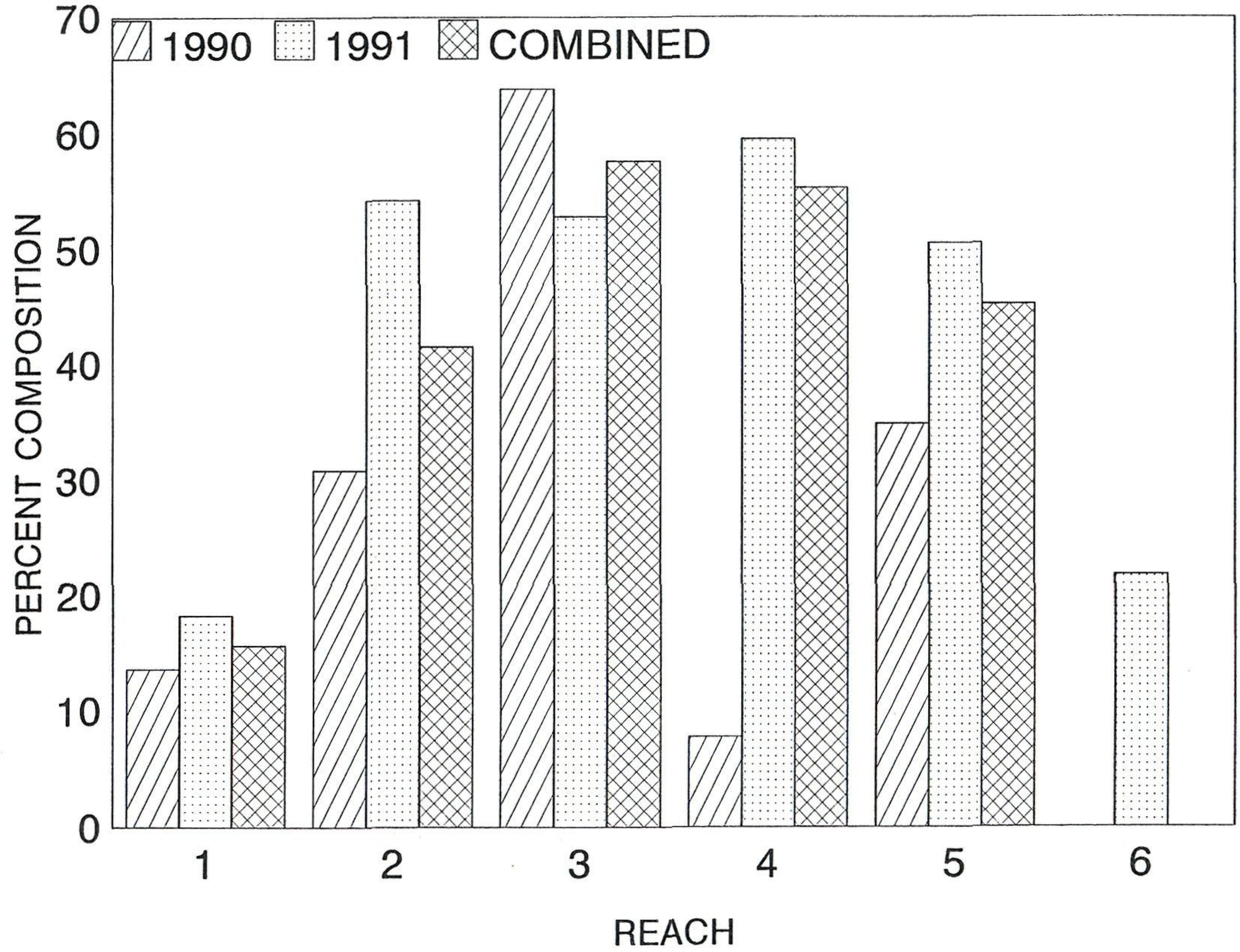

Figure 4. Composition of flannelmouth sucker captured by netting and electrofishing in six reaches of the Dolores River by BIO/WEST, 1990-91.

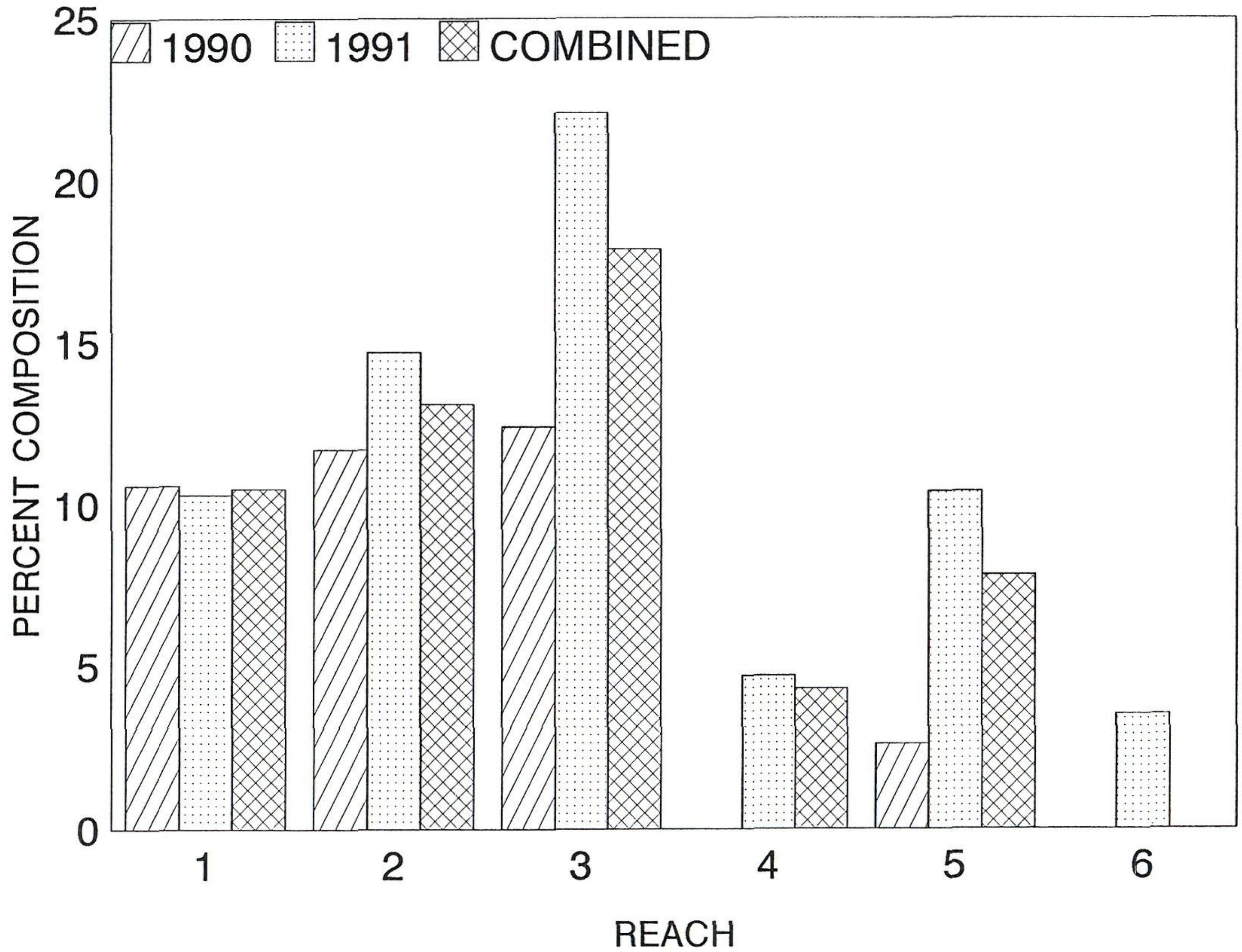

Figure 5. Composition of bluehead sucker captured by netting and electrofishing in six reaches of the Dolores River by BIO/WEST, 1990-91.

