State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Northern District

LAKE OROVILLE RUNOFF ENHANCEMENT PROGRAM

ENVIRONMENTAL MONITORING REPORT

1990-1994

December 1996

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Governor
State of California

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CONVERSION FACTORS

Quantity	To Convert from Metric Unit	To Customary Unit	Multiply Metric Unit By	To Convert to Metric Unit Multiply Customary Unit By
Length	millimetres (mm)	inches (in)	0.03937	25.4
	centimetres (cm) for snow depth	inches (in)	0.3937	2.54
	metres (m)	feet (ft)	3.2808	0.3048
	kilometres (km)	miles (mi)	0.62139	1.6093
Area	square millimetres (mm^2)	square inches (in^2)	0.00155	645.16
	square metres (m^2)	square feet (ft^2)	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometres (km^2)	square miles (mi^2)	0.3861	2.590
Volume	litres (L)	gallons (gal)	0.26417	3.7854
	megalitres	million gallons (10^6 gal)	0.26417	3.7854
	cubic metres (m^3)	cubic feet (ft^3)	36.315	0.028317
	cubic metres (m^3)	cubic yards (yd^3)	1.308	0.76455
	cubic dekametres (dam^3)	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic metres per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
	litres per minute (L/mn)	gallons per minute (gal/mn)	0.26417	3.7854
	litres per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megalitres per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic dekametres per day (dam^3/day)	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lbs)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb)	1.1023	0.90718
Velocity	metres per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (k/W)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0.14505	6.8948
	kilopascals (kPa)	feet head of water	0.32456	2.989
Specific Capacity	litres per minute per metre drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per litre (mg/L)	parts per million (ppm)	1.0	1.0
Electrical Conductivity	microsiemens per centimetre (uS/cm)	micromnos per centimetre	1.0	1.0
Temperature	degrees Celsius (°C)	degrees Fahrenheit (°F)	(1.8X°C) + 32	(°F-321/18

FOREWORD

The Department of Water Resources began a cloud seeding project in the Middle Fork Feather River watershed in October 1991. Some local groups were concerned that the project would cause increased runoff-related stream degradation. Therefore, DWR conducted monitoring to determine the environmental effects of the prototype project to augment snow pack by cloud seeding using ground-based propane dispensers in Plumas and Sierra counties. DWR's Division of Operations and Maintenance funded this study as part of the Lake Oroville Runoff Enhancement Program.

The prototype project was scheduled to include five winter seasons. DWR chose to terminate the project after three winter seasons for several reasons. These reasons include: 1) the U.S. Bureau of Reclamation's policy decision to no longer participate in weather modification research; 2) Precipitation patterns over three years significantly reduced the number of randomized tests suitable for statistical analysis of the effectiveness of the project; 3) tracer studies showed that dispensers should be moved further west and south of their current positions; and 4) new regulations on the allocation and distribution of State Water Project water in Oroville Reservoir which could diminish the project benefits to DWR.

Randomized seeding experiments were employed to determine the effectiveness of the prototype project. Results indicate no statistically significant differences in snow accumulations between seeded and non-seeded periods. The project designer estimates that an additional four to five years of randomized seeding would be necessary to document a statistically valid five to ten percent change in target-area precipitation.

Because DWR is unable to determine if the cloud seeding program had any measurable effect on precipitation, it is impossible to determine if environmental changes (positive or negative) observed during the course of the monitoring program were related to the program. However, data developed from this monitoring program, will be useful to DWR for any future cloud seeding programs in the Middle Fork Feather River as well as to local agencies.

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SUMMARY

The Department of Water Resources conducted a study of the feasibility of using ground-based propane dispensers to augment snow pack on a portion of the Plumas and Tahoe National forests from 1991 through 1994. These dispensers were on National Forest lands and were authorized through a special use permit issued by the Plumas National Forest. The Plumas National Forest required an environmental monitoring program before the special use permit was issued. Components of the plan included monitoring project effects on water quality, channel morphology, stream sedimentation, benthic macroinvertebrate populations, fish populations, streamflow, and fish habitat within nine watersheds. A paired watershed study design was employed with a station within the cloud seeding project area paired with a station located outside the project area. The final monitoring plan included monitoring of soil surface erosion rates.

Water quality data analyses generally suggest excellent water quality that is suitable for all beneficial uses. Stream temperatures were at levels hazardous to cold water fisheries at the Middle Fork Feather River at Portola, Willow Creek, and Freeman Creek. Dissolved oxygen concentrations were generally suitable for the maintenance and reproduction of aquatic life. However, dissolved oxygen concentrations outside the range of values considered optimal for rainbow trout were occasionally detected at the Middle Fork Feather River at Portola, Nelson Creek, Freeman Creek, Greenhorn Creek, and Squirrel Creek and concentrations less than Regional Water Quality Control Board objectives were occasionally found at the Middle Fork Feather River at Portola and Nelson Creek. All pH, alkalinity, and conductivity levels measured were suitable for beneficial uses. Turbidity values were generally extremely low and well below levels known to adversely affect aquatic life. With very few exceptions, turbidity levels met drinking water standards. Turbidity levels greater than Environmental Protection Agency and California Department of Health Services drinking water standards were occasionally detected at the Middle Fork Feather River at Portola, Middle Fork Feather River at Quincy La Porte Road, Willow Creek, and Squirrel Creek. The investigation found generally low nutrient concentrations which are well below levels know to stimulate nuisance algal or periphyton growth in downstream receiving waters. However, dissolved ammonia at a concentration of 0.42 mg/L was detected at the Middle Fork Feather River at the Quincy La Porte Road which is within the range of values known to adversely influence fisheries. None of the identified water quality impairments (i.e., high stream temperatures, low dissolved oxygen concentrations, or elevated dissolved ammonia) appear to be related to the prototype cloud seeding project. No water quality effects specifically related to the cloud seeding project, either positive or negative, were identified.

The study found short-term impairments of the benthic macroinvertebrate communities at Willow Creek, Freeman Creek, and Onion Valley Creek. The Middle Fork Feather River at Portola benthic community was stressed on nearly every date sampled with unstable and chronic low species richness and diversity. The benthic

community impairments at Willow Creek (the only impaired benthic community within the influence of the cloud seeding project) were caused by desiccation since the portion of the stream sampled was dry during fall 1992 and 1994. Impacts to the benthic community at this station are obviously unrelated to the cloud seeding project. The fall 1994 Onion Valley Creek benthic community was severely degraded by undetermined impacts.

Moderate changes in channel cross sectional dimensions were measured over the course of the study at the Middle Fork Feather River at the Quincy La Porte Road and at Squirrel Creek. Severe down-cutting was apparent on all three channel cross sections at the Willow Creek station. The observed down-cutting at Willow Creek is the result of head-cut extension from the culvert on the county road located approximately 120 feet downstream from the monitoring site. The factors responsible for the more moderate changes in stream cross sectional dimensions at Squirrel Creek and at the Middle Fork Feather River at the Quincy La Porte Road were not apparent.

The amount of fine sediment in riffle spawning gravels ranged widely from station to station and at the same station over time. The levels of fine materials in spawning gravels generally exceeded levels known to impair the reproductive success of substrate spawning fish, except in Onion Valley Creek and Squirrel Creek. Highly elevated levels of fine materials were present in spawning substrates at the Middle Fork Feather River at Portola, Willow Creek, Greenhorn Creek, and Jamison Creek. However, the levels of fine materials at both the Middle Fork Feather River at Portola and Greenhorn Creek were substantially (>70 percent) reduced after the cloud seeding program was initiated. The increasing level of fine material in spawning substrates at Willow Creek is probably a localized response to the head-cut and the influence of the unstable borrow area located just upstream.

Rainbow trout populations were relatively stable in the Middle Fork Feather River at Portola, Willow Creek, Squirrel Creek, and Jamison Creek between 1991 and 1994. Onion Valley Creek and Freeman Creek rainbow trout populations exhibited increasing trends while populations at Nelson Creek, Middle Fork Feather River at the Quincy La Porte Road, and Greenhorn Creek generally decreased. Although strong positive correlations between streamflow and rainbow trout populations were documented at the Middle Fork Feather River at the Quincy La Porte Road and at Freeman Creek, populations appeared most strongly influenced by changes in micro-habitat (particularly cover) within the 30-meter stream stretch sampled.

Data analyses (paired t-test) show no statistically significant differences in erosion rates between stations located within the cloud seeding area and those outside. Over 98 percent of the surface erosion measured occurred during the summer when the cloud seeding program was inactive. These results are statistically significant at the 90 percent confidence interval. Summer (cloud seeding inactive) erosion rates averaged over 914 pounds per acre while winter (cloud seeding active) erosion rates

averaged less than 15 pounds per acre. These results indicate that snow cover may inhibit erosion and off-site transport of fine materials. These results further suggest that summer rainstorms may be responsible for most of the observed surface erosion and subsequent deposition in stream channels. Based on these results, the prototype cloud seeding program (if effective) has the potential to slightly reduce surface erosion by extending the period when soils are frozen or protected by snow cover.

INTRODUCTION

In an effort to explore opportunities to increase water yield to the State Water Project, the Department of Water Resources conducted a study to determine the feasibility of using ground-based propane dispensers to augment snow pack on a portion of the Plumas and Tahoe National forests from 1991 through 1994. These dispensers were on National Forest lands (Figure 1) and authorized through a special use permit issued by the Plumas National Forest. U.S. Forest Service staff developed an environmental monitoring plan for the prototype cloud seeding program as a prerequisite for issuing a special use permit. Monitoring of water quality, channel morphology, sedimentation, benthic macroinvertebrate populations, fish populations, stream flow, and fish habitat at paired watershed stations (Appendix A) were components of the adopted monitoring plan. Other elements of the monitoring plan included monitoring of soil surface erosion rates and botanical surveys conducted across an ecotonal gradient (i.e., wet meadow to upland habitats).

A Joint Environmental Impact Report/Environmental Impact Statement (USFS and DWR 1990) for the cloud seeding project identified no significant adverse environmental impacts. The EIR/EIS projected environmental impacts to be below detection levels. However, public concerns related to the cloud seeding program's potential effects on water quality, erosion, channel stability, and aquatic life persisted throughout the environmental review process. This monitoring program was required by the USFS in response to these public concerns.

This report represents the results of environmental monitoring of the effects of the cloud seeding program. All environmental monitoring for this project was conducted by DWR's Northern District personnel. Assistance was provided by Plumas National Forest fisheries and hydrology personnel during 1992 and 1994. The monitoring program was funded by DWR's Division of Operations and Maintenance. O&M personnel tested the effectiveness of cloud seeding using a network of precipitation gauging stations scattered throughout the project area and tracer studies. Their tests were designed to provide statistically valid data related to the program's ability to increase snow pack.

The prototype project was scheduled to include five winter seasons. DWR chose, for several reasons, to terminate the project after three winter seasons. These reasons include: 1) the U.S. Bureau of Reclamation's policy decision to no longer participate in weather modification research and the subsequent loss of the USBR's project scientist who designed and implemented this prototype project; 2) two of the three years the program was in place were excessively dry (1991-2 and 1993-4) while the remaining year (1992-3) was excessively snowy; these precipitation patterns significantly reduced the number of randomized tests (from 180 expected over three years to 93 actual) suitable for statistical analysis of the effectiveness of the project; 3) tracer studies showed that seeding target success was adversely influenced by both strong updrafts and strong downdrafts on the lee of the main Sierran crest which

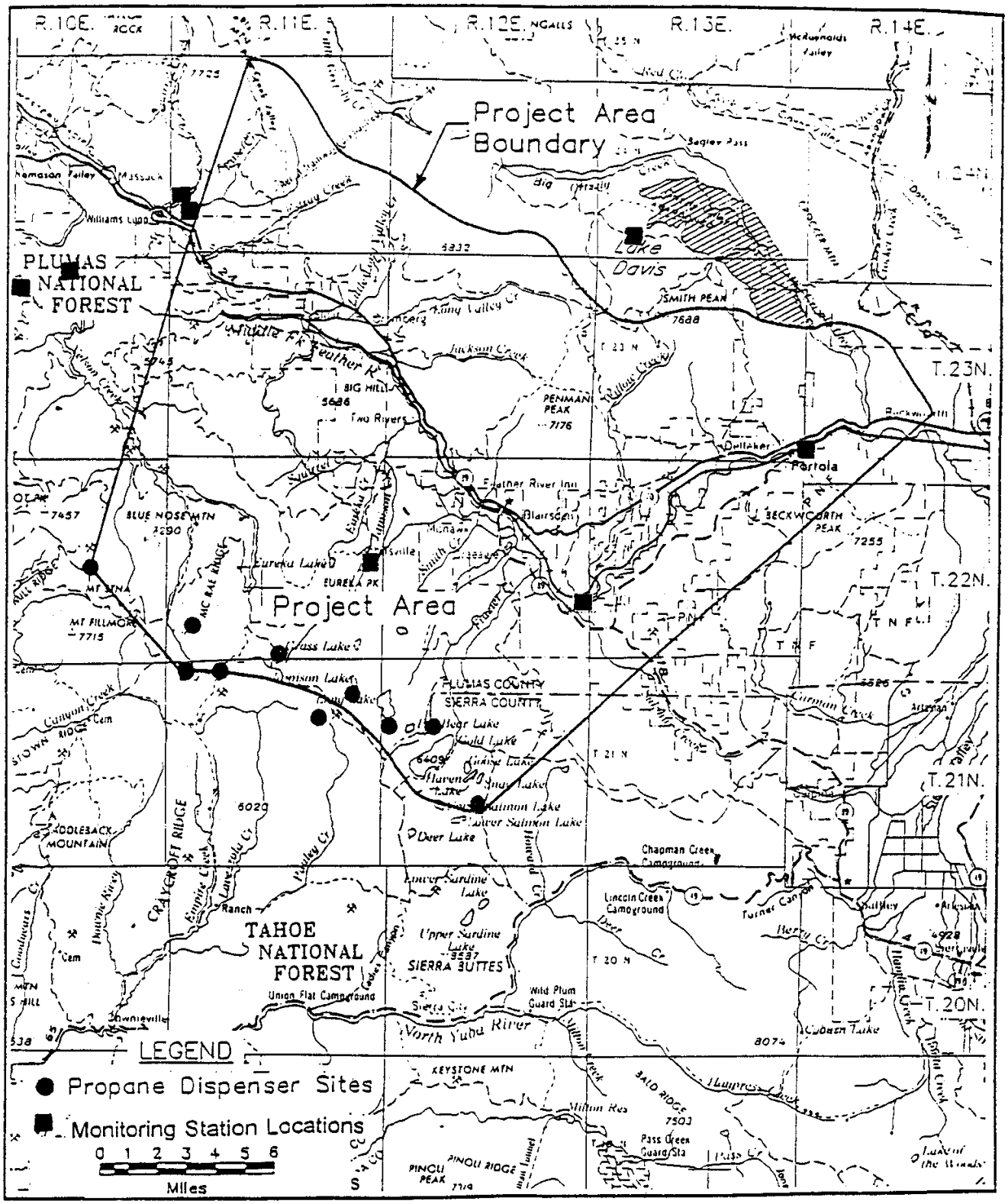


Figure 1. Cloud Seeding Project Area

required moving the dispensers further west and south of their current positions; and 4) new regulations on the allocation and distribution of State Water Project water in Oroville Reservoir which could diminish the project benefits to DWR.

Analysis of the limited randomized seeding experiments that were conducted shows no statistically significant difference between seeded and non-seeded precipitation tests (USBR 1995). These results are not surprising based on the limited sample size. An estimated 500 paired comparisons (seeded versus non-seeded events) would be necessary over the course of the five-year prototype project to provide statistically significant results. With the data available, the effectiveness of the prototype project cannot be determined, or even detected. This makes determination of the environmental effects of the prototype project impossible. If the project caused no change in precipatation, then any observed environmental changes cannot realistically be attributed to the project. On the other hand, if the project was successful in enhancing snowpack, some of the observed or monitored effects may be due to the project.

Results of environmental monitoring for other cloud seeding programs cited in the EIR/EIS demonstrated that the potential for significant environmental effects related to the prototype project was negligible. As a result, no baseline environmental data were collected prior to implementation of the prototype cloud seeding project. However, comparison of baseline monitoring data with operational data is the best method for detecting project effects. The collection of baseline environmental data following completion of the five year project was rejected as a monitoring program design due to the possibility of some project effects extending beyond the project's operational period (i.e., landslides, erosion, and channel degradation). As an alternate approach, USFS staff selected "paired" watersheds for monitoring with each pair containing a monitoring station located within the cloud seeding target area and another station located outside of the project influence. The criteria used to select paired watersheds were based on USFS staff knowledge of local watershed conditions. The project became operational before adequate pre-project monitoring was conducted to determine how watershed conditions varied between paired watersheds.

DWR's decision to terminate the five-year prototype project after only three years of operation reduced the anticipated number of paired station data available for statistical comparison, which decreased the environmental monitoring program's ability to seperate the effects of the prototype project from other concurrent land use activities.

Lack of baseline data, reduced number of paired station comparisons, and no detectable project related increase in precipitation all adversely influenced the effectiveness of the environmental monitoring program. However, the monitoring program has provided valuable information on watershed conditions within a portion of the Middle Fork Feather River drainage. The Middle Fork Feather River is a major contributer to Oroville Reservoir and hence, the SWP. Watershed conditions influence

water quality and quantity available for downstream beneficial uses. Other local beneficiaries of the cloud seeding environmental monitoring program include the members of the Feather River Coordinated Resource Management Group (which has used these data to develop stream restoration projects) and USFS for land management planning activities.

METHODS

Monitoring stations were established on nine streams which included five watersheds within the cloud seeding project area and four watersheds outside. Comparisons of stream data from paired stations, inside and outside the project area, were used to identify potential project effects.

The stream monitoring station located on the Middle Fork Feather River at Portola is upstream from the influence of the project while the Middle Fork Feather River at the Quincy La Porte Road is near the downstream end of the project area. The Willow Creek near Clio stream monitoring station is paired with Freeman Creek (outside the project area) for analyses. The Nelson Creek station is paired with Onion Valley Creek (outside the project area). Greenhorn Creek was paired with tributary Squirrel Creek which is largely outside the project area. No suitable site (high elevation, granitic watershed) was available nearby to pair with Jamison Creek.

Water Quality

Northern District staff conducted monthly water sampling from each of the nine aquatic monitoring stations. However, excessive snow depths frequently prevented vehicular access to some high elevation stations during the winter months. Staff collected water samples before in-channel disturbance from other sampling activities. Grab samples were taken in flowing water. Sample containers, preservation techniques, and holding times followed EPA standards (EPA 1983). Dissolved nutrient samples were filtered (0.45 µm pore polycarbonate filter) and refrigerated until laboratory analyses.

Dissolved oxygen, conductivity, pH, and temperature were analyzed in the field using standard methods. Alkalinity, turbidity, and conductivity were analyzed at DWR's Northern District Laboratory using standard methods. Nutrient samples were analyzed at DWR's Bryte Chemical Laboratory in West Sacramento, California. Blank nutrient samples were submitted to the laboratory monthly as part of the quality control/quality assurance plan. Methods, references, equipment, and minimum detection limits used to analyze each water quality parameter are shown in Appendix B.

Benthic Macroinvertebrates

Benthic macroinveterbrate samples were collected during June and September each year from a riffle environment at each aquatic monitoring station. Two four square feet benthic samples were collected using a kick screen. The use of the kick screen allows qualitative sampling of larger substrates, deeper water, and greater substrate depths than other benthic sampling devices. An area approximately 4 square feet above the kickscreen was sampled by hand scrubbing the larger substrate. Remaining gravels and other smaller substrates within the 4 square feet sampling area were agitated to a depth of four to six inches. Water current washes invertebrates dislodged by scrubbing rocks and raking the gravel into the kickscreen. The material collected on the screen was washed through a 0.6 mm mesh sieve. Materials retained on the sieve were transferred into a one quart plastic jar and preserved with 10 percent formalin. Staff collected and combined two 4 square feet benthic samples at each aquatic monitoring station. Northern District laboratory specialists sorted the invertebrates from the debris, identified each organism to its lowest practical taxonomic classification, and provided a total count of each taxon. Shannon diversity and equitability indices (Weber 1973) were calculated for each sample. Staff also determined benthic macroinvertebrate community biomass for each sample collected after June 1991 using volumetric displacement.

Stream Channel Cross Sections

Three stream channel cross sections were surveyed at each aquatic monitoring station. At each station, pool, riffle, and run cross sections were selected for survey. The identical cross sections were resurveyed annually to monitor alterations in stream channel geomorphology over time.

The location of each transect was marked with a perment monument. The cross sections were surveyed using an Automatic Level, a 25-foot Philadelphia rod, and a fiberglass measuring tape. The level was placed directly over each monument. The height of the instrument over the monument was determined using a pocket tape to the center of the eyepiece. The monument was always assumed to be at 100.00 feet elevation. The tape was laid out using the horizontal angle marks on the auto-level. An object was backsighted on a specific horizontal angle associated with a permanent fixed point (i.e., bridge abutment or fence post). Angles were turned off the backsight point to lay out the riffle, run, and pool cross sections. The rod person would start at the instrument and give elevations for the distances prescribed by the previous surveys. Cross sectional lengths, elevations, and instrument heights were recorded in the field. Cross sectional data were transfered to a spreadsheet for storage and graphic presentation.

Stream Sediment

Three to five replicate sediment samples were collected annually at each aquatic monitoring station during September and October. Samples were collected from riffle environments with a maximum water depth of less than 20 inches using a McNeil gravel sampler. The McNeil gravel sampler is a stainless steel cylinder with an internal retaining basin (McNeil and Ahnell 1964). The 15 cm diameter tube of the gravel sampler was worked into the gravel to a depth of 15 cm. This represents a sampled volume of approximately 2.6 liters. The sand, gravel, and cobble present in the tube were extracted by hand and placed in the internal retaining basin until the nubs at the bottom of the sampler were uncovered. A stainless steel sealing plunger with a compressible O-ring was then fitted in the bottom of the tube and tightened to prevent water leakage. This allowed all the water and silt in the sampler to be collected and measured. The sampler was then removed from the streambed complete with all the materials sampled. A bucket was placed under the sampler tube to insure that none of the liquid portion of the sample was lost. The liquid portion of the sample (which contains the suspended fine materials) was drained into two half-gallon plastic containers. If more than one gallon was present in the liquid portion of the sample, then the remainder was quantified and discarded. Sediments stored in the internal retaining basin were removed and placed in a plastic bag. All sediments adhering to the sampler were rinsed into the bag using a squirt bottle containing clear water. The half-gallon containers and bag containing the water and bulk sediment portions of the sample were labeled with the appropriate station and replicate designation as well as the amount of excess liquid discarded. Laboratory analyses indicate three to five replicate samples per riffle will provide statistically valid results only if materials sampled are of a relatively similiar range of sizes.

All sediment samples were analyzed at DWR's Bryte Soils Laboratory in West Sacramento. In the laboratory, the distribution of particle sizes for each sampling replicate was determined by sieve analysis. Laboratory procedures are summarized in Appendix C.

Fish Population Monitoring

Each aquatic monitoring station was sampled once per year during low flow conditions (normally in September). Block nets were placed at the upstream and downstream ends of a representative 30-meter stream section. The same 30-meter stream section was sampled annually. The area was electrofished in two or three passes of equivalent effort to calculate fish populations based on a decreasing catch (Van Deventer and Platts 1989). The number of fish caught on each of the first two passes was compared using a table developed from the Seber and LeCren (1967) methodology. The table allowed DWR staff to determine the maximum number of fish that could be caught on the second pass compared with the first pass to reduce the error in the population estimate. If the number of fish captured on the second pass exceeded the appropriate number identified in the table, a third pass was conducted.

Fork length measurement was recorded to the nearest millimeter on all fish captured. Biomass was determined for each species using volumetric displacement. Fish were returned to the water (below the downstream net) as quickly as possible to limit handling stress.

Fish Habitat Description

Fish habitat was rated annually within the 30-meter stream section subject to electrofishing. Stream habitat characteristics inventoried included substrate composition, pool/riffle/run ratio, cover type rating, canopy cover, streamflow, cross sectional dimensions (three-meter intervals), and thalweg location and depth. Substrate composition, pool/riffle/run ratios, cover types, and canopy cover were visually accessed using the average value of two independent observers. Streamflow was calculated from current meter measurements using standard procedures (USGS 1968) at all aquatic monitoring stations except the Middle Fork Feather River at Portola. This site is serviced by a DWR continuous recording gauging station. Cross sectional dimensions were recorded at three-meter intervals measured from the water's edge on the left bank. Along each cross section, thalweg depth and distances were determined and recorded.

Microwatershed Erosion Sampling

Soil surface erosion at eight sites was assessed using 24 microwatershed plots. Four of the sites were within the cloud seeding project area and four sites were outside the project area (Appendix D). The sites located outside the cloud seeding area served as a control. Each control site was paired with a site within the project area. Each control site was selected to be as similar as possible to the paired project site. Slope, aspect, elevation, canopy cover, vegetative cover, ground disturbance, and soil type were all considered when selecting the control sites. A physical site description of each set of paired microwatershed plots is presented in Appendix E.

Each site included three 64 ft^2 microwatershed plots. Each plot consisted of an eight foot by eight foot redwood frame placed on the ground. Soil was mounded against the outside of the frame to prevent overland flow. All plots selected were on slopes. The down hill edge of the redwood frame was open slightly so that eroded materials leaving the plot were captured in a buried section of commercial aluminum raingutter (sealed at both ends). The materials captured in the raingutter were collected twice per year, once in the fall (before installation of the cloud seeding propane dispensers) and again in the spring (after cloud seeding activities were completed). Collected materials were sieved through a No. 30 U.S. Standard sieve at the laboratory to remove organic material (pine cones, leaves, needles). The remaining materials were oven dried (seven days at 113° C) and weighed to the nearest 0.1 mg. Dried weights per 64 ft^2 were converted to pounds per acre for reporting purposes.

Evaluation Criteria

In addition to the paired station comparisons the data collected at each station was evaluated against criteria established to protect beneficial uses. The potential for water quality degradation related to the cloud seeding program was identified as a public concern during the environmental review process. The anticipated effects of the prototype project on physical water quality parameters include a slighty extended period of cooler water temperatures, slightly higher dissolved oxygen concentrations for a longer period during the spring and early summer, slightly extended period of low conductivity and alkalinity levels during snow melt, and possibly a slight increase in turbidity.

Water quality samples were collected using grab sampling techniques. Data represent conditions at a single point in time and space. However, both stream temperature and dissolved oxygen concentrations fluctuate continuously. Stream temperature measurements and dissolved oxygen concentrations collected at different points in time are not comparable nor are statistical evaluations possible.

Temperature - Criteria selected to evaluate stream temperature were impacts to cold water fishery beneficial uses. Stream temperatures greater than 77° F are lethal to adult rainbow trout (Black 1953, Lagler 1956, McAfee 1966, Bigood and Berst 1969, Hokanson et al. 1977). Temperatures greater than 77° F were used as evaluation criteria. Temperatures of 32° F or less are also lethal to trout. Temperatures of 32° F were not uncommon during winter sampling below ice. However, for safety reasons sampling during iced over conditions was conducted near shore. Temperatures found in deeper pools probably are adequate to allow overwintering of fish populations. No minimum temperature criteria were employed. Stream temperatures greater than 69.8° F can be detrimental to rainbow trout embryos (Calhoun 1966). This species normally spawns between February and June but at high elevations spawning may be delayed until July or August (Moyle 1976). Lack of precise information on annual spawning dates in relation to the extremes in streamflow and temperature regimes produced by drought (1990-91, 1991-92, and 1993-94) and heavy snowpack (1992-93) preclude the use of the 69.8° F temperature threshold as a meaningful evaluation criteria. RWQCB temperature objectives have not been established for non-point discharges.

Dissolved Oxygen - Dissolved oxygen concentrations are one of the most important variables measured in water as it is essential to both aquatic plants and animals. The amount of oxygen dissolved in water is a function of stream temperature, altitude (air pressure), and dissolved mineral concentrations. The two most important sources of dissolved oxygen in aquatic systems are natural aeration and photosynthetic production. Dissolved oxygen is consumed by plant respiration and through biochemical demands associated with decomposition. Fish dissolved oxygen requirements vary with fish species, age, activity, prior acclimation, and water temperature, velocity, and salinity (McKee and Wolfe 1971) Optimal dissolved oxygen

levels for rainbow trout should exceed 7.0 mg/L at temperatures less than 59° F and be greater than 9.0 mg/L at temperatures greater than 59° F (Doudoroff and Shumway 1970). The Regional Water Quality Control Board objective is to maintain dissolved oxygen levels greater than 7.0 mg/L for cold-water fishery and spawning uses. Dissolved oxygen concentrations less than 3.0 mg/L can be lethal to rainbow trout depending on environmental conditions (primarily temperature) (Gutsel 1929, Burdick et al. 1954, Alabaster et al. 1957, Downing and Merken 1957, Doudoroff and Warren 1962). Supersaturation of dissolved oxygen has also been reported as detrimental to fish (Anonymous 1938, Lassleben 1951). However, Keim (1942) reported that concentration of bubbles on the gills rather than dissolved oxygen concentrations were responsible for the observed mortality of fish under supersaturated conditions. Based on these findings no upper dissolved oxygen concentration was employed as an evaluation criteria. The range of optimal rainbow trout dissolved oxygen concentrations and the RWQCB objective were selected as evaluation criteria.

pH - pH is a measure of acidity (hydrogen ion concentration) in water. The pH scale ranges from zero to fourteen with a value of seven being neutral. Most natural waters range in pH from 6.5 to 8.5. The permissible range of pH for fish depends on several factors including temperature, dissolved oxygen concentrations, prior acclimatization, and the concentrations of various anions and cations (McKee and Wolfe 1971). pH levels between 5.8 and 9.6 can support rainbow trout although slightly alkaline pH levels (7.0 to 8.0) are considered optimal for growth (Moyle 1976). The pH range of 6.5 to 8.5 is considered acceptable for most other beneficial uses (RWQCB 1994) and was employed as an evaluation criterion.

Conductivity - Conductivity is related to the ionic content of water. Many of these ions commonly found in water (calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulfate, chloride, and boron) are important in biological processess and to beneficial uses. Conductivity levels less than 750 µmhos/cm are considered good to excellent for beneficial uses while levels as high as 2,000 µmhos/cm are adequate for most uses (McKee and Wolfe 1971). The RWQCB objective of 150 µmhos/cm was selected as an evaluation criterion for the maximum conductivity.

Turbidity - Turbidity is a measure of the clarity of water. Turbidity levels greater than 3,000 turbidity units for a period of ten days are considered dangerous to fish (Kemp 1949). Rainbow trout eggs can be destroyed under continuous turbidity levels of 1,000 to 2,500 turbidity units over a six-day period (McKee and Wolfe 1971). Other forms of aquatic life can be affected by somewhat lower levels of turbidity over shorter time periods. Several domestic water suppliers and individual residents in the project area use surface waters for domestic use. Both Willow and Jamison creeks are subject to domestic use. The EPA drinking water standard specifies an average turbidity of 1.0 nephelometric turbidity unit for 95 percent of the time with no reading greater than 5.0 NTU (EPA 1992). The EPA criterion of 5.0 NTU was used for evaluation of turbidity.

Alkalinity - Alkalinity is a measure of a water's ability to withstand changes in pH generally precipitated by waste discharge or intense algal growth. Alkalinity serves as a buffer to help prevent any sudden changes in pH that could adversely influence aquatic life. Continuous alkalinity levels less than 20 mg/L can result in excessive corrosion and impairment of some beneficial uses. Levels greater than 150 mg/L can also impair some industrial uses. However, the Regional Water Quality Control Board's Sacramento River Basin Water Quality Control Plan (1994) does not identify any specific alkalinity goals or requirements. No specific alkalinity levels are used as evaluation criteria. However, levels less than 20 mg/L or greater than 150 mg/L are noted.

Nutrient Concentrations - Nutrient concentrations were monitored to determine if increased amounts of organic materials may be deposited in stream channels because of increased snow pack. Anticipated cloud seeding effects on nutrient concentrations included the possibility of a slight increase in total phosphorus and dissolved orthophosphate during snow melt. Specific criteria for nutrient concentrations in surface water are generally lacking. However, excessive nitrogen and phosphorus concentrations can lead to algal blooms and associated nuisance taste and odor problems. Phosphorus and nitrogen concentrations are frequently the most important factors regulating biological productivity. Nitrogen is present in water in the form of nitrate, nitrite, ammonia ions, ammonia gas, and as a component of organic compounds. Most aquatic plants can use nitrate, ammonia, and simple organic nitrogen compounds. Phosphorus is present in water as orthophosphates, metaphosphates, polyphosphates, and organic phosphorus. These forms can be converted through bacterial action or hydrolysis to orthophosphates. No evaluation criteria were used to evaluate nutrient concentrations except dissolved ammonia levels. Dissolved ammonia concentrations ranging from 0.2 to 0.6 mg/L can be lethal to trout (McKee and Wolfe 1971). The effect of dissolved ammonia on aquatic life is a direct function of pH. Dissolved ammonia has a greater effect as pH values become more basic.

Benthic Macroinvertebrates - Benthic macroinvertebrate communities are excellent indicators of water quality. Most benthic macroinvertebrates dwell within or upon stream substrates and are relatively immobile. Thus, they are affected by even temporary alteration of the aquatic environment. While water quality grab samples reflect water quality conditions at a single point in time and space, benthic macroinvertebrate community samples serve as a continuous record of aquatic perturbations. Evaluation criteria for benthic macroinvertebrate communites include total density, species richness, diversity, biomass, and equitability. The presence or absence of indicator organisms was used as a secondary criterion to determine the factors responsible for significant changes in the benthic macroinvertebrate community.

Channel Cross Sectional Analyses - Many land use activities including timber harvesting, grazing, mining, and development of roads and residential areas can

increase peak flows or flow response times. These flow alterations can lead to stream channel degradation. Wildfire and extensive loss of vegetation from disease or insect damage can also lead to increased flows and subsequent channel degradation. The prototype cloud seeding program is not expected to increase peak flows or contribute to channel degradation. Computer modeling indicates that increased snow depth produced by the cloud seeding program may serve to buffer peak flow during rain-on-snow events by absorbing additional water (USFS and DWR 1991). No specific criteria were used to evaluate changes in stream cross sectional profiles.

Stream Sediment Monitoring - Stream sediment monitoring was conducted to identify changes in substrate composition. Land use activities that remove vegetation, disturb soil, or concentrate flow can lead to increased surface and rill erosion. These eroded materials are transported by runoff to stream channels resulting in increased amounts of fine materials in the stream substrate. Sedimentation can be detrimental to aquatic life through altered water chemistry, reduced food production, and reduced habitat for rearing and reproduction. Snow cover protects soil from the impact of rainfall and absorbs rainfall that slows runoff. These characteristics of snow pack serve to decrease surface soil erosion. Increased snow depth produced by the cloud seeding program should generally result in a slightly decreased potential for surface erosion.

Sediment samples were collected in riffle environments where trout spawning could potentially occur. Successful reproduction of substrate spawning fish depends on the presence of clean gravels of the appropriate size. If the gravel substrate is embedded due to fine materials, substrate spawning fish may not be able to dig redds. If eggs are successfully laid in redds, fine sediments may prevent sufficient water flow from reaching the eggs, resulting in egg mortality. Flow through gravels is necessary to remove metabolic wastes and to provide well-oxygenated waters (Coble 1961, Cordone and Kelly 1961, Hall and Lantz 1969). McNeil and Ahnell (1964) determined that fine materials in excess of five percent in spawning gravels severely restricted the permeability of gravels. Laboratory studies have demonstrated that survival to emergence of salmonids is inversely related to the amount of fine materials in the sediments (Phillips et al. 1975, Hall and Lantz 1969). Fine sediments are defined for evaluation purposes in this study as passing a 0.595 mm sieve which is equivalent to a Number 30 U.S. Standard seive.

Fish Populations and Habitat - Sport fishing is an important recreational activity in Plumas County. No adverse impacts to fish populations were identified in the final EIR/EIS. However, sport fish advocates were major project opponents. Fish, in general, and rainbow trout *(Oncorhynchus mykiss),* specifically, are considered excellent indicators of water quality and health of aquatic ecosystems. Fish occupy the upper trophic levels of aquatic ecosystems and respond rapidly to alterations in the lower trophic levels of the food web. The habitat characteristics of a stream segment influence the species present and their density. Streams are dynamic ecosystems

and changes within the 30 meter fish population monitoring section occur annually. These habitat alterations can dramatically influence fish populations when sampling is limited to a 30 meter stream stretch. The fish habitat data were primarily collected to help identify the microhabitat alterations influencing population changes.

RESULTS AND DISCUSSION

Monthly water quality sampling was initiated at five monitoring sites during December 1990 through September 1994 (Appendix F). Sampling of additional water quality monitoring sites was initiated as they were selected. Parameters collected included temperature, dissolved oxygen, pH, conductivity, turbidity, alkalinity, and nutrient concentrations. Benthic macroinvertebrate sampling began during June 1991. Annual monitoring of sediments, fish populations and habitats, and stream channel cross sections began in September 1991.

Middle Fork Feather River at Portola and at the Quincy La Porte Road

The Middle Fork Feather River at Portola is upstream of the influence of the cloud seeding project and served as a control station while the Middle Fork Feather River at the Quincy La Porte Road is immediately downstream of the project area.

Temperature - Stream temperatures in the Middle Fork Feather River at the Portola monitoring station ranged from 32° F to 78° F (Figure 2). Temperatures potentially lethal to trout were detected on only one occasion.

Stream temperatures in the Middle Fork Feather River at the Quincy La Porte Road monitoring station ranged from 32° F to 72° F. No stream temperatures were identified which could adversely affect the cold water fishery at the Middle Fork Feather River at the Quincy La Porte Road stream monitoring station.

Dissolved Oxygen - Dissolved oxygen concentrations at the Portola station ranged from 6.6 to 19.8 mg/L (Figure 3). Dissolved oxygen concentrations were outside the optimal range for rainbow trout on approximately 11 percent of the dates sampled. The sample containing the lowest dissolved oxygen concentration (6.6 mg/L) was collected in February 1993 under a thick layer of ice. Large amounts of organic material are present at this station and decomposition of these materials uses dissolved oxygen. The presence of ice prevents the exchange of oxygen from the atmosphere to the water and inhibits photosynthesis which could replace oxygen. Extreme oxygen depletion can occur under such conditions. The other samples containing less than optimal dissolved oxygen levels occurred during the late spring and summer of 1994. High spring air temperatures increased evapotranspiration and

Figure 2. Comparison of Stream Temperatures from the Middle Fork Feather River at Portola and the Quincy La Porte Road

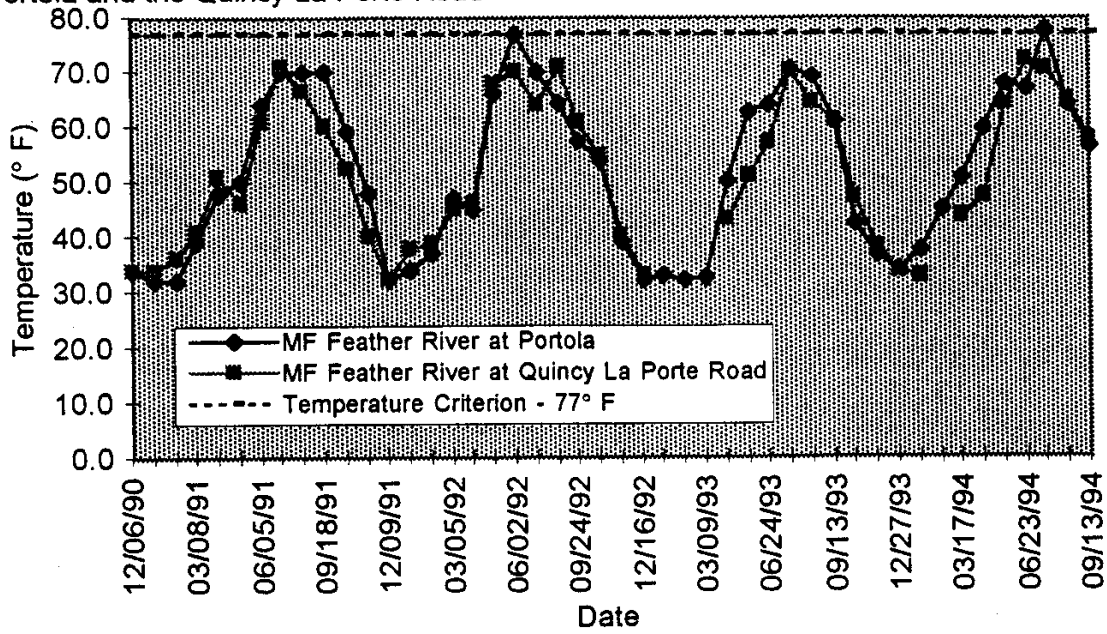
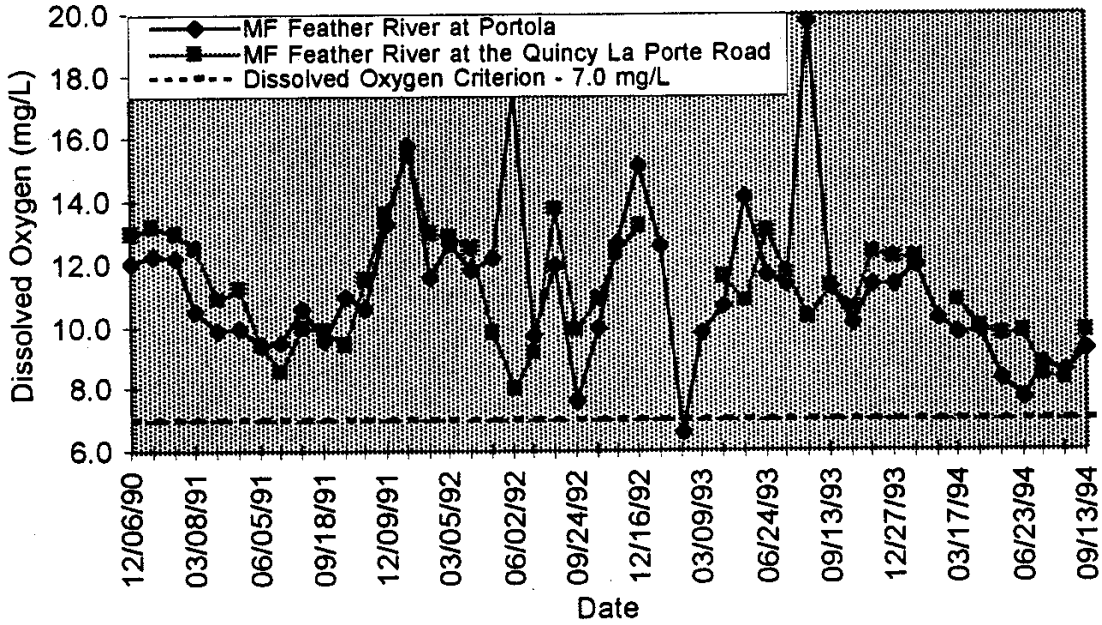


Figure 3. Comparison of Dissolved Oxygen Concentrations from the Middle Fork Feather River at Portola and the Quincy La Porte Road



water use in Sierra Valley during 1994. Little or no outflow from Sierra Valley occurred during this period. The only flow passing the Portola monitoring station was derived from Lake Davis releases to Grizzly Creek which fluctuate significantly depending on the amount of water being diverted for agricultural use. High air temperature and low flow increased water temperature which reduces the potential oxygen carrying capacity and resulted in decreased dissolved oxygen concentrations at this station during this period. The RWQCB objective of 7.0 mg/L was met on all but one occasion.

Dissolved oxygen levels at the Quincy La Porte Road station ranged from 8.0 to 15.6 mg/L. All dissolved oxygen concentrations were within the range of suitability for the maintenance of cold water fisheries and met the RWQCB objective. Unlike the Middle Fork Feather River at Portola monitoring station, this site was never totally iced over during sampling and experienced none of the depressed dissolved oxygen levels associated with that condition.

pH - Middle Fork Feather River at Portola pH levels ranged from 6.4 to 8.4 (Figure 4). Relatively basic pH levels generally occurred during the summer months while the more acidic levels occurred during the winter under ice. Decomposition of organic material consumes dissolved oxygen and produces carbon dioxide. The presence of an ice sheet precludes oxygen exchange and replenishment. Carbonic acid forming under these conditions increases acidity. However, pH levels observed at this station were generally suitable for beneficial uses.

pH levels measured at the Quincy La Porte Road station ranged from 7.3 to 8.5. This range of pH is less acidic than those encountered at Portola. The pH levels encountered were suitable for all beneficial uses.

Conductivity - Conductivity was relatively stable ranging from 107 to 187 µmhos/cm at Portola (Figure 5). Higher conductivity values were obtained under both low flow conditions and under ice. Under low flow conditions most of the streamflow is derived from mineralized groundwater sources. Evaporation under low flow conditions can further concentrate mineral salts increasing conductivity. High percent contribution by mineralized groundwater under iced over conditions can result in higher conductivity values. All conductivity concentrations measured at this station were suitable for all beneficial uses. However, 17 percent of the conductivity values measured exceeded RWQCB objectives for the watershed.

Middle Fork Feather River at the Quincy La Porte Road stream monitoring station conductivity values ranged from 64 to 179 µmhos/cm. Average conductivity values were slightly less at this site compared to Portola. Conductivity values were suitable for all beneficial uses. However, 28 percent of the conductivity values measured exceeded RWQCB objectives for the Middle Fork Feather River watershed.

Turbidity - Turbidity levels measured at the Portola monitoring station ranged from 0.1 to 20 NTU. Periods of increased turbidity were observed to be of relatively

Figure 4. Comparison of pH Values from the Middle Fork Feather River at Portola and the Quincy La Porte Road

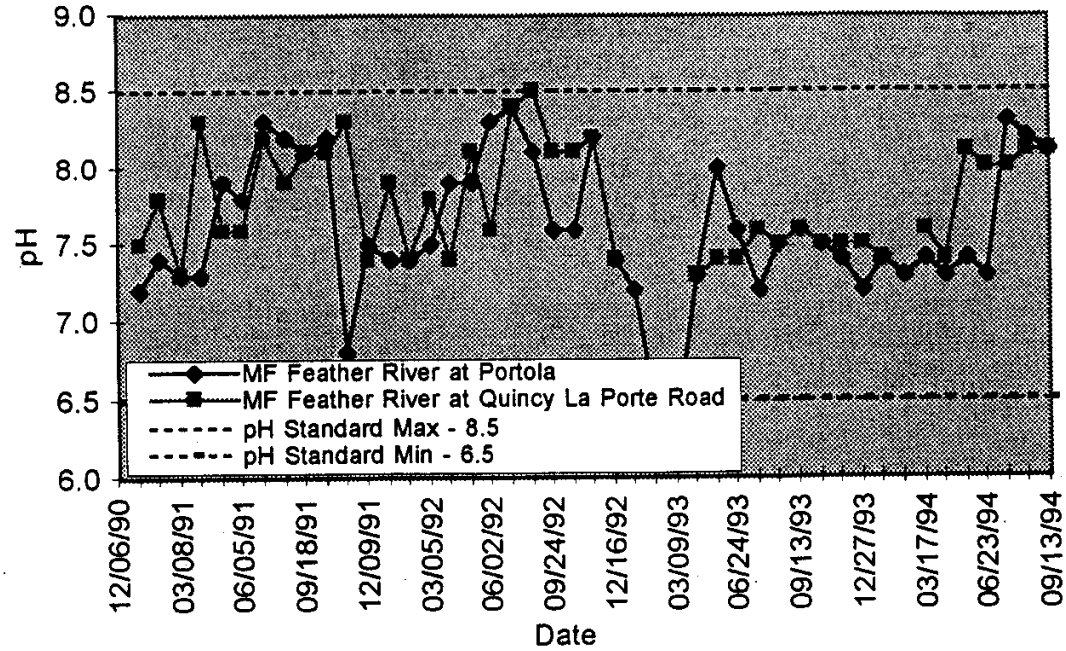
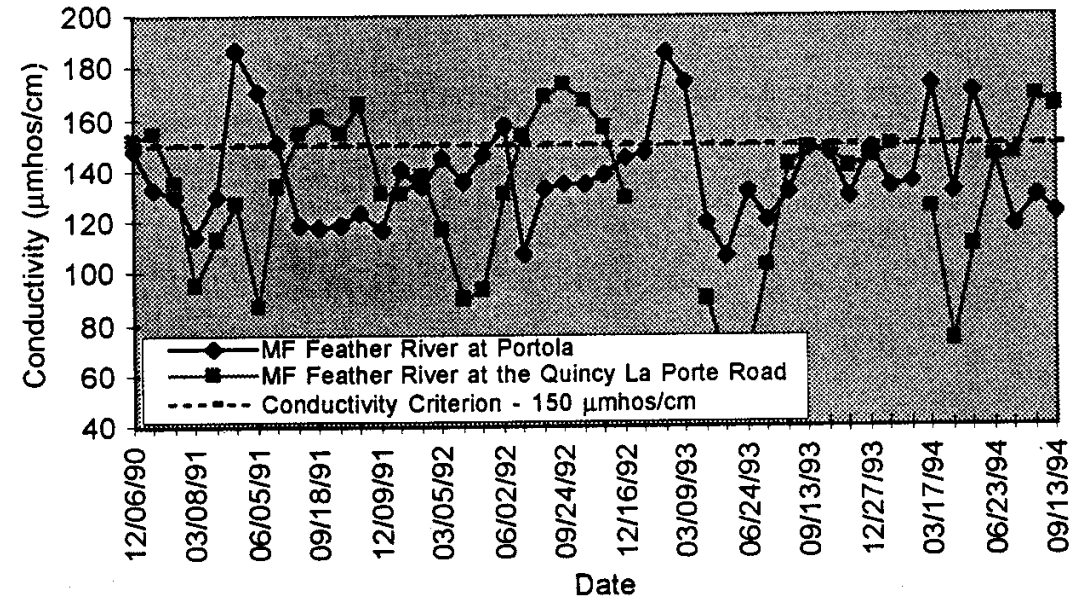


Figure 5. Comparison of Conductivity Values from the Middle Fork Feather River at Portola and the Quincy La Porte Road



short duration and associated with rainfall induced storm runoff. The two turbidity levels greater than 10 NTU measured at this site were associated with winter rainfall events (Figure 6). April and May turbidity levels associated with the snow melt period ranged from 2.2 to 7.5 NTU. None of the turbidity levels detected approached levels hazardous to aquatic life.

Turbidity levels at the Quincy La Porte Road station ranged from 0.1 to 16 NTU. Average, maximum, and minimum turbidity levels were lower than at the Portola station. Average turbidity was 1.6 NTU at this site compared to 3.5 NTU at the upstream Portola station. Turbidity levels during snow melt (April through June) never exceeded 1.0 NTU at this site indicating relatively minor transport of suspended or dissolved materials. These turbidity levels are suitable for the maintenance of aquatic life and generally comply with EPA drinking water standards (EPA 1992).

Alkalinity - The alkalinity values detected at the Middle Fork Feather River at Portola station were suitable for all beneficial uses. Alkalinity levels at Portola ranged from 43 to 135 mg/L (Figure 7). Alkalinities generally increased during periods of low flow and decreased during snow melt.

Alkalinity concentrations at the Quincy La Porte Road station ranged from 34 to 85 mg/L. Average, maximum, and minimum alkalinity levels were less than at Portola. The lowest alkalinity levels recorded were during the primary snow melt period.

Nutrient Concentrations - All nutrient concentrations measured at the Portola station were suitable for all beneficial uses (Figures 8, 9, 10, and 11). Total phosphorus (Figure 9) and dissolved organic nitrogen (Figure 10) concentrations at the Portola station ranged from less than detection levels to 0.1 mg/L and 1.0 mg/L, respectively. A dissolved nitrate concentration of 0.4 mg/L was recorded during December 1992 (Figure 11).

Nutrient concentrations at the Middle Fork Feather River at the Quincy La Porte Road were similar to those encountered at Portola. Dissolved ammonia concentrations were generally at or slightly above detection limits (Figure 8). However, on August 14, 1991 a dissolved ammonia concentration of 0.42 mg/L was detected at this site. This dissolved ammonia level is potentially lethal to fish. The maximum total phosphorus concentration detected was 0.26 mg/L during July 1993 (Figure 9). Except for the single elevated dissolved ammonia concentration all nutrient concentrations were at levels suitable for beneficial use.

Benthic Macroinvertebrates - Benthic macroinvertebrate samples collected from the Middle Fork Feather River at Portola stream monitoring station varied greatly in the total number of organisms present, ranging from 213 to 15,613 individuals (Table 1). Spring samples averaged almost four times as many individuals as late-summer samples. Species richness was low in relation to results obtained from the other eight aquatic monitoring locations in this study. Spring and late-summer samples

Figure 6. Comparison of Turbidity Values from the Middle Fork Feather River at Portola and the Quincy La Porte Road

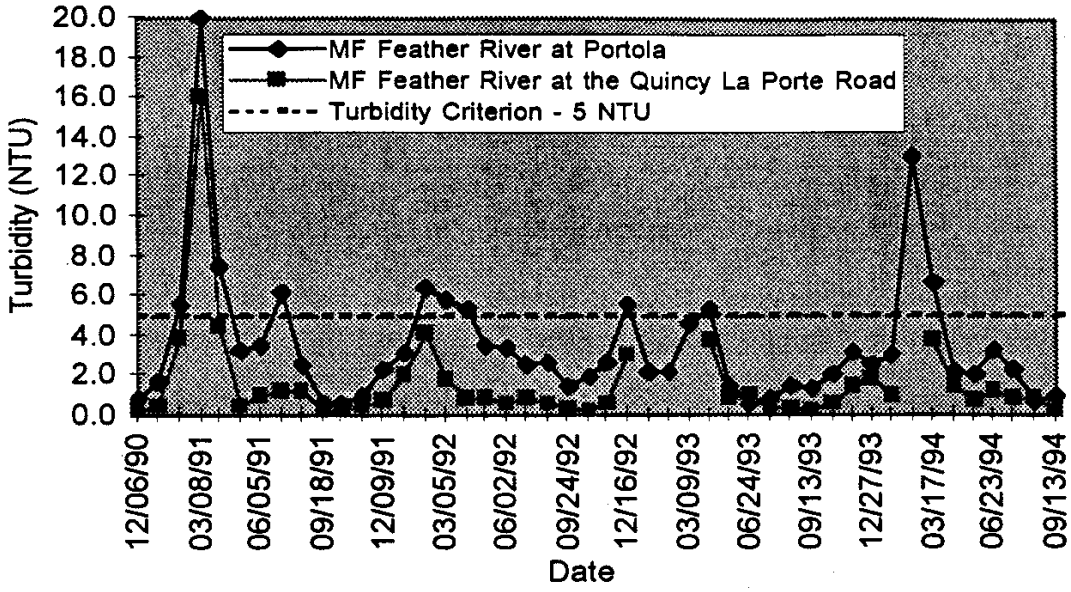


Figure 7. Comparison of Alkalinity Values from the Middle Fork Feather River at Portola and the Quincy La Porte Road

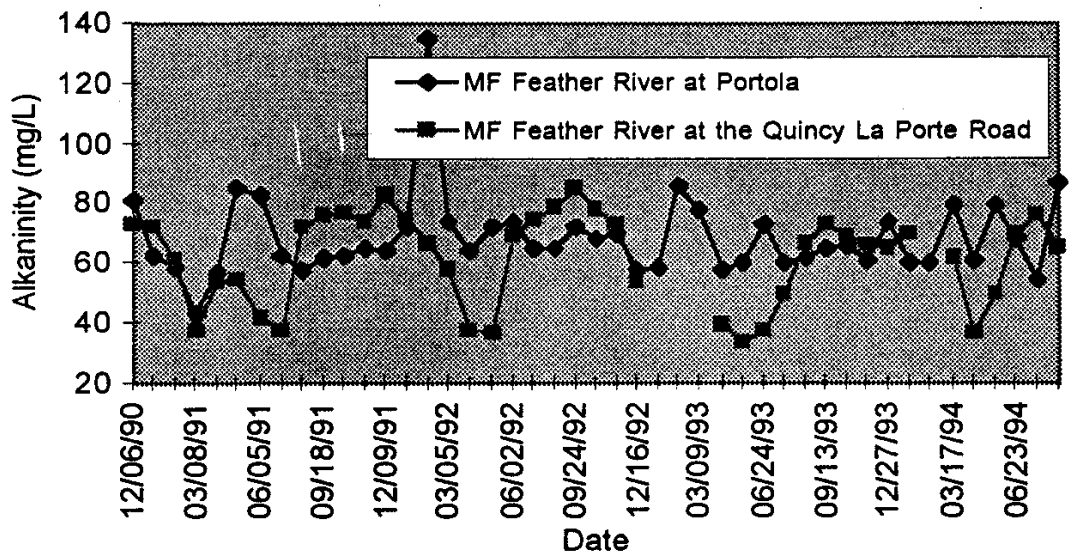


Figure 8. Comparison of Dissolved Ammonia Concentrations from the Middle Fork Feather River at Portola and the Quincy La Porte Road

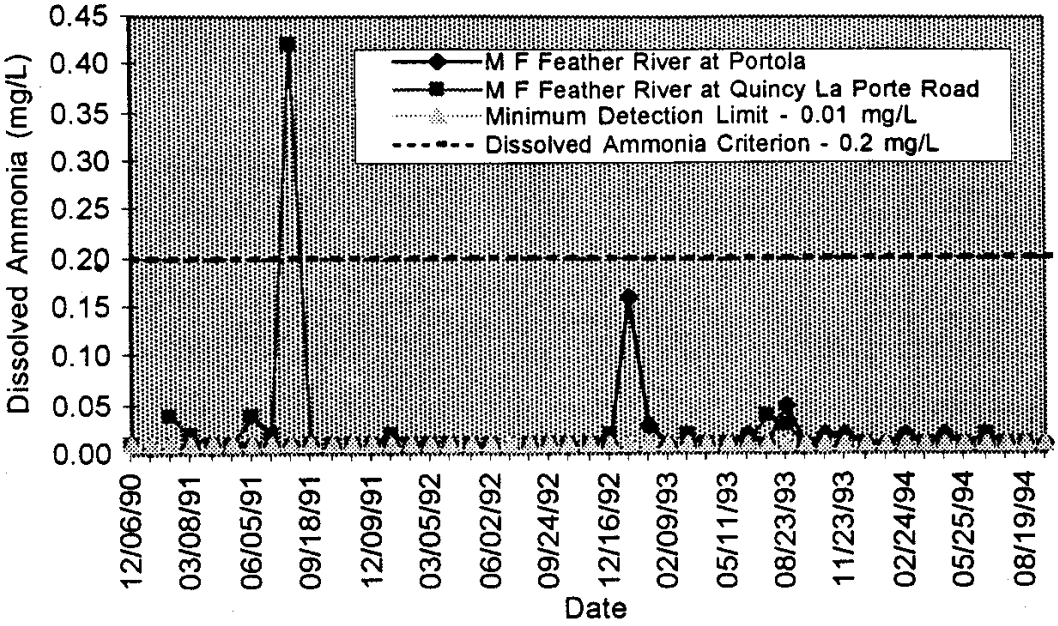


Figure 9. Comparison of Total Phosphorus Concentrations from the Middle Fork Feather River at Portola and the Quincy La Porte Road

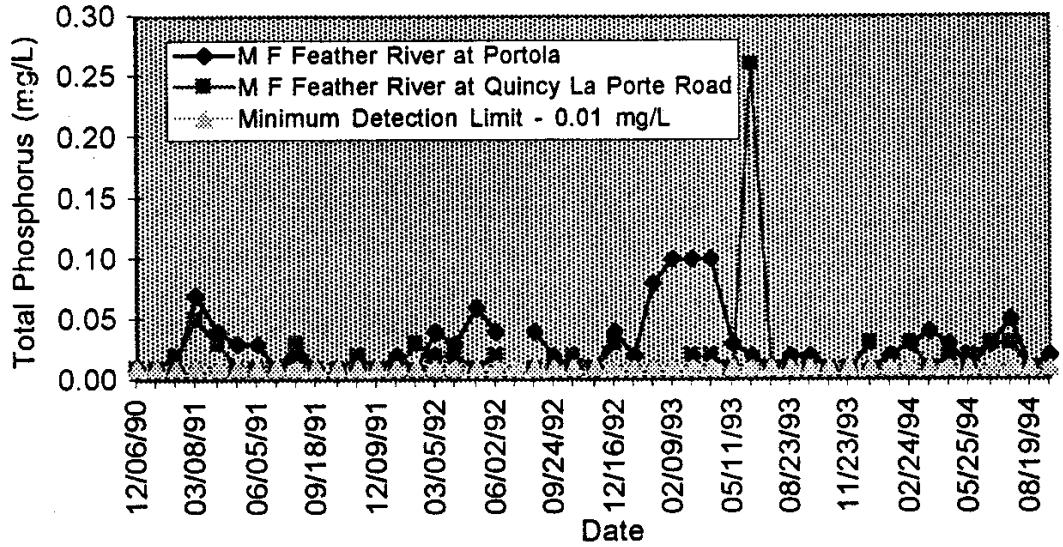


Figure 10. Comparison of Dissolved Organic Nitrogen Concentrations from the Middle Fork Feather River at Portola and the Quincy La Porte Road

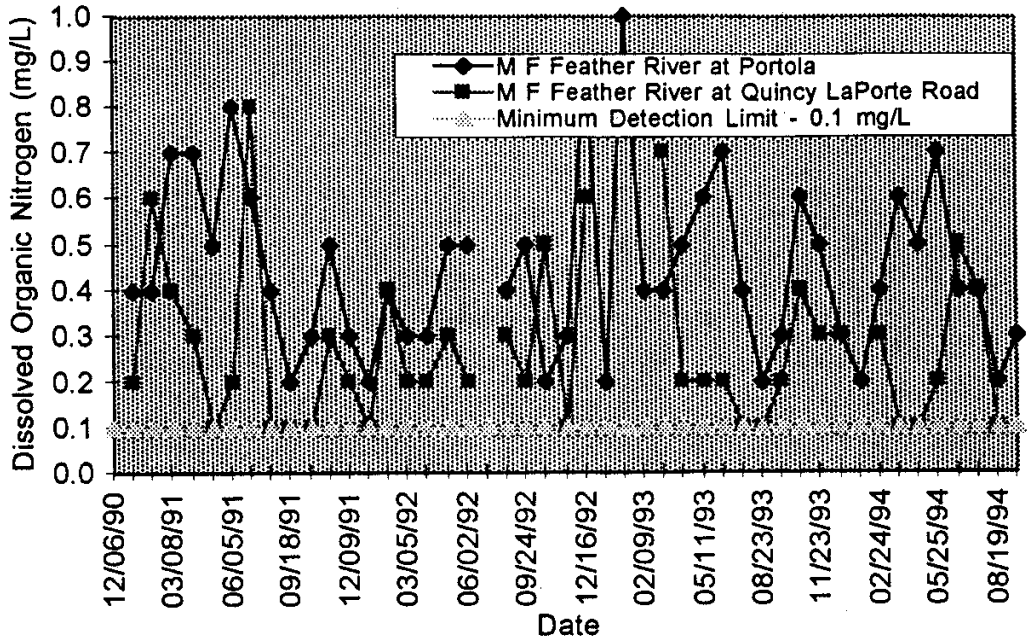
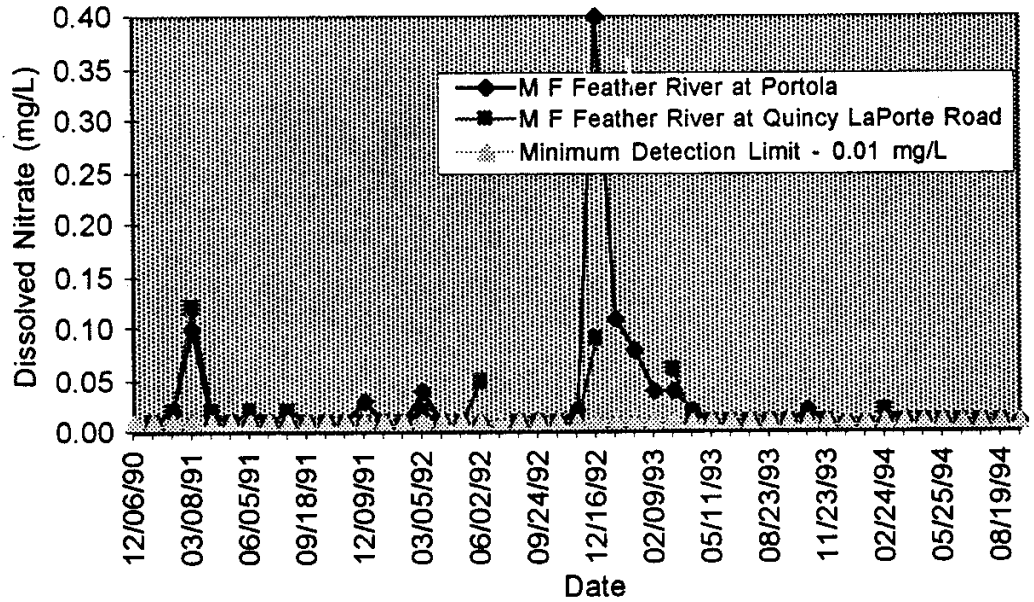


Figure 11. Comparison of Dissolved Nitrate Concentrations from the Middle Fork Feather River at Portola and the Quincy La Porte Road



averaged only 15 and 17 species, respectively. Species diversity was very low ranging from 0.6 to 2.6. Benthic biomass varied widely depending primarily upon the number of crayfish collected in the sample.

Table 1. Middle Fork Feather River at Portola Benthic Macroinvertebrate Community Analyses (Per Square Meter)

	Date							
	5/91	9/91	6/92	9/92	6/93	9/93	6/94	9/94
No. of Organisms	15,613	1,086	4,061	3,750	9,396	2,219	213	277
No. of Species	14	14	21	15	16	24	9	15
Diversity	0.6	1.9	2.6	2.2	1.4	2.2	1.9	2.2
Equitability	0.11	0.36	0.40	0.42	0.20	0.25	0.53	0.40
Biomass (mL)	-	-	4.0	104.0	32.0	6.0	8.5	4.0

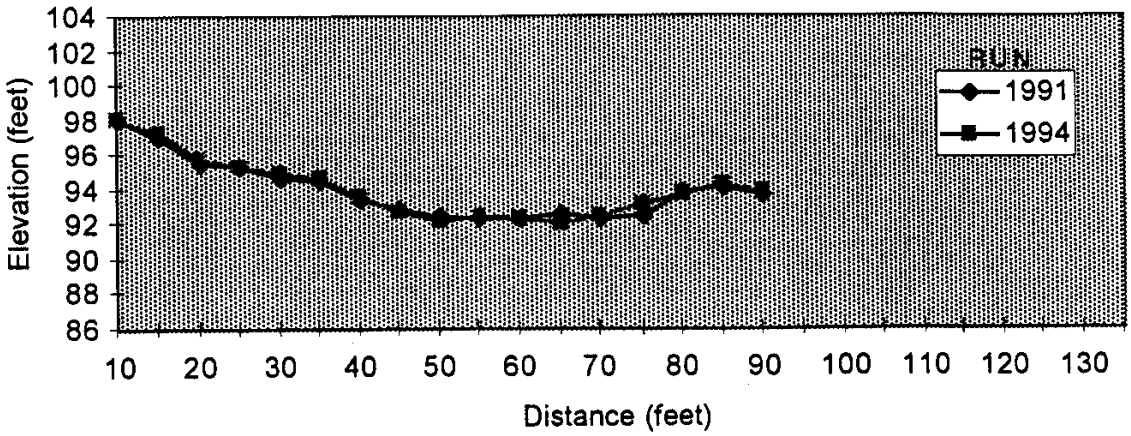
The benthic communities at the Middle Fork Feather River at the Quincy La Porte Road monitoring station was more stable and diverse than those found at Portola (Table 2). Unlike Portola, which generally had a decreasing number of total individuals from spring to summer, this site generally increased in both total number and biomass. Late summer samples averaged approximately four times as many individuals as spring samples, while biomass doubled. Average species richness was approximately 80 percent greater at this site than at Portola. Average species diversity was 3.1 compared to 1.8 at Portola. However, substrates of the riffles sampled at these two sites are quite different. At Portola the substrate contained embedded cobble with abundant periphyton. The substrate sampled at the Middle Fork Feather River at the Quincy La Porte Road is loose gravels with no attached periphyton. Embedded substrates do not generally provide habitat for as many benthic species as looser substrates. However, periphyton can provide habitat for many species not found in clean gravels.

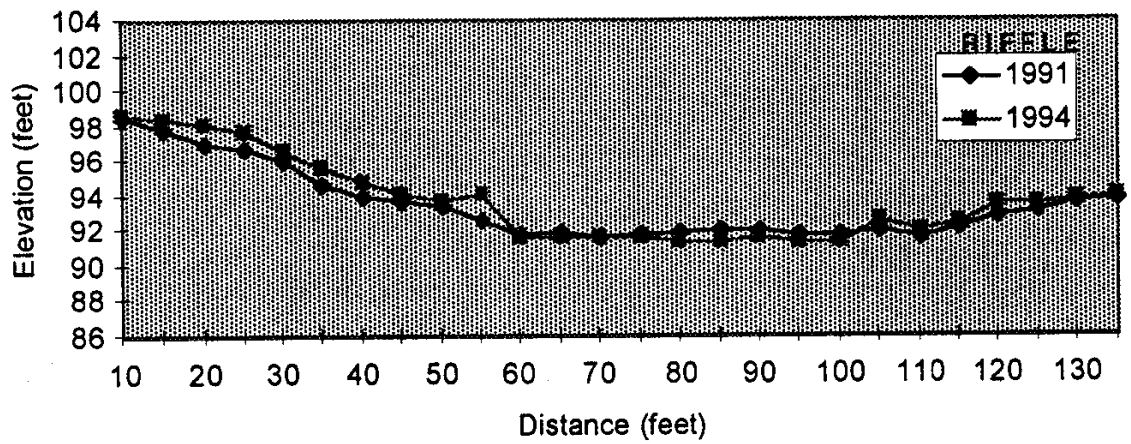
Table 2. Middle Fork Feather River at the Quincy La Porte Road Benthic Macroinvertebrate Community Analyses (Per Square Meter)

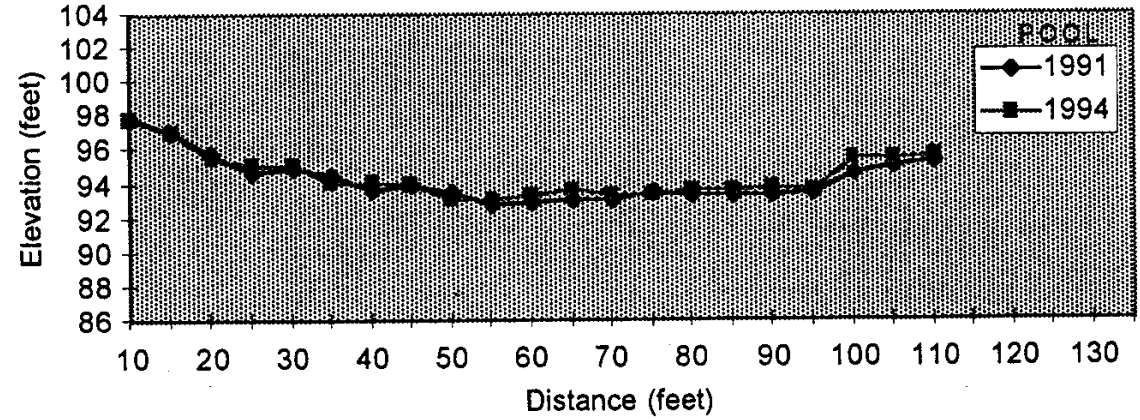
	Date							
	5/91	9/91	6/92	9/92	6/93	9/93	6/94	9/94
No. of Organisms	443	7,345	5,270	4,834	842	20,589	1,391	1,447
No. of Species	30	33	28	26	35	26	30	25
Diversity	3.7	2.5	3.9	3.3	3.6	1.9	3.8	2.3
Equitability	0.62	0.23	0.75	0.53	0.49	0.19	0.66	0.30
Biomass (mL)	-	25.0	48.0	16.0	6.0	114.0	3.8	12.5

Stream Cross Sections - Analysis of stream cross sectional data collected at the Middle Fork Feather River at Portola shows a stable channel since 1991 (Figure 12). Flooding (7,600 cfs) during March 1993 reached to the transect survey monument and resulted in some limited deposition on the terrace and floodplain. This deposition is

Figure 12. Middle Fork Feather River at Portola Stream Cross Sectional Comparisons



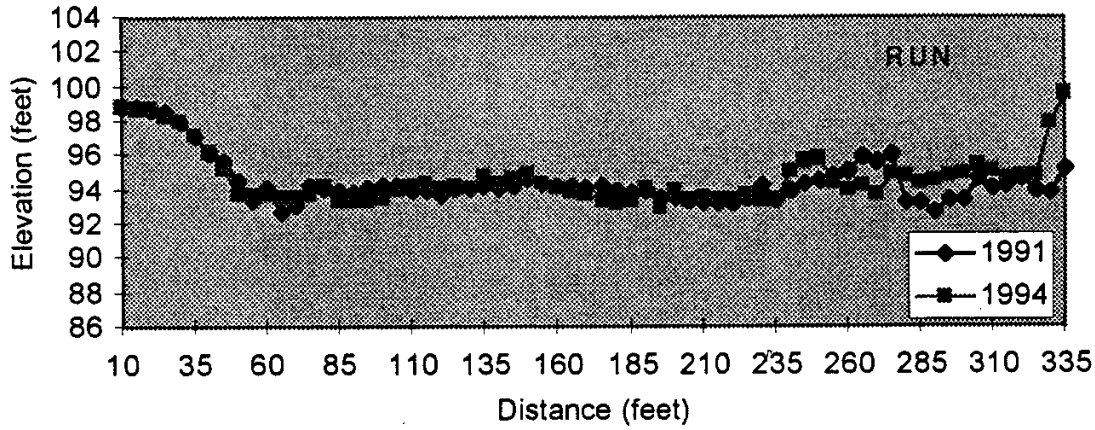




most evident in the pool cross section. Minor scouring of the pool was also observed related to the 1993 flooding.

The Middle Fork Feather River at the Quincy La Porte Road run cross section displays a slightly reduced width and a shifting of the thalweg toward the center of the channel (Figure 13). The riffle cross section has shown an outward migration of the thalweg toward the far end of the transect (275 feet) and the build up or shifting of a bar at approximately 225 feet. The pool cross section has remained relatively stable since 1991. The shallow riffle which slopes into the floodplain (0 to 50 feet) has remained very stable on all three transects suggesting minimal deposition on the floodplain during the study. No clear trend toward either aggradation or degradation is apparent in any of the three transects.

Figure 13. Middle Fork Feather River at the Quincy La Porte Road Stream Cross Sectional Comparisons



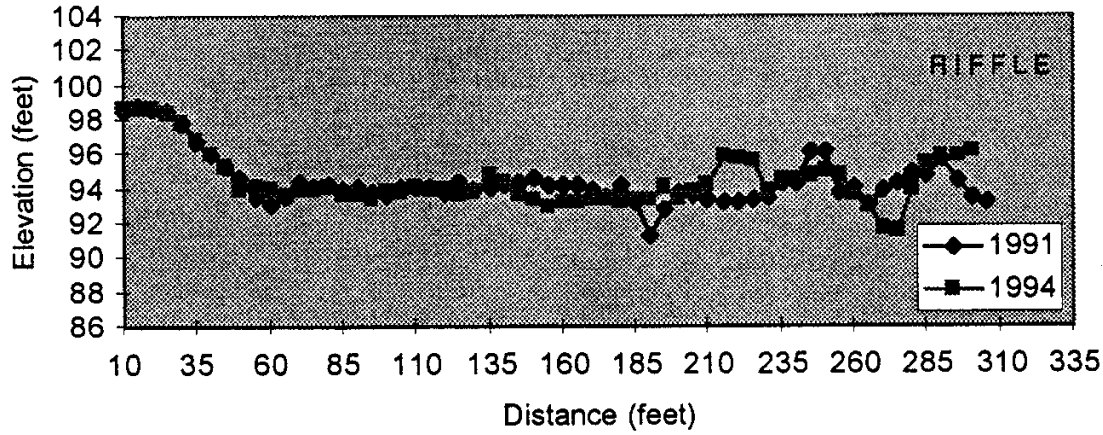
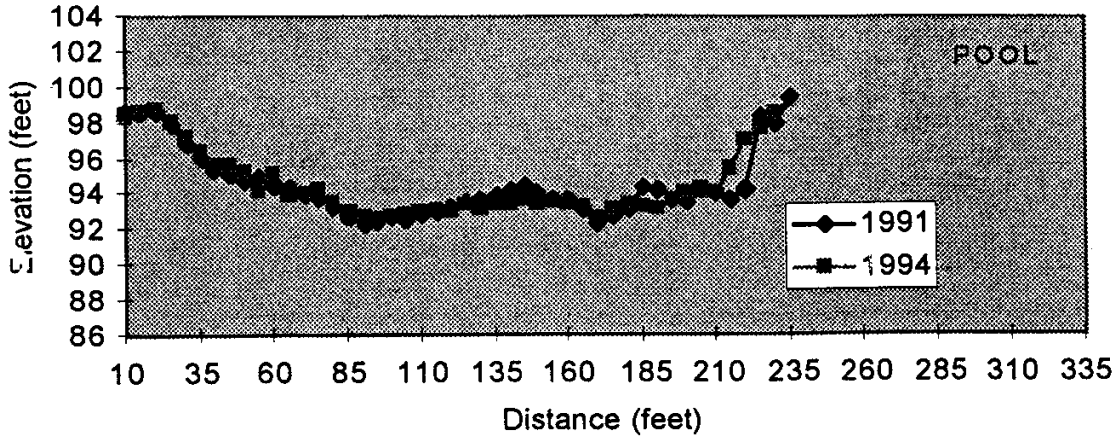
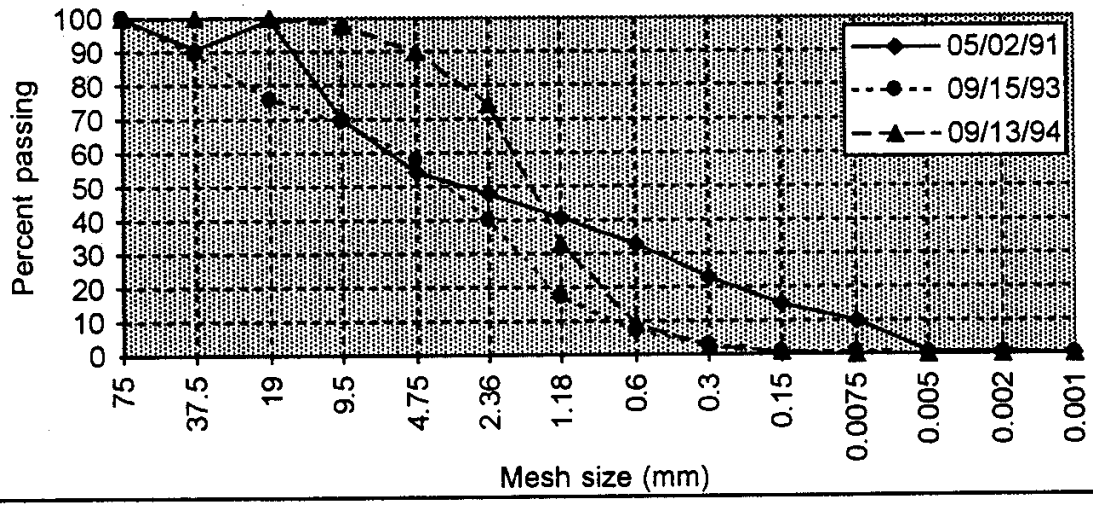


Figure 13. Middle Fork Feather River at the Quincy La Porte Road Stream Cross Sectional Comparisons (Continued)



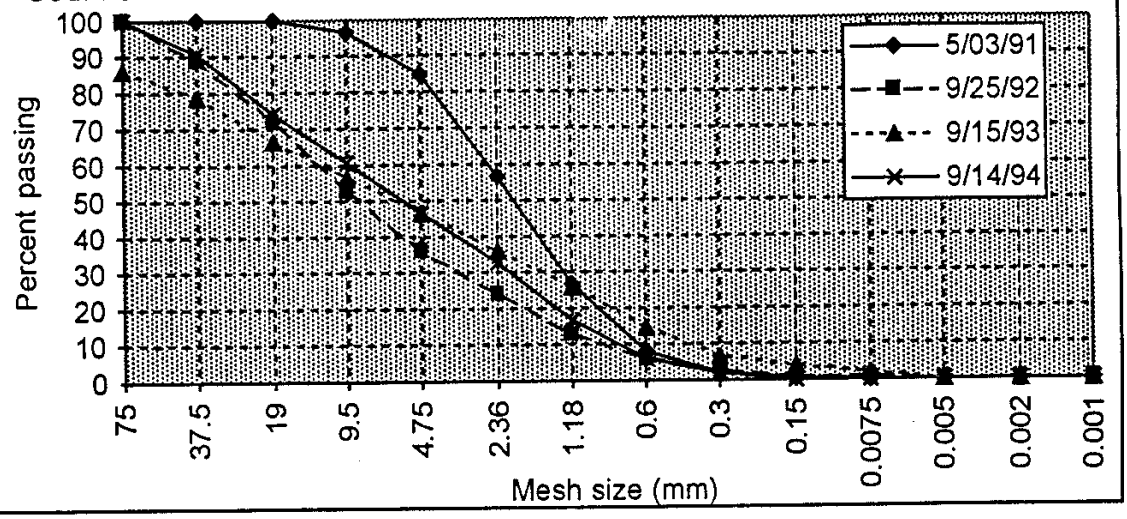
Stream Sediment - Results indicate variable but relatively high percentages of fine sediments in stream substrates at the Portola stream monitoring station ranging from 7 to 33 percent (Figure 14). These levels of fine materials in stream sediments can impair reproductive success of substrate spawning fish. The highest level of fine sediments was present during 1991. The percentage of fine materials decreased substantially following the 1993 high flows. The results of 1992 sampling were discarded because a sample container leaked during storage.

