98-275 Project Completion Report

Project Description

Over the last five years Department of Environmental Quality (DEQ) has been developing a Total Maximum Daily load (TMDL) and Water Quality Plan for the Applegate River Basin. The TMDL included temperature, habitat modification, flow modification, and sediment. Additionally the Oregon Plan, designed to restore salmonid population, was progressing in the Applegate River Basin.

The TMDL, WQMP, and the Oregon Plan were in need of baseline data and assessment to fill data gaps. The Applegate River Watershed council initiated a monitoring study to provide necessary data. The watershed council designed a monitoring plan to study the chemical, physical and biological aspects of the river system. The attached document Monitoring and Assessing the Applegate River Basin provides detailed information on the study, methods and findings.

These findings were distributed to the agencies involved in basin restoration including the forest service, Bureau of Land Management, DEQ, and the monitoring team of the Oregon Plan. The watershed Council will continue to work closely with these partners in designing and implementing watershed restoration projects. The data provided through the councils monitoring will provide the logic necessary to make sensible, informed decisions.

Volunteer Efforts

Hans Rilling, project manager 1998-1999 and assistant in 2000, spent over 2000 hours in every aspect of the monitoring program. Tim Monfort and Dave Squires of the BLM donated staff plates and expertise in identifying appropriate staff locations. Tim and Dave donated 40 hours. Debbie Whitall and Mike Zan, hydrologists for the Rogue National Forest donated 80 hours assisting with sampling design, site locations, and data collection. Randy Frick, Rogue River Fish biologist, donated 60 hours for presentations, database assistance and data interpretation.

Five individuals from Southern Oregon Fly fishers donated 80 hours to assist with macroinvertebrate data collection. Additionally, numerous individuals participated in our volunteer turbidity program (see attached sheet – **Turbidity Monitoring**)

Participants

Please see attached sheet *Participants for Grant 98-275, water quality monitoring.*

Materials and Methods used in the Project

Please see attached document *Monitoring and Assessing the Applegate*

The Results Shown or Expected from the Completed Project

Please see attached document *Monitoring and Assessing the Applegate*

accepted 1-30-02

Expenditures

Please see attached expenditure Spreadsheet.

Information helpful in evaluating the Strengths and Weaknesses

Please see attached document *Monitoring and Assessing the Applegate*

The Applegate River Watershed Council

Monitoring and Assessing the Applegate River Basin

 

The Applegate River Watershed Council

Monitoring and Assessing the Applegate River Basin

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Acknowledgments

The projects presented represent considerable efforts by numerous individuals over the last five years. I want to thank the field crews, namely, Dave Livingston and Steve Sagmiller for their dedication to collecting field data, maintaining high quality data standards and providing insightful interpretation. The Williams Creek Watershed Council provided assistance with field work, land owner contacts, and data summaries.

I also extend my appreciation to the countless volunteers who provided access to their lands and needed labor. Without the help of volunteers and streamside residents this work would not have been possible. A special thanks goes to Mr. Hans Rilling who collected and analyzed much of the material contained in this document. The monitoring program and the watershed council have greatly benefited from his commitment and support.

The projects were funded by the Oregon Watershed Enhancement Board, Department of Environmental Quality, National Fish and Wildlife Service, USDA Forest Service, and CAG Charitable Corporation.

Tim Franklin, Alan Whiting, Eric Miller Collecting bugs

Dave Livingston, Southern Oregon Fly fishers volunteers Dick Butler and Jimmie Teehan, Hans Rilling collecting more than bugs

1.0 Introduction

The *Water Quality and Stream Habitat Monitoring program* monitors the Chemical, physical, and biological conditions in the Applegate Watershed. Our monitoring activities are basin-wide, focusing on private lands. Students, residents, and staff collected and examined water quality/quantity, channel morphology and sediment discharge, and fish/ macroinvertebrate information. The technical investigations/evaluations were intended to provide facts on watershed conditions and processes and to display the distribution of conditions across the landscape in order to sensibly and logically develop restoration, protection, and collaborative recommendations. Additionally, monitoring protocols were established to assess project effectiveness of current and planned projects.

The Applegate River Watershed Council and its volunteers collected the majority of data presented; however, to provide a more holistic "picture" of the watershed, the final report integrates forest service, BLM, ODFW, and DEQ data with ARWC monitoring information.