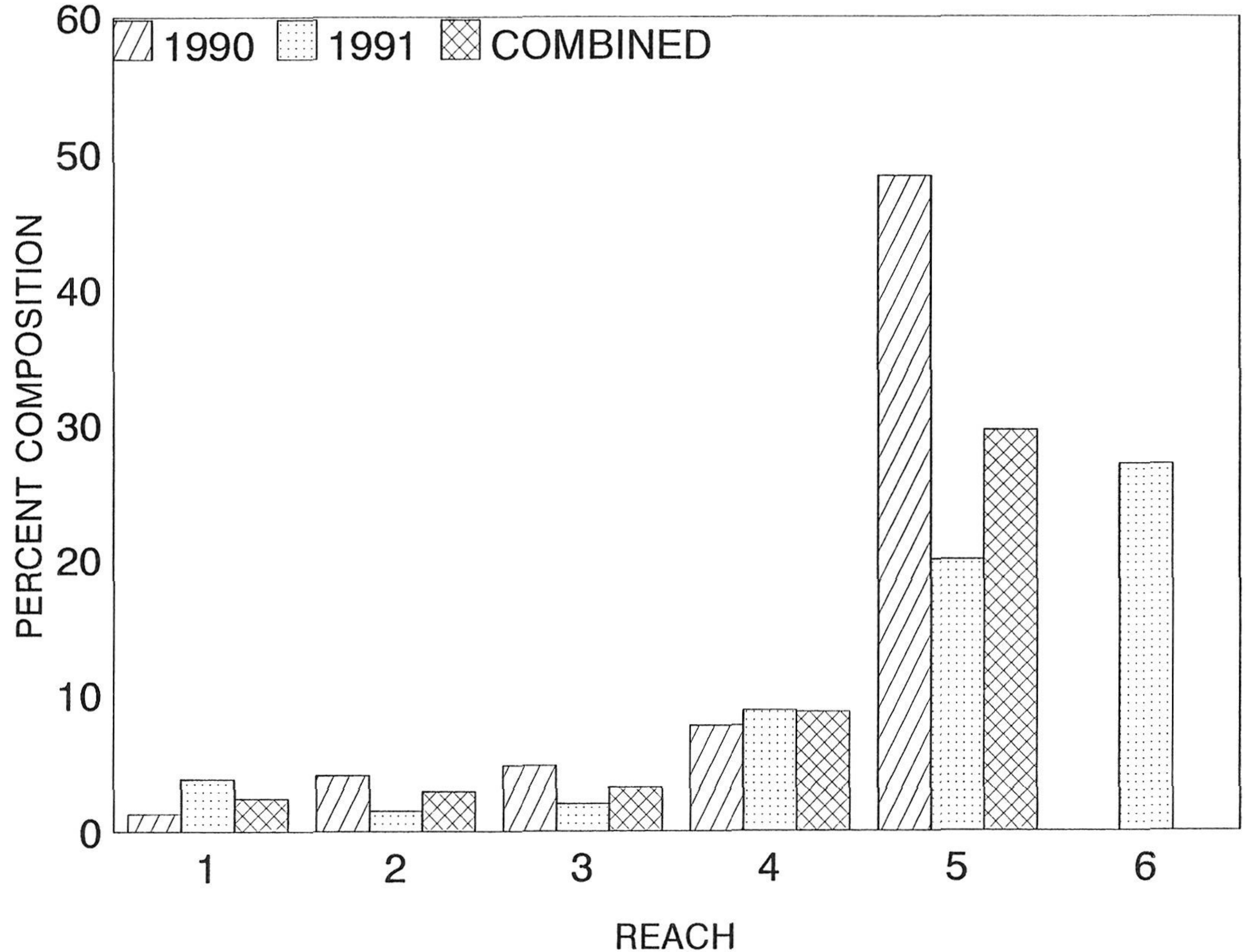

Figure 6. Composition of roundtail chub captured by netting and electrofishing in six reaches of the Dolores River by BIO/WEST, 1990-91.

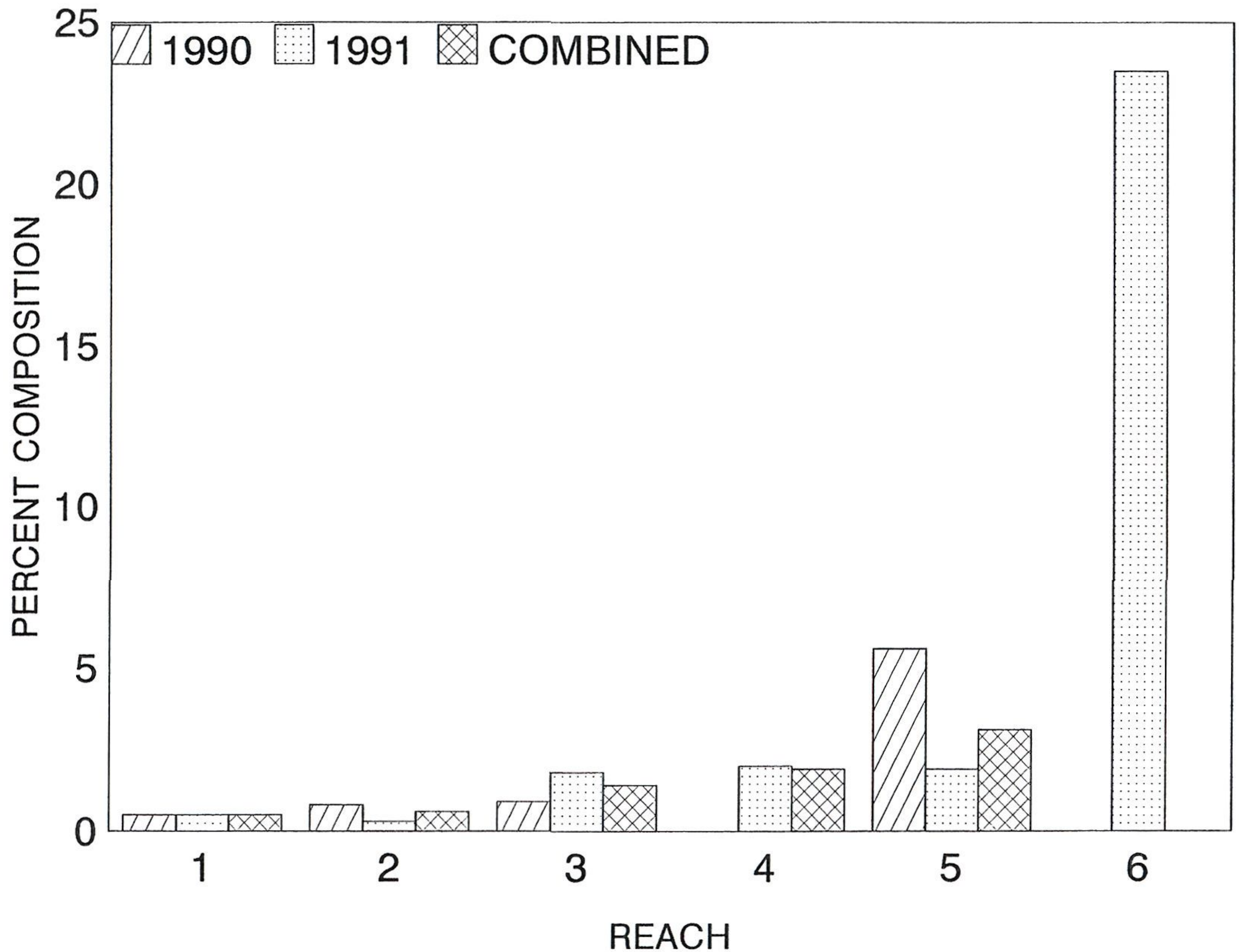

Figure 7. Composition of speckled dace captured by netting and electrofishing in six reaches of the Dolores River by BIO/WEST, 1990-91.