Figure 14. Middle Fork Feather River at Portola Sediment Particle Size Distribution



The amount of fine sediments present at the Quincy La Porte Road station have been relatively stable throughout the four years sampled, ranging from five to eight percent by weight (Figure 15). These levels of fine material are slightly greater than those known to adversely affect substrate spawning fish. These levels are substantially less than the 33 percent present at Portola in 1991, but very similar to levels detected in post-1991 sampling at Portola. Levels of fine materials in spawning gravels at both sites could adversely influence cold water fishery beneficial uses.

Figure 15. Middle Fork Feather River at the Quincy La Porte Road Sediment Particle Size Distribution



Fish Populations and Habitat - The aquatic monitoring station selected in the Middle Fork Feather River at Portola is a low gradient section with a compacted rubble and boulder substrate (Appendix H). Periphyton growth is abundant. Five fish species were identified at this stream monitoring station including rainbow trout, green sunfish *(Lepomis cyanellus)*, brown trout *(Salmo trutta)*, largemouth bass *(Micropterus salmoides)*, and fathead minnow *(Pimephales promelas)* (Table 3). Green sunfish were numerically dominant in every year sampled except 1994 when fathead minnows were first identified. Trout populations remained at low levels throughout the period sampled possibly due to the high stream temperatures present during low flow conditions. Populations and biomass of rainbow trout, green sunfish, and brown trout have generally decreased since 1991 at this station. A very limited number of juvenile largemouth bass were captured annually.

Stream flow at the Portola monitoring station is largely controlled by upstream releases from Lake Davis to Grizzly Creek. Streamflow varied from 5 to 13 cfs on the dates fish populations were sampled. Annual changes in streamflow do not appear to correlate with changes in rainbow trout populations, biomasses, or fork lengths. Similarly, neither benthic macroinvertebrate biomasses nor total numbers per sample

appear related to annual fluctuations in rainbow trout populations, biomasses, or fork lengths.

Table 3. Fish Population Estimates for the Middle Fork Feather River at Portola

Year	Species	Total Catch	Population Estimate	Confidence Interval	Capture Probability	Biomass (mL)	Average Fork Length (mm)	Number per Stream Mile
1991	green sunfish	23	27	10.4	0.45	291	83.3	1,448
1992	green sunfish	28	44	11.3	0.48	390	87.7	2,359
1993	green sunfish	16	16	2.6	0.80	440	107.6	858
1994	green sunfish	12	14	10.2	0.44	75	67.1	750
1991	rainbow trout	10	11	5.4	0.50	135	92.5	589
1992	rainbow trout	6	6	3.5	0.55	136	112.5	321
1993	rainbow trout	1	1	-	-	95	204.0	53
1994	rainbow trout	6	6	1.7	0.67	50	86.0	322
1991	brown trout	3	3	5.4	0.50	89	103.6	160
1992	brown trout	0	0	-	-	0	0.0	0
1993	brown trout	1	1	-	-	200	263.0	53
1994	brown trout	2	2	13.2	0.50	30	108.0	107
1991	largemouth bass	1	1	-	-	8	52.0	53
1992	largemouth bass	2	2	4.9	0.67	89	152.0	107
1993	largemouth bass	3	3	5.5	0.50	10	63.3	160
1994	largemouth bass	3	3	5.4	0.50	40	99.0	161
1991	fathead minnow	0	0	-	-	0	0.0	0
1992	fathead minnow	0	0	-	-	0	0.0	0
1993	fathead minnow	0	0	-	-	0	0.0	0
1994	fathead minnow	13	16	13.8	0.41	35	54.8	858

The Middle Fork Feather River at the Quincy La Porte Road monitoring site is a low to moderate gradient stream section with a gravel and rubble substrate. Four species were collected during population sampling at this station, including rainbow trout, brown trout, Sacramento sucker *(Catostomus occidentalis)*, and California roach *(Hesperoleucas symmetricus)* (Table 4). Rainbow trout were numerically dominant during 1992 and 1993 while Sacramento suckers dominated during 1991 and 1994. Brown trout and California roach were only present in 1991 and 1994, respectively. No clear population or biomass trends were exhibited for any of the species sampled at this site. However, rainbow trout biomass measurements decreased from 945 mL in

1991 to 66 mL in 1994. The factors responsible for the decreased biomass in rainbow trout in this stream section remain unidentified.

Table 4. Fish Population Estimates for the Middle Fork Feather River at the Quincy La Porte Road

Year	Species	Total Catch	Population Estimate	Confidence Interval	Capture Probability	Biomass (mL)	Average Fork Length (mm)	Number per Stream Mile
1991	rainbow trout	12	13	5.1	0.52	945	145.8	697
1992	rainbow trout	9	9	0.2	0.90	685	147.6	482
1993	rainbow trout	16	31	58.6	0.21	224	83.0	1,662
1994	rainbow trout	2	2	12.1	0.67	66	116.0	107
1991	brown trout	1	1	-	-	100	238.0	53
1992	brown trout	0	0	-	-	0	0.0	0
1993	brown trout	0	0	-	-	0	0.0	0
1994	brown trout	0	0	-	-	0	0.0	0
1991	Sacramento sucker	4	20	328.9	0.07	12	60.0	1,072
1992	Sacramento sucker	2	2	-	-	4	44.0	107
1993	Sacramento sucker	12	12	0.7	0.80	15	37.1	643
1994	Sacramento sucker	3	3	7.6	0.60	-	-	161
1991	California roach	-	-	-	-	0	0.0	0
1992	California roach	-	-	-	-	0	0.0	0
1993	California roach	-	-	-	-	0	0.0	0
1994	California roach	1	1	-	-	2	34.0	54

Due to the size of the river at this location and the limitation of backpack electroshocking, only a portion of the river was sampled. A side channel separated from the main portion of the river by a gravel bar was selected for population sampling. Stream flow was calculated for this side channel rather than the river as a whole. Streamflow shows a positive correlation (r=0.85) with rainbow trout populations. No correlations between stream flow and either biomass or fork length were observed.

Paired Station Comparison

Distinct improvement in water quality occurred as the Middle Fork Feather River moved downstream through the cloud seeding project area. Maximum stream temperature decreased and dissolved oxygen levels stabilized within the optimum level for rainbow trout. However, without extensive baseline comparisons, assumptions should not be made that these observed water quality improvements are related to the cloud seeding program. The relatively low turbidity levels present during snow melt do, however, indicate that the cloud seeding program did not increase surface or stream bank erosion to the detriment of beneficial uses as feared by project opponents.

Benthic macroinvertebrate community diversity and species richness were substantially higher at the downstream station.

Greater variations in stream geomorphology were present at the downstream station. This result is not unexpected due to the greatly increased drainage area, sediment load, and streamflow at the downstream station. Also, flows to the upstream Portola station are largely regulated by Lake Davis releases.

Initial baseline stream sediment sampling showed a very high percentage of fine materials in spawning gravels at the Portola station. Subsequent sampling revealed decreased levels similar to those present at the downstream station. The percentage of fine materials in riffle environments did not show any correlation with precipitation.

The upstream station exhibited a relatively low potential to support a cold water fishery. Changes in rainbow trout populations at the downstream station exhibited a positive correlation with streamflow. One of the projected (but unquantified) benefits of the cloud seeding program is more streamflow for a longer period of the year.

Willow Creek near Clio and Freeman Creek

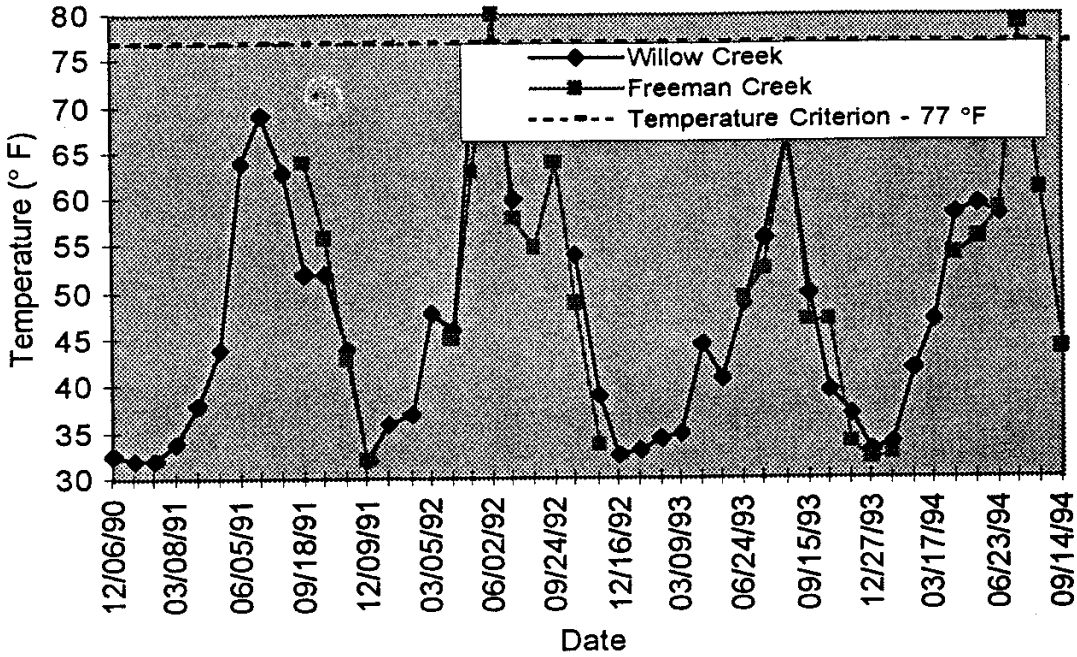
Willow Creek is within the cloud seeding project area while Freeman Creek serves as a control station.

Temperature - Stream temperatures at Willow Creek ranged from 32° F to 77° F. A single temperature measurement greater than 70° F was recorded during June 1992 (Figure 16). This was the only temperature measurement that could impair cold water fish beneficial use.

Freeman Creek stream temperatures ranged from 32° F to 80° F. Stream temperatures greater than those known to be lethal to trout were recorded twice. Freeman Creek, a meadow stream, generally lacks overstory cover and is instead dependent upon streamside willows for shading and water temperature control. Grazing pressure has reduced the quantity and quality of willow cover along a substantial portion of Freeman Creek. A grazing exclosure upstream of the monitoring

station has successfully allowed willow regrowth and establishment to occur along part of the stream channel. Extension of the grazing enclosure to include the entire meadow riparian zone may be necessary to eliminate lethal stream temperatures in Freeman Creek.

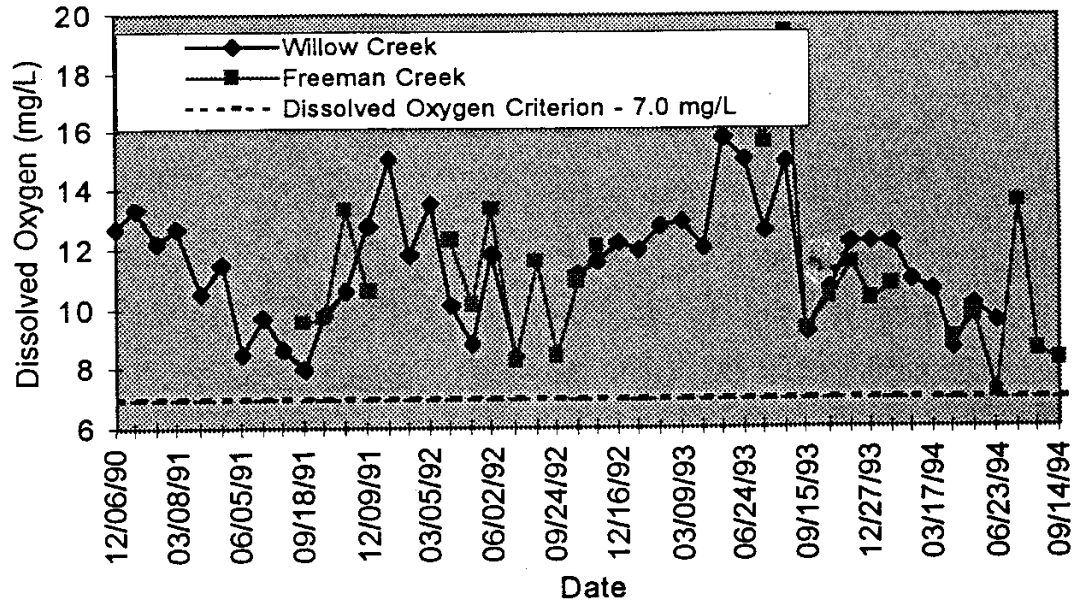
Figure 16. Comparison of Stream Temperatures from Willow Creek near Clio and Freeman Creek



Dissolved Oxygen - Dissolved oxygen levels recorded at Willow Creek ranged from 8.0 to 15.8 mg/L (Figure 17). All dissolved oxygen concentrations were suitable for all beneficial uses.

Freeman Creek dissolved oxygen levels ranged from 7.1 to 19.4 mg/L. Approximately 12 percent of the dissolved oxygen measurements were outside the optimal range for rainbow trout. Extensive periphyton growth within this stream resulted in supersaturated dissolved oxygen concentrations (sometimes greater than 225 percent) during summer and early fall afternoons. No diurnal dissolved oxygen sampling was conducted. However, a sample collected during June 1994 at 0715 PST had a dissolved oxygen concentration of 7.1 mg/L which probably reflects the influence of diurnal periphyton respiration.

Figure 17. Comparison of Dissolved Oxygen Concentrations from Willow Creek near Clio and Freeman Creek



pH - pH levels masured at Willow Creek ranged between 7.2 and 8.2 (Figure 18) with an average of 7.6. These levels are suitable for beneficial uses.

Freeman Creek pH levels ranged from 7.0 to 8.6.

Conductivity - Conductivity at Willow Creek varied widely ranging from 48 to 231 µmhos/cm (Figure 19). Conductivity values less than 100 µmhos/cm were uncommon and always associated with snow melt runoff. Conductivity levels greater than 200 µmhos/cm were restricted to low flow conditions. Conductivity levels greater than RWQCB objectives occurred on 63 percent of the dates sampled.

Conductivity measurements at Freeman Creek ranged from 61 to 189 µmhos/cm. Lower conductivity values were generally associated with snow melt periods while higher levels did not necessarily correspond with the lowest streamflow. Conductivity levels greater than RWQCB objectives occurred on 38 percent of the dates sampled.

Turbidity - Willow Creek turbidities ranged from 0.2 to 14 NTU (Figure 20). Approximately 7 percent of the dates sampled exceeded the EPA turbidity standard. One turbidity greater than 10 NTU was encountered during a minor rain on snow event on January 21, 1993. A short-term turbidity level of 14 NTU is not a threat to aquatic life. A Plumas County Road Department borrow area is immediately upstream from

Figure 18. Comparison of pH Values from Willow Creek near Clio and Freeman Creek

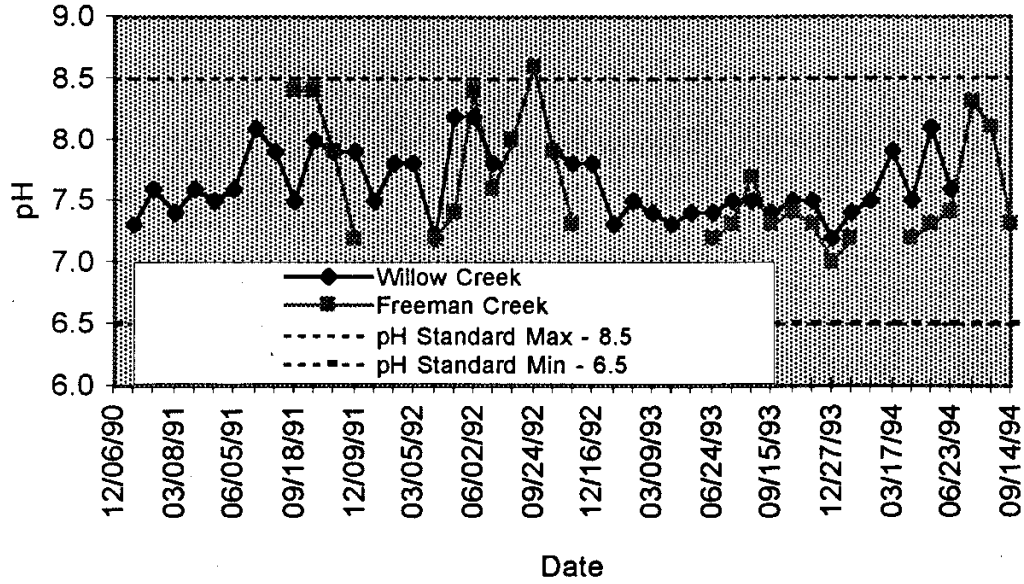
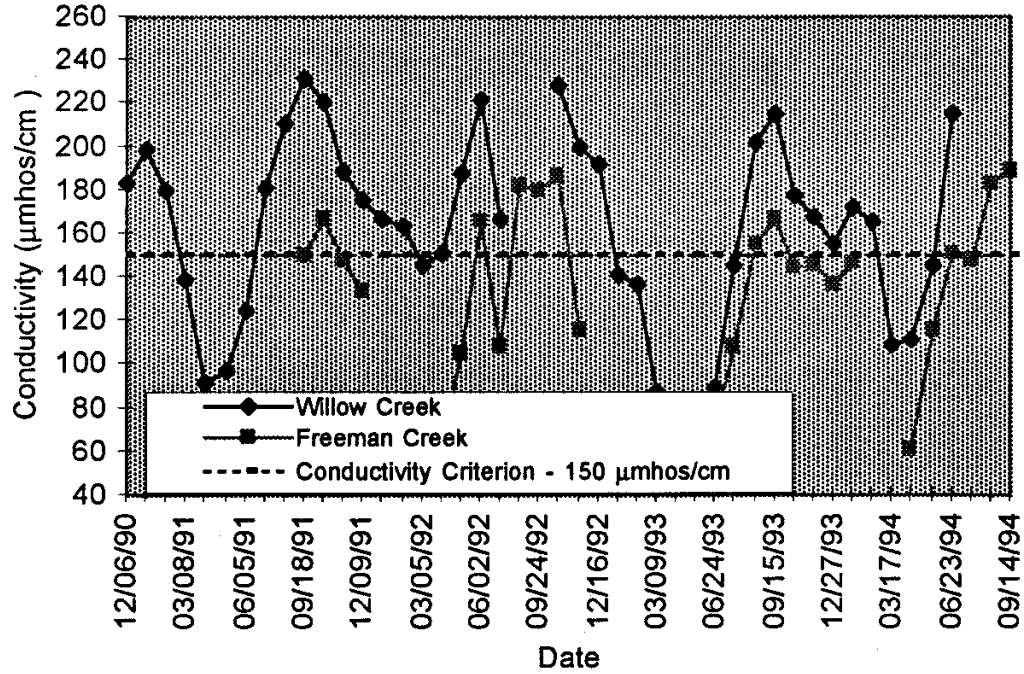
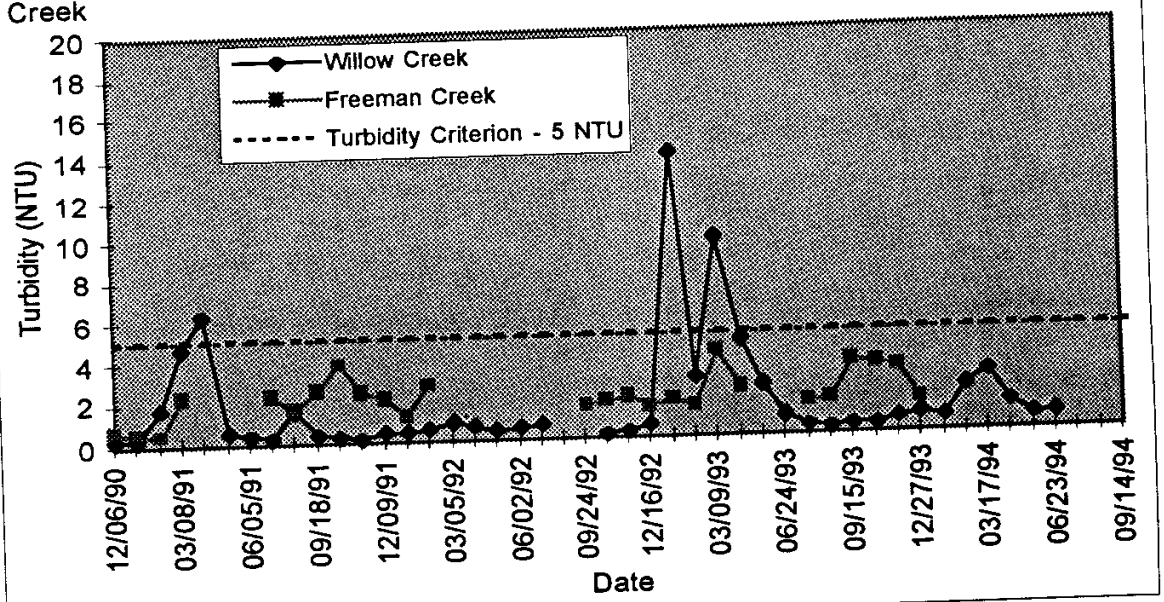


Figure 19. Comparison of Conductivity Values from Willow Creek near Clio and Freeman Creek



the sampling location. Extensive erosion and sedimentation have occurred within the borrow area and may be factors in the elevated turbidity levels at this site. Freeman Creek turbidity levels ranged from 0.5 to 4.2 NTU. These turbidity levels are suitable for the maintenance of aquatic life.

Figure 20. Comparison of Turbidity Values from Willow Creek near Clio and Freeman Creek



Alkalinity - Alkalinity levels ranged from 28 to 110 mg/L at Willow Creek near Clio (Figure 21). Higher alkalinity values were present during low flow conditions while lower alkalinity values were common during snow melt periods. Alkalinity values detected were suitable for beneficial use.

Freeman Creek alkalinity levels ranged from 33 to 104 mg/L. Alkalinity values followed a pattern similiar to that at Willow Creek. Alkalinity levels detected were suitable for beneficial uses.

Nutrient Concentrations - The highest Willow Creek dissolved ammonia level (0.05 mg/L) (Figure 22) was present during a period of low flow. The greatest concentrations of total phosphorus (0.08 mg/L), dissolved organic nitrogen (0.3 mg/L), and dissolved nitrate (0.06 mg/L) occurred during a 1993 January rain on snow event (Figures 23, 24, and 25). Nutrient concentrations were suitable for all beneficial uses.

Freeman Creek nutrient concentrations were similar to those observed in Willow Creek. Dissolved ammonia concentrations above detection limits were uncommon and ranged to a maximum of 0.07 mg/L. Maximum total phosphorus and dissolved nitrate concentrations were slightly less than those recorded at Willow Creek at 0.03 and 0.04 mg/L, respectively. The maximum dissolved organic nitrogen level (0.3

mg/L) was identical at Freeman and Willow creeks. Freeman Creek nutrient concentrations were suitable for all beneficial uses.

Figure 21. Comparison of Alkalinity Values from Willow Creek near Clio and Freeman Creek

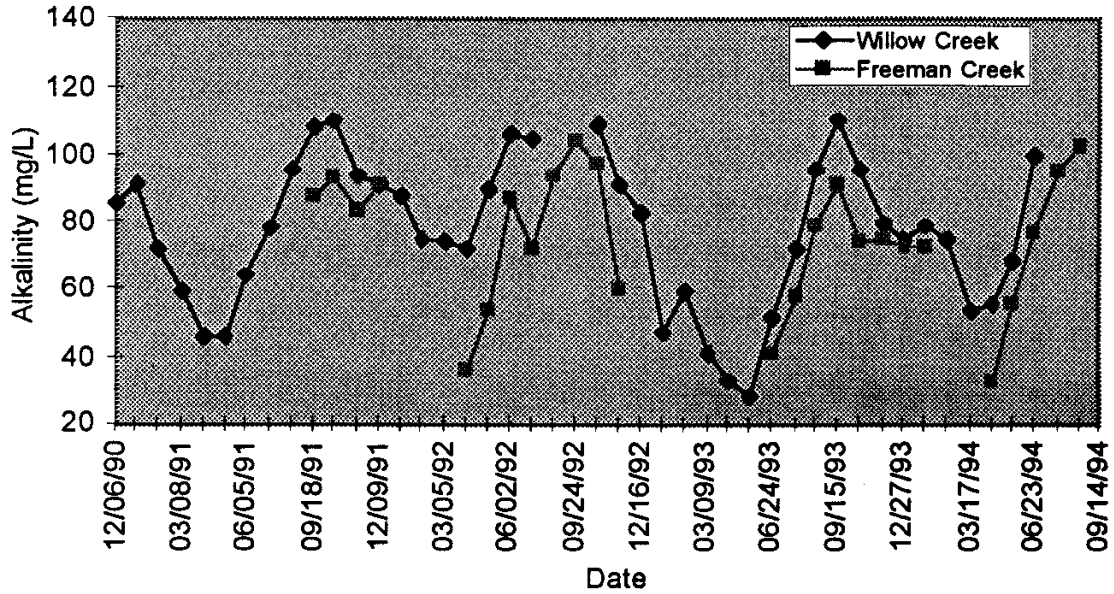


Figure 22. Comparison of Dissolved Ammonia Concentrations from Willow Creek near Clio and Freeman Creek

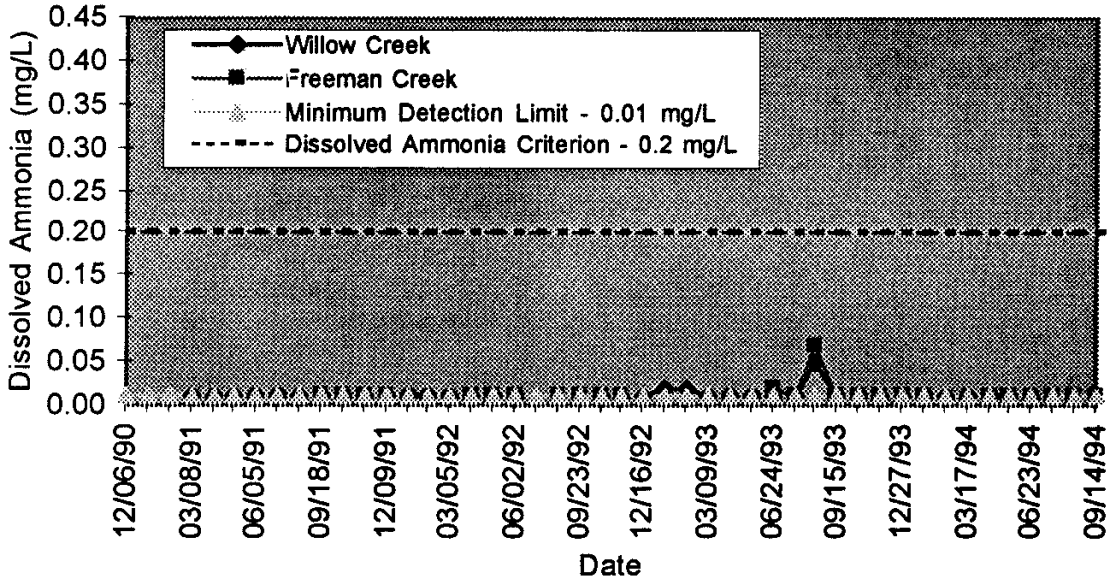


Figure 23. Comparison of Total Phosphorus Concentrations from Willow Creek near Clio and Freeman Creek

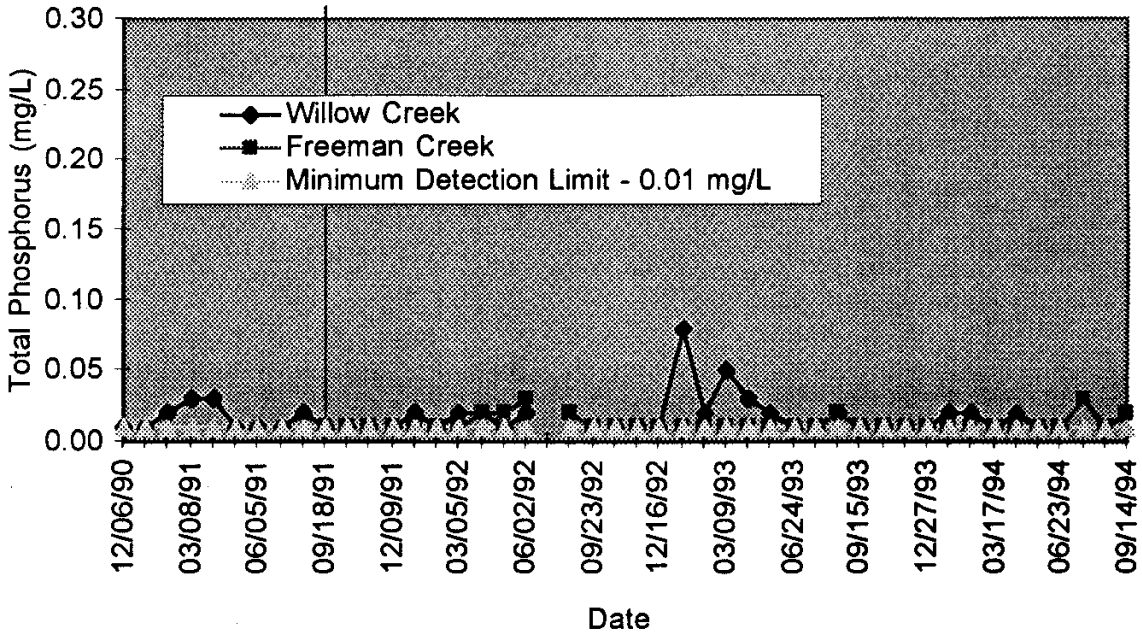


Figure 24. Comparison of Dissolved Organic Nitrogen Concentrations from Willow Creek near Clio and Freeman Creek

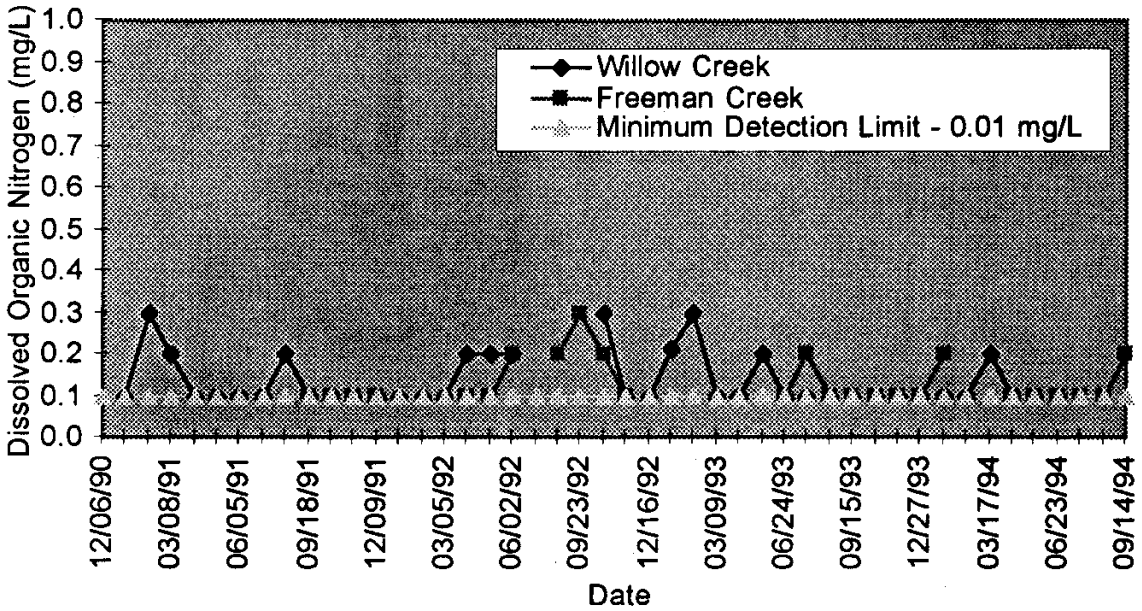
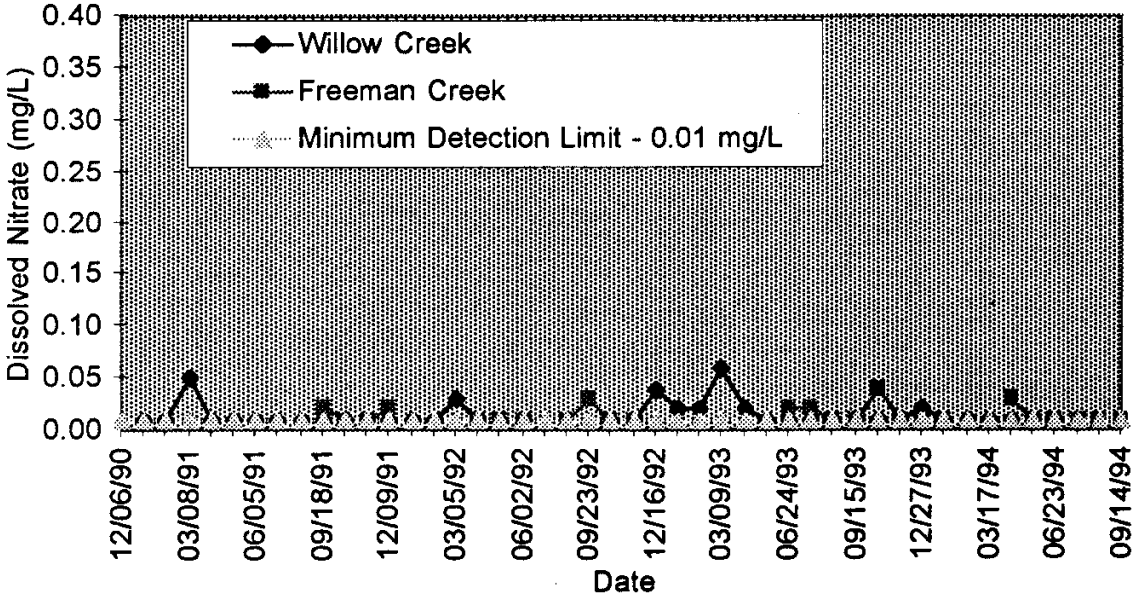


Figure 25. Comparison of Dissolved Nitrate Concentrations from Willow Creek near Clio and Freeman Creek



Benthic Macroinvertebrates - The benthic macroinvertebrate community at Willow Creek near Clio (Table 5) was subjected to drastic changes in environmental conditions during this study. Willow Creek went dry at the sampling location during summer/fall 1992 and 1994. The total number of organisms ranged from 0 to 4,017 with the greatest number of individuals present during spring sampling. Species richness ranged from 0 to 40 species with generally greater species richness during spring sampling. Species diversity ranged from 0.0 to 4.1. Biomass measurements ranged from 0.0 to 32.0 mL. Biomass was always greater in spring samples and averaged 19.8 mL. Samples collected in spring 1993, after the site was dry in September 1992, reveal near average total species numbers, species richness, and above average diversity indicating rapid recolonization following stream desiccation.

The riffle environments sampled for benthic macroinvertebrates at Freeman Creek were shallow, primarily mud substrate with limited small gravels, and extensive emergent vegetation and periphyton growth. These riffle environments are unlike those present at Willow Creek or any of the other benthic sampling sites. These microhabitat differences influence the benthic macroinvertebrate species present and reduce the value of comparison of benthic communities at these paired stations.

Table 5. Willow Creek near Clio Benthic Macroinvertebrate Community Analyses (Per Square Meter)

	Date							
	5/91	9/91	6/92	9/92	6/93	9/93	6/94	9/94
No. of organisms	1,891	1,490	4,017	*	2,420	766	994	*
No. of Species	28	38	40	*	32	26	35	*
Diversity	2.3	3.7	3.5	*	3.5	2.4	4.1	*
Equitability	0.25	0.49	0.42	*	0.53	0.28	0.71	*
Biomass (mL)	-	6.0	32.0	*	-	3.0	7.5	*

* dry no sample

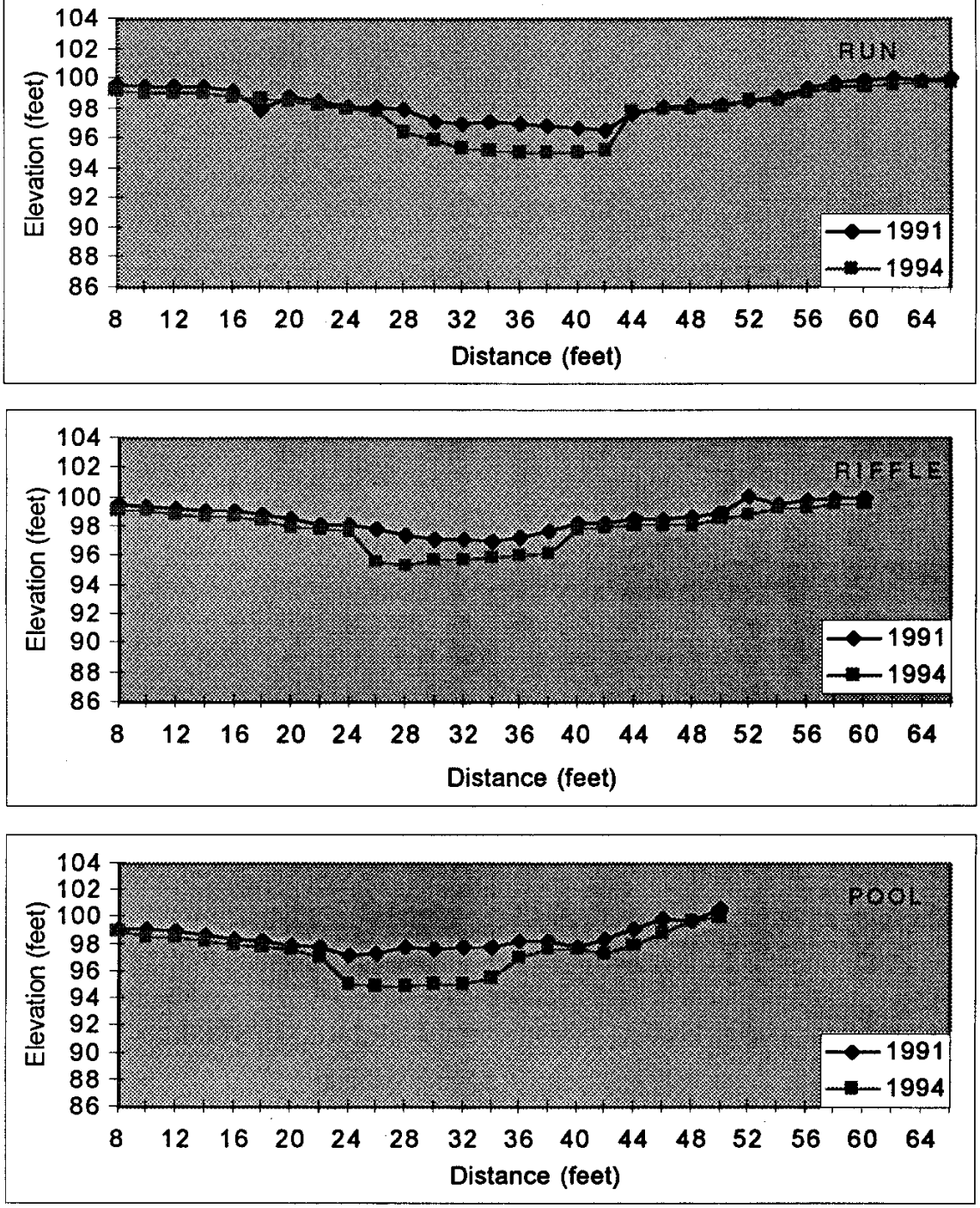
The total number of organisms present at Freeman Creek ranged from 416 to 3,216 per square meter (Table 6). The average number of organisms was over twice as great in spring samples as in fall samples. Species richness ranged from 15 to 47. Species diversity values ranged from 1.6 to 3.5. Benthic biomass measurements ranged from 1.5 to 11.0 mL per square meter. Relatively high number of organisms (3,216), low species richness (15), low diversity (1.6), and low equitability (0.25) were apparent in June 1993 samples. These conditions reflect a recovering ecosystem. High flows associated with snow melt may have scoured benthic populations from the stream channel. Normally snow melt occurs slowly over time in watersheds due to the differences in melting rates produced by aspect, elevation, and forest cover. The Freeman Creek watershed contains an extensive open, flat, meadow habitat. Snow melt under these condition occurs over a much shorter time period resulting in characteristically flashy peak flows in the snow melt hydrograph. Evidence of overbank flow was evident at the sampling site in 1993.

Table 6. Freeman Creek Benthic Macroinvertebrate Community Analyses (Per Square Meter)

	Date							
	5/91	9/91	6/92	9/92	6/93	9/93	6/94	9/94
No. of Organisms	-	1,451	1,975	1,956	3,216	1,042	2,355	416
No. of Species	-	26	47	33	15	25	38	31
Diversity	-	2.6	3.5	2.7	1.6	3.3	2.9	3.5
Equitability	-	0.32	0.34	0.28	0.25	0.56	0.27	0.51
Biomass (mL)	-	2.8	4.0	11.0	8.0	2.0	4.8	1.5

Stream Cross Sections - All three Willow Creek stream cross sections show severe stream down-cutting and widening since 1991 (Figure 26). Average channel down-cutting of 1.6 feet and widening over 2.0 feet are apparent on all three cross sectional comparisons. Local residents report that the stream channel had moved during a 1986 storm. The new channel has been head-cutting from the control point at the culvert on the county road. The head-cut has eroded past each of the three stream cross sections and the channel will continue to widen as the banks slough toward the

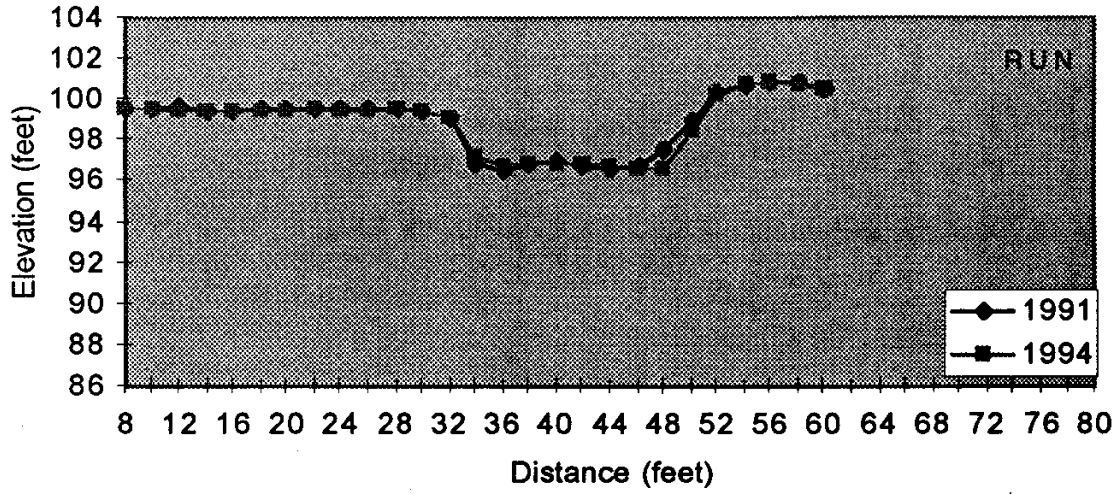
Figure 26. Willow Creek near Clio Stream Cross Sectional Comparisons



angle of repose. Major stream alterations in stream cross sections are believed to be related to major storm events and high peak flows. The erosion at this site took place in the absence of major high flows and represents the stream channel moving toward equilibrium from changes produced by the 1986 storm.

Freeman Creek stream cross sectional data reveal a very stable channel with little detectable change in stream dimensions (Figure 27).

Figure 27. Freeman Creek Stream Cross Sectional Comparisons



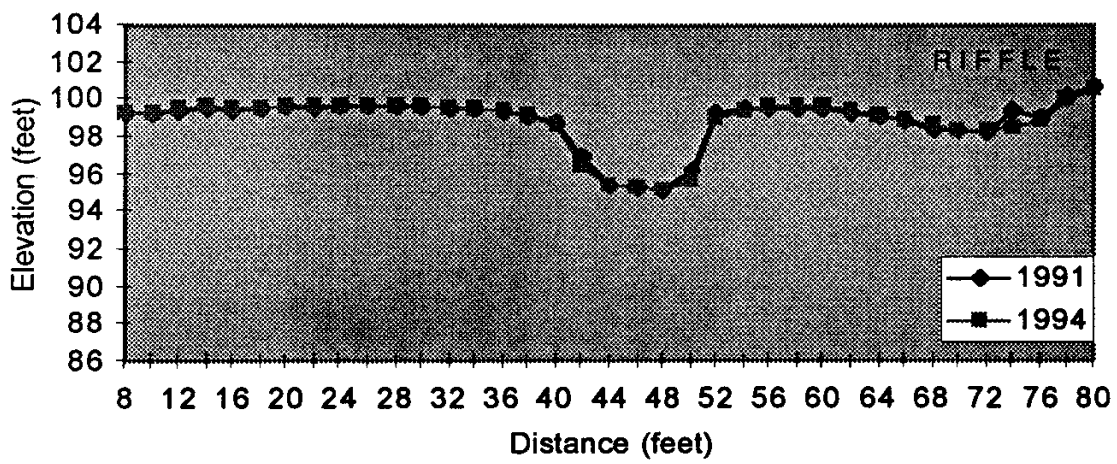
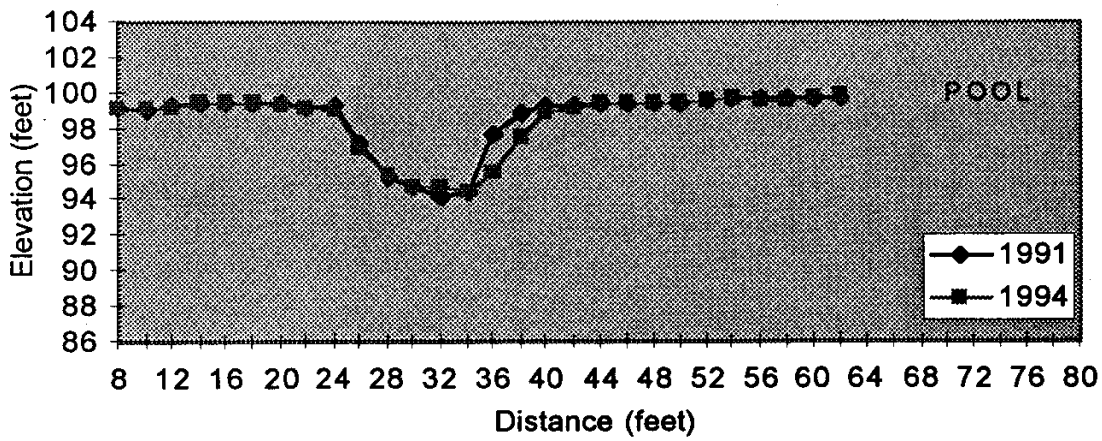
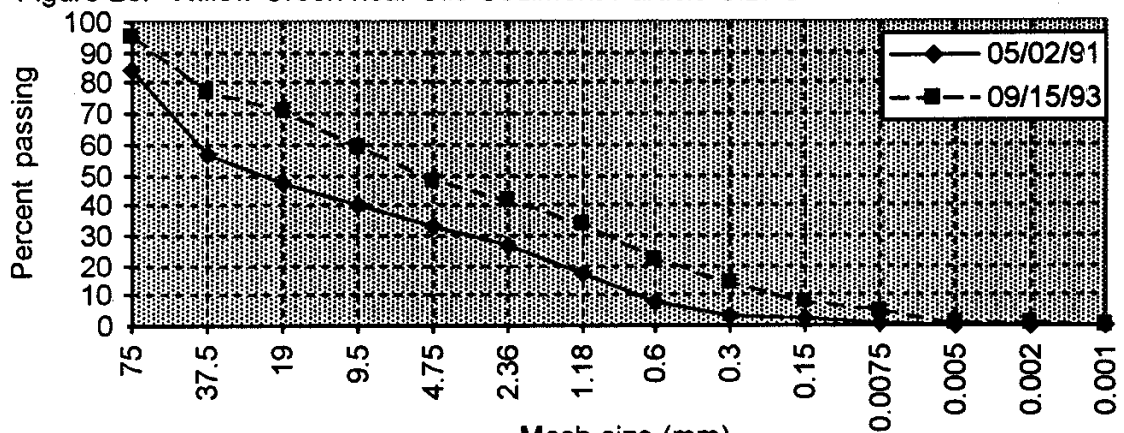


Figure 27. Freeman Creek Stream Cross Sectional Comparison (Continued)



Stream Sediment - The level of fine materials in Willow Creek stream sediments indicate a substantial increase over time from 8 percent in 1991 to 22 percent in 1993 (Figure 28). The trend toward increasing level of fine materials at this site should be expected to continue as the stream channel head-cuts and widens through old floodplain deposits. The current level of fine materials in spawning gravels are approximately four times levels known to impair reproductive success of substrate spawning fish species.

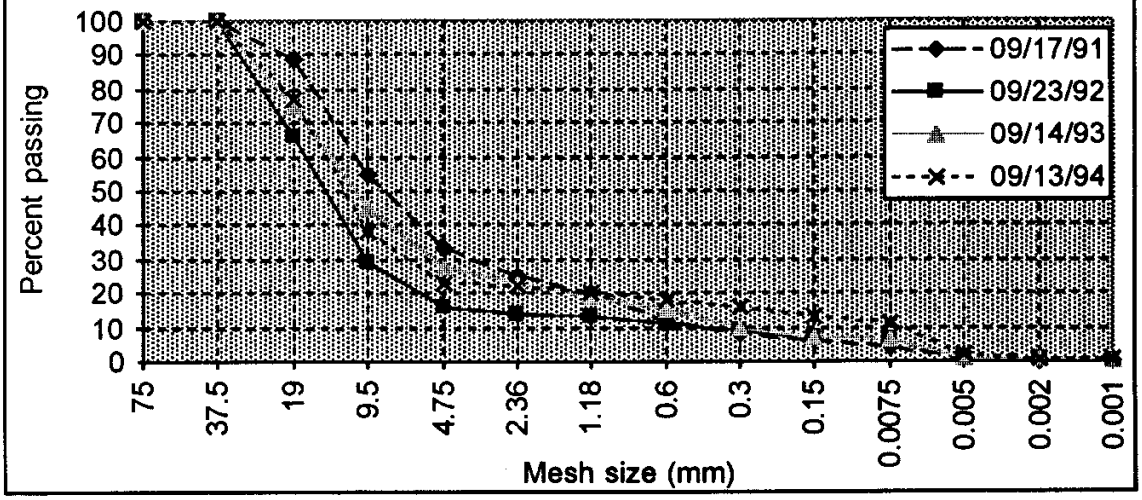
Figure 28. Willow Creek near Clio Sediment Particle Size Distribution



The level of fine materials in spawning gravels at the Freeman Creek stream monitoring station ranged from 11 to 18 percent by weight (Figure 29). These levels are two to three times levels known to adversely impact substrate spawning fish. The amount of fine materials has generally exhibited an increasing trend over time. The

source of the increasing level of fine materials does not appear to be in-channel which is generally stable and well vegetated.

Figure 29. Freeman Creek Sediment Particle Size Distribution



Fish Populations and Habitat - Willow Creek at the aquatic monitoring station is a small, shallow, low gradient stream with sharply incised banks. Substrate composition is largely rubble with some gravels. Only rainbow trout and riffle sculpin were present at the Willow Creek stream monitoring station during sampling (Table 7). Both species were captured in greater numbers during 1993 than during 1991. However, the confidence intervals of population estimates overlap indicating no statistically valid population change in rainbow trout density. Trout biomass was nearly identical during both years sampled. Average fork length decreased slightly over time. Streamflow was drastically lower during 1993 than during 1991 with 0.13 cfs and 1.72 cfs, respectively, but the reduced streamflow did not adversely influence trout numbers in the stream section sampled. Data show that Willow Creek provides nursery habitat for 750 to 1,018 rainbow trout per stream mile.

Changes in Willow Creek fish habitat over time include increased percent sand in the streambed composition, increased instream cover, increased overstory shading, and decreased streamflow.

Freeman Creek is a small tributary to Lake Davis that meanders through several miles of meadow habitat before reaching the aquatic monitoring station. The stream substrate is almost entirely composed of fine sediments with relatively few small patches of shallow gravels suitable for trout spawning. Extensive periphyton growth is present in pools.

Table 7. Fish Population Estimates for Willow Creek near Clio								
Year	Species	Total Catch	Population Estimate	Confidence Interval	Capture Probability	Biomass (mL)	Average Fork Length (mm)	Number per Stream Mile
1991	rainbow trout	12	14	8.2	0.44	44	64.3	750
1992	dry-not sampled	-	-	-	-	-	-	0
1993	rainbow trout	19	19	1.0	0.91	43	56.4	1,018
1994	dry-not sampled	-	-	-	-	-	-	0
1991	riffle sculpin	0	0	-	-	0	0.0	0
1992	dry-not sampled	-	-	-	-	-	-	0
1993	riffle sculpin	2	2	12.7	0.67	2	41.0	107
1994	dry-not sampled	-	-	-	-	-	-	0

Six species of fish have been identified at the Freeman Creek stream monitoring station (Table 8). These species include rainbow trout, Lahontan redside *(Richardsonius eregius)*, tui chub *(Gila bicolor)*, speckled dace *(Rhinichthys osculus)*, Sacramento sucker, and green sunfish. Rainbow trout population estimates ranged from 321 to 6,617 fish per stream mile. Rainbow trout population estimates exhibited a strong positive correlation with streamflow (r=0.975). Numerous factors related to increased streamflow (i.e., access for lake run spawners, cooler water temperatures, and more nursery habitat) probably influence the higher recruitment of rainbow trout in 1993. Lahontan redsides are the dominant species in terms of both biomass and total population. During 1994, the populations of green sunfish, Sacramento sucker, and Lahontan redside exceeded that of rainbow trout. The factors responsible for the presence of green sunfish in large numbers at the sampling location only during 1994 are unknown.

Paired Station Comparison

Stream temperatures greater than those known to be lethal to trout were observed in Freeman Creek, while all Willow Creek temperatures measured were suitable for cold water fisheries beneficial uses. Willow Creek dissolved oxygen concentrations remained within optimal levels throughout the sampling. Greater dissolved oxygen fluctuations were present in Freeman Creek with less than optimal dissolved oxygen levels present in about 12 percent of the samples. The pH levels encountered at both stations were suitable for beneficial uses. Conductivity levels detected at both aquatic monitoring stations were suitable for beneficial uses. However, levels greater than RWQCB objectives were documented in each stream. Much higher turbidity levels were present during high runoff storm events at Willow Creek but Freeman Creek turbidity measurements indicated greater average levels. The elevated turbidity levels present at the Willow Creek monitoring station during high runoff events may be

Table 8. Fish Population Estimates for Freeman Creek								
Year	Species	Total Catch	Population Estimate	Confidence Interval	Capture Probability	Biomass (mL)	Average Fork Length (mm)	Number per Stream Mile
1991	rainbow trout	6	6	1.7	0.67	44	68.0	321
1992	rainbow trout	12	12	1.1	0.75	199	103.8	643
1993	rainbow trout	102	115	15.7	0.66	255	58.5	6,617
1994	rainbow trout	25	26	5.3	0.76	175	82.3	1.393
1991	Lahontan redside	56	65	13.7	0.48	210	67.3	3,485
1992	Lahontan redside	74	83	12.0	0.52	352	59.2	4,451
1993	Lahontan redside	305	383	102.2	0.44	640	49.2	20,528
1994	Lahontan redside	305	369	85.4	0.58	675	50.0	19,778
1991	tui chub	8	8	1.2	0.73	22	54.8	429
1992	tui chub	0	0	-	-	0	0.0	0
1993	tui chub	0	0	-	-	0	0.0	0
1994	tui chub	0	0	-	-	0	0.0	0
1991	speckled dace	0	0	-	-	0	0.0	0
1992	speckled dace	41	62	40.3	0.30	49	51.4	3,325
1993	speckled dace	0	0	-	-	0	0.0	0
1994	speckled dace	0	0	-	-	0	0.0	0
1991	Sacramento sucker	0	0	-	-	0	0.0	0
1992	Sacramento sucker	0	0	-	-	0	0.0	0
1993	Sacramento sucker	8	12	22.9	0.39	15	53.8	643
1994	Sacramento sucker	6	30	439.6	0.10	57	90.5	1,608
1991	green sunfish	0	0	-	-	0	0.0	0
1992	green sunfish	0	0	-	-	0	0.0	0
1993	green sunfish	0	0	-	-	0	0.0	0
1994	green sunfish	22	110	854.6	0.10	135	62.0	5,896

influenced by erosion at the borrow area immediately upstream and do not appear to be related to the cloud seeding program. Alkalinity levels were similar between these paired stations and suitable for beneficial use.

Nutrient concentrations were similiar on most dates sampled, and all concentrations were suitable for beneficial uses.

Impacts to the benthic macroinvertebrate communities at both stations were observed. Willow Creek went dry during late summer/fall 1992 and 1994. The

Freeman Creek benthic community exhibited a species composition characteristic of a recovering community during June 1993. The initial stress to the community may be related to spring high flow scour of the benthic community.

Cross sectional comparison of these two stations reveal stable stream channel conditions at Freeman Creek. Willow Creek cross sections were drastically altered with both substantial channel widening and deepening apparent. These changes are in response to channel movement related to a 1986 rain-on-snow storm event. The new channel has head-cut from the culvert control point through the old floodplain. The observed channel degradation at this site was not initiated by the cloud seeding project as the channel movement occurred before activation of the DWR program.

Both aquatic monitoring stations exhibit trends toward increased percentage of fine materials in riffle substrates over time. The level of fine materials in both streams is over three times levels known to adversely influence substrate spawning fish.

Willow Creek fisheries population data (excluding 1992 and 1994 when dry) indicate relatively stable rainbow trout populations. Freeman Creek trout populations and biomass have remained greater than baseline levels in every subsequent sampling.

Nelson Creek at the Quincy La Porte Road and Onion Valley Creek near the Mouth

The Nelson Creek drainage is largely within the cloud seeding project area while Onion Valley Creek serves as a control station.

Temperature - Stream temperatures at Nelson Creek ranged from 32° F to 64° F and were excellent for cold water beneficial uses (Figure 30). Nelson Creek flows are instrumental in maintaining cooler water temperatures in the Middle Fork Feather River below their confluence (USFS 1982).

Stream temperatures in Onion Valley Creek ranged from 39° F to 67° F. This temperature regime is excellent for cold water fishery beneficial uses and undoubtedly helps maintain cooler water temperatures in the receiving Middle Fork Feather River. Both Onion Valley Creek and Nelson Creek drain higher elevations, and spring/early summer water temperatures are strongly influenced by snow melt. Minimum stream temperatures at Onion Valley Creek are relatively higher than Nelson Creek due to a sampling artifact. Onion Valley Creek was inaccessible (thus not sampled) during the winter. All of the water quality comparisons at these paired stations were influenced by this reduced comparative sampling.

Dissolved Oxygen - Dissolved oxygen concentrations at Nelson Creek ranged from 6.2 to 18.1 mg/L (Figure 31). The low dissolved oxygen is outside of the optimal range for rainbow trout. Only one other dissolved oxygen concentration less than optimum was detected at this station. All dissolved oxygen concentrations met the Regional Water Quality Control Board objective.

Figure 30. Comparison of Stream Temperatures from Nelson Creek at the Quincy La Porte Road and Onion Valley Creek near Mouth

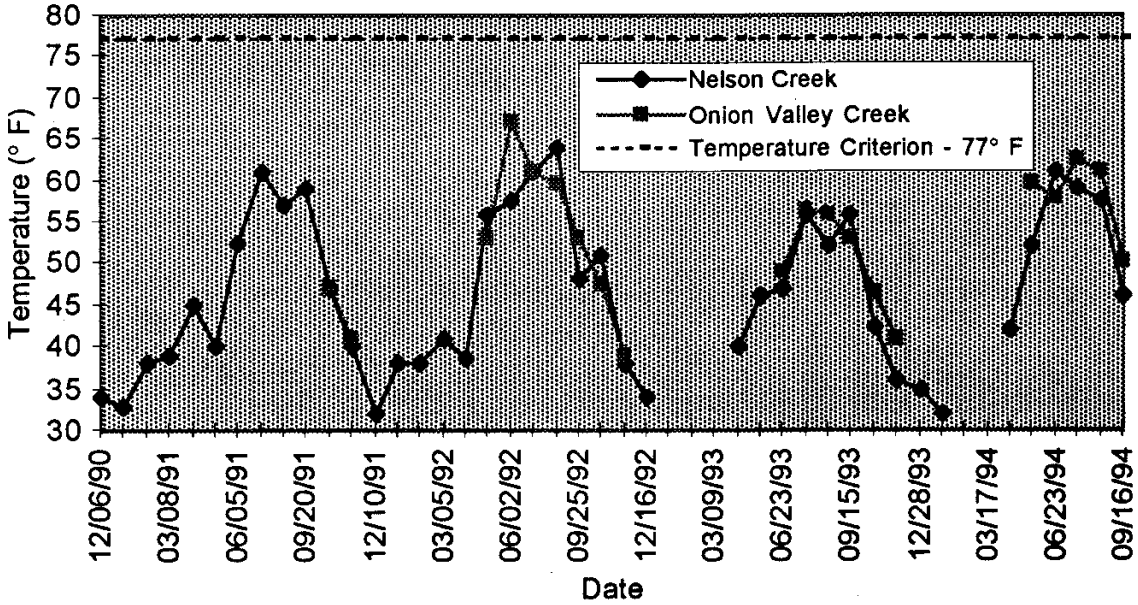
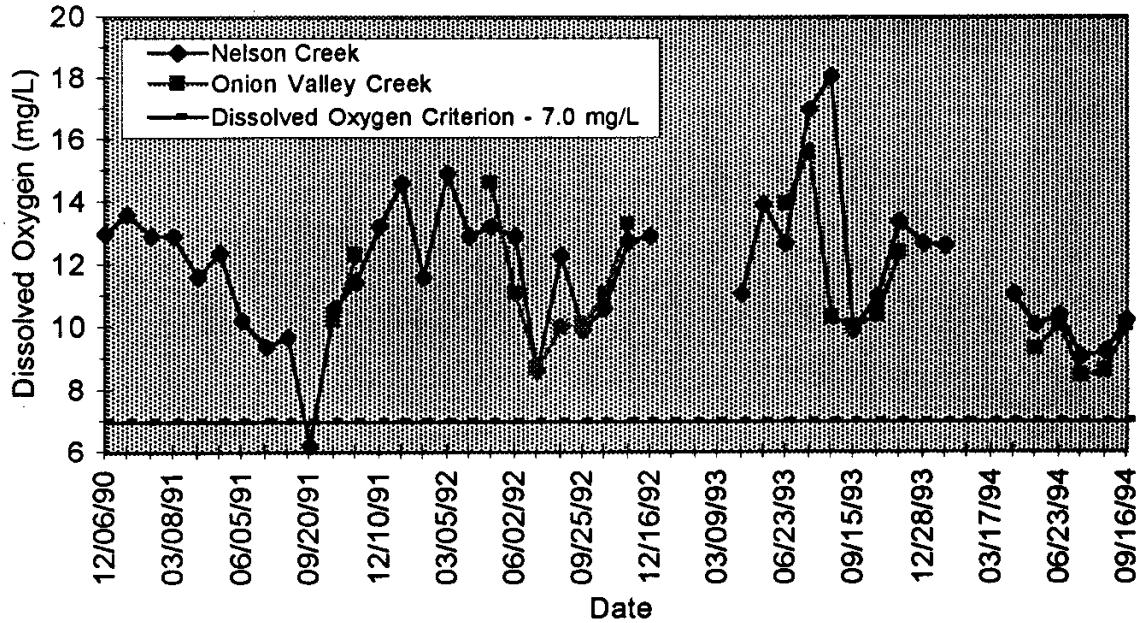


Figure 31. Comparison of Dissolved Oxygen Concentrations from Nelson Creek at the Quincy La Porte Road and Onion Valley Creek near Mouth



Dissolved oxygen levels at Onion Valley Creek ranged from 8.5 to 15.6 mg/L. Average dissolved oxygen concentrations were similar to those obtained at Nelson Creek. Dissolved oxygen levels at Onion Valley Creek were generally within the optimum range for rainbow trout.

pH - Nelson Creek pH measurements exhibited minimal variability ranging from 7.3 to 8.3 (Figure 32). These pH levels are suitable for all beneficial uses.

The range of pH values (7.0 to 8.3) obtained at Onion Valley Creek was nearly identical, but slightly more acidic than the Nelson Creek range.

Conductivity - Conductivity values obtained from sampling Nelson Creek ranged from 63 to 188 µmhos/cm (Figure 33). Nelson Creek conductivity values exceeded RWQCB objectives in 46 percent of the samples collected.

Onion Valley Creek conductivity values ranged from 66 to 197 µmhos/cm. Onion valley conductivity values exceeded the RWQCB objective of 150 µmhos/cm in 70 percent of the samples. Conductivity values at both monitoring stations were suitable for beneficial uses.

Turbidity - Nelson Creek turbidity levels were extremely low, ranging from 0.5 to 1.8 NTU (Figure 34). Turbiditiy was not statistically greater during the snow melt period (April through June) than during the remainder of the year. These turbidity values generally meet EPA drinking water standards and are suitable for beneficial uses.

Onion Valley Creek turbidity levels were generally lower than those found at Nelson Creek with values ranging from 0.0 to 0.7 NTU. However, access was restricted during the major snow melt period each year. Turbidity levels at Onion Valley Creek were within EPA drinking water standards on every date sampled.

Alkalinity - Alkalinity levels at Nelson Creek ranged from 33 to 94 mg/L (Figure 35) and were suitable for beneficial uses.

Onion Valley Creek alkalinity levels were nearly identical to those obtained at Nelson Creek, ranging from 35 to 91 mg/L. Alkalinity levels at both stations were lowest during high-flow periods.

Nutrient Concentrations - Nutrient concentrations at the Nelson Creek monitoring station were relatively low (Figures 36, 37, 38, and 39). Higher dissolved nitrate levels (to a maximum of 0.11 mg/L) were detected during the snow melt period (Figure 39). The greatest concentrations of dissolved ammonia and dissolved nitrate were present during July and August.

Onion Valley Creek nutrient concentrations also remained at relatively low levels, similar to those obtained from Nelson Creek, throughout the sampling period.

Figure 32. Comparison of pH Values from Nelson Creek at the Quincy La Porte Road and Onion Valley Creek near Mouth

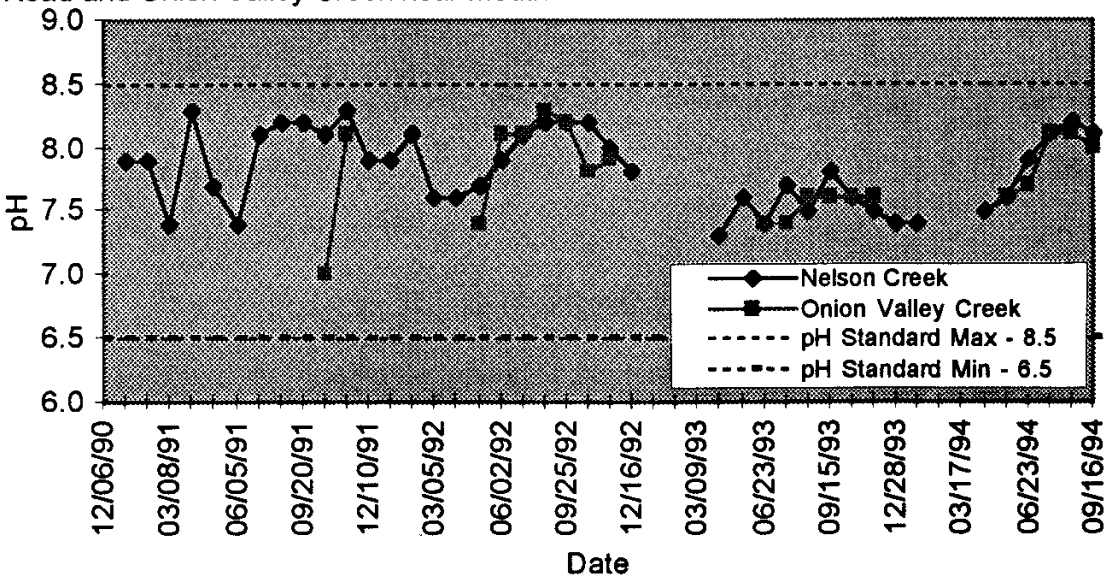


Figure 33. Comparison of Conductivity Values from Nelson Creek at the Quincy La Porte Road and Onion Valley Creek near Mouth

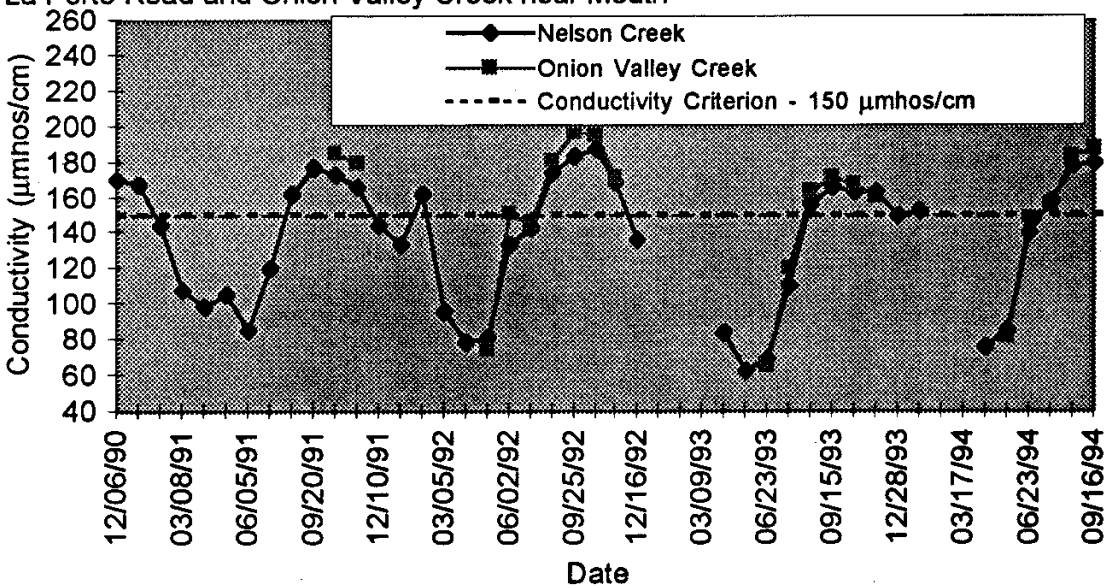


Figure 34. Comparison of Turbidity Values from Nelson Creek at the Quincy La Porte Road and Onion Valley Creek near Mouth

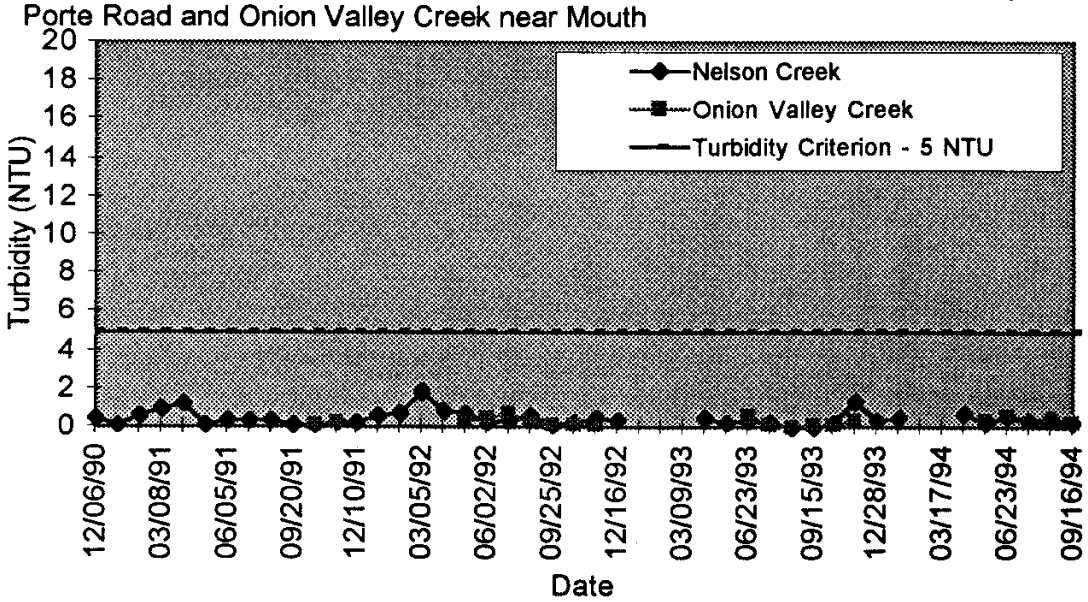


Figure 35. Comparison of Alkalinity Values from Nelson Creek at the Quincy La Porte Road and Onion Valley Creek near Mouth

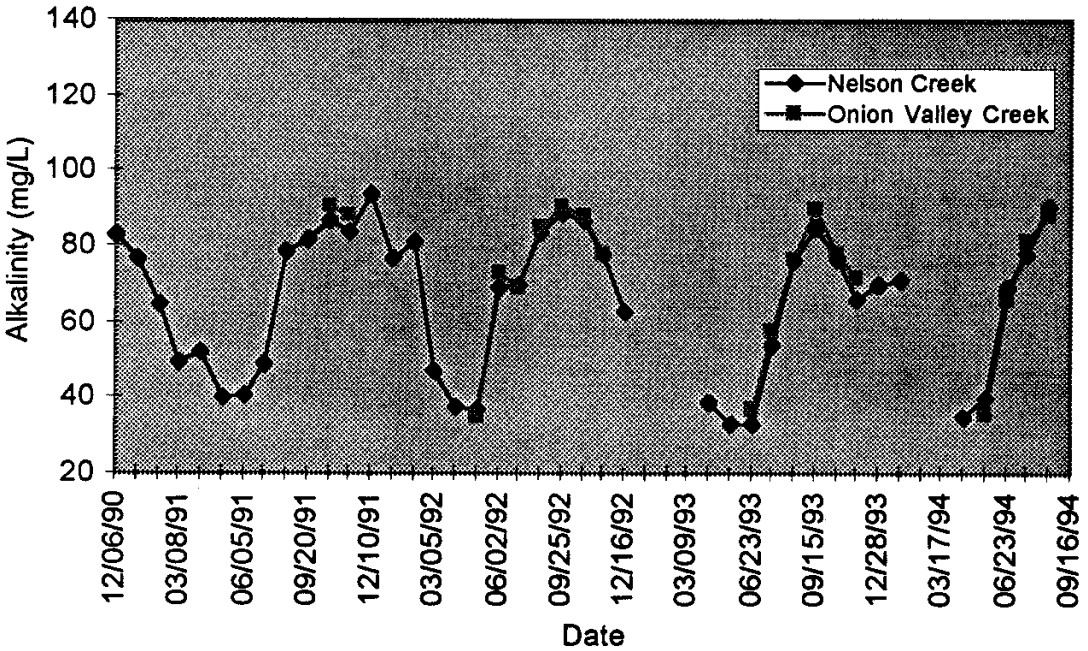


Figure 36. Comparison of Dissolved Ammonia Concentrations from Nelson Creek at the Quincy La Porte Road and Onion Valley Creek near Mouth

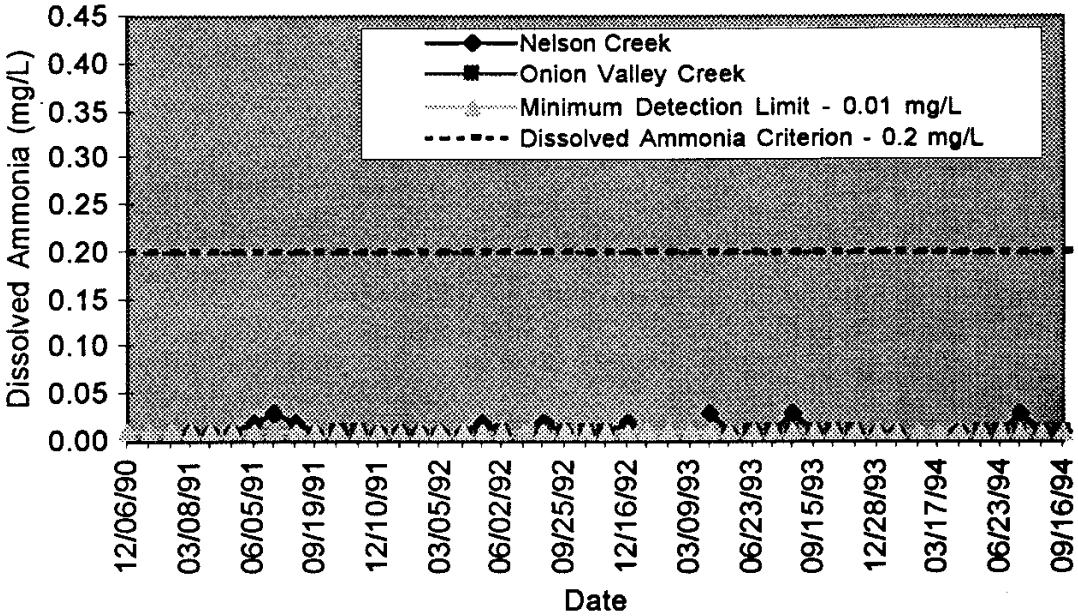


Figure 37. Comparison of Total Phosphorus Concentrations from Nelson Creek at the Quincy La Porte Road and Onion Valley Creek near Mouth

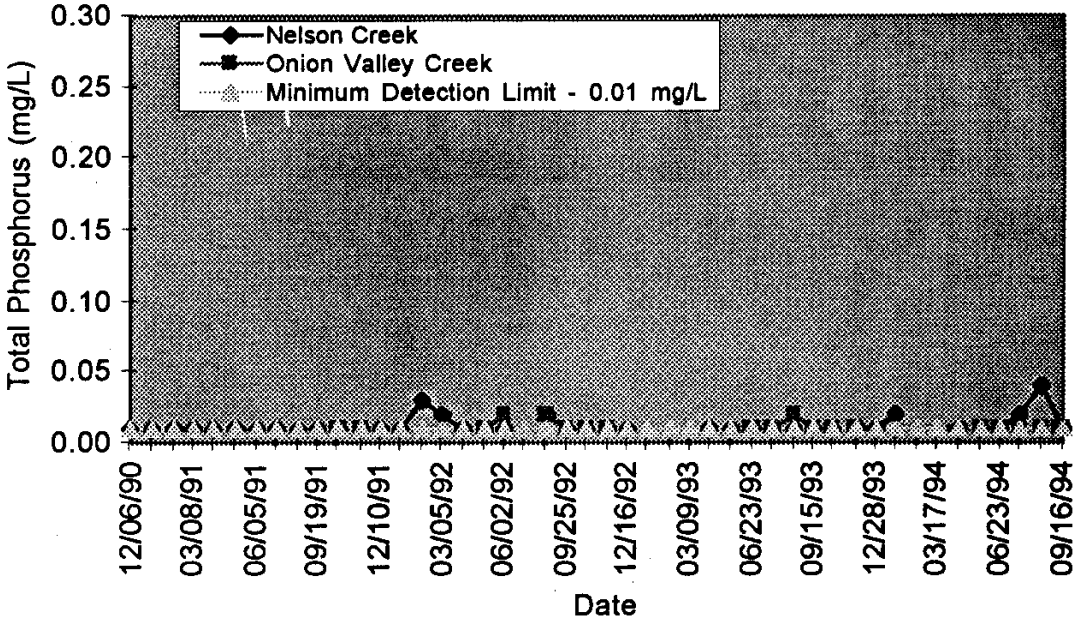


Figure 38. Comparison of Dissolved Organic Nitrogen Concentrations from Nelson Creek at the Quincy La Porte Road and Onion Valley Creek near Mouth

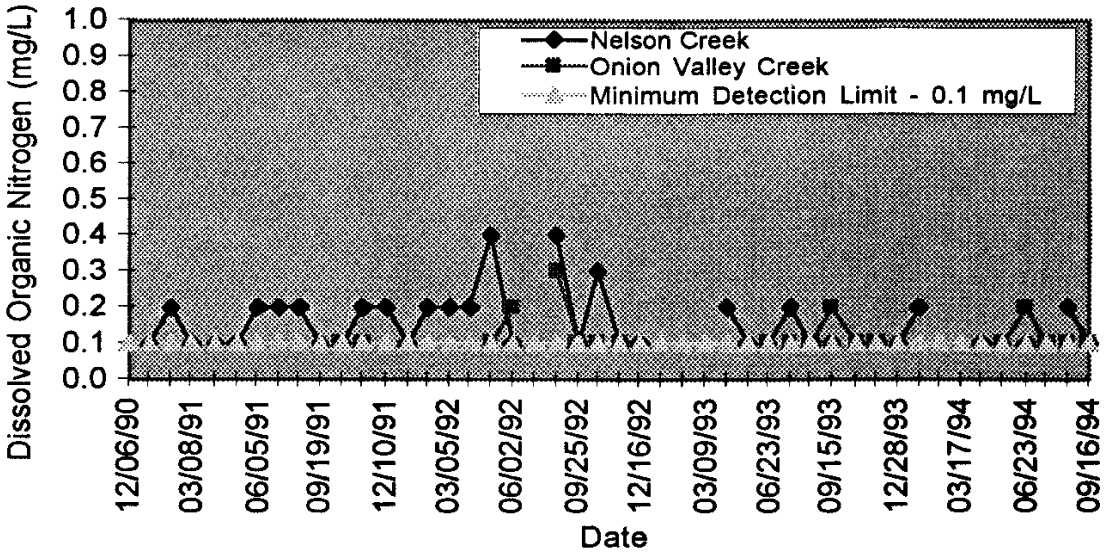
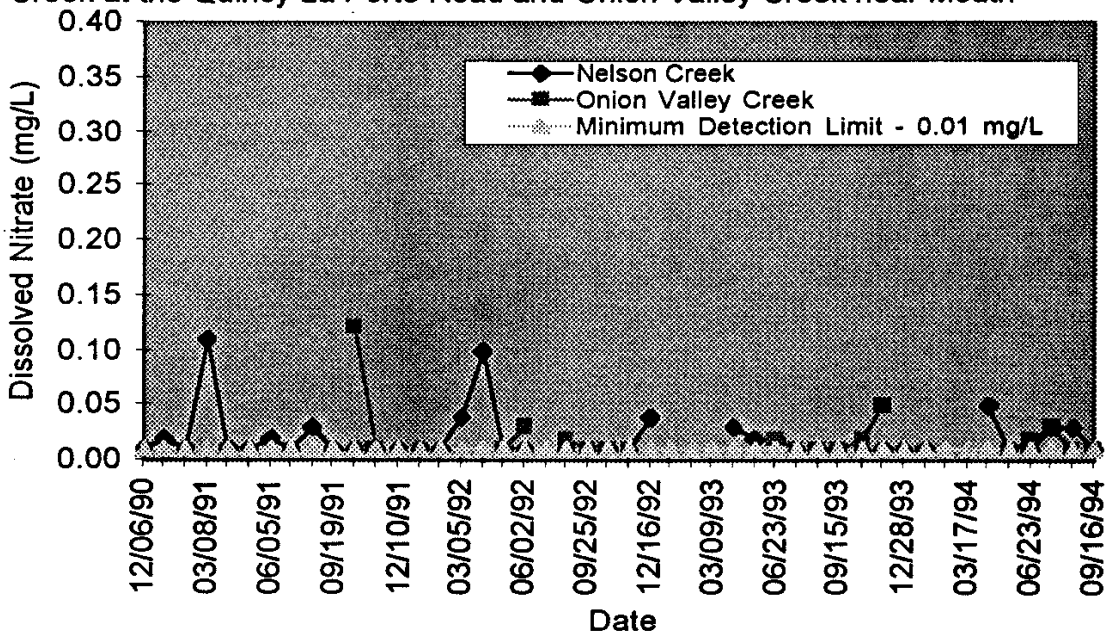


Figure 39. Comparison of Dissolved Nitrate Concentrations from Nelson Creek at the Quincy La Porte Road and Onion Valley Creek near Mouth



Benthic Macroinvertebrates - The benthic macroinvertebrate community at Nelson Creek was both relatively stable and diverse during the period sampled (Table 9). Total number of individuals ranged from 966 to 2,048 per square meter and averaged slightly more individuals during fall sampling. Species richness ranged from 26 to 45. Fall sample diversity values averaged 4.2 compared to spring samples that averaged 3.5. One of the ways that the prototype project could potentially impact benthic macroinvertebrate communities is through extending the period of spring high flows resulting in scouring and subsequent washout of the community. Observations at the sampling site indicate that velocities capable of scouring benthic macroinvertebrates can be obtained in this confined channel annually with or without the cloud seeding project. Biomass was relatively high ranging from 2 to 22 mL.