The format and technical evaluations are not only intended to fulfill grant obligations but also to provide:

1. A technical update to Applegate River Watershed Assessment
2. An aquatic assessment based on comparison to ODFW and NMFS benchmarks
3. A monitoring and planning tool for implementing the Applegate River Water Quality Management Plan

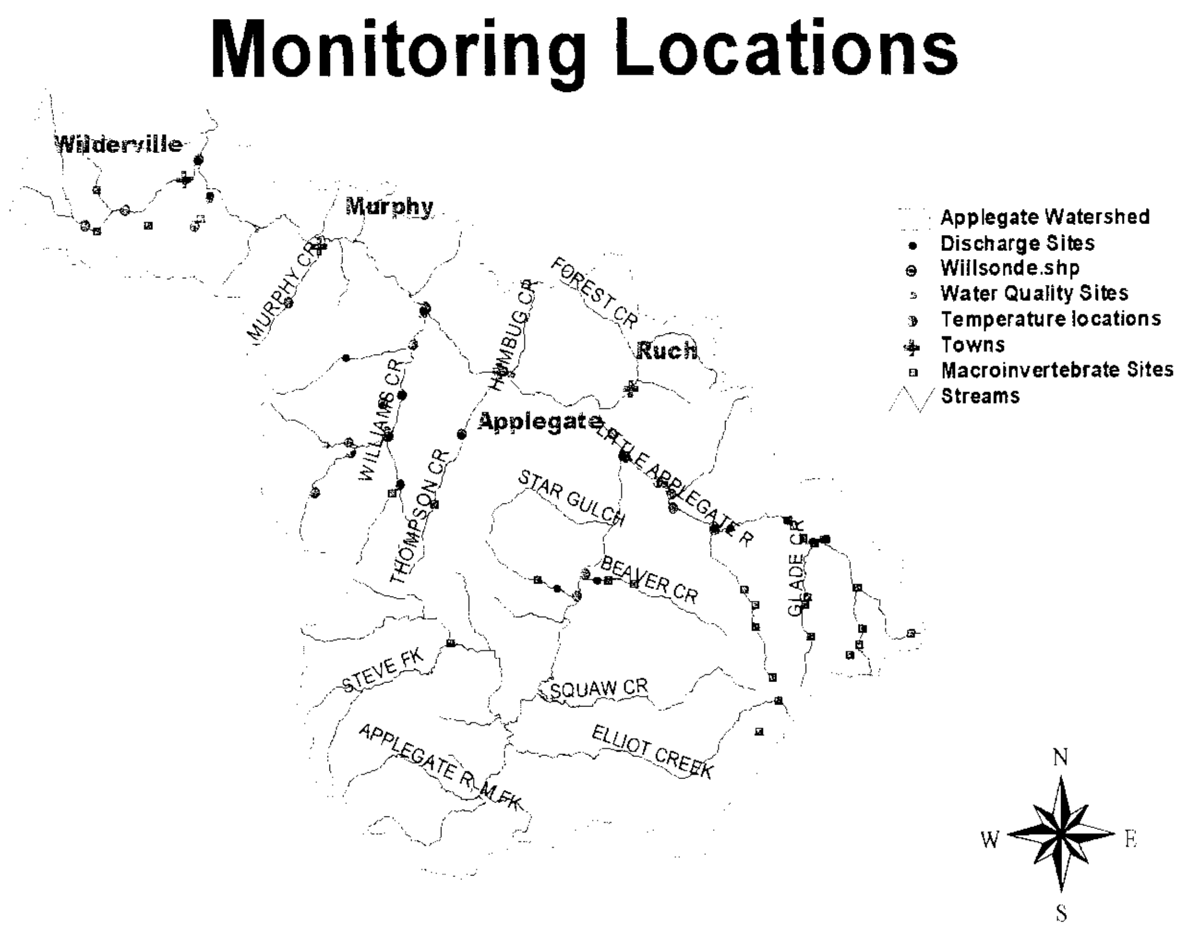
2.0 Evaluations

The evaluation section provides methods, data findings and interpretation of our water quality, physical habitat and biological monitoring.

2.1 Water Quantity

In the Applegate Valley, as with most watersheds in the west, water is the life of many farmers and ranchers. The low gradient floodplain valleys are very productive with a variety of crops and livestock. Accordingly, an adequate water supply is critical for agricultural success. Likewise, aquatic biota equally rely on adequate streamflows for their life cycle. Unfortunately, water availability is not sufficient to accommodate all beneficial uses in the watershed. The Oregon Department of Water Resources publishes water availability and water allocation on the department's web site. From the data, many of our streams, particularly in the lower gradient valleys, are over appropriated. In year 2000, streamflow contribution to the mainstem from our largest tributary basins, Williams Creek, Little Applegate River, and Slate Creek representing over 150,000 acres, was approximately 15 Cubic Feet per Second (CFS). In 2001, Contribution was under 10 CFS.