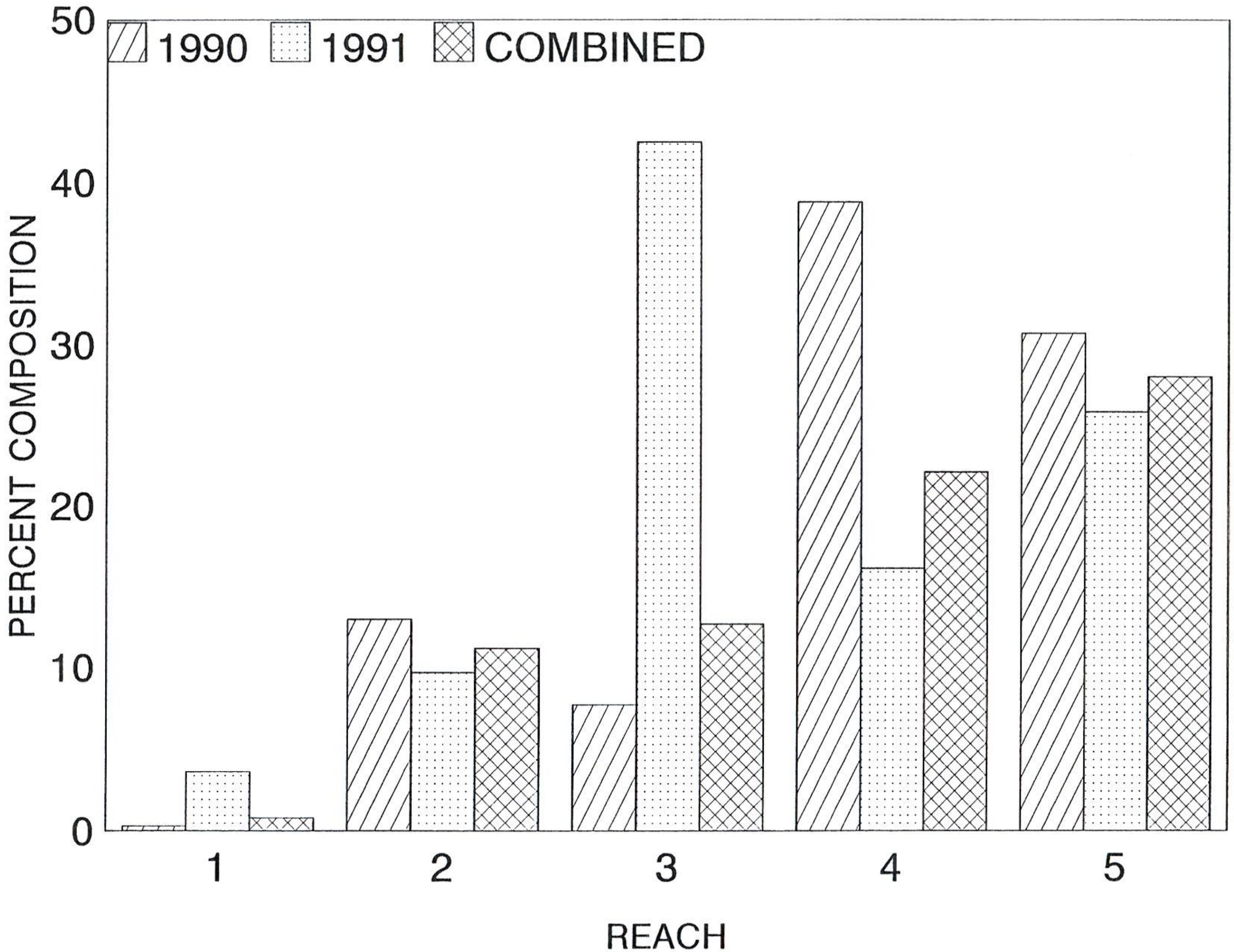

Figure 8. Composition of native species captured by seining in six reaches of the Dolores River by BIO/WEST, 1990-91.

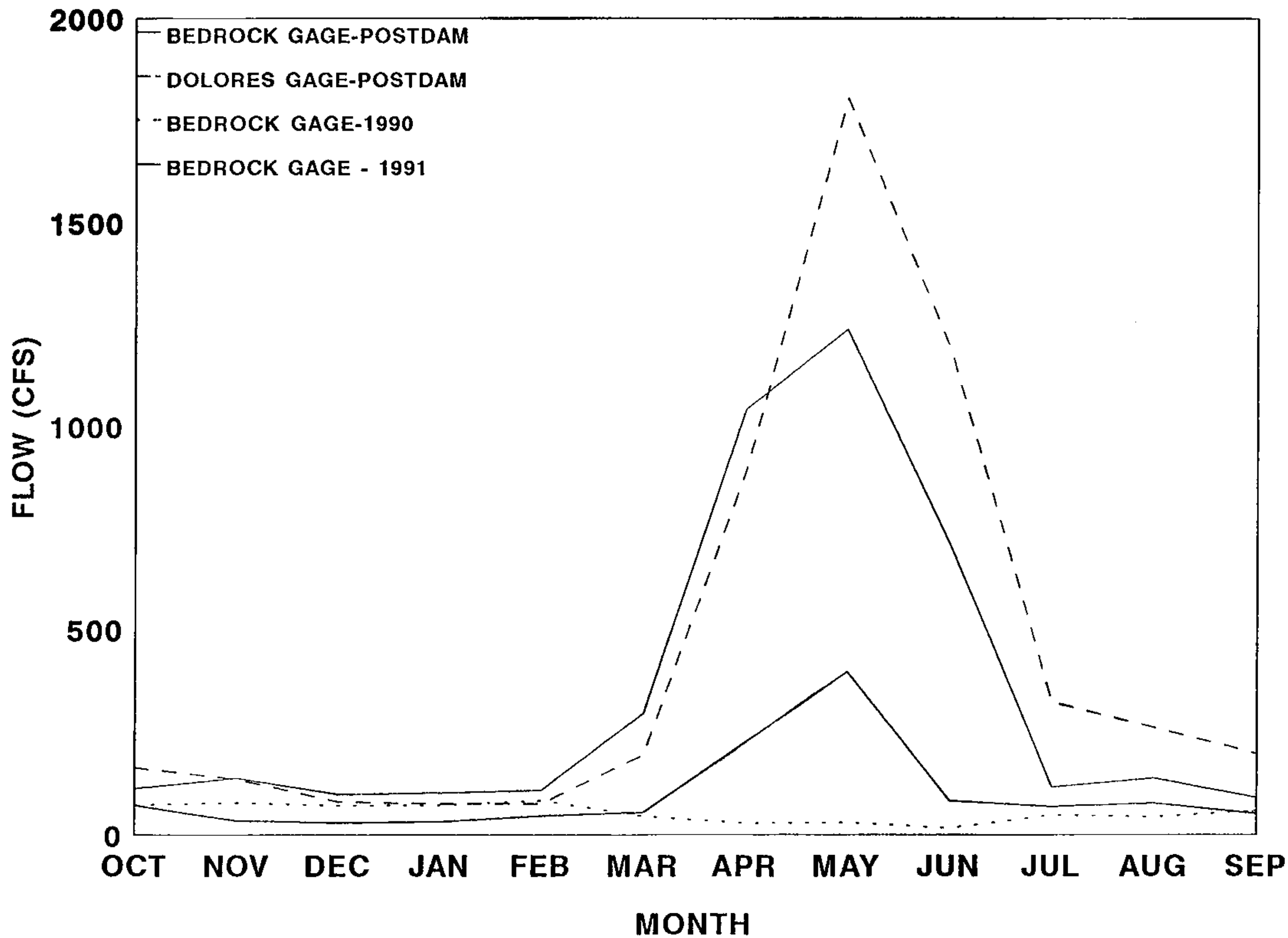

Figure 9. Comparison of flows above and below McPhee Reservoir. Flows above McPhee from USGS gage at Dolores, flows below McPhee from USGS gage at Bedrock. Post dam data (March 1984 to Sept. 1991) used to calculate mean monthly flows are provisional.