Table 9. Nelson Creek at the Quincy La Porte Road Benthic Macroinvertebrate Community Analyses (Per Square Meter)

	Date							
	5/91	9/91	6/92	9/92	6/93	9/93	6/94	9/94
No. of organisms	966	1,153	2,023	1,177	988	2,048	1,089	1,270
No. of Species	28	32	37	35	26	34	33	45
Diversity	3.1	3.7	3.5	4.4	3.7	4.2	3.6	4.5
Equitability	0.44	0.58	0.44	0.88	0.73	0.79	0.53	0.76
Biomass (mL)	-	2.0	22.0	8.0	8.0	18.0	5.0	9.5

The Onion Valley Creek benthic macroinvertebrate community was severely impacted between the spring 1993 and fall 1993 sampling periods (Table 10). Members of the

Table 10. Onion Valley Creek near Mouth Benthic Macroinvertebrate Community Analyses (Per Square Meter)

	Date							
	5/91	10/91	6/92	9/92	6/93	9/93	6/94	9/94
No. of Organisms	-	1,237	2,008	1,523	415	40	867	1,037
No. of Species	-	34	31	42	25	9	37	52
Diversity	-	3.2	3.6	4.1	3.5	2.8	3.7	4.3
Equitability	-	0.39	0.58	0.61	0.64	1.06	0.52	0.58
Biomass (mL)	-	4.0	6.1	4.0	2.0	-	2.7	9.5

Ephemeroptera and Plecoptera were absent while both Diptera and Coleoptera were greatly reduced in total number of individuals and species. Equitabilities remained high indicating that pioneering species had not had time to build up high populations in the absence of competition and predation. No chemical spills or other environmental contamination into Onion Valley Creek during this period were reported. Lack of both Plecoptera and Ephemeroptera is an indicator of excessive siltation. However, sediment analyses do not suggest adverse levels of fine materials. Excluding this sample, the benthic community was very stable and diverse throughout the period sampled. Total number of individuals (415 to 2,008), species richness (31

to 52), and species diversity values (3.2 to 4.3) were similar to values obtained from the Nelson Creek samples. The factors responsible for the stress on the fall 1993 Onion Valley Creek benthic community remain unidentified.

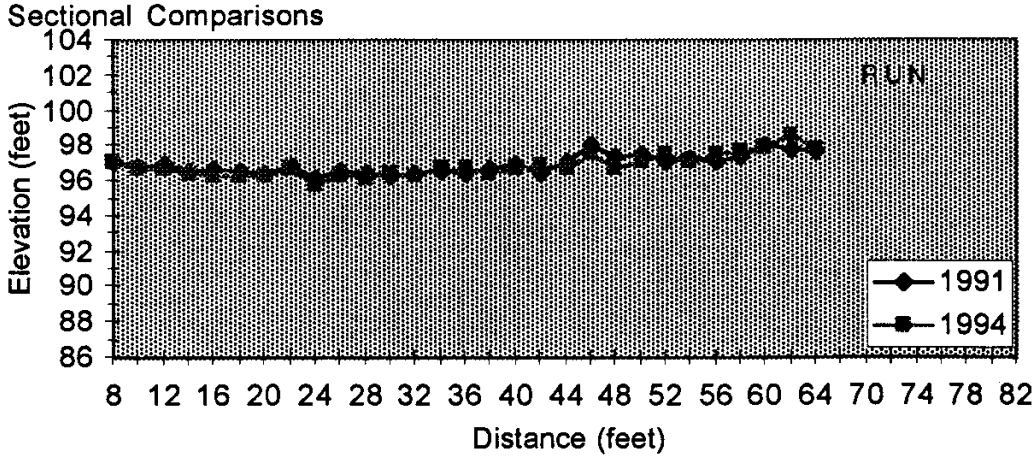
Stream Cross Sections - The Nelson Creek monitoring station is in a steep, confined, narrow gorge. Substrate is largely comprised of boulders. Larger substrate sizes result in less accuracy in elevational measurements. However, stream cross sectional comparisons suggest that Nelson Creek may achieve velocities sufficient to move large boulders. Although bottom contours fluctuated from year to year (Figure 40) these fluctuations remained within the error of the methodology when dealing with larger substrates. A debris slide along the far canyon wall on the pool transect during 1991 and 1992 was washed away during 1993. No significant channel aggradation or degradation were identified at the Nelson Creek monitoring site.

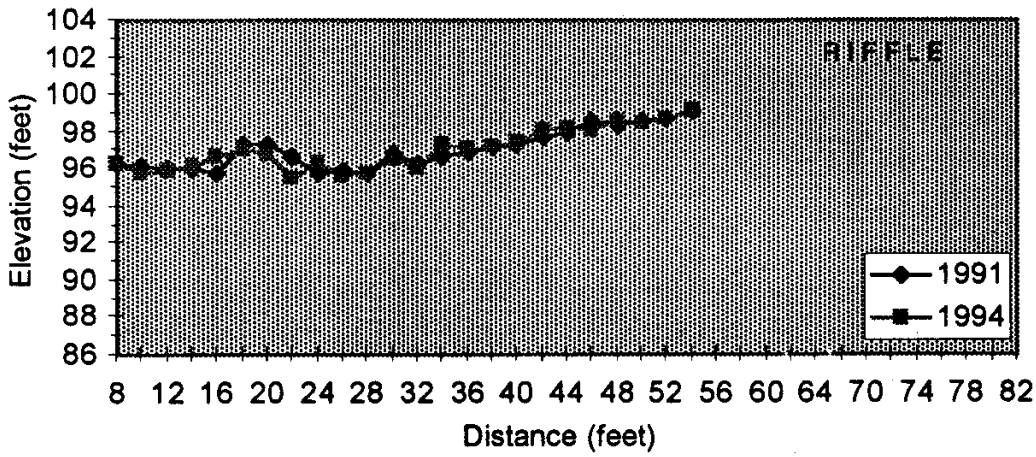
The Onion Valley Creek survey control point established in 1991 was lost and resurveying of the point may not have been absolutely precise. The cross sectional comparisons at this site are of questionable validity and should be interpreted with caution (Figure 41). Even a slight error in control point replacement can be magnified at the end of each transect. Cross sectional data indicate that the bedrock face at the end of each transect has moved towards the channel thalweg. This is highly unlikely.

Stream Sediment - Fine materials exceeded the 5 percent criterion on every date sampled in stream sediments from spawning gravels at the Nelson Creek monitoring site (Figure 42). The amount of fine materials ranged from 6 to 15 percent. Deposition of fine materials during the high snow pack year of 1993 was apparent. However, whether these materials were transported and deposited during snow melt or in response to spring/summer thundershowers is unclear. Without baseline data, it is impossible to determine whether the increased level of fine materials in 1993 is greater than could be expected within this watershed under that year's hydrologic regime.

Onion Valley Creek sediment sampling revealed a very low percentage of fine materials in spawning gravels (Figure 43). The level of fine materials ranged from one to two percent. These levels are suitable for substrate spawning fish species.

Figure 40. Nelson Creek at the Quincy La Porte Road Stream Cross Sectional Comparisons





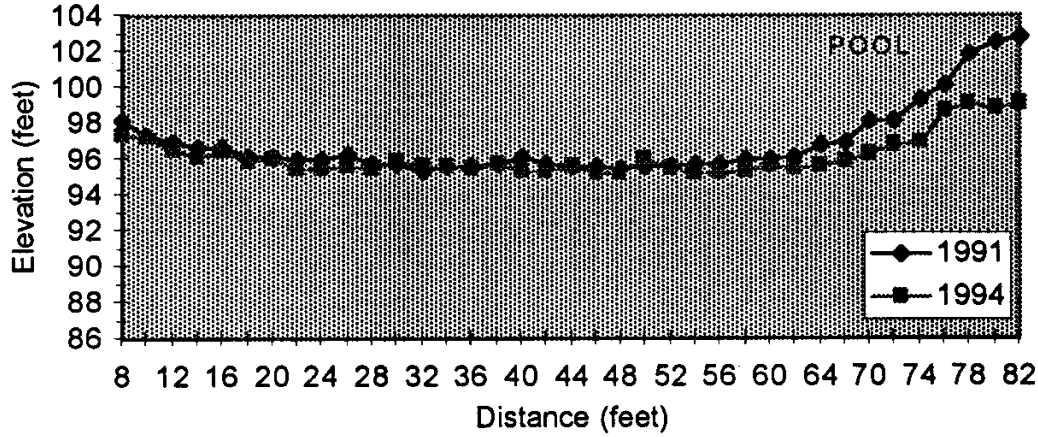
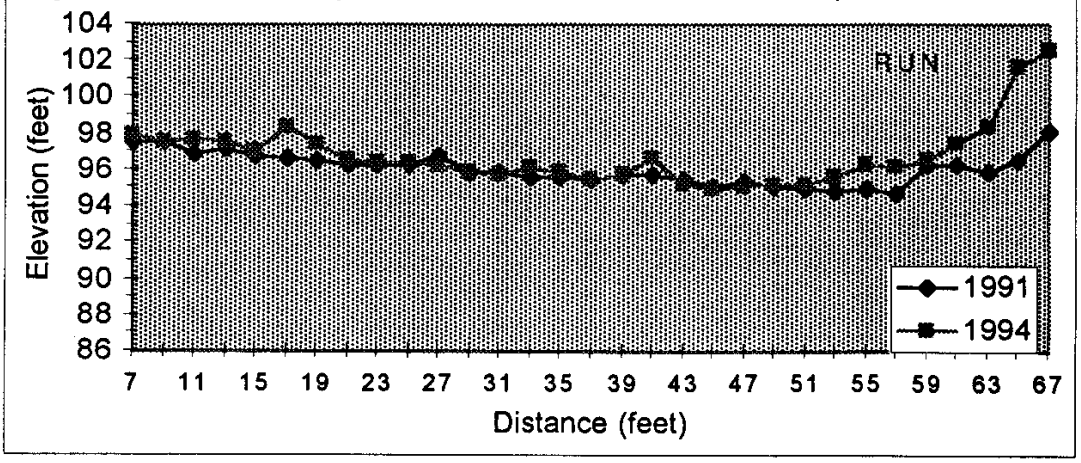
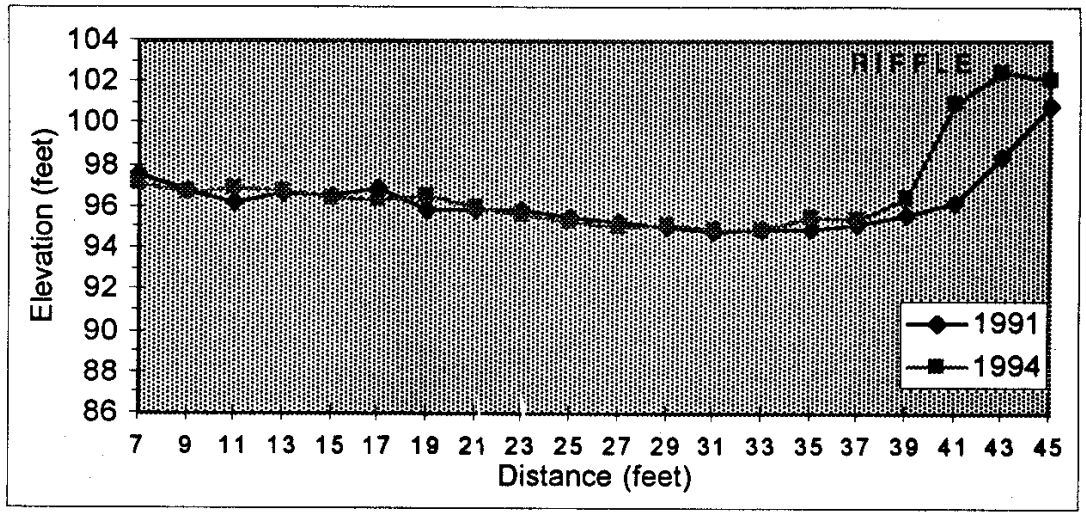


Figure 41. Onion Valley Creek Stream Cross Sectional Comparisons





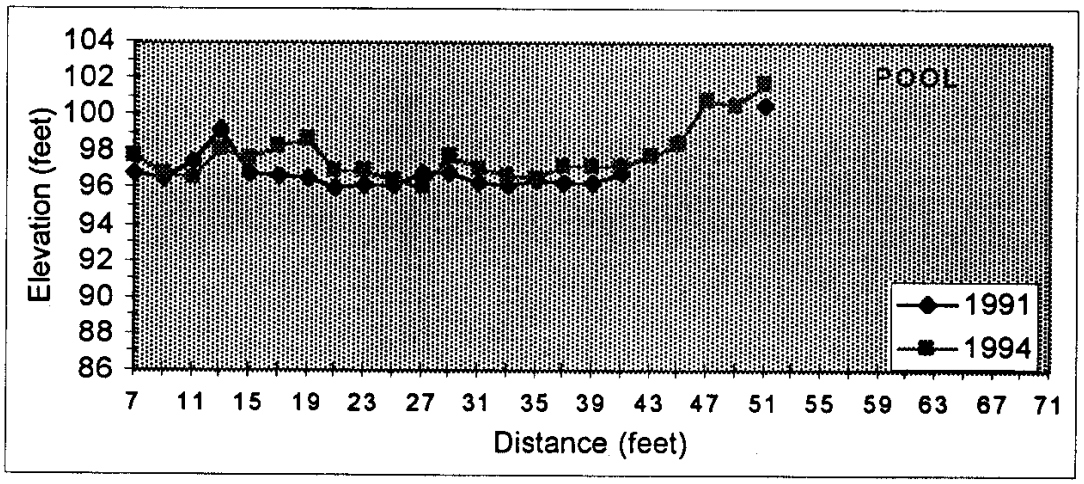


Figure 42. Nelson Creek at the Quincy La Porte Road Sediment Particle Size Distribution

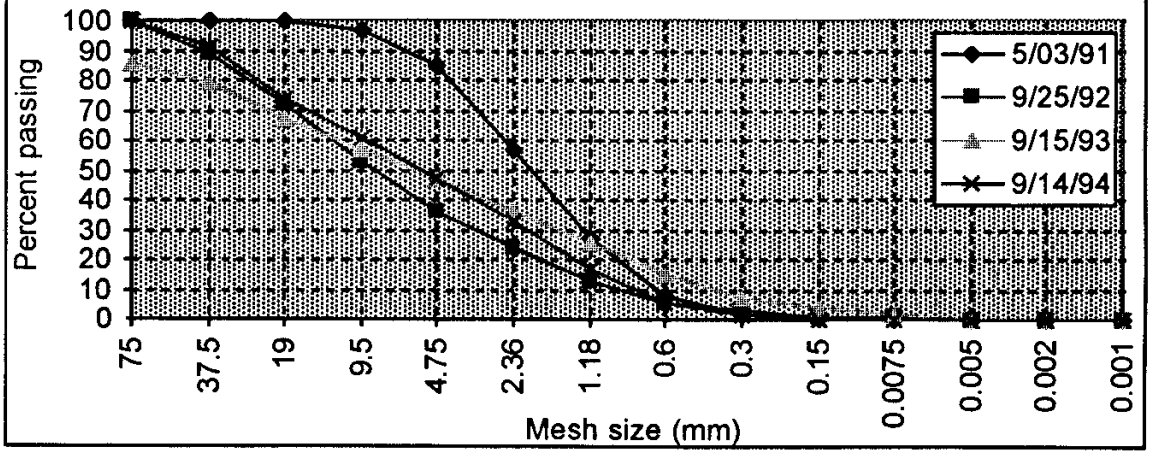
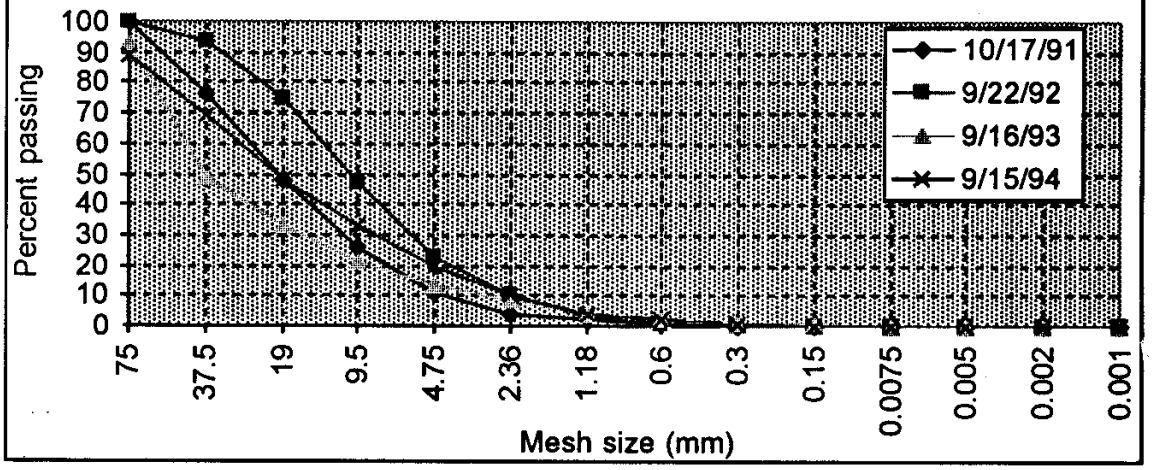


Figure 43. Onion Valley Creek at Mouth Sediment Particle Size Distribution



Fish Populations and Habitat - Nelson Creek is the largest tributary to the Middle Fork Feather River in the study area and has been designated as a "Wild Trout" stream by the California Department of Fish and Game. The section sampled is a steep gradient, confined channel with a rubble-boulder dominated substrate. Sand and gravel generally comprise less than 30 percent of the substrate. Rainbow trout, brown trout, and riffle sculpin were present on each date sampled (Table 11). Rainbow trout population estimates ranged from 2,572 to 3,485 trout per stream mile. At least three age classes of rainbow trout were present in the portion of Nelson Creek sampled. Brown trout were far less common with population estimates ranging from 53 to 161 per stream mile. Rainbow trout populations exhibited a decreasing trend over time. Rainbow trout biomass decreased by 67 percent between 1991 and 1994.

Trout population estimates at this site do not exhibit a positive correlation with stream flow which varied substantially from year to year .

Table 11. Fish Population Estimates for Nelson Creek at the Quincy La Porte Road

Year	Species	Total Catch	Population Estimate	Confidence Interval	Capture Probability	Biomass (mL)	Average Fork Length (mm)	Number per Stream Mile
1991	rainbow trout	60	65	8.3	0.56	1,027	86.6	3,485
1992	rainbow trout	52	56	7.5	0.57	730	93.3	3,003
1993	rainbow trout	48	48	2.3	0.87	212	63.1	2,572
1994	rainbow trout	46	48	6.7	0.63	340	74.3	2,572
1991	brown trout	2	2	-	-	45	110.0	107
1992	brown trout	1	1	-	-	5	86.0	53
1993	brown trout	2	2	12.7	0.67	9	75.0	107
1994	brown trout	3	3	-	-	30	76.6	161
1991	riffle sculpin	42	45	6.4	0.58	359	84.8	2,413
1992	riffle sculpin	46	49	6.1	0.59	450	78.1	2,466
1993	riffle sculpin	52	60	13.6	0.63	340	67.6	3,217
1994	riffle sculpin	34	37	9.8	0.55	170	68.9	1,983

Onion Valley Creek is a small, steep gradient, well-shaded tributary to the Middle Fork Feather River. Stream flow in Onion Valley Creek averages less than 20 percent of that in Nelson Creek. The portion of Onion Valley Creek sampled contained only rainbow trout (Table 12). Population estimates at this station ranged from 1,233 to 7,664 trout per mile. The population trend was generally upward. Relatively few trout in the 1+ age classes were captured. This stream appears to mainly provide rainbow trout nursery habitat. No correlation between trout population estimates and stream flow were identified.

Table 12. Fish Population Estimates for Onion Valley Creek near Mouth

Year	Species	Total Catch	Population Estimate	Confidence Interval	Capture Probability	Biomass (mL)	Average Fork Length (mm)	Number per Stream Mile
1991	rainbow trout	25	27	6.1	0.54	248	79.0	1,448
1992	rainbow trout	22	23	3.8	0.61	214	76.2	1,233
1993	rainbow trout	48	51	6.6	0.74	190	65.5	2,735
1994	rainbow trout	120	143	45.7	0.45	1,222	82.7	7,664

Paired Station Comparison

Both streams exhibited very similar and excellent water quality. No impacts related to the cloud seeding program are apparent. Stream temperatures were excellent for cold water beneficial uses. Dissolved oxygen concentrations with two exceptions at Nelson Creek were within the range of optimal values for rainbow trout. pH averaged slightly alkaline and was relatively stable. Conductivity was relatively low with all values less than 200 µmohs/cm in both streams. However, levels greater than RWQCB objectives were documented in each stream.

Turbidity was extremely low even during snow melt periods. Turbidity levels greater than 1.8 NTU were not detected in either watershed.

Alkalinity values were very similiar at both stations on all dates sampled. Annual fluctuations in alkalinity values occurred with lower levels during snow melt periods and higher levels during low flow periods. Alkalinity values were suitable for all beneficial uses.

Nutrient concentrations in both streams were similar and did not approach nuisance concentrations.

Benthic macroinvertebrate communities were diverse and generally stable at both sites. A severe disruption of the benthic community was apparent at the Onion Valley Creek station during fall 1993. The factors responsible for this observed disruption remains unidentified but are unlikely to be related to the cloud seeding program since the stream is outside of the project influence. Relatively high benthic biomass measurements were recorded at each stream.

Minor annual alterations in stream cross sections at Nelson Creek were judged to be within the range of error when sampling boulder substrates. No stream channel aggradation or degradation were identified at Nelson Creek during the course of the study. Loss of the control point on Onion Valley Creek transects resulted in potentially unreliable cross sectional data.

Nelson Creek sediment analyses show unacceptable levels of fine materials in spawning gravels. The level of fine materials ranged from 6 to 15 percent. A higher level of fine materials was present during 1993 when snow melt runoff was highest. Sediment analyses of Onion Valley Creek indicate stable watershed conditions with relatively little fine sediment in spawning gravels.

Rainbow trout populations at Nelson Creek appear to have decreased slightly over time. Reductions in the number of rainbow trout in the older age classes resulted in an estimated 67 percent decrease in biomass at this station. Cloud seeding could adversely influence trout recruitment by inducing erosion and sedimentation. The number of young-of-the-year trout at this site remained relatively constant indicating

that recruitment was not adversely affected. Cloud seeding could adversely affect adult trout through increased erosion and sedimentation disruptions of the aquatic food chain. However, the benthic macroinvertebrate community has remained stable and diverse. Populations of benthic indicator organisms sensitive to siltation have remained stable throughout the study period. Analyses of Onion Valley Creek trout populations indicate a five fold increase between 1991 and 1994 suggesting excellent reproduction and recruitment. Flow regimes and microhabitat conditions cause species and age composition in these two streams to differ substantially.

Greenhorn Creek above Squirrel Creek and Squirrel Creek at Mouth

The Greenhorn Creek drainage is within the cloud seeding project area while the Squirrel Creek drainage is outside the cloud seeding project area and serves as a project control.

Temperature - Greenhorn Creek stream temperatures ranged from 37° F to 60° F (Figure 44). Squirrel Creek temperatures ranged from 37° F to 65° F.

Squirrel Creek temperatures averaged 2.5° F warmer than Greenhorn Creek. Temperature comparisons at these two sampling locations are more reliable than for the other paired stations due to their proximity. Temperatures were taken at each station within minutes of each other. The ranges of temperatures at both monitoring stations were suitable for cold water fishery beneficial uses.

Dissolved Oxygen - Greenhorn Creek dissolved oxygen concentrations ranged from 8.8 to 18.2 mg/L (Figure 45). All dissolved oxygen concentrations were within the RWQCB objective.

Squirrel Creek dissolved oxygen concentrations ranged from 7.4 to 18.0 mg/L. Two of the dissolved oxygen concentrations were outside the optimal range for rainbow trout. However, all dissolved oxygen measurements met the Regional Water Quality Control Board objective.

pH - pH values at both Greenhorn Creek and Squirrel Creek were within the range of 7.3 to 8.2 (Figure 46). These slightly basic pH values are suitable for beneficial uses.

Conductivity - Conductivity measurements at Greenhorn Creek ranged between 49 and 139 µmhos/cm (Figure 47) with an average value of 120.9 µmhos/cm. Lower conductivity values were generally associated with snow melt periods while higher

Figure 44. Comparison of Stream Temperatures from Greenhorn Creek above Squirrel Creek and Squirrel Creek at Mouth

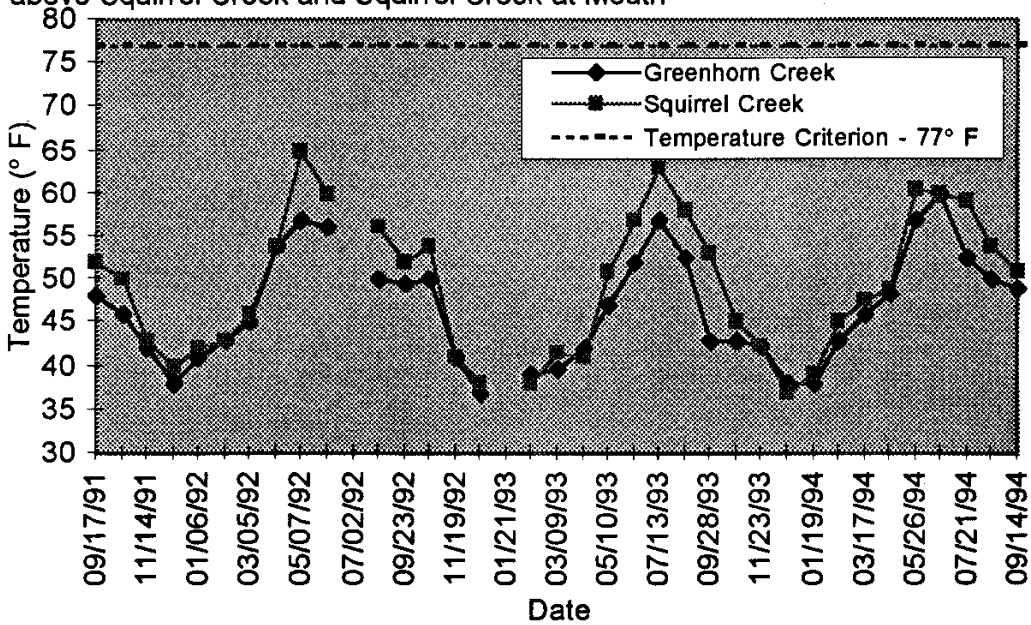


Figure 45. Comparison of Dissolved Oxygen Concentrations from Greenhorn Creek above Squirrel Creek and Squirrel Creek at Mouth

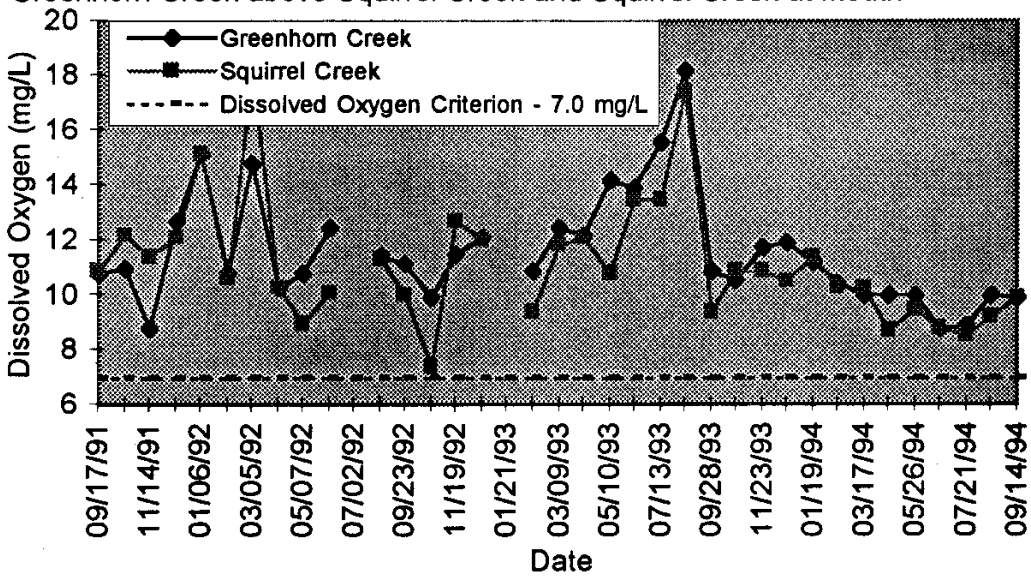


Figure 46. Comparison of pH Values from Greenhorn Creek above Squirrel Creek and Squirrel Creek at Mouth

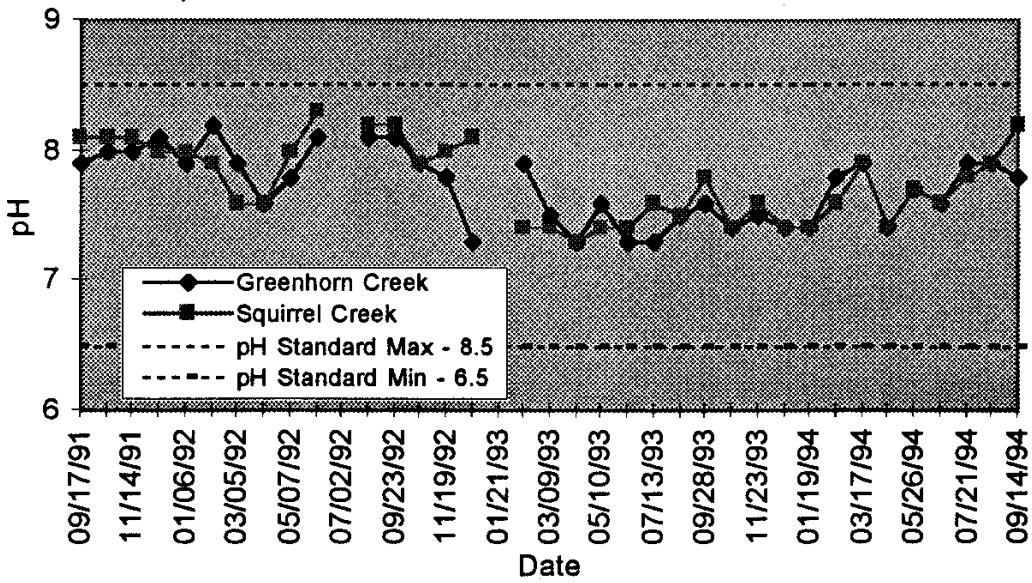
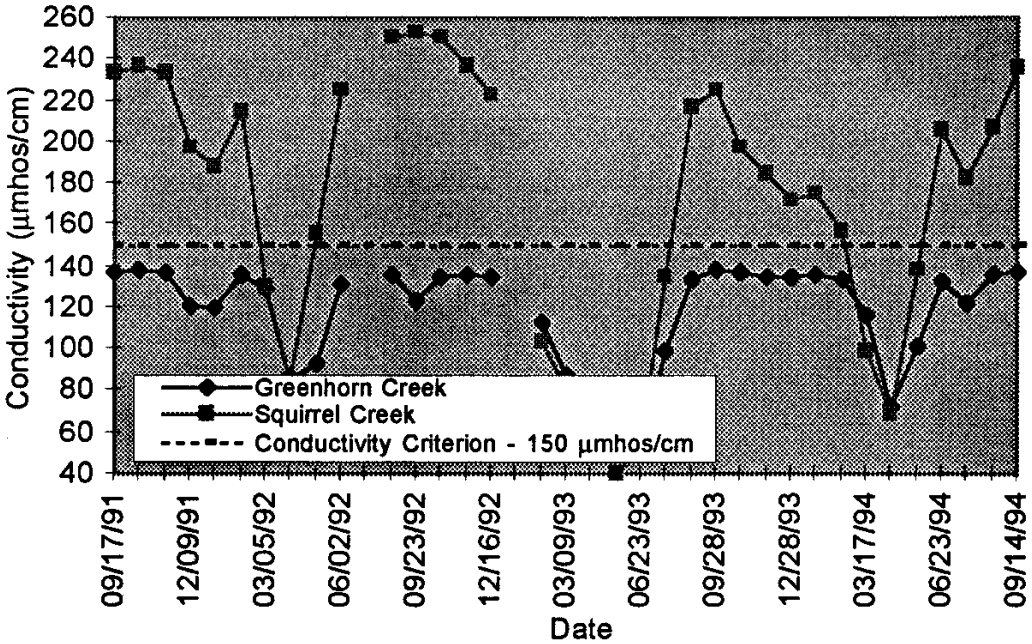


Figure 47. Comparison of Conductivity Values from Greenhorn Creek above Squirrel Creek and Squirrel Creek at Mouth



values frequently occurred during periods of low flow. Conductivity levels exceeded RWQCB objectives on three percent of the dates sampled.

Conductivity values at Squirrel Creek (40 to 253 µmhos/cm) ranged significantly higher than those encountered at Greenhorn Creek. Average Squirrel Creek conductivity values (172 µmhos/cm) were statistically greater than those documented at Greenhorn Creek. However, during snow melt periods conductivity measurements from Squirrel Creek were frequently as low or lower than those obtained at Greenhorn Creek. Conductivity values at both monitoring stations were suitable for all beneficial uses. The RWQCB conductivity standard of 150 µmohs/cm was exceeded in 67 percent of the samples.

Turbidity - Greenhorn Creek turbidity levels were relatively low ranging from 0.2 to 4.4 NTU (Figure 48) and averaged 0.8 NTU. These turbidity levels are generally within the EPA criterion for drinking water. Only two turbidity levels greater than 2.0 NTU were observed during the course of the sampling.

Squirrel Creek turbidity levels showed greater fluctuation ranging from 0.1 to 10 NTU. Average turbidity levels were over twice as high as those encountered at Greenhorn Creek.

Alkalinity - Greenhorn Creek alkalinity values ranged from 28 to 78 mg/L (Figure 49) with an average concentration of 61.4 mg/L. The lowest alkalinity levels were present during snow melt periods.

Squirrel Creek alkalinity values ranged from 24 to 127 mg/L with an average of 85.3 mg/L. Alkalinity levels at both sites were suitable for beneficial uses.

Nutrient Concentrations - The ranges of most nutrient concentrations at both stations were relatively low and similar (Figures 50, 51, 52, and 53). The range of total phosphorus concentrations was greater at Greenhorn Creek (<0.01 to 0.06 mg/L) than at Squirrel Creek (<0.01 to 0.01 mg/L) (Figure 51). Total phosphorus concentrations greater than detection limits were only encountered during the spring and summer. Nutrient concentrations detected at both monitoring stations did not appear to produce nuisance algae growth and were suitable for beneficial uses.

Benthic Macroinvertebrates - The Greenhorn Creek benthic macroinvertebrate community was relatively stable and diverse throughout the period sampled (Table 13). Total individuals ranged from 475 to 1,984 individuals per square meter with no significant differences between spring and fall samples. Species richness ranged from 25 to 46 species with fall samples containing greater species richnesses than spring samples. Species diversity values ranged from 3.2 to 4.3 with slightly higher diversities during the fall. Biomass ranged from 1.8 to 12 mL per square meter.

Figure 48. Comparison of Turbidity Values from Greenhorn Creek above Squirrel Creek and Squirrel Creek at Mouth

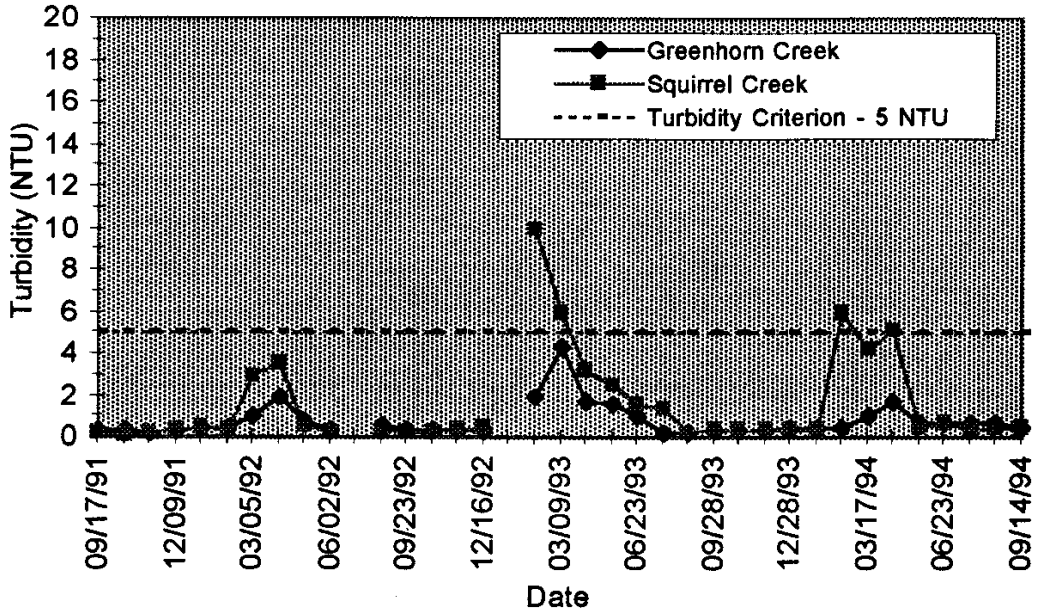


Figure 49. Comparison of Alkalinity Values from Greenhorn Creek above Squirrel Creek and Squirrel Creek at Mouth

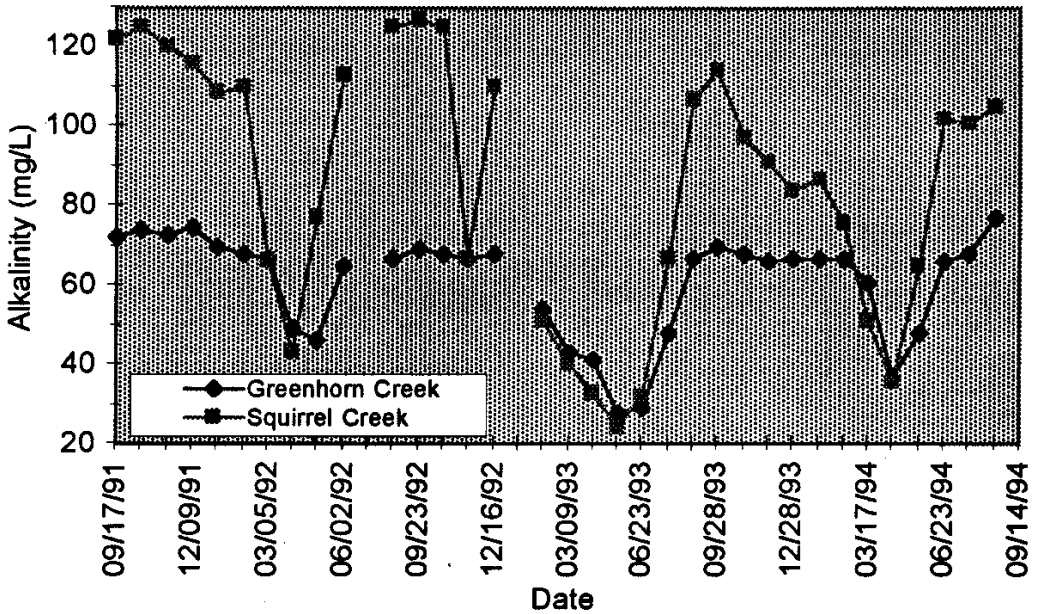


Figure 50. Comparison of Dissolved Ammonia Concentrations from Greenhorn Creek above Squirrel Creek and Squirrel Creek at Mouth

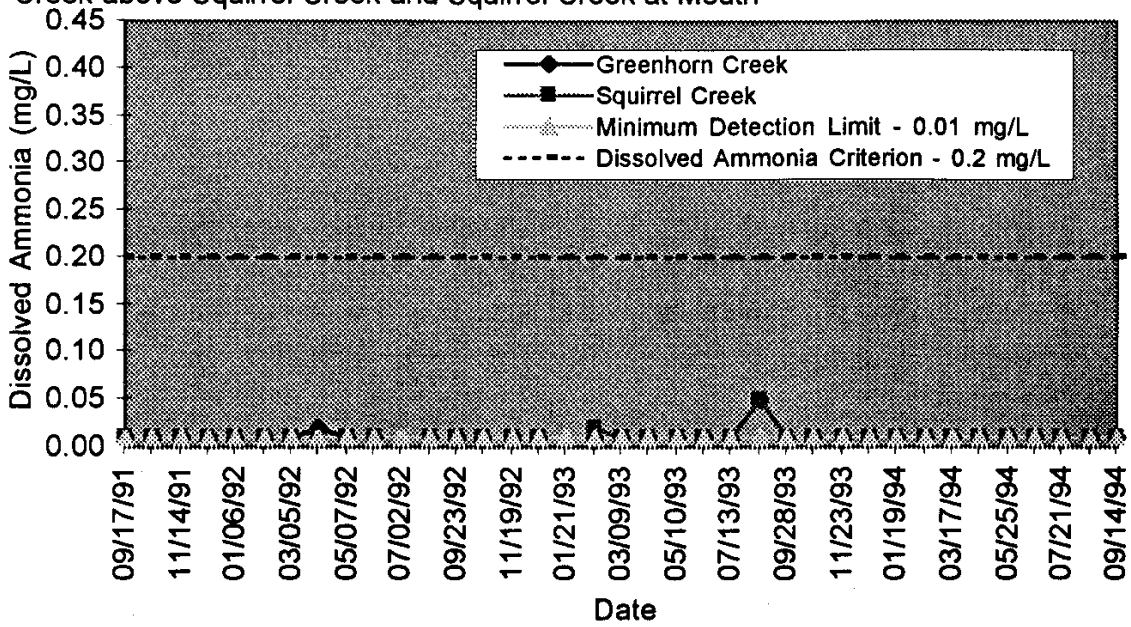


Figure 51. Comparison of Total Phosphorus Concentrations from Greenhorn Creek above Squirrel Creek and Squirrel Creek at Mouth

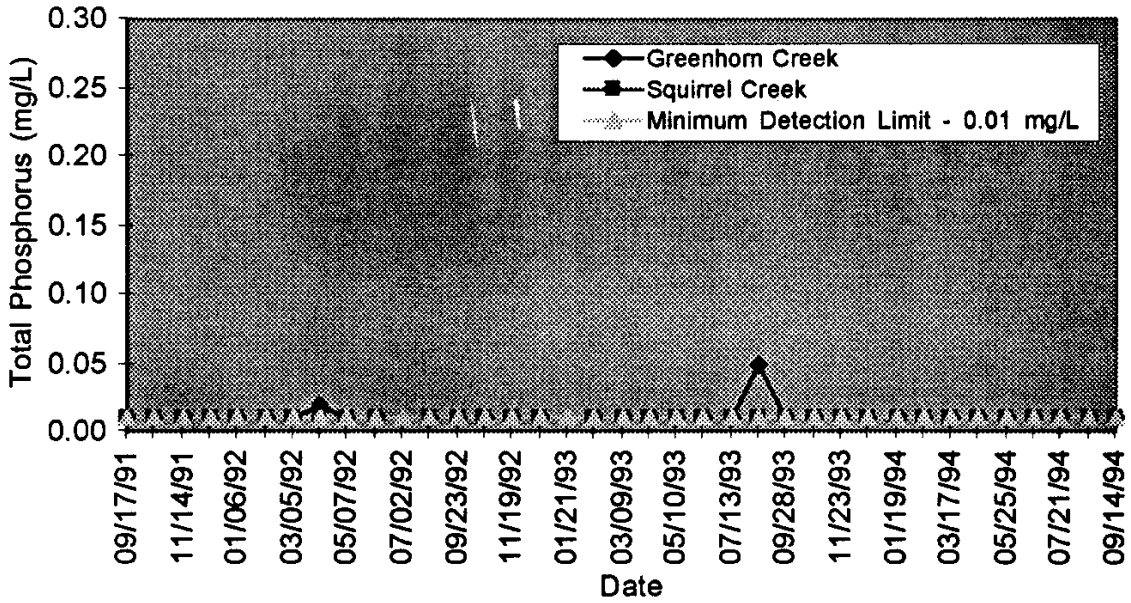


Figure 52. Comparison of Dissolved Organic Nitrogen Concentrations from Greenhorn Creek above Squirrel Creek and Squirrel Creek at Mouth

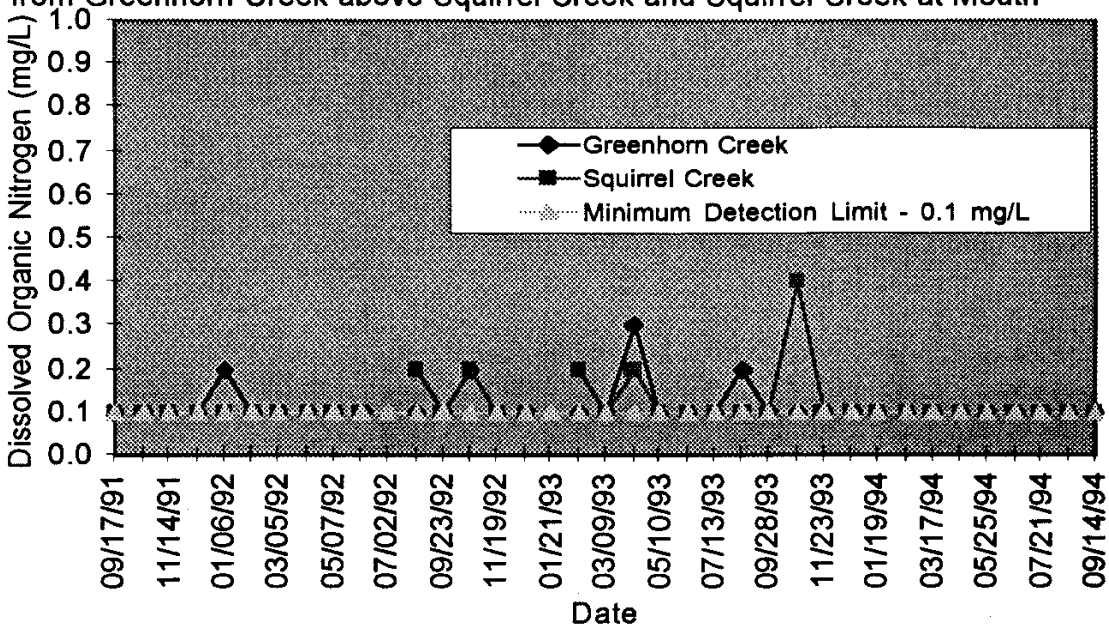


Figure 53. Comparison of Dissolved Nitrate Concentrations from Greenhorn Creek above Squirrel Creek and Squirrel Creek at Mouth

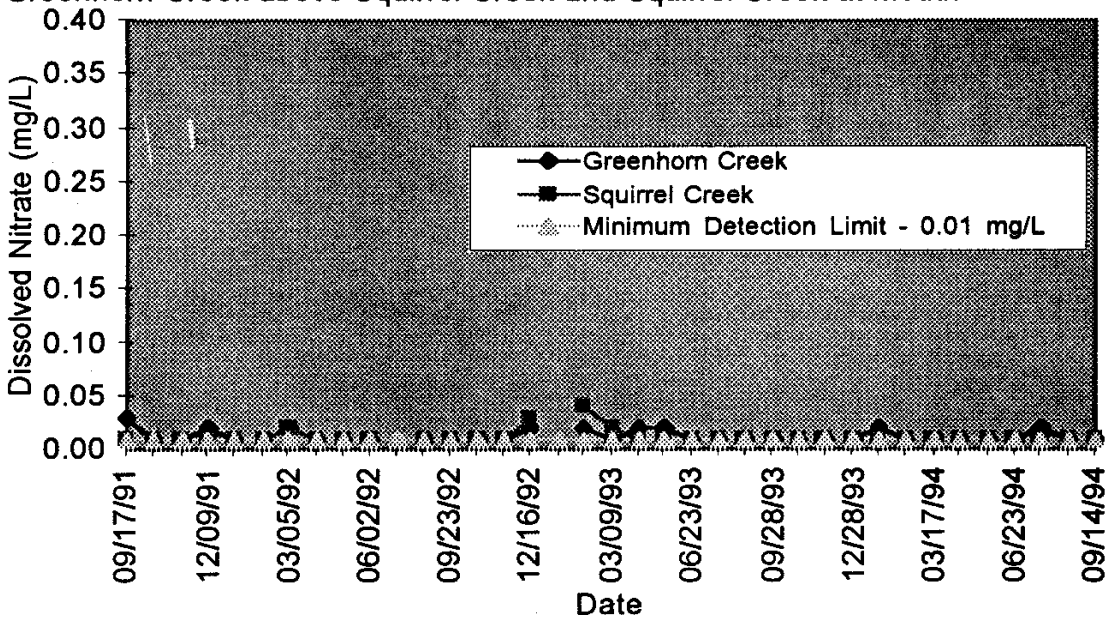


Table 13. Greenhorn Creek above Squirrel Creek Benthic Macroinvertebrate Community Analyses (Per Square Meter)

	Date							
	5/91	9/91	6/92	9/92	6/93	9/93	6/94	9/94
No. of Organisms	-	1,736	1,011	1,320	1,984	844	554	475
No. of Species	-	46	28	45	25	31	31	38
Diversity	-	4.3	4.0	4.0	3.2	3.8	3.9	4.0
Equitability	-	0.63	0.81	0.51	0.50	0.63	0.68	0.60
Biomass (mL)	-	7.8	12.0	4.5	12.0	6.0	1.8	3.0

Although the total number of organisms fluctuated from sample to sample, the Squirrel Creek benthic community was also relatively stable and diverse throughout the study period (Table 14). Fall samples generally contained greater numbers of organisms, species richness, and biomass than spring samples. Total numbers of organisms ranged from 622 to 3,537 individuals per square meter. Species richness ranged from 30 to 51. Diversities ranged from 2.5 to 4.4. Biomass ranged from 1.5 to 12.0 mL per square meter.

Table 14. Squirrel Creek at Mouth Benthic Macroinvertebrate Community Analyses (Per Square Meter)

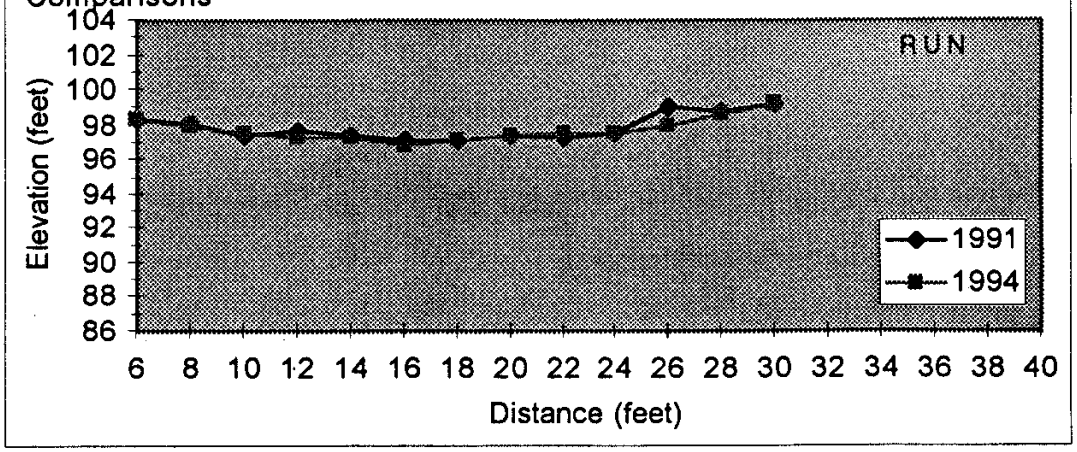
	Date							
	5/91	9/91	6/92	9/92	6/93	9/93	6/94	9/94
No. of Organisms	-	3,537	667	2,785	986	1,206	862	622
No. of Species	-	44	30	51	37	41	43	40
Diversity	-	2.5	4.0	4.1	3.2	4.2	4.4	4.4
Equitability	-	0.18	0.79	0.49	0.36	0.67	0.72	0.80
Biomass (mL)	-	7.8	1.5	12.0	5.0	10.0	6.5	8.5

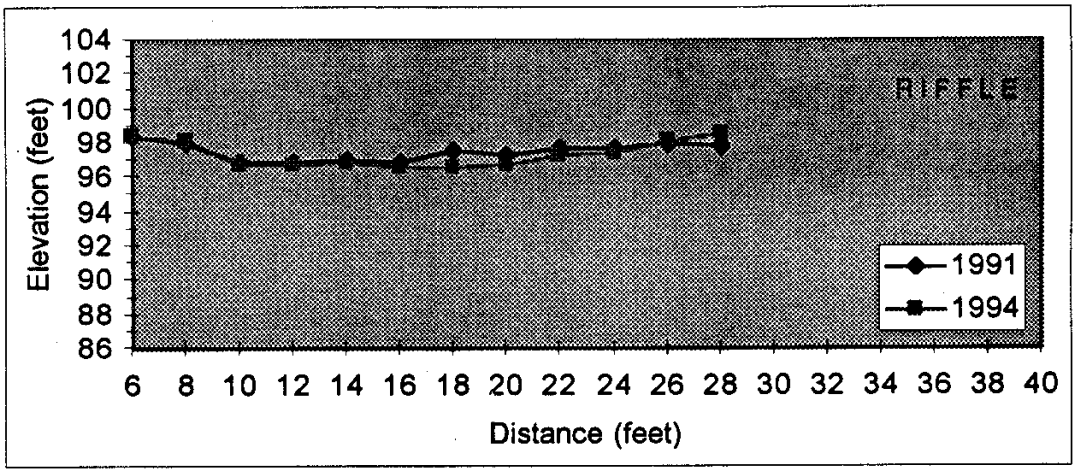
No evidence of scour or washout of benthic macroinvetebrates related to the heavy 1993 snow pack was observed at either monitoring site.

Stream Cross Sections - Analyses of Greenhorn Creek cross sectional comparisons show relatively stable channel conditions throughout the period monitored on the run and riffle cross sections (Figures 54). The pool cross section shows moderate down-cutting at transect distances between 14 and 22 feet.

Squirrel Creek run and riffle cross sectional data identify moderate channel down-cutting (Figures 55). Approximately 6 inches of down-cutting is apparent on the run cross section from 7 to 20 feet on the transect. A similar amount of down-cutting on the riffle cross section from 6 to 30 feet on the transect is evident. The pool cross section shows relatively stable conditions with only limited down-cutting near the thalweg since 1991. Stream channel degradation within these two streams is *probably related to upstream logging and roading. Watershed cumulative affects*

Figure 54. Greenhorn Creek above Squirrel Creek Stream Cross Sectional Comparisons





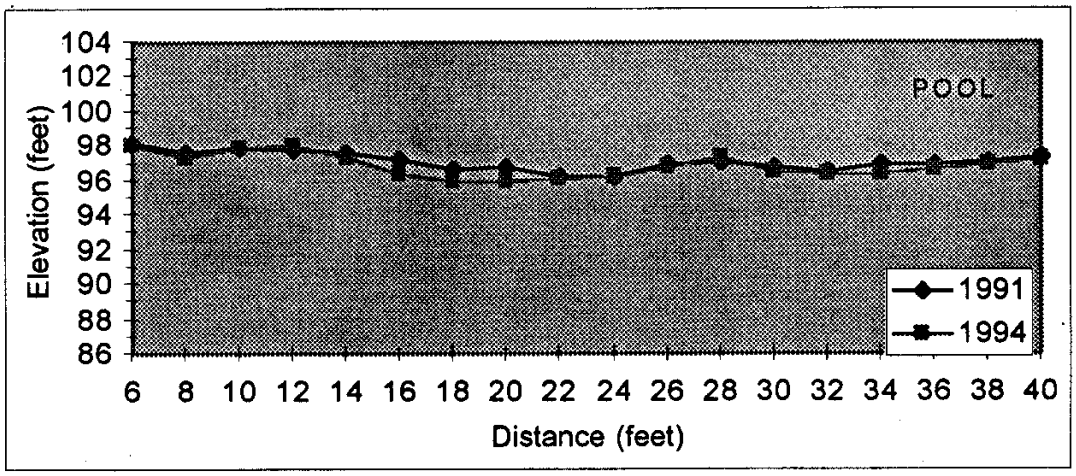
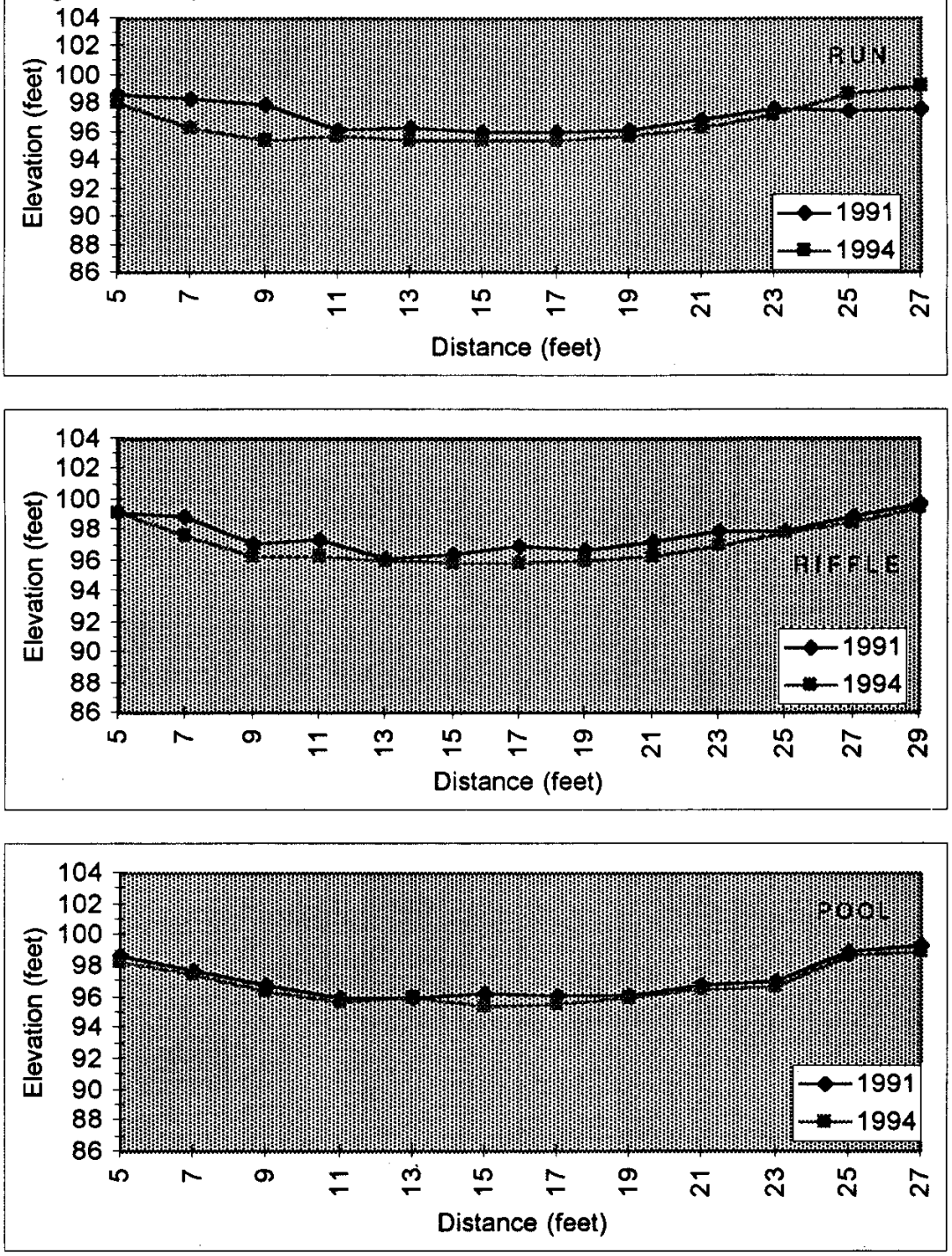


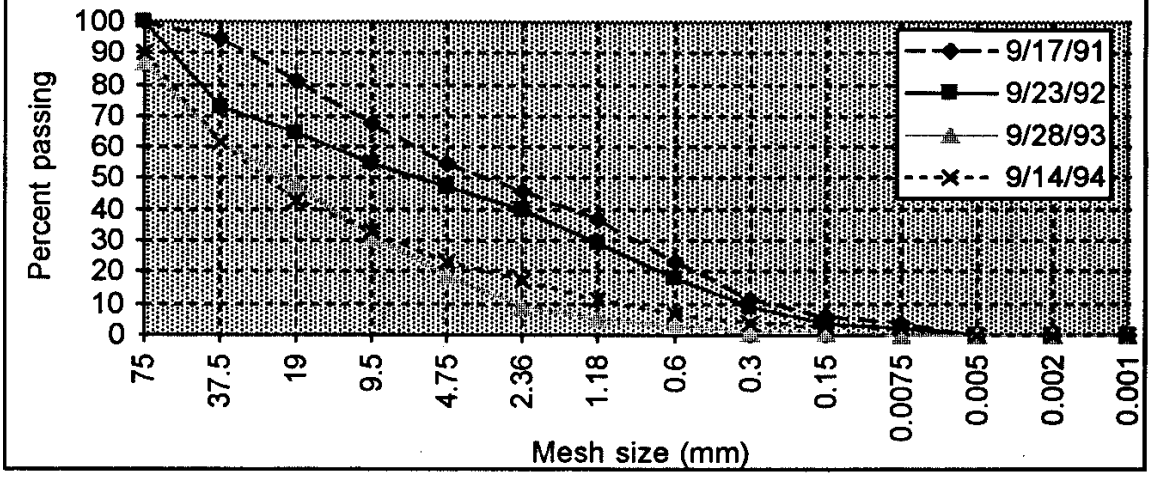
Figure 55. Squirrel Creek at Mouth Stream Cross Sectional Comparisons



studies completed in 1991 show projected equivalant roaded acre values approaching the threshold of concern in both watersheds. (USFS and DWR 1991).

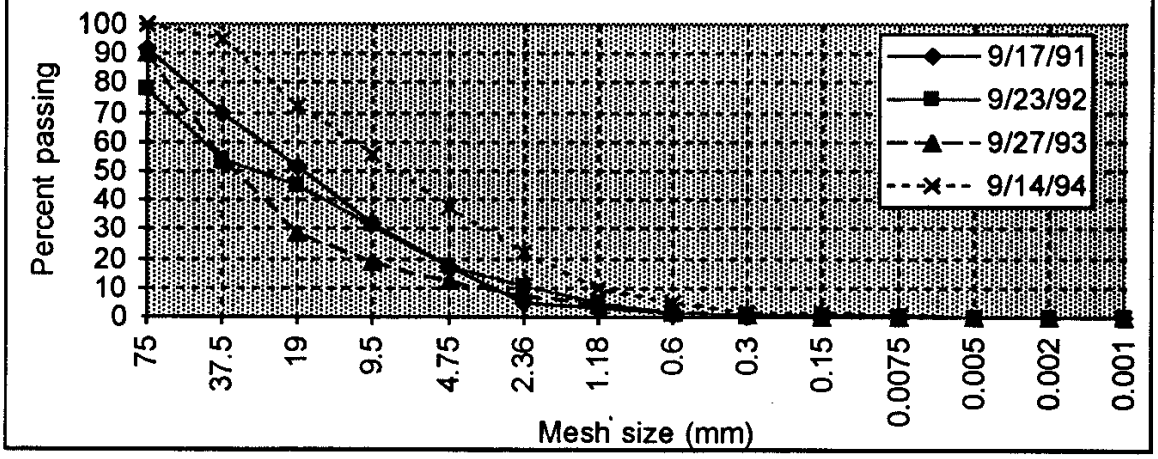
Stream Sediment - Analyses of Greenhorn Creek sediments indicate high initial levels of fine materials in the substrate (Figure 56). These levels decreased from 23 percent in 1991 to 7 percent in 1994. Except for 1993, all sediment analyses at this site contained levels of fine materials unsuitable for successful reproduction by substrate spawning fish.

Figure 56. Greenhorn Creek above Squirrel Creek Sediment Particle Size Distribution



All Squirrel Creek sediment analyses indicate low levels of fine materials (two to five percent) in spawning substrates (Figure 57). The level of fine materials in Squirrel Creek substrates were suitable for successful reproduction by substrate spawning fish.

Figure 57. Squirrel Creek at Mouth Sediment Particle Size Distribution



Fish Populations and Habitat - Greenhorn Creek is a relatively small, steep gradient, well-shaded stream. Sand, gravel, and rubble are the dominant substrate components. The portion of the stream subject to population analyses contained a significant instream woody cover component during 1991 and 1992. A log and debris dam washed out during 1993 and substantially reduced the habitat diversity at this site. Stream flow measurements (ranging from 4.1 to 5.2 cfs) show relatively stable conditions that do not appear to follow precipitation patterns. The factors responsible for this stream flow anomaly are not apparent. Rainbow trout, brown trout, and riffle sculpin were present during each sampling period at Greenhorn Creek (Table 15). Rainbow trout were always numerically dominant (population estimates of 589 to 1,769 per stream mile) and exhibited a generally decreasing trend over time. No clear trend for brown trout populations was identified. A few larger brown trout present during 1991 were not captured subsequently resulting in a substantial decrease in biomass after 1991. Riffle sculpin were present during each year. Loss of large object cover served to selectively reduce the number of 2+ age class fish (particularly brown trout) which resulted in reduced total biomass over time.

Table 15. Fish Population Estimates for Greenhorn Creek above Squirrel Creek

Year	Species	Total Catch	Population Estimate	Confidence Interval	Capture Probability	Biomass (mL)	Average Fork Length (mm)	Number per Stream Mile
1991	rainbow trout	33	33	1.7	0.75	765	113.2	1,769
1992	rainbow trout	23	23	0.4	0.89	415	99.7	1,233
1993	rainbow trout	11	11	0.7	0.92	334	128.0	589
1994	rainbow trout	19	19	2.0	0.83	185	89.7	1,018
1991	brown trout	1	1	-	-	20	29.0	53
1992	riffle sculpin	7	7	2.1	0.64	93	43.8	375
1993	riffle sculpin	1	1	-	-	8	82.0	53
1994	riffle sculpin	1	1	-	-	10	80.0	53
1991	brown trout	6	6	3.5	0.55	867	84.5	321
1992	brown trout	11	11	0.4	0.85	93	81.4	589
1993	brown trout	4	4	1.9	0.80	33	88.7	214
1994	brown trout	11	11	1.0	0.85	115	73.7	590

Squirrel Creek is a small, steep gradient, well-shaded stream with a substrate consisting of sand, gravel, and boulders. The rainbow trout catch ranged from 22 in 1991 to 9 in 1992 and 1993 to 18 in 1994 (Table 16). An increasing catch on subsequent electroshocking passes in 1991 yielded a wide confidence interval in the

population estimate. Subsequent population estimates were within the range of the 1991 estimate even though substantially fewer fish were captured in 1992, 1993, and 1994. These results indicate a stable population. Rainbow trout biomass decreased substantially after 1991. A single brown trout was captured in 1993. A small number of riffle sculpin were present during each year sampled.

Table 16. Fish Population Estimates for Squirrel Creek at Mouth

Year	Species	Total Catch	Population Estimate	Confidence Interval	Capture Probability	Biomass (mL)	Average Fork Length (mm)	Number per Stream Mile
1991	rainbow trout	22	42	64.5	0.30	765	113.2	2,252
1992	rainbow trout	9	9	0.2	0.90	415	99.7	482
1993	rainbow trout	9	9	-	-	334	128.0	482
1994	rainbow trout	18	18	1.7	0.72	185	89.7	965
1991	brown trout	2	2	13.2	0.50	20	29.0	107
1992	riffle sculpin	2	2	-	-	93	43.8	107
1993	riffle sculpin	5	5	2.2	0.63	8	82.0	268
1994	riffle sculpin	3	3	-	-	10	80.0	161
1991	brown trout	0	0	-	-	867	84.5	0
1992	brown trout	0	0	-	-	93	81.4	0
1993	brown trout	1	1	-	-	33	88.7	53
1994	brown trout	0	0	-	-	115	73.7	0

Paired Station Comparison

Analyses of water quality data generally show excellent water quality in both Greenhorn and Squirrel creeks. Stream temperatures were consistently higher in Squirrel Creek which averaged 2.5 degrees warmer than Greenhorn Creek. Stream temperatures were well within the range acceptable for cold water fisheries beneficial use at both stations.

Dissolved oxygen concentrations at these two stations were similiar on most dates sampled. Dissolved oxygen concentrations were generally within the optimal range for rainbow trout.

The range of pH values obtained was similar and varied within 0.5 pH units on each date sampled for each station. pH was suitable for all beneficial uses.

Conductivity was generally higher at Squirrel Creek than Greenhorn Creek. These differences are probably related to variation in geologic parent material in the two watersheds. Conductivity values at both monitoring stations were suitable for beneficial uses. However, levels greater than RWQCB objectives were documented in each stream.

Turbidity values at the Squirrel Creek control station averaged twice as much as those obtained at Greenhorn Creek. Turbidity differences were greatest between the two stations during the snow melt period, as were the maximum values detected.

Squirrel Creek alkalinity values averaged significantly greater than those obtained from Greenhorn Creek. Alkalinity values at both monitoring stations were suitable for beneficial uses.

Both monitoring stations exhibited similar low ranges of nutrient concentrations that appear suitable for beneficial uses. Total phosphorus concentrations ranged slightly higher at Greenhorn Creek and were greatest during spring and summer.

Both monitoring stations contained diverse and stable benthic macroinvertebrate assemblages throughout the study. The benthic communities at both sites were characterized by high species diversity, equitability, and biomass. No adverse impacts to the benthic communities at either site were identified.

Greenhorn Creek cross sectional comparisons show relatively stable channel conditions throughout the study period on the riffle and run cross sections. The pool cross section shows limited down-cutting along the thalweg. Squirrel Creek cross sections show channel degradation in two of the three cross sections. These results suggest that the cumulative watershed affects study's projected threshold of concern estimates may be too high.

The level of fine materials in spawning gravels in Squirrel Creek remained low and suitable for successful trout spawning throughout the period sampled. Initial sediment analyses in 1991 (before the initiation of the cloud seeding program) showed an elevated level of fine material (23 percent) in spawning substrates in Greenhorn Creek. Subsequent sampling revealed much lower levels of fine materials. However, in 1992 and 1994 the level of fine materials in Greenhorn Creek still remained greater than levels known to adversely influence trout reproduction.

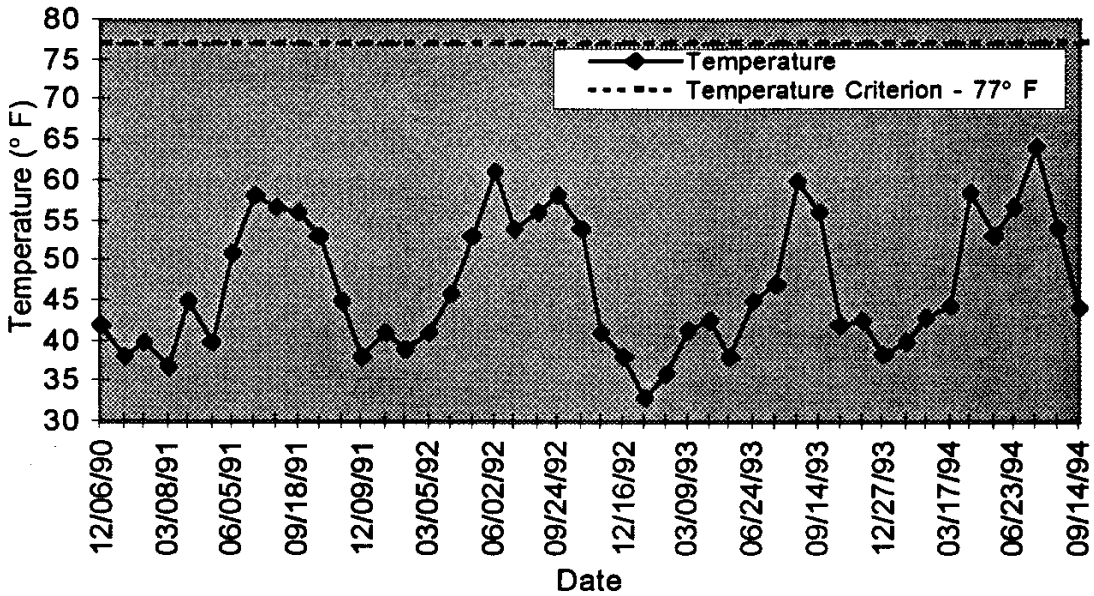
Both stream monitoring stations exhibited a decreasing trend in rainbow trout captures. A wide confidence interval for the 1991 Squirrel Creek rainbow trout population estimate resulted in a stable population trend even though fewer trout were captured in subsequent years. Loss of large instream woody cover at the Greenhorn Creek sampling site is believed to be at least partially responsible for the decreased rainbow trout and brown trout populations and biomass measurements.

Jamison Creek near Johnsville

Jamison Creek is within the cloud seeding project area. No nearby, granitic watersheds were available to pair with Jamison Creek.