Figure 1. Monitoring locations



ARWC monitored streamflows at cross sections with staff plates and with continuous sampling equipment. Each gauging station was rated (stage to discharge relationship), allowing an estimate of flow from a staff plate reading . Discharge measurements are fundamental to heat source modeling, pollutant loading and sediment transport. Figure 1 displays our sampling locations. Additionally, with continuous sampling we were able to determine summer yields, display hydrographs, determine use patterns and diurnal variation Figures 2-4. The continuous recording are key to quantifying instream flow benefits resulting from water rights transfer and irrigation efficiency improvement projects. Appendix A.1 provides all discharge measurements.

Figure 2. Little Applegate Hydrograph above and below project

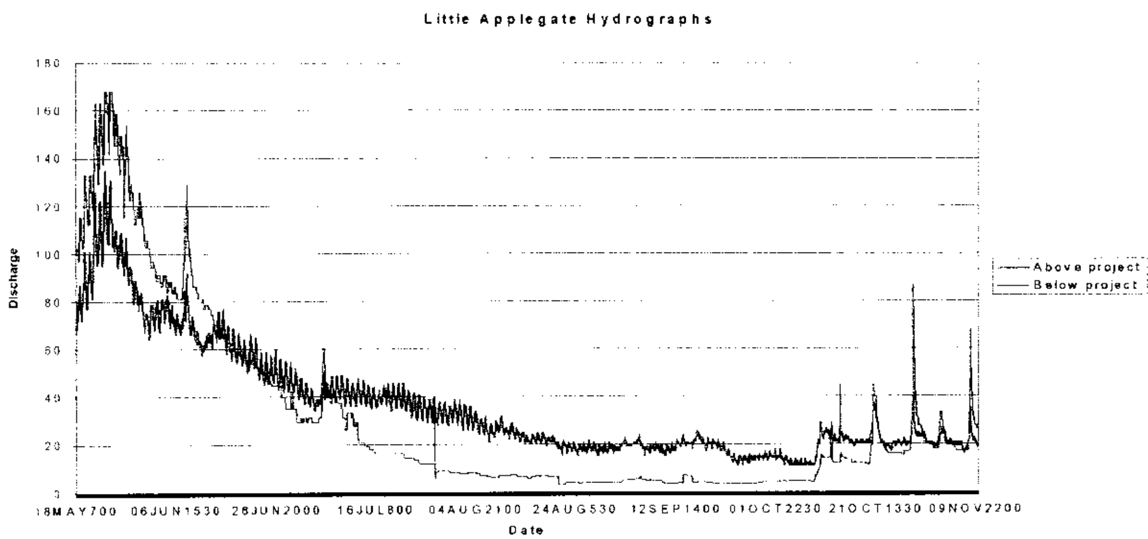


Figure 3. Little Applegate Hydrograph 200-2001 comparison

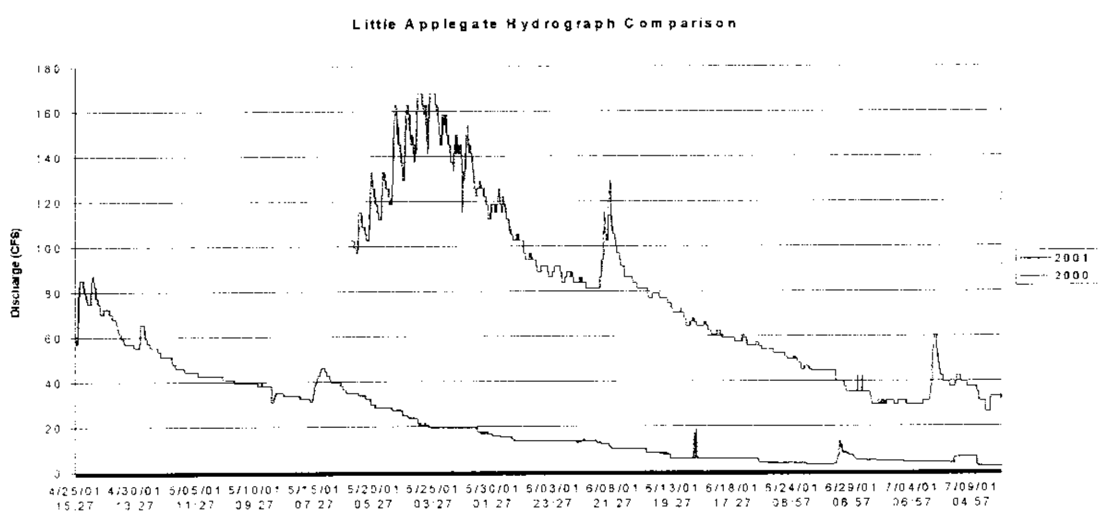