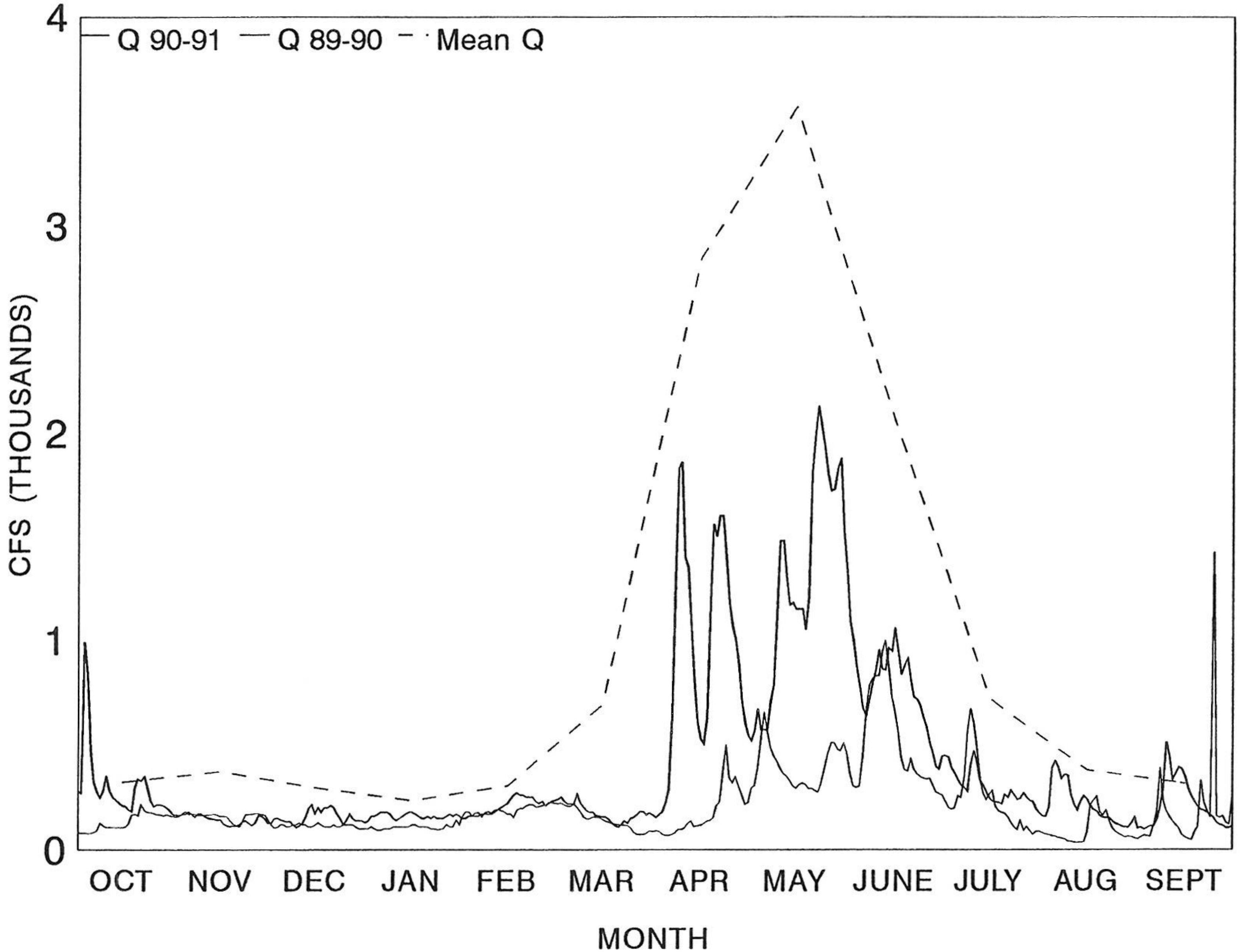

FIGURE 10. DAILY DISCHARGE FOR THE DOLORES RIVER DURING THE STUDY PERIOD (OCT. 89 - SEPT. 91) COMPARED TO MEAN MONTHLY FLOWS. DATA FROM USGS GAGE NEAR CISCO.

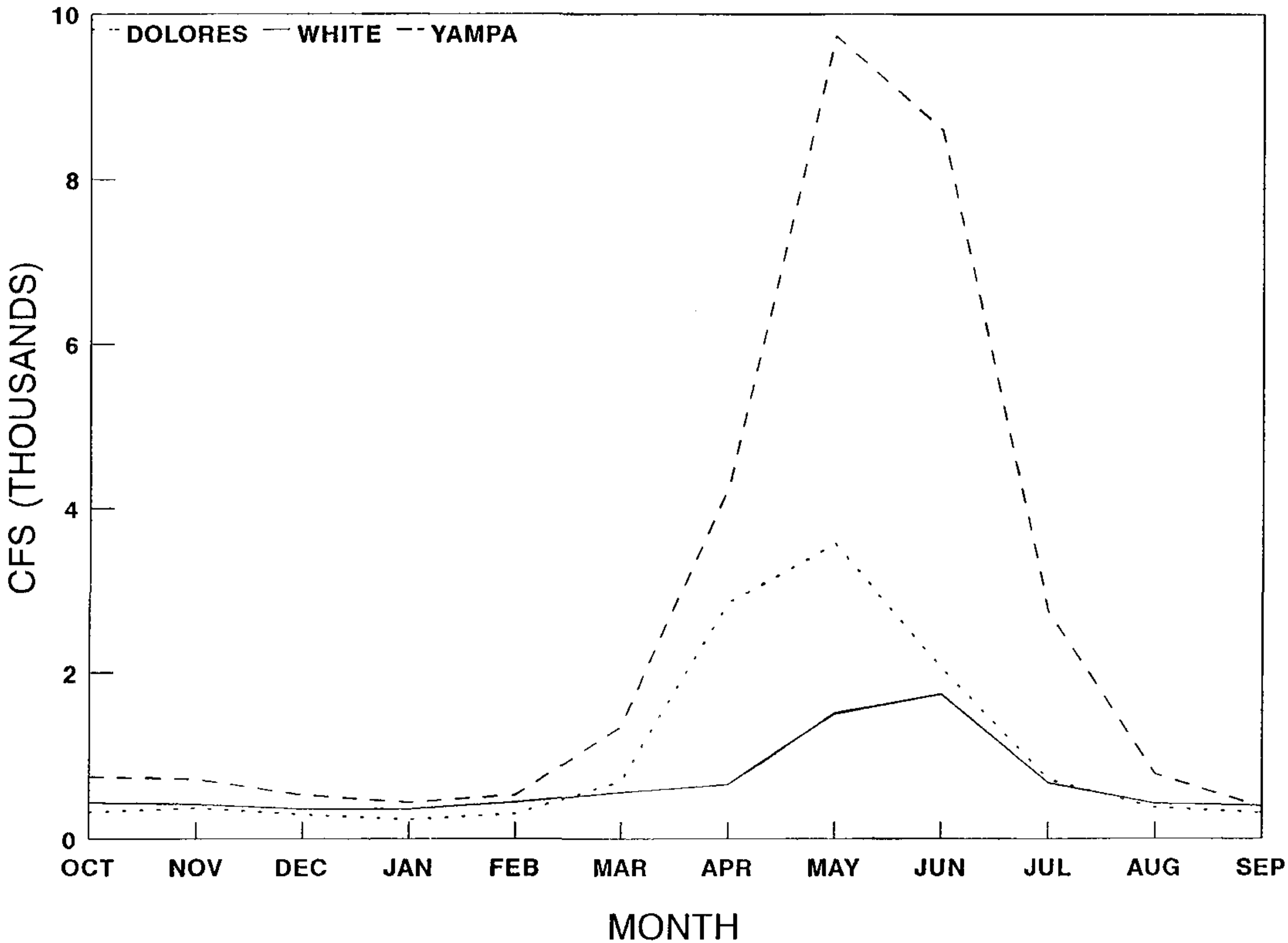

FIGURE 11. MEAN MONTHLY FLOW COMPARISON FOR THE DOLORES (USGS GAGE NEAR CISCO), WHITE (USGS GAGE NEAR WATSON), AND YAMPA (USGS GAGE AT DEERLODGE) RIVERS. DOLORES RIVER FLOWS ARE POSTDAM, MARCH 1984 TO DECEMBER 1990.