Temperature - Stream temperatures at Jamison Creek ranged from 33° F to 64° F (Figure 58) and averaged 47° F. Even during midwinter and snow melt periods stream temperatures generally remained greater than 38° F at this high elevation stream, which may be due to high groundwater input. The higher winter temperatures allow greater biological activity than streams which remained near freezing throughout the winter. Stream temperatures monitored were suitable for cold water fishery beneficial use.

Figure 58. Jamison Creek near Johnsville Stream Temperatures



Dissolved Oxygen - Dissolved oxygen concentrations at Jamison Creek ranged from 8.6 to 15.6 mg/L (Figure 59). All dissolved oxygen concentrations were within the optimal range for rainbow trout.

pH - Jamison Creek pH values ranged from 7.2 to 8.2 (Figure 60). This slightly basic pH range is suitable for beneficial uses.

Figure 59. Jamison Creek near Johnsville Dissolved Oxygen Concentrations

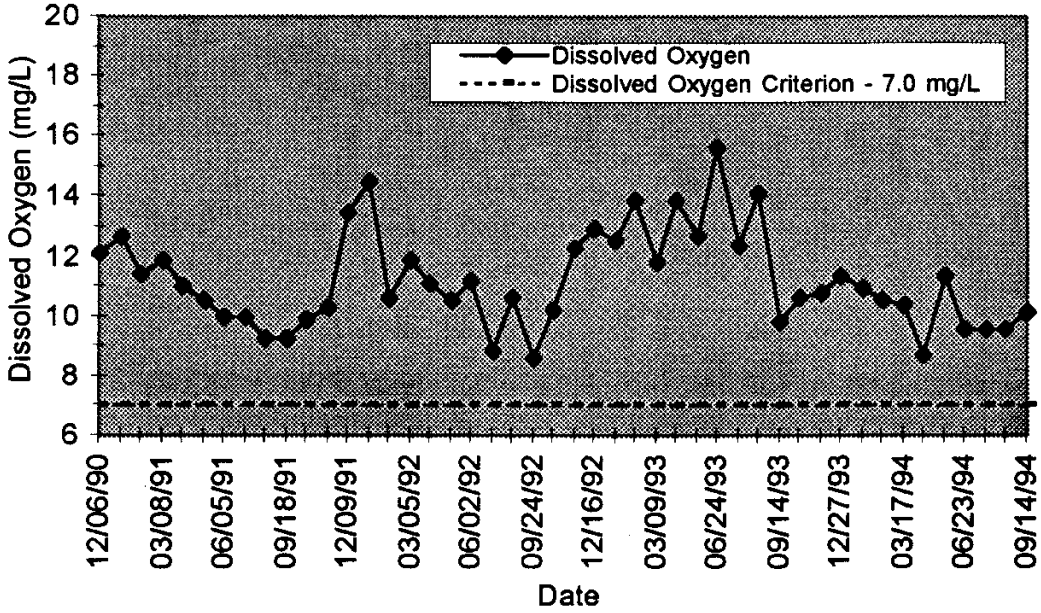
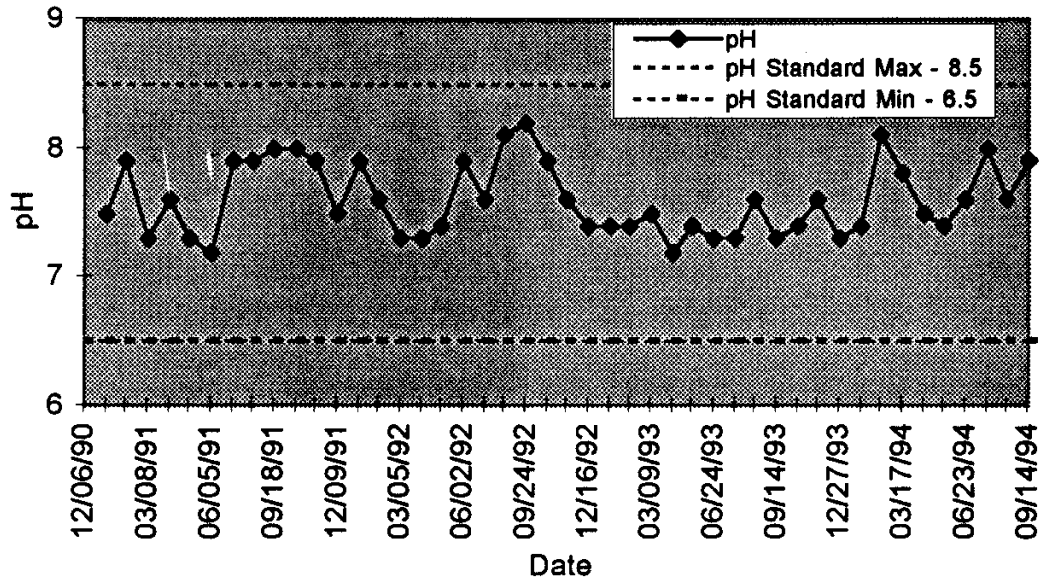


Figure 60. Jamison Creek near Johnsville pH Values



Conductivity - Jamison Creek exhibited a relatively low range (50 to 143 µmhos/cm) of conductivity values (Figure 61). Granitic watersheds like Jamison Creek frequently

Figure 61. Jamison Creek near Johnsville Conductivity Values

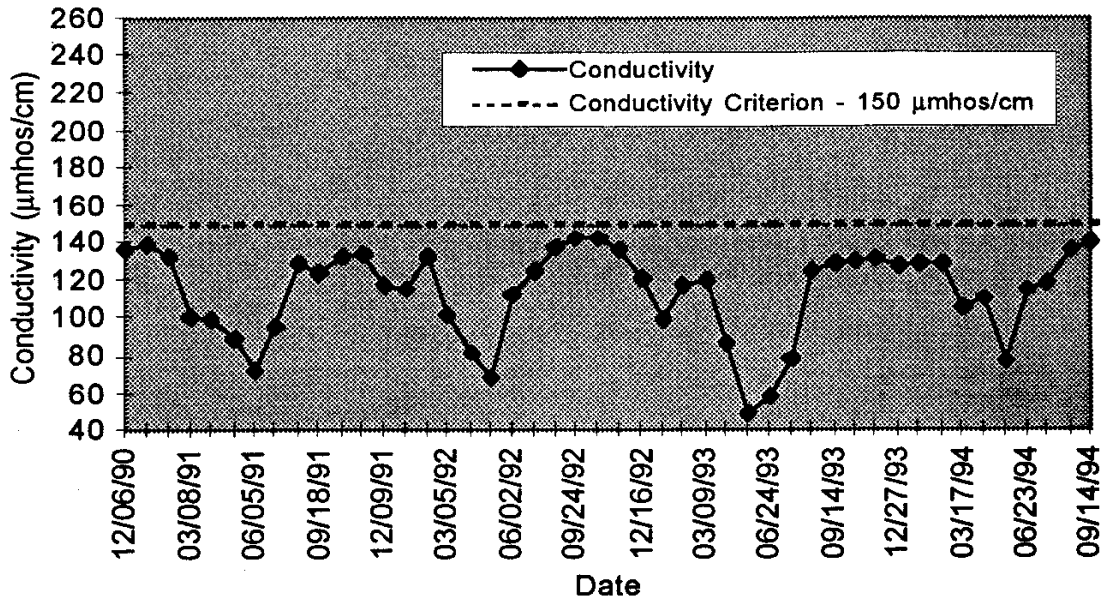


exhibit low mineral, nutrient, and conductivity levels. Jamison Creek conductivity levels were suitable for beneficial uses. All Jamison Creek conductivity measurements did not exceed the RWQCB objective.

Turbidity - Jamison Creek turbidity levels ranged from 0.0 to 3.4 NTU (Figure 62) and averaged 0.5 NTU. Highest turbidity levels were detected in December and February samples. A single turbidity value greater than 1.0 NTU was recorded during the snow melt period. Jamison Creek turbidity levels are within EPA and California Department of Health Services drinking water standards.

Alkalinity - Jamison Creek alkalinity levels remained low throughout the study period, ranging from 29 to 75 mg/L (Figure 63). These alkalinity levels are suitable for beneficial uses.

Nutrient Concentrations - Jamison Creek nutrient concentrations remained low throughout the study period (Figure 64, 65, 66, and 67). Total phosphorus concentrations ranged from <0.01 to 0.06 mg/L. Total phosphorus levels greater than detection limits were uncommon and generally associated with snow melt periods. Dissolved ammonia concentrations greater than detection limits were uncommon. Dissolved organic nitogen concentrations ranged from less than 0.1 to 0.4 mg/L and were highest during February, April, and June. The highest dissolved nitrate concentration (0.2 mg/L) was observed during February 1993.

Figure 62. Jamison Creek near Johnsville Turbidity Values

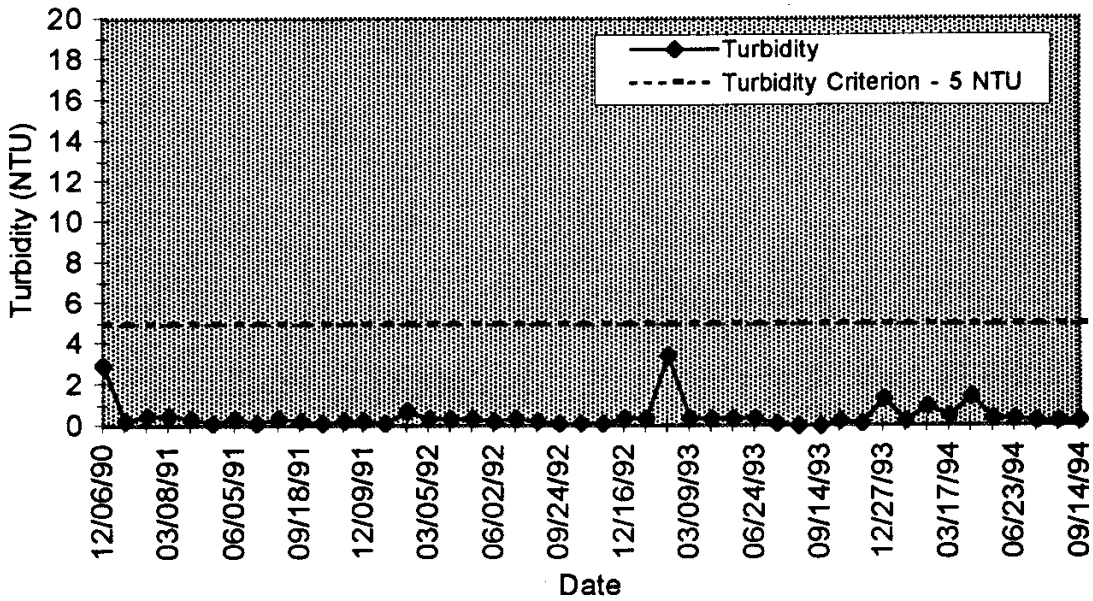


Figure 63. Jamison Creek near Johnsville Alkalinity Values

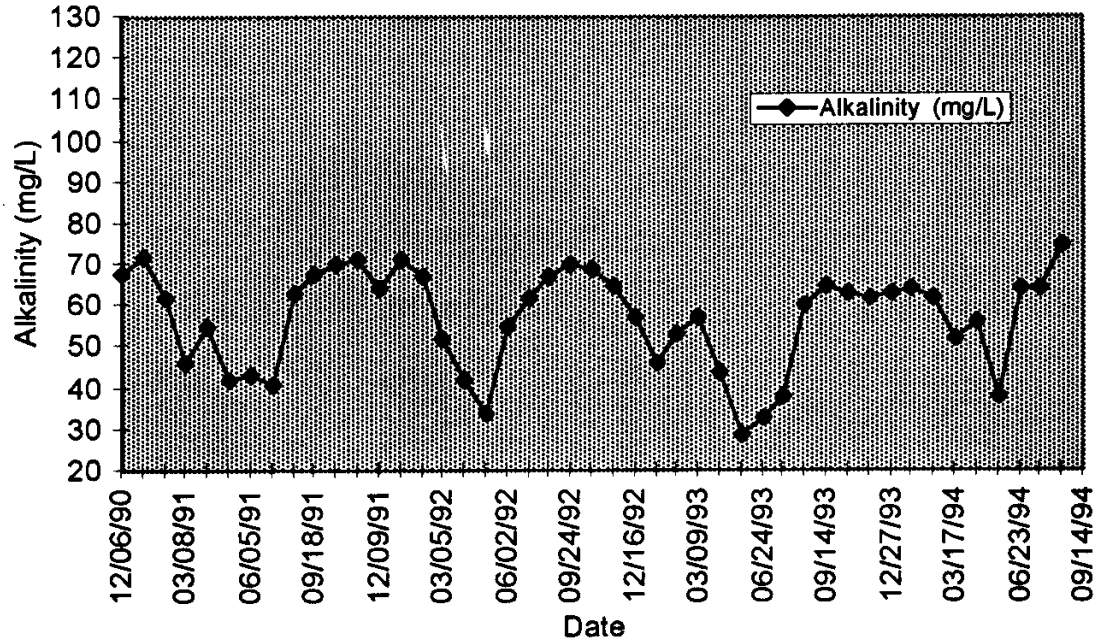


Figure 64. Jamison Creek near Johnsville Dissolved Ammonia Concentrations

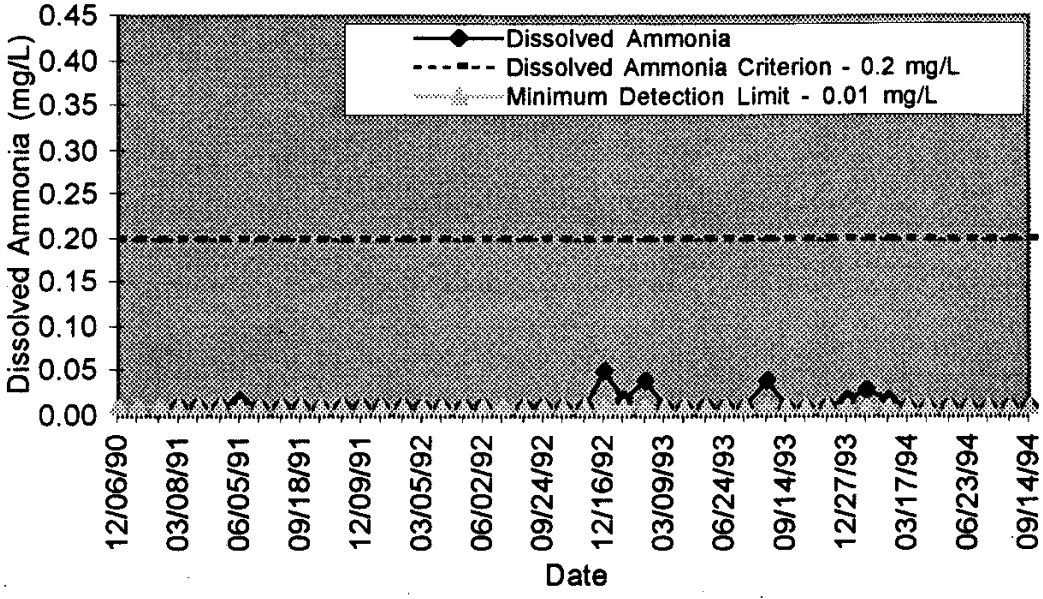


Figure 65. Jamison Creek near Johnsville Total Phosphorus Concentrations

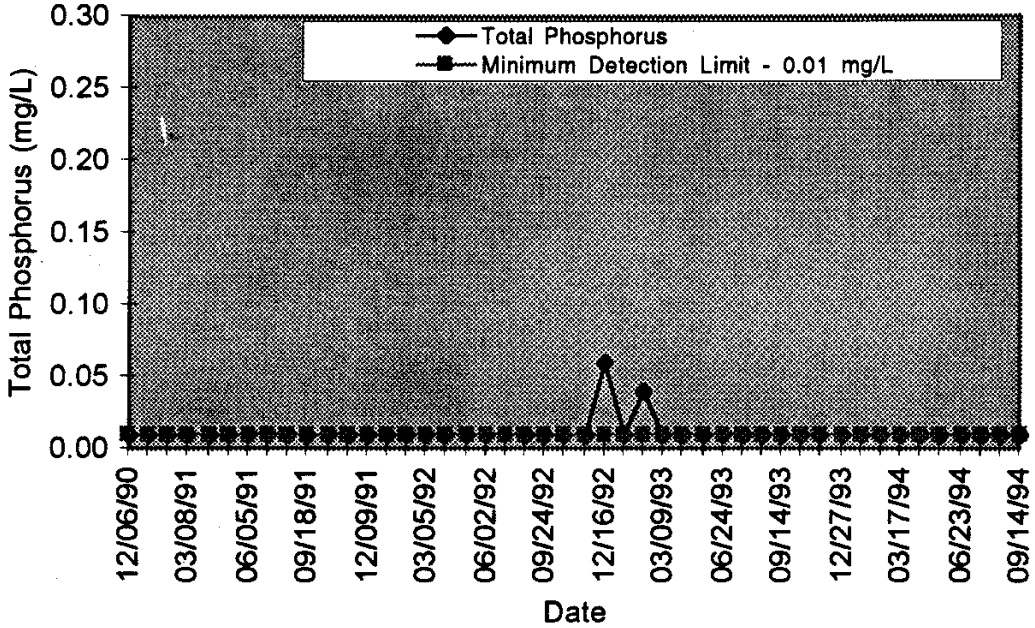


Figure 66. Jamison Creek near Johnsville Dissolved Organic Nitrogen Concentrations

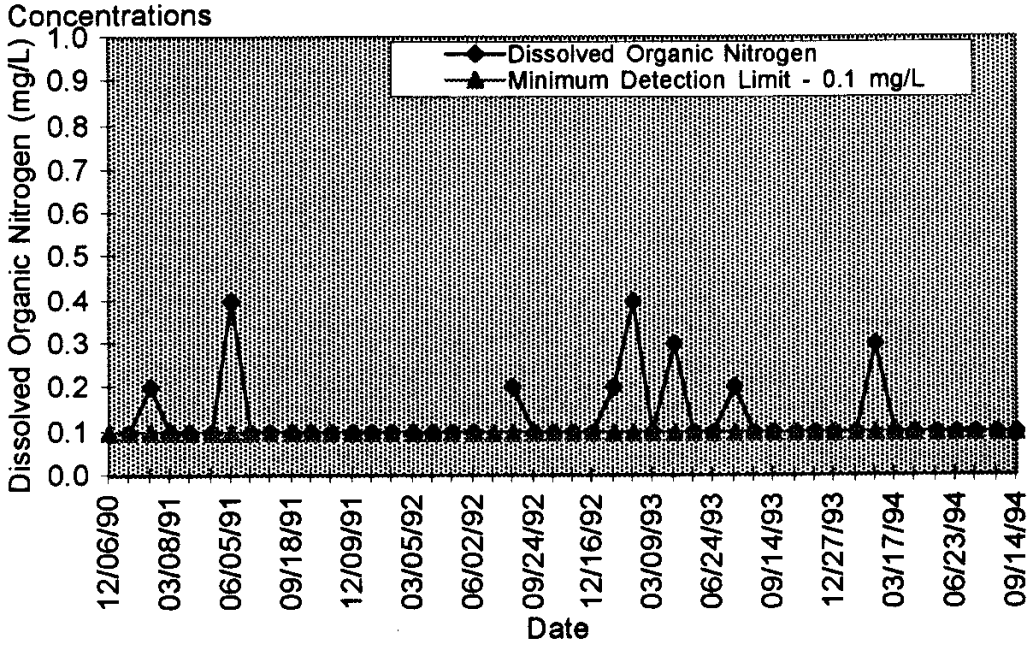
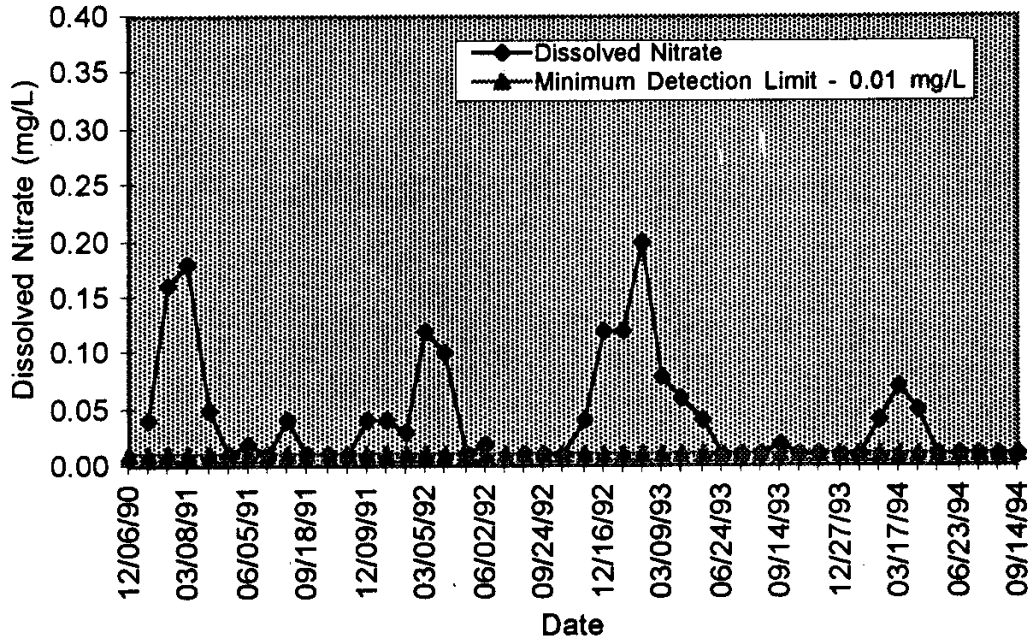


Figure 67. Jamison Creek near Johnsville Dissolved Nitrate Concentrations



Benthic Macroinvertebrates - The Jamison Creek benthic macroinvertebrate community is characterized by moderate densities (565 to 4,921 individuals per square meter), moderate species richness (26 to 42 species), moderate to high diversity values (3.3 to 4.3), and low to moderate biomass (3.5 to 20.0 mL per square meter) (Table 17). No significant disruptions of the benthic community were identified.

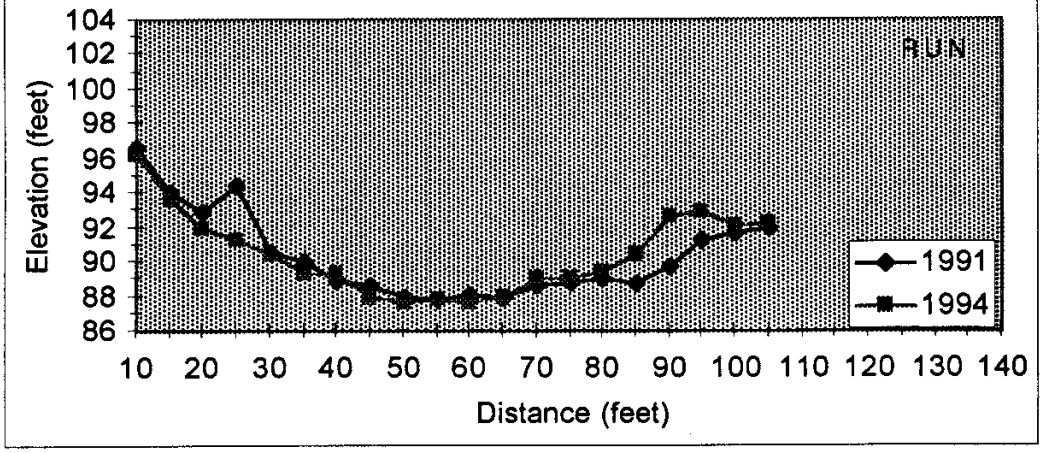
Table 17. Jamison Creek near Johnsville Benthic Macroinvertebrate Community Analyses (Per Square Meter)

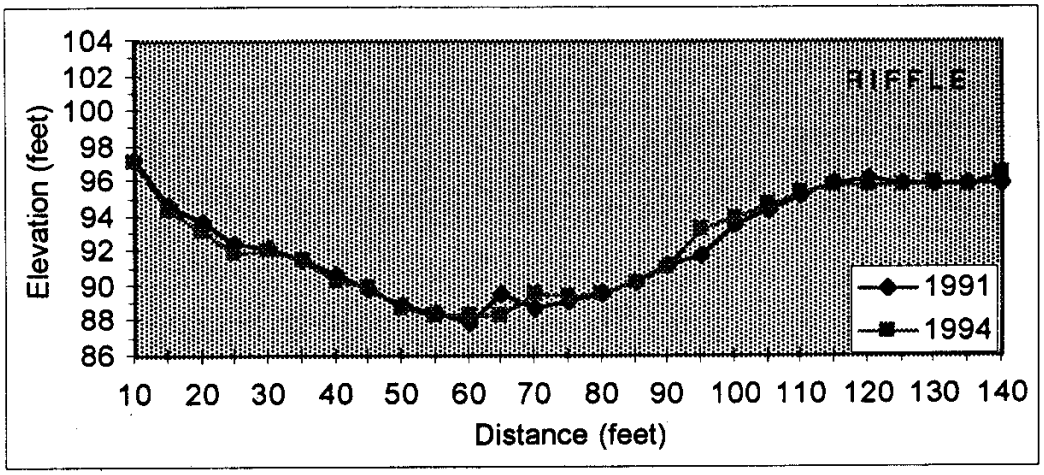
	Date							
	5/91	9/91	6/92	9/92	6/93	9/93	6/94	9/94
No. of organisms	630	4,921	1,526	596	565	775	986	762
No. of Species	26	42	35	32	28	28	31	41
Diversity	3.3	3.5	4.1	4.1	3.6	3.3	4.2	4.3
Equitability	0.54	0.39	0.72	0.80	0.64	0.52	0.86	0.71
Biomass (mL)	-	8.0	20.0	3.5	3.5	3.5	-	6.0

Stream Cross Sections - Analyses of the stream cross sectional data show stable channel conditions throughout the study period (Figure 68) on run and pool cross sections. Extensive floodplain deposition on the run transect was noted following the 1993 snow melt. During high flows the bridge at Johnsville restricts flows resulting in some deposition upstream of this impediment. Portions of Jamison Creek have experienced severe channel disruption resulting in high width/depth ratios and high bedload. The aquatic monitoring site and the stream channel cross sections are immediately above a control point (bridge) and may not be representative of Jamison Creek as a whole. This site does, however, allow year-round sampling access.

Stream Sediment - The level of fine sediments in spawning gravels at the Jamison Creek monitoring site varied annually from 1991 through 1993 with a high of 33 percent in 1992 to only 2 percent in 1993 (Figure 69). The level of fine materials in both 1991 and 1994 were at the upper limit for successful trout reproduction at 5 and 6 percent, respectively. The 1992 level of fine materials in spawning substrates was over six times levels known to impair spawning success. It appears that high flows during 1993 removed fine sediments from the confined channel at the bridge sampling site.

Figure 68. Jamison Creek near Johnsville Stream Cross Sectional Comparisons





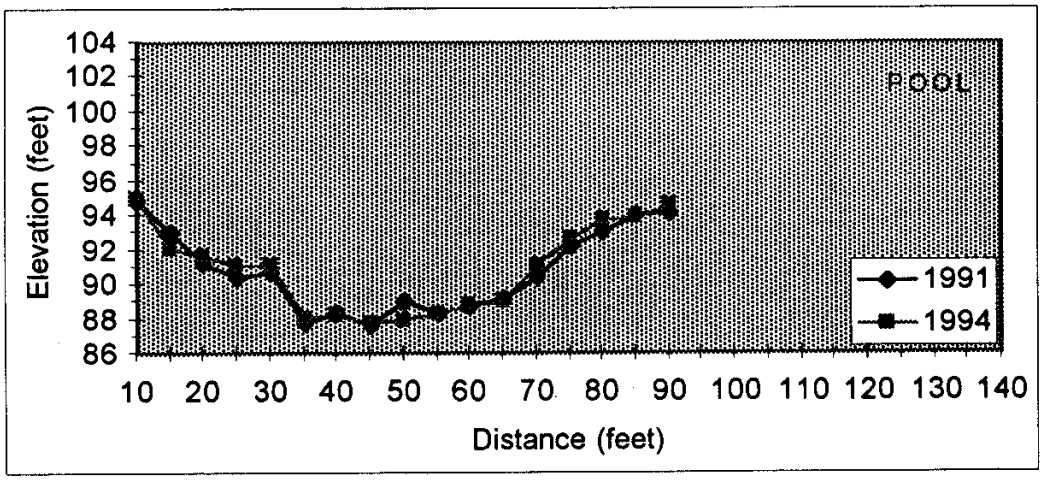
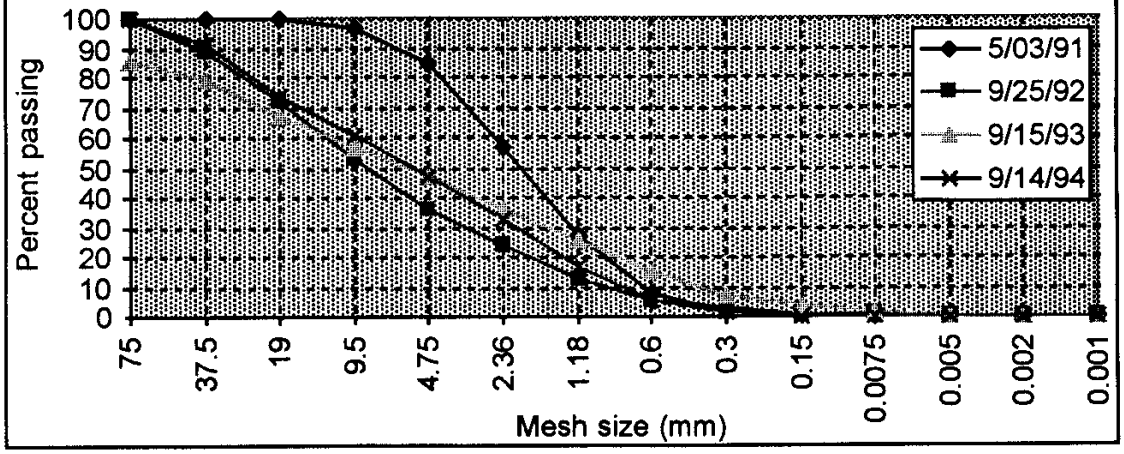


Figure 42. Nelson Creek at the Quincy La Porte Road Sediment Particle Size Distribution



Fish Populations and Habitat - The site selected for aquatic monitoring in Jamison Creek contains a diversity of habitats. Jamison Creek is the second largest tributary to the Middle Fork Feather River that was sampled. The gradient is moderately steep. Substrate is largely composed of rubble and boulders with some sand, gravel, and bedrock present.

Rainbow trout, brown trout, and riffle sculpin were identified in this stream reach. Rainbow trout were the dominant species during each period sampled (Table 18). Rainbow trout population estimates ranged from 3,593 per stream mile in 1993 to 8,259 per stream mile in 1992. All rainbow trout population estimates (except 1992) were within the range of the baseline (1991) population estimate indicating a relatively stable population. The high rainbow trout population in 1992 is believed to reflect the improved nursery habitat within the stream reach sampled. Low flows during 1992 created a large, shallow side pool area where large numbers of young-of-the-year age class trout found refuge within the cobbles. Relatively higher flows during other years allowed access by larger fish to the side pool which probably increased predation. Rainbow trout biomass (per 30 meters) ranged from 1,139 mL in 1991 to 1,490 mL in 1994. Rainbow trout biomass was greater than baseline levels in each subsequent survey. This stream reach consistently contained the highest rainbow trout populations and biomasses of any stream sampled. Although brown trout were captured during each sampling period, they represented a relatively minor component of the fishery at this site. The capture of five brown trout, including a very large individual in 1992, resulted in a significant increase in brown trout biomass. Data analyses show no adverse impacts to fisheries or their habitats associated with the prototype cloud seeding project at this site.

Table 18. Fish Population Estimates for Jamison Creek near Johnsville								
Year	Species	Total Catch	Population Estimate	Confidence Interval	Capture Probability	Biomass (mL)	Average Fork Length (mm)	Number per Stream Mile
1991	rainbow trout	67	82	20.0	0.43	1,139	98.4	4,397
1992	rainbow trout	143	154	11.4	0.58	1,464	83.5	8,259
1993	rainbow trout	58	67	13.5	0.48	1,224	111.9	3,593
1994	rainbow trout	99	104	12.4	0.78	1,490	85.9	5,574
1991	brown trout	3	3	-	-	160	148.3	160
1992	brown trout	5	5	1.2	0.71	598	150.0	268
1993	brown trout	3	3	3.1	0.60	75	136.0	160
1994	brown trout	1	1	-	-	7	71.0	54
1991	riffle sculpin	1	1	-	-	10	83.0	53
1992	riffle sculpin	0	0	-	-	0	0.0	0
1993	riffle sculpin	0	0	-	-	0	0.0	0
1994	riffle sculpin	0	0	-	-	0	0.0	0

Microwatershed Erosion Sampling

Analyses (paired t test) of erosion monitoring results (Table 19) at the paired microwatershed plots indicate no statistically significant differences in erosion between paired stations. Two of the paired sites exhibited greater erosion rates within the cloud seeding area while the two other pairs showed greater erosion rates in the contol area (Figure 70). Comparisons of all stations within the project area to all the control stations outside the project area (Figure 71) also show no statistically significant differences in erosion rates. Comparison of erosion rates when the cloud seeding dispensers were installed (winter) and after they were removed (summer) indicate statistically (at the 90 percent confidence interval) greater erosion during the summer. The summer erosion rate averaged 914.17 pounds per acre while winter erosion rates averaged 14.86 pounds per acre (Figure 72). All erosion monitoring plots were established on disturbed sites (i.e., clear-cuts, skid trails, wildfires) so these erosion rates are not applicable to the forest as a whole. Summer thundershowers are generally brief, high intensity storm events that affect only part of the cloud seeding project area at a time. Over 98 percent of the surface erosion measured occurred in the summer (June through November) when the cloud seeding program was inactive. The greatest erosion rate identified exceeded 14 tons per acre. These results indicate that summer rainstorms may be responsible for most of the

Table 19. Comparison of Soil Erosion Rates (Pounds Per Acre) from the Paired Microwatershed Plots

Station	Time Period					
	9/91-6/92	6/92-11/92	11/92-6/93	6/93-11/93	11/93-5/94	5/94-11/94
Calfpasture Creek #1	1.59	5.14	1.11	27.84	0.33	5.69
#2		14.56	3.28	238.54	7.02	5.29
#3		31.49	21.21	6,222.55	234.34	72.41
McNair Meadows #1	0.04	32.78	6.26	*	40.79	204.25
#2		86.78	22.95	1,961.60	9.89	174.62
#3		137.94	15.83	2,350.73	1.79	22.13
Willow Creek #1	7.03	10.90	52.15	2,053.50	*	124.55
#2		30.64	*	3,085.32	3.14	5.13
#3		139.86	*	3,081.90	11.79	74.40
Prospect Peak #1	8.88	14.57	*	1,708.99	65.18	22.13
#2		245.96	23.09	1,624.88	0.02	82.59
#3		23.49	15.78	674.19	*	4.13
Jackson Creek #1	2.83	3.21	5.32	34.08	3.26	4.83
#2		8.54	0.63	34.46	0.13	6.33
#3		95.77	*	5,629.80	*	43.86
Grizzly Peak #1	12.34	46.10	2.64	28,995.14	18.23	195.37
#2		9.38	7.57	327.30	23.95	19.09
#3		4.60	1.38	191.88	9.21	*
Big Hill #1	19.55	12.71	75.84	361.31	18.47	16.90
#2		15.86	7.86	1,243.81	13.11	42.36
#3		12.68	5.12	209.23	10.27	12.66
Nelson Creek #1	1.78	3.35	*	3,250.90	0.79	6.97
#2		4.79	*	184.07	5.29	2.17
#3		5.90	*	43.23	*	3.40

* Plot vandalized or damaged; no data

Figure 70. Average Annual Soil Loss at Erosion Monitoring Stations

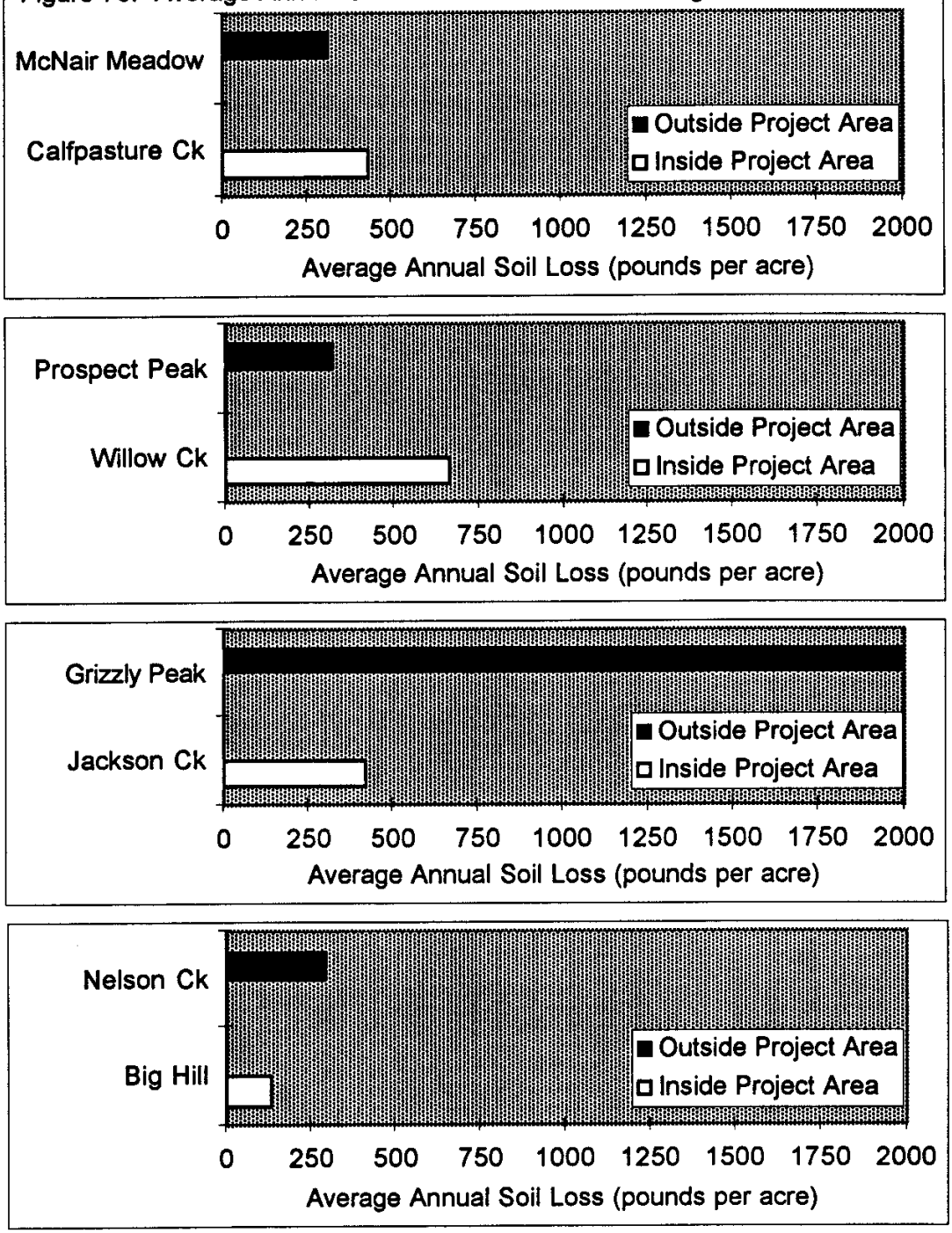


Figure 71. Comparison of Average Annual Soil Erosion Rates from Plots Located Inside and Outside the Cloud Seeding Project Area

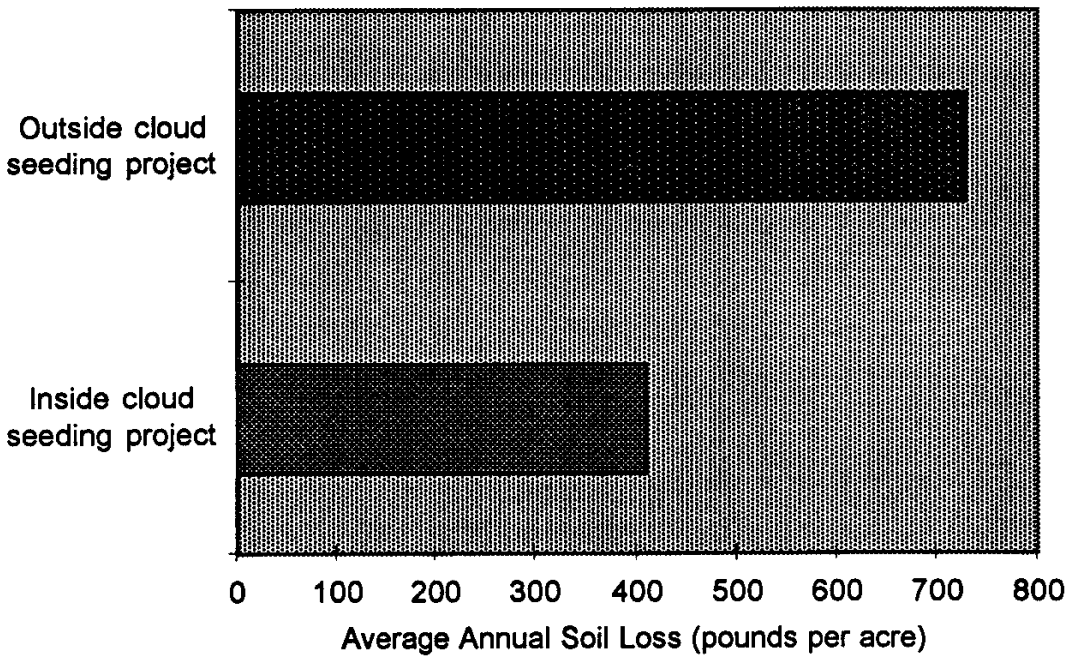
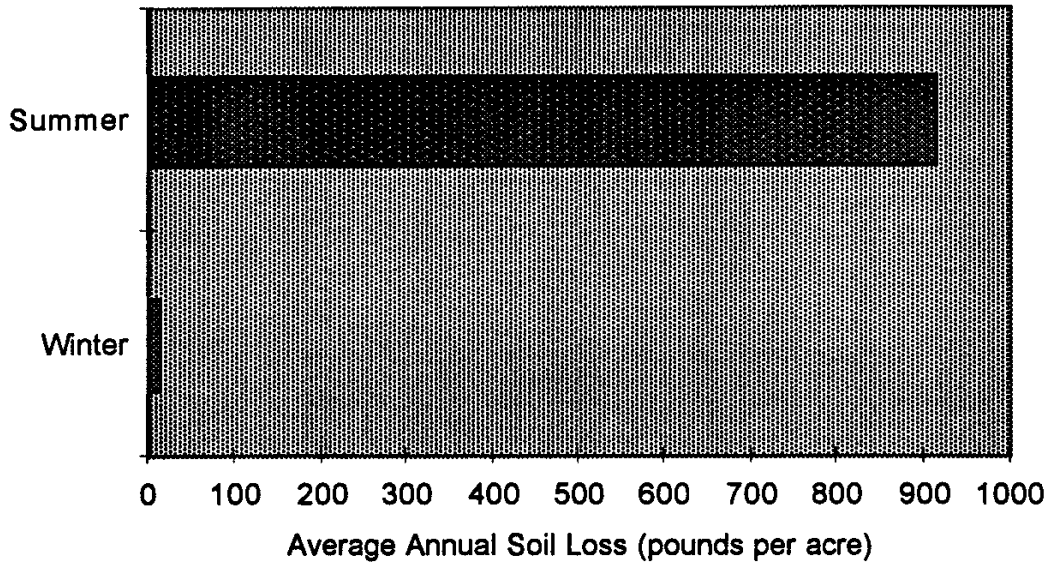


Figure 72. Comparison of Soil Loss by Season



observed surface erosion. These results also suggest that snow cover may inhibit erosion and off-site transport of fine materials.

Vegetation Monitoring

DWR monitored changes in the species composition across the ecotonal gradient of wet to dry meadow edges. This previously released report is included in Appendix I (excluding the photos of the transects)

No major changes in vegetation distribution were observed over the four year period monitored. A trend toward greater species diversity and frequency was observed following the very wet winter of 1993. No observable differences between study (within the cloud seeding area) and control (outside the cloud seeding area) transects were identified. The study concluded that any discernible effects due to the cloud seeding program were no more apparent than effects potentially due to general weather patterns.

CONCLUSIONS

None of the water quality impairments identified (i.e., high stream temperatures, low dissolved oxygen concentrations, and elevated dissolved ammonia concentrations) could be related to the prototype cloud seeding project.

Willow Creek was the only sampling location within the project area that exhibited any impairment of the benthic macroinvertebrate community. The impairments identified were the result of drought-related desiccation at the sampling site. No impairments of the benthic macroinvertebrate communities related to the cloud seeding project occurred.

Changes in stream channel cross sectional dimension were identified at stations located inside and outside the cloud seeding project area. Most of these changes were relatively minor. Significant down-cutting was identified only at the Willow Creek near Clio monitoring station. A head-cut from the culvert on the county road progressed past all three stream transects resulting in extensive down-cutting since 1991. No significant stream channel modifications related to the cloud seeding project were documented.

The level of fine materials in spawning gravels generally exceeded levels known to impair the reproductive success of some substrate spawning fish. Highly elevated levels of fine materials were present in spawning substrates at the Middle Fork Feather River at Portola, Willow Creek, Greenhorn Creek, and Jamison Creek. No consistent trend in the amount of fine materials in spawning gravels relative to the cloud seeding project (or precipitation in general) is apparent.

Rainbow trout populations appeared to increase or decrease in response to microhabitat changes within the 30-meter stream segments sampled. These microhabitat changes may or may not be representative of the entire stream or related to the effects of the prototype project.

Over 98 percent of the surface soil erosion occurred during the period that the cloud seeding program was inactive (summer). Snow cover appears to protect disturbed soils from erosion and subsequent off-site transport. Based on these observations, if the prototype project was effective in increasing snow pack, then a slight decrease in the erosion rate may have occurred.

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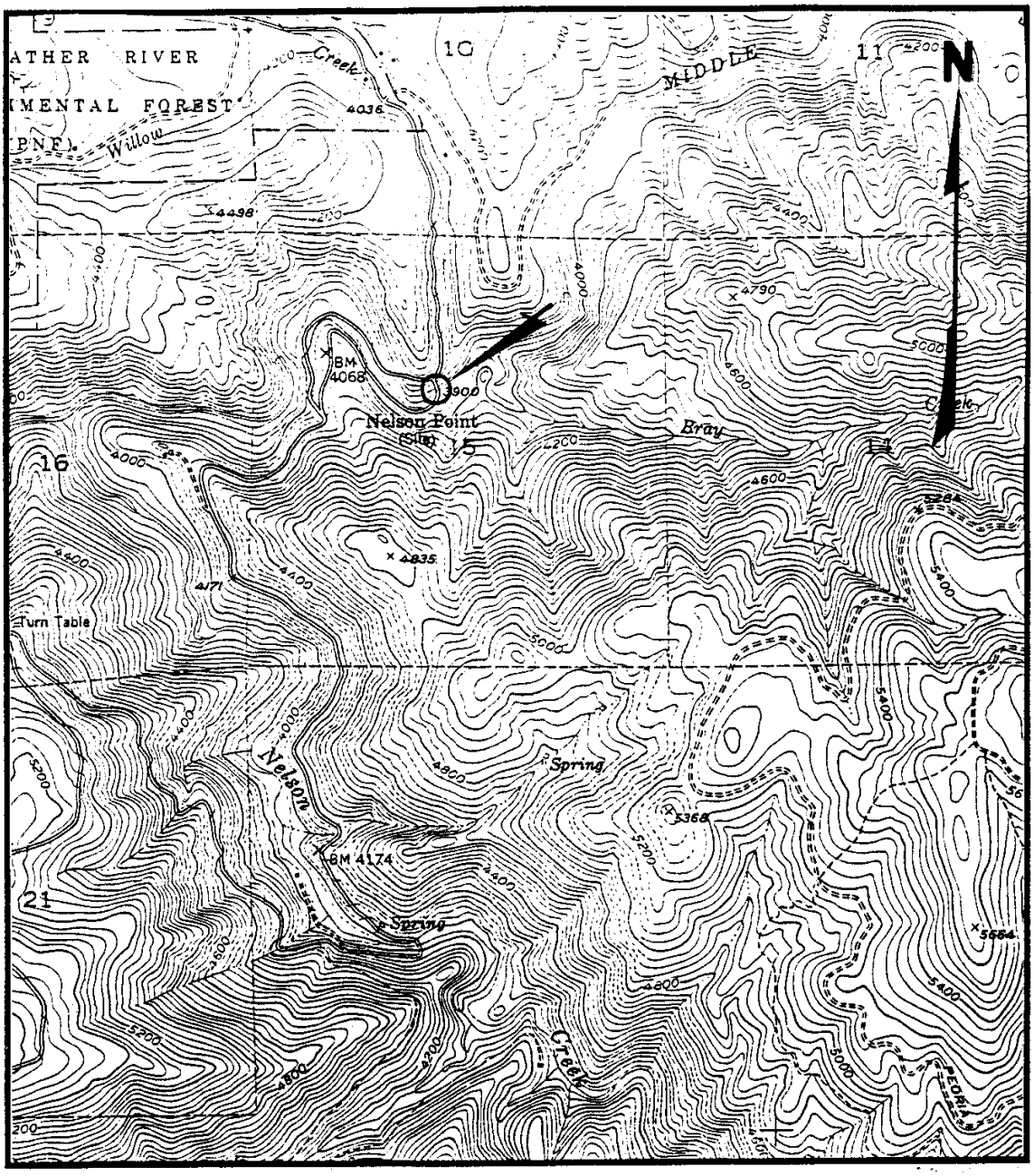
Appendix A

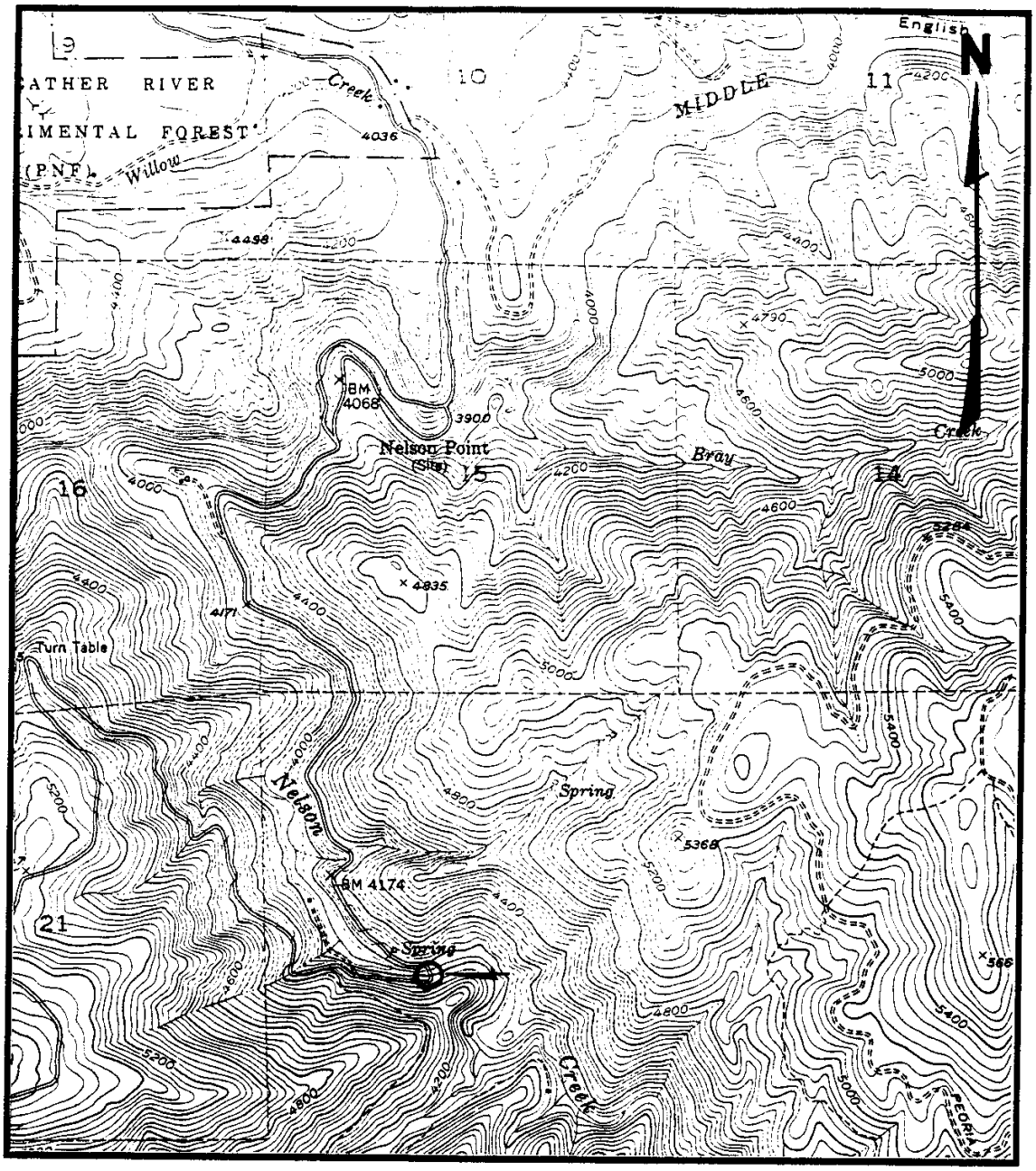
Locations of the Nine Aquatic Monitoring Stations



Appendix A1. Middle Fork Feather River at the Quincy La Porte Road Aquatic Monitoring Station

Blue Nose Mtn. USGS 7.5 Quad T 23N, R 10E, SE 1/4 of the NW 1/4 of section 15

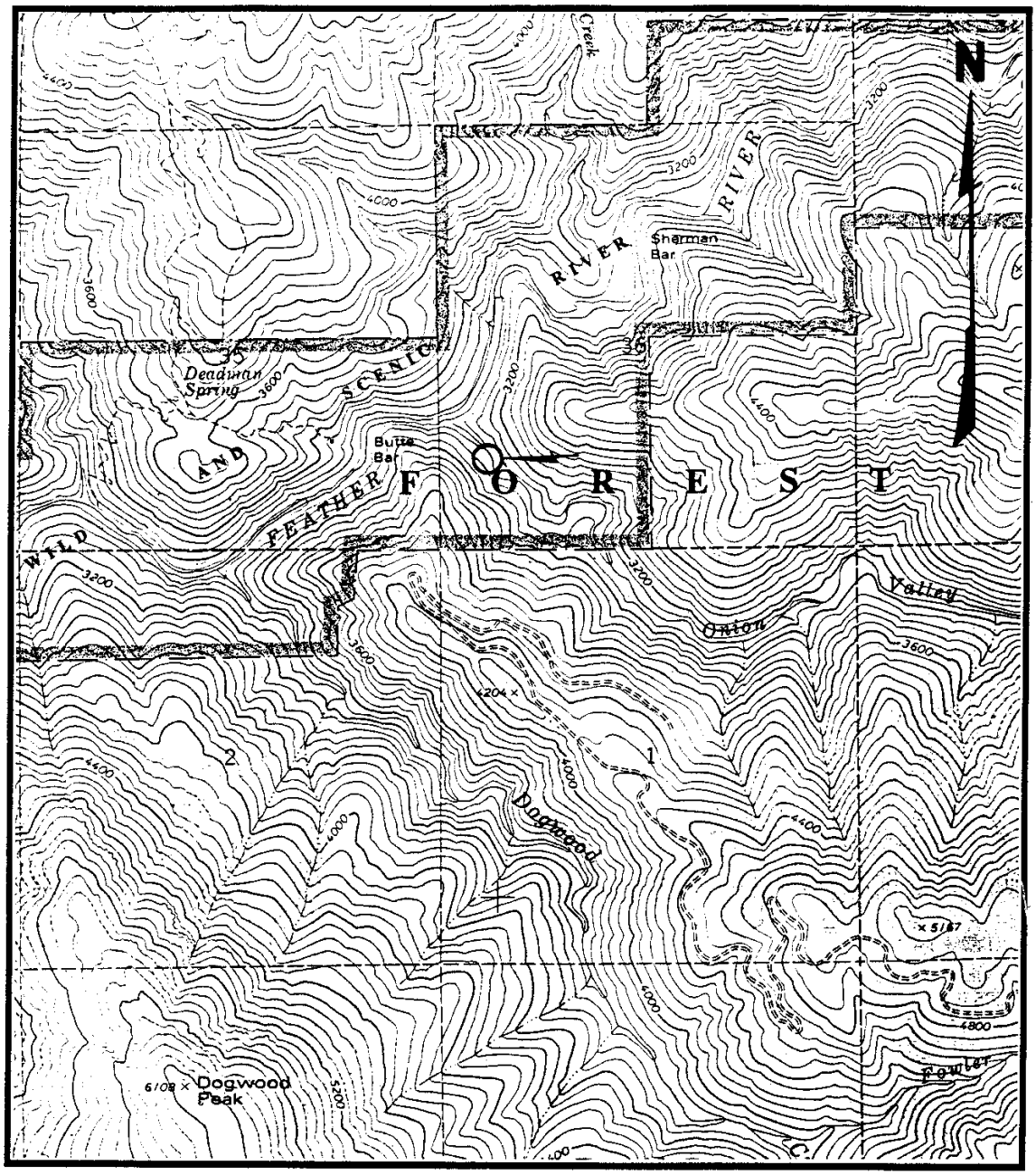
Scale 2.6 inches = 1 mile
Contour interval = 40 feet



Appendix A2. Nelson Creek at the Quincy La Porte Road Aquatic Monitoring Station

Blue Nose Mtn. USGS 7.5 Quad T 23N, R 10E, NE 1/4 of the SW 1/4 of section 22

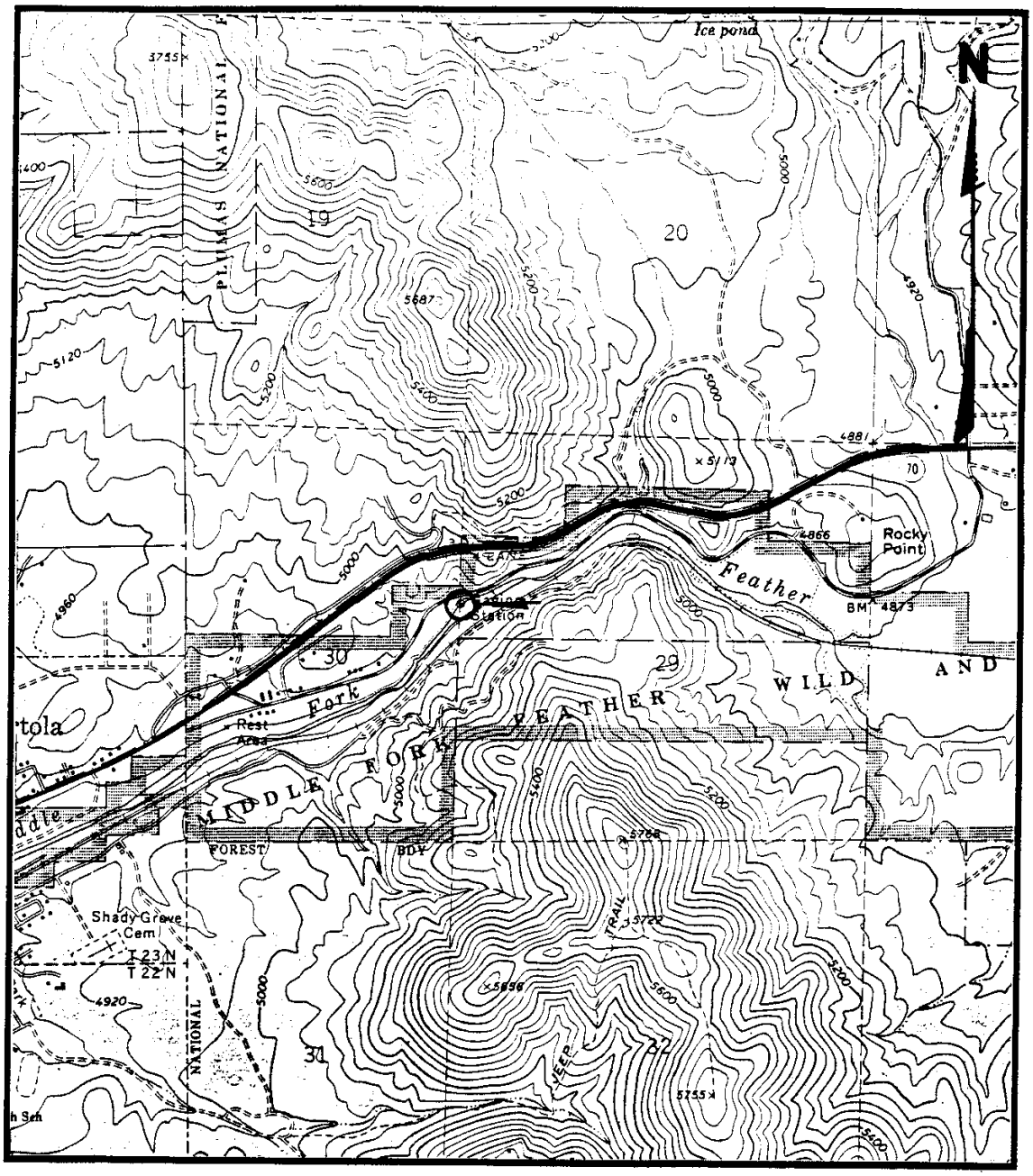
Scale 2.6 inches = 1 mile
Contour interval = 40 feet



Appendix A3. Onion Valley Creek at Mouth Aquatic Monitoring Station

Dogwood Ck. USGS 7.5 Quad T 23N, R 8E, SW 1/4 of the SW 1/4 of section 36

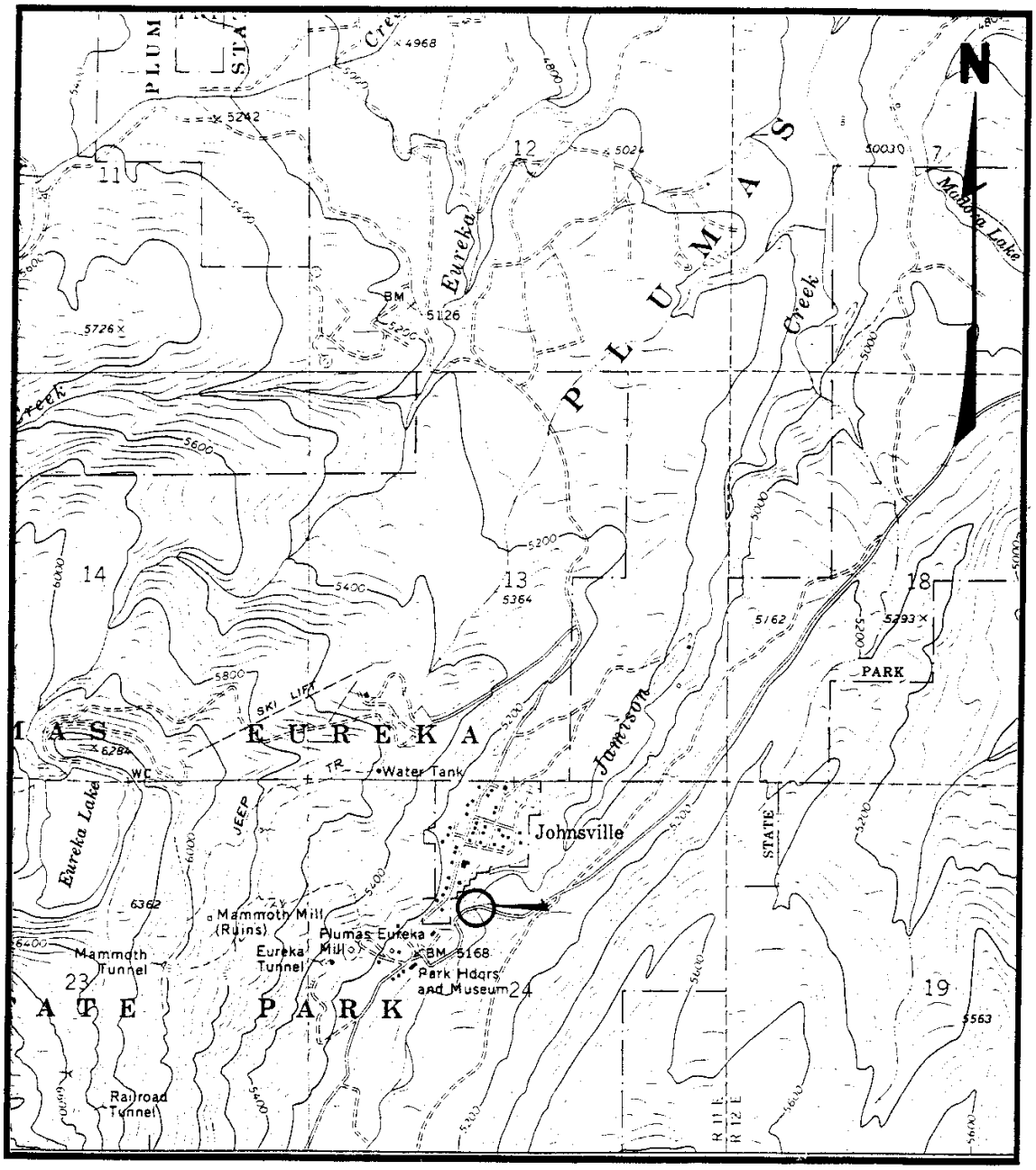
Scale 2.6 inches = 1 mile
Contour interval = 80 feet



Appendix A4. Middle Fork Feather River at Portola Aquatic Monitoring Station

Portola USGS 7.5 Quad T 23N, R 14E, SW 1/4 of the NW 1/4 of section 29

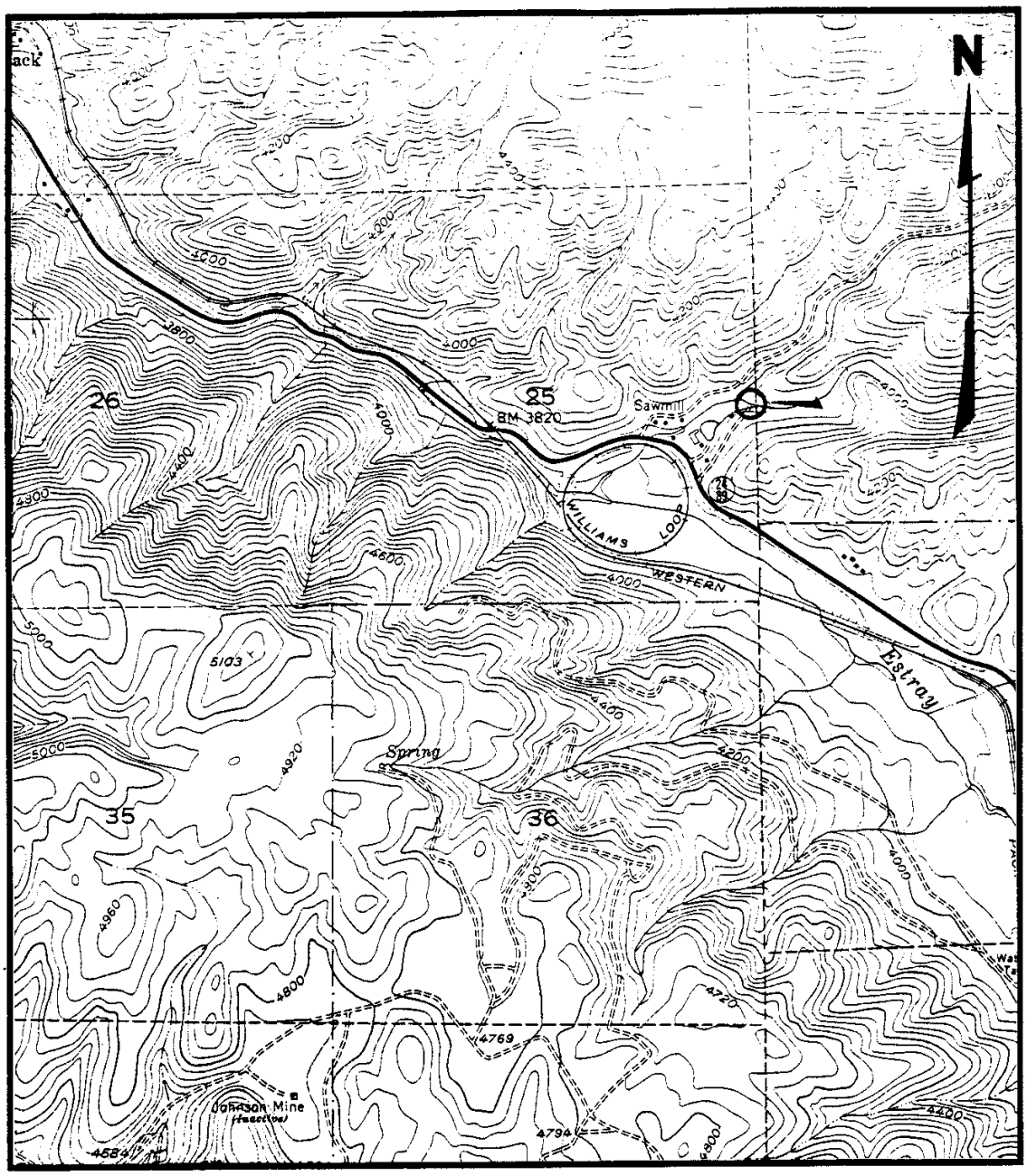
Scale 2.6 inches = 1 mile
Contour interval = 40 feet



Appendix A5. Jamison Creek near Johnsville Aquatic Monitoring Station

Johnsville USGS 7.5 Quad T 22N, R 11E, SE 1/4 of the NW 1/4 of section 24

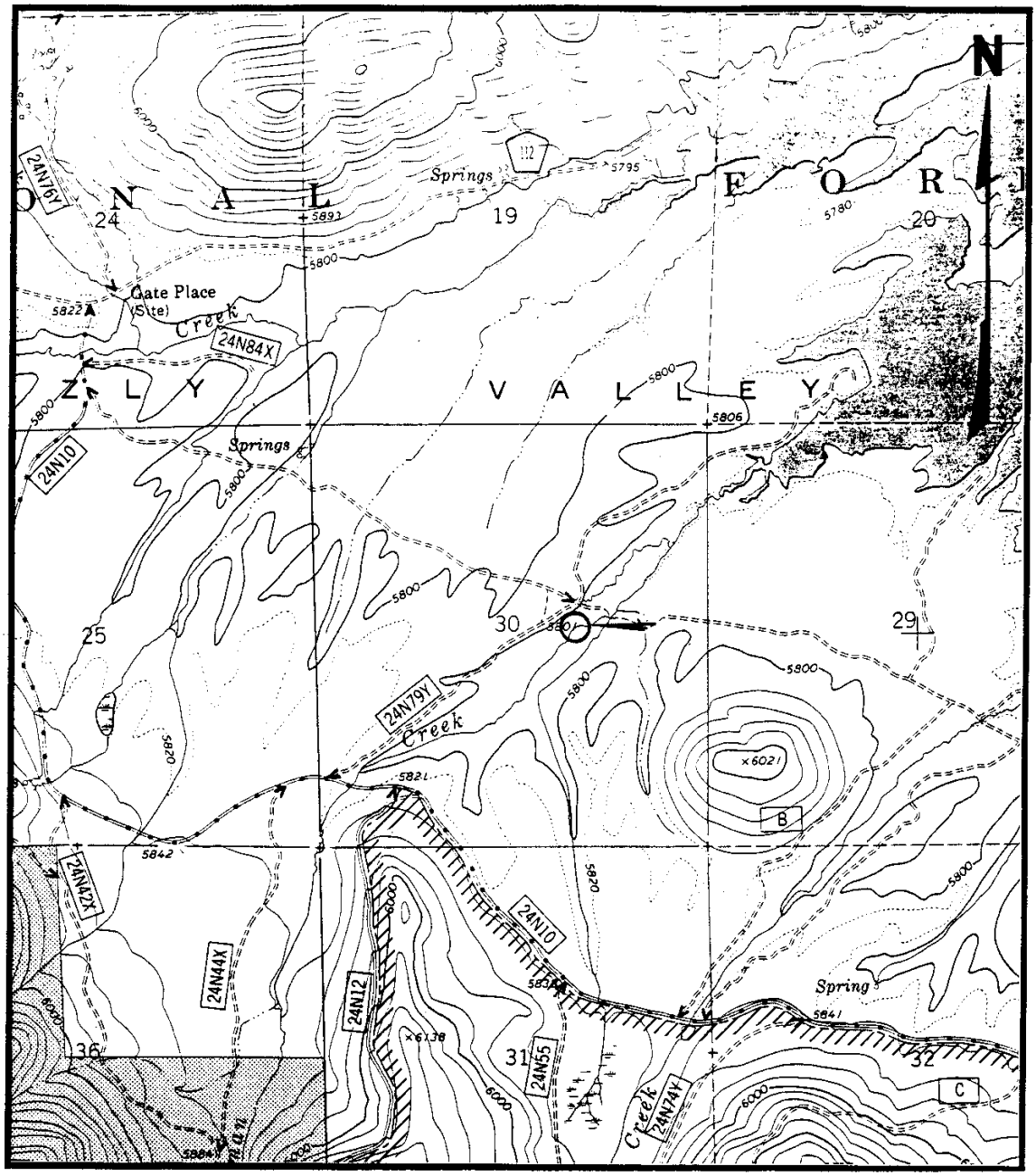
Scale 2.6 inches = 1 mile
Contour interval = 40 feet



Appendix A6. Greenhorn Creek above Squirrel Creek Aquatic Monitoring Station

Spring Garden USGS 7.5 Quad T 24N, R 10E, NE 1/4 of the SE 1/4 of section 25

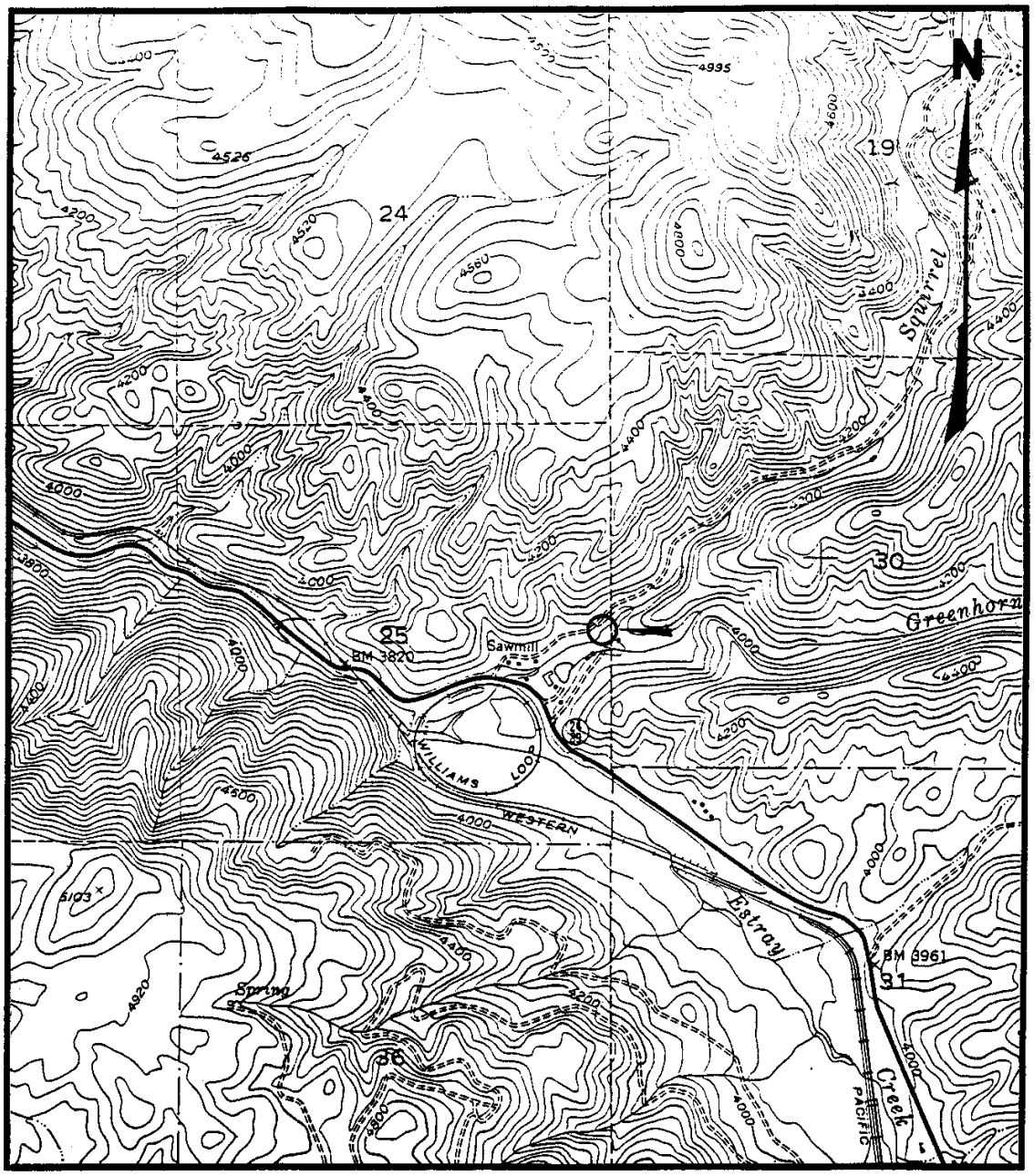
Scale 2.6 inches = 1 mile
Contour interval = 40 feet



Appendix A7. Freeman Creek Aquatic Monitoring Station

Grizzly Valley USGS 7.5 Quad T 24N, R 13E, SW 1/4 of the NE 1/4 of section 30

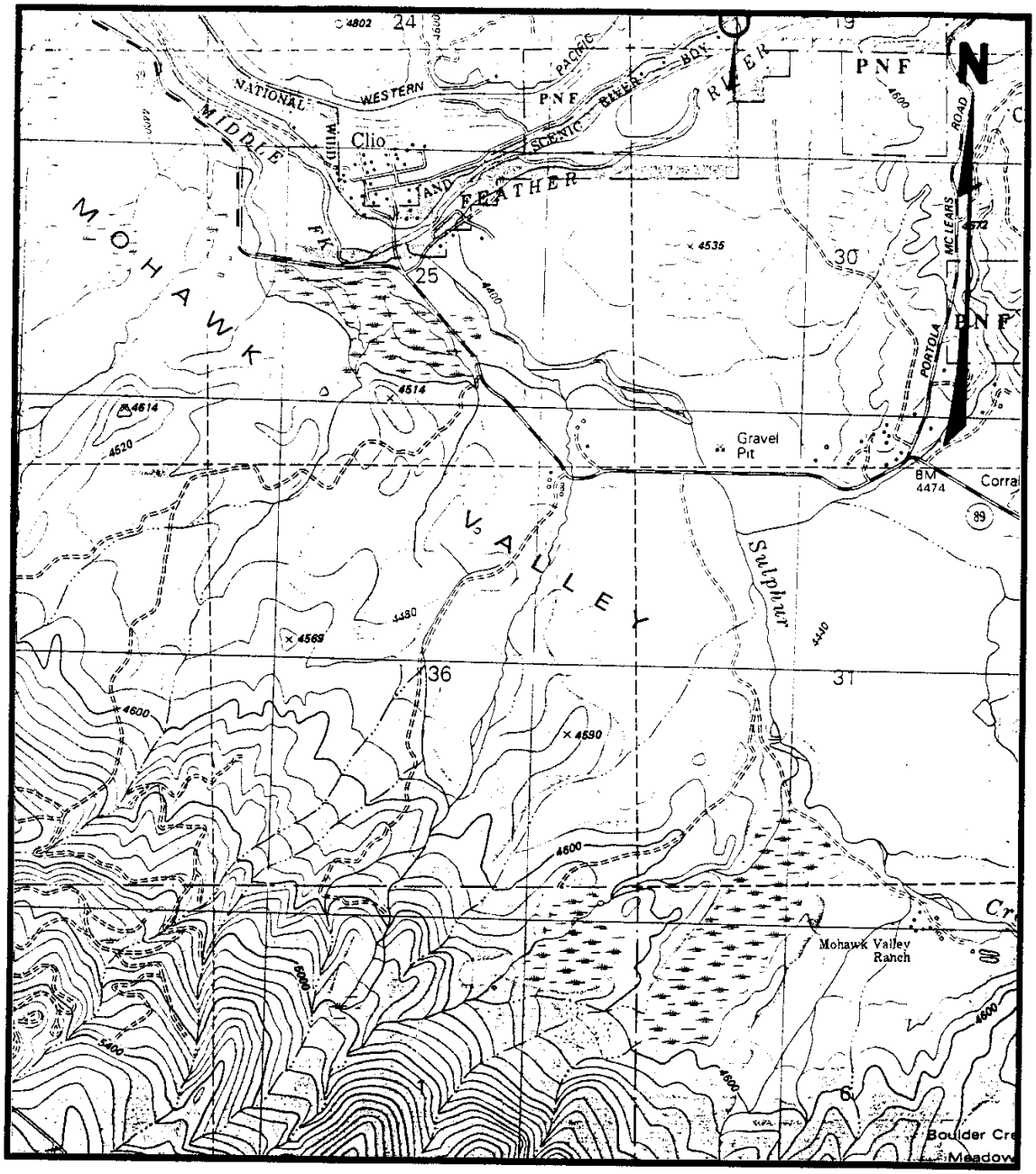
Scale 2.6 inches = 1 mile
Contour interval = 40 feet



Appendix A8. Squirrel Creek at Mouth Aquatic Monitoring Station

Spring Garden USGS 7.5 Quad T 24N, R 10E, NE 1/4 of the SE 1/4 of section 25

Scale 2.6 inches = 1 mile
Contour interval = 40 feet



Appendix A9. Willow Creek near Clio Aquatic Monitoring Station

Clio USGS 7.5 Quad T 22N, R 13E, SW 1/4 of the SW 1/4 of section 19

Scale 2.6 inches = 1 mile
Contour interval = 40 feet

Appendix B

Water Quality Methodologies

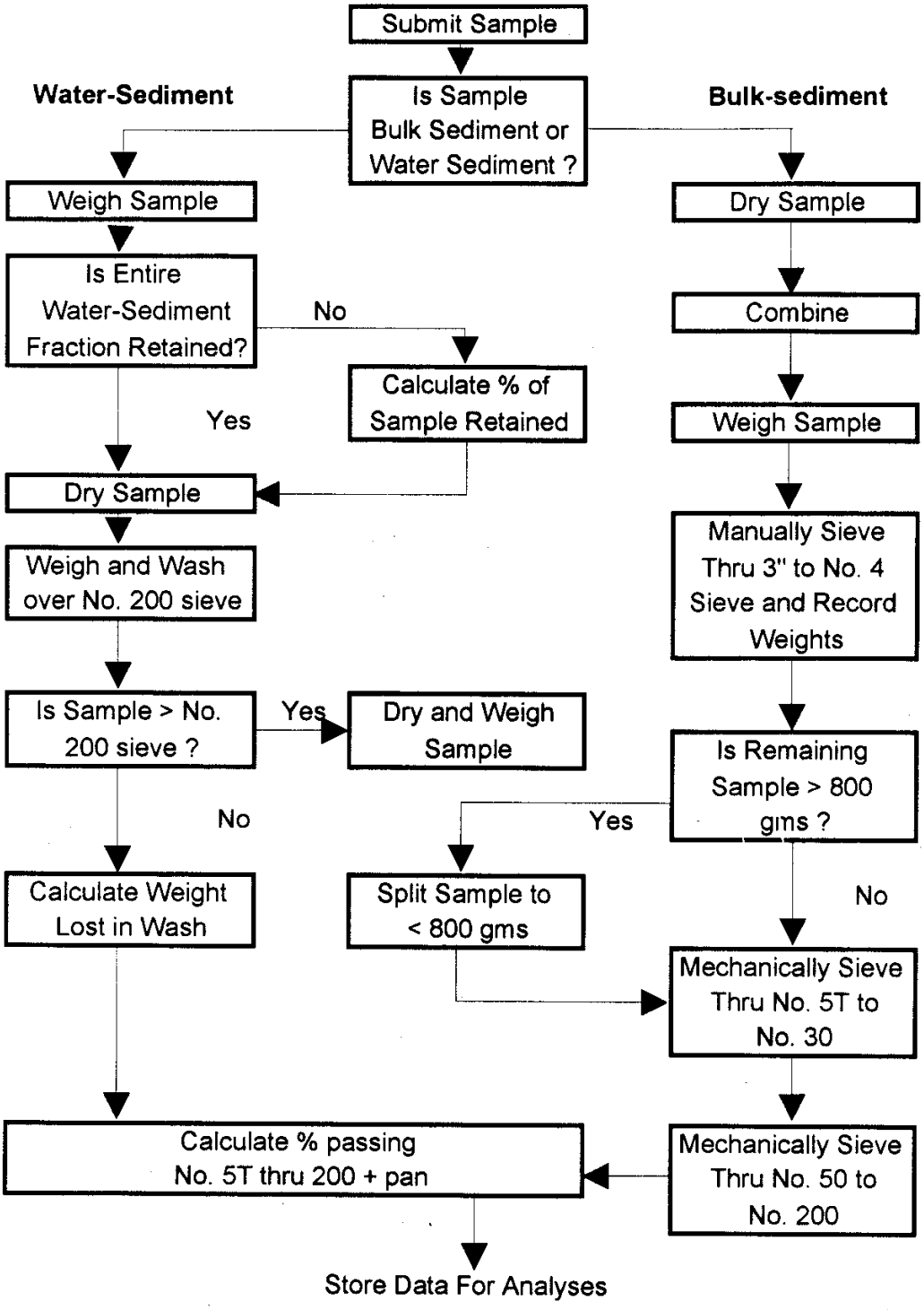
Appendix B. Field and Laboratory Methodologies Used for Water Quality Evaluation.

Laboratory Analysis	Method/Reference	Equipment	Minimum Detection Limit	Maximum Holding Time
Alkalinity	Potentiometric Titration APHA 1980, p. 225	Corning Model 110	2.0 mg/L	14 days
Electrical Conductivity	Wheatstone Bridge Conductimetry, APHA 1980, p. 195	YSI Model 34 (Lab) Orion Model 124 (field)	10 µmhos/cm	28 days
Dissolved Ammonia	EPA Method 350.1 EPA 1983	Technicon Colorometric Auto-Analyzer	0.01 mg/L	30 days (Frozen)
Total Phosphorus	EPA Method 365.1 EPA 1983	Technicon Colorometric Auto-Analyzer	0.01 mg/L	30 days (Frozen)
Dissolved Organic Nitrogen	EPA Method 351.2 & EPA 350.1EPA 1983	Technicon Colorometric Auto-Analyzer	0.1 mg/L	30 days (Frozen)
Dissolved Nitrate	EPA Method 353.2 EPA 1983	Technicon Colorometric Auto-Analyzer	0.1 mg/L	30 days (Frozen)
Dissolved Oxygen	Azide Modification of Iodometric APHA 1980, p. 390	Hach D.O. kit	0.1 mg/L	1 hour
Flow	Current Meter USBR 1968	Price Meter Pygmy Meter	10% + or -	-
pH	Hellige Comparator	Hellige Comparator	0.1 unit	immediately
Temperature	Mercury Thermometer APHA 1980, p. 124	Mercury Thermometer	0.5 °F	immediately
Turbidity	Nephelometric APHA 1980, p. 132	Hach 2100A	0.1 NTU	2 days

Appendix C

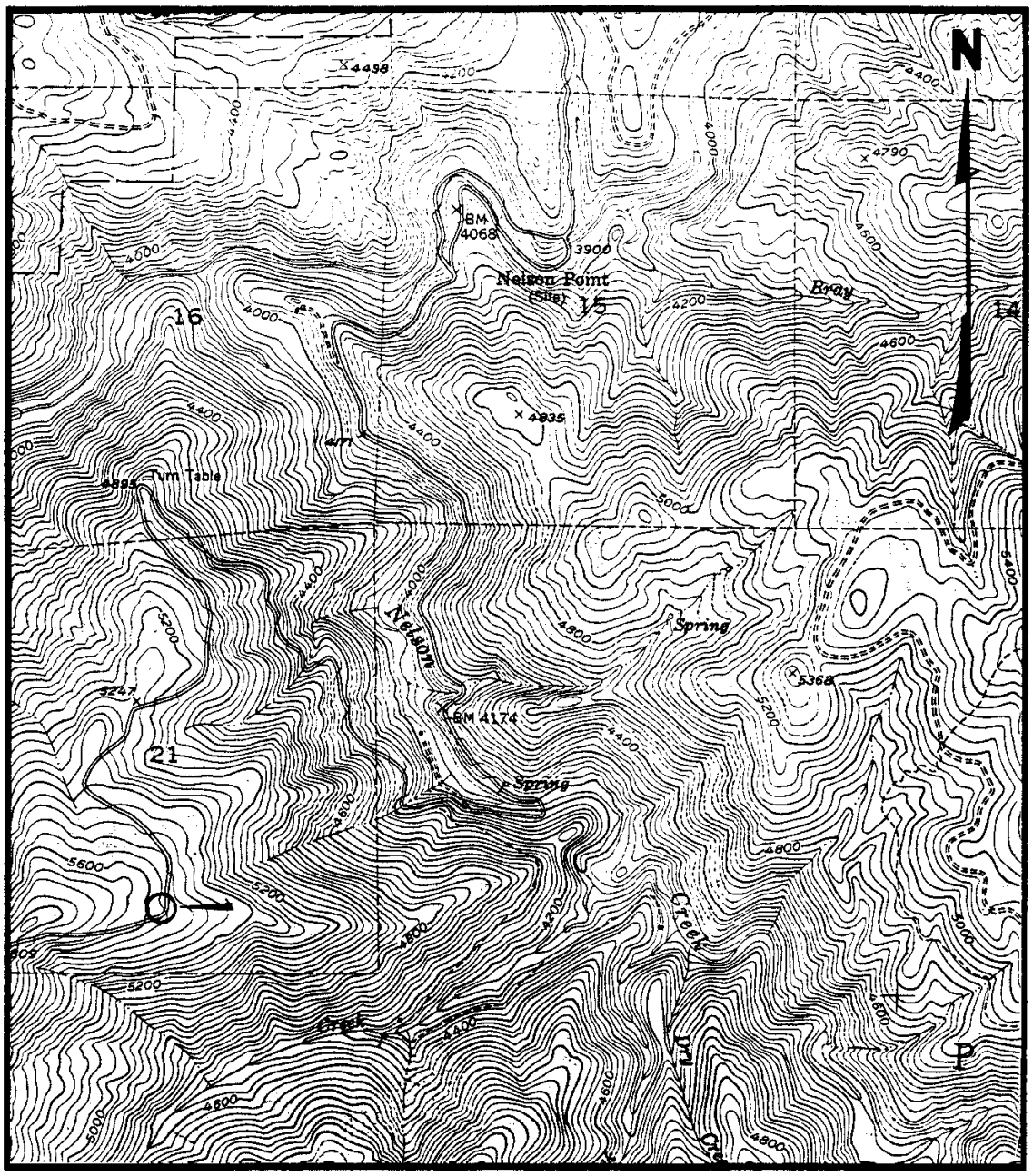
Summary of Laboratory Proceedures Employed in Sediment Analyses

Appendix C. Summary of Laboratory Proceedures Employed in Sediment Analyses.



Appendix D

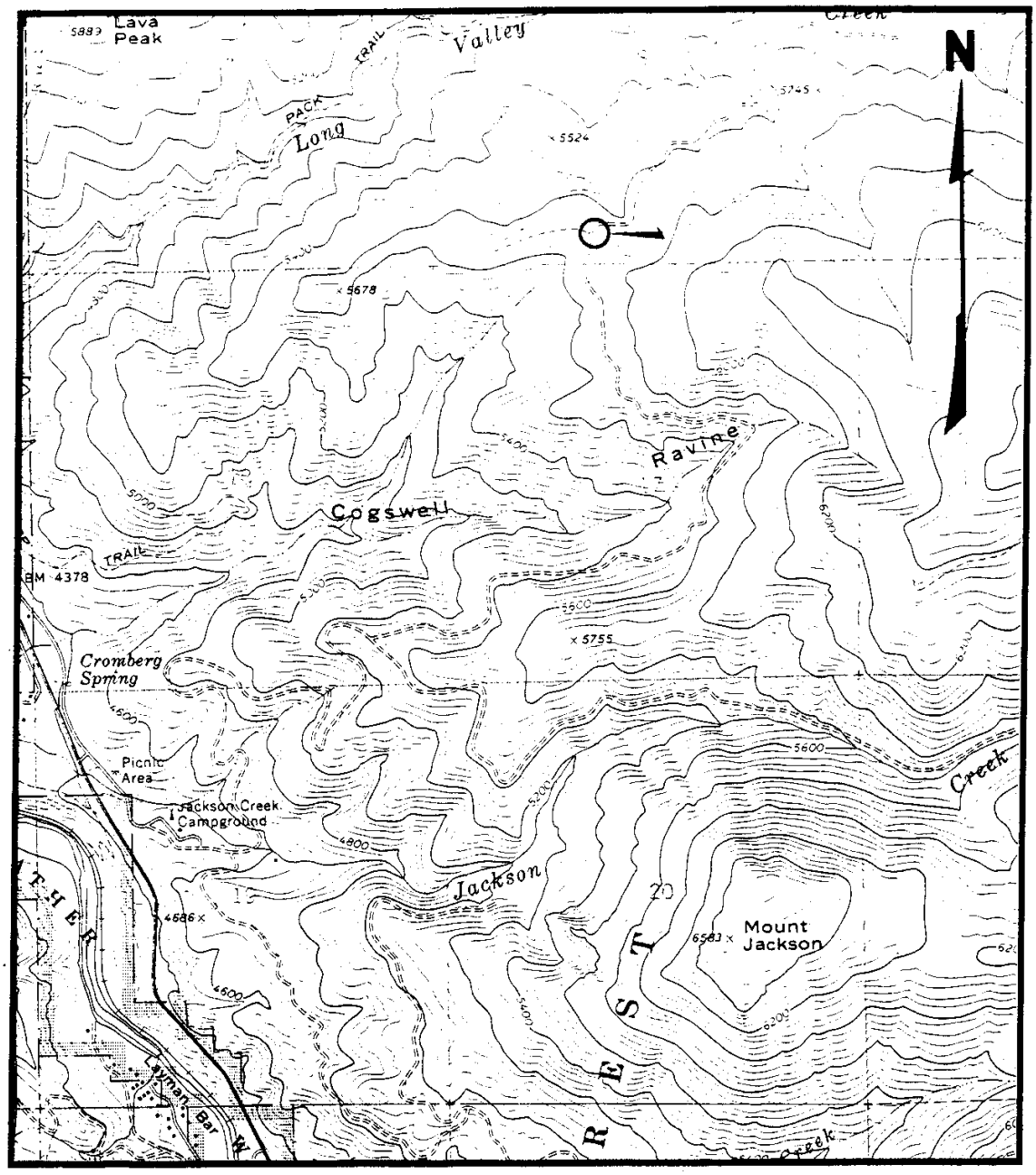
Locations of the Paired Microwatershed Erosion Sampling Plots



Appendix D1. Nelson Creek Microwatershed Erosion Monitoring Plots

Blue Nose USGS 7.5 Quad T 23N, R 10E, SE 1/4 of the SW 1/4 of section 21

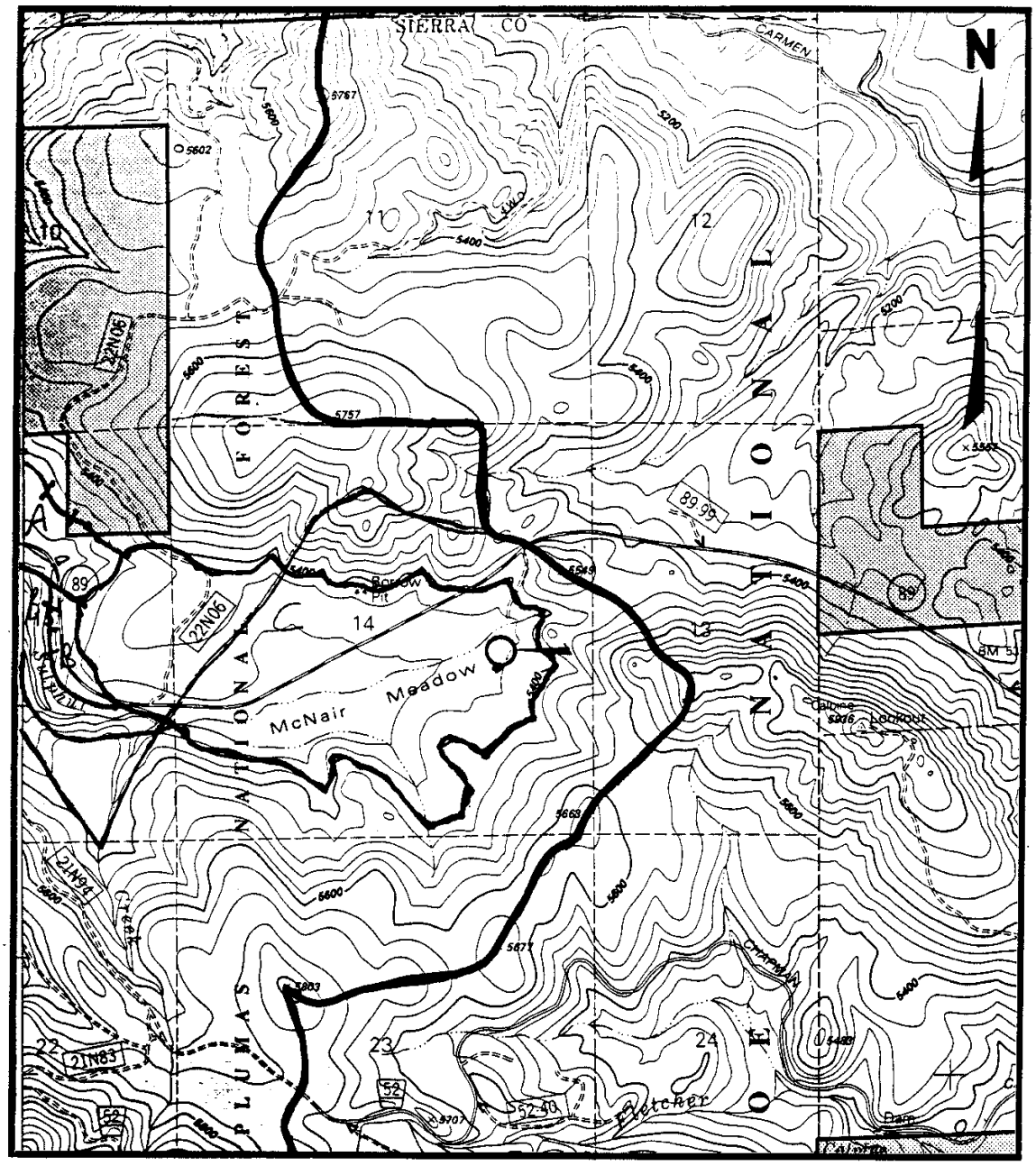
Scale 2.6 inches = 1 mile
Contour interval = 40 feet



Appendix D2. Jackson Creek Microwatershed Erosion Monitoring Plots

Johnsville USGS 7.5 Quad T 23N, R 12E, SE 1/4 of the SW 1/4 of section 8

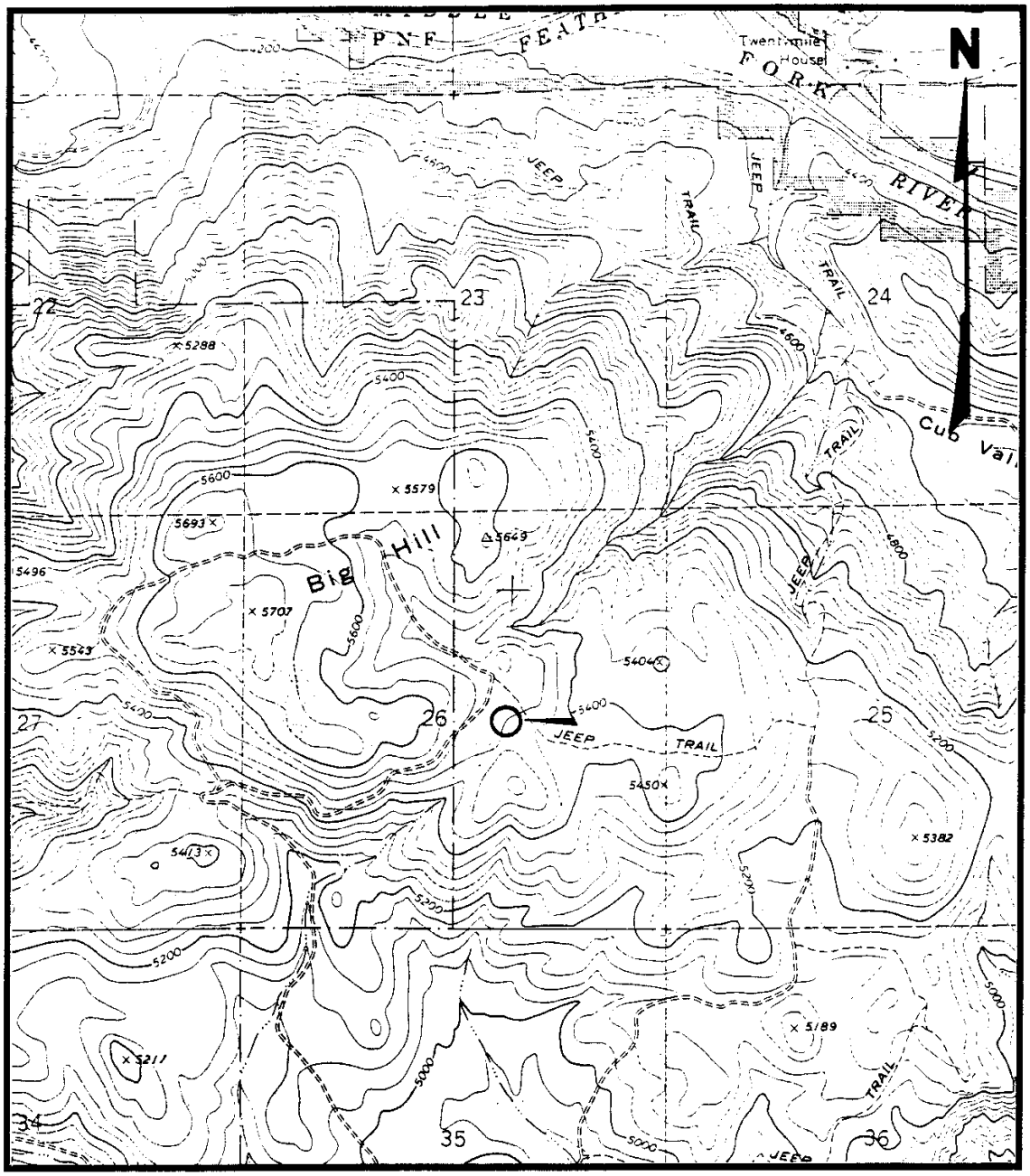
Scale 2.6 inches = 1 mile
Contour interval = 40 feet



Appendix D3. McNair Meadows Microwatershed Erosion Monitoring Plots

Calpine USGS 7.5 Quad T 21N, R 13E, NE 1/4 of the SE 1/4 of section 14

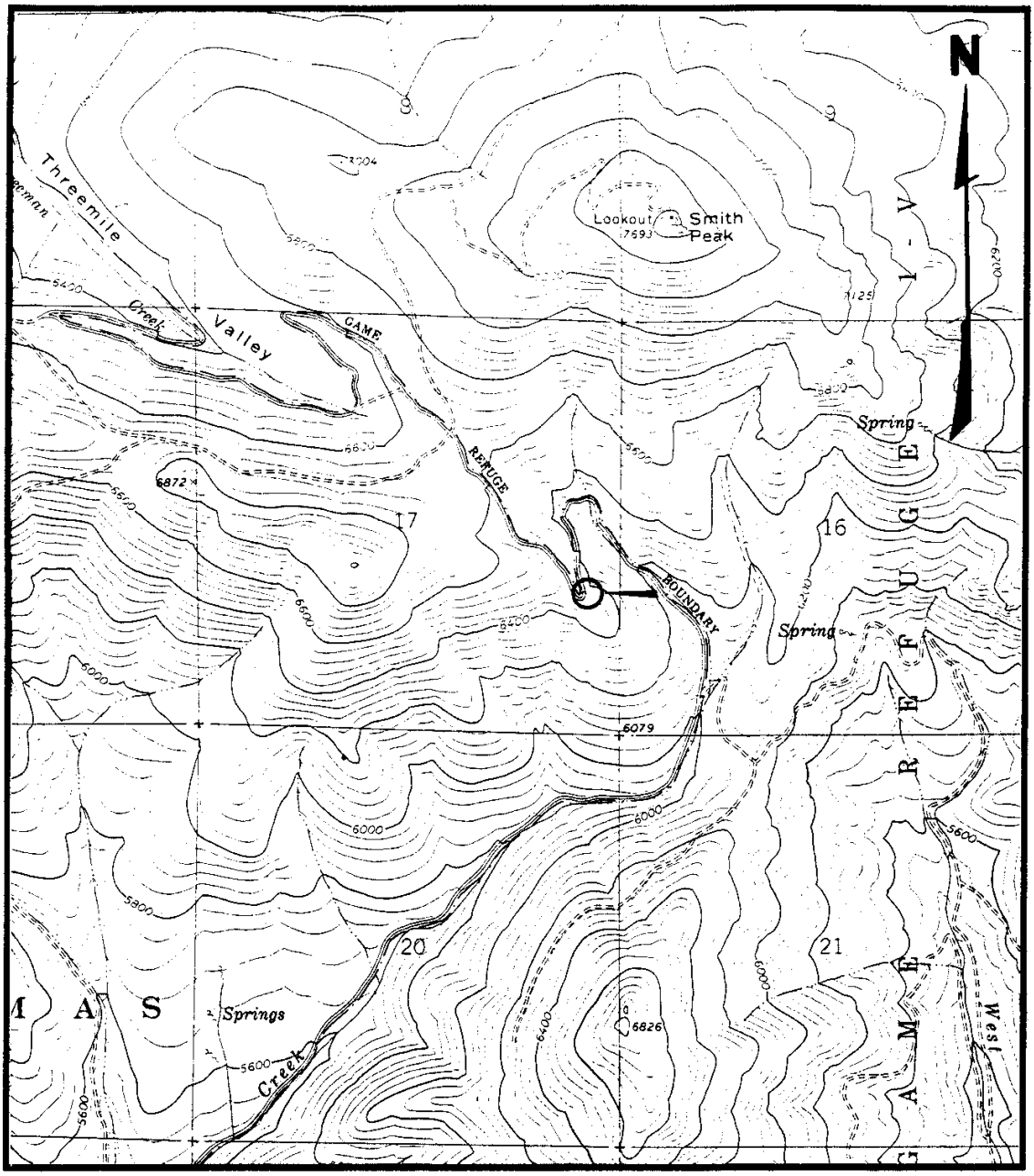
Scale 2.6 inches = 1 mile
Contour interval = 40 feet



Appendix D4. Big Hill Microwatershed Erosion Monitoring Plots

Johnsville USGS 7.5 Quad T 23N, R 11E, SE 1/4 of the NE 1/4 of section 26

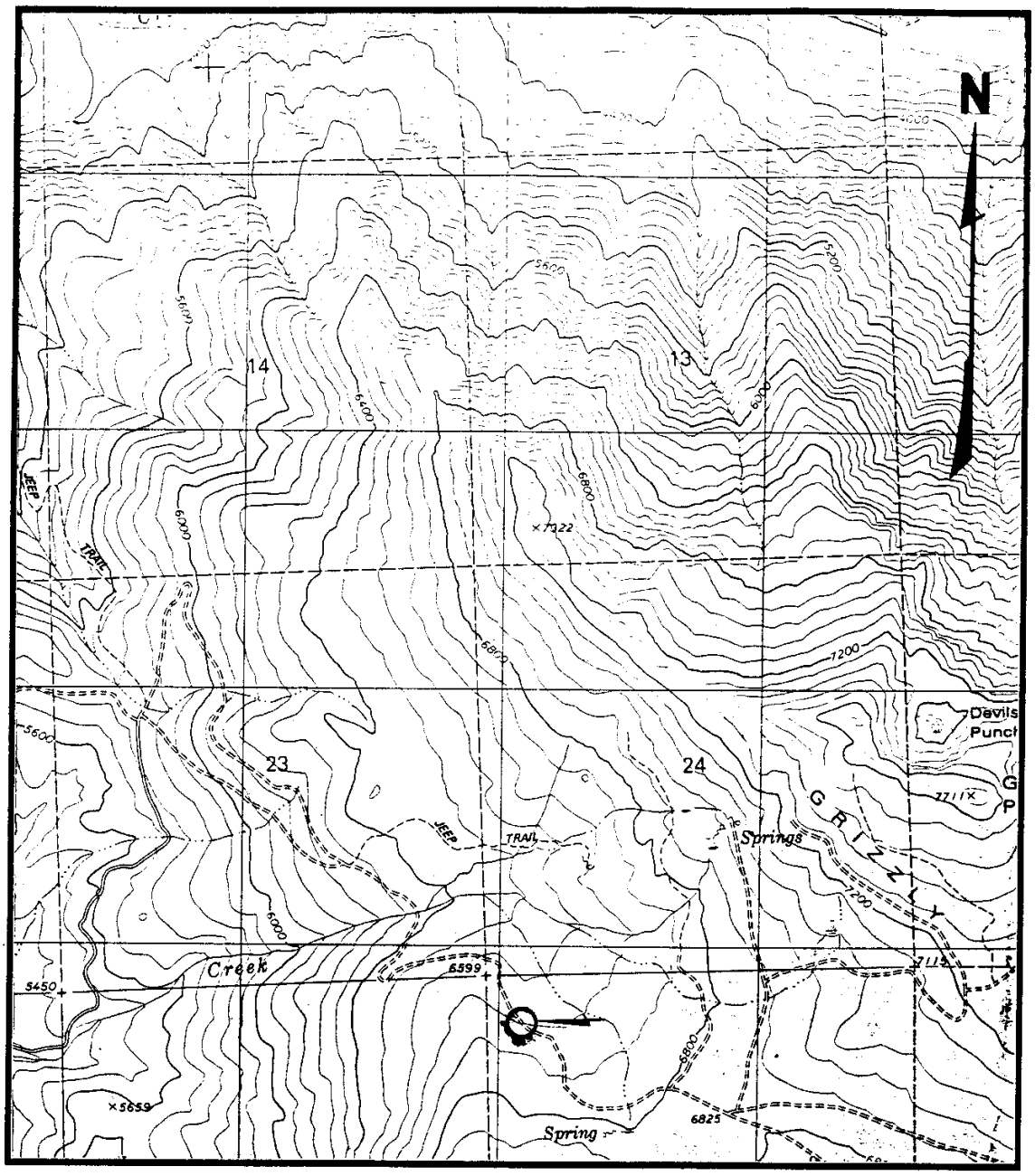
Scale 2.6 inches = 1 mile
Contour interval = 40 feet



Appendix D5. Willow Creek Microwatershed Erosion Monitoring Plots

Blairsden USGS 7.5 Quad T 23N, R 13E, NE 1/4 of the SE 1/4 of section 17

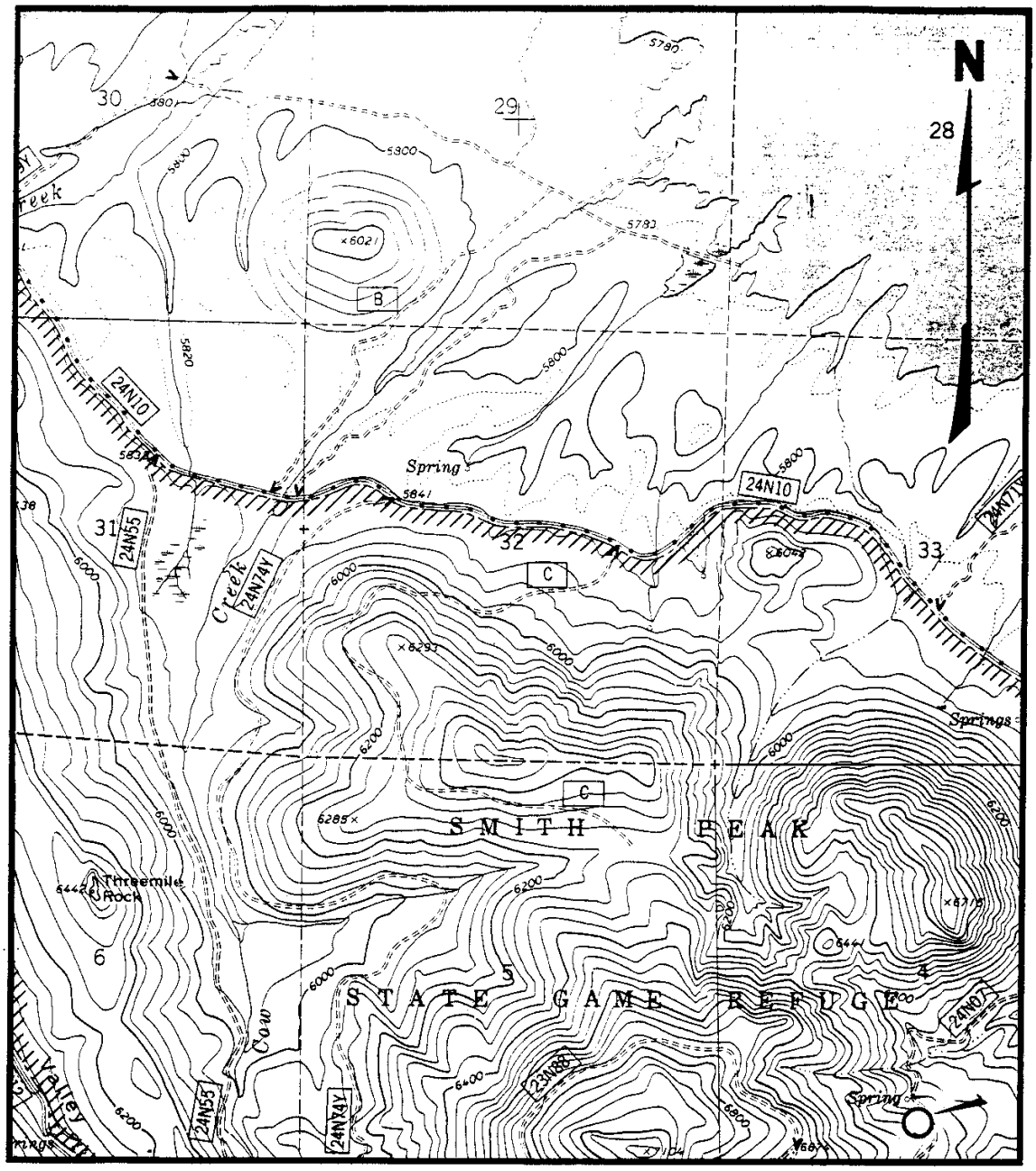
Scale 2.6 inches = 1 mile
Contour interval = 40 feet



Appendix D6. Squirrel Creek Microwatershed Erosion Monitoring Plots

Taylorsville USGS 7.5 Quad T 25N, R 10E, NW 1/4 of the NW 1/4 of section 25

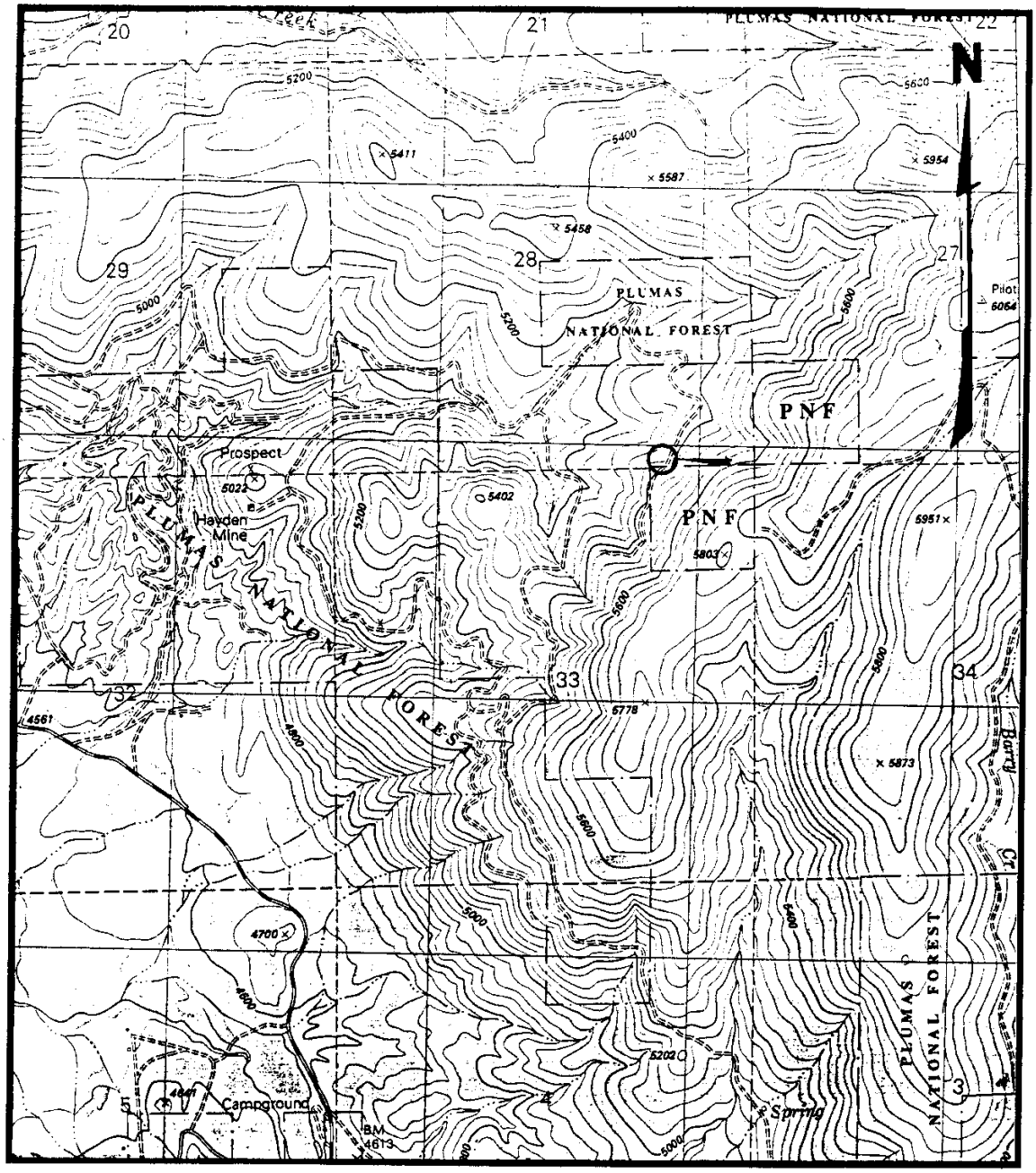
Scale 2.6 inches = 1 mile
Contour interval = 80 feet



Appendix D7. Prospect Creek Microwatershed Erosion Monitoring Plots

Grizzly Valley USGS 7.5 Quad T 23N, R 13E, SE 1/4 of the SW 1/4 of section 4

Scale 2.6 inches = 1 mile
Contour interval = 40 feet



Appendix D8. Calfpasture Creek Microwatershed Erosion Monitoring Plots

Clio USGS 7.5 Quad T 22N, R 13E, SE 1/4 of the SE 1/4 of section 28

Scale 2.6 inches = 1 mile
Contour interval = 40 feet

Appendix E

Site Description of Paired Microwatershed Erosion Plots

Appendix E. Site Description of Paired Microwatershed Erosion Plots.

Microwatershed Descriptions

Station	Elevation (feet)	Aspect	Percent Slope	Percent Canopy Cover	Percent Ground Cover Composition	Notes
Calfpasture Creek #1	5360	W	28	0	90% pine needles	old skid trail
#2	5360	W	20	0	5% rock-15% bare soil-5% forb-75% pine needles	old skid trail
#3	5360	W	21	0	5% shrub-5% forb-5% litter-85% bare soil	old skid trail
McNair Meadows #1	5320	W	11	0	100% pine needles	old skid trail
#2	5320	W	9	10	20% forb-80% erosion pavement	old skid trail
#3	5320	W	8	0	10% forb-5% litter-85% erosion pavement	old skid trail
Willow Creek #1	6450	E	22	0	5% shrub-50% pine needles-45% bare soil	open rocky slope
#2	6450	E	24	0	10% bare soil-30% litter-5% shrub-5% rock-50% forb	open rocky slope
#3	6450	E	21	0	5% shrub-10% forb-85% erosion pavement	open rocky slope
Prospect Peak #1	6340	E	30	0	5% grass/forb-75% pine needles-20% bare soil	old skid trail
#2	6340	E	23	0	10% litter-90% bare soil	landing fill slope
#3	6340	E	11	0	80% litter-5% rock-15% bare soil	rocky
Jackson Creek #1	6440	E	25	30	15% shrub-35% bare soil-50% pine needles	recent burn
#2	6440	E	16	35	5% grass/forb-5% shrub-5% bare soil-85% pine needles	recent burn
#3	6440	E	15	25	10% bare soil-10% forb-80% pine needles	recent burn
Grizzly Peak #1	6800	E	18	0	5% shrub/tree-25% litter-70% bare soil	recent cat log
#2	6800	E	15	5	15% bare soil-55% litter-20% forb-10% erosion pavement	recent cat log
#3	6800	E	16	0	5% rock-5%litter-5% tree-50% forb-35% erosion pavement	recent cat log
Big Hill #1	5520	S	15	0	20% litter-5% shrub-85% bare soil	old burn
#2	5520	S	9	0	95% litter-5% shrub	old burn
#3	5520	S	10	40	50% erosion pavement-50% litter	old burn
Nelson Creek #1	5600	E	12	0	85% litter-15% bare soil	old skid trail
#2	5600	E	14	0	90% pine needles-5% grass-5%litter	old skid trail
#3	5600	E	24	75	5% tree-5% litter-90% pine needles	old skid trail

Appendix F

Water Quality Data

Appendix F1a. General Water Quality Parameters for the Middle Fork Feather River at Portola

Date	Time (PST)	Temp. ° F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
12/06/90	1147	34.0	12.1	101.1	-	148	150	0.8	81
01/03/91	1040	32.0	12.3	99.4	7.2	133	132	1.7	63
02/04/91	1120	32.0	12.2	98.6	7.4	130	128	5.6	59
03/08/91	0800	39.0	10.5	94.8	7.3	114	121	20.0	43
04/04/91	1130	48.0	9.9	101.6	7.3	130	163	7.5	57
05/02/91	1100	50.0	10	105.4	7.9	187	187	3.2	85
06/05/91	1100	64.0	9.4	117.5	7.8	171	170	3.5	83
07/02/91	1030	70.0	9.5	126.8	8.3	151	151	6.1	63
08/14/91	1430	70.0	10.6	141.5	8.2	119	121	2.5	58
09/18/91	1400	70.0	9.6	128.2	8.1	118	120	0.6	62
10/07/91	1500	59.0	11.0	129.7	8.2	119	123	0.6	63
11/13/91	1400	48.0	10.6	108.8	6.8	124	128	1.0	65
12/09/91	1245	32.0	13.3	107.5	7.5	117	135	2.3	64
01/06/92	1115	34.0	15.8	132.0	7.4	141	153	3.1	72
02/06/92	1300	37.0	11.6	101.6	7.4	134	135	6.4	135
03/05/92	1130	47.0	12.7	128.6	7.5	145	146	5.8	74
04/02/92	1200	45.0	11.8	116.2	7.9	136	139	5.3	64
05/07/92	1100	66.0	12.2	155.9	7.9	146	150	3.5	72
06/02/92	1520	77.0	17.5	251.2	8.3	158	161	3.4	74
07/02/92	1045	70.0	9.7	129.5	8.4	108	138	2.5	65
08/06/92	0825	64.5	12.0	150.8	8.1	133	135	2.6	65
09/24/92	0721	57.5	7.6	88.0	7.6	135	137	1.4	72
10/13/92	1130	54.0	10.0	110.9	7.6	135	136	1.9	68
11/18/92	1045	39.0	12.7	114.7	8.2	139	137	2.6	70
12/16/92	1045	32.0	15.2	122.9	7.4	145	148	5.5	58
01/21/93	1315	33.0	12.6	103.6	7.2	147	145	2.2	59
02/18/93	1100	32.0	6.6	53.4	6.4	186	194	2.2	86
03/09/93	1100	32.5	9.8	79.9	6.4	175	175	4.6	78
04/05/93	1415	50.0	10.7	112.8	7.3	120	120	5.3	58
05/11/93	0810	62.5	14.2	174.5	8.0	107	123	1.5	60
06/24/93	1015	64.0	11.7	146.2	7.6	132	148	0.6	73
07/13/93	0915	70.5	11.4	153.0	7.2	121	122	0.9	60
08/23/93	1440	69.0	19.8	261.5	7.5	132	129	1.5	62

Appendix F1a. General Water Quality Parameters for the Middle Fork Feather River at Portola

Date	Time (PST)	Temp. °F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
09/13/93	1100	61.0	11.3	136.4	7.6	149	122	1.3	65
10/21/93	1430	42.0	10.1	95.3	7.5	147	148	2.0	66
11/23/93	0945	36.5	11.4	99.1	7.4	130	130	3.1	61
12/27/93	1500	34.0	11.4	95.2	7.2	149	146	2.5	74
01/19/94	1250	37.5	12.0	105.9	7.4	134	134	3.0	60
02/24/94	1300	45.0	10.3	101.5	7.3	136	134	13.0	60
03/17/94	1330	50.5	9.8	104.0	7.4	174	169	6.6	80
04/21/94	1330	59.5	9.9	117.5	7.3	132	128	2.2	61
05/25/94	0900	68.0	8.3	108.4	7.4	171	167	2.0	80
06/23/94	0830	67.0	7.7	99.5	7.3	145	144	3.2	68
07/21/94	1300	78.0	8.8	127.6	8.3	119	132	2.3	55
08/19/94	0810	64.0	8.6	107.5	8.2	130	174	0.7	87
09/13/94	1330	56.0	9.3	105.8	8.1	124	126	1.0	
Average		51.8	11.2	120.7	7.6	138.6	142.5	3.5	68.6
Max		78.0	19.8	261.5	8.4	187.0	194.0	20.0	135.0
Min		32.0	6.6	53.4	6.4	107.0	120.0	0.6	43.0

Appendix F1b. Nutrient Analyses for the Middle Fork Feather River at Portola (mg/L)

Date	Time (PST)	Total NH3+Org. N.	Dissolved NO2 + NO3	Dissolved NH3	Dissolved o-PO4	Total P	Dissolved Org. N	Dissolved Nitrate
12/06/90	1147	0.3	0.02	-	<0.01	<0.01	-	-
01/03/91	1040	-	-	-	-	0.01	0.4	0.01
02/04/91	1120	0.3	-	-	-	0.01	0.4	0.02
03/08/91	0800	-	-	0.01	-	0.07	0.7	0.10
04/04/91	1130	-	-	0.01	-	0.04	0.7	<0.01
05/02/91	1100	-	-	<0.01	-	0.03	0.5	<0.01
06/05/91	1100	-	-	0.01	-	0.03	0.8	<0.01
07/02/91	1030	-	-	<0.01	-	<0.01	0.6	<0.01
08/14/91	1430	-	-	<0.01	-	0.02	0.4	<0.01
09/18/91	1500	-	-	<0.01	-	0.01	0.2	<0.01
10/07/91	1500	-	-	<0.01	-	0.01	0.3	<0.01
11/13/91	1400	-	-	<0.01	-	<0.01	0.5	<0.01
12/09/91	1245	-	-	<0.01	-	<0.01	0.3	0.03
01/06/92	1115	-	-	<0.01	-	0.02	0.2	<0.01
02/06/92	1315	-	-	<0.01	-	0.01	0.4	<0.01
03/05/92	1130	-	-	<0.01	-	0.04	0.3	0.04
04/02/92	1200	-	-	0.01	-	0.03	0.3	<0.01
05/07/92	1100	-	-	<0.01	-	0.06	0.5	<0.01
06/02/92	1530	-	-	<0.01	-	0.04	0.5	<0.01
07/02/92	1045	Contaminated sample						
08/06/92	0825	-	-	<0.01	-	0.04	0.4	<0.01
09/24/92	0721	-	-	<0.01	-	0.02	0.5	<0.01
10/13/92	1500	-	-	<0.01	-	0.01	0.2	<0.01
11/18/92	1045	-	-	<0.01	-	<0.01	0.3	0.02
12/16/92	1045	-	-	<0.01	-	0.04	0.9	0.40
01/21/93	1315	-	-	0.16	-	0.02	0.2	0.11
02/18/93	1100	-	-	0.03	-	0.08	1.0	0.08
02/09/93	1100	-	-	<0.01	-	0.1	0.4	0.04
03/09/93	1100	-	-	<0.01	-	0.1	0.4	0.04
04/05/93	1415	-	-	0.01	-	0.1	0.5	0.02
05/11/93	0810	-	-	<0.01	-	0.03	0.6	<0.01
06/24/93	1015	-	-	0.02	-	0.02	0.7	<0.1
07/13/93	0915	-	-	<0.01	-	<0.01	0.4	<0.01
08/23/93	1440	-	-	0.05	-	0.02	0.2	<0.01
09/15/93	0800	-	-	<0.01	-	0.02	0.3	<0.01
10/21/93	1430	-	-	0.02	-	0.01	0.6	0.02
11/23/93	0945	-	-	0.02	-	<0.01	0.5	0.01
12/27/93	1500	-	-	0.01	-	0.01	0.3	0.01
01/19/94	1250	-	-	0.01	-	0.02	0.2	0.01
02/24/94	1300	-	-	0.02	-	0.03	0.4	<0.01
03/17/94	1330	-	-	<0.01	-	0.04	0.6	<0.01
04/21/94	1330	-	-	0.02	-	0.03	0.5	<0.01
05/25/94	0900	-	-	0.01	-	0.01	0.7	<0.01
06/23/94	0830	-	-	<0.01	-	0.03	0.4	<0.01
07/21/94	1300	-	-	<0.01	-	0.05	0.4	<0.01
08/19/94	0810	-	-	<0.01	-	0.01	0.2	<0.01
09/13/94	1330	-	-	<0.01	-	0.02	0.3	<0.01
Max		0.3	0.02	0.16	<0.01	0.10	1.0	0.40

Appendix F2a. General Water Quality Parameters for the Middle Fork Feather River at the Quincy La Porte Road

Date	Time (PST)	Temp. ° F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
12/06/90	1530	34.0	13.0	104.8	-	152	156	0.3	73
01/03/91	1420	34.0	13.2	106.5	7.5	155	154	0.5	72
02/04/91	1500	36.0	13.0	108.2	7.8	135	135	3.9	61
03/08/90	1130	41.0	12.5	112.3	7.3	96	112	16.0	38
04/04/91	1500	51.0	10.9	112.3	8.3	113	124	4.4	54
05/03/91	1130	46.0	11.2	108.0	7.6	128	106	0.5	55
06/05/91	1415	61.0	9.4	109.5	7.6	87	87	1.0	42
07/02/91	1400	71.0	8.6	111.9	8.2	134	133	1.2	38
08/14/91	1200	66.5	10.0	124.0	7.9	155	156	1.2	72
09/16/91	1300	60.0	9.9	114.0	8.1	161	157	0.3	76
10/07/91	0930	52.0	9.4	98.1	8.1	155	161	0.2	77
11/14/91	1230	40.0	11.5	101.8	8.3	166	160	0.5	74
12/10/91	0900	32.0	13.6	106.1	7.4	131	155	0.7	83
01/06/92	1545	38.0	15.6	134.0	7.9	131	156	2.0	75
02/07/92	0830	38.5	13.0	112.5	7.4	138	140	4.1	67
03/05/92	1515	45.0	12.9	122.6	7.8	117	118	1.8	58
04/03/92	0830	46.0	12.5	120.5	7.4	90	81	0.9	38
05/07/92	1530	68.0	9.8	123.5	8.1	94	83	0.8	37
06/02/92	0630	70.0	8.0	103.0	7.6	131	138	0.6	69
07/01/92	1600	64.0	9.2	110.9	8.4	154	148	0.8	75
08/05/92	1500	71.0	13.8	179.6	8.5	169	174	0.6	79
09/21/92	1117	61.0	9.9	115.3	8.1	174	179	0.4	85
10/13/92	1500	55.0	10.9	118.2	8.1	167	171	0.3	78
11/19/92	1510	40.0	12.4	109.7	8.2	157	160	0.6	73
12/16/92	1615	33.0	13.2	104.7	7.4	129	130	3.0	54
01/21/93	NO DATA-SNOW								
02/18/93	NO DATA-SNOW								
03/09/93	NO DATA-SNOW								
04/05/93	1030	43.0	11.6	107.2	7.3	90	90	3.7	39
05/10/93	1140	51.0	10.8	111.3	7.4	64	73	0.9	34
06/23/93	1235	57.0	13.1	145.5	7.4	70	80	1.0	38
07/13/93	1200	70.0	11.7	150.7	7.6	103	103	0.3	50
08/23/93	1030	64.5	10.3	124.9	7.5	143	142	0.4	67

Appendix F2a. General Water Quality Parameters for the Middle Fork Feather River at the Quincy La Porte Road

Date	Time (PST)	Temp. ° F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
09/13/93	1100	61.0	11.3	131.6	7.6	149	150	0.3	73
10/22/93	1040	47.0	10.6	103.6	7.5	148	148	0.6	69
11/23/93	1430	38.0	12.4	106.5	7.5	142	141	1.4	66
12/28/93	0750	33.5	12.2	97.6	7.5	145	143	1.8	65
01/20/94	0820	32.5	12.2	96.0	7.4	150	151	1.0	70
02/24/94	NO DATA-SNOW								
03/18/94	0730	43.5	10.8	100.5	7.6	126	125	3.7	62
04/21/94	1045	47.0	10.0	97.7	7.4	74	74	1.5	37
05/26/94	1300	64.0	9.7	116.9	8.1	111	111	0.7	50
06/23/94	1400	72.0	9.8	128.9	8.0	145	146	1.2	70
07/21/94	1000	70.5	8.4	108.7	8.0	146	162	0.8	76
08/19/94	1100	65.0	8.3	101.2	8.1	169	130	0.8	65
09/12/94	1100	57.5	9.8	109.5	8.1	165	166	0.3	
Average		51.7	11.2	114.5	7.8	132.4	133.5	1.6	61.8
Max		72.0	15.6	179.6	8.5	174.0	179.0	16.0	85.0
Min		32.0	8.0	96.0	7.3	64.0	73.0	0.2	34.0

Appendix F2b. Nutrient Analyses for the Middle Fork Feather River at the Quincy La Porte Road in (mg/L)

Date	Time (PST)	Total NH3+Org. N.	Dissolved NO2 + NO3	Dissolved NH3	Dissolved o-PO4	Total P	Dissolved Org. N	Dissolved Nitrate
12/06/90	1530	<0.1	0.01	<0.01	<0.01	0.01	-	-
01/03/91	1420	-	-	-	-	0.01	0.2	<0.01
02/04/91	1500	0.4	-	0.04	-	0.02	0.6	0.02
03/08/91	1130	-	-	0.02	-	0.05	0.4	0.12
04/04/91	1500	-	-	0.01	-	0.03	0.3	0.02
05/03/91	1130	-	-	<0.01	-	0.01	<0.1	<0.01
06/05/91	1415	-	-	0.04	-	<0.01	0.2	0.02
07/02/91	1400	-	-	0.02	-	<0.01	0.8	<0.01
08/14/91	1200	-	-	0.42	-	0.03	<0.1	0.02
09/01/91	1300	-	-	0.01	-	0.01	<0.1	<0.01
10/07/91	0930	-	-	<0.01	-	<0.01	0.1	<0.01
11/14/91	1300	-	-	<0.01	-	0.02	0.3	<0.01
12/10/91	0900	-	-	<0.01	-	0.01	0.2	<0.01
01/06/92	1545	-	-	0.02	-	0.01	<0.1	<0.01
02/07/92	0830	-	-	<0.01	-	0.03	0.4	0.01
03/05/92	1515	-	-	0.01	-	0.02	0.2	0.02
04/03/92	0830	-	-	0.01	-	0.02	0.2	0.01
05/07/92	0000	-	-	0.01	-	0.01	0.3	<0.01
06/02/92	0630	-	-	<0.01	-	0.02	0.2	0.05
07/01/92	1600	Contaminated sample						
08/05/92	1500	-	-	0.01	-	0.01	0.3	<0.01
09/21/92	1117	-	-	<0.01	-	0.01	0.2	<0.01
10/13/92	1130	-	-	<0.01	-	0.02	0.5	<0.01
11/19/92	1510	-	-	<0.01	-	<0.01	<0.1	<0.01
12/16/92	1615	-	-	0.02	-	0.03	0.6	0.09
01/21/93	NO DATA-SNOW							
02/18/93	NO DATA-SNOW							
03/09/93	NO DATA-SNOW							
04/05/93	1030	-	-	0.02	-	0.02	0.7	0.06
05/10/93	1200	-	-	0.01	-	0.02	0.2	0.01
06/23/93	1235	-	-	0.01	-	<0.01	0.2	0.01
07/13/93	1200	-	-	0.01	-	0.26	0.2	<0.01
08/23/93	1030	-	-	0.04	-	<0.01	0.1	<0.01
09/13/93	1100	-	-	0.03	-	<0.01	0.1	<0.01
10/22/93	1030	-	-	<0.01	-	<0.01	0.2	0.01
11/23/93	1430	-	-	<0.01	-	<0.01	0.4	0.01
12/28/93	0750	-	-	<0.01	-	0.01	0.3	0.01
01/20/94	0820	-	-	<0.01	<0.01	0.03	0.3	-
02/24/94	NO DATA-SNOW							
03/18/94	0730	-	-	<0.01	-	0.03	0.3	0.02
04/21/94	1045	-	-	0.01	-	0.01	0.1	0.01
05/26/94	1300	-	-	<0.01	-	0.02	0.1	<0.01
06/23/94	1400	-	-	<0.01	-	0.02	0.2	<0.01
07/21/94	1000	-	-	0.02	-	0.03	0.5	0.01
08/19/94	1100	-	-	0.01	-	0.03	0.4	<0.01
09/12/94	1100	-	-	<0.01	-	<0.01	<0.1	<0.01
Max		0.4	0.01	0.42	<0.01	0.26	0.8	0.12

Appendix F3a. General Water Quality Parameters for Willow Creek near Clio

Date	Time (PST)	Temp. °F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
12/06/90	1245	32.5	12.7	93.5	-	183	185	0.3	86
01/03/91	1130	32.0	13.4	107.1	7.3	198	203	0.3	91
02/04/91	1230	32.0	12.2	89.1	7.6	180	164	1.8	72
03/08/91	0900	34.0	12.7	95.8	7.4	139	143	4.7	59
04/04/91	1220	38.0	10.5	84.3	7.6	92	102	6.3	46
05/02/91	1330	44.0	11.5	100.8	7.5	97	109	0.6	46
06/05/91	1155	64.0	8.5	95.7	7.6	125	124	0.4	64
07/02/91	1130	69.0	9.7	115.4	8.1	181	182	0.3	78
08/04/91	1400	63.0	8.7	96.9	7.9	210	209	1.6	96
09/18/91	0800	52.0	8.0	78.0	7.5	231	227	0.4	108
10/07/91	1200	52.0	9.8	95.6	8.0	220	223	0.3	110
11/13/91	1445	44.0	10.6	92.9	7.9	189	195	0.2	94
12/09/91	1330	32.0	12.8	93.5	7.9	175	192	0.5	91
01/06/92	1230	36.0	15.1	117.6	7.5	166	181	0.5	88
02/06/92	1335	37.0	11.8	93.3	7.8	163	165	0.6	75
03/05/92	1215	48.0	13.5	125.0	7.8	146	148	1.0	74
04/02/92	1310	46.0	10.1	91.0	7.2	151	151	0.8	72
05/07/92	1250	70.0	8.8	105.8	8.2	187	192	0.5	90
06/02/92	1200	77.0	11.8	152.5	8.2	222	224	0.6	106
07/02/92	1000	60.0	8.4	90.4	7.8	167	223	0.7	105
08/06/92	0905	DRY-NO SAMPLE							
09/24/92	0700	DRY-NO SAMPLE							
10/13/92	1230	54.0	11.2	112.0	7.9	228	230	0.2	109
11/19/92	1230	39.0	11.6	94.6	7.8	199	200	0.3	91
12/16/92	1240	32.5	12.2	89.8	7.8	192	195	0.6	83
01/21/93	1430	33.0	12.0	89.1	7.3	141	143	14.0	47
02/18/93	1200	34.5	12.8	97.3	7.5	137	139	2.9	59
03/09/93	1200	35.0	13.0	99.6	7.4	87	90	9.7	41
04/05/93	1235	44.5	12.1	106.8	7.3	66	66	4.7	33
05/11/93	0730	41.0	15.8	132.7	7.4	48	57	2.5	28
06/24/93	0800	49.0	15.1	141.7	7.4	90	102	1.0	52
07/13/93	0730	56.0	12.6	129.2	7.5	146	146	0.4	72
08/23/93	1240	67.0	15.0	174.6	7.5	202	197	0.3	96

Appendix F3a. General Water Quality Parameters for Willow Creek near Clio

Date	Time (PST)	Temp. °F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
09/15/93	1000	50.0	9.2	87.5	7.4	215	214	0.4	110
10/22/93	0700	39.5	10.7	87.9	7.5	177	177	0.4	96
11/23/93	1200	37.0	12.2	96.5	7.5	168	166	0.7	80
12/27/93	1530	33.0	12.2	90.6	7.2	155	152	1.0	75
01/19/94	1330	34.0	12.2	92.0	7.4	172	169	0.8	79
02/24/94	1400	42.0	10.9	92.9	7.5	165	161	2.2	75
03/17/94	1400	47.0	10.6	96.8	7.9	109	106	2.9	54
04/21/94	1400	58.5	8.7	91.9	7.5	111	107	1.4	56
05/25/94	1000	59.5	10.1	108.0	8.1	146	143	0.8	69
06/23/94	0930	58.5	9.6	101.4	7.6	215	212	0.9	100
07/21/94	1230	DRY-NO SAMPLE							
08/19/94	0830	DRY-NO SAMPLE							
09/14/94	0700	DRY-NO SAMPLE							
Average		46.5	11.5	103.1	7.6	160.8	163.8	1.7	77.0
Max		77.0	15.8	174.6	8.2	231.0	230.0	14.0	110.0
Min		32.0	8.0	78.0	7.2	48.0	57.0	0.2	28.0

Appendix F3b . Nutrient Analyses for Willow Creek near Clio (mg/L)

Date	Time (PST)	Total NH3+Org. N.	Dissolved NO2 + NO3	Dissolved NH3	Dissolved o-PO4	Total P	Dissolved Org. N	Dissolved Nitrate
12/06/90	1245	<0.1	0.01	-	<0.01	0.01	-	-
01/03/91	1130	-	-	-	-	0.01	0.1	<0.01
02/04/91	1230	<0.1	-	-	-	0.02	0.3	0.01
03/08/91	0900	-	-	<0.01	-	0.03	0.2	0.05
04/04/91	1220	-	-	<0.01	-	0.03	0.1	<0.01
05/02/91	1330	-	-	<0.01	-	0.01	<0.1	<0.01
06/05/91	1155	-	-	0.01	-	<0.01	<0.1	<0.01
07/02/91	1130	-	-	<0.01	-	<0.01	0.1	<0.01
08/14/91	1400	-	-	<0.01	-	0.02	0.2	0.01
09/18/91	0915	-	-	<0.01	-	<0.01	<0.1	<0.01
10/07/91	1200	-	-	<0.01	-	<0.01	<0.1	<0.01
11/13/91	1445	-	-	<0.01	-	<0.01	<0.1	<0.01
12/09/91	1330	-	-	<0.01	-	<0.01	<0.1	<0.01
01/06/92	1230	-	-	<0.01	-	0.02	<0.1	<0.01
02/06/92	1335	-	-	<0.01	-	0.01	<0.1	<0.01
03/05/92	1215	-	-	<0.01	-	0.02	<0.1	0.03
04/02/92	1310	-	-	<0.01	-	0.02	0.2	<0.01
05/07/92	1250	-	-	<0.01	-	0.01	0.2	<0.01
06/02/92	1200	-	-	<0.01	-	0.02	0.2	<0.01
07/02/92	1000	Contaminated sample						
08/06/92	0900	DRY						
09/23/92	1245	DRY						
10/13/92	1230	-	-	<0.01	-	0.01	0.3	<0.01
11/19/92	1230	-	-	<0.01	-	<0.01	<0.1	<0.01
12/16/92	1240	-	-	<0.01	-	0.01	0.1	0.04
01/21/93	1430	-	-	0.02	-	0.08	0.2	0.02
02/18/93	1200	-	-	0.02	-	0.02	0.3	0.02
03/09/93	1200	-	-	<0.01	-	0.05	0.1	0.06
04/05/93	1235	-	-	<0.01	-	0.03	0.1	0.02
05/11/93	0730	-	-	<0.01	-	0.02	0.2	0.01
06/24/93	0800	-	-	<0.01	-	<0.01	<0.1	<0.01
07/13/93	0730	-	-	<0.01	-	<0.01	0.1	<0.01
08/23/93	1240	-	-	0.05	-	0.02	<0.1	<0.01
09/15/93	1000	-	-	<0.01	-	0.01	<0.1	<0.01
10/22/93	0700	-	-	<0.01	-	<0.01	0.1	0.01
11/23/93	1200	-	-	<0.01	-	<0.01	<0.1	0.01
12/27/93	1530	-	-	<0.01	-	<0.01	0.1	0.02
01/19/94	1330	-	-	<0.01	-	0.02	<0.1	<0.01
02/24/94	1400	-	-	<0.01	-	0.02	<0.1	<0.01
03/17/94	1400	-	-	<0.01	-	0.01	0.2	<0.01
04/21/94	1400	-	-	0.01	-	0.02	<0.1	<0.01
05/25/94	1000	-	-	<0.01	-	<0.01	<0.1	<0.01
06/23/94	0930	-	-	0.01	-	<0.01	0.1	<0.01
07/21/94	1230	DRY						
08/19/94	0830	DRY						
09/14/94	0645	DRY						
Max		<0.1	0.01	0.05	<0.01	0.08	0.3	0.06

Appendix F4a. General Water Quality Parameters for Freeman Creek

Date	Time (PST)	Temp. °F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
09/17/91	1620	64.0	9.6	108.1	8.4	150	173	0.7	88
10/17/91	1400	56.0	9.7	99.5	8.4	167	172	0.6	93
11/13/91	1300	43.0	13.4	115.8	7.9	148	158	0.5	84
12/09/91	1145	32.0	10.6	77.4	7.2	133	161	2.4	91
01/06/92	NO DATA-SNOW								
02/06/92	NO DATA FROZEN SOLID								
03/05/92	NO DATA-SNOW								
04/02/92	1115	45.0	12.3	109.3	7.2	69	73	2.3	36
05/07/92	1200	63.0	10.1	112.5	7.4	105	108	1.7	54
06/02/92	1340	80.0	13.4	178.3	8.4	165	168	2.6	87
07/02/92	1200	58.0	8.3	87.2	7.6	108	139	3.9	72
08/06/92	0725	55.0	11.6	117.5	8.0	182	184	2.5	94
09/23/92	1500	64.0	8.4	94.6	8.6	180	185	2.1	104
10/13/92	1000	49.0	10.9	102.3	7.9	186	188	1.3	97
11/18/92	1130	33.5	12.1	90.5	7.3	116	120	2.8	60
12/16/92	NO DATA-SNOW								
01/21/93	NO DATA-SNOW								
02/18/93	NO DATA-SNOW								
03/09/93	NO DATA-SNOW								
04/05/93	NO DATA-SNOW								
05/10/93	NO DATA-SNOW								
06/24/93	0930	49.5	17.5	165.3	7.2	70	80	1.6	41
07/13/93	0930	52.5	15.6	153.1	7.3	108	110	1.8	58
08/23/93	1340	67.0	19.4	225.8	7.7	155	151	2.0	79
09/14/93	0800	47.0	9.3	85.0	7.3	166	162	1.5	91
10/20/93	1330	47.0	10.4	95.0	7.4	144	143	1.8	74
11/23/93	0830	34.0	11.5	86.8	7.3	146	147	1.5	75
12/27/93	1330	32.0	10.3	75.2	7.0	137	134	4.2	73
01/19/94	1200	32.5	10.8	79.5	7.2	147	146	2.3	73
02/24/94	NO DATA-SNOW								
03/17/94	NO DATA-SNOW								

Appendix F4a. General Water Quality Parameters for Freeman Creek

Date	Time (PST)	Temp. ° F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
04/21/94	1245	54.0	9.0	90.0	7.2	61	59	1.6	33
05/25/94	0730	56.0	9.7	99.5	7.3	116	113	1.7	56
06/23/94	0715	59.0	7.1	75.5	7.4	151	149	3.5	77
07/21/94	1400	79.0	13.5	177.9	8.3	148	165	3.4	95
08/19/94	1500	61.0	8.6	93.6	8.1	183	188	3.2	103
09/13/94	0745	44.0	8.3	72.8	7.3	189	189	1.6	
Average		52.2	11.2	110.3	7.6	139.6	144.8	2.1	75.5
Max		80.0	19.4	225.8	8.6	189.0	189.0	4.2	104.0
Min		32.0	7.1	72.8	7.0	61.0	59.0	0.5	33.0

Appendix F4b. Nutrient Analyses for Freeman Creek (mg/L)

Date	Time (PST)	Dissolved NH3	Total P	Dissolved Org. N	Dissolved Nitrate
09/17/91	1620	0.01	<0.01	<0.1	0.02
10/07/91	1400	<0.01	0.01	<0.1	<0.01
11/13/91	1300	<0.01	<0.01	<0.1	<0.01
12/09/91	1145	<0.01	<0.01	<0.1	0.02
01/06/92	NO DATA-SNOW				
02/06/92	NO DATA-SNOW				
03/05/92	NO DATA-SNOW				
04/02/92	1115	<0.01	0.02	0.1	<0.01
05/07/92	1200	<0.01	0.02	0.1	<0.01
06/02/92	1340	<0.01	0.03	0.2	<0.01
07/02/92	Contaminated sample				
08/06/92	0725	<0.01	0.02	0.2	<0.01
09/23/92	1600	<0.01	0.01	0.3	0.03
10/13/92	1000	<0.01	<0.01	0.2	<0.01
11/18/92	1130	<0.01	<0.01	<0.1	<0.01
12/16/92	NO DATA-SNOW				
01/21/93	NO DATA-SNOW				
02/18/93	NO DATA-SNOW				
03/09/93	NO DATA-SNOW				
04/05/93	NO DATA-SNOW				
05/10/93	NO DATA-SNOW				
06/24/93	0930	0.02	<0.01	<0.1	0.02
07/13/93	0830	0.01	<0.01	0.2	0.02
08/23/93	1340	0.07	0.02	0.1	<0.01
09/14/93	0800	<0.01	<0.01	0.1	<0.01
10/20/93	1330	<0.01	0.01	0.1	0.04
11/23/93	0830	<0.01	<0.01	<0.1	<0.01
12/27/93	1330	<0.01	0.01	<0.1	<0.01
01/19/94	1200	<0.01	0.01	0.2	<0.01
02/24/94	NO DATA-SNOW				
03/17/94	NO DATA-SNOW				
04/21/94	1245	<0.01	<0.01	0.1	0.03
05/25/94	0730	<0.01	<0.01	<0.1	<0.01
06/23/94	0715	<0.01	0.01	<0.1	<0.01
07/21/94	1400	<0.01	0.03	0.1	<0.01
08/19/94	0710	<0.01	<0.01	0.1	<0.01
09/13/94	0745	<0.01	0.02	0.2	<0.01
Max		0.07	0.03	0.3	0.04

Appendix F5a. General Water Quality Parameters for Nelson Creek at the Quincy La Porte Road

Date	Time (PST)	Temp. °F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
12/06/90	1500	34.0	13.0	106.1		170	173	0.5	83
01/03/91	1345	33.0	13.6	109.2	7.9	168	166	0.16	77
02/04/91	1445	38.0	12.9	112.1	7.9	145	145	0.6	65
03/08/91	1100	39.0	12.9	113.8	7.4	109	106	1.0	50
04/04/91	1430	45.0	11.6	111.6	8.3	99	114	1.2	52
05/03/91	0930	40.0	12.4	111.0	7.7	106	112	0.1	40
06/05/91	1340	52.5	10.2	108.4	7.4	85	80	0.4	41
07/02/91	1330	61.0	9.4	110.8	8.1	121	125	0.4	49
08/14/91	1130	57.0	9.7	109.0	8.2	162	167	0.4	79
09/20/91	1630	59.0	6.2	71.4	8.2	177	177	0.1	82
10/07/91	0900	47.0	10.6	104.8	8.1	173	182	0.1	87
11/14/91	1230	40.0	11.5	103.0	8.3	166	175	0.2	84
12/10/91	0830	32.0	13.2	104.2	7.9	145	169	0.2	94
01/06/92	1510	38.0	14.6	126.8	7.9	134	159	0.6	77
02/07/92	0750	38.0	11.6	100.8	8.1	162	165	0.8	81
03/05/92	1445	41.0	14.9	135.4	7.6	96	98	1.8	47
04/03/92	0800	38.5	12.9	112.9	7.6	79	81	0.9	38
05/07/92	1500	56.0	13.2	146.6	7.7	81	83	0.8	37
06/02/92	0730	57.5	12.9	145.9	7.9	134	135	0.2	69
07/01/92	1530	61.0	8.6	101.4	8.1	143	144	0.4	70
08/05/92	1430	64.0	12.3	150.1	8.2	174	180	0.6	84
09/25/92	0830	48.0	9.9	99.2	8.2	183	188	0.1	89
10/13/92	1430	51.0	10.6	110.5	8.2	188	188	0.3	87
11/19/92	1438	38.0	12.8	111.2	8.0	169	171	0.5	78
12/16/92	1525	34.0	12.9	105.2	7.8	137	139	0.4	63
01/21/93	NO DATA-SNOW								
02/18/93	NO DATA-SNOW								
03/09/93	NO DATA-SNOW								
04/05/93	1000	40.0	11.1	99.4	7.3	84	85	0.5	39
05/10/93	1117	46.0	13.9	135.6	7.6	63	71	0.3	33
06/23/93	1145	47.0	12.7	125.6	7.4	70	68	0.4	33
07/13/93	1125	56.0	17.0	188.8	7.7	111	114	0.2	54
08/23/93	1000	52.0	18.1	191.2	7.5	157	157	0.0	76

Appendix F5a. General Water Quality Parameters for Nelson Creek at the Quincy La Porte Road

Date	Time (PST)	Temp. °F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
09/15/93	1400	56.0	9.9	109.9	7.8	166	166	0.0	85
10/22/93	1010	42.5	11.0	102.1	7.6	163	162	0.2	77
11/23/93	1400	36.0	13.4	112.9	7.5	163	160	1.4	66
12/28/93	0750	35.0	12.7	105.3	7.4	150	149	0.4	70
01/20/94	0740	32.0	12.6		7.4	153	153	0.5	71
02/24/94	NO DATA-SNOW								
03/17/94	NO DATA-SNOW								
04/21/94	1010	42.0	11.1	102.3	7.5	76	76	0.7	35
05/26/94	1230	52.0	10.1	106.7	7.6	86	86	0.3	40
06/23/94	1300	61.0	10.4	122.6	7.9	140	139	0.6	69
07/21/94	0930	59.0	9.1	104.8	8.1	158	172	0.4	78
08/19/94	1045	57.5	9.2	104.0	8.2	178	180	0.5	91
09/16/94	0730	46.0	10.2	99.5	8.1	179	180	0.3	
Average		46.4	11.9	115.8	7.8	136.7	140.0	0.5	65.5
Max		64.0	18.1	191.2	8.3	188.0	188.0	1.8	94.0
Min		32.0	6.2	71.4	7.3	63.0	68.0	0.0	33.0

Appendix F5b. Nutrient Analyses for Nelson Creek at the Quincy La Porte Road (mg/L)

Date	Time (PST)	Total NH3+Org. N.	Dissolved NO2 + NO3	Dissolved NH3	Dissolved o-PO4	Total P	Dissolved Org. N	Dissolved Nitrate
12/06/90	1500	<0.1	0.03	-	<0.01	0.01	-	-
01/03/91	1345	-	-	-	-	<0.01	<0.1	0.02
02/04/91	1445	0.3	-	-	-	<0.01	0.2	0.01
03/08/91	1100	-	-	<0.01	-	0.01	<0.1	0.11
04/04/91	1430	-	-	0.01	-	<0.01	0.1	<0.01
05/03/91	0930	-	-	<0.01	-	<0.01	<0.1	<0.01
06/05/91	1340	-	-	0.02	-	<0.01	0.2	0.02
07/02/91	1330	-	-	0.03	-	<0.01	0.2	0.01
08/14/91	1130	-	-	0.02	-	0.01	0.2	0.03
09/19/91	1630	-	-	<0.01	-	<0.01	<0.1	<0.01
10/07/91	0900	-	-	<0.01	-	0.01	<0.1	0.01
11/14/91	1230	-	-	<0.01	-	<0.01	0.2	<0.01
12/10/91	0830	-	-	<0.01	-	<0.01	0.2	<0.01
01/06/92	1510	-	-	<0.01	-	0.01	<0.1	<0.01
02/07/92	0750	-	-	<0.01	-	0.03	0.2	0.01
03/05/92	1445	-	-	<0.01	-	0.02	0.2	0.04
04/03/92	0800	-	-	0.01	-	<0.01	0.2	0.10
05/07/92	1500	-	-	0.02	-	<0.01	0.4	<0.01
06/02/92	0730	-	-	<0.01	-	0.01	<0.1	<0.01
07/01/92	1530	Contaminated sample						
08/05/92	1430	-	-	0.02	-	0.02	0.4	0.01
09/25/92	0800	-	-	<0.01	-	<0.01	0.1	0.01
10/13/92	1430	-	-	<0.01	-	0.01	0.3	<0.01
11/19/92	1438	-	-	0.01	-	<0.01	<0.1	<0.01
12/16/92	1525	-	-	0.02	-	0.01	0.1	0.04
01/21/93	NO DATA-SNOW							
02/18/93	NO DATA-SNOW							
03/09/93	NO DATA-SNOW							
04/05/93	1000	-	-	0.03	-	<0.01	0.2	0.03
05/10/93	1117	-	-	0.01	-	0.01	<0.1	0.02
06/23/93	1145	-	-	<0.01	-	<0.01	<0.1	0.02
07/13/93	1125	-	-	<0.01	-	<0.01	0.2	<0.01
08/23/93	1000	-	-	0.03	-	<0.01	<0.1	<0.01
09/15/93	1000	-	-	<0.01	-	<0.01	<0.1	<0.01
10/22/93	1010	-	-	<0.01	-	<0.01	<0.1	<0.01
11/23/93	1400	-	-	0.01	-	0.01	<0.1	<0.01
12/28/93	0750	-	-	<0.01	-	<0.01	0.1	<0.01
01/20/94	0740	-	-	0.01	-	0.02	0.2	<0.01
02/24/94	NO DATA-SNOW							
03/17/94	NO DATA-SNOW							
04/21/94	1010	-	-	0.01	-	<0.01	<0.1	0.05
05/26/94	1230	-	-	<0.01	-	<0.01	<0.1	<0.01
06/23/94	1300	-	-	<0.01	-	0.01	<0.1	<0.01
07/21/94	0930	-	-	0.03	-	0.02	-	0.03
08/19/94	1045	-	-	0.01	-	0.04	0.2	0.03
09/16/94	0730	-	-	<0.01	-	<0.01	<0.1	0.01
Max		0.3	0.03	0.03	<0.01	0.04	0.4	0.11