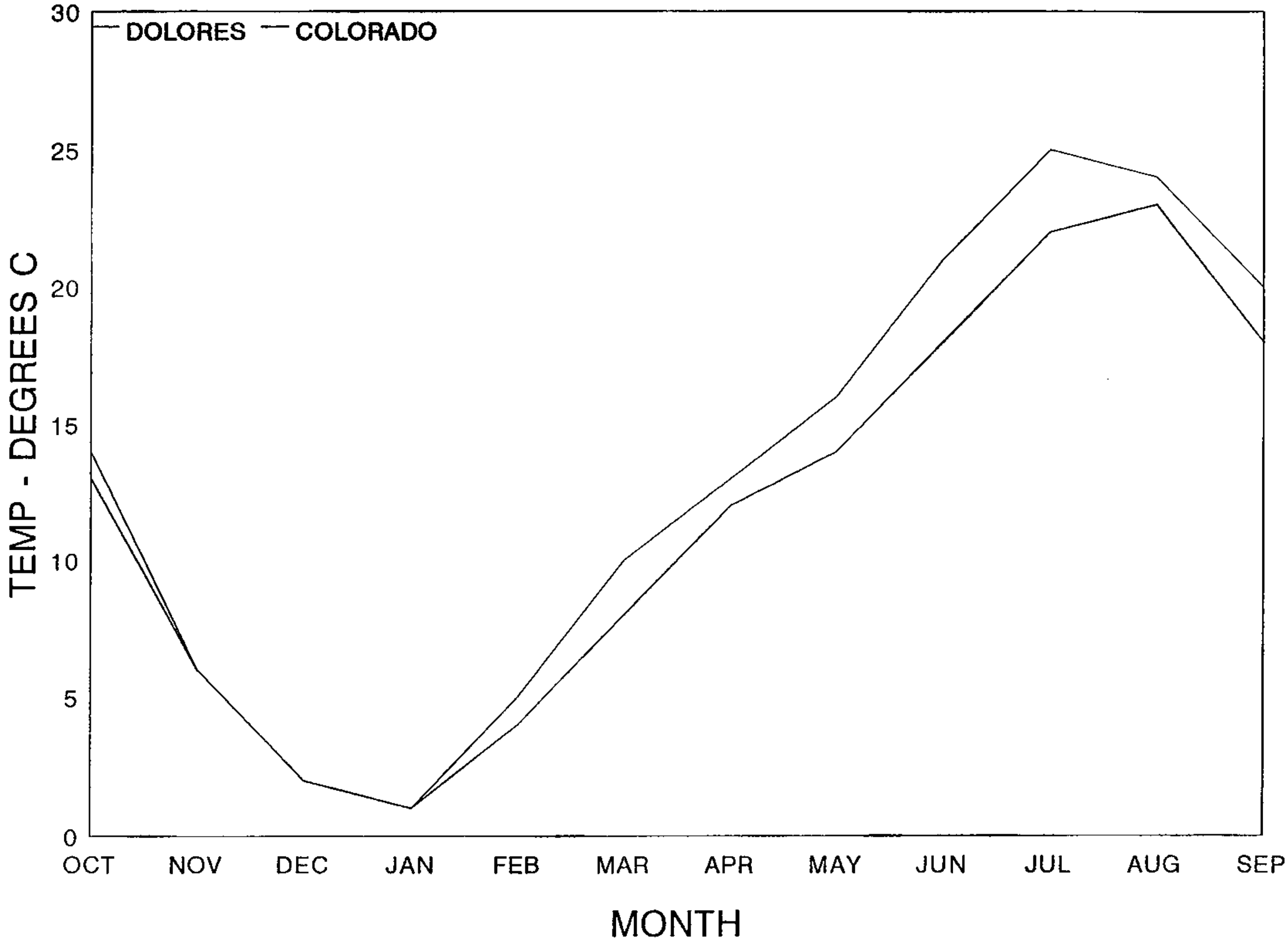

FIGURE 12. MEAN MONTHLY TEMPERATURES - DOLORES RIVER (USGS GAGE NEAR CISCO) VS. COLORADO RIVER (USGS GAGE NEAR CISCO). DOLORES RIVER TEMPERATURES ARE POST DAM, MARCH 1984 TO DECEMBER 1990.

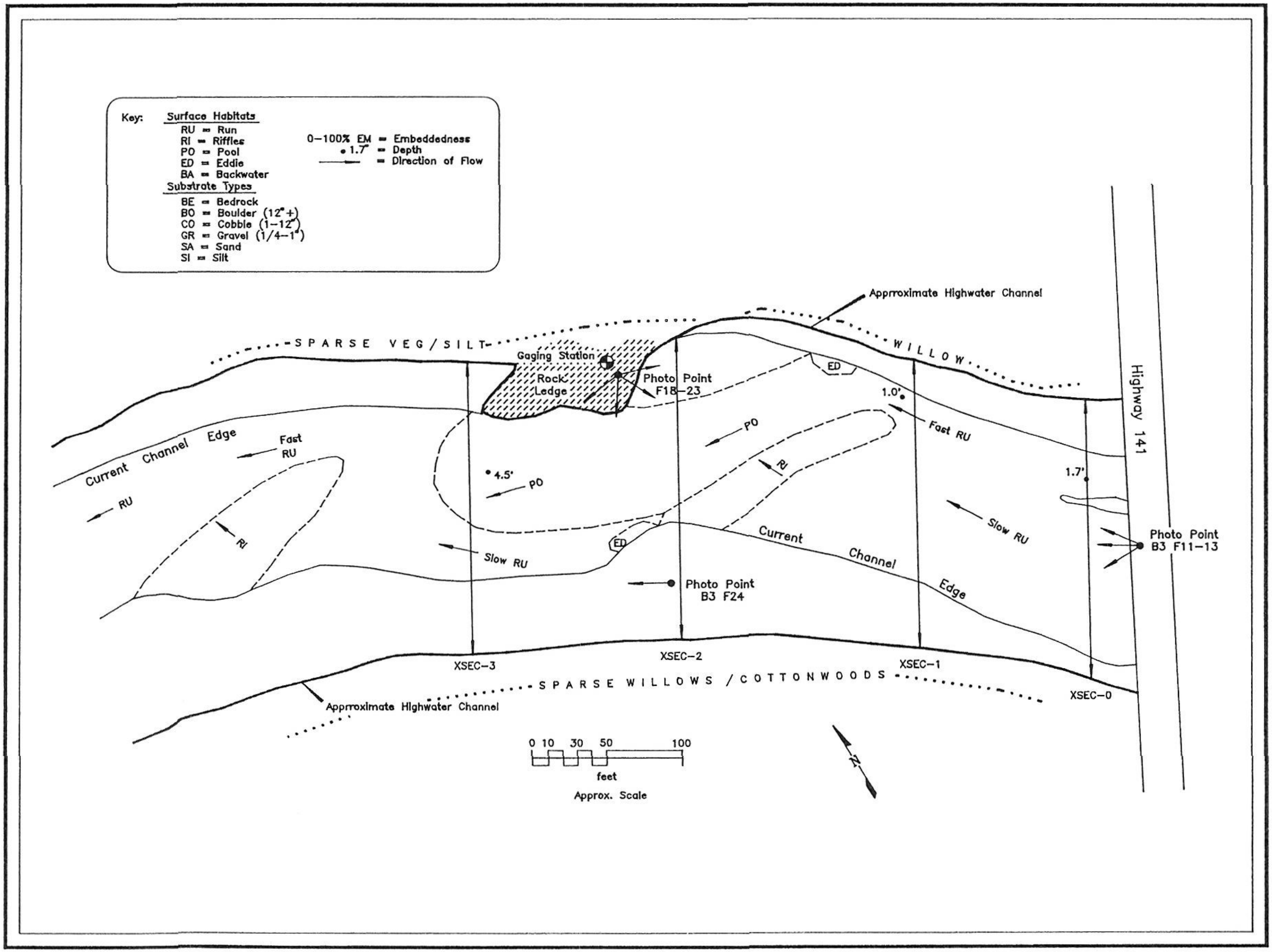

Figure 13. Detailed map of potential spawning area at RM 30.8 on the Dolores River, 1990-1991. Refer to Appendix A for specific transect data.