Appendix F6a. General Water Quality Parameters for Onion Valley Creek near Mouth

Date	Time (PST)	Temp. °F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
10/16/91	1130	47.0	10.2	93.2	7.0	185	189	0.1	91
11/14/91	1000	41.0	12.3	103.3	8.1	179	187	0.2	88
12/09/91	NO DATA-SNOW								
01/06/92	NO DATA-SNOW								
02/06/92	NO DATA-SNOW								
03/05/92	NO DATA-SNOW								
04/04/92	NO DATA-SNOW								
05/08/92	0830	53.0	14.6	144.2	7.4	75	76	0.4	35
06/01/92	1145	67.0	11.1	129.2	8.1	152	156	0.5	73
07/01/92	1130	61.0	8.7	94.7	8.1	144	147	0.7	69
08/05/92	1100	59.5	10.0	106.9	8.3	181	186	0.2	85
09/22/92	0900	53.0	10.1	99.8	8.2	197	196	0.1	91
10/14/92	0800	47.5	11.1	102.1	7.8	196	195	0.1	88
11/19/92	0900	39.0	13.3	108.4	7.9	171	173	0.2	78
12/16/92	NO DATA-SNOW								
01/21/93	NO DATA-SNOW								
02/18/93	NO DATA-SNOW								
03/09/93	NO DATA-SNOW								
04/05/93	NO DATA-SNOW								
05/10/93	NO DATA-SNOW								
06/23/93	0800	49.0	13.9	130.4	7.4	66	76	0.6	37
07/15/93	0800	56.5	15.6	160.9	7.4	121	122	0.1	58
08/24/93	0800	56.0	10.3	105.6	7.6	163	159	0.0	77
09/16/93	0800	53.0	10.0	98.8	7.6	172	171	0.1	90
10/21/93	0900	46.5	10.4	94.4	7.6	167	166	0.1	78
11/22/93	1330	41.0	12.4	104.1	7.6	161	160	0.4	72
12/27/93	NO DATA-SNOW								
01/19/94	NO DATA-SNOW								
02/24/94	NO DATA-SNOW								
03/17/94	NO DATA-SNOW								
04/21/94	NO DATA-SNOW								

Appendix F6a. General Water Quality Parameters for Onion Valley Creek near Mouth

Date	Time (PST)	Temp. °F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
05/26/94	1430	59.5	9.3	99.4	7.6	81	81	0.4	36
06/24/94	0815	58.0	10.1	106.1	7.7	148	148	0.6	66
07/22/94	0730	62.5	8.5	94.1	8.1	156	171	0.3	81
08/18/94	1500	61.0	8.6	93.6	8.1	183	183	0.2	88
09/15/94	1500	50.0	10.1	96.0	8.0	187	188	0.2	
Average		53.1	11.0	108.3	7.8	154.3	156.5	0.3	72.7
Max		67.0	15.6	160.9	8.3	197.0	196.0	0.7	91.0
Min		39.0	8.5	93.2	7.0	66.0	76.0	0.0	35.0

Appendix F6b. Nutrient Analyses for Onion Valley Creek near Mouth (mg/L)

Date	Time (PST)	Dissolved NH3	Total P	Dissolved Org. N	Dissolved Nitrate
10/16/91	1130	<0.01	<0.01	<0.1	0.12
11/14/91	1000	<0.01	<0.01	<0.1	<0.01
12/09/91	NO DATA-SNOW				
01/06/92	NO DATA-SNOW				
02/06/92	NO DATA-SNOW				
03/05/92	NO DATA-SNOW				
04/03/92	NO DATA-SNOW				
05/08/92	0830	<0.01	<0.01	0.1	<0.01
06/01/92	1145	<0.01	0.02	0.2	0.03
07/01/92	1130	Contaminated sample			
08/05/92	1100	0.01	0.02	0.3	0.02
09/22/92	0900	<0.01	0.01	0.1	0.01
10/14/92	0800	<0.01	<0.01	<0.1	<0.01
11/19/92	0900	<0.01	<0.01	<0.1	<0.01
12/16/92	NO DATA-SNOW				
01/21/93	NO DATA-SNOW				
02/18/93	NO DATA-SNOW				
03/09/93	NO DATA-SNOW				
04/05/93	NO DATA-SNOW				
05/10/93	NO DATA-SNOW				
06/23/93	0800	<0.01	<0.01	0.1	0.02
07/14/93	0800	0.01	<0.01	<0.1	<0.01
08/24/93	0800	<0.01	0.02	<0.1	<0.01
09/16/93	1000	<0.01	<0.01	0.2	0.01
10/21/93	0900	<0.01	<0.01	<0.1	0.02
11/22/93	1330	<0.01	0.01	0.1	0.05
12/27/93	NO DATA-SNOW				
01/19/94	NO DATA-SNOW				
02/24/94	NO DATA-SNOW				
03/17/94	NO DATA-SNOW				
04/21/94	NO DATA-SNOW				
05/25/94	1430	<0.01	<0.01	<0.1	<0.01
06/24/94	0815	<0.01	0.01	0.2	0.02
07/22/93	0730	<0.01	0.01	<0.1	0.03
08/18/94	1500	<0.01	<0.01	<0.1	<0.01
09/15/94	1500	<0.01	0.01	<0.1	0.01
Max		0.01	0.02	0.3	0.12

Appendix F7a. General Water Quality Parameters for Greenhorn Creek above Squirrel Creek

Date	Time (PST)	Temp. ° F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
09/17/91	0700	48.0	10.8	100.0	7.9	137	137	0.4	72
10/07/91	1045	46.0	11.0	99.1	8.0	139	140	0.3	74
11/14/91	1500	42.0	8.8	75.0	8.0	137	144	0.2	73
12/09/91	1430	38.0	12.7	102.0	8.1	121	143	0.3	75
01/06/92	1415	41.0	15.1	126.8	7.9	120	143	0.5	70
02/06/92	1345	43.0	10.8	93.3	8.2	136	137	0.5	68
03/05/92	1355	45.0	14.8	131.5	7.9	129	130	1.0	67
04/02/92	1510	54.0	10.3	103.0	7.6	85	99	1.9	49
05/07/92	1415	57.0	10.8	112.1	7.8	93	96	0.8	46
06/02/92	0930	56.0	12.4	127.2	8.1	131	132	0.4	65
07/02/92	0715	52.0	9.8	95.6	7.9	134	158	0.6	78
08/06/92	1030	50.0	11.4	108.4	8.1	136	137	0.6	67
09/23/92	1100	49.5	11.1	104.8	8.1	123	140	0.3	69
10/13/92	1400	50.0	9.9	94.1	7.9	135	139	0.4	68
11/19/92	1325	41.0	11.5	96.6	7.8	136	138	0.4	67
12/16/92	1420	37.0	12.1	95.7	7.3	135	136	0.3	68
01/21/93	NO DATA-SNOW								
02/18/93	1415	39.0	10.9	88.9	7.9	113	114	2.0	54
03/09/93	1330	39.5	12.4	101.8	7.5	88	90	4.4	43
04/05/93	1100	42.0	12.2	103.9	7.3	84	85	1.7	41
05/10/93	1245	47.0	14.2	129.7	7.6	49	57	1.6	28
06/23/93	1400	52.0	13.9	135.6	7.3	51	59	1.0	29
07/13/93	1245	57.0	15.6	161.9	7.3	99	100	0.3	48
08/23/93	1130	52.5	18.2	178.7	7.5	134	132	0.2	67
09/28/93	0630	43.0	10.9	94.2	7.6	138	141	0.4	70
10/22/93	0945	43.0	10.5	90.7	7.4	137	137	0.3	68
11/23/93	1340	42.5	11.7	100.4	7.5	135	134	0.3	66
12/28/93	0930	38.0	11.9	95.6	7.4	135	130	0.5	67
01/19/94	1515	38.0	11.2	89.9	7.4	136	135	0.5	67
02/24/94	1545	43.0	10.4	89.9	7.8	134	135	0.5	67
03/17/94	1545	46.0	10.0	90.1	7.9	117	115	1.0	61
04/21/94	1120	48.5	10.0	93.2	7.4	72	71	1.7	37
05/26/94	1130	57.0	10.0	103.8	7.7	101	99	0.7	48

Appendix F7a. General Water Quality Parameters for Greenhorn Creek above Squirrel Creek

Date	Time (PST)	Temp. °F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
06/23/94	1145	60.0	8.8	94.7	7.6		132	0.7	66
07/21/94	1055	52.5	8.9	87.4	7.9	122	135	0.7	68
08/19/94	1100	50.0	10.0	95.1	7.9	136	136	0.7	77
09/14/94	1350	49.0	9.9	92.9	7.8	137	140	0.5	
Average		46.9	11.5	105.1	7.7	118.4	122.9	0.8	61.4
Max		60.0	18.2	178.7	8.2	139.0	158.0	4.4	78.0
Min		37.0	8.8	75.0	7.3	49.0	57.0	0.2	28.0

Appendix F7b. Nutrient Analyses for Greenhorn Creek above Squirrel Creek (mg/L)

Date	Time (PST)	Dissolved NH3	Total P	Dissolved Org. N	Dissolved Nitrate
09/17/91	0700	<0.01	<0.01	<0.1	0.03
10/07/91	1045	<0.01	<0.01	<0.1	0.01
11/14/91	1500	<0.01	0.01	<0.1	<0.01
12/09/91	1430	<0.01	<0.01	<0.1	0.02
01/06/92	1415	0.01	<0.01	0.2	<0.01
02/06/92	1345	<0.01	<0.01	<0.1	<0.01
03/05/92	1355	<0.01	<0.01	<0.1	0.02
04/02/92	1455	0.02	0.02	0.1	<0.01
05/07/92	1415	<0.01	0.01	<0.1	<0.01
06/02/92	0930	<0.01	0.01	<0.1	0.01
07/02/92	0700	Contaminated sample			
08/06/92	1015	<0.01	0.01	<0.1	<0.01
09/23/92	0930	<0.01	<0.01	<0.1	<0.01
10/13/92	1400	<0.01	0.01	0.2	<0.01
11/19/92	1325	<0.01	<0.01	<0.1	<0.01
12/16/92	1420	0.01	<0.01	<0.1	0.02
01/21/93	NO DATA-SNOW				
02/18/93	1415	<0.01	0.01	0.1	0.02
03/09/93	1330	<0.01	0.01	<0.1	0.01
04/05/93	1100	<0.01	<0.01	0.3	0.02
05/10/93	1245	0.01	0.01	<0.1	0.02
06/23/93	1400	<0.01	<0.01	<0.1	<0.01
07/13/93	1245	<0.01	<0.01	<0.1	<0.01
08/23/93	1130	0.05	<0.01	0.2	0.01
09/28/93	0630	<0.01	<0.01	<0.1	0.01
10/22/93	0945	<0.01	<0.01	0.1	<0.01
11/23/93	1340	<0.01	<0.01	<0.1	<0.01
12/28/93	0930	<0.01	<0.01	<0.1	<0.01
01/19/94	1515	<0.01	<0.01	<0.1	0.02
02/24/94	1545	<0.01	0.06	<0.1	0.01
03/17/94	1545	<0.01	0.01	<0.1	0.01
04/21/94	1120	<0.01	<0.01	<0.1	<0.01
05/25/94	1130	<0.01	<0.01	<0.1	<0.01
06/23/94	1130	<0.01	<0.01	<0.1	<0.01
07/21/94	1055	0.01	<0.01	<0.1	0.02
08/19/94	1100	<0.01	0.02	<0.1	0.01
09/14/94	1350	<0.01	<0.01	<0.1	0.01
Max		0.05	0.06	0.3	0.03

Appendix F8a. General Water Quality Parameters for Squirrel Creek at Mouth

Date	Time (PST)	Temp. °F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
09/17/91	0630	52.0	10.9	106.3	8.1	233	243	0.2	122
10/07/91	1030	50.0	12.2	116.0	8.1	237	248	0.1	125
11/14/91	1430	43.0	11.4	98.5	8.1	233	239	0.2	120
12/09/91	1445	40.0	12.1	100.1	8.0	197	227	0.3	116
01/06/91	1400	42.0	15.1	128.6	8.0	188	220	0.5	109
02/06/92	1315	43.0	10.6	91.6	7.9	215	216	0.3	110
03/05/92	1345	46.0	18.0	162.2	7.6	130	132	3.0	66
04/02/92	1510	54.0	10.3	103.0	7.6	85	88	3.5	43
05/07/92	1400	65.0	9.0	102.5	8.0	156	160	0.6	77
06/02/92	0900	60.0	10.1	108.6	8.3	225	228	0.2	113
07/02/92	FAILED QA/QC								
08/06/92	1015	56.0	11.3	115.9	8.2	251	254	0.3	125
09/23/92	0700	52.0	10.0	97.6	8.2	253	258	0.2	127
10/13/92	1330	54.0	7.4	74.0	7.9	251	252	0.2	125
11/19/92	1310	41.0	12.7	106.6	8.0	237	138	0.4	67
12/16/92	1410	38.0	12.0	96.4	8.1	223	223	0.5	110
01/21/93	NO DATA-SNOW								
02/18/93	1430	38.0	9.4	75.5	7.4	104	104	10.0	51
03/09/93	1300	41.5	11.8	99.8	7.4	80	81	6.0	40
04/05/93	1115	41.0	12.1	101.6	7.3	67	68	3.2	33
05/10/93	1255	51.0	10.8	104.0	7.4	40	48	2.5	24
06/23/93	1355	57.0	13.5	140.1	7.4	57	66	1.6	32
07/13/93	1300	63.0	13.5	150.3	7.6	135	136	1.4	67
08/23/93	1115	58.0	17.4	182.8	7.5	217	210	0.2	107
09/27/93	1215	53.0	9.4	92.9	7.8	225	221	0.4	114
10/22/93	0930	45.0	10.9	96.9	7.4	197	196	0.3	97
11/23/93	1330	42.5	10.9	93.5	7.6	185	183	0.3	91
12/28/93	0915	37.0	10.5	83.0	7.4	172	168	0.4	84
01/19/94	1500	39.0	11.4	92.9	7.4	175	173	0.4	87
02/24/94	1530	45.0	10.3	91.6	7.6	157	153	6.0	76
03/17/94	1530	47.5	10.3	94.7	7.9	99	97	4.2	51
04/21/94	1140	49.0	8.7	81.6	7.4	69	67	5.2	36
05/26/94	1130	60.5	9.5	102.8	7.7	138	138	0.5	65

Appendix F8a. General Water Quality Parameters for Squirrel Creek at Mouth

Date	Time (PST)	Temp. °F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
06/23/94	1145	60.0	8.8	94.7	7.6	206	203	0.7	102
07/21/94	1100	59.0	8.5	90.4	7.8	183	203	0.3	101
08/19/94	1115	54.0	9.2	92.0	7.9	207	206	0.5	105
09/14/94	1130	51.0	9.9	95.3	8.2	236	238	0.5	
Average		49.4	11.1	104.7	7.8	173.2	173.9	1.6	85.8
Max		65.0	18.0	182.8	8.3	253.0	258.0	10.0	127.0
Min		37.0	7.4	74.0	7.3	40.0	48.0	0.1	24.0

Appendix F8b. Nutrient Analyses for Squirrel Creek at Mouth (mg/L)

Date	Time (PST)	Dissolved NH3	Total P	Dissolved Org. N	Dissolved Nitrate
09/17/91	0630	<0.01	<0.01	<0.1	<0.01
10/07/91	1030	<0.01	<0.01	<0.1	<0.01
11/14/91	1430	<0.01	<0.01	<0.1	<0.01
12/09/91	1445	<0.01	<0.01	<0.1	<0.01
01/06/92	1400	0.01	<0.01	<0.1	<0.01
02/06/92	1315	<0.01	<0.01	<0.1	<0.01
03/05/92	1345	<0.01	<0.01	<0.1	0.02
04/02/92	1510	0.01	<0.01	<0.1	<0.01
05/07/92	1400	<0.01	<0.01	<0.1	<0.01
06/02/92	0900	<0.01	<0.01	<0.1	<0.01
07/02/92	0715	Contaminated sample			
08/06/92	1015	<0.01	<0.01	0.2	<0.01
09/23/92	0700	<0.01	<0.01	<0.1	<0.01
10/13/92	1330	<0.01	<0.01	0.2	<0.01
11/19/92	1310	<0.01	<0.01	<0.1	<0.01
12/16/92	1410	<0.01	<0.01	<0.1	0.03
01/21/93	NO DATA-SNOW				
02/18/93	1430	0.02	0.01	0.2	0.04
03/09/93	1300	<0.01	0.01	0.1	0.02
04/05/93	1115	<0.01	<0.01	0.2	<0.01
05/10/93	1255	<0.01	0.01	<0.1	<0.01
06/23/93	1355	<0.01	<0.01	<0.1	<0.01
07/13/93	1300	<0.01	<0.01	<0.1	<0.01
08/23/93	1115	0.05	<0.01	0.1	<0.01
09/27/93	1215	<0.01	<0.01	0.1	0.01
10/22/93	0930	<0.01	<0.01	0.4	<0.01
11/23/93	1330	<0.01	<0.01	<0.1	<0.01
12/28/93	0915	<0.01	<0.01	0.1	<0.01
01/19/94	1500	0.01	<0.01	<0.1	<0.01
02/24/94	1530	<0.01	<0.01	<0.1	0.01
03/17/94	1530	<0.01	<0.01	<0.1	<0.01
04/21/94	1140	<0.01	0.01	<0.1	<0.01
02/25/94	1130	<0.01	<0.01	<0.1	<0.01
06/23/94	1145	<0.01	<0.01	0.1	<0.01
07/21/94	1100	<0.01	<0.01	<0.1	0.01
08/19/94	1115	<0.01	<0.01	<0.1	<0.01
09/14/94	1130	<0.01	<0.01	<0.1	<0.01
Max		0.05	0.01	0.4	0.04

Appendix F9a. General Water Quality Parameters for Jamison Creek near Johnsville

Date	Time (PST)	Temp. °F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
12/06/90	1321	42.0	12.1	115.6	-	136	144	3.0	68
01/03/91	1205	38.0	12.7	114.3	7.5	139	140	0.2	72
02/04/91	1310	40.0	11.4	105.8	7.9	133	134	0.5	62
03/08/91	1000	37.0	11.9	105.5	7.3	100	105	0.5	46
04/04/91	1300	45.0	11.0	109.7	7.6	99	114	0.4	55
05/02/91	1510	40.0	10.5	97.4	7.3	90	95	0.1	42
06/05/91	1225	51.0	10.0	108.1	7.2	72	72	0.3	43
07/02/91	1200	58.0	10.0	118.0	7.9	96	98	0.1	41
08/14/91	1315	56.5	9.3	107.7	7.9	129	132	0.3	63
09/18/91	0113	56.0	9.3	107.1	8.0	124	136	0.2	68
10/07/91	1245	53.0	9.9	109.8	8.0	133	138	0.1	70
11/13/91	1515	45.0	10.3	102.7	7.9	134	141	0.2	71
12/09/91	1400	38.0	13.5	121.5	7.5	118	137	0.2	64
01/06/92	1310	41.0	14.5	136.5	7.9	115	138	0.1	71
02/06/92	1420	39.0	10.6	96.9	7.6	133	136	0.7	67
03/05/92	1250	41.0	11.9	112.1	7.3	102	103	0.3	52
04/02/92	1410	46.0	11.1	112.2	7.3	82	82	0.4	42
05/07/92	1320	53.0	10.5	116.4	7.4	69	71	0.4	34
06/02/92	1100	61.0	11.2	136.9	7.9	113	115	0.2	55
07/02/92	0900	54.0	8.9	100.0	7.6	125	127	0.3	62
08/06/92	0925	56.0	10.6	122.0	8.1	138	140	0.2	67
09/24/92	1600	58.0	8.6	101.5	8.2	143	147	0.1	70
10/13/92	1300	54.0	10.2	114.6	7.9	143	146	0.1	69
11/19/92	1200	41.0	12.3	115.8	7.6	137	138	0.2	65
12/16/92	1325	38.0	12.9	116.1	7.4	122	121	0.3	57
01/21/93	1515	33.0	12.5	104.0	7.4	99	100	0.4	46
02/18/93	1315	36.0	13.9	121.3	7.4	118	119	3.4	53
03/09/93	1230	41.5	11.8	111.9	7.5	120	121	0.4	57
04/05/93	1215	42.5	13.9	133.8	7.2	87	88	0.4	44
05/10/93	0635	38.0	12.7	114.3	7.4	50	60	0.3	29
06/24/93	0700	45.0	15.6	155.5	7.3	59	68	0.4	33
07/13/93	0620	47.0	12.4	127.1	7.3	78	79	0.1	38
08/23/93	1215	60.0	14.1	170.3	7.6	125	121	0.0	60

Appendix F9a. General Water Quality Parameters for Jamison Creek near Johnsville

Date	Time (PST)	Temp. °F	D.O. mg/L	D.O. % Sat.	pH Field	EC (µmhos/cm) Field	EC (µmhos/cm) Lab	Turbidity (NTU)	Alkalinity (mg/L) as (CaCO3)
09/14/93	1400	56.0	9.8	112.8	7.3	129	129	0.0	65
10/23/93	0730	42.0	10.6	101.3	7.4	130	130	0.2	63
11/23/93	1230	42.5	10.8	103.9	7.6	131	129	0.1	62
12/27/93	1600	38.5	11.3	102.5	7.3	128	126	1.3	63
01/19/94	1400	40.0	10.9	101.1	7.4	129	127	0.2	64
02/24/94	1430	43.0	10.5	101.8	8.1	129	128	1.0	62
03/17/94	1500	44.5	10.4	103.0	7.8	106	103	0.5	52
04/21/94	1400	58.5	8.7	103.3	7.5	111	107	1.4	56
05/25/94	1030	53.0	11.3	125.3	7.4	77	76	0.4	38
06/23/94	1015	56.5	9.6	111.2	7.6	116	117	0.3	64
07/21/94	1200	64.0	9.6	121.5	8.0	119	131	0.2	64
08/19/94	0900	54.0	9.6	107.8	7.6	137	137	0.2	75
09/14/94	0700	44.0	10.1	99.3	7.9	140	142	0.2	
Average		47.0	11.2	113.9	7.6	114.0	117.1	0.5	57.0
Max		64.0	15.6	170.3	8.2	143.0	147.0	3.4	75.0
Min		33.0	8.6	96.9	7.2	50.0	60.0	0.0	29.0

Appendix F9b. Nutrient Analyses for Jamison Creek near Johnsville (mg/L)

Date	Time (PST)	Total NH3+Org. N.	Dissolved NO2 + NO3	Dissolved NH3	Dissolved o-PO4	Total P	Dissolved Org. N	Dissolved Nitrate
12/06/90	1321	<0.1	0.04	-	<0.01	<0.01	-	-
01/03/91	1205	-	-	-	-	<0.01	<0.1	0.04
02/04/91	1310	<0.1	-	-	-	<0.01	0.2	0.16
03/08/91	1000	-	-	<0.01	-	<0.01	0.1	0.18
04/04/91	1300	-	-	<0.01	-	<0.01	<0.1	0.05
05/02/91	1300	-	-	<0.01	-	<0.01	<0.1	0.01
06/05/91	1225	-	-	0.02	-	<0.01	0.4	0.02
07/02/91	1200	-	-	<0.01	-	<0.01	<0.1	0.01
08/14/91	1315	-	-	0.01	-	<0.01	<0.1	0.04
09/18/91	1130	-	-	<0.01	-	<0.01	<0.1	<0.01
10/07/91	1245	-	-	<0.01	-	<0.01	<0.1	<0.01
11/13/91	1515	-	-	<0.01	-	<0.01	<0.1	0.01
12/09/91	1400	-	-	<0.01	-	<0.01	<0.1	0.04
01/06/92	1310	-	-	0.01	-	<0.01	<0.1	0.04
02/06/92	1420	-	-	<0.01	-	<0.01	0.1	0.03
03/05/92	1250	-	-	<0.01	-	<0.01	<0.1	0.12
04/02/92	1410	-	-	<0.01	-	<0.01	<0.1	0.10
05/07/92	1320	-	-	<0.01	-	<0.01	<0.1	<0.01
06/02/92	1100	-	-	<0.01	-	<0.01	<0.1	0.02
07/02/92	0900	Contaminated sample						
08/06/92	0925	-	-	<0.01	-	<0.01	0.2	<0.01
09/24/92	1600	-	-	<0.01	-	<0.01	<0.1	<0.01
10/13/92	1300	-	-	<0.01	-	<0.01	0.1	<0.01
11/19/92	1200	-	-	<0.01	-	<0.01	<0.1	0.04
12/16/92	1325	-	-	0.05	-	0.06	<0.1	0.12
01/21/93	1515	-	-	0.02	-	0.01	0.2	0.12
02/18/93	1315	-	-	0.04	-	0.04	0.4	0.20
03/09/93	1230	-	-	<0.01	-	<0.01	<0.1	0.08
04/05/93	1215	-	-	<0.01	-	<0.01	0.3	0.06
05/11/93	0635	-	-	<0.01	-	<0.01	<0.1	0.04
06/24/93	0700	-	-	0.01	-	<0.01	<0.1	<0.01
07/13/93	0620	-	-	0.01	-	<0.01	0.2	0.01
08/23/93	1215	-	-	0.04	-	<0.01	0.1	<0.01
09/14/93	1400	-	-	<0.01	-	<0.01	<0.1	0.02
10/22/93	0730	-	-	0.01	-	<0.01	<0.1	<0.01
11/23/93	1230	-	-	<0.01	-	<0.01	<0.1	<0.01
12/27/93	1600	-	-	0.02	-	<0.01	<0.1	<0.01
01/19/94	1400	-	-	0.03	-	0.01	<0.1	<0.01
02/24/94	1430	-	-	0.02	-	0.01	0.3	0.04
03/17/94	1500	-	-	<0.01	-	<0.01	0.1	0.07
04/21/94	1435	-	-	<0.01	-	<0.01	<0.1	0.05
05/25/94	1030	-	-	<0.01	-	<0.01	<0.1	0.01
06/23/94	1015	-	-	<0.01	-	<0.01	<0.1	<0.01
07/21/94	1200	-	-	<0.01	-	<0.01	<0.1	<0.01
08/19/94	0900	-	-	<0.01	-	<0.01	<0.1	0.01
09/14/94	0700	-	-	<0.01	-	<0.01	<0.1	<0.01
Max		<0.1	0.04	0.05	<0.01	0.06	0.4	0.20

Appendix G

Benthic Macroinvertebrate Population Data

Appendix G1a. Benthic Macroinvertebrates Collected from the Middle Fork Feather River at Portola (number per square meter)

	Date 5/91	9/91
Coleoptera		
Elmidae		
Optioservus sp.		4.0
Zaitzevia parvula		2.7
Hydraenidae		
Diptera		4.0
Chironomidae		30.9
Orthocladiinae	139.9	76.7
Tanypodinae	26.9	
Tanytarsus sp.	32.2	2.7
Simuliidae	915.3	13.4
Simulium sp.	13,046	
Tipulidae		
Antocha sp.	5.4	
Ephemeroptera		
Baetidae		
Baetis sp.	1,298	
Centroptilum sp.		340.5
Ephemerellidae		6.7
Heptageniidae		
Epeorus sp.	5.4	
Tricorythidae		
Tricorythodes fallax	16.2	21.5

	Date 5/91	9/91
Plecoptera		9.4
Caenidae		
Caenis sp.		6.7
Chloroperlidae		
Nemouridae	5.4	
Perlodidae		
Isoperla sp.	5.4	
Trichoptera		
Hydropsychidae		1.3
Cheumatopsyche sp.	16.2	534.4
Hydropsyche sp.	5.4	2.7
Hydroptilidae	26.9	
Ochrotrichia sp.	32.3	
Limnephilidae		
Dicosmoecus sp.	5.4	
Annelida		
Oligochaeta	5.4	18.8
Platyhelminthes		
Planariidae		
Dugesia sp.		9.4
Number of Organisms	15,613	1,086
Number of Species	14	14
Diversity	0.6	1.9
Equitability	0.11	0.36

Appendix G1b. Benthic Macroinvertebrates Collected from the Middle Fork Feather River at Portola (number per square meter)

	Date	
	6/2/92	9/24/92
Amphipoda		
Talitridae		
Hyalella azteca	96.8	48.4
Coleoptera	5.4	
Optioservus sp.	10.8	
Diptera		
Ceratopogonidae		
Bezzia sp.	5.4	
Chironomidae	10.8	86.0
Chironominae	75.3	48.4
Orthocladiinae	1,501	268.9
Tanypodinae	53.7	
Empididae		5.4
Muscidae	5.4	
Simuliidae	129.0	
Simulium sp.	1,151	666.9
Tipulidae		
Antocha sp.	5.4	5.4
Ephemeroptera		
Baetidae		
Baetis sp.	451.8	1,631
Heptageniidae		
Epeorus sp.	16.1	
Tricorythidae		
Tricorythodes fallax		26.8
Lepidoptera		
Pyralidae		
Petrophila sp.		5.4

	Date	
	6/2/92	9/24/92
Plecoptera		
Nemouridae	306.6	
Trichoptera	5.4	
Hydropsychidae	123.7	
Cheumatopsyche sp.	21.5	903.6
Hydropsyche sp.		59.1
Hydroptilidae		
Hydroptila sp.	145.2	10.8
Leucotrichia pictipes		5.4
Philopotamidae		
Dolophilodes sp.	43.0	
Wormaldia sp.	10.8	
Arachnoidea		
Hydracarina	10.8	
Annelida		
Oligochaeta	16.1	48.4
Nematoda		
Mermithiidae	5.4	
Decapoda		
Astacidae		
Pacifasticus sp.	5.4	16.1
Number of Organisms	4,061	3,750
Number of Species	21	15
Diversity	2.6	2.2
Equitability	0.40	0.42
Biomass (ml)	4.0	104.0

Appendix G1c. Benthic Macroinvertebrates Collected from the Middle Fork Feather River at Portola (number per square meter)

	Date	
	6/24/93	9/13/93
Amphipoda		
Talitridae		
Hyalella azteca	580.9	18.8
Coleoptera		
Optioservus sp.	5.4	4.0
Zaitzevia parvula		1.3
Diptera		
Chironomidae	32.2	13.4
Chironominae	182.8	10.8
Orthocladiinae	215.1	69.9
Tanypodinae	16.1	12.1
Empididae		1.3
Muscidae	5.4	
Simuliidae	37.6	9.4
Simulium sp.	7,289	1,122
Tipulidae		
Antocha sp.		5.4
Dicranota sp.	16.1	4.0
Ephemeroptera		
Baetidae		
Baetis sp.	591.6	367.1
Heptageniidae		
Epeorus sp.		1.3
Rhithrogena sp.		1.3
Leptophlebiidae		
Paraleptophlebia sp.	10.8	20.1
Tricorythidae		
Tricorythodes fallax		21.5

	Date	
	6/24/93	9/13/93
Plecoptera		
Nemouridae		
Zapada sp.		5.4
Perlodidae		
Skwala sp.		1.3
Trichoptera		1.3
Hydropsychidae		
Cheumatopsyche sp.	145.2	9.4
Hydropsyche sp.	268.9	462.6
Hydroptilidae		
Hydroptila sp.	5.4	
Philopotamidae		2.7
Wormaldia sp.	43.0	51.1
Arachnoidea		
Hydracarina		1.3
Annelida		
Oligochaeta	16.1	18.8
Nematoda		
Mermithiidae	5.4	6.7
Decapoda		
Astacidae		
Pacifasticus sp.		2.7
Number of Organisms	9,397	2,220
Number of Species	16	24
Diversity	1.4	2.2
Equitability	0.20	0.25
Biomass (ml)	32.0	6.0

Appendix G1d. Benthic Macroinvertebrates Collected from the Middle Fork Feather River at Portola (number per square meter)

	Date	
	6/23/94	9/13/94
Amphipoda		
Talitridae		
Hyalella azteca	41.7	
Araneae	1.3	
Elmidae		
Optioservus sp.		25.5
Psephenidae		
Psephenus sp.		1.3
Ephemeroptera		
Tricorythidae		
Tricorythodes fallax	2.7	10.7
Veliidae		
Rhagovelia sp.		1.3
Lepidoptera		
Pyralidae		
Petrophila sp.		4.0
Trichoptera		
Glossosomatidae		
Agapetus sp.	1.3	
Glossosoma sp.		1.3
Hydropsychidae		
Cheumatopsyche sp.		21.5
Hydropsyche sp.	117.0	165.4
Hydroptilidae		
Hydroptila sp.	8.1	
Leucotrichia pictipes		1.3
Limnephilidae		1.3
Philopotamidae		
Doliphiloides sp.		4.0
Wormaldia sp.	34.9	25.5
Rhyacophilidae		
Rhyacophila sp.		1.3
Mollusca		
Gastropoda		
Lymnaeidae		1.3
Arachnoidea		
Hydracarina		12.1
Annelida		
Oligochaeta	5.4	
Platyhelminthes		
Planariidae		
Dugesia sp.	1.3	
Number of Organisms	213.7	277.8
Number of Species	9	15
Diversity	1.9	2.2
Equitability	0.53	0.40
Biomass (ml)	8.5	4.0

Appendix G2a. Benthic Macroinvertebrates Collected from the Middle Fork Feather River at the Quincy La Porte Road (number per square meter)

	Date 5/91	Date 9/91
Coleoptera		
Elmidae		
Cleptelmis sp.	4.0	
Narpus sp.	1.3	
Optioservus sp.	8.1	613.3
Ordobrevia nubifera		53.8
Zaitzevia parvula	6.7	808.3
Psephenidae		
Eubrianax edwardsi	1.3	1.3
Psephenus sp.	12.1	22.8
Diptera		2.7
Athericidae		
Atherix sp.	1.3	
Chironomidae	6.7	18.8
Chironominae	5.4	8.1
Orthocladiinae	29.6	173.5
Empididae	1.3	
Simuliidae		
Simulium sp.		52.4
Tipulidae	2.7	
Antocha sp.	10.7	13.5
Ephemeroptera		
Baetidae		
Baetis sp.	51.1	707.4
Ephemerellidae		
Drunella coloradensis	41.7	
Ephemerella sp.	4.0	2.7
Serratella sp.		8.1
Heptageniidae		
Epeorus sp.	26.9	25.5
Rhithrogena sp.	14.8	437.1
Siphlonuridae		
Ameletus sp.		26.9
Siphlonurus sp.	1.3	
Tricorythidae		
Tricorythodes fallax	10.7	
Lepidoptera		
Pyralidae		2.7
Odonata		
Gomphidae		1.3
Ophiogomphus bison	2.7	
Libellulidae		
Paltothemes sp.	1.3	
Plecoptera		
Chloroperlidae		
Suwallia sp.	1.3	2.7
Leuctridae		
Leuctra sp.	1.3	
Nemouridae		
Zapada sp.		2.7
Perlidae		
Calineuria californica	1.3	55.1
Classenia sabulosa		1.3
Hesperoperla pacifica		8.1
Perlodidae		
Isoperla sp.	20.2	169.4
Skwala sp.		12.1
Pteronarcyidae		
Pteronarcys californica		8.1
Trichoptera		
Brachycentridae		
Micrasema sp.	2.7	
Glossosomatidae		
Glossosoma sp.	6.7	
Helicopsychidae		
Helicopsyche borealis	126.2	
Hydropsychidae		
Cheumatopsyche sp.	32.3	
Hydropsyche sp.		3,917
Ochrotrichia sp.		5.4
Hydroptilidae		8.1
Lepidostomatidae		
Lepidostoma sp.		5.4
Philopotamidae		
Wormaldia sp.		29.5
Rhyacophilidae		53.8
Rhyacophila sp.		16.1
Annelida		
Oligochaeta	4.0	67.3
Nematoda		
Platyhelminthes		
Planariidae		
Dugesia sp.	1.3	2.7
Number of Organisms	443.4	7,345
Number of Species	30	33
Diversity	3.7	2.5
Equitability	0.62	0.23
Biomass (ml)	-	25.0

Appendix G2b. Benthic Macroinvertebrates Collected from the Middle Fork Feather River at the Quincy La Porte Road (number per square meter)

	Date 6/2/92	Date 9/21/92
Coleoptera		
Elmidae		91.4
Optioservus sp.	295.8	236.6
Ordobrevia nubifera	123.7	48.4
Zaitzevia/Heterlimnus	112.9	242.0
Zaitzevia parvula	527.1	161.3
Psephenidae		
Psephenus sp.	139.8	43.0
Diptera		
Blephariceridae	5.4	
Bezzia sp.	10.8	
Chironomidae	53.7	21.5
Chironominae	349.6	43.0
Orthocladiinae	451.8	376.5
Tanypodinae	21.5	
Simuliidae	32.2	21.5
Simulium sp.	1,135	1,743
Tipulidae		
Antocha sp.	32.2	10.8
Hexatoma sp.		5.4
Ephemeroptera		
Baetidae		
Baetis sp.	656.2	548.6
Ephemerellidae	16.1	
Caudatella sp.	16.1	
Drunella coloradensis	10.8	
Serratella sp.	150.6	
Heptageniidae	102.2	
Epeorus sp.	177.5	5.4
Rhithrogena sp.		43.0
Leptophlebiidae		
Paraleptophlebia sp.		26.8
Oligoneuriidae		
Isonychia velma		5.4
Hemiptera		
Gerridae	5.4	
Lepidoptera		
Pyralidae		
Petrophila sp.		5.4
Odonata		
Cordulegastridae		
Cordulegaster sp.	5.4	
Plecoptera		
Perlidae		
Calineuria californica	53.7	21.5
Hesperoperla pacifica	118.3	
Perlodidae	43.0	
Pteronarcyidae		
Pteronarcys californica	59.1	
Trichoptera		
Brachycentridae		
Micrasema sp.		59.1
Glossosomatidae		
Glossosoma sp.	69.9	
Hydropsychidae		
Cheumatopsyche sp.		239.3
Hydropsyche sp.	204.4	508.3
Hydroptilidae		
Neotrichia sp.	5.4	
Lepidostomatidae		
Lepidostoma sp.		279.7
Philopotamidae		
Chimarra sp.		32.2
Wormaldia sp.	274.4	32.2
Rhyacophilidae		10.8
Rhyacophila sp.	215.1	
Arachnoidea		
Hydracarina	5.4	
Annelida		
Oligochaeta		16.1
Number of Organisms	5,271	4,835
Number of Species	28	26
Diversity	3.9	3.3
Equitability	0.75	0.53
Biomass (ml)	48.0	16.0

Appendix G2c. Benthic Macroinvertebrates Collected from the Middle Fork Feather River at the Quincy La Porte Road (number per square meter)

	Date	
	6/23/93	9/13/93
Coleoptera	1.3	
Elmidae		
Ampumixis dispar	1.3	5.4
Optioservus sp.	20.2	301.2
Ordobrevia nubifera	1.3	26.8
Zaitzevia/Heterlimnus	4.0	5.4
Zaitzevia parvula	20.1	441.0
Psephenidae		
Eubrianax edwardsi	6.7	
Psephenus sp.	60.5	
Diptera		
Chironomidae	2.7	43.0
Chironominae	17.4	139.8
Orthocladiinae	71.3	123.7
Tanypodinae	2.7	
Empididae	2.7	
Simuliidae	1.3	419.5
Simulium sp.	207.1	13,915
Tipulidae	1.3	
Antocha sp.		10.8
Tipula sp.		10.8
Ephemeroptera		10.8
Baetidae		
Baetis sp.	147.9	1,468
Ephemerellidae		
Caudatella sp.	4.0	
Drunella coloradensis	4.0	
Ephemerella sp.	6.7	5.4
Serratella sp.	1.3	10.8
Heptageniidae	37.6	
Cinygmula sp.	1.3	
Epeorus sp.	75.3	
Rhithrogena sp.		602.4
Tricorythidae		
Tricorythodes fallax	4.0	
Megaloptera		
Corydalidae		
Neohermes/Protochauliodes	1.3	

	Date	
	6/23/93	9/13/93
Odonata		
Coenagrionidae		
Argia sp.	1.3	
Gomphidae		
Ophiogomphus bison	4.0	
Plecoptera		48.4
Chloroperlidae		
Suwallia sp.	1.3	
Sweltza sp.	1.3	
Nemouridae		
Malenka sp.	1.3	
Zapada sp.		32.2
Perlidae		
Calineuria californica	6.7	37.6
Hesperoperla pacifica		26.8
Perlodidae	2.7	
Isoperla sp.		75.3
Skwala sp.		43.0
Thysanoptera	1.3	
Trichoptera		
Glossosomatidae		
Glossosoma sp.	6.7	10.8
Hydropsychidae	1.3	
Cheumatopsyche sp.		828.3
Hydropsyche sp.	82.0	1,936
Lepidostomatidae		
Lepidostoma sp.		26.8
Philopotamidae		
Wormaldia sp.	17.4	419.5
Rhyacophilidae		21.5
Rhyacophila sp.	41.6	53.7
Annelida		
Oligochaeta	13.4	32.2
Number of Organisms	842	20,589
Number of Species	35	26
Diversity	3.6	1.9
Equitability	0.49	0.19
Biomass (ml)	6.0	114.0

Appendix G2d. Benthic Macroinvertebrates Collected from the Middle Fork Feather River at the Quincy La Porte Road (number per square meter)

	Date	
	6/23/94	9/12/94
Cladocera		1.3
Coleoptera		
Elmidae		
Heterlimnius sp.		1.3
Optioservus sp.	161.4	47.1
Ordobrevia nubifera	2.7	10.7
Zaitzevia parvula	41.7	21.5
Psephenidae		
Eubrianax edwardsi	5.4	
Psephenus sp.	13.4	41.7
Diptera		
Ceratopogonidae		
Bezzia sp.	1.3	
Chironomidae	8.1	14.8
Chironominae	227.3	10.8
Orthocladiinae	95.5	30.9
Tanypodinae	1.3	
Simuliidae		1.3
Simulium sp.	83.4	910.8
Tipulidae		
Antocha sp.	9.4	1.3
Ephemeroptera		1.3
Baetidae		
Baetis sp.	216.6	84.7
Pseudocloeon sp.		16.1
Ephemerellidae		
Caudatella sp.	9.4	
Drunella coloradensis	8.1	
D. doddsi	1.3	
Ephemerella sp.	5.4	
Serratella sp.	57.8	2.7
Heptageniidae	25.5	16.1
Epeorus sp.	131.8	6.7
Odonata		
Gomphidae		2.7

	Date	
	6/23/94	9/12/94
Plecoptera	71.3	
Chloroperlidae	1.3	
Suwallia sp.		10.8
Nemouridae		
Malenka sp.	24.2	
Zapada sp.	5.4	
Perlidae		
Calineuria californica	33.6	25.5
Hesperoperla pacifica	8.1	4.0
Perlodidae		
Skwala sp.		1.3
Pteronarcyidae		
Pteronarcys californica		2.7
Trichoptera		
Brachycentridae		
Micrasema sp.	2.7	
Glossosomatidae		
Glossosoma sp.	1.3	
Hydropsychidae	10.8	
Cheumatopsyche sp.		75.3
Hydropsyche sp.	68.6	113.0
Hydroptilidae		2.7
Philopotamidae		
Wormaldia sp.	115.7	21.5
Polycentropodidae		
Polycentropus sp.		1.3
Rhyacophilidae		2.7
Rhyacophila sp.	40.3	1.3
Arachnoidea		
Hydracarina	1.3	
Annelida		
Oligochaeta	16.1	
Number of Organisms	1,392	1,447
Number of Species	30	25
Diversity	3.8	2.3
Equitability	0.66	0.30
Biomass (ml)	3.8	12.5

Appendix G3a. Benthic Macroinvertebrates Collected from Willow Creek near Clio (number per square meter)

	Date 5/91	Date 9/91
Coleoptera		
Dryopidae		
Helichus sp.		10.7
Dytiscidae		4.0
Elmidae		
Ampumixis dispar	1.3	
Optioservus sp.	20.3	169.8
Zaitzevia parvula	4.0	45.7
Hydraenidae		
Hydraena sp.		1.3
Psephenidae		
Eubrianax edwardsi	84.8	98.1
Staphylinidae		1.3
Diptera		
Blephariceridae	2.7	
Chironomidae	10.8	2.7
Chironominae		36.3
Orthocladiinae	33.7	60.5
Tanypodinae		4.0
Tanytarsus sp.	6.7	
Empididae	1.3	
Psychodidae	8.1	
Simuliidae	161.5	
Prosimulium sp.	912.6	
Simulium sp.		95.4
Tabanidae		1.3
Tipulidae		1.3
Antocha sp.	5.4	
Dicronota sp.		12.1
Tipula sp.	6.7	1.3
Hexatoma sp.	2.7	5.4
Ephemeroptera		2.7
Baetidae		
Baetis sp.	300.2	16.1
Ephemerellidae		
Drunella coloradensis	114.4	
D. pelosa	9.4	
Ephemerella sp.	2.7	10.8
Heptageniidae		18.8
Epeorus sp.	64.6	6.7
Ironodes sp.		24.2
Rhithrogena sp.	36.3	67.3
Leptophlebiidae		
Paraleptophlebia sp.		48.4
Siphlonuridae		
Ameletus sp.		9.4
Hemiptera		6.7
Odonata		
Coenagrionidae		
Argia sp.	1.3	20.2
Cordulegastridae		
Cordulegastor sp.		2.7
Plecoptera		
Capniidae		5.4
Nemouridae	22.9	
Amphinemura sp.		21.5
Zapada sp.		10.8
Perlidae		
Calineuria californica	1.3	25.5
Perlodidae		
Isoperla sp.	17.4	
Trichoptera		
Brachycentridae		
Amiocentrus sp.	14.8	
Micrasema sp.		2.7
Calamoceratidae		
Heteroplectron sp.		16.1
Glossosomatidae		
Glossosoma sp.	1.3	
Hydropsychidae		
Hydropsyche sp.	28.2	156.0
Lepidostomatidae		
Lepidostoma sp.	4.0	453.2
Philopotamidae		4.0
Wormaldia sp.		2.7
Rhyacophilidae		
Rhyacophila sp.	1.3	2.7
Arachnoidea		
Hydracarina		1.3
Aranae		1.3
Nematomorpha		1.3
Number of Organisms	1,891	1,490
Number of Species	28	38
Diversity	2.3	3.7
Equitability	0.25	0.49
Biomass (ml)	-	6.0

Appendix G3b. Benthic Macroinvertebrates Collected from Willow Creek near Clio (number per square meter)

	Date 6/2/92
Coleoptera	5.4
Elmidae	
Optioservus sp.	328.1
Zaitzevia/Heterlimnius	16.1
Zaitzevia parvula	32.3
Psephenidae	
Eubrianax edwardsi	231.3
Diptera	
Ceratopogonidae	
Bezzia sp.	37.6
Chironomidae	53.7
Chironominae	290.4
Orthocladiinae	1,672
Tanypodinae	37.6
Simuliidae	5.4
Simulium sp.	155.9
Tipulidae	5.4
Antocha sp.	37.6
Hexatoma sp.	139.8
Ephemeroptera	
Baetidae	
Baetis sp.	139.8
Ephemerellidae	
Drunella coloradensis	5.4
Ephemerella sp.	64.5
Serratella sp.	59.1
Heptageniidae	5.4
Cinygmula sp.	5.4
Epeorus sp.	26.9
Odonata	
Coenagrionidae	
Argia sp.	16.1
Cordulegastridae	5.4
Cordulegaster sp.	5.4
Gomphidae	
Gomphus sp.	43.0
Orthoptera	5.4
Pelecypoda	21.5

	Date 6/2/92
Plecoptera	
Chloroperlidae	
Suwallia sp.	64.5
Nemouridae	
Malenka sp.	10.8
Perlidae	
Calineuria californica	112.9
Perlodidae	
Isoperla sp.	5.4
Trichoptera	
Brachycentridae	5.4
Glossosomatidae	5.4
Agapetus sp.	91.4
Hydropsychidae	5.4
Hydropsyche sp.	96.8
Hydroptilidae	
Hydroptila sp.	5.4
Neotrichia sp.	21.5
Lepidostomatidae	
Lepidostoma sp.	96.8
Limnephilidae	
Dicosmoecus sp.	10.8
Philopotamidae	
Wormaldia sp.	16.1
Rhyacophilidae	
Rhyacophila sp.	21.5
Mollusca	
Gastropoda	
Lymnaeidae	5.4
Physidae	53.7
Arachnoidea	
Hydracarina	16.1
Annelida	
Oligochaeta	5.4
Nematoda	
Mermithiidae	5.4
Number of Organisms	4,017
Number of Species	40
Diversity	3.5
Equitability	0.42
Biomass (ml)	32.0

Appendix G3c. Benthic Macroinvertebrates Collected from Willow Creek near Clio
(number per square meter)

	Date	
	6/24/93	9/15/93
Coleoptera		
Dryopidae		
Helichus sp.		4.0
Elmidae		
Optioservus sp.	53.7	14.7
Zaitezevia/Heterlimnus		1.3
Zaitzevia parvula	21.5	9.4
Hydraenidae		
Hydraena sp.	5.4	
Hydrophilidae		
Laccobius sp.	5.4	
Psephenidae		
Eubrianax edwardsi	53.7	20.2
Diptera		
Ceratopogonidae		
Bezzia sp.		1.3
Chironomidae		6.7
Chironominae	48.4	25.5
Orthocladiinae	32.3	84.7
Tanypodinae	26.9	1.3
Empididae		1.3
Simuliidae		
Simulium sp.	129.0	466.6
Stratiomyidae		
Tipulidae	10.8	
Antocha sp.		4.0
Dicranota sp.	53.7	
Ephemeroptera		
Baetidae		
Baetis sp.	43.0	17.5
Centroptilum sp.	16.1	
Ephemerellidae		1.3
Drunella coloradensis		1.3
Ephemerella sp.	10.8	
Heptageniidae	5.4	2.7
Cinygmula sp.		
Epeorus sp.	5.4	17.5
Ironodes sp.	107.5	
Rhithrogena sp.	10.8	
Leptophlebiidae		
Paraleptophlebia sp.	86.1	
Siphlonuridae		
Ameletus sp.	10.8	
Tricorythidae		
Tricorythodes fallax	5.4	
Veliidae		
Microvelia sp.	10.8	
Rhagovelia sp.	5.4	
Megaloptera		
Sialidae		
Sialis sp.	5.4	
Odonata		
Coenagrionidae		
Argia sp.	10.8	2.7
Plecoptera		
Nemouridae		
Malenka sp.	16.1	17.5
Zapada sp.	779.9	
Perlidae		
Calineuria californica	37.6	8.1
Perlodidae		
Isoperla sp.		5.4
Trichoptera		
Brachycentridae		
Micrasema sp.	107.5	
Hydropsychidae		
Hydropsyche sp.	258.1	32.3
Lepidostomatidae		
Lepidostoma sp.	398.0	1.3
Philopotamidae	16.1	
Chimarra sp.		
Wormaldia sp.	43.0	4.0
Rhyacophilidae		1.3
Rhyacophila sp.		13.4
Sericostomatidae		
Gumaga nigricula		6.7
Annelida		
Oligochaeta	10.8	1.3
Nematoda		
Mermithiidae		2.7
Number of Organisms	2,420	766.0
Number of Species	32	26
Diversity	3.5	2.4
Equitability	0.53	0.28
Biomass (ml)	8.0	3.0

Appendix G3d. Benthic Macroinvertebrates Collected from Willow Creek near Clio (number per square meter)

	Date 6/23/94
Araneae	1.3
Coleoptera	
Dryopidae	
Helichus sp.	5.4
Elmidae	
Optioservus sp.	91.4
Zaitzevia parvula	32.2
Hydraenidae	
Hydraena sp.	2.7
Psephenidae	
Eubrianax edwardsi	14.8
Diptera	
Chironomidae	5.4
Chironominae	154.7
Orthocladiinae	125.1
Tanypodinae	2.7
Simuliidae	
Simulium sp.	51.1
Tipulidae	
Antocha sp.	17.4
Dicranota sp.	20.2
Hexatoma sp.	8.1
Ephemeroptera	
Baetidae	
Baetis sp.	61.8
Ephemerellidae	
Drunella coloradensis	1.3
Ephemerella sp.	8.1
Heptageniidae	5.4
Cinygmula sp.	2.7
Heptagenia sp.	52.4
Odonata	
Cordulegasteridae	
Cordulegaster sp.	2.7
Gomphidae	1.3

	Date 6/23/94
Plecoptera	
Chloroperlidae	
Sweltza sp.	1.3
Nemouridae	34.9
Perlidae	
Calineuria californica	39.0
Perlodidae	
Isoperla sp.	9.4
Trichoptera	
Brachycentridae	
Micrasema sp.	1.3
Calamoceratidae	
Heteroplectron sp.	6.7
Glossosomatidae	
Agapetus sp.	9.4
Hydropsychidae	1.3
Hydropsyche sp.	59.2
Parapsyche sp.	2.7
Hydroptilidae	
Hydroptila sp.	1.3
Lepidostomatidae	
Lepidostoma sp.	17.4
Philopotamidae	
Wormaldia sp.	111.6
Rhyacophilidae	
Rhyacophila sp.	29.6
Mollusca	
Physidae	9.4
Annelida	
Oligochaeta	4.0
Number of Organisms	994.6
Number of Species	35
Diversity	4.1
Equitability	0.71
Biomass (ml)	7.5

Appendix G4a. Benthic Macroinvertebrates Collected from Freeman Creek (number per square meter)

	Date 9/91
Coleoptera	
Dytiscidae	
Laccophilus sp,	1.3
Elmidae	
Optioservus sp.	225.9
Haliplidae	
Peltodytes	1.3
Diptera	1.3
Chironomidae	25.5
Chironominae	13.4
Orthocladiinae	94.1
Tanypodinae	67.3
Ephemeroptera	2.7
Baetidae	22.8
Baetis sp.	13.5
Centroptilum sp.	12.1
Ephemerellidae	
Serratella sp.	4.0
Leptophlebiidae	
Paraleptophlebia sp.	652.3
Siphlonuridae	
Ameletus sp.	59.2
Tricorythidae	
Tricorythodes fallax	6.7
Megaloptera	
Sialidae	
Sialis sp.	30.9
Odonata	
Coenagrionidae	
Argia sp.	8.1
Gomphidae	
Ophiogomphus sp.	1.3

	Date 9/91
Plecoptera	
Perlodidae	
Isoperla sp.	1.3
Trichoptera	
Hydroptilidae	
Oxyethira sp.	1.3
Lepidostomatidae	
Lepidostoma sp.	1.3
Leptoceridae	
Oecetis sp.	1.3
Sericostomatidae	
Gumaga nigricula	1.3
Mollusca	
Gastropoda	4.0
Crustacea	
Ostracoda	2.7
Arachnoidea	
Hydracarina	5.4
Annelida	
Oligochaeta	168.1
Nematoda	
Nematomorpha	2.7
Amphipoda	
Gammarrus	
Talitridae	
Hyalella azteca	8.1
Number of Organisms	1,451
Number of Species	26
Diversity	2.6
Equitability	0.32
Biomass (ml)	2.8

Appendix G4b. Benthic Macroinvertebrates Collected from Freeman Creek
(number per square meter)

	Date	
	6/2/92	9/23/92
Amphipoda		
Taliridae		
Hyalella azteca	1.3	4.0
Araneae	17.5	
Coelenterata	1.3	
Coleoptera		
Curculionidae	1.3	1.3
Dytiscidae		
Laccophilus sp.		1.3
Oreodytes sp.		9.4
Elmidae		
Optioservus sp.	277.0	467.9
Zaitzevia/Heterlimnus	4.0	2.7
Halipidae		
Peltodytes sp.		1.3
Hydraenidae		
Octhebius sp.	6.7	
Hydrophilidae	1.3	
Laccobius sp.	1.3	
Tropisternus sp.	2.7	
Psephenidae		
Eubrianax edwardsi	2.7	
Diptera		
Ceratopogonidae		
Bezzia sp.	9.4	
Chironomidae	47.0	4.0
Chironominae	76.6	4.0
Orthocladiinae	556.7	4.0
Tanypodinae	63.2	34.9
Empididae		
Muscidae	4.0	
Simuliidae	49.7	1.3
Prosimulium sp.		
Simulium sp.	404.7	
Tabanidae	4.0	1.3
Tipulidae		
Dicranota sp.	2.7	
Hexatoma sp.	2.7	2.7
Tipula sp.		1.3
Ephemeroptera		
Baetidae		
Baetis sp.	92.7	92.7
Caenidae		
Caenis sp.		10.8
Ephemerellidae		
Ephemerella sp.	30.9	
Heptageniidae	69.9	
Leptophlebiidae		
Paraleptophlebia sp.	47.0	723.5
Tricorythidae		
Tricorythodes fallax	96.8	1.3
Hemiptera		
Notonectidae		
Notonecta sp.		1.3
Hirudinea	1.3	

	Date	
	6/2/92	9/23/92
Megaloptera		
Sialidae		
Sialis sp.		302.5
Odonata		
Aeshnidae		
Anax sp.		1.3
Coenagrionidae		
Argia sp.	5.4	14.7
Zoniagrion sp.		24.2
Cordulegastridae		
Cordulegaster sp.	1.3	2.7
Gomphidae		
Ophiogomphus bison	8.1	9.4
Plecoptera		
Nemouridae		
Zapada sp.	1.3	
Perlidae		
Perlodidae	5.4	
Thysanoptera	2.7	
Trichoptera	1.3	
Glossosomatidae		
Agapetus sp.	1.3	
Hydropsychidae	1.3	
Hydropsyche sp.	2.7	
Hydroptilidae		
Hydroptila sp.	8.1	
Neotrichia sp.	1.3	
Oxyethria sp.	4.0	
Leptoceridae		
Oecetis sp.		2.7
Philopotamidae		
Wormaldia sp.	57.8	
Rhyacophilidae		
Rhyacophila sp.	2.7	
Sericostomatidae		
Gumaga nigricula	6.7	30.9
Mollusca		
Gastropoda		
Ancylidae		
Ferrissia sp.	1.3	1.3
Lymnaeidae	4.0	30.9
Physidae	4.0	
Planorbidae	5.4	17.4
Ostracoda		2.7
Arachnoidea		
Hydracarina	33.6	2.7
Annelida		
Oligochaeta	37.6	146.5
Number of Organisms	1,976	1,957
Number of Species	47	33
Diversity	3.5	2.7
Equitability	0.34	0.28
Biomass (ml)	4.0	11.0

Appendix G4c. Benthic Macroinvertebrates Collected from Freeman Creek
(number per square meter)

	Date	
	6/24/93	10/20/93
Amphipoda		
Talitridae		
Hyalella azteca		12.1
Araneae	5.4	
Coleoptera		
Dytiscidae		
Hydrotrupes sp.	5.4	
Oreodytes sp.		1.3
Uvarus sp.	5.4	
Elmidae		
Optioservus sp.		83.3
Zaitzevia parvula		5.4
Hydrophilidae	5.4	
Diptera	5.4	
Chironomidae	139.8	14.7
Chironominae	145.2	17.4
Orthocladiinae	505.6	112.9
Tanypodinae		59.1
Muscidae	5.4	
Simuliidae	5.4	
Simulium sp.	2,211	13.4
Tipulidae		
Dicranota sp.	5.4	
Hexatoma sp.		25.5
Ephemeroptera		
Baetidae		
Baetis sp.	188.2	2.7
Leptophlebiidae		
Paraleptophlebia sp.	21.5	318.7
Tricorythidae		
Tricorythodes fallax		1.3
Notonectidae		
Notonecta sp.	5.4	
Megaloptera		
Sialidae		
Sialis sp.		4.0
Odonata		
Coenagrionidae		
Argia sp.		5.4
Gomphidae		5.4
Ophiogomphus bison		2.7
Plecoptera		
Nemouridae		6.7
Zapada sp.	5.4	
Perlodidae		
Skwala sp.		2.7
Trichoptera		
Hydropsychidae		
Cheumatopsyche sp.		157.3
Hydropsyche sp.		96.8
Lepidostomatidae		
Lepidostoma sp.		65.8
Leptoceridae		
Oecetis sp.		5.4
Philopotamidae		
Wormaldia sp.	10.8	
Sericostomatidae		
Gumaga nigricula		18.8
Mollusca		
Planorbidae		1.3
Arachnoidea		
Hydracarina		2.7
Annelida		
Oligochaeta	91.4	20.1
Number of Organisms	3,217	1,043
Number of Species	15	25
Diversity	1.6	3.3
Equitability	0.25	0.56
Biomass (ml)	8.0	2.0

Appendix G4d. Benthic Macroinvertebrates Collected from Freeman Creek
(number per square meter)

	Date	
	6/23/94	9/13/94
Amphipoda		
Talitridae		
Hyalella azteca	12.1	
Coleoptera		
Dytiscidae		
Deronectes sp.	1.3	
Laccophilius sp.	1.3	
Uvarus sp.		5.4
Elmidae		
Optioservus sp.	152.0	141.2
Heteroceridae	1.3	
Hydraena sp.		1.3
Ochthebius sp.		5.4
Hydrophilidae		
Helophorus sp.		1.3
Paracymus sp.		1.3
Tropisternus sp.	2.7	
Copepoda	1.3	
Diptera		
Chironomidae	76.6	1.3
Chironominae	1025.7	5.4
Orthocladiinae	415.7	40.3
Tanypodinae	44.4	8.1
Simuliidae		
Simulium sp.	44.4	8.1
Tipulidae		
Dicranota sp.	2.7	2.7
Hexatoma sp.	1.3	22.8
Limonia sp.		1.3
Ephemeroptera		
Baetidae		
Baetis sp.	92.5	1.3
Ephemerella sp.	4.0	
Serratella sp.	1.3	1.3
Heptageniidae	37.6	
Leptophlebiidae		
Paraleptophlebia sp.	162.8	36.3
Tricorythidae		
Tricorythodes fallax	195.0	4.0
Megaloptera		
Sialidae		
Sialis sp.	14.8	1.3
Odonata		
Coenagrionidae		
Argia sp.	6.7	1.3
Cordulegasteridae		
Cordulegaster sp.	1.3	
Gomphidae		
Ophiogomphus bison	10.8	6.7
Pelecypoda	84.7	
Margaritiferidae	1.3	
Unionidae	1.3	
Plecoptera		
Nemouridae	4.0	
Zapada sp.		4.0
Peltoperlidae		
Yoraperla sp.		1.3
Perlodidae	10.8	
Isoperla sp.		8.1
Trichoptera		1.3
Brachycentridae		
Micrasema sp.	10.8	
Hydropsychidae		
Cheumatopsyche sp.	1.3	24.2
Hydropsyche sp.		56.5
Hydroptilidae		
Hydroptila sp.	2.7	
Lepidostomatidae		
Lepidostoma sp.	5.4	8.1
Leptoceridae		
Oecetis sp.		1.3
Limnephilidae		
Psychoglypha sp.	1.3	
Polycentropodidae		
Polycentropus sp.		1.3
Sericostomatidae		
Gumaga nigricula	51.1	12.1
Mollusca		
Gastropoda		
Ancylidae	4.0	1.3
Lymnaeidae	1.3	1.3
Physidae		
Planorbidae	1.3	
Arachnoidea		
Hydracarina	8.1	
Annelida		
Oligochaeta	17.4	
Number of Organisms	2355.1	416.3
Number of Species	38	31
Diversity	2.9	3.5
Equitability	0.27	0.51
Biomass (ml)	4.8	1.5

Appendix G5a. Benthic Macroinvertebrates Collected from Nelson Creek at the Quincy La Porte Road (number per square meter)

	Date 5/91	Date 9/91
Coleoptera		
Elmidae		
Ampumixis dispar		9.4
Optioservus sp.	1.3	28.2
Zaitzevia parvula		6.7
Psephenidae		
Eubrianax edwardsi		1.3
Diptera		2.7
Ceratopogonidae		
Bezzia sp.		1.3
Chironomidae	34.9	2.7
Chironominae	339.2	8.1
Orthocladiinae	88.8	56.4
Simuliidae		
Prosimulium sp.		
Simulium sp.	33.6	33.6
Tipulidae		
Antocha sp.		1.3
Hexatoma sp.	1.3	
Ephemeroptera		1.3
Baetidae		
Baetis sp.	37.6	208.4
Ephemerellidae		
Drunella coloradensis	5.4	
D. doddsi	8.1	21.5
D. proserpina		14.7
Serratella sp.	10.7	13.5
Heptageniidae		91.4
Cinygmula sp.	91.5	5.4
Epeorus sp.	157.4	294.5
Ironodes sp.		24.2
Rhithrogena sp.	22.8	14.7
Leptophlebiidae		
Paraleptophlebia sp.	8.1	4.0
Siphlonuridae		
Ameletus sp.	4.0	4.0
Plecoptera		
Chloroperlidae		
Suwallia sp.	31.7	1.3
Leuctridae		
Leuctra sp.	41.7	
Nemouridae		
Zapada sp.		41.7
Perlidae		
Calineuria californica	1.3	10.7
Perlodidae		
Isoperla sp.	2.7	1.3
Perlinodes aurea	1.3	17.4
Taeniopterygidae		
Taenionema sp.	1.3	
Trichoptera		
Brachycentridae		
Amiocentrus sp.	2.7	
Micrasema sp.	2.7	1.3
Glossosomatidae		26.9
Glossosoma sp.		4.0
Hydropsychidae		
Arctopsyche sp.		55.1
Hydropsyche sp.	6.7	60.5
Lepidostomatidae		
Lepidostoma sp.	1.3	9.4
Limnephilidae	8.1	
Neophylax sp.		32.3
Rhyacophilidae		1.3
Rhyacophila sp.	5.4	40.3
Arachnoidea		
Hydracarina	5.1	
Annelida		
Oligochaeta	2.7	
Number of Organisms	966.9	1,153
Number of Species	28	32
Diversity	3.1	3.7
Equitability	0.44	0.58
Biomass (ml)		2.0

Appendix G5b. Benthic Macroinvertebrates Collected from Nelson Creek at the Quincy La Porte Road (number per square meter)

	Date	
	6/2/92	9/25/92
Coleoptera		
Dytiscidae		16.1
Elmidae	5.4	
Ampumixis dispar	16.1	16.1
Optioservus sp.	16.1	96.8
Rhizelmis sp.		5.4
Zaitzevia parvula	5.4	10.8
Diptera		
Ceratopogonidae		
Bezzia sp.		10.8
Chironomidae	37.6	5.4
Chironominae	48.4	5.4
Orthocladiinae	123.7	16.1
Tanypodinae	10.8	
Dolichopodidae	5.4	
Psychodidae		
Pericoma sp.		5.4
Simuliidae	5.4	
Simulium sp.	91.4	16.1
Tipulidae		
Antocha sp.	16.1	
Hexatoma sp.	10.8	5.4
Ephemeroptera		
Baetidae		
Baetis sp.	199.0	118.3
Ephemerellidae	5.4	
Caudatella sp.	75.3	
Drunella coloradensis	64.5	
D. doddsi	32.2	21.5
D. pelosa	5.4	
D. proserpina/grandis	10.8	10.8
Ephemerella sp.	10.8	80.6
Serratella sp.	21.5	
Heptageniidae	5.4	
Cinygmula sp.	26.8	107.5
Epeorus sp.	849.8	96.8
Ironodes sp.	10.8	26.8
Rhithrogena sp.	37.6	139.8
Leptophlebiidae		
Paraleptophlebia sp.	21.5	37.6
Siphlonuridae		
Ameletus sp.	5.4	
Lepidoptera		5.4

	Date	
	6/2/92	9/25/92
Megaloptera		
Corydalidae		
Neohermes/Protochauliodes	10.8	10.8
Plecoptera		5.4
Capniidae		5.4
Chloroperlidae	5.4	
Suwallia sp.	21.5	
Sweltza sp.		5.4
Nemouridae		
Malenka sp.	21.5	
Zapada sp.	5.4	48.4
Perlidae		
Calineuria californica	26.8	53.7
Perlodidae		5.4
Isoperla sp.		5.4
Oroperla sp.		5.4
Skwala sp.		5.4
Trichoptera		
Brachycentridae		
Amiocentrus sp.	5.4	
Micrasema sp.	16.1	59.2
Glossosomatidae		5.4
Agapetus sp.		10.8
Hydropsychidae		
Arctopsyche sp.	10.8	5.4
Cheumatopsyche sp.	5.4	
Hydropsyche sp.	53.7	48.4
Lepidostomatidae		
Lepidostoma sp.		21.5
Limnephilidae		
Neophylax sp.		26.8
Rhyacophilidae		
Rhyacophila sp.	119.6	26.8
Arachnoidea		
Hydracarina	5.4	
Nematoda		
Mermithiidae	5.4	
Number of Organisms	2,033	1,178
Number of Species	37	35
Diversity	3.5	4.4
Equitability	0.44	0.88
Biomass (ml)	22.0	8.0

Appendix G5c. Benthic Macroinvertebrates Collected from Nelson Creek at the Quincy La Porte Road (number per square meter)

	Date	
	6/23/93	9/15/93
Coleoptera		
Elmidae		
Ampumixis dispar		64.5
Optioservus sp.	5.4	53.7
Zaitzevia/Heterlimnus		10.8
Zaitzevia parvula		5.4
Staphylinidae		5.4
Diptera		
Ceratopogonidae		
Bezzia sp.		16.1
Chironomidae	10.8	5.4
Chironominae	10.8	59.1
Orthocladiinae	21.5	48.4
Simuliidae	5.4	
Simulium sp.		10.8
Tabanidae		5.4
Tipulidae	5.4	5.4
Antocha sp.	10.8	5.4
Hexatoma sp.		26.8
Ephemeroptera		
Baetidae		
Baetis sp.	145.2	349.6
Ephemerellidae		
Caudatella sp.	5.4	
Drunella		
coloradensis	10.8	59.1
D. doddsi		204.4
Ephemerella sp.	59.1	
Serratella sp.	16.1	
Heptageniidae		
Cinygmula sp.	64.5	64.5
Epeorus sp.	259.8	96.8
Ironodes sp.	5.4	
Rhithrogena sp.		26.8
Leptophlebiidae		
Paraleptophlebia sp.	91.4	10.8
Siphlonuridae		
Ameletus sp.	16.1	

	Date	
	6/23/93	9/15/93
Megaloptera		
Corydalidae		5.4
Neohermes/Protochauliodes	16.1	16.1
Plecoptera		5.4
Chloroperlidae		
Suwallia sp.	80.6	21.5
Sweltza sp.		26.8
Nemouridae		
Malenka sp.	16.1	204.4
Perlidae		
Calineuria californica	10.8	134.4
Perlodidae		
Oroperla sp.		10.8
Trichoptera		
Glossosomatidae		139.8
Anagapetus sp.		209.7
Hydropsychidae		
Arctopsyche sp.	5.4	32.2
Hydropsyche sp.	43.0	80.1
Parapsyche sp.	5.4	16.1
Lepidostomatidae		
Lepidostoma sp.	21.5	
Odontoceridae		
Marilia sp.		32.2
Rhyacophilidae		26.8
Rhyacophila sp.	26.8	123.7
Arachnoidea		
Hydracarina	32.2	
Annelida		
Oligochaeta	32.2	5.4
Nematoda		
Mermithiidae		5.4
Platyhelminthes		
Planariidae		
Dugesia sp.		5.4
Number of Organisms	989	2,049
Number of Species	26	34
Diversity	3.7	4.2
Equitability	0.73	0.79
Biomass (ml)	8.0	18.0

Appendix G5d. Benthic Macroinvertebrates Collected from Nelson Creek at the Quincy La Porte Road (number per square meter)

	Date	
	6/23/94	9/16/94
Coleoptera		1.3
Curculionidae		
Hydronomini sp.		1.3
Elmidae		
Ampumixis dispar	18.8	52.4
Optioservus sp.	17.4	57.8
Ordobrevia nubifera		1.3
Rhizelmis nigra	1.3	
Zaitzevia parvula	2.7	13.5
Psephenidae		
Eubrianax edwardsi		4.0
Diptera		
Ceratopogonidae		
Bezzia sp.		4.0
Chironomidae	8.1	12.1
Chironominae	6.7	51.1
Orthocladiinae	9.4	48.4
Empididae	2.7	2.7
Psychodidae		1.3
Simuliidae		2.7
Simulium sp.	13.5	24.2
Tipulidae		5.4
Antocha sp.		12.1
Hexatoma sp.		1.3
Ephemeroptera		
Baetidae		
Baetis sp.	192.4	238.2
Ephemerellidae		
Attenella sp.	1.3	
Caudatella sp.	119.7	1.3
Drunella coloradensis	10.7	
D. doddsi	6.7	92.8
D.proserpina/grandis		24.2
Ephemerella sp.	125.1	
Serratella sp.	59.2	24.2
Heptageniidae		827.4
Cinygmula sp.	6.7	17.4
Epeorus sp.	281.2	72.6
Ironodes sp.	16.1	28.2
Rhithrogena sp.		41.7
Leptophlebiidae		
Paraleptophlebia sp.	10.7	78.0
Siphlonuridae		
Ameletus sp.	6.7	5.4
Megaloptera		
Corydalidae		
Protochauliodes/Neohermes	5.4	10.7

	Date	
	6/23/94	9/16/94
Plecoptera		
Chloroperlidae		
Suwallia sp.	14.8	
Sweltza sp.		21.5
Nemouridae	37.6	26.9
Malenka sp.		9.4
Zapada sp.		4.0
Peltoperlidae		
Yoraperla sp.		9.4
Perlidae		1.3
Calineuria californica	21.5	25.5
Hesperoperla pacifica	1.3	2.7
Perlodidae		
Oroperla sp.	2.7	
Skwala sp.		6.7
Trichoptera	1.3	
Brachycentridae		
Micrasema sp.	6.7	95.5
Glossosomatidae		48.4
Agapetus sp.		33.6
Glossosoma sp.		2.7
Hydropsychidae		
Arctopsyche sp.		4.0
Cheumatopsyche sp.		9.4
Hydropsyche sp.	25.5	43.0
Lepidostomatidae		
Lepidostoma sp.	1.3	
Limnephilidae		
Apatania sp.		36.3
Philopotamidae		12.1
Rhyacophilidae		1.3
Rhyacophila sp.	40.4	24.2
Sericostomatidae		
Gumaga nigricula		4.0
Arachnoidea		
Hydracarina	1.3	8.1
Annelida		
Oligochaeta	18.8	8.1
Nematoda		
Mermithidae	2.7	
Number of Organisms	1,089	1,270
Number of Species	33	45
Diversity	3.6	4.5
Equitability	0.53	0.76
Biomass (ml)	5.0	9.5

Appendix G6a. Benthic Macroinvertebrates Collected from Onion Valley Creek near mouth (number per square meter)

	Date 10/91	Date 6/92
Coleoptera		
Elmidae	5.4	
Ampumixis dispar	9.4	10.7
Cleptelmis sp.		20.2
Optioservus sp.	102.2	154.6
Ordobrevia nubifera	17.4	246.1
Stenelmis sp.		
Zaitzevia parvula	26.8	139.8
Psephenidae		
Eubrianax edwardsi	25.5	156.0
Psephenus sp.		
Diptera		
Chironomidae	4.0	162.7
Chironominae	10.7	135.8
Orthocladiinae	5.4	274.3
Tanypodinae		2.7
Empididae	14.7	2.7
Simuliidae	6.7	
Prosimulium sp.		
Simulium sp.	12.1	
Tipulidae		
Dicronota sp.	1.3	
Hexatoma sp.	12.1	6.7
Ephemeroptera		4.0
Baetidae		
Baetis sp.	56.4	411.5
Ephemerellidae	1.3	
Drunella coloradensis		4.0
D. doddsi	12.1	
Serratella sp.		5.4
Timpanoga sp.		2.7
Heptageniidae	67.3	61.8
Epeorus sp.		115.6
Ironodes sp.	36.3	
Rhithrogena sp.	554.1	5.4
Leptophlebiidae		
Paraleptophlebia sp.	13.5	
Megaloptera		
Sialidae		
Neohermes sp.	5.4	8.1

	Date 10/91	Date 6/92
Plecoptera		
Capniidae	2.7	
Chloroperlidae		
Suwallia sp.	1.3	
Nemouridae		
Zapada sp.	5.4	8.1
Perlidae		
Calineuria californica	121.0	94.2
Hesperoperla pacifica	1.3	
Perlodidae		
Oroperla sp.	1.3	
Trichoptera		
Brachycentridae	12.1	
Micrasema sp.		8.1
Glossosomatidae		
Glossosoma sp.	1.3	2.7
Agapetus sp.		1.3
Hydropsychidae		6.7
Cheumatopsyche sp.		
Hydropsyche sp.	39.0	
Lepidostomatidae		
Lepidostoma sp.	8.1	6.7
Philopotamidae		
Dolophilodes sp.	1.3	
Polycentropodidae		
Polycentropus sp.	1.3	10.7
Rhyacophilidae	2.7	1.3
Rhyacophila sp.	30.9	32.2
Sericostomatidae		
Gumaga nigricula		5.4
Arachnoidea		2.7
Hydracarina		115.6
Annelida		
Oligochaeta	2.7	10.7
Nematomorpha sp.		1.3
Number of Organisms	1,237	2,243
Number of Species	34	31
Diversity	3.2	3.6
Equitability	0.39	0.58
Biomass (ml)	4.0	6.1

Appendix G6b. Benthic Macroinvertebrates Collected from Onion Valley Creek near mouth (number per square meter)

	Date	
	6/1/92	9/22/92
Araneae		1.3
Coleoptera		1.3
Dryopidae		
Helichus sp.		1.3
Elmidae		
Ampumixis dispar	10.8	33.5
Cleptelmis sp.	20.1	
Optioservus sp.	154.6	322.7
Ordobrevia nubifera	246.0	60.5
Zaitzevia/Heterlimnus		110.2
Zaitzevia parvula	139.8	63.2
Psephenidae		
Eubrianax edwardsi	155.9	38.9
Diptera		
Chironomidae	162.7	18.8
Chironominae	135.8	69.9
Orthocladiinae	274.3	60.5
Tanypodinae	2.7	
Dixidae		
Meringodixa sp.		1.3
Empididae	2.7	9.4
Simuliidae		1.3
Simulium sp.		10.8
Tabanidae		1.3
Tipulidae		1.3
Antocha sp.		14.7
Hexatoma sp.	6.7	21.5
Ephemeroptera	4.0	
Baetidae		
Baetis sp.	411.4	52.4
Ephemerellidae		
Drunella coloradensis	4.0	
D. doddsi		8.1
Ephemerella sp.		4.0
Serratella sp.	5.4	
Timpanoga sp.	2.7	
Heptageniidae	61.8	25.5
Epeorus sp.	115.6	1.3
Ironodes sp.		4.0
Rhithrogena sp.	5.4	33.6
Leptophlebiidae		
Paraleptophlebia sp.		18.8
Lepidoptera		
Pyralidae		
Petrophila sp.		1.3

	Date	
	6/1/92	9/22/92
Megaloptera		
Corydalidae		
Neohermes/Protochauliodes	8.1	8.1
Plecoptera		2.7
Chloroperlidae		
Sweltza sp.		2.7
Leuctridae		1.3
Nemouridae		
Malenka sp.		1.3
Zapada sp.	8.1	30.9
Perlidae		
Calineuria californica	94.1	98.1
Perlodidae		
Cultus sp.		8.1
Trichoptera	2.7	1.3
Brachycentridae		
Micrasema sp.	8.1	199.0
Glossosomatidae	1.3	8.1
Agapetus sp.	1.3	2.7
Glossosoma sp.	2.7	
Helicopsychidae		
Helicopsyche borealis		1.3
Hydropsychidae		
Arctopsyche sp.		4.0
Hydropsyche sp.	6.7	37.6
Lepidostomatidae		
Lepidostoma sp.	6.7	84.7
Polycentropodidae		
Polycentropus sp.	10.8	1.3
Rhyacophilidae	1.3	8.1
Rhyacophila sp.	32.2	47.1
Sericostomatidae		
Gumaga nigricula	5.4	
Arachnoidea		
Hydracarina	118.3	48.4
Annelida		
Oligochaeta	10.8	
Nematoda		
Mermithiidae		1.3
Nematomorpha	1.3	
Number of Organisms	2,009	1,524
Number of Species	31	42
Diversity	3.6	4.1
Equitability	0.58	0.61
Biomass (ml)	6.1	4.0

Appendix G6c. Benthic Macroinvertebrates Collected from Onion Valley Creek near mouth (number per square meter)

	Date	
	6/23/93	10/21/93
Coleoptera		
Elmidae		
Ampumixis dispar	4.0	
Optioservus sp.	20.2	4.0
Ordobrevia nubifera	12.1	4.0
Zaitzevia/Heterlimnus	6.8	
Zaitzevia parvula	37.6	8.1
Psephenidae		
Eubrianax edwardsi	33.6	2.7
Diptera		
Chironomidae	1.3	
Chironominae	5.4	1.3
Orthocladiinae	8.1	
Empididae	1.3	
Stratiomyidae		
Caloparyphus sp.		1.3
Tipulidae		
Hexatoma sp.	5.4	
Ephemeroptera		
Baetidae		
Baetis sp.	154.6	
Ephemerellidae	1.3	
D. doddsi	1.3	
Serratella sp.	10.8	
Heptageniidae		
Epeorus sp.	33.6	
Siphlonuridae		
Ameletus sp.	8.1	
Libellulidae		
Paltothemes sp.	2.7	

	Date	
	6/23/93	10/21/93
Plecoptera	5.4	
Chloroperlidae		
Suwallia sp.	18.8	
Nemouridae		
Malenka sp.	4.0	
Perlidae		
Calineuria californica	18.8	
Perlodidae		
Oroperla sp.	1.3	
Trichoptera		13.4
Brachycentridae		
Micrasema sp.	4.0	
Glossosomatidae		
Agapetus sp.		5.4
Hydropsychidae		
Hydropsyche sp.	5.4	
Lepidostomatidae		
Lepidostoma sp.		1.3
Rhyacophilidae		
Rhyacophila sp.	9.4	
Sericostomatidae		
Gumaga nigricula	2.7	
Arachnoidea		
Hydracarina		12.1
Number of Organisms	415.4	40.2
Number of Species	25	9
Diversity	3.5	2.8
Equitability	0.64	1.06
Biomass (ml)	2.0	-

Appendix G6d. Benthic Macroinvertebrates Collected from Onion Valley Creek near mouth (number per square meter)

	Date	
	6/24/94	9/15/94
Araneae		2.7
Coleoptera	1.3	1.3
Dytiscidae		
Deronectes sp.		1.3
Elmidae		
Ampumixis dispar	5.4	9.4
Optioservus sp.	26.9	127.8
Ordobrevia nubifera	28.2	47.1
Zaitzevia parvula	95.5	111.6
Psephenidae		
Eubrianax edwardsi	24.2	26.9
Diptera		
Ceratopogonidae		
Bezzia sp.	1.3	1.3
Chironomidae	2.7	9.4
Chironominae	71.3	48.4
Orthocladiinae	29.6	44.4
Tanypodinae	1.3	
Empididae		5.4
Psychodidae		6.7
Simuliidae		1.3
Simulium sp.	1.3	4.0
Stratiomyidae		
Caloparyphus sp.		4.0
Tipulidae		2.7
Antocha sp.	6.7	2.7
Dicranota sp.		4.0
Hexatoma sp.	6.7	10.7
Ephemeroptera		
Baetidae		
Baetis sp.	129.1	49.7
Pseudocloeon sp.		5.4
Ephemerellidae		
Caudatella sp.	2.7	
Drunella coloradensis	2.7	
D. doddsi	1.3	5.4
D.proserpina/grandis		1.3
Ephemerella sp.	22.8	
Heptageniidae	18.8	30.9
Epeorus sp.	236.8	2.7
Ironodes sp.		1.3
Rhithrogena sp.	5.4	10.7
Leptophlebiidae		
Paraleptophlebia sp.	1.3	14.8
Siphlonuridae		
Ameletus sp.	10.7	
Megaloptera		
Corydalidae		
Protochauliodes/Neohermes	2.7	25.5
Sialidae		
Sialis sp.		1.3
Plecoptera	18.8	
Chloroperlidae		1.3
Sweltza sp.	2.7	9.4
Leuctridae	1.3	10.7
Nemouridae		8.1
Malenka sp.	49.7	1.3
Perlidae		24.2
Calineuria californica	28.2	53.8
Hesperoperla pacifica	2.7	4.0
Perlodidae		1.3
Perlinodes sp.		1.3
Skwala sp.		1.3
Thysanoptera		2.7
Trichoptera		
Brachycentridae		
Micrasema sp.		193.7
Glossosomatidae		
Agapetus sp.		16.1
Anagapetus sp.		13.4
Glossosoma sp.	5.4	6.7
Helicopsychidae		
Helicopsyche borealis		1.3
Hydropsychidae		
Arctopsyche sp.	2.7	
Cheumatopsyche sp.		2.7
Hydropsyche sp.	8.1	14.8
Hydroptilidae		1.3
Lepidostomatidae		
Lepidostoma sp.	1.3	18.8
Limnephilidae	1.3	
Apatania sp.	2.7	2.7
Philopotamidae		
Wormaldia sp.	5.4	1.3
Polycentropodidae		
Polycentropus sp.	9.4	6.7
Rhyacophilidae		1.3
Rhyacophila sp.	13.4	22.8
Sericostomatidae		
Gumaga nigricula		6.7
Arachnoidea		
Hydracarina		64.5
Number of Organisms	867	1,037
Number of Species	37	52
Diversity	3.7	4.3
Equitability	0.52	0.58
Biomass (ml)	2.7	9.5

Appendix G7a. Benthic Macroinvertebrates Collected from Greenhorn Creek above Squirrel Creek (number per square meter)

	Date 9/91
Coleoptera	
Elmidae	
Ampumixis dispar	6.7
Cleptelmis sp.	1.3
Heterlimnius sp.	5.4
Lara sp.	5.4
Optioservus sp.	36.3
Zaitzevia parvula	1.3
Diptera	
Ceratopogonidae	2.7
Atrichopogon sp.	2.7
Bezzia sp.	1.3
Chironomidae	25.5
Chironominae	79.3
Diasminae sp.	1.3
Orthocladiinae	79.3
Empididae	8.1
Pelecorynchidae	2.7
Psychodidae	
Pericoma sp.	8.1
Simuliidae	
Simulium sp.	2.7
Tipulidae	
Dicronota sp.	4.0
Hexatoma sp.	1.3
Ephemeroptera	
Baetidae	
Baetis sp.	269.0
Ephemerellidae	
Caudatella sp.	6.7
D. doddsi	57.8
D. spinifera	1.3
Serratella sp.	43.0
Heptageniidae	88.7
Cinygmula sp.	43.0
Epeorus sp.	65.9
Ironodes sp.	51.1
Rhithrogena sp.	1.3
Leptophlebiidae	
Paraleptophlebia sp.	18.8

	Date 9/91
Plecoptera	
Chloroperlidae	
Suwallia sp.	21.5
Nemouridae	
Zapada sp.	223.2
Peltoperlidae	
Yoraperla sp.	32.2
Perlidae	
Calineuria californica	64.5
Hesperoperla pacifica	1.3
Perlodidae	
Isoperla sp.	1.3
Oroperla sp.	2.7
Pteronarcyidae	
Pteronarcys californica	1.3
Trichoptera	
Brachycentridae	
Micrasema sp.	17.5
Glossosomatidae	1.3
Glossosoma sp.	4.8
Hydropsychidae	
Arctopsyche sp.	53.8
Hydropsyche sp.	40.3
Philopotamidae	
Dolophilodes sp.	90.1
Rhyacophilidae	
Rhyacophila sp.	100.8
Sericostomatidae	
Gumaga nigricula	1.3
Arachnoidea	2.7
Hydracarina	14.7
Annelida	
Oligochaeta	36.3
Nematoda	
Nematomorpha	2.7
Platyhelminthes	
Planariidae	
Dugesia sp.	22.8
Number of Organisms	1,736
Number of Species	46
Diversity	4.3
Equitability	0.63
Biomass (ml)	7.8

Appendix G7b. Benthic Macroinvertebrates Collected from Greenhorn Creek above Squirrel Creek (number per square meter)

	Date	
	6/2/92	9/23/92
Coleoptera		
Elmidae		
Ampumixis dispar	10.8	1.3
Heterlimnius sp.		1.3
Lara sp.	53.8	6.7
Optioservus sp.	21.5	37.6
Zaitzevia/Heterlimnus	10.8	5.4
Diptera		
Chironomidae		4.0
Chironominae		14.7
Orthocladiinae	107.5	29.6
Tanypodinae	10.8	1.3
Empididae		4.0
Pelechrynchidae		1.3
Psychodidae		
Pericoma sp.		4.0
Simuliidae		1.3
Simulium sp.	123.7	30.9
Tipulidae		
Antocha sp.	5.4	
Ephemeroptera		
Baetidae		
Baetis sp.	102.2	211.1
Ephemerellidae		
Caudatella sp.	53.7	30.9
Drunella		
coloradensis	10.8	
D. doddsi	16.1	10.8
D. proserpina/grandis	5.4	
Serratella sp.	5.4	4.0
Heptageniidae	37.6	12.1
Cinygmula sp.	16.1	68.6
Epeorus sp.	69.9	48.4
Ironodes sp.	64.5	112.7
Rhithrogena sp.		16.1
Leptophlebiidae		
Paraleptophlebia sp.		64.5
Homoptera	10.8	
Megaloptera		
Corydalidae		
Neohermes/Protochauliodes	10.8	1.3
Sialidae		
Sialis sp.		1.3
Plecoptera		1.3
Chloroperlidae		
Sweltza sp.		5.4
Nemouridae		
Zapada sp.		134.4
Peltoperlidae		
Yoraperla sp.	172.1	297.1
Perlidae	5.4	
Calineuria californica	37.6	5.4
Doroneuria sp.		2.7
Hesperoperla pacifica		2.7
Perlodidae		
Isoperla sp.		2.7
Pteronarcyidae		
Pteronarcys californica	5.5	4.0
Trichoptera		
Brachycentridae		
Amiocentrus sp.		1.3
Micrasema sp.	5.4	17.4
Calamoceratidae		
Heteroplectron sp.		1.3
Glossosomatidae		1.3
Anagapetus sp.		18.8
Glossosoma sp.	5.4	
Hydropsychidae	10.8	4.0
Arctopsyche sp.		22.8
Hydropsyche sp.	5.4	2.7
Lepidostomatidae		
Lepidostoma sp.		1.3
Limnephilidae		
Neophylax sp.	5.4	
Philopotamidae		
Dolophilodes sp.		21.5
Wormaldia sp.	5.4	
Rhyacophilidae	10.8	
Rhyacophila sp.	59.0	41.7
Arachnoidea		
Hydracarina		6.7
Annelida		
Oligochaeta		14.7
Nematoda		
Mermithiidae		1.3
Platyhelminthes		
Planariidae		5.4
Number of Organisms	1,011	1,320
Number of Species	28	45
Diversity	4.0	4.0
Equitability	0.81	0.51
Biomass (ml)	12.0	4.5

Appendix G7c. Benthic Macroinvertebrates Collected from Greenhorn Creek above Squirrel Creek (number per square meter)

	Date	
	6/23/93	10/22/93
Coleoptera		
Elmidae		
Ampumixis dispar	5.4	
Heterlimnius sp.		67.2
Lara sp.		2.7
Diptera		
Chironomidae		1.3
Chironominae		2.7
Orthocladiinae	43.0	18.8
Tanypodinae		1.3
Pericoma sp.		6.7
Simuliidae		
Simulium sp.		8.1
Tipulidae		
Antocha sp.	16.1	
Hexatoma sp.	5.4	
Ephemeroptera		
Baetidae		
Baetis sp.	424.9	272.9
Ephemerellidae	5.4	
Attenella sp.	5.4	
Caudatella sp.	32.2	33.6
Drunella coloradensis	26.8	
D. doddsi	10.8	63.2
Serratella sp.	139.8	
Heptageniidae		
Cinygmula sp.	16.1	26.8
Epeorus sp.	69.9	47.0
Ironodes sp.	182.8	12.1
Rhithrogena sp.	16.1	26.8
Leptophlebiidae		
Paraleptophlebia sp.	247.4	36.3
Megaloptera		
Corydalidae		
Neohermes/Protochauliodes		1.3

	Date	
	6/23/93	10/22/93
Plecoptera		
Chloroperlidae		
Kathroperla sp.		1.3
Sweltza sp.		21.5
Nemouridae		
Malenka sp.	5.4	
Zapada sp.	5.4	36.3
Peltoperlidae		
Yoraperla sp.	37.6	55.1
Perlidae		61.8
Calineuria californica	37.6	
Doroneuria sp.		9.4
Hesperoperla pacifica		1.3
Perlodidae		1.3
Oroperla sp.		2.7
Skwala sp.		1.3
Pteronarcyidae		
Pteronarcys californica	10.8	
Trichoptera		
Brachycentridae		
Micrasema sp.	607.8	14.7
Glossosomatidae		
Glossosoma sp.	5.4	
Hydropsychidae		
Arctopsyche sp.		8.1
Hydropsyche sp.		17.4
Parapsyche sp.		1.3
Limnephilidae		
Psychoglypha sp.	5.4	
Philopotamidae		
Dolophilodes sp.		17.4
Rhyacophilidae		
Rhyacophila sp.	21.6	28.1
Annelida		
Oligochaeta	5.0	1.3
Number of Organisms	1,984	845
Number of Species	25	31
Diversity	3.2	3.8
Equitability	0.50	0.63
Biomass (ml)	12.0	6.0

Appendix G7d. Benthic Macroinvertebrates Collected from Greenhorn Creek above Squirrel Creek (number per square meter)

	Date	
	6/23/94	9/14/94
Coleoptera		1.3
Elmidae		
Heterlimnius sp.	13.4	55.1
Lara sp.	6.7	5.4
Optioservus sp.		1.3
Ordobrevia nubifera	1.3	
Rhizelmis nigra		2.7
Zaitzevia parvula		2.7
Diptera		
Ceratopogonidae		
Bezzia sp.	1.3	
Chironomidae	1.3	2.7
Chironominae	4.0	1.3
Orthocladiinae	20.1	4.0
Dixidae		
Dixa sp.		1.3
Muscidae		5.4
Psychodidae		
Pericoma sp.		1.3
Simuliidae		
Simulium sp.	5.4	1.3
Tipulidae		
Antocha sp.	1.3	
Hexatoma sp.		1.3
Ephemeroptera		
Baetidae		
Baetis sp.	118.4	65.9
Ephernerellidae		
Attenella sp.	1.3	
Caudatella sp.	14.8	
Drunella	10.7	
coloradensis		
D. doddsi	16.1	20.1
D.proserpina/grandis		1.3
Serratella sp.	21.5	26.9
Heptageniidae	1.3	21.5
Cinygmula sp.	8.1	
Epeorus sp.	68.6	8.1
Ironodes sp.	2.7	2.7
Leptophlebiidae		
Paraleptophlebia sp.	5.4	9.4
Megaloptera		
Corydalidae		
Protochauliodes/Neohermes		2.7

	Date	
	6/23/94	9/14/94
Plecoptera		
Chloroperlidae		
Suwallia sp.		2.7
Sweltza sp.	6.7	
Nemouridae		
Malenka sp.	4.0	12.1
Zapada sp.	1.3	21.5
Peltoperlidae		
Yoraperla sp.	14.8	113.0
Perlidae		
Calineuria californica	20.1	9.4
Hesperoperla pacifica		1.3
Perlodidae		
Isoperla sp.		1.3
Oroperla sp.	6.7	1.3
Thysanoptera		1.3
Trichoptera		
Brachycentridae		
Micrasema sp.	1.3	14.8
Glossosomatidae		
Agapetus sp.		4.0
Hydropsychidae		1.3
Arctopsyche sp.		20.1
Cheumatopsyche sp.		26.9
Hydropsyche sp.	14.8	
Leptoceridae		
Oecetis sp.		1.3
Limnephilidae		
Apatania sp.		1.3
Philopotamidae		
Wormaldia sp.	106.2	
Rhyacophilidae	1.3	
Rhyacophila sp.	29.6	17.4
Arachnoidea		
Hydracarina		4.0
Annelida		
Oligochaeta	8.0	1.3
Nematoda		
Mermithidae	2.7	
Platyhelminthes		
Planariidae		
Dugesia sp.	17.4	
Number of Organisms	554.7	475.2
Number of Species	31	38
Diversity	3.9	4.0
Equitability	0.68	0.60
Biomass (ml)	1.8	3.0

Appendix G8a. Benthic Macroinvertebrates Collected from Squirrel Creek at mouth (number per square meter)

	Date 9/91
Coleoptera	
Elmidae	
Ampumixis dispar	79.3
Lara sp.	1.3
Optioservus sp.	504.3
Ordobrevia nubifera	8.1
Zaitzevia parvula	8.1
Diptera	1.3
Blephariceridae	1.3
Chironomidae	8.1
Chironominae	49.7
Orthocladiinae	137.2
Tanypodinae	4.0
Dixidae	
Dixa sp.	1.3
Empididae	6.7
Pelecorhynchidae	4.0
Psychodidae	
Maruina lanceolata	2.7
Simuliidae	2.7
Simulium sp.	25.5
Tipulidae	
Antocha sp.	32.2
Tipula sp.	13.5
Ephemeroptera	
Baetidae	
Baetis sp.	44.3
Ephemerellidae	
Caudatella sp.	1.3
D. doddsi	12.1
D. proserpina	36.3
Heptageniidae	
Epeorus sp.	14.7
Hemiptera	
Veliidae	
Rhyagovelia sp.	1.3
Lepidoptera	
Noctuidae	2.7
Megaloptera	
Corydalidae	9.4
Neohermes sp.	1.3
Odonata	
Gomphidae	
Ophiogomphus specularis	13.5

	Date 9/91
Plecoptera	
Nemouridae	
Zapada sp.	2.7
Peltoperlidae	
Yoraperla sp.	84.7
Perlidae	
Hesperoperla pacifica	1.3
Pteronarcyidae	
Pteronarcys californica	1.3
Trichoptera	
Brachycentridae	
Amiocentrus sp.	28.2
Micrasema sp.	1,969
Calamoceratidae	
Heteroplectron sp.	4.0
Glossosomatidae	1.3
Hydropsychidae	
Hydropsyche sp.	40.3
Lepidostomatidae	
Lepidostoma sp.	5.4
Limnephilidae	1.3
Apatania sp.	2.7
Rhyacophilidae	1.3
Rhyacophila sp.	38.9
Mollusca	
Gastropoda	
Lymnaeidae	10.7
Pelecypoda	1.3
Arachnoidea	
Hydracarina	298.6
Aranae sp.	2.7
Annelida	
Oligochaeta	4.0
Nematomorpha	9.4
Number of Organisms	3,537
Number of Species	44
Diversity	2.5
Equitability	0.18
Biomass (ml)	7.8

Appendix G8b. Benthic Macroinvertebrates Collected from Squirrel Creek at mouth
(number per square meter)

	Date	
	6/2/92	9/23/92
Araneae		1/04
Coleoptera	1.3	
Elmidae		
Ampumixis dispar	10.8	104.8
Optioservus sp.	51.1	584.9
Zaitzevia/Heterlimnius		1.3
Zaitzevia parvula	2.7	
Diptera		
Ceratopogonidae		
Bezzia sp.		2.7
Chironomidae	1.3	12.1
Chironominae	16.1	51.1
Orthocladiinae	86.0	94.1
Tanypodinae	1.3	2.7
Empididae	5.4	5.0
Psychodidae		1.3
Pericoma sp.		1.3
Maruina lanceolata		1.3
Simuliidae		
Simulium sp.	84.7	2.7
Tipulidae		1.3
Antocha sp.	1.3	8.1
Dicronata sp.		4.0
Tipula sp.		2.7
Hexatoma sp.		1.3
Ephemeroptera		
Baetidae		
Baetis sp.	100.8	67.2
Ephemerellidae		
Caudatella sp.	17.4	1.3
D. doddsi	16.1	4.0
D. proserpina	4.0	41.6
Ephemerella sp.		8.0
Serratella sp.	5.4	
Heptageniidae		44.3
Cinygmula sp.		32.3
Epeorus sp.	48.4	41.6
Ironodes sp.		160.0
Leptophlebiidae		
Paraleptophlebia sp.		197.6
Megaloptera		
Corydalidae	4.0	10.7
Neohermes sp.		12.1
Cordulegastridae		
Cordulegaster sp.		2.7
Gomphidae		
Octogomphus sp.	9.4	44.3
Plecoptera	1.3	2.7
Nemouridae		
Malenka sp.	1.3	4.0
Zapada sp.		30.9

	Date	
	6/2/92	9/23/92
Peltoperlidae		
Yoraperla sp.	33.6	147.9
Perlidae		
Hesperoperla pacifica		1.3
Perlodidae		
Isoperla sp.		6.7
Pteronarcyidae	4.0	
Pteronarcys californica		9.4
Trichoptera		
Brachycentridae	1.3	
Amiocentrus sp.	1.3	8.1
Micrasema sp.	32.2	291.8
Calamoceratidae		
Heteroplectron sp.		4.0
Glossosomatidae		
Agapetus sp.		12.1
Anagapetus sp.		5.4
Glossosoma sp.		1.3
Hydropsychidae	9.4	
Arctopsyche sp.	13.4	5.4
Cheumatopsyche sp.		99.5
Hydroptilidae		
Hydroptila sp.	1.3	
Ochrotrichia sp.	10.8	
Lepidostomatidae		
Lepidostoma sp.		9.4
Limnephilidae		8.1
Apatania sp.		1.3
Neophylax sp.		2.7
Philopotamidae		
Dolophilodes sp.	20.1	
Rhyacophilidae		2.7
Rhyacophila sp.	10.8	65.8
Sericostomatidae		
Gumaga nigricula		43.0
Mollusca		
Gastropoda	4.0	18.8
Lymnaeidae		20.1
Planorbidae		360.3
Arachnoidea		
Hydracarina	57.8	154.6
Annelida		
Oligochaeta	12.1	
Nematoda		
Mermithiidae		9.4
Number of Organisms	667.6	2,786
Number of Species	30	51
Diversity	4.0	4.1
Equitability	0.79	0.49
Biomass (ml)	1.5	12.0

Appendix G8c. Benthic Macroinvertebrates Collected from Squirrel Creek at mouth (number per square meter)

	Date	
	6/23/93	10/22/93
Coleoptera	1.3	
Elmidae		
Ampumixis dispar	21.5	18.8
Lara sp.	1.3	
Narpus sp.	1.3	
Optioservus sp.	14.7	71.3
Diptera		
Chironomidae	5.4	8.1
Chironominae	21.5	84.7
Orthocladiinae	52.4	
Tanypodinae	4.0	1.3
Empididae	1.3	
Pelechorynchidae		2.7
Psychodidae		
Maruina lanceolata	1.3	
Pericoma sp.		1.3
Simuliidae		
Simulium sp.	21.5	1.3
Tipulidae		
Antocha sp.	1.3	
Dicranota sp.		2.7
Hexatoma sp.		4.0
Ephemeroptera		
Baetidae		
Baetis sp.	415.5	146.5
Ephemerellidae		
Drunella coloradensis	13.4	
D. doddsi	2.7	33.6
Ephemerella sp.		2.7
Serratella sp.	4.0	
Heptageniidae		9.4
Cinygmula sp.		106.2
Epeorus sp.	102.2	18.8
Ironodes sp.	41.6	103.5
Rhithrogena sp.	1.3	4.0
Leptophlebiidae		
Paraleptophlebia sp.	6.7	6.7
Siphlonuridae		
Ameletus sp.		1.3
Lepidoptera	1.3	
Megaloptera		
Corydalidae		20.1
Neohermes/Protochauliodes	2.7	
Gomphidae		
Octogomphus sp.	36.3	10.8
Plecoptera	1.3	2.7
Chloroperlidae		
Sweltza sp.		47.1
Nemouridae		20.2
Malenka sp.	129.1	4.0
Zapada sp.		73.9
Perlidae		
Calineuria californica	8.1	34.9
Hesperoperla pacifica		1.3
Perlodidae	1.3	
Isoperla sp.		8.1
Oroperla sp.	4.0	
Yoraperla sp.		2.7
Pteronarcyidae		
Pteronarcys californica	2.7	1.3
Trichoptera		9.4
Micrasema sp.	1.3	
Calomoceratidae		
Heteroplectron sp.		1.3
Glossosomatidae		14.7
Apapetus sp.		9.4
Anagapetus sp.		13.4
Glossosoma sp.		20.2
Hydropsychidae		
Arctopsyche sp.		41.6
Cheumatopsyche sp.	9.4	
Hydropsyche sp.		189.6
Lepidostomatidae	1.3	
Lepidostoma sp.	4.0	
Leptoceridae	1.3	
Limnephilidae	1.3	1.3
Neophylax sp.	8.1	1.3
Philopotamidae		
Dolophilodes sp.		40.3
Polycentropodidae		
Polycentropus sp.	1.3	
Rhyacophilidae		1.3
Rhyacophila sp.	12.1	43.0
Sericostomatidae		
Gumaga nigricula	6.7	
Mollusca		
Gastropoda	4.0	8.0
Arachnoidea		
Hydracarina	4.0	5.4
Annelida		
Oligochaeta	20.1	16.1
Nematoda		
Mermithiidae		1.3
Number of Organisms	986	1,207
Number of Species	37	41
Diversity	3.2	4.2
Equitability	0.36	0.67
Biomass (ml)	5.0	10.0

Appendix G8d. Benthic Macroinvertebrates Collected from Squirrel Creek at mouth (number per square meter)

	Date	
	6/23/94	9/14/94
Coleoptera		
Elmidae		
Ampumixis dispar	37.6	
Lara sp.	1.3	
Optioservus sp.	6.7	29.6
Rhizelmis nigra		12.1
Diptera		
Ceratopogonidae		
Bezzia sp.		1.3
Chironomidae		10.7
Chironominae	12.1	24.2
Orthocladiinae	106.2	12.1
Tanypodinae	2.7	
Dolichopodidae		1.3
Psychodidae		1.3
Simuliidae	1.3	
Simulium sp.	8.1	5.4
Tipulidae		2.7
Antocha sp.	1.3	1.3
Hexatoma sp.		5.4
Ephemeroptera		
Baetidae		
Baetis sp.	55.1	83.4
Ephemerellidae		
Caudatella sp.	25.5	1.3
Drunella coloradensis	17.4	8.1
D. doddsi	1.3	2.7
D.proserpina/grandis		2.7
Ephemerella sp.		1.3
Serratella sp.	65.9	2.7
Heptageniidae		123.7
Cinygmula sp.	1.3	
Epeorus sp.	115.7	1.3
Ironodes sp.	20.1	4.0
Rhithrogena sp.	2.7	
Paraleptophlebia sp.	8.1	53.8
Siphlonuridae		
Ameletus sp.		4.0
Tricorythidae		
Tricorythodes fallax	4.0	
Megaloptera		
Corydalidae		
Protochauliodes/Neohermes	1.3	9.4
Odonata		
Octogomphus sp.	18.8	8.1
Plecoptera		
Chloroperlidae		
Suwallia sp.		30.9
Sweltza sp.	2.7	
Nemouridae		59.2
Malenka sp.	48.4	
Zapada sp.		13.4
Peltoperlidae		
Yoraperla sp.	28.2	67.2
Perlidae		
Calineuria californica	5.4	16.1
Perlodidae		
Isoperla sp.	8.1	
Pteronarcyidae		
Pteronarcys californica	1.3	
Thysanoptera		1.3
Trichoptera		
Brachycentridae		
Amiocentrus sp.		2.7
Micrasema sp.	28.2	25.5
Glossosomatidae	1.3	12.1
Agapetus sp.	1.3	20.1
Glossosoma sp.	2.7	51.1
Hydropsychidae		
Arctopsyche sp.		21.5
Cheumatopsyche sp.	64.5	
Hydropsyche sp.	20.1	44.4
Parapsyche sp.	4.0	
Lepidostomatidae		
Lepidostoma sp.	10.7	4.0
Limnephilidae		
Apatania sp.	2.7	
Dicosmoecus sp.	1.3	
Philopotamidae	1.3	2.7
Doliphiloides sp.	5.4	14.8
Polycentropodidae		
Polycentropus sp.	1.3	
Rhyacophilidae		
Rhyacophila sp.	72.6	17.4
Sericostomatidae		
Gumaga nigricula	12.1	4.0
Mollusca		
Gastropoda		2.7
Hydrobiidae	10.7	
Arachnoidea		
Hydracarina	13.4	8.1
Annelida		
Oligochaeta	4.0	
Number of Organisms	862.3	622.0
Number of Species	43	40
Diversity	4.4	4.4
Equitability	0.72	0.80
Biomass (ml)	6.5	8.5

Appendix G9a. Benthic Macroinvertebrates Collected from Jamison Creek near Johnsville
(number per square meter)

	Date 5/91	Date 9/91
Coleoptera		
Dytiscidae		1.3
Elmidae		
Cleptelmis sp.		1.3
Optioservus sp.	1.3	5.4
Ordobrevia nubifera		2.7
Zaitzevia parvula	6.7	122.3
Psephenidae		
Eubrianax edwardsi	2.7	
Diptera		5.4
Ceratopogonidae		
Bezzia sp.		1.3
Chironomidae	22.8	12.1
Chironominae		75.3
Cricotopus sp.	53.8	
Orthocladiinae		591.8
Tanypodinae	1.3	6.7
Dixidae		
Dixa sp.		2.7
Psychodidae	1.3	
Pericoma sp.		1.3
Simuliidae		
Prosimulium sp.	12.1	
Simulium sp.	12.1	5.4
Tipulidae		
Hexatoma sp.	1.3	8.1
Tipula sp.	4.0	
Ephemeroptera		
Baetidae		
Baetis sp.	51.1	291.8
Ephemerellidae		
Attenella sp.	1.3	
Caudatella sp.		44.3
Drunella coloradensis	67.3	1.3
D. doddsi		143.9
Ephemerella sp.	6.7	
Serratella sp.		60.5
Heptageniidae		500.3
Cinygmula sp.	126.5	21.5
Epeorus sp.	60.5	180.2
Ironodes sp.		8.1
Rhithrogena sp.	12.1	415.6
Leptophlebiidae		
Paraleptophlebia sp.	6.7	39.0
Siphlonuridae		
Ameletus sp.	1.3	1.3
Hemiptera		
Gerridae		1.3
Plecoptera		
Chloroperlidae		
Suwallia sp.	152.1	30.9
Nemouridae		13.5
Zapada sp.		174.8
Perlidae		
Calineuria californica		79.3
Hesperoperla pacifica	1.3	
Perlodidae		
Isoperla sp.		13.5
Megarcys sp.		1.3
Oroperla sp.		1.3
Perlinodes sp.		2.7
Trichoptera		1.3
Brachycentridae		
Glossosomatidae		44.3
Glossosoma sp.	2.7	47.0
Hydropsychidae		
Arctopsyche sp.		90.1
Hydropsyche sp.	4.0	1,467
Hydroptilidae		
Hydroptila sp.		1.3
Lepidostomatidae		
Lepidostoma sp.		1.3
Limnephilidae		
Neophylax sp.		1.3
Oligophlebodes sp.	10.7	
Rhyacophilidae		4.0
Himalopsyche sp.	1.3	
Rhyacophila sp.	5.4	83.4
Arachnoidea		
Hydracarina		17.4
Annelida		
Oligochaeta		393.2
Number of Organisms	630.5	4,921
Number of Species	26	42
Diversity	3.3	3.5
Equitability	0.54	0.39
Biomass (ml)		8.0

Appendix G9b. Benthic Macroinvertebrates Collected from Jamison Creek near Johnsville (number per square meter)

	Date	
	6/2/92	9/24/92
Coleoptera		
Optioservus sp.		1.3
Ordobrevia nubifera		1.3
Rhizelmis sp.	48.4	24.2
Zaitzevia/Heterlimnius	16.1	34.9
Zaitzevia parvula	43.0	
Psephenidae		
Psephenus sp.		1.3
Diptera		
Ceratopogonidae		
Bezzia sp.	32.2	
Chironomidae	37.6	4.0
Chironominae	37.6	
Orthocladiinae	317.3	28.2
Empididae	5.4	
Psychodidae		
Pericoma sp.		2.7
Simuliidae		
Simulium sp.	10.8	
Tipulidae		
Antocha sp.	5.4	16.1
Ephemeroptera		
Baetidae		
Baetis sp.	75.3	12.6
Ephemerellidae		
Caudatella sp.	48.4	9.4
Drunella coloradensis	155.9	
D. doddsi	80.6	40.3
D. proserpina/grandis	5.4	
Ephemerella sp.	21.5	12.1
Serratella sp.	10.8	
Heptageniidae		24.2
Cinygmula sp.	21.5	61.8
Epeorus sp.	188.2	44.3
Ironodes sp.		1.3
Rhithrogena sp.	5.4	43.0
Leptophlebiidae		
Paraleptophlebia sp.	10.8	8.1
Siphlonuridae		
Ameletus sp.	5.4	
Megaloptera		
Corydalidae		
Neohermes/Protochauliodes		1.3
Plecoptera		
Chloroperlidae	5.4	
Suwallia sp.	32.2	
Nemouridae		
Malenka sp.	10.8	16.1
Zapada sp.		1.3
Peltoperlidae		
Yoraperla sp.	5.4	
Perlidae		
Calineuria californica	59.1	6.7
Perlodidae		
Isoperla sp.		1.3
Trichoptera		
Brachycentridae		
Glossosomatidae	5.4	14.7
Anagapetus sp.	5.4	10.7
Hydropsychidae	5.4	
Arctopsyche sp.	21.5	53.7
Cheumatopsyche sp.		16.1
Hydropsyche sp.	96.8	102.2
Parapsyche sp.	10.8	12.1
Hydroptilidae		
Ochrotrichia sp.	5.4	
Limnephilidae		
Apatania sp.		1.3
Rhyacophilidae		4.0
Rhyacophila sp.	107.5	24.2
Ostracoda	5.4	
Annelida		
Oligochaeta	10.8	1.3
Nematoda		
Mermithiidae		1.3
Platyhelminthes		
Planariidae		4.0
Dugesia sp.	5.4	
Number of Organisms	1,527	596.5
Number of Species	35	32
Diversity	4.1	4.1
Equitability	0.72	0.80
Biomass (ml)	20.0	3.5

Appendix G9c. Benthic Macroinvertebrates Collected from Jamison Creek near Johnsville (number per square meter)

	Date	
	6/24/93	10/23/93
Coleoptera		
Elmidae		
Ampumixis dispar		1.3
Rhizelmis sp.	12.1	44.3
Zaitzevia/Heterlimnius	1.3	8.1
Zaitzevia parvula	1.3	1.3
Diptera		
Ceratopogonidae		
Bezzia sp.	104.8	
Chironomidae	69.9	1.3
Chironominae	1.3	
Diamesinae	2.7	
Orthocladiinae	36.3	25.5
Psychodidae		
Pericoma sp.		2.7
Simuliidae	1.3	1.3
Simulium sp.	1.3	32.3
Tipulidae	1.3	
Antocha sp.	2.7	
Hexatoma sp.		1.3
Ephemeroptera		
Baetidae		
Baetis sp.	41.6	238.0
Ephemerellidae	4.0	
Caudatella sp.		21.5
Drunella coloradensis	37.6	
D. doddsi		61.8
Ephemerella sp.	10.8	
Serratella sp.	16.1	
Heptageniidae		
Cinygmula sp.	43.0	
Epeorus sp.	135.8	98.1
Rhithrogena sp.	1.3	129.1
Leptophlebiidae		
Paraleptophlebia sp.	4.0	13.4
Siphlonuridae		
Ameletus sp.	20.1	
Megaloptera		
Corydalidae		1.3

	Date	
	6/24/93	10/23/93
Plecoptera	1.3	4.0
Chloroperlidae		
Suwallia sp.	32.2	1.3
Sweltza sp.	2.7	9.4
Nemouridae		
Malenka sp.	1.3	
Perlidae		
Calineuria californica	8.1	34.9
Perlodidae		
Perlinodes sp.		1.3
Taeniopterygidae		1.3
Trichoptera		
Glossosomatidae		
Agapetus sp.		8.1
Hydropsychidae		13.4
Arctopsyche sp.		2.7
Cheumatopsyche sp.		5.4
Hydropsyche sp.	20.1	8.1
Leptoceridae	16.1	
Odontoceridae		
Marilia sp.	1.3	
Rhyacophilidae		2.7
Rhyacophila sp.	6.7	16.1
Annelida		
Oligochaeta	1.3	2.7
Nematoda		
Mermithiidae		1.3
Nematomorpha	1.3	
Platyhelminthes		
Planariidae		
Dugesia sp.		2.7
Number of Organisms	565.2	775.2
Number of Species	28	28
Diversity	3.6	3.3
Equitability	0.64	0.52
Biomass (ml)	3.5	3.5

Appendix G9d. Benthic Macroinvertebrates Collected from Jamison Creek near Johnsville (number per square meter)

	Date	
	6/23/94	9/14/94
Coleoptera		
Elmidae		
Ampumixis dispar		1.3
Lara sp.		1.3
Optioservus sp.	12.1	5.4
Ordobrevia nubifera		1.3
Rhizelmis nigra	10.7	1.3
Zaitzevia parvula	24.2	69.9
Psephenidae		
Eubrianax edwardsi	1.3	
Diptera		
Ceratopogonidae		
Bezzia sp.		1.3
Chironomidae	1.3	4.0
Chironominae	5.4	12.1
Orthocladiinae	169.5	21.5
Tanypodinae	8.1	
Dixidae		1.3
Simuliidae		
Simulium sp.	135.8	4.0
Tipulidae		
Antocha sp.	12.1	
Dicranota sp.		1.3
Hexatoma sp.	28.2	26.9
Limonia sp.		2.7
Ephemeroptera		
Baetidae		
Baetis sp.	45.7	57.8
Pseudocloeon sp.		2.7
Ephemerellidae		
Caudatella sp.	29.6	4.0
Drunella coloradensis	41.7	
D. doddsi	25.5	40.3
Ephemerella sp.		25.5
Serratella sp.	41.7	
Heptageniidae		83.4
Cinygmula sp.	8.1	
Epeorus sp.	108.9	14.8
Leptophlebiidae		
Paraleptophlebia sp.		25.5
Megaloptera		
Protochauliodes/Neohermes	1.3	1.3

	Date	
	6/23/94	9/14/94
Plecoptera		
Chloroperlidae		
Suwallia sp.	37.6	21.5
Leuctridae		4.0
Nemouridae	21.5	9.4
Malenka sp.	4.0	
Zapada sp.	1.3	1.3
Peltoperlidae		
Yoraperla sp.	37.6	1.3
Perlidae		1.3
Calineuria californica	40.3	41.7
Perlodidae		
Isoperla sp.		1.3
Oroperla sp.		2.7
Perlinodes sp.		14.8
Trichoptera	1.3	1.3
Glossosomatidae		4.0
Anagapetus sp.		4.0
Glossosoma sp.	14.8	9.4
Hydropsychidae	5.4	
Arctopsyche sp.	2.7	17.4
Cheumatopsyche sp.	10.7	99.5
Hydropsyche sp.	16.1	82.0
Lepidostomatidae		
Lepidostoma sp.	39.1	2.7
Philopotamidae		4.0
Rhyacophilidae		
Rhyacophila sp.	39.0	33.6
Arachnoidea		
Hydracarina		5.4
Platyhelminthes		
Planariidae		
Dugesia sp.	12.1	
Number of Organisms	986.7	762.9
Number of Species	31	41
Diversity	4.2	4.3
Equitability	0.86	0.71
Biomass (ml)	-	6.0

Appendix H

Fish Habitat Descriptions

Appendix H1a. Fish Habitat Description for the Middle Fork Feather River at Portola on 9/17/91

% Bottom Composition	
clay	0
silt	0
sand	5
gravel	10
rubble	80
boulder	5
bedrock	0

% Composition	
riffle	5
run	80
pool	15

% Cover Type Rating	
overhanging vegetation	10
surface turbulence	5
undercut banks	0
object cover	5

% Canopy Cover
0

Cross Sectional Stream Depths

Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	1.1	0.8	1.0	28.2
6m	0.9	0.8	0.3	22.9
9m	0.9	0.7	0.8	26.2
12m	1.1	0.9	0.8	27.5
15m	0.7	1.0	0.8	33.7
18m	0.7	0.9	0.8	31.4
21m	0.1	0.3	0.9	36.0
24m	0.4	0.2	0.8	33.7
27m	0.7	0.4	0.6	34.7
30m	0.8	0.0	0.1	39.3

Flow (cfs)
10.0

Appendix H1b. Fish Habitat Description for the Middle Fork Feather River at Portola on 9/24/92

% Bottom Composition	
clay	0
silt	5
sand	5
gravel	10
rubble	45
boulder	35
bedrock	0

% Composition	
riffle	25
run	60
pool	15

% Cover Type Rating	
overhanging vegetation	15
surface turbulence	10
undercut banks	15
object cover	20

% Canopy Cover
0

Cross Sectional Stream Depths					Thalweg
Distance	Cell 1 (ft)	Cell2 (ft)	Cell 3 (ft)	Width (ft)	Depth/Distance (ft)
3m	0.4	0.9	0.7	37.1	0.9/17.4
6m	0.4	0.8	0.7	34.4	1.0/17.0
9m	1.0	1.2	0.2	36.1	1.2/16.1
12m	1.2	0.9	0.4	35.2	1.2/9.4
15m	1.3	1.1	0.1	34.2	1.4/7.2
18m	0.9	0.6	1.2	28.3	1.3/19.5
21m	0.8	1.0	1.4	28.5	1.35/21.0
24m	1.0	1.1	1.3	25.0	1.45/19.6
27m	1.1	1.3	0.0	26.5	1.45/11.3
30m	0.7	1.0	0.3	27.5	1.5/21.5

Flow (cfs)
12.0

Appendix H1c. Fish Habitat Description for Middle Fork Feather River at Portola on 9/15/93

% Bottom Composition	
clay	0
silt	0
sand	5
gravel	10
rubble	50
boulder	30
bedrock	5

% Composition	
riffle	35
run	65
pool	0

% Cover Type Rating	
overhanging vegetation	5
surface turbulence	10
undercut banks	5
object cover	35

% Canopy Cover
0

Cross Sectional Stream Depths					Thalweg (ft)	
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)	Distance	Depth
3m	0.0	1.0	0.8	28.5	11.8	1.3
6m	1.5	0.9	0.3	23.0	6.2	1.5
9m	0.8	1.1	1.2	25.0	10.2	1.3
12m	1.2	0.0	1.2	27.0	16.2	1.3
15m	0.6	1.0	1.0	29.8	19.0	1.1
18m	0.7	1.1	0.6	34.5	17.2	1.1
21m	0.5	1.2	0.1	36.0	17.0	1.2
24m	0.5	0.6	0.1	35.2	14.7	0.8
27m	0.8	0.3	0.4	33.5	7.0	0.9
30m	0.0	1.1	0.9	38.3	19.4	1.1

Flow (cfs)
10.0

Appendix H1d. Fish Habitat Description for the Middle Fork Feather River at Portola on 9/12/94

% Bottom Composition	
clay	5
silt	0
sand	0
gravel	5
rubble	70
boulder	20
bedrock	0

% Composition	
riffle	55
run	45
pool	0

% Cover Type Rating	
overhanging vegetation	25
surface turbulence	50
undercut banks	5
object cover	5

% Canopy Cover
0

Cross Sectional Stream Depths				
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.5	1.0	0.7	25.6
6m	1.0	1.2	1.2	24.0
9m	0.8	0.9	1.1	25.8
12m	1.1	0.7	0.6	23.4
15m	0.2	0.6	0.7	32.0
18m	0.7	0.8	0.4	31.8
21m	0.0	0.6	0.0	34.0
24m	0.5	0.0	0.0	33.0
27m	0.5	1.5	0.0	36.3
30m	0.3	0.2	0.7	36.9

Thalweg (ft)	
Distance	Depth
8.0	1.3
14.4	1.4
10.6	1.2
6.7	1.2
12.8	0.9
5.3	0.9
14.5	1.0
12.0	0.7
17.3	1.7
28.0	1.0

Flow (cfs)
5.0

Appendix H2a. Fish Habitat Description for the Middle Fork Feather River at the Quincy La Porte Road on 9/16/91

% Bottom Composition	
clay	0
silt	0
sand	5
gravel	45
rubble	45
boulder	5
bedrock	0

% Composition	
riffle	50
run	50
pool	0

% Cover Type Rating	
overhanging vegetation	5
surface turbulence	20
undercut banks	0
object cover	15

% Canopy Cover
0

Cross Sectional Stream Depths

Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.7	0.7	0.8	6.5
6m	0.7	0.8	0.6	5.5
9m	0.9	0.8	1.0	6.5
12m	1.1	0.5	0.8	9.2
15m	0.9	0.4	1.2	8.8
18m	1.0	0.4	1.2	7.2
21m	1.2	0.7	1.3	6.2
24m	1.3	0.7	1.7	7.5
27m	1.5	0.6	1.0	6.8
30m	1.4	0.9	1.4	7.8

Flow (cfs)
24.02

Appendix H2b. Fish Habitat Description for Middle Fork Feather River at the Quincy La Porte Road on 9/21/92

% Bottom Composition	
clay	0
silt	0
sand	5
gravel	10
rubble	70
boulder	10
bedrock	5

% Composition	
riffle	15
run	85
pool	0

% Cover Type Rating	
overhanging vegetation	40
surface turbulence	1
undercut banks	25
object cover	5

% Canopy Cover
0

Cross Sectional Stream Depths					Thalweg
Distance	Cell 1 (ft)	Cell2 (ft)	Cell 3 (ft)	Width (ft)	Depth/Distance (ft)
3m	1.1	1.0	0.6	25.4	1.0/20.2
6m	1.0	1.0	0.7	23.1	1.1/16.6
9m	1.1	0.9	1.2	22.2	1.4/8.2
12m	1.5	0.8	1.1	20.0	1.5/13.7
15m	1.2	1.2	0.8	20.7	1.5/12.5
18m	1.6	1.1	0.8	22.9	1.8/17.4
21m	1.2	1.2	0.8	20.7	1.4/15.0
24m	1.1	0.8	0.4	22.1	1.3/14.9
27m	0.8	1.1	0.4	27.2	1.1/20.5
30m	0.6	0.5	0.6	25.0	1.1/15.0

Flow (cfs)
15.22

Appendix H2c. Fish Habitat Description for the Middle Fork Feather River at the Quincy La Porte Road on 9/13/93

% Bottom Composition	
clay	0
silt	0
sand	10
gravel	25
rubble	60
boulder	5
bedrock	0

% Composition	
riffle	25
run	75
pool	0

% Cover Type Rating	
overhanging vegetation	5
surface turbulence	15
undercut banks	5
object cover	5

% Canopy Cover
5

Cross Sectional Stream Depths					Thalweg (ft)	
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)	Distance	Depth
3m	1.6	1.6	1.7	33.0	21.0	2.1
6m	1.5	1.5	1.1	28.0	8.5	1.7
9m	1.6	1.6	1.3	25.0	13.5	1.8
12m	1.4	1.3	1.2	26.5	11.5	1.6
15m	1.5	1.3	1.0	23.0	10.3	1.7
18m	1.3	1.4	1.3	27.0	17.0	1.6
21m	0.9	1.3	0.9	26.5	10.9	1.6
24m	1.0	1.6	0.5	26.3	12.8	1.8
27m	1.1	1.3	1.3	28.4	14.4	1.5
30m	0.9	1.2	0.7	27.2	18.0	1.4

Flow (cfs)
41.4

Appendix H2d. Fish Habitat Description for the Middle Fork Feather River at the Quincy La Porte Road on 9/12/94

% Bottom Composition	
clay	0
silt	0
sand	35
gravel	10
rubble	40
boulder	5
bedrock	10

% Composition	
riffle	95
run	5
pool	0

% Cover Type Rating	
overhanging vegetation	12
surface turbulence	10
undercut banks	5
object cover	5

% Canopy Cover
0

Cross Sectional Stream Depths				
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.8	1.5	0.8	29.1
6m	1.4	1.5	2.2	29.6
9m	1.5	2.2	2.2	32.3
12m	1.7	2.0	2.3	32.6
15m	1.8	1.5	2.1	32.6
18m	1.6	2.9	1.8	35.0
21m	1.4	2.6	2.7	35.4
24m	1.5	2.0	2.0	34.6
27m	1.5	1.6	2.0	36.0
30m	1.8	1.2	1.8	36.0

Thalweg (ft)	
Distance	Depth
20.8	1.7
23.0	2.4
24.1	2.2
24.6	2.3
24.6	2.1
18.0	2.9
25.0	2.8
22.5	2.4
31.5	2.1
36.5	1.8

Flow (cfs)
23.0

Appendix H3a. Fish Habitat Description for Willow Creek near Clio on 9/18/91

% Bottom Composition	
clay	0
silt	0
sand	0
gravel	20
rubble	80
boulder	0
bedrock	0

% Composition	
riffle	10
run	30
pool	60

% Cover Type Rating	
overhanging vegetation	10
surface turbulence	0
undercut banks	5
object cover	0

% Canopy Cover
5

Cross Sectional Stream Depths (ft)

Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.1	0.1	0.2	2.6
6m	0.0	0.2	0.0	4.9
9m	0.0	0.1	0.1	3.2
12m	0.2	0.1	0.0	7.2
15m	0.6	0.5	0.8	7.2
18m	0.9	0.9	0.7	6.5
21m	0.0	0.5	0.1	9.8
24m	0.0	0.0	0.0	11.1
27m	0.0	0.2	0.3	10.4
30m	0.3	0.1	0.0	7.2

Flow (cfs)
1.72

Appendix H3c. Fish Habitat Description for Willow Creek near Clio on 9/15/93

% Bottom Composition	
clay	0
silt	0
sand	10
gravel	15
rubble	55
boulder	20
bedrock	0

% Composition	
riffle	50
run	0
pool	50

% Cover Type Rating	
overhanging vegetation	20
surface turbulence	5
undercut banks	5
object cover	15

% Canopy Cover
15

Cross Sectional Stream Depths				
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.4	0.4	0.2	7.2
6m	1.0	0.9	0.8	7.4
9m	0.5	0.8	0.2	6.0
12m	0.1	0.0	0.4	7.4
15m	0.0	0.0	0.1	12.5
18m	0.1	0.0	0.0	9.2
21m	0.2	0.0	0.2	12.3
24m	0.2	0.6	0.0	10.8
27m	1.3	0.5	0.3	10.5
30m	0.2	0.3	0.4	7.8

Thalweg (ft)	
Distance	Depth
2.4	0.48
2.8	1.25
2.7	0.90
5.9	0.45
10.1	0.20
8.0	0.10
8.7	0.35
5.4	0.60
6.6	0.70
6.3	0.46

Flow (cfs)
0.13

Appendix H4a. Fish Habitat Description for Freeman Creek on 9/17/91

% Bottom Composition	
clay	0
silt	90
sand	0
gravel	10
rubble	0
boulder	0
bedrock	0

% Composition	
riffle	0
run	40
pool	60

% Cover Type Rating	
overhanging vegetation	30
surface turbulence	0
undercut banks	5
object cover	5

% Canopy Cover
0

Cross Sectional Stream Depths

Distance	Cell 1 (ft)	Cell 2(ft)	Cell 3 (ft)	Width (ft)
3m	0.0	0.3	0.1	4.0
6m	0.1	0.6	0.1	9.0
9m	0.2	0.5	0.5	9.0
12m	0.6	1.0	1.0	11.0
15m	1.0	2.1	1.5	14.0
18m	1.9	1.6	2.4	12.0
21m	0.2	0.4	0.3	7.0
24m	0.2	0.1	0.2	7.0
27m	0.1	0.3	0.5	10.0
30m	0.2	0.3	0.0	12.0

Flow (cfs)
0.032

Appendix H4b. Fish Habitat Description for Freeman Creek on 9/23/92

% Bottom Composition	
clay	10
silt	75
sand	10
gravel	5
rubble	0
boulder	0
bedrock	0

% Composition	
riffle	10
run	65
pool	25

% Cover Type Rating	
overhanging vegetation	5
surface turbulence	5
undercut banks	5
object cover	30

% Canopy Cover
0

Cross Sectional Stream Depths					Thalweg
Distance	Cell 1 (ft)	Cell2 (ft)	Cell 3 (ft)	Width (ft)	Depth/Distance (ft)
3m	0.3	0.3	0.2	5.0	0.7/3.2
6m	1.4	1.4	1.5	9.3	0.7/5.6
9m	1.1	1.4	2.0	11.0	1.9/6.9
12m	1.3	1.7	1.8	10.3	0.8/1.0
15m	1.1	1.3	1.0	9.3	1.3/4.5
18m	0.4	0.3	0.1	6.0	0.6/0.6
21m	0.2	0.2	0.2	7.0	0.8/5.3
24m	0.2	0.2	0.0	10.0	0.2/1.0
27m	0.3	0.5	0.6	4.3	0.4/0.6
30m	0.1	0.2	0.3	3.0	0.4/0.1

Flow (cfs)
0.14

Appendix H4c. Fish Habitat Description for Freeman Creek on 9/14/93

% Bottom Composition	
clay	75
silt	0
sand	15
gravel	10
rubble	0
boulder	0
bedrock	0

% Composition	
riffle	5
run	45
pool	50

% Cover Type Rating	
overhanging vegetation	5
surface turbulence	0
undercut banks	5
object cover	25

% Canopy Cover
5

Cross Sectional Stream Depths					Thalweg (ft)	
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)	Distance	Depth
3m	0.5	0.5	0.5	5.7	4.2	0.6
6m	0.1	0.3	0.7	4.2	3.1	0.7
9m	0.4	0.5	0.6	5.7	4.0	0.7
12m	0.7	0.8	0.6	5.1	2.9	0.9
15m	0.4	1.0	0.8	10.6	6.7	1.1
18m	2.0	2.0	1.8	13.0	5.2	2.1
21m	2.5	2.4	2.3	12.4	4.4	2.7
24m	0.4	0.5	0.4	6.5	2.7	0.6
27m	0.5	0.3	0.2	7.3	1.5	0.5
30m	0.0	0.0	0.7	9.9	7.7	0.7

Flow (cfs)
0.49

Appendix H4d. Fish Habitat Description for Freeman Creek
on 9/13/94

% Bottom Composition	
clay	95
silt	0
sand	5
gravel	0
rubble	0
boulder	0
bedrock	0

% Composition	
riffle	10
run	30
pool	60

% Cover Type Rating	
overhanging vegetation	5
surface turbulence	0
undercut banks	10
object cover	80

% Canopy Cover
0

Cross Sectional Stream Depths				
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.2	0.5	0.5	2.9
6m	0.3	0.5	0.6	4.2
9m	0.3	0.5	0.1	8.2
12m	0.1	0.2	0.5	7.7
15m	0.2	0.7	0.8	10.2
18m	1.5	1.8	1.7	12.0
21m	2.5	2.4	2.4	13.0
24m	2.3	2.4	2.2	11.6
27m	0.2	0.4	0.4	6.8
30m	0.4	0.4	0.3	6.7

Thalweg (ft)	
Distance	Depth
2.1	0.5
3.0	0.6
3.8	0.5
6.2	0.5
7.0	0.9
6.4	1.9
2.9	2.5
5.5	2.6
3.3	0.5
2.9	0.4

Flow (cfs)
0.2

Appendix H5a. Fish Habitat Description for Nelson Creek at the Quincy La Porte Road on 9/19/91

% Bottom Composition	
clay	0
silt	0
sand	0
gravel	10
rubble	80
boulder	10
bedrock	0

% Composition	
riffle	0
run	100
pool	0

% Cover Type Rating	
overhanging vegetation	0
surface turbulence	40
undercut banks	0
object cover	5

% Canopy Cover
10

Cross Sectional Stream Depths

Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.6	0.2	0.8	34.1
6m	1.0	0.0	0.7	34.1
9m	0.8	0.3	0.6	32.8
12m	1.2	0.8	0.9	26.2
15m	1.2	0.0	0.6	24.6
18m	1.0	0.3	1.0	26.2
21m	0.9	0.6	0.7	26.2
24m	0.5	0.9	1.6	20.9
27m	0.9	0.7	0.3	22.9
30m	0.1	0.7	0.6	13.1

Flow (cfs)
15.22

Appendix H5b. Fish Habitat Description for Nelson Creek at the Quincy La Porte Road on 9/25/92

% Bottom Composition	
clay	0
silt	0
sand	5
gravel	10
rubble	50
boulder	35
bedrock	0

% Composition	
riffle	70
run	20
pool	10

% Cover Type Rating	
overhanging vegetation	1
surface turbulence	50
undercut banks	0
object cover	20

% Canopy Cover
5

Cross Sectional Stream Depths					Thalweg
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)	Depth/Distance (ft)
3m	0.5	1.0	0.4	16.6	0.95/8.2
6m	0.7	1.2	0.0	22.6	1.30/11.5
9m	0.7	0.8	0.2	23.9	1.05/10.3
12m	1.0	0.8	0.7	26.0	1.15/11.7
15m	0.4	0.9	0.7	25.2	0.95/11.4
18m	0.3	1.2	1.0	24.7	1.40/12.8
21m	0.7	0.8	0.7	26.2	1.05/16.2
24m	0.0	0.4	0.8	35.3	0.85/24.2
27m	0.1	0.7	0.9	40.2	1.15/28.6
30m	0.0	0.8	0.3	34.6	1.0/23.5

Flow (cfs)
9.965

Appendix H5c. Fish Habitat Description for Nelson Creek at the Quincy La Porte Road on 9/15/93

% Bottom Composition	
clay	0
silt	0
sand	5
gravel	15
rubble	60
boulder	20
bedrock	0

% Composition	
riffle	85
run	15
pool	0

% Cover Type Rating	
overhanging vegetation	5
surface turbulence	55
undercut banks	0
object cover	40

% Canopy Cover
20

Cross Sectional Stream Depths				
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.1	1.0	0.8	42.4
6m	0.3	0.9	1.0	41.7
9m	0.3	1.0	0.8	37.3
12m	0.5	1.2	0.7	31.0
15m	1.2	1.3	1.0	30.3
18m	0.7	1.1	1.1	28.5
21m	0.3	1.2	1.0	24.7
24m	0.8	1.2	0.7	23.0
27m	0.0	0.2	1.0	52.0
30m	0.0	0.6	0.4	47.2

Thalweg (ft)	
Distance	Depth
25.2	1.2
22.7	1.2
23.3	1.4
15.1	1.4
17.7	1.4
25.6	1.5
9.3	1.4
11.5	1.2
35.3	1.3
34.5	1.4

Flow (cfs)
28.4

Appendix H5d. Fish Habitat Description for Nelson Creek at Quincy La Porte Road on 9/16/94

% Bottom Composition	
clay	0
silt	0
sand	10
gravel	5
rubble	30
boulder	50
bedrock	5

% Composition	
riffle	25
run	70
pool	5

% Cover Type Rating	
overhanging vegetation	5
surface turbulence	75
undercut banks	0
object cover	20

% Canopy Cover
33

Cross Sectional Stream Depths				
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.7	0.8	0.1	35.3
6m	0.3	0.6	0.3	34.8
9m	0.6	0.5	0.7	29.6
12m	0.1	0.9	0.3	24.4
15m	1.0	1.0	0.7	30.0
18m	0.7	1.2	0.6	27.6
21m	0.3	0.8	0.6	23.2
24m	0.1	0.7	0.5	26.6
27m	0.3	0.0	0.0	32.4
30m	0.7	0.9	0.3	32.3

Thalweg (ft)	
Distance	Depth
15.5	1.2
15.8	0.9
14.3	1.1
12.3	1.0
16.8	1.1
13.9	1.2
15.1	1.0
13.2	1.1
20.3	1.3
14.2	1.1

Flow (cfs)
9.8

Appendix H6a. Fish Habitat Description for Onion Valley Creek near mouth on 10/16/91

% Bottom Composition	
clay	0
silt	0
sand	5
gravel	5
rubble	80
boulder	5
bedrock	5

% Composition	
riffle	5
run	45
pool	55

% Cover Type Rating	
overhanging vegetati	5
surface turbulence	5
undercut banks	0
object cover	10

% Canopy Cover
10

Cross Sectional Stream Depths

Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.0	0.5	0.5	14.4
6m	0.6	0.6	1.0	10.4
9m	0.6	0.3	1.2	20.6
12m	1.2	0.3	1.4	18.7
15m	0.5	0.6	0.7	15.4
18m	1.2	0.6	0.0	16.4
21m	1.3	0.5	1.8	19.6
24m	1.7	0.6	2.8	15.7
27m	2.1	0.0	2.8	30.5
30m	2.3	1.0	3.0	32.8

Flow (cfs)
2.33

Appendix H6b. Fish Habitat Description for Onion Valley Creek Creek near mouth on 9/22/92

% Bottom Composition	
clay	0
silt	5
sand	5
gravel	25
rubble	50
boulder	10
bedrock	5

% Composition	
riffle	10
run	20
pool	70

% Cover Type Rating	
overhanging vegetation	5
surface turbulence	5
undercut banks	5
object cover	15

% Canopy Cover
20

Cross Sectional Stream Depths					Thalweg
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)	Depth/Distance (ft)
3m	0.0	0.2	0.8	16.6	0.97/10.8
6m	0.3	0.7	1.3	14.5	1.25/3.5
9m	0.2	0.7	1.6	16.6	1.8/11.3
12m	0.4	0.6	0.7	17.0	1.52/10.5
15m	0.0	0.1	1.1	18.1	2.5/13.2
18m	0.0	0.9	1.1	19.0	1.3/14.5
21m	0.4	1.5	2.5	16.4	2.52/12.0
24m	0.8	1.7	3.0	15.6	3.0/12.0
27m	0.0	2.5	1.8	26.5	2.95/22.1
30m	1.3	1.6	2.4	29.0	2.5/20.3

Flow (cfs)
1.996

Appendix H6c. Fish Habitat Description for Onion Valley Creek near mouth on 9/16/93

% Bottom Composition	
clay	0
silt	0
sand	15
gravel	20
rubble	45
boulder	15
bedrock	5

% Composition	
riffle	10
run	30
pool	60

% Cover Type Rating	
overhanging vegetation	5
surface turbulence	5
undercut banks	5
object cover	20

% Canopy Cover
20

Cross Sectional Stream Depths					Thalweg (ft)	
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)	Distance	Depth
3m	1.5	1.5	2.4	28.0	20.0	2.7
6m	0.8	2.4	2.9	27.3	21.6	3.3
9m	1.1	2.6	3.3	19.5	14.5	3.4
12m	0.6	1.8	2.8	18.2	15.2	2.4
15m	0.5	1.5	2.1	19.4	14.3	2.1
18m	0.6	0.7	1.1	16.5	11.3	1.4
21m	0.1	0.9	1.1	17.5	14.1	1.2
24m	0.7	1.2	1.0	17.9	10.1	1.4
27m	0.1	0.0	1.1	19.5	13.2	1.3
30m	0.1	0.3	0.9	15.4	14.0	1.1

Flow (cfs)
4.17

Appendix H6d. Fish Habitat Description for Onion Valley Creek near mouth on 9/15/94

% Bottom Composition	
clay	0
silt	10
sand	5
gravel	10
rubble	60
boulder	10
bedrock	5

% Composition	
riffle	45
run	5
pool	50

% Cover Type Rating	
overhanging vegetation	5
surface turbulence	20
undercut banks	5
object cover	15

% Canopy Cover
50

Cross Sectional Stream Depths				
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.0	0.3	0.5	15.6
6m	0.5	0.8	0.1	15.0
9m	0.6	0.5	1.2	21.2
12m	0.0	1.1	0.0	20.0
15m	0.2	0.9	1.0	17.5
18m	0.3	1.9	1.3	17.6
21m	0.2	1.6	2.4	15.3
24m	1.1	2.4	3.1	18.1
27m	0.0	2.6	3.0	27.0
30m	1.1	1.6	2.7	27.9

Thalweg (ft)	
Distance	Depth
13.2	0.8
12.8	1.1
18.8	1.4
11.1	2.2
13.3	1.4
13.2	1.4
11.9	2.5
13.5	3.2
19.0	3.0
20.3	2.7

Flow (cfs)
3.1

Appendix H7a. Fish Habitat Description for Greenhorn Creek above Squirrel Creek on 9/17/91

% Bottom Composition	
clay	0
silt	0
sand	0
gravel	15
rubble	70
boulder	15
bedrock	0

% Composition	
riffle	20
run	75
pool	5

% Cover Type Rating	
overhanging vegetation	15
surface turbulence	20
undercut banks	5
object cover	15

% Canopy Cover
75

Cross Sectional Stream Depths

Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	1.2	1.3	0.2	11.0
6m	0.6	0.4	0.2	15.0
9m	0.8	0.4	0.4	15.0
12m	0.4	0.6	0.7	12.0
15m	1.0	0.7	0.5	10.0
18m	0.5	0.0	0.5	12.0
21m	0.6	0.4	0.6	11.0
24m	0.8	0.5	0.6	11.0
27m	0.0	0.6	0.7	11.0
30m	0.6	0.6	0.4	10.0

Flow (cfs)
5.26

Appendix H7b. Fish Habitat Description for Greenhorn Creek above Squirrel Creek on 9/23/92

% Bottom Composition	
clay	0
silt	5
sand	15
gravel	25
rubble	45
boulder	10
bedrock	0

% Composition	
riffle	50
run	30
pool	20

% Cover Type Rating	
overhanging vegetation	80
surface turbulence	40
undercut banks	15
object cover	25

% Canopy Cover
80

Cross Sectional Stream Depths					Thalweg
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)	Depth/Distance (ft)
3m	0.7	0.4	1.0	11.3	1.05/8.4
6m	0.1	0.8	0.6	11.1	0.85/5.3
9m	0.4	0.8	0.9	10.5	0.95/5.8
12m	0.3	0.7	0.9	11.7	0.85/8.4
15m	0.4	0.8	0.5	11.6	0.85/3.1
18m	0.4	0.8	0.6	11.2	0.75/5.7
21m	0.2	0.8	0.7	14.3	0.95/6.5
24m	0.4	0.5	0.2	17.2	0.8/5.7
27m	1.3	0.7	0.5	8.8	1.3/0.1
30m	0.5	0.6	0.6	12.6	0.8/7.0

Flow (cfs)
4.967

Appendix H7c. Fish Habitat Description for Greenhorn Creek above Squirrel Creek on 9/17/93

% Bottom Composition	
clay	0
silt	0
sand	25
gravel	30
rubble	30
boulder	15
bedrock	0

% Composition	
riffle	55
run	25
pool	20

% Cover Type Rating	
overhanging vegetation	40
surface turbulence	30
undercut banks	5
object cover	30

% Canopy Cover
80

Cross Sectional Stream Depths					Thalweg (ft)	
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)	Distance	Depth
3m	0.3	0.4	0.2	16.6	6.8	0.8
6m	1.1	1.1	0.5	14.2	6.8	1.2
9m	0.7	0.4	0.1	10.5	1.5	1.1
12m	0.0	0.2	0.4	16.3	11.1	0.9
15m	0.9	0.8	0.2	13.5	3.3	0.9
18m	0.7	0.6	0.8	13.6	3.5	0.9
21m	0.7	0.7	0.6	11.0	1.8	0.8
24m	0.6	0.7	0.5	11.2	5.7	0.9
27m	0.5	0.3	0.5	11.1	5.3	0.8
30m	0.5	0.9	0.8	10.1	5.7	1.0

Flow (cfs)
4.15

Appendix H7d. Fish Habitat Description for Greenhorn Creek above Squirrel Creek on 9/14/94

% Bottom Composition	
clay	0
silt	0
sand	5
gravel	10
rubble	60
boulder	25
bedrock	0

% Composition	
riffle	40
run	40
pool	30

% Cover Type Rating	
overhanging vegetation	95
surface turbulence	70
undercut banks	40
object cover	25

% Canopy Cover
95

Cross Sectional Stream Depths				
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.8	0.9	0.6	13.5
6m	0.7	0.3	0.7	11.0
9m	0.1	0.7	0.2	10.8
12m	0.8	0.7	0.5	14.0
15m	0.8	0.7	0.5	10.0
18m	0.5	0.7	0.7	11.6
21m	0.3	0.7	0.6	9.6
24m	0.5	0.9	0.7	10.7
27m	0.6	0.0	0.6	10.3
30m	0.5	0.2	0.0	10.6

Thalweg (ft)	
Distance	Depth
6.5	1.0
2.1	1.0
8.5	0.5
7.9	0.8
5.3	0.8
5.3	0.8
5.5	0.8
5.3	0.9
7.1	0.6
1.8	1.0

Flow (cfs)
4.2

Appendix H8a. Fish Habitat Description for Squirrel Creek at mouth on 9/17/91

% Bottom Composition	
clay	0
silt	0
sand	0
gravel	35
rubble	35
boulder	30
bedrock	0

% Composition	
riffle	35
run	35
pool	40

% Cover Type Rating	
overhanging vegetation	20
surface turbulence	10
undercut banks	0
object cover	20

% Canopy Cover
90

Cross Sectional Stream Depths

Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.7	0.6	0.4	9.0
6m	0.4	0.6	0.5	11.0
9m	0.0	0.1	0.0	11.0
12m	0.2	0.1	0.2	7.0
15m	0.2	0.2	0.2	7.0
18m	0.0	0.6	0.2	7.0
21m	0.6	0.3	0.9	16.0
24m	0.7	0.4	0.5	7.7
27m	0.4	0.0	0.2	12.0
30m	0.5	0.3	0.0	11.0

Flow (cfs)
1.23

Appendix H8b. Fish Habitat Description for Squirrel Creek at mouth on 9/23/92

% Bottom Composition	
clay	0
silt	10
sand	15
gravel	20
rubble	30
boulder	25
bedrock	0

% Composition	
riffle	40
run	30
pool	30

% Cover Type Rating	
overhanging vegetation	35
surface turbulence	30
undercut banks	10
object cover	20

% Canopy Cover
65

Cross Sectional Stream Depths					Thalweg
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)	Depth/Distance (ft)
3m	0.2	0.2	0.5	10.5	0.55/8.0
6m	0.5	0.6	0.4	9.3	0.55/4.4
9m	0.5	0.5	0.0	8.2	0.6/2.75
12m	0.0	0.2	0.4	6.7	0.4/5.7
15m	0.7	0.8	0.1	10.0	0.9/5.8
18m	0.3	0.7	0.5	14.4	1.1/10.4
21m	0.2	0.7	0.6	6.8	0.7/3.1
24m	0.1	0.2	0.0	10.1	0.45/6.0
27m	0.2	0.4	0.0	7.3	0.4/5.1
30m	0.0	0.3	0.3	10.3	0.5/6.4

Flow (cfs)
0.953

Appendix H8c. Fish Habitat Description for Squirrel Creek at mouth on 9/17/93

% Bottom Composition	
clay	0
silt	0
sand	15
gravel	40
rubble	25
boulder	20
bedrock	0

% Composition	
riffle	35
run	45
pool	20

% Cover Type Rating	
overhanging vegetation	25
surface turbulence	5
undercut banks	5
object cover	20

% Canopy Cover
75

Cross Sectional Stream Depths					Thalweg (ft)	
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)	Distance	Depth
3m	0.3	0.4	0.0	10.2	3.5	0.7
6m	0.0	0.6	0.5	10.9	5.7	0.8
9m	0.2	0.6	0.5	7.1	4.3	0.9
12m	0.3	0.7	0.9	14.0	9.5	1.1
15m	0.0	0.6	0.4	9.9	5.3	0.9
18m	0.4	0.5	0.0	9.2	1.8	0.5
21m	0.4	0.1	0.3	7.8	1.4	0.6
24m	0.0	0.6	0.7	11.3	8.0	0.8
27m	0.4	0.5	0.6	10.2	3.2	0.9
30m	1.0	0.6	0.5	8.3	2.0	1.0

Flow (cfs)
1.14

Appendix H8d. Fish Habitat Description for Squirrel Creek at mouth on 9/14/94

% Bottom Composition	
clay	0
silt	0
sand	5
gravel	10
rubble	60
boulder	25
bedrock	0

% Composition	
riffle	15
run	65
pool	20

% Cover Type Rating	
overhanging vegetation	90
surface turbulence	70
undercut banks	5
object cover	20

% Canopy Cover
90

Cross Sectional Stream Depths				
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.2	0.0	0.1	9.4
6m	0.1	0.6	0.3	9.2
9m	0.4	0.7	0.6	7.2
12m	0.3	0.7	0.7	12.8
15m	0.6	0.0	0.1	10.7
18m	0.0	0.0	0.0	6.1
21m	0.2	0.2	0.3	7.8
24m	0.3	0.0	0.4	10.4
27m	0.5	0.6	0.6	11.7
30m	0.3	0.1	0.4	12.5

Thalweg (ft)	
Distance	Depth
3.5	0.4
4.9	0.6
4.2	0.8
8.6	1.1
1.2	0.9
3.0	0.4
5.3	0.3
9.7	0.5
4.6	0.7
10.8	0.6

Flow (cfs)
3.3

Appendix H9a. Fish Habitat Description for Jamison Creek near Johnsville on 9/18/91

% Bottom Composition	
clay	0
silt	0
sand	10
gravel	25
rubble	50
boulder	15
bedrock	0

% Composition	
riffle	20
run	60
pool	20

% Cover Type Rating	
overhanging vegetation	0
surface turbulence	10
undercut banks	0
object cover	20

% Canopy Cover
5

Cross Sectional Stream Depths

Distance	Cell 1 (ft(	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.1	0.7	0.8	20.9
6m	0.3	0.6	0.0	17.3
9m	0.4	0.5	1.0	14.4
12m	0.8	0.5	0.3	19.0
15m	2.1	0.9	1.3	12.4
18m	2.3	1.6	2.2	13.1
21m	0.8	0.7	0.7	9.1
24m	0.1	0.7	0.4	26.2
27m	0.8	0.0	0.6	27.5
30m	0.5	0.5	0.7	30.8

Flow (cfs)
9.22

Appendix H9b. Fish Habitat Description for Jamison Creek near Johnsville on 9/24/92

% Bottom Composition	
clay	0
silt	0
sand	10
gravel	20
rubble	35
boulder	35
bedrock	0

% Composition	
riffle	30
run	30
pool	40

% Cover Type Rating	
overhanging vegetation	0
surface turbulence	15
undercut banks	5
object cover	20

% Canopy Cover
0

Cross Sectional Stream Depths					Thalweg
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)	Depth/Distance (ft)
3m	0.5	0.0	0.3	35.0	0.65/4.6
6m	1.2	0.7	0.0	9.7	1.15/6.7
9m	1.7	1.5	2.7	14.2	2.85/2.7
12m	1.1	1.7	1.3	12.9	1.8/6.2
15m	0.4	1.1	0.6	17.3	1.0/8.8
18m	0.2	0.9	0.0	15.3	1.0/1.9
21m	0.6	0.7	0.0	20.6	0.8/10.3
24m	0.4	0.8	0.0	19.0	0.8/6.4
27m	0.2	0.6	0.7	15.5	0.7/6.8
30m	0.0	0.6	0.7	12.0	0.9/5.8

Flow (cfs)
5.638

Appendix H9c. Fish Habitat Description for Jamison Creek near Johnsville on 9/14/93

% Bottom Composition	
clay	0
silt	0
sand	15
gravel	20
rubble	45
boulder	15
bedrock	5

% Composition	
riffle	40
run	20
pool	40

% Cover Type Rating	
overhanging vegetation	5
surface turbulence	15
undercut banks	5
object cover	30

% Canopy Cover
30

Cross Sectional Stream Depths				
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.8	1.1	0.5	18.9
6m	0.6	0.9	0.6	19.7
9m	0.0	1.0	0.5	17.0
12m	0.2	1.1	0.5	20.0
15m	2.5	1.5	1.3	31.1
18m	2.1	1.6	1.2	36.5
21m	0.8	0.7	0.8	32.5
24m	0.2	0.5	0.5	35.0
27m	0.3	0.7	0.0	30.5
30m	0.6	1.0	0.5	28.5

Thalweg (ft)	
Distance	Depth
8.8	1.1
8.0	1.0
7.6	1.1
10.9	1.3
2.7	2.6
1.2	2.8
5.6	1.3
16.9	0.9
18.0	1.0
14.1	1.1

Flow (cfs)
10.9

Appendix H9d. Fish Habitat Description for Jamison Creek near Johnsville on 9/15/94

% Bottom Composition	
clay	0
silt	0
sand	5
gravel	10
rubble	45
boulder	40
bedrock	0

% Composition	
riffle	50
run	10
pool	40

% Cover Type Rating	
overhanging vegetation	5
surface turbulence	50
undercut banks	0
object cover	10

% Canopy Cover
25

Cross Sectional Stream Depths				
Distance	Cell 1 (ft)	Cell 2 (ft)	Cell 3 (ft)	Width (ft)
3m	0.6	0.4	0.9	16.3
6m	0.5	0.5	0.5	18.9
9m	0.6	1.0	0.1	17.4
12m	0.4	1.2	0.3	16.8
15m	2.2	0.9	1.1	14.4
18m	2.4	1.5	1.3	12.8
21m	1.0	0.5	0.7	14.4
24m	0.0	0.3	0.6	33.0
27m	0.6	0.6	0.1	26.4
30m	0.4	0.6	0.3	27.4

Thalweg (ft)	
Distance	Depth
8.1	0.9
8.2	0.8
9.0	1.0
10.8	1.2
3.2	1.3
2.3	2.6
5.4	1.0
29.6	0.9
15.7	0.8
8.4	0.8

Flow (cfs)
8.2

Appendix I

Lake Oroville Runoff Enhancement Project 1994 Vegetation Monitoring Report

INTRODUCTION

Vegetation monitoring was conducted for four summers (1991 through 1994) in the Plumas National Forest to evaluate the potential effects of the Lake Oroville Runoff Enhancement Project.

In most meadows, a distinct edge occurs between the forest floor and meadow. Therefore, rather than monitoring a single species, transects were established at meadow edges to ascertain vegetation responses to increased moisture and snowpack. This study involved monitoring transects set up on wet to dry meadow transition areas in four study sites and two control sites. The presence of each plant species was recorded on line transects at all the sites. Surveys were conducted for four summers at the peak of the flowering season.

Four study sites were chosen in areas that would be downstream from the targeted cloud seeding area. Two control sites were set up outside of the targeted cloud seeding area. All of the sites were in the Plumas National Forest except for Site 6 which was in the Tahoe National Forest. Two line transects were set up at each of the six sites. Additionally, surveys were conducted at the six sites for sensitive species. None were found in the study sites.

Work was conducted by J. Lacey, J. Cunningham and J. Witzman, Environmental Specialists; and J. Brown, E. Hubert, and G. Kuenster, Graduate Student Assistants with DWR.

No major changes in vegetation distribution were observed over the four-year period. A trend of greater species diversity and frequency was observed in 1993, which had been a very wet winter. No observable differences in the study plots vs. the control plots were found, indicating that any discernible effects due to the cloud seeding were no more apparent than effects potentially due to the general weather patterns. Detailed vegetation studies should be conducted over a longer period of time to show more definite results.

METHODOLOGY

Field reconnaissance was conducted at all locations deemed appropriate for monitoring. Six study populations were selected: two control sites, one west (site 5) and one east (site 6) of the project area, and four sites within the area expected to receive enhanced snowfall. All sites are located within the Plumas National Forest with the exception of site 6 - Church Creek - which is in the Tahoe National Forest. The overall project area with propane dispenser locations, precipitation gauge sites, and transect study sites is shown in Figure 1. Figures 2-6 give more detailed locations of each study site.