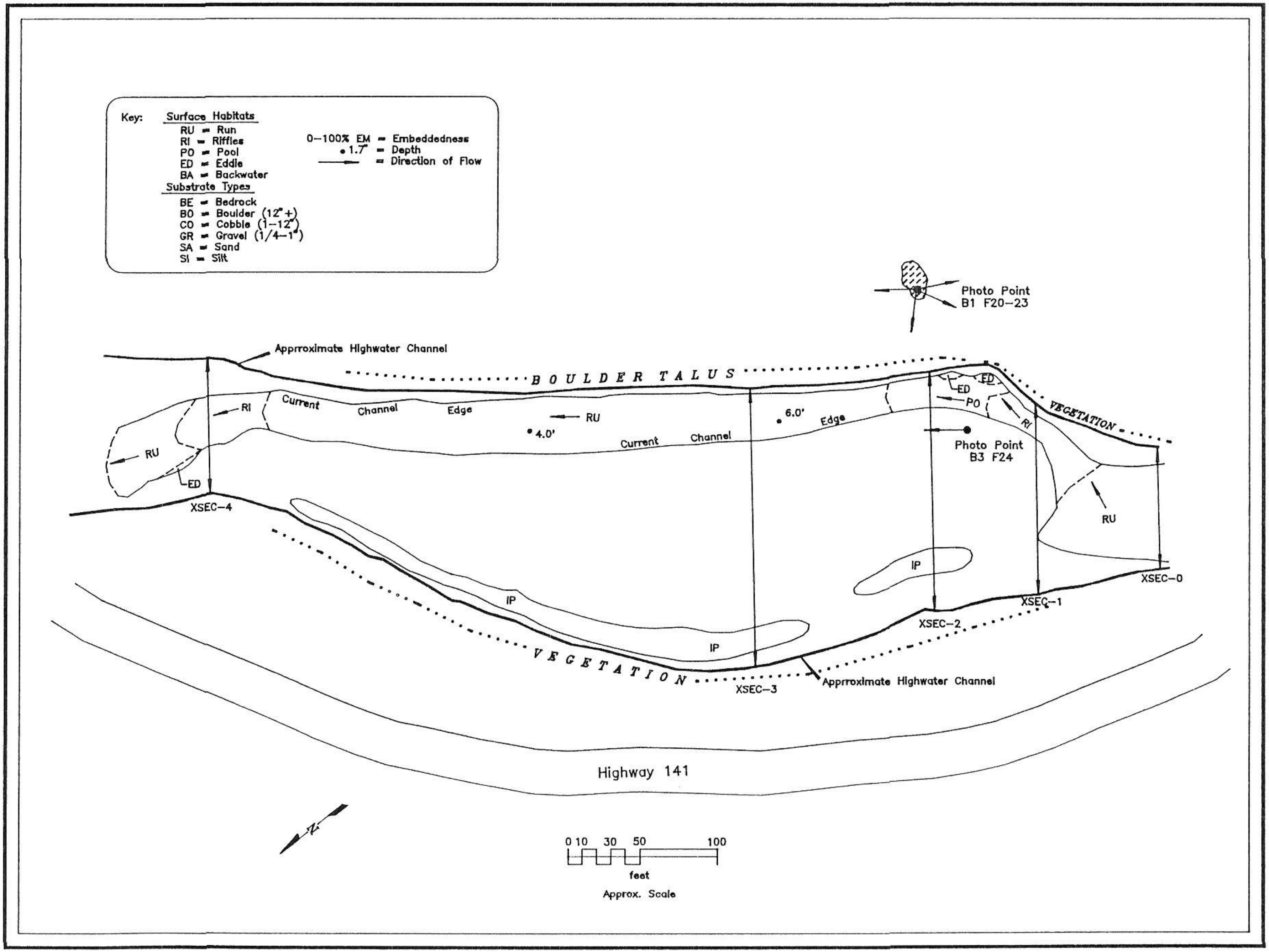

Figure 14. Detailed map of potential spawning area at RM 49.5 on the Dolores River, 1990-1991. Refer to Appendix A for specific transect data.

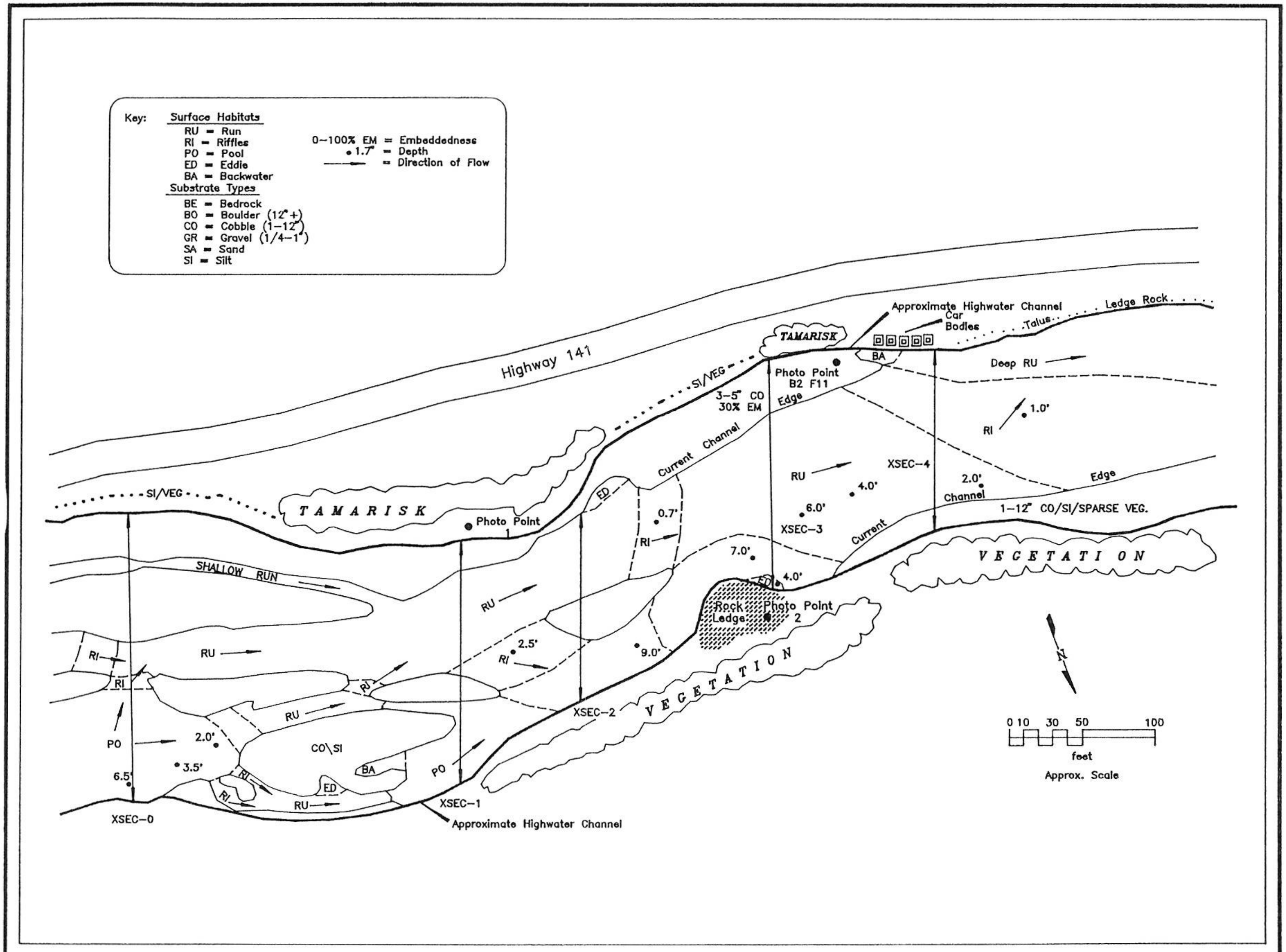

Figure 15. Detailed map of potential spawning area at RM 53.7 on the Dolores River, 1990-1991. Refer to Appendix A for specific transect data.

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APPENDIX A

Mapping Site: SA-53.7
Date: 911004

TRANSECT #0					
LOCATION	**HAB**	**DEPTH**	**VEL**	**SUB**	**IMB(%)**
10	IP	.5	0	SI,BO	100
20	Sandbar	0	0	SA,VE	-
30	Sandbar	0	0	SA,CO	100
40	Sandbar	0	0	SA,CO	100
50	Sandbar	0	0	SA,SA	-
60	Sandbar	0	0	SA,CO	100
68(LBWE)	Sandbar	0	0	GR,CO	30
70	SW	.5	0	GR,CO	10
80	RU	2	1.8	GR,CO	5
90	RU	2.4	2.2	CO,GR	0
100	RU	1.6	1.0	CO,GR	5
105(WE)	Cobblebar	0	0	CO,GR	40
110	Cobblebar	0	0	CO,SA	75
120	Cobblebar	0	0	CO,VE	85
127(WE)	Cobblebar	0	0	CO,SI	80
130	RU	.4	.2	CO,SI	80
140	RU	.4	.1	SI,CO	90
146(WE)	Gravelbar	0	0	GR,SI	50
150	Gravelbar	.05	0	GR,SI	80
155(WE)	Gravelbar	.05	0	GR,SI	50
160	SW	.2	0	SI,GR	100
170	RU	.3	.1	CO,SI	60
179(RBWE)	-	0	0	CO,SI	40
180	-	0	0	GR,CO	30
190	-	0	0	CO,SI	70
200	-	0	0	CO,GR	60
210	-	0	0	GR,CO	70
216(RBWE)	-	0	0	BO,SI	-

TRANSECT #1					
LOCATION	HAB	DEPTH	VEL	SUB	IMB(%)
10	-	0	0	SA,VE	-
20	-	0	0	CO,VE	50
30	-	0	0	SI,VE	-
40	-	0	0	SI,CO	80
41(LBWE)	-	0	0	SI,CO	80
50	RU	.4	.4	CO,SI	60
60	RU	1.2	.8	CO,GR	60
70	RU	1.0	1.5	CO,GR	20
80	RU	1.3	2.5	CO,GR	20
90	RU	1.2	2.7	CO,GR	20
100	RU	1.0	3.2	CO,GR	20
110	RI	1.2	2.0	CO,GR	10
120	ED	3.8	0.1	SI,CO	91
130	ED	5.0	0.4	SA,SI	-
140	ED	3.3	.15	SI,SI	-
147	RBWE	0	0	SI,SI	-
150	-	0	0	SI,VE	-
160	Edge of Channel	0	0	BO,SI	50

TRANSECT #2					
LOCATION	HAB	DEPTH	VEL	SUB	IMB(%)
10	-	0	0	SI,SI	-
11	LBWE	0	0	SI,SI	-
20	RU	1.1	.1	SI,GR	100
30	RU	.8	.1	SI,GR	100
40	RU	.4	.1	SI,CO	100
45	WE	0	0	SI,CO	100
50	Silt/ Cobblebar	0	0	SI,CO	100
60	Silt/ Cobblebar	0	0	SI,CO	95
70	Silt/ Cobblebar	0	0	CO,SI	75
80	Silt/ Cobblebar	0	0	CO,SI	40
84	WE	0	0	GR,CO	20
90	RU	1.8	1.3	GR,CO	10
100	RU	3.9	1.8	GR,CO	10
110	RU	4.9	.5	CO,BO	5
120	ED	.5	.1	BO,CO	50
121	RBWE	0	0	BO,SI	-

TRANSECT #3					
LOCATION	**HAB**	**DEPTH**	**VEL**	**SUB**	**IMB(%)**
0	-	0	0	SI,VE	-
10	-	0	0	SI,VE	-
20	-	0	0	SI,VE	-
30	-	0	0	SI,VE	-
40	-	0	0	SI,CO	95
50	-	0	0	CO,GR	60
54	LBWE	0	0	SI,CO	80
60	SW	.4	0	SI,GR	90
70	RU	3.1	.1	SI,CO	100
80	RU	5.1	.4	CO,GR	75
90	PO	7.1	1.0	CO,SI	70
100	PO	7.4	.6	CO,SI	70
110	PO	7.4	-.05	SA,CO	100
120	PO	2.9	-.2	SA,SI	-
130	PO	.3	0	SI,SI	-
132	RBWE	0	0	SI,SI	-

TRANSECT #4					
LOCATION	**HAB**	**DEPTH**	**VEL**	**SUB**	**IMB(%)**
10	-	0	0	BO,SA,VE	70
15	LBWE	0	0	BO,CO	50
20	RI	2.4	2.3	BO,CO	50
30	RI	1.3	0	CO,GR	30
40	RI	.3	1.6	CO,GR	20
50	RI	.4	1.9	CO,GR	20
60	RI	.6	1.6	CO,GR	10
70	RI	.5	.9	CO,GR	10
80	RI	.9	1.6	CO,GR	0
90	RU	1.0	1.7	CO,GR	50
100	RU	1.2	1.4	CO,GR	40
110	RU	1.4	1.4	CO,GR	40
120	RU	1.3	1.4	CO,GR	30
130	RBWE	0	0	CO,SI	80
140	-	0	0	SA,VE	-
150	-	0	0	CO,SA,VE	50
160	-	0	0	CO,SA,VE	50
170	-	0	0	SI,VE	-
180	-	0	0	SI,VE	-
184	RT Bank	0	0	SI,VE	-

TRANSECT #5					
LOCATION	**HAB**	**DEPTH**	**VEL**	**SUB**	**IMB(%)**
0	LBWE	0	0	BE	-
10	RU	4.2	1.1	BO,SA	20
20	RU	4.0	.6	CO,GR	20
30	RU	3.0	.5	CO,GR	30
40	RU	1.4	.8	CO,GR	15
50	RI	.4	.8	CO,GR	10
60	RI	.6	.5	CO,SI	40
70	RI	.4	.3	CO,SI	50
80	RBWE	0	0	CO,SI	85
90	-	0	0	SI,VE	-
100	-	0	0	SI,VE	-
110	-	0	0	CO,SA	95
120	-	0	0	CO,SA	90
130	-	0	0	SA,VE	-
140	-	0	0	SA,VE	-
150	-	0	0	SA,VE	-
160	Rt. Bank	0	0	SA,VE	-

Mapping Site: SA-30.8
Date: 911004

TRANSECT #0					
LOCATION	**HAB**	**DEPTH**	**VEL**	**SUB**	**IMB(%)**
0	Channel Edge	0	0	SA,VE	-
10	-	0	0	SA,VE	-
20	-	0	0	SA,VE	-
30	-	0	0	SA,VE	-
40	-	0	0	SI,VE	-
49	LBWE	0	0	SI,SA	-
50	RU	.2	.2	SI,SA	-
60	RU	2	.4	SI,GR	-
70	RU	2.5	.6	CO,SI	80
80	RU	3.2	.7	CO,GR	80
90	RU	4.0	.8	CO,GR	20
100	RU	6.5	.7	CO,SI	80
110	SW	5.6	.05	SI,SI	-
120	ED	1.8	-.15	SI,SI	-
123	WE	0	0	SI,SI	-
130	-	0	0	SI,SA	-
138	WE	0	-	SI,SI	-
140	RU	.6	0	SI,SI	-
150	RU	1.2	.1	SI,SI	-
160	SW	.4	0	SI,SI	-
162	RBWE	0	0	SI,SI	-
170	-	0	0	SI,VE	-
180	-	0	0	SI,VE	-
190	Channel Edge	0	0	SI,VE	-

TRANSECT #1					
LOCATION	HAB	DEPTH	VEL	SUB	IMB(%)
0	Channel Edge	0	0	SA,VE	-
10	-	0	0	SA,VE	-
20	-	0	0	CO,SA,VE	70
30	-	0	0	SA,VE	-
35	LBWE	0	0	CO,SI	50
40	RU	1.1	.4	CO,SI	20
50	RU	1.9	.7	CO,SI	30
60	RU	1.9	.6	BO,CO	20
70	RU	1.9	.6	BO,CO	20
80	RU	1.6	.7	CO,BO	20
90	RU	1.3	.8	CO,BO	20
100	RU	.7	.4	CO,CO	20
110	RI	.2	1.0	CO,BO	10
120	RI	.2	.9	CO,BO	10
130	RI	.5	1.9	CO,CO	5
140	RI	.7	4.6	CO,CO	10
146	RBWE	0	0	CO,GR	30
150	-	0	0	SA,CO	80
160	-	0	0	SI,VE	-
170	-	0	0	SI,VE	-
180	-	0	0	SI,SI	-
190	-	0	0	SI,SI	-
200	Channel Edge	0	0	SA,VE	-