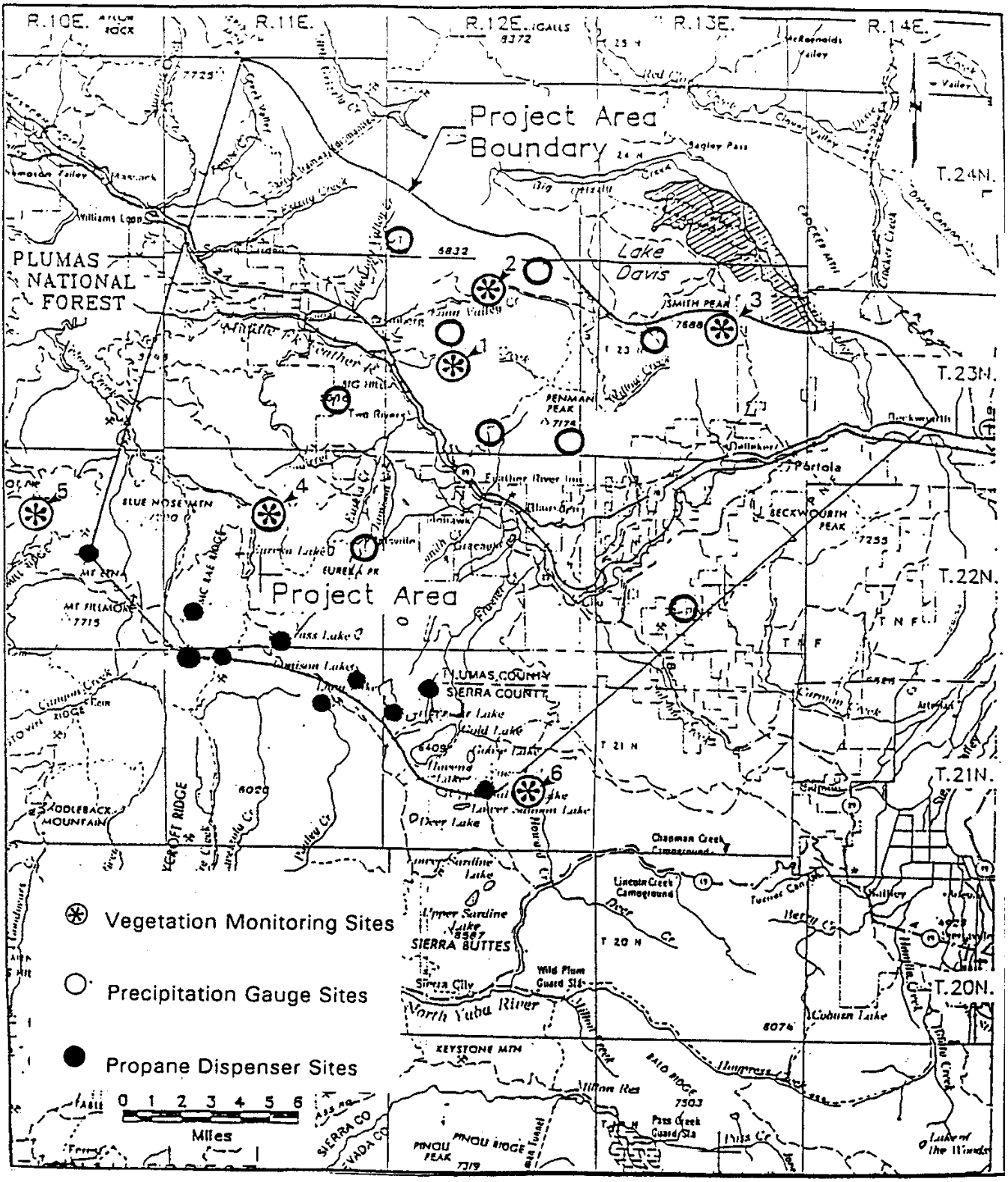


Figure 1. Vegetation Monitoring Locations

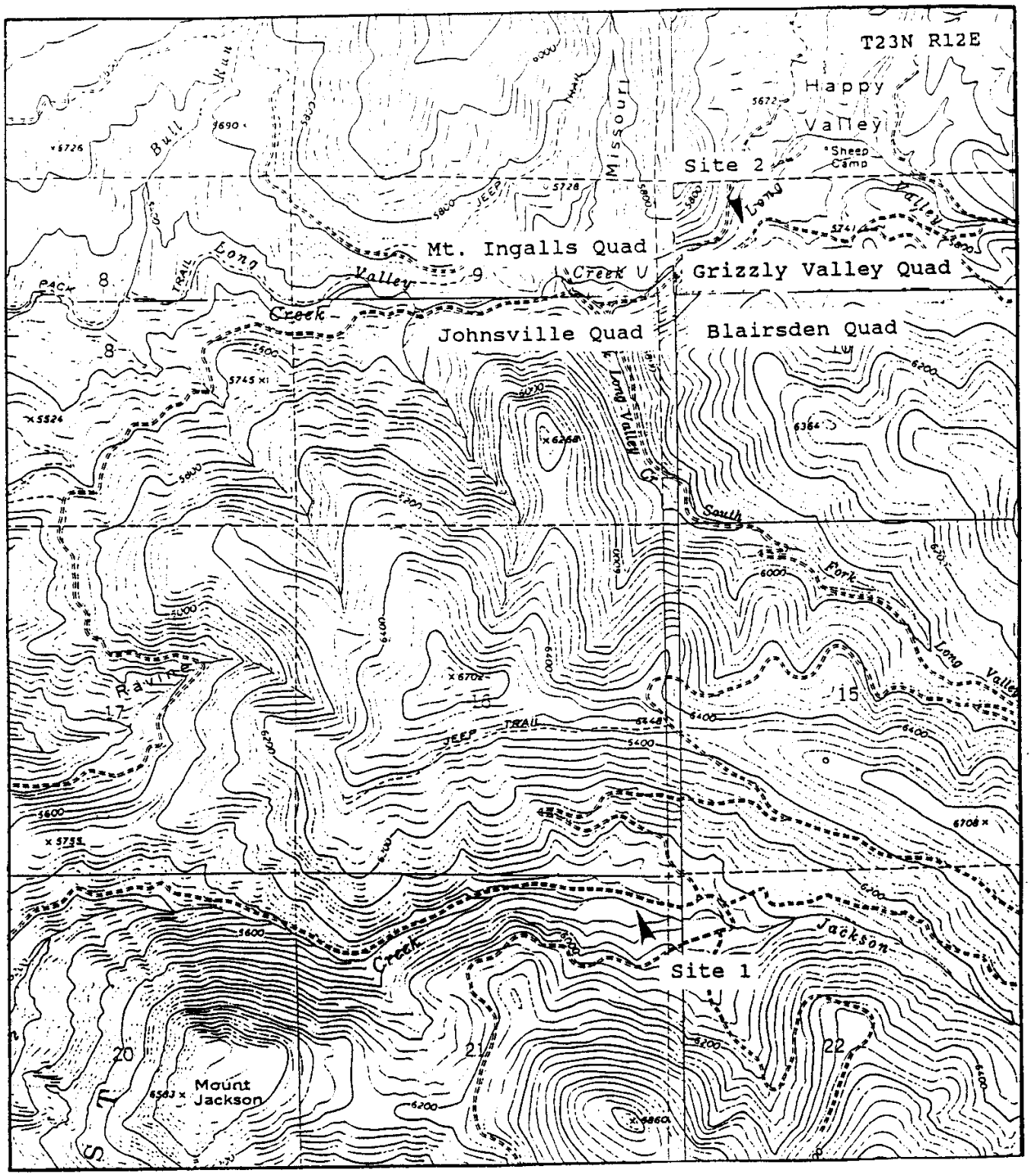


Figure 2. Site 1, Jackson Creek and Site 2, Long Valley Creek

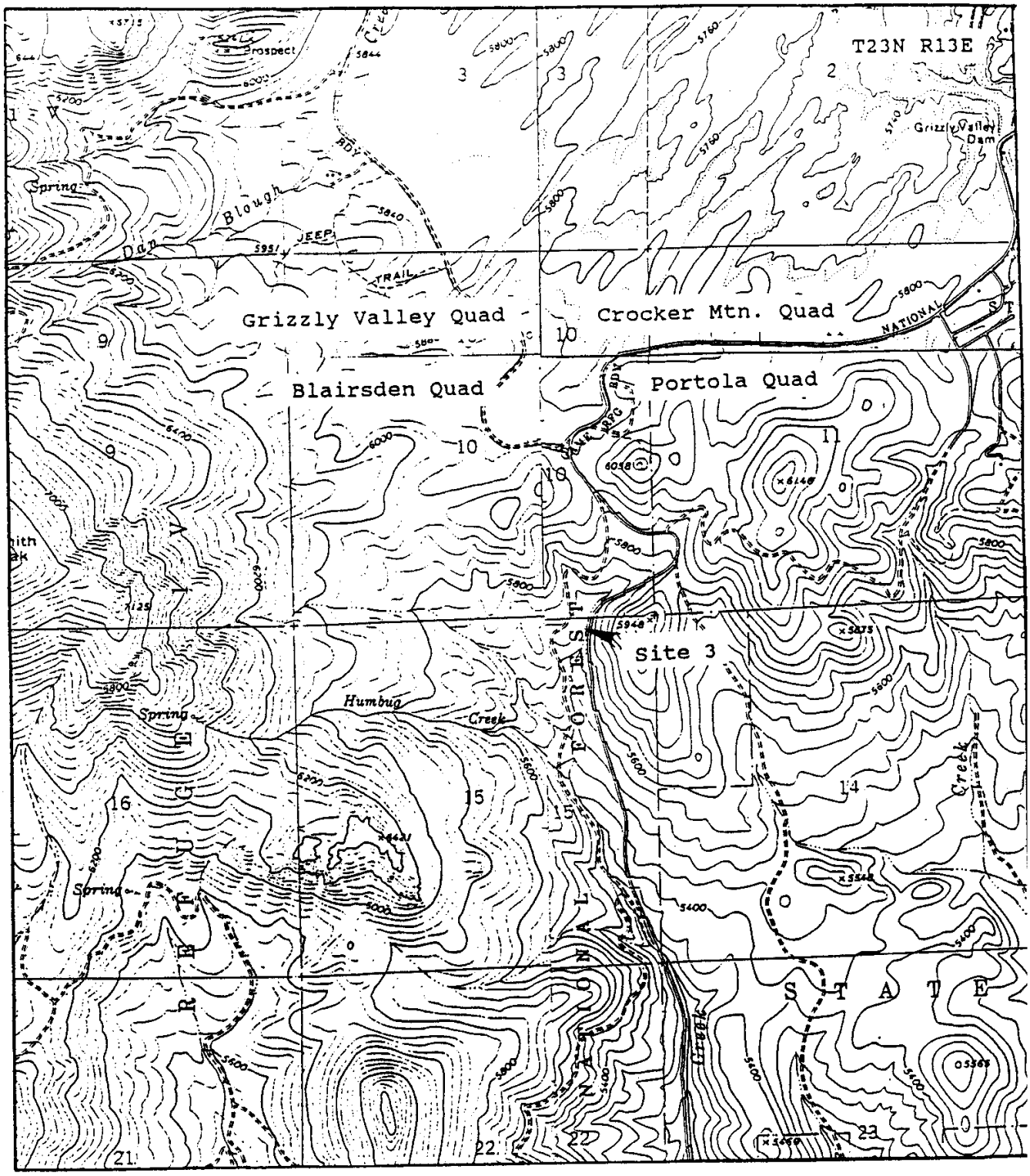


Figure 3. Site 3, Humbug Creek

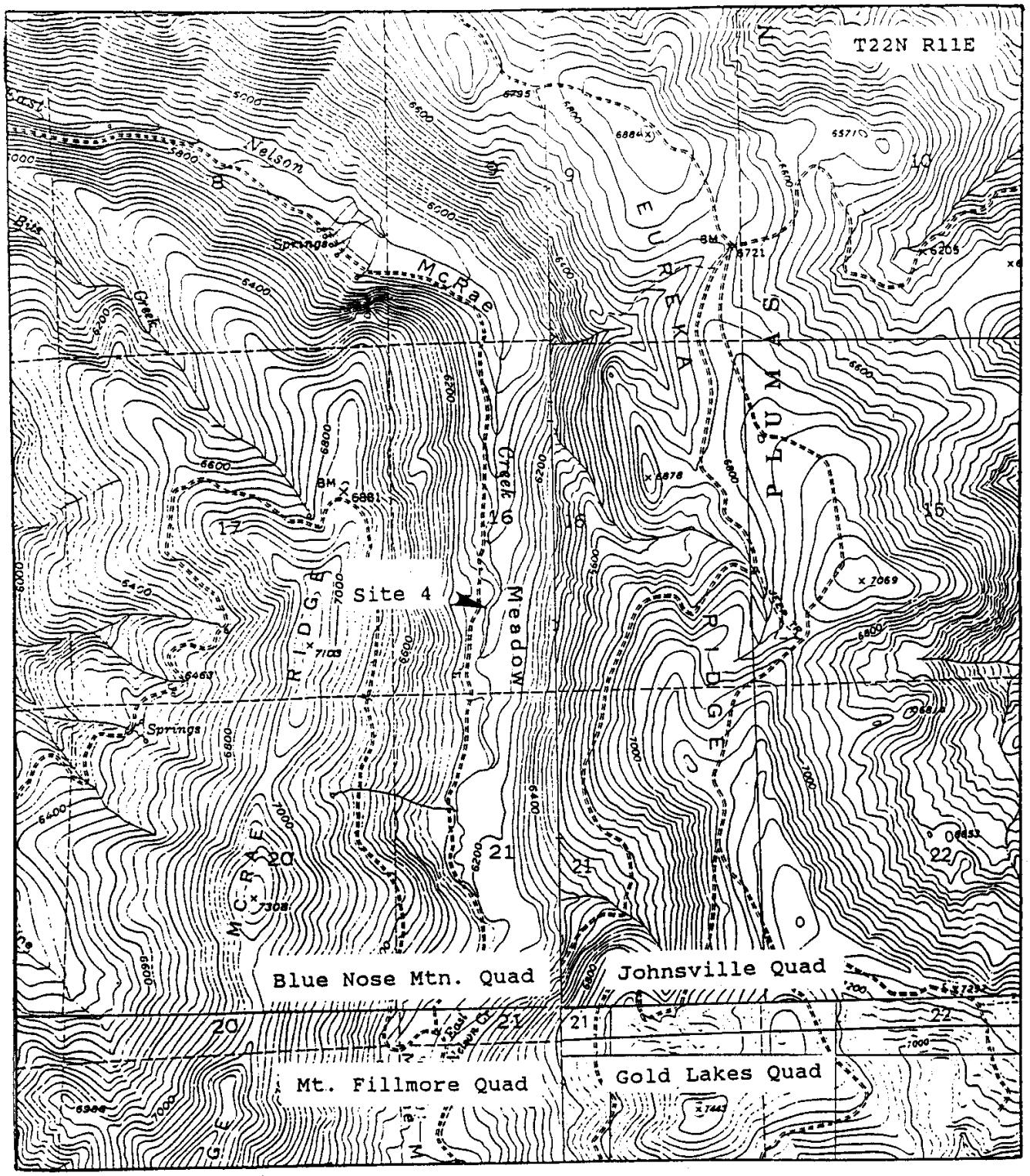


Figure 4. Site 4, McRae Meadow - Nelson Creek

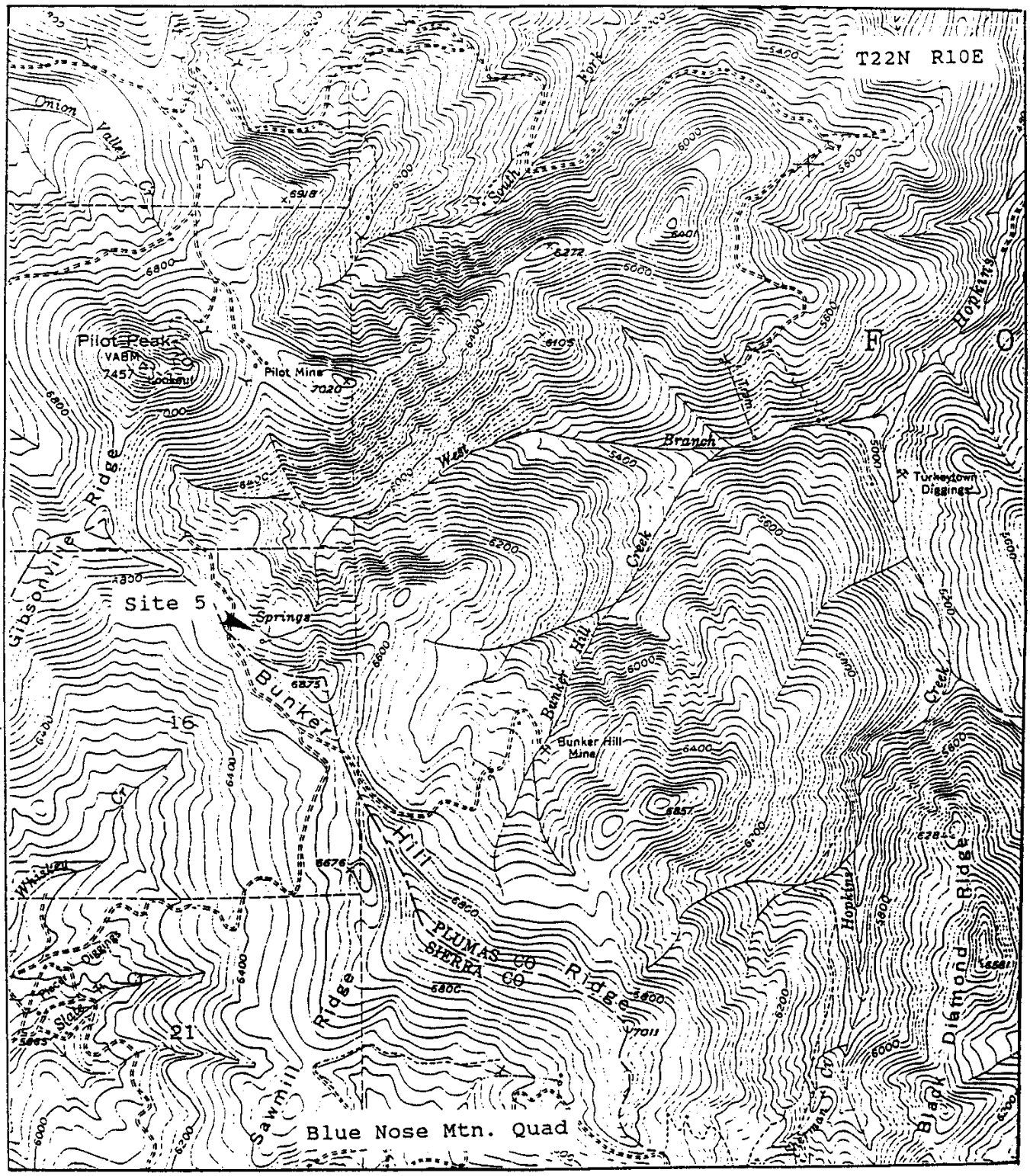


Figure 5. Site 5, Pilot Peak

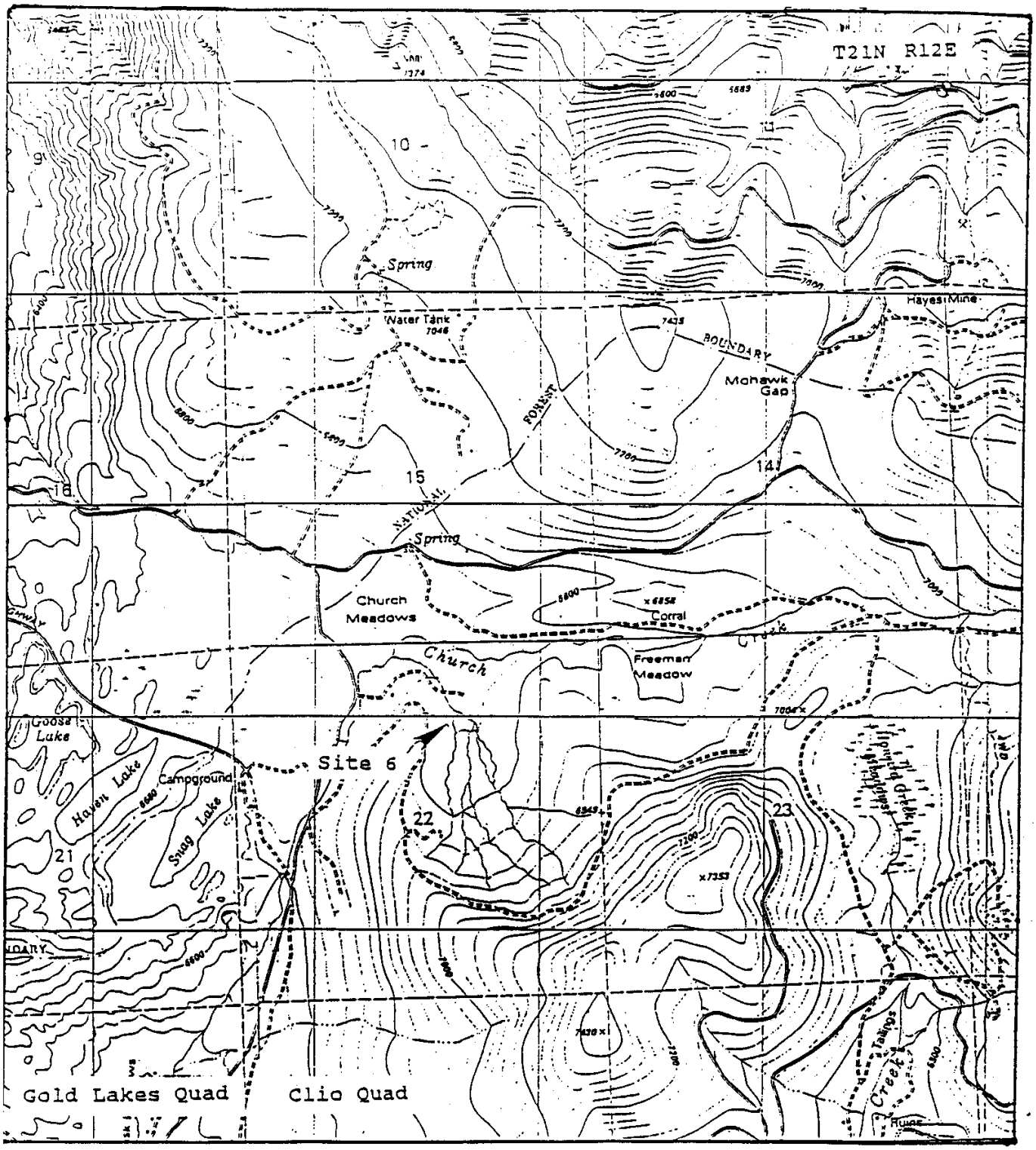


Figure 6. Site 6, Church Creek

All sites chosen were meadow edges, adjacent to streams. Transect areas were fairly flat where snow could accumulate and each site had a fairly distinct meadow edge. Two transects, labelled A and B, were set up at each site. These varied from 30 feet to 200 feet apart. Each transect is 30 feet long, starting from within the meadow and running into the adjacent dry meadow. The midpoint lies along the transition from wet to dry meadow areas. Permanent flagged markers were set at either end of the transects. Taller vegetation adjacent to the transect was also flagged to facilitate finding the exact location.

Physical and ecological data were collected for each site. Elevation, exposure, slope steepness, and a soil description were determined for each site, as well as plant community types. Photographs were taken of each transect.

All vegetation rooted within 6" of each side of the tape measure was recorded at one foot intervals. Plants were identified to the most specific taxonomic level possible. Some plants were not at a suitable phenological stage for identification at the time of the measurements. Plants were identified using the Jepson manual (Hickman 1993), Munz and Keck (1968), and Weeden (1981).

RESULTS

Sensitive Plant Species

A list of sensitive plant species that potentially occur within the project area was compiled using the California Natural Diversity Database's RAREFIND (1994) and the California Native Plant Society's (CNPS) "Electronic Inventory" 1994. Potential species are listed in Table 1. No sensitive plant species were found within the study sites. *Carex* specimens, however, were not identified to the specific level.

Vegetation Monitoring

No measurable trends were observed on the study plots (sites 1 through 4) vs. the control plots (sites 5 & 6). Additionally, no obvious trends were observed overall among all the species at each site.

The following section will include a discussion of trends observed in meadow perennial species over the four year study period at each site. Each plot included a 30-foot transect. Data were collected at one-foot intervals, with #1 at the wet end, and becoming a gradually drier meadow at #30. Numbers given will refer to the actual foot location along the transect (e.g. a plant at foot #2-4 would be a wet meadow species, and one at #25-30 would be tolerant of drier sites). Plants found only in the middle may be tolerant of varied conditions, but neither extreme moisture nor extreme drought. The following results show only the distribution of plant species along the transect. Refer to Appendix A for a complete data set (1994). Physical biotic data for each study site are presented in Appendix B. Photographs of each transect are contained in Appendix C.

Species	Status Fed/State/CNPS	Quads	Flowering dates	Habitat/Elevations
Carex lasiocarpa Slender sedge	/ / 2	Gold Lake	June & July	Lakes, pond shores, standing water, marshes & swamps 1800 - 2100 m
Carex sheldonii Sheldon's sedge	/ / 2	Crocker Mountain Grizzly Valley	Aug.	Mesic lower montane coniferous forests & riparian scrub. 1200 - 1500 m
Epilobium luteum Yellow willowherb	/ / 2	Blue Nose Mtn.	July - Sept.	Streams & seeps of lower montane coniferous forests, moist meadows ± 1500 m
Ivesia aperta var. aperta Sierra Valley ivesia	C2/ /1B	Portola Reconaissance Peak	June - Aug.	Dry meadows Lower montane coniferous forests 1500-2300 m
Ivesia sericoleuca Plumas ivesia	C2/ /1B	Haypress Valley Crocker Mtn. Portola Reconaissance Peak	May - Sept.	Vernally mesic meadows, usually volcanic 1500-2200 m
Lupinus dalesiae Quincy lupine	C3c/ /1B	Mt. Fillmore Laporte	May - Aug.	Upper & Lower montane coniferous forests - often disturbed. 1000 - 2500 m
Marsilea oligospora Nelson's pepperwort	/ / 3	Mt. Ingalls Johnsville	July - Aug.	Marshes 1400 - 2000 m
Scirpus subterminalis Water bulrush	/ / 2	Onion valley Gold Lake	July - Aug.	Marshes, swamps, lake margins 750 - 2250 m
Scuttelaria galericulata Marsh skullcap	/ / 2	Blairsden	June - Sept.	Mesic meadows, lower montane coniferous forests, marshes & swamps 1000 - 2100 m
Senecio hydrophiloides Sweet march ragwort	/ / 3	Crocker Mtn. Mt. Ingalls	May - July	Lower montane coniferous forests, Mesic meadows. 1500 - 2800 m
Silene invisa Short-petaled campion	C3c/ / 4		July - Aug.	Edges of subalpine coniferous forests, open areas 900 - 2800 m
Veronica cusickii Cusick's speedwell	/ / 4		July - Aug.	Meadows, Seeps, subalpine & upper montane coniferous forest openings < 3000 m

Table 1. Potential Sensitive Plant Species Within the Transect Study Sites

Transect 1A

The distribution of Elymus glaucus, a perennial grass usually found in open areas, stayed relatively constant throughout the four years. Potentilla glandulosa, a plant of moist and rocky places, also showed no significant changes. Deschampsia elongata, a plant of wet, shady places, increased from only a small area in 1991 at 12-13 feet to scattered from #21-29 in 1994. Elymus elymoides (formerly named Sitanion hystrix) which is found in dry, open areas, showed little change over the 4 years. In 1991, '92, and '94, it was found around feet #18-20. However, in 1993, a relatively wet year, it was found spreading over a larger area, from #16-25. Veratrum californicum, a plant of moist meadows, was found relatively constant at #0-9 throughout the project.

Transect 1B

Abies concolor seedlings remained more or less constant over the 4 years at #12-16. Apparently a new one sprouted, however, at #21-26 in 1992 through 1993 but was gone in 1994. Potentilla glandulosa was found at the same areas throughout 1991-1993 at #9-16 but was only found at #13-17 in 1994. Pyrola asarifolia (formerly P. californica) increased slightly from #6-11 in 1991 to #4-13 in 1994. Thalictrum fendleri, a plant of moist forests, also increased slightly from #5-14 in 1991 to #7-17 in 1994. Ribes, a shrub of forests and streams, showed no major changes.

Transect 2A

A plant of wet meadows, Sidalcea oregana, was found at #3-13 in 1991, but at only #3-9 in 1992. Equisetum, a plant found in both moist and disturbed areas, showed no significant changes over the four years. Perideridia parishii, a plant tolerant of moist conditions, was found between #0-4 for the first 2 years and then was not found in 1993 and 1994.

Transect 2B

Delphinium nuttalianum, usually found in open areas, meadows and streamsides, appeared in 1994 at #18-24. Additionally, Paeonia brownii, a plant of dry forest openings, appeared in the dry edge of the transect, #28, in '93 and '94. Sidalcea, found at #5-8 in 1991, increased gradually to 1-8 in 1993 and 1-14 in 1994. Equisetum stayed constant. Thalictrum fendleri was found at #0-1 in 1991 and `94 but was not found in '92 and '93. Viola was found at the wet edge of the transect in '91 to '93 but not in '94. New conifer seedlings (unidentifiable to genus and species) were found in '91 and '92 but disappeared in '93 and '94.

Transect 3A

Stachys, a plant found in moist areas, varied from #7-11 in 1991 and 1992, and was found in slightly drier areas in 1993 (#14-15); and in 1994 (#13-18). Viola was found from #0-12 in 1991 and increased to #0-16 in 1993, and was found only intermittently in this area in 1994. Achnatherum lemmonii (formerly Stipa), a plant of dry sites, was found in the driest part of the transect in 1992 and in slightly wetter areas, #24-25, in 1994. Cirsium vulgare was found at #9-14 in 1991, increased to #17 in 1992, was found at only #11 and #12 in '93, and was found scattered loosely through #0-15 in 1994. Wyethia was found only at the end of the dry areas in 1991-93 (#29-30) but was no longer present in 1994. Veratrum californicum was found throughout a constant area #0-13 in 1991-93, but only intermittently in 1994.

Transect 3B

Transect 3B was re-established in 1992 because the site used in 1991 was heavily disturbed during construction of a livestock watering trough. Sidalcea oregana was found at #0-3 in 1992 and 1993, and at #1-6 in 1994. Mertensia ciliata, a plant of saturated conditions, showed no change from 1992-1994. Bromus tectorum, a grass of open and sometimes disturbed sites, was found throughout #12-30 all three years, but was more scattered in 1994. Hordeum brachyantherum was found at #16 in 1992 but was found only at #0-11 in 1994.

Transect 4A

Perideridia parishii was found with no changes throughout the four years on most of the transect. Veratrum californicum was found from only #12-17 in 1991, and 1992; in 1993 was at #6-18 and in 1994 at #7-14. Sidalcea oregana was at #29 in 1991 and `93 but was gone in `92 and `94. Stachys showed no changes.

Transect 4B

Sidalcea oregana was found at #0-15 and #26; increased in '92 and '93, and was found in '94 only at #0-16 and #21-28. Perideridia parishii was found relatively constantly between #0-8 for the four years, except in 1992 only at #5-7. Potentilla gracilis was found at #6-8 and #15-21 and remained constant throughout the study. Polygonum douglasii, a plant of drying places, was found from #0-10 and #15-30 in '91, to throughout #0-30 in 1993, to #0-6 and #16-30 in 1994. Navarretia divaricata, a dry meadow plant, was absent from the transect in 1991-1993 but appeared at #30 in '94.

Transect 5A

Abies seedlings were found from #27-30 in 1991, scattered from #3-30 in 1992, dwindled to #15 and #23-29 in 1993, and only from #25-29 in 1994. Perideridia parishii was found only at #8 throughout the study but disappeared in 1993. Veratrum californicum was found between #2-7 throughout 1991-93 but was not found in 94. Ranunculus and Erythronium purpurascens stayed constant through the project period.

Transect 5B

Aster occidentalis was found consistently at 0-20' throughout the project. Monardella odoratissima increased slightly from about #15 in 1991 to #8-15 in 1993, then down to #14-17. Sidalcea glaucescens was found at #6-30 in 1991-1993, and was found in slightly wetter parts of the transect in 1994 (#2-30). Achnatherum occidentalis ssp. californicum (formerly Stipa californica) remained constant from #16-30. Veratrum californicum was found throughout the four years from #0 to 16-18 feet.

Transect 6A

Hordeum brachyantherum was found scattered along the transect all four years, increasing in 1992 and more scattered in 1994. Perideridia parishii was found throughout #0-20 through the project, but was more scattered in 1993 and 1994. Veratrum californicum stayed the same, around #1-3. Sidalcea oregana had a greater change; scattered widely from #5-19 in 1991 and 1993, but only at #8 in 1994. Viola was at #7-8 in '91-'93 but was not found in 1994.

Transect 6B

Potentilla gracilis was found at #29 in '91 but disappeared in '92-'94. Sphenosciadium was found at the wetter areas #3-4 in 1991 and 92 but was gone in '93-'94. Veratrum californicum stayed at the same intervals during the project. Sidalcea oregana was found only at #0-1 in 1991, was scattered loosely from #8-30 in 1992, 93 from #1-24, and in 1994 was found to a lesser extent at #1, #8, and #22-23. Hordeum brachyantherum changed most significantly from #0-3 in 1991, #10-14 in 1992, but then was scattered at points from #0-30 in 1993 and 1994. Pedicularis, usually in moist sites, also increased from the beginning of the transect in 1991, to #0-7 in 1994. Penstemon heterodoxus appeared in the dry part of the transect only in '93 and '94. Finally, Perideridia parishii was found from #0-11 in 1991, additionally at #18 in 1992, decreased to #0-12 (scattered) in 1993, and was found from #0-13 and in a dry area (#28-29) in 1994.

DISCUSSION

As shown in the results, several of the species found at the six sites varied over the four years, but no overall trend of wet or dry meadow species changing significantly in distribution was observed among the six transects. Similarly, no overall trends were observed in the four study plots (sites 1-4) vs. observations at the two controls (sites 5 and 6). Variations in specific perennial species will be discussed here, when they might be indicators of more wet or dry conditions. Facultative species, which are found over a wider range of conditions (e.g., *Achillea lanulosa*, found in both moist and drier areas) will not be discussed.

Transect 1A

Changes were observed in *Deschampsia elongata*, which was found in the moist meadow end of the transect in 1991, while by 1994, was found in the dry end. This suggests the possibility of greater water availability at the dry edge of the meadow in the later years of the study. No significant changes were observed in other species. *Veratrum californicum*, a wet meadow species, showed no changes.

Transect 1B

Abies concolor seedlings, found in the dry meadow, disappeared in 1994. This may have been due to a variety of reasons and is probably not related to a change in water availability. Yet *Potentilla* was distributed along drier parts of the meadow in 1994, as were *Thalictrum* and *Pyrola* which moved slightly into the dry parts. These trends suggest more water availability in the dry parts of the meadow, though various other factors may have contributed to the spread of these plants.

Transect 2A

Perideridia parishii, usually found in moist conditions, disappeared from the transect in 1993 and 1994. *Sidalcea oregana* also was found in a slightly drier area in 1992. Although this could have been due to limited moisture availability, it is likely other factors could have contributed as well.

Transect 2B

Both *Delphinium nuttalianum* and *Paeonia brownii* appeared in the drier parts of the transect in 1994 (*Delphinium* was present in 1993). Since *Delphinium* is a wet meadow species and *Paeonia* is of dryer areas, this shows no significant trend, *Sidalcea* increased gradually into both the wet and dry areas. *Thalictrum*, *Viola*, and the conifer seedlings disappeared at the end of the project. None of these species show an overall significant trend towards more or less water availability in either transect 2A or 2B, and these changes in species distribution may be due to other factors.

Transect 3A

Stachys, usually found in moist areas, spread into the dry areas of the transect in 1993 and 1994. Viola was also found in the progressively drier edges of the meadow from 1991 to 1993, but decreased in 1994. Wyethia, however, disappeared from the dry areas of the transect. Veratrum californicum decreased in frequency over the project period.

The only overall trend observed on this transect was the movement of the first two moisture-loving species into drier areas of the transect. This may have been due to a variety of factors, although a change in the amount of moisture availability may have been a contributing factor to the wider distribution of these plants.

Transect 3B

Sidalcea increased in distribution along the transect line during the project period. There were no significant changes on this transect overall which would point to any common trend of wetter or drier conditions.

Transect 4A

Veratrum increased slightly in the wetter parts of the transect during the project. Sidalcea was only present at the dry end of the transect in 1991 and 1993 but was not present in 1992 and 1994. No obvious trends in species distribution were observed on this transect.

Transect 4B

Sidalcea increased in 1992 and 1993 through much of the first two-thirds of the transect, but in 1994, decreased to near 1991 frequencies. Polygonum douglasii did the same, increasing until 1993, then decreasing along the line in 1994. Navarretia, however, appeared in the dry end of the transect in 1994. No significant trends were thus indicated overall in either Transect 4A or 4B during the project.

CONTROL PLOTS

Transect 5A

There were many new Abies seedlings in 1992, but these dwindled during the following years. Perideridia was found at one interval (#8) during the project but was not found in 1993. Veratrum californicum disappeared in 1994. The disappearance of these plants from isolated areas of the transect is most likely due to various environmental factors and not directly due to any changes in water availability. The Abies seedlings, which decreased in 1993, probably were not responding directly to water availability. Since 1993 had been a very wet year, they may have been affected by some other factor.

Transect 5B

Monardella increased in distribution during 1992 and 1993, but decreased in 1994. No significant trends were therefore displayed in this transect.

Transect 6A

Hordeum brachyantherum increased slightly through 1991 to 1993, but was more scattered in 1994, which was a drier year. Sidalcea showed the greatest change on this site - it was scattered from #5-17 in 1991-93, but was only at #8 in 1994. Viola disappeared in 1994. The trend overall on this transect was of fewer species and a lowered frequency of these species in 1994. This trend may have been due to 1994 being a drier year overall.

Transect 6B

Potentilla and Sphenosciadium were present at the beginning of the project, but disappeared in 1993 and 1994. Sidalcea, which increased during the wetter year of 1993, decreased somewhat in 1994. Hordeum brachyantherum, however, increased over most of the transect during these years. Pedicularis increased over the project time span. Penstemon appeared in the dry meadow side of the transect in 1993-94. Some moisture-loving plants, especially Potentilla, Sphenosciadium, and Sidalcea, showed a general trend of decreasing in the drier year of 1994. Pedicularis, "Pedic, also a moisture loving plant however,..." also a moisture-loving plant however, increased during the same period. Therefore, no overall trend was shown in transect 6B. An increase in the frequency and diversity of plants may have been due to the much greater rain availability in 1993, in contrast to the preceding years of drought in California. Some plants decreased during the summer of 1994 which was drier overall in the north state.

This vegetation monitoring project took place over a time span that had significant changes in precipitation pattern and accumulation in the Sierra Nevada overall. 1991 and 1992 were near the end of a seven-year drought cycle. The winter and spring of 1993 were in contrast very wet, with a much higher than average accumulation of snow, which remained well into early summer in some places. 1994 was a drier year, with less snow accumulations in the Sierra. Additionally, there was lower than average precipitation in the winter of 1994, with much of the precipitation for that year occurring during the month of March. These extreme variations in widespread rainfall pattern probably influenced the vegetation on the transects more significantly than any possible changes in precipitation pattern and accumulation from the cloud seeding project.

As shown in the results, no significant overall differences in the frequency of certain species were observed in the four study sites (sites 1-4) vs. the controls (sites 5 and 6). Additionally, no significant changes were observed on any of the transects that would point to a major change in water

availability. The most apparent overall trend found was an increase in species diversity and at times species distribution on all six transects during 1993, a much wetter than average year, and slightly fewer species and more limited distribution in 1994. At several sites, plant frequency increased during the first three years of the project (as snow accumulation increased in the Sierra Nevada) and then decreased in 1994, which was a drier year than 1993 had been. Any significant changes which may have occurred due to the cloud seeding were less apparent than these changes potentially due to overall weather patterns.

Changes observed in single plant species during the project may have been due to a change in short-term water availability. But these changes additionally may have been due to a wide set of factors acting over the long term: soil chemistry and depth, species competition age of the plants, seed bank size and diversity, and genetic influences on plant species. Additionally, physical impacts such as grazing may have had long term effects on the condition of the vegetation community here. This study would have to be continued over a longer period to show more definitive results concerning changes in moisture pattern and availability.

Recommendations

As shown previously, variations in the transect vegetation may have occurred due to extreme changes in the pattern and accumulation of precipitation which occurred throughout the Sierra Nevada during the study period. No significant changes in species distribution were observed in the project study plots vs. the control plots, which may indicate there was no measurable effect on the vegetation due to cloud seeding alone. However, any effects resulting from the cloud seeding project may have been obscured by the overall change in precipitation pattern and accumulation.

Many other possible causes might affect vegetation pattern, and studies should be conducted over a longer time period to show definite results due to cloud seeding. Many combinations of differences in factors may contribute to species frequency and diversity in addition to moisture availability. These include differences in soil types and historical depth, species competition, and the historical condition of the vegetation community prior to the 1991 initiation of the study. Most of these factors have not been measured and are difficult to ascertain over the short term. In addition, plants may not respond immediately to any possible increased moisture from cloud seeding and results may not be apparent for several years. Studies need to be continued over a longer period of time to determine these effects.

Other studies which may yield information on changes in plant populations due to cloud seeding include measuring the vigor of a particular plant population: measuring its size, density, and reproductive success over several years. Additionally,

correlating these measurements of the vegetation community in the study area vs. the control plots during the cloud seeding period, together with accumulated precipitation data might yield more definite results.

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APPENDIX A

TRANSECT DATA
(1994)

Jackson Creek
Transect #1A
Summer 1994

DISTANCE IN FEET

SPECIES	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Achillea lanulosa				X	X	X		X	X				X	X	X		X				X			X	X					X
Aconitum columbianum	X	X	X	X	X	X																								
Aster sp.																X	X			X	X									
Bromus carinatus																X										X				
Bromus sp. (1)												X	X				X	X	X	X	X	X	X	X						
Carex sp. (1)		X			X	X		X	X					X		X	X													
Carex sp. (2)										X																				
Cryptantha affinis																						X	X			X	X	X		X
Cryptantha torreyana																	X	X	X	X		X	X			X	X	X	X	X
Deschampsia elongata																							X		X		X	X	X	
Elymus elymoides ssp. californicus																				X			X							
Elymus glaucus ssp. glaucus	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X												
Epilobium foliosum																			X											
Festuca sp.				X	X	X	X			X	X						X						X							
Gayophytum heterozygum																				X		X	X			X	X	X	X	X
Fragaria vesca								X		X																				
Geum macrophyllum	X																													
Gilia capillaris													X				X	X	X	X	X							X		X
Gnaphalium palustre									X								X													
Lotus purshianus var. purshianus																					X	X			X					
Lupinus sp.	X	X		X	X	X	X			X																				

Jackson Creek 1A 1994

SPECIES	DISTANCE IN FEET																													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Mimulus breweri																					X									
Mimulus primuloides ssp. primuloides			X	X	X	X																								
Perideridia parishii					X																X			X						
Poa pratensis ssp. pratensis	X	X	X	X	X	X	X	X		X	X	X	X	X	X															
Polemonium occidentale	X	X	X																											
Polygonum douglasii																	X					X	X							
Potentilla glandulosa ssp. nevadensis						X	X	X	X					X	X															
Sanicula tuberosa																						X								
Senecio triangularis	X	X	X	X	X																									
Sidalcea oregana ssp. spicata							X			X	X	X																		
Stellaria longipes var. longipes		X		X	X	X		X		X																				
Taraxacum officianale				X	X	X	X	X	X	X	X	X	X																	
Trifolium cyathiferum				X		X	X	X	X	X		X																		
Trifolium kingii var. productum																					X				X					
Trisetum canescens												X																		
Veratrum californicum	X	X			X	X			X																					
Veronica serpyllifolia ssp. humifusa			X	X	X																									
Moss																	X				X									
Unknown #1 (Poaceae)				X																										
Unknown #2 (seedling)	X																													

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Jackson Creek
Transect #1B
Summer 1994

DISTANCE IN FEET

SPECIES	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Abies concolor (seedling)														X	X	X			X											
Achillea lanulosa										X	X	X	X		X		X													
Aconitum columbianum	X	X	X	X	X	X	X		X																					
Aster sp. seedling														X																
Calamagrostis canadensis				X	X	X			X	X		X	X		X															
Carex sp. (1)	X	X		X	X	X	X	X	X	X	X	X																		
Cornus sericea ssp. sericea	X																													
Elymus glaucus ssp. glaucus																		X												
Epilobium angustifolum ssp. circumvagum					X	X	X		X	X	X	X	X	X																
Festuca occidentalis																					X	X								
Fragaria vesca										X		X	X		X															
Galium triflorum	X					X	X	X			X	X																		
Geum macrophyllum										X																				
Hieracium albiflorum																	X	X	X	X	X									
Lupinus sp. (1)				X		X		X	X		X	X	X	X					X											
Lupinus sp. (2)																	X	X	X	X			X	X						
Osmorhiza chilensis												X	X		X	X		X	X											
Panicum capillare		X	X					X	X																					
Poa sp.																		X		X				X						
Potentilla glandulosa ssp. nevadensis												X	X			X	X													
Pyrola asarifolia ssp. asarifolia *				X	X	X	X	X	X	X	X	X	X																	

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Jackson Creek 1B 1994

SPECIES	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Ribes inerme													X																	
Senecio triangularis	X	X	X	X			X	X	X																					
Smilacena stellata		X	X	X																										
Stachys ajugoides var. rigida			X	X			X																							
Stellaria borealis ssp. sitchana															X						X	X		X		X	X	X	X	X
Thalictrum fendleri								X	X	X	X		X	X	X		X													
Trisetum canescens						X	X				X		X	X			X	X	X					X						
Moss	X	X	X																											
Unknown #1 (Poaceae)													X					X	X	X			X							
Unknown #2 (Pinaceae)																						X		X	X					
Unknown #3 (seedling)																													X	
Unknown #4 (seedling)	X	X	X	X	X	X	X	X																						

* = P. californica 1993

Long Valley
Transect #2A
Summer 1994

DISTANCE IN FEET

SPECIES	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Achillea lanulosa		X	X	X	X	X	X	X	X	X			X																	
Aster occidentalis var. occidentalis					X					X	X	X																		
Bromus orcuttianus															X			X	X	X	X	X	X				X	X		X
Castilleja miniata							X																							
Carex sp.(1)	X	X	X	X	X			X	X																					
Carex sp. (2)				X	X	X			X	X	X				X	X														
Carex sp. (3)					X																									
Cerastium fontanum ssp. vulgare	X			X																										
Collinsia parviflora													X					X	X	X	X	X	X	X	X	X	X	X	X	X
Cryptantha affinis																		X	X	X	X	X	X	X	X	X	X	X	X	X
Elymus glaucus ssp. glaucus									X	X		X	X	X	X	X	X	X	X											
Equisetum arvense		X			X		X				X	X	X	X	X	X	X	X	X	X	X		X	X		X				
Festuca sp.	X			X																										
Fragaria virginiana		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X													
Juncus sp.								X	X	X	X			X																
Lupinus sp.1		X		X		X		X			X	X	X	X	X			X												
Lupinus sp.2																								X						
Mimulus guttatus	X																													
Pinus sp.																														X
Platanthera leucostachys				X																										

Long Valley 2A 1994

SPECIES	DISTANCE IN FEET																													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Poa pratensis ssp. pratensis									X		X	X																		
Poa sp. (1)														X	X															
Polygonum bistortoides				X	X	X		X	X	X	X	X	X	X	X		X	X	X											
Polygonum douglasii																						X	X	X	X	X	X			X
Sphenosciadium capitellatum				X																										
Sanicula tuberosa																												X		
Saxifraga oregana	X																													
Sidalcea oregana ssp. spicata				X		X		X	X																					
Stellaria longipes var. longipes																			X	X					X	X	X		X	
Taraxacum officianale		X	X	X	X		X																							
Trifolium sp.	X		X																											
Veratrum californicum		X	X	X																										
Unknown #1 (Castilleja)	X	X																												
Unknown #2 (Lamiaceae)		X	X											X		X	X													
Unknown #3 (Asteraceae)	X	X	X	X	X										X	X	X	X												
Unknown #4 (Poaceae)			X																											

Transects 2A and 2B both very disturbed by hiking, other human activities.

Long Valley
Transect #2B
Summer 1994

DISTANCE IN FEET

SPECIES	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Achillea lanulosa	X	X	X	X	X	X			X	X	X	X				X	X													
Agoseris sp.	X																													
Allium sp.																						X	X							
Barbarea orthoceras						X	X	X	X																					
Bromus orcuttianus											X		X	X	X	X	X	X	X	X	X									
Carex sp.(1)	X	X	X	X	X	X																								
Carex sp.(2)		X		X	X		X	X	X	X	X	X	X	X																
Cerastium glomeratum															X	X	X	X	X											
Collinsia parviflora								X						X		X	X	X	X	X			X	X	X	X				
Delphinium nuttalianum																			X	X	X	X	X		X					
Elymus glaucus ssp. glaucus			X		X		X	X				X																		
Equisetum arvense					X				X				X																	
Festuca sp.						X																								
Fragaria virginiana	X	X	X	X	X	X	X		X		X																			
Gilia capillaris																				X	X	X								
Ligusticum californicum																		X												
Linanthus sp.																				X	X	X	X	X	X	X	X	X	X	
Lotus purshianus var. purshianus												X	X		X	X	X	X	X	X	X	X		X	X		X		X	X
Nemophila pedunculata								X	X																					
Paeonia brownii																													X	
Perideridia parishii ssp. latifolia																		X		X								X		
Poa pratensis ssp. pratensis	X		X	X	X	X	X	X	X	X	X	X		X	X	X		X												
Polygonum bistortoides	X		X	X	X	X	X	X	X																					
Polygonum douglasii var. douglasii							X									X				X	X	X	X	X	X	X	X	X	X	X
Potentilla glandulosa												X	X																	

Long Valley 2B 1994

SPECIES	DISTANCE IN FEET																												
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Sanicula tracyi																			X	X	X	X			X			X	X	X
Sidalcea oregana ssp. spicata	X	X	X		X	X	X	X							X															
Stellaria longipes var. longipes		X																												
Thalictrum fendleri var. fendleri	X	X																												
Trifolium longipes var. nevadense	X		X	X	X	X	X	X	X	X	X	X	X																	
Cuscuta sp. (on P. bistortoides)							X																							

Humbug Creek
Transect # 3A
Summer 1994

DISTANCE IN FEET

SPECIES	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Achillea lanulosa	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
Achnatherum lemmonii																												X	X	
Agoseris sp.		X													X										X	X				
Agrostis sp.	X	X		X	X		X	X	X	X	X	X	X						X	X										
Aster occidentalis var. occidentalis			X	X		X	X	X		X	X	X	X		X	X	X	X												
Bromus tectorum																			X	X	X	X	X	X	X			X	X	X
Carex sp. 1	X	X	X	X	X				X				X	X																
Carex sp. 2			X	X	X	X	X	X	X	X	X	X			X															
Carex sp. 3															X															
Chrysothamnus nauseosus																											X			
Cirsium douglasii var. breweri								X																						
Cirsium vulgare	X		X		X				X							X														
Collinsia parviflora																		X		X	X	X		X						
Collomia grandiflora																	X	X	X	X					X	X	X	X		
Cryptantha torreyana																		X	X	X	X			X	X	X	X	X	X	
Elymus glaucus ssp. glaucus																								X	X			X	X	X
Epilobium sp.																										X				
Equisetum arvense						X			X																					
Gilia capillaris																					X	X	X	X	X	X	X	X	X	X
Juncus sp.	X	X	X	X	X	X	X	X	X	X			X	X	X	X														
*Lactuca serriola**	X	X	X						X	X	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X	X	X	X

Humbug Creek 3A 1994

DISTANCE IN FEET

SPECIES	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Lotus purshianus var. purshianus																	X	X		X				X	X	X				
Madia gracilis																				X	X	X	X	X	X	X	X	X	X	X
Mimulus guttatus						X				X	X	X						X												
Myosotis discolor	X		X		X	X	X	X	X	X	X	X	X	X																
Pinus jeffreyi (seedling)																		X												
Cryptantha sp.					X			X	X																					
Poa pratensis ssp. pratensis		X	X	X		X		X		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X
Ranunculus occidentalis																			X											
Sidalcea oregana ssp. spicata				X	X	X	X	X									X													
Stachys ajugoides var. rigida													X					X												
Stellaria longipes var. longipes					X		X		X						X															
Achnatherum occidentalis																												X	X	
Trifolium microcephalum	X																	X	X	X	X		X							
Trifolium wormskioldii										X																				
Veratrum californicum	X	X	X		X						X	X	X	X																
Veronica serpyllifolia ssp. humifusa						X	X	X	X																					
Verbascum thapsus	X					X	X													X		X		X	X				X	
Vicia americana var. americana																	X	X	X	X	X	X		X	X	X				
Viola adunca	X						X	X	X	X	X	X	X																	
Unknown #1	X																													
Unknown # 2	X						X									X														
Unknown #3 (Asteraceae)																			X											

* = L. serriola var. integra

Humbug Creek
Transect #3B
Summer 1994

DISTANCE IN FEET

SPECIES	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Achillea lanulosa	X	X	X	X	X	X	X	X	X			X																		
Agoseris elata	X	X					X	X																						
Agoseris heterophylla														X		X		X	X	X	X		X	X	X	X	X	X	X	X
Agrostis pallens										X	X	X																		
Aster sp.										X	X	X																		
Bromus japonicus												X		X	X	X					X									
Bromus tectorum													X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X
Carex sp. (1)	X	X		X	X	X	X	X	X	X	X																			
Carex sp. (2)				X		X	X	X	X	X	X																			
Carex sp. (3)										X	X	X																		
Cirsium douglasii var. breweri						X	X																							
Cirsium vulgare	X		X				X				X	X					X						X	X	X					
Collinsia parviflora														X	X	X			X					X	X	X	X	X	X	X
Elymus glaucus ssp. glaucus													X												X		X	X	X	X
Epilobium brachycarpum															X		X				X			X	X		X	X	X	X
Equisetum arvense				X				X	X	X	X		X	X	X	X				X	X		X	X		X		X		
Erodium cicutarium																	X			X	X			X						
Gilia capillaris																	X	X	X	X	X	X	X	X	X		X		X	X
Hordeum brachyantherum	X	X		X	X	X	X	X			X																			
Eleocharis sp.									X																					
Lactuca serriola *												X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
Lotus purshianus var. purshianus											X						X	X	X	X							X		X	X

Humbug Creek 3B 1994

SPECIES	DISTANCE IN FEET																												
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Madia gracilis														X	X	X	X	X	X			X	X	X	X	X	X	X	X	
Mertensia ciliata	X	X	X	X	X																									
Mimulus floribundus					X	X																								
Mimulus guttatus							X	X	X	X	X																			
Poa pratensis ssp. pratensis	X	X	X			X	X		X	X			X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
Rumex acetosella													X	X	X		X	X	X		X	X	X	X	X	X		X	X	X
Sidalcea oregana ssp. spicata		X					X																							
Stachys ajugoides var. rigida	X	X	X	X	X	X	X	X		X			X																	
Trifolium microcephalum											X			X																
Trifolium variegatum							X	X	X	X	X																			
Veratrum californicum							X																							
Verbascum thapsus																					X	X								
Veronica serpyllifolia ssp. humifusa									X	X																				
Viola glabella									X	X			X																	

* = L. serriola var. integra

Nelson Creek
Transect #4A
Summer 1994

DISTANCE IN FEET

SPECIES	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Achillea lanulosa																													X	X
Agoseris heterophylla																								X						X
Agrostis sp.										X	X	X					X	X		X	X									
Aster occidentalis var. occidentalis	X	X	X	X	X	X	X	X			X				X	X	X	X	X	X	X	X	X			X	X			X
Barbarea orthoceras	X			X				X				X																		
Carex sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X														
Castilleja tenuis	X																						X							
Cerastium fontanum ssp. vulgare															X	X	X	X	X		X	X								X
Danthonia californica var. americana																						X								
Deschampsia cespitosa		X								X	X	X			X		X	X	X	X	X	X			X	X			X	X
Epilobium minutum							X		X	X	X	X	X							X	X			X		X		X		
Gayophytum heterozygum	X												X	X	X			X	X								X		X	
Gilia capillaris															X								X			X	X	X	X	X
Hypericum anagalloides				X		X			X	X		X	X				X	X	X	X		X		X						
Juncus sp.	X	X	X	X	X	X		X			X	X	X			X			X											
Lotus purshianus var. purshianus																X								X	X	X	X	X	X	X
Luzula subcongesta													X						X											
Mimulus moschatus	X	X	X	X	X	X		X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X	X	X
Mimulus primuloides ssp. primuloides	X	X		X	X			X		X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X	X	
Montia linearis	X		X			X	X	X	X	X	X	X	X	X																
Periderida parishii ssp. latifolia	X	X	X	X		X	X		X	X			X	X	X	X	X	X	X	X	X	X	X	X		X	X			X

Nelson Creek 4A 1994

SPECIES	DISTANCE IN FEET																													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Polygonum douglasii ssp douglasii																						X	X	X	X		X			
Polygonum douglasii ssp. johnstonii																												X	X	X
Potentilla gracilis var. fastigiata																														X
Ranunculus alismifolius var. alismellus						X	X	X	X	X	X	X		X			X	X												
Ranunculus occidentalis														X				X		X					X	X				
Rorippa curvisiliqua																						X								
Sagina saginoides										X	X			X			X		X				X	X				X		
Stachys ajugoides var. rigida	X	X	X	X	X	X	X	X	X	X			X	X		X	X	X	X	X	X		X	X	X		X	X		X
Stellaria longipes var. longipes	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X				X	X								X
Trifolium cyathiferum	X		X	X	X			X						X	X	X	X		X		X	X	X	X	X	X		X	X	X
Veratrum californicum							X						X	X	X			X												
Cuscuta sp. (on Juncus sp.)	X																													
Unknown #1- (Poaceae)	X			X																										
Unknown #2 - (Poaceae)				X	X				X																					
Unknown #3 - (Poaceae)								X	X																					
Unknown #4 - (Asteraceae)				X					X			X	X																	

Nelson Creek
Transect #4B
Summer 1994

DISTANCE IN FEET

SPECIES	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Achillea lanulosa							X	X	X	X	X	X	X			X	X		X	X	X					X	X	X	X	X
Agoseris heterophylla																			X						X					
Aster occidentalis var. occidentalis																							X							
Barbarea orthoceras																		X				X			X					
Carex sp.	X	X	X	X	X																									
Cryptantha sp.																				X	X					X		X	X	
Gayophytum racemosum																X	X	X				X	X	X	X	X	X	X		
Gilia capillaris																			X			X					X	X	X	
Heracleum lanatum														X																
Hordeum brachyantherum	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X												
Linanthus harknessii						X										X	X	X	X									X		
Lotus purshianus var. purshianus																X	X	X	X	X	X		X	X	X	X	X	X	X	X
Navarretia divaricata ssp. divaricata																														X
Perideridia howelli		X																												
Perideridia parishii ssp. latifolia	X		X	X	X			X																						
Phlox gracilis				X																										
Poa pratensis ssp. pratensis	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X								
Polemonium occidentale	X																													
Polygonum douglasii ssp. douglasii	X	X					X									X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Potentilla gracilis ssp. fastigiata							X	X												X	X	X	X	X						

Nelson Creek 4B 1994

SPECIES	DISTANCE IN FEET																												
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Ranunculus alsimifolius			X						X						X															
Ranunculus occidentalis								X								X	X	X												
Senecio triangularis		X		X				X																						
Sidalcea oregana ssp. spicata	X	X	X	X	X	X	X				X		X	X	X												X	X		
Stachys ajugoides var. rigida																				X										
Stellaria longipes var. longipes						X	X	X	X		X	X	X	X	X	X	X			X		X	X	X						
Trifolium sp.				X	X	X		X								X														
Veronica serpyllifolia ssp. humifusa			X		X	X	X																							
Unknown #1 (Poaceae)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X													
Unknown #2 (Ranunculaceae)	X	X							X				X				X													

Pilot Peak
Transect #5A
Summer 1994

DISTANCE IN FEET

SPECIES	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Abies (seedling)																										X		X		X
Agrostis sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X													
Aster sp.																			X											
Carex sp.												X			X															
Deschampsia elongata						X		X	X	X	X	X	X	X	X	X	X	X	X	X	X									
Epilobium hornemanii ssp. hornem	X	X	X	X	X						X	X		X	X		X		X											
Erythonium purpurascens																					X									
Galium sp.	X	X																												
Ligusticum grayi						X																								
Luzula sp.																X	X	X												
Mimulus floribundus	X		X		X																									
Perideridia parishii ssp. latifolia							X																							
Ranunculus alismifolius	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X												
Poa sp.														X	X	X	X	X			X				X	X	X	X		
Senecio triangularis	X	X																												
Stellaria calycantha						X	X	X	X	X	X	X	X	X	X															
Stellaria crispa	X	X	X	X	X	X	X																							
Trifolium breweri	X	X				X	X	X	X	X	X	X	X	X			X													
Veronica serpyllifolia ssp. humifusa										X																				
Moss																X	X	X	X	X	X	X	X	X	X	X	X			
Unknown #1 (Apiaceae)												X			X															

Pilot Peak
Transect 5B
Summer 1994

SPECIES	DISTANCE IN FEET																													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
*Achnatherum occidentalis ssp. californicum**																		X	X	X	X	X	X	X	X	X	X	X	X	X
Aster occidentalis ssp. occidentalis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X									
Aster sp.															X		X	X	X											
Bromus sp.										X		X		X		X	X	X								X	X	X	X	X
Collinsia parviflora																						X	X					X		X
Elymus glaucus ssp. glaucus					X													X												
Gayophytum heterozygum							X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X			X	X		
Gilia capillaris							X																							
Monardella odoratissima ssp. pallida														X	X	X														
Navarretia divaricata ssp. divaricata																														X
Poa pratensis ssp. pratensis															X	X		X												
Polygonum douglasii																									X			X		
Sidalcea glaucescens			X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Triteleia montana								X	X	X									X	X	X			X		X	X			
Veratrum californicum		X	X	X	X	X		X	X	X	X		X	X	X	X														
Cuscuta sp. (on Gayophytum sp.)																														

* = *Stipa californica (1992)*

Church Creek
Transect #6A
Summer 1994

SPECIES	DISTANCE IN FEET																													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Achillea lanulosa																										X				
Aster occidentalis ssp. occidentalis																						X	X	X	X					X
Carex sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X														
Castilleja tenuis																												X	X	
Deschampsia cespitosa																													X	
Epilobium halleanum								X			X	X							X											
Epilobium minutum																X	X	X	X			X		X						X
Gilia capillaris																			X		X	X	X			X	X	X	X	X
Gnaphalium palustre																			X											X
Hordeum brachyantherum		X	X					X	X	X	X		X					X	X	X	X	X	X				X			
Juncus sp. (1)													X		X	X	X													
Juncus sp. (2)																												X	X	
Lewisia nevadensis																X				X		X						X		
Madia gracilis																X	X	X		X		X	X	X	X	X	X	X	X	X
Mimulus breweri																	X		X	X	X									
Montia linearis																				X										
Muhlenbergia filiformis																								X	X	X	X	X		X
Perideridia parishii ssp. latifolia	X	X	X	X	X	X	X	X	X	X		X	X			X					X									
Plagiobothrys hispidulus																			X			X		X	X	X				X
Polygonum bistortoides	X	X	X		X				X					X	X	X	X	X			X		X		X	X	X	X		X
Polygonum polygaloides ssp. kelloggii																X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Church Creek 6A 1994

SPECIES	DISTANCE IN FEET																													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Ranunculus alismifolius				X	X	X	X					X		X	X		X	X			X						X	X	X	
Rorippa curvisiliqua																X									X				X	
Salix sp.	X																													
Sidalcea oregana ssp. spicata									X																					
Trifolium longipes var. nevadense	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Veratrum californicum			X																											
Unknown #1 (Poaceae)																							X	X						

Church Creek
Transect #6B
Summer 1994

SPECIES	DISTANCE IN FEET 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Achillea lanulosa	X	X	X	X	X				X	X	X	X	X	X					X		X			X			X	X	X	X
Agrostis sp. (1)									X				X	X		X	X	X		X	X							X		
Agrostis sp. (2)		X	X	X	X			X		X																				
Aster occidentalis var. occidentalis			X	X				X	X	X	X				X	X		X		X		X								
Aster sp.										X																X			X	
Carex sp. (1)	X	X	X	X	X	X	X	X																						
Carex sp. (2)				X	X		X	X			X	X																		
Carex sp. (3)										X	X	X	X	X	X	X														
Castilleja tenuis										X		X	X	X	X											X				
Deschampsia elongata											X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Dodecatheon alpinum				X	X	X	X																							
Epilobium minutum								X	X		X			X																
Epilobium sp.								X	X	X	X	X	X	X	X	X	X	X	X	X										
Galium sp.		X	X	X																										
Gayophytum sp.																														X
Gilia capillaris										X	X		X	X	X					X	X	X	X		X	X	X	X	X	X
Gnaphalium palustre																			X											
Hordeum brachyantherum	X	X	X							X				X	X	X	X					X	X		X					X
Hypericum anagalloides				X	X			X	X																					
Juncus sp. (1)							X	X	X	X	X																			
Lewisia nevadensis														X							X	X	X			X		X	X	

Church Creek 6B 1994

SPECIES	DISTANCE IN FEET																													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Ligusticum grayi			X	X	X				X																					
Linanthus harknessii								X								X	X	X		X	X	X	X	X	X	X	X	X	X	X
Madia gracilis									X								X	X			X	X	X	X	X	X	X	X	X	X
Mimulus primuloides ssp. primuloides							X	X	X	X	X																			
Mimulus floribundus								X																						
Montia linearis																														X
Pedicularis groenlandica	X	X	X	X				X																						
Penstemon heterodoxus																									X					
Penstemon rydbergii var. oreocharis					X																									
Perideridia parishii ssp. latifolia	X	X	X	X		X	X	X		X	X	X	X	X															X	X
Phleum alpinum		X	X										X																	
Pinus contorta (seedling)									X																					
Plagiobothrys hispidulus												X			X	X	X	X	X	X	X	X	X	X	X	X	X			
Polygonum bistortoides																								X	X					X
Polygonum douglasii																						X	X						X	X
Polygonum polygaloides ssp. kelloggii									X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ranunculus alismifolius			X					X			X				X	X	X	X	X		X							X	X	
Rorippa curvisiliqua												X	X			X	X											X		X
Senecio triangularis	X																													
Sidalcea oregana ssp. spicata		X								X	X											X	X							X
Spergula arvensis																							X	X						
Stellaria longipes var. longipes.	X		X		X		X		X																					
Trifolium longipes var. nevadense	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X			X				X	X	X		X	X	X	X
Veratrum californicum	X		X																											
Viola macloskeyi	X	X	X				X		X																					

Church Creek 6B 1994

SPECIES	DISTANCE IN FEET																													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Liverwort							X																							
Moss			X	X			X	X	X																					
Unknown # 1(Polemoniaceae)																							X	X						X

APPENDIX B

PHYSICAL BIOTIC DATA AND DIRECTIONS TO STUDY SITES

Site: 1 - Jackson Creek Dates of field work: 7/26/91
7/16/92
7/22/93
6/29/94

Location: Approximately 5 miles east of Hwy. 70 along Jackson Creek, just south of USFS Road 23N48.

Directions: Take Hwy. 70 from Quincy towards Portola. Just past Cromburg, turn left to the Jackson Creek Campground (Mt. Tomba Rd.). Go 5 miles from Hwy. 70 turnoff to parking area of site 1, located to the right of the road.

Quad: Johnsville Township: 23North Range: 12East

NE 1/4 NE 1/4 Section: 21 Elev: 6160'

Site Description: Jackson Creek flows east to west along a gentle gradient in the area of the transects, allowing development of small meadow areas. The surrounding forest burned in the summer of 1989 and on the north side of the creek, blackened areas extend right up to the edge of the riparian zone. The study area was established in an area along the south side where the fire did not encroach upon the riparian zone or the forested area directly uphill of the transects.

Habitat: The slopes above the creek consist of mixed conifer forest dominated by white fir (*Abies concolor*) and lodgepole pine (*Pinus murryana*). The riparian area is overgrown with willow (*Salix* sp., approximately 6-8' high) with scattered aspen (*Populus tremuloides*), lodgepole pine, and occasional white fir.

Soil: gravelly, metavolcanic

Transect 1A

Description: Transect 1A is located at the western edge of a small open meadow approximately 50' wide. Vegetation within the meadow consists of scattered corn lily (*Veratrum californicum*), aspen saplings, grasses, sedges, and herbs approximately 1-3' high. The site has full morning and early afternoon sun, and is shaded from mid-afternoon.

Transect 1B

Description: Transect 1B crosses a narrow band of meadow vegetation between the willows at creekside and the conifer forest. It is located approximately 40' west (downstream) of Transect 1A. Vegetation within the meadow area is dense and up to 4' high. Toward the meadow edge, vegetation is still dense but reduced to 1' or less in height. The area is shaded with only filtered sun for most of the day.

Site: 2 - Long Valley Creek Dates of field work: 8/1/91
7/16/92
7/22/93
6/30/94

Location: Approximately 6 miles east of Hwy. 70 (Jackson Creek Campground) along Long Valley Creek, just north of USFS Road 23N11.

Directions: Take Hwy. 70 from Quincy towards Portola. Just past Cromburg, turn left to the Jackson Creek Campground (Mt. Tomba Rd.). Go 5.2 miles from Hwy. 70 turnoff to fork in road, turn left on Road 23N48 Proceed 1.4 miles and turn left on USFS road 23N12. Continue on Road 23N12 for 1.7 miles to junction and tun left (keeping on USFS road 23N12). Go 2.2 miles to intersection with USFS road 23N11. Turn right, and go 0.5 miles to undeveloped campsite on right. Park here.

Quad: Johnsville Township: 23North Range: 12East

NW 1/4 NW 1/4 Section: 10 Elev: 5640'

Site Description: Long Valley Creek runs NE to SW in this area. As the creek continues NE from the study site, it opens up into a large, wide meadow. The meadow in the area of the transects is approximately 120 feet wide but narrows to 60 feet in places. The slope of the forest floor is approximately 20%. The transects are established along the eastern side of the drainage.

Habitat: The slopes above the meadow consists of mixed conifer forest dominated by white fir (Abies concolor) and lodgepole pine (Pinus murryana) with scattered Jeffrey pine (Pinus jeffreyi). The edges of the meadow have young white fir and the tree species inside the meadow are mainly young lodgepole pine with occasional large willow thickets (Salix sp.).

Soil: gravelly, metavolcanic

Transect 2A

Description: Transect 2A is located at the edge of a small spring which drains into the main meadow area. Vegetation within the meadow is dense and 1-3' high. The meadow edge opens into a dry zone with many young white fir. Ground cover is less than 15% in the dry area. The site is shaded until late morning, then has full sun until late afternoon.

Transect 2B

Description: Transect 2B runs perpendicular to the main creek, approximately 200' north (upstream) from Transect 2A. The meadow area is dry, consisting of sedges, grasses, and herbs. The dry area is mostly open ground with 10% ground cover. The terrain is

nearly flat with full sun from late morning to late afternoon.

Site: 3 - Humbug Creek Dates of field work: 9/6/91
7/1/92
7/30/93
7/12/94

Location: Just west of the Lake Davis/Portola Road, approximately 4.5 miles north of Portola.

Directions: Take Davis Lake Rd. out of Portola, 4.4 miles to where site 3 is visable to your left of the Road. Continue up the road to large stand of Aspens on the left and park here.

Quad: Portola Township: 23North Range: 13East

NE 1/4 NE 1/4 Section: 15 Elev: 5640'

Site Description: Humbug Creek begins just beyond where the transects are established and runs in a southernly direction. An aspen (Populus tremuloides) forest opens up to a meadow approximately 60' wide with a 20% slope. Small seep areas occur throughout the meadow, converging at the bottom in the main drainage area. The aspen forest/meadow area has been enclosed by the USFS to exclude range animals, although deer were observed within the exclosure.

Habitat: The slopes (approximately 45%) above the drainage are dominated by sagebrush (Artemisia tridentata) with scattered Jeffrey pine (Pinus jeffreyi) and mule-ears (Wyethia mollis). The study area consists of aspen at the north edge of the wet area with dense sedges, grasses, and herbs approximately 1-3' high within the meadow. At the bottom of the meadow, the slope tapers off and the creek flows at a gentle gradient southward.

Soil: sandy, grayish-brown

Transect 3A

Description: Transect 3A is established within the exclosure on the western edge of the meadow and runs in an east to west direction. Vegetation is dense within the meadow side of the transect, consisting mainly of 1-2' high sedges and grasses. The vegetation in the dry zone is dense (80-90% cover) but less than 1' high, with cheat grass (Bromus tectorum) as the main component. The site receives full sun from mid morning until late afternoon.

Transect 3B

Description: Transect 3B is established approximately 100' south of Transect 3A and 50' outside of the exclosure fence. The transect runs perpendicular across the creek bed from east to west. In August, the drainage had approximately 1" of running water, but in September standing water only was present. At the

south end of the exclosure fence, the terrain flattens out with only a 5% slope on the west side of the drainage. Vegetation within the wet area consists of sedges, grasses, and thistles approximately 1-3' tall with low grasses (mainly Bromus tectorum) within the dry zone. The site receives full sun from mid morning until late afternoon.

Site: 4 - East Nelson Creek Dates of field work: 8/23/91
7/3/92
7/23/93
7/5/94

Location: Approximately 1.5 miles west of the Plumas Eureka State Park boundary and north of USFS Road 23N08. The study site is approximately 1 mile from the end of the road in McRae Meadows.

Directions: Take Hwy. 70 out of Quincy towards Portola. Approximately 8 miles out of Quincy, turn right at the "Sloat" exit. Locate road 23N08 and turn right. Continue on road 23N08 approximately 8 miles to the McRae Meadows Campground. Road 23N08 to McRae Meadows is gravel for about six miles, then degrades to unimproved dirt for the last two miles toward the campground.

Quad: Blue Nose Mtn. Township: 22North Range: 11East

SW 1/4 SW 1/4 Section: 16 Elev: 6120'

Site Description: Nelson Creek flows north to south through a gently-sloping opening in the coniferous forest. The open area referred to as McRae Meadows is approximately 2 miles long and 1000' wide. At the south end of the meadow, the road has been blocked to motor vehicles and is now a meandering trail. The study area was established on the west side of the main drainage.

Habitat: The slopes above the meadow are fairly steep (approximately 70%) and vegetation consists of a red fir (Abies magnifica) forest. As the forest meets the meadow, the slope tapers off, and the tree species are a mix of lodgepole pine (Pinus murryana), red fir, white fir (Abies concolor), and Jeffrey pine (Pinus jeffreyi). Most of the trees are old and large, with some smaller trees near the meadow edge. Numerous springs drain into the meadow, with alder thickets (Alnus tenuifolia) developing upslope. The main meadow areas are very diverse in plant species with sedges, grasses and various herbs. Nelson Creek is overgrown with alder in most areas, but is somewhat open in rocky areas. The meadow area where the transects are located opens up into a large dry, grassy zone before the coniferous forest begins.

Soil: sandy, gravelly, and gray in color

Transect 4A

Description: Transect 4A is located on the western edge of the meadow and runs in an east to west direction. Vegetation within the meadow is very dense and consists of grasses, sedges, and herbs, approximately 2' high. Density and height of the plants both decrease within the dry zone, with ground cover of about 75%. Species diversity also decreases in the drier area. The site receives full sun from mid-morning until late afternoon.

Transet 4B

Description: Transect 4B is located 30' south (downstream) of Transect 4A. The inside edge is established at the edge of the alder thicket that runs along the creek. Meadow vegetation is dense, 2-3' high, and consists of rushes, grasses, and herbs. Species diversity is lower than at 4A. The dry zone has 50% ground cover, less than 1' high. The site receives full sun from mid-morning until late afternoon.

Site: 5 - Pilot Peak Dates of field work: 8/22/91, 7/15/92, 8/4/93, 7/18/94

Location: Approximately 1 mile southeast of Pilot Peak along a northeast-facing slope below Bunker Hill Ridge.

Directions: Take Hwy. 70 out of Qunicy (approximately 2 miles) towards Portola. Turn right on the road to "LaPorte" and continue for 17 miles to dirt road on left (sign on tree says "NO TRESPASSING"). Turn left here and proceed 2.6 miles to the site.

Quad: Blue Nose Mtn. Township: 22North Range: 10East

NW 1/4 NE 1/4 Section: 16 Elev: 6650'

Site Description: The study site is located at meadows formed by springs which begin the West Branch of Hopkins Creek. These are located on the north side of Bunker Hill Ridge and the drainages run in a southwest to northeast direction. The slope is moderate in the area where the meadows have formed, but the surrounding forest slopes have 50-75% slopes.

Habitat: The slopes surrounding the meadow area are dominated by red fir (*Abies magnifica*). Logging has occurred nearby, but adjacent forested areas are undisturbed. The meadow is fed by two springs whose drainages converge approximately 150' downstream. Alder thickets (*Alnus tenuifolia*), mule-ears (*Wyethia mollis*), and corn lily (*Veratrum californicum*) patches occur throughout the area.

Transect 5A

Description: Transect 5A is located along a north-facing slope, just south (upslope) of the southern-most drainage. Alder thickets, 5-7' high occur along the sides of the drainage. Vegetation within the wet zone of the transect consists of herbaceous perennials of less than 1' high providing 80% ground cover. The dry zone has less than 20% ground cover, consisting mostly of mosses, sedges, and scattered herbs. The sites remains shaded throughout most of the day, with filtered afternoon sun.

Transect 5B

Description: Transect 5B is located 50' feet north of Transect 5A. The terrain is fairly flat and species diversity is very low. Corn lily and aster predominate throughout the meadow area. Vegetation is dense and 2-3'high. The dry area consists of grasses and herbs but the ground cover is only 50% and this area is also low in species diversity.

This site receives full sun from late-morning until late-afternoon.

Site: 6 - Church Creek Dates of field work: 8/23/91
7/2/92
7/29/93
7/11/94

Location: Approximately 1.5 miles east of Gold Lake and .75 miles east of Gold Lake Highway at Snag Lake.

Directions: Turn off Hwy. 70 to Grayeagle. Pass through Grayeagle and turn right (just past Frazier Creek) on the Gold Lake Hwy. Go past Gold Lake and Snag Lake, make a left turn to Church Creek. At fork in road go left, site is approx. 0.5 miles on left.

Quad: Clio Township: 21North Range: 12East

NW 1/4 NE 1/4 Section: 22 Elev: 6740'

Site Description: Numerous tributaries feed into Church Creek at a gentle slope creating a wide meadow area. Small areas of forest occur between the tributaries. The slopes immediately surrounding the meadow area are moderate.

Habitat: The forest is dominated by lodgepole pine (*Pinus murryana*) with scattered western white pine (*Pinus monticola*). The tributaries within the meadow have scattered willow thickets (*Salix* sp., 5-6' high) and the forested areas within the meadow are mainly lodgepole pines. The study area was established along the western-most tributary.

Soil: gray-brown, cobbly, with larger stones scattered in dry areas

Transect 6A

Description: Transect 6A is located on the west side of a small drainage. Willow, 5-6' high, is thick along the waterway, then opens up to a thick stand of sedges with scattered corn lily, asters, and grasses. The dry area is 70-80% vegetated with plants 2-3" high. The site receives full sun from late morning until mid afternoon.

Transect 6B

Description: Transect 6B is located approximately 70' south (upslope) from Transect 6A. It lies on the east side of the same drainage as 6A. The inner edge of the transect lies within a 6-8' tall willow thicket, then crosses the drainage. Vegetation is dense but less than 1.5' tall. As the transect enters the dry zone, vegetation lessens to 50% ground cover, consisting of small herbaceous perennials. The site receives full sun from mid morning until late afternoon.