TRANSECT #2					
LOCATION	HAB	DEPTH	VEL	SUB	IMB(%)
0	Channel Edge	0	0	CO,VE,SA	90
10	-	0	0	CO,VE,SA	80
20	-	0	0	CO,VE,SA	50
30	-	0	0	CO,VE,SA	50
40	-	0	0	BO,SA,VE	50
50	-	0	0	CO,SI	40
53	LBWE	0	0	CO,SI	40
60	RI	.6	.3	BO,CO	20
70	RI	.8	.6	BO,CO	10
80	RI	.9	.5	CO,BO	10
90	RI	.6	.4	BO,CO	5
100	ri	.1	.4	BO,CO	5
110	RI	.4	.3	CO,SI	30
120	PO	2	.1	CO,SA	50
130	PO	4.8	.1	SI,SA	50
140	PO	4.8	.1	BO,SA	75
150	PO	6.5	0	SI,SA	-
160	PO	6.4	0	BO,SI	80
170	PO	4.5	.1	BO,SI	90
180	PO	2.4	.2	GR,SA	90
190	RU	1.8	.6	GR,SA	70
200	RU	1.2	.5	GR,CO	50
210	RU	.2	.2	SI,SI	-
216	RBWE	0	0	SI,SI	-
220	-	0	0	SA,VE	-
230	Channel Edge	0	0	SA,VE	-

TRANSECT #3					
LOCATION	HAB	DEPTH	VEL	SUB	IMB(%)
0	Channel Edge	0	0	SA,VE	-
10	-	0	0	SA,VE	-
20	-	0	0	SA,VE	-
30	-	0	0	SI,CO	60
40	-	0	0	SI,CO	60
50	-	0	0	SI,CO,VE	40
60	-	0	0	CO,VE	60
70	-	0	0	SI,CO,VE	60
80	LBWE	0	0	SI,CO	95
90	ED	.2	-.1	CO,SI	30
100	ED	1.6	-.2	CO,SI	20
110	ED	2.5	-.2	BO,CO	20
120	RU	4.4	.05	BO,CO	20
130	RU	5.4	1.2	CO,SA	80
140	RU	4.2	1.0	SA,SA	-
150	RU	1.8	.2	SA,SI	-
154	RBWE	0	0	SA,SI	-
160	-	0	0	SA,SI	-
170	-	0	0	BO,GR	-
180	Channel Edge	0	0	BO,SA	-

Mapping Site: SA-49.5
Date: 911005

TRANSECT #0					
LOCATION	HAB	DEPTH	VEL	SUB	IMB(%)
0	-	-	-	SI,VE	-
10	-	-	-	SI,VE	-
14	lbwe	0	-	SI,SI	-
20	RU	2.0	0.2	SI,SI	-
30	RU	3.5	0.4	SI,SI	-
40	RU	2.5	0.5	SI,SI	-
50	RU	3.3	0.5	SI,SA	-
60	RU	2.9	0.5	SI,SA	-
70	RU	2.7	0.6	SI,SA	-
80	RU	2.3	0.6	SI,SA	-
90	RU	1.8	0.3	CO,SI	90
100	RU	1.1	0.2	CO,SI	90
109	RBWE	-	-	SI,SI	-
110	-	-	-	SI,SI	-
120	-	-	-	SI,VE	-
127	Edge of Channel	-	-	SI,VE	-

TRANSECT #1					
LOCATION	HAB	DEPTH	VEL	SUB	IMB(%)
0	Edge of Channel	-	-	SI,VE	-
10	-	-	-	SI,VE	-
20	-	-	-	SI,VE	-
30	-	-	-	SI,SI	-
40	-	Mud Flat	-	SI,SI	-
50	-	Mud Flat	-	SI,SI	-
60	SW	0.2	0	SI,SI	-
70	-	-	-	BO,SI	80
80	-	-	-	BO,CO	90
90	-	-	-	BO,CO	70
100	-	-	-	CO,BO	50
110	-	-	-	CO,BO	40
120	LBWD	0	-	CO,BO	30
130	RI	0.5	1.1	BO,CO	5
140	RI	1.3	2.5	BO,CO	5
150	RI	1.4	2.6	BO,CO	0
160	RI	1.6	2.0	BO,CO	0
170	RI	1.6	2.8	CO,GR	5
180	RI	0.5	2.1	CO,GR	10
184	RBWE	-	-	CO,GR	10
194	Edge of Channel	-	-	CO,GR	-

TRANSECT #2					
LOCATION	HAB	DEPTH	VEL	SUB	IMB(%)
0	Edge of Channel	-	-	SI,VE	-
10	-	-	-	SI,VE	-
20	-	-	-	SI,VE	-
30	-	-	-	SI,VE	-
40	(High water side channel)	-	-	SI,CO	90
50	(High water side channel)	-	-	SI,CO	95
60	(High water side channel)	-	-	SI,CO	95
70	-	-	-	SI,VE	-
80	-	-	-	SI,CO	95
90	-	-	-	SI,VE	-
100	-	-	-	SI,CO	95
110	-	-	-	SI,CO	95
120	-	-	-	SI,CO	80
130	-	-	-	CO,SI	60
140	-	-	-	CO,SI	50
150	-	-	-	SI,CO	70
160	-	-	-	SI,CO	80
170	-	-	-	SI,VE	-
180	-	-	-	SI,VE	-
190	-	-	-	SA,SI	-
200	-	-	-	SI,CO	80
202	LBWE	-	-	SI,SI	-
210	PO	2.0	0.3	CO,SA	10
220	PO	4.8	0.4	BO,GR	5
230	PO	7.0	0.7	CO,GR	5
240	PO	4.5	0.7	BO,CO	10
250	ED	2.0	-0.1	BO,SI	50

253	RBWE	-	-	BO,SI	25

TRANSECT #3					
LOCATION	HAB	DEPTH	VEL	SUB	IMB(%)
0	Channel Edge	-	-	-	-
8	LBWE of IP	-	-	-	-
10	IP	2/10'	0	SI,SI	-
19	RBWE of IP	-	-	SI,CO	95
20	-	-	-	SI,CO	95
30	-	-	-	SI,VE	-
40	-	-	-	SI,VE	-
50	-	-	-	SI,CO	80
60	-	-	-	CO,SI	50
70	-	-	-	CO,SI	30
80	-	-	-	CO,SI	40
90	-	-	-	CO,SI	50
100	-	-	-	SI,CO	70
110	-	-	-	CO,SI	50
120	-	-	-	CO,SI	50
130	-	-	-	CO,SI	50
140	-	-	-	CO,SI	50
150	-	-	-	CO,SI	50
160	-	-	-	CO,SI	40
170	-	-	-	CO,SI	40
180	-	-	-	SI,CO	60
190	-	-	-	SI,CO	95
200	-	-	-	SI,CO	98
210	-	-	-	SI,SA	-
220	-	-	-	SI,CO	70
224	LBWE	-	-	SI,CO	60
230	RU	1.5	0.5	CO,GR	50
240	RU	2.1	0.6	BO,CO	20
250	RU	4.5	0.8	CO,GR	40

TRANSECT #3					
LOCATION	**HAB**	**DEPTH**	**VEL**	**SUB**	**IMB(%)**
260	RU	4.2	0.7	BO,CO	30
270	RU	3.2	0.4	BO,SI	50
277	RBWE	-	-	BO,SI	80
280	-	-	-	SA,SI	-
290	Edge of Channel	-	-	(cut bank)	-

TRANSECT #4					
LOCATION	**HAB**	**DEPTH**	**VEL**	**SUB**	**IMB(%)**
0	Channel Edge	-	-	VE	-
10	-	-	-	SI,VE	-
20	-	-	-	SI,SI	-
30	-	-	-	SI,SI	-
40	-	-	-	SI,SI	-
50	-	-	-	SI,SI	-
55	LBWE	-	-	CO,SI	50
60	RI	0.8	1.4	CO,GR	10
70	RI	2.6	2.0	CO,GR	10
80	RI	1.4	2.0	GR,CO	20
90	RI	1.0	2.2	GR,CO	15
100	RI	0.5	1.2	CO,GR	10
110	RI	0.5	0.8	CO,GR	20
120	RI	0.2	0	CO,SI	30
120.5	RBWE	-	-	CO,SI	30
130	-	-	-	SI,CO	90
140	-	-	-	SI,CO	90
150	-	-	-	SI,VE	-
160	-	-	-	SI,VE	-
165	Channel Edge	-	-	-	-

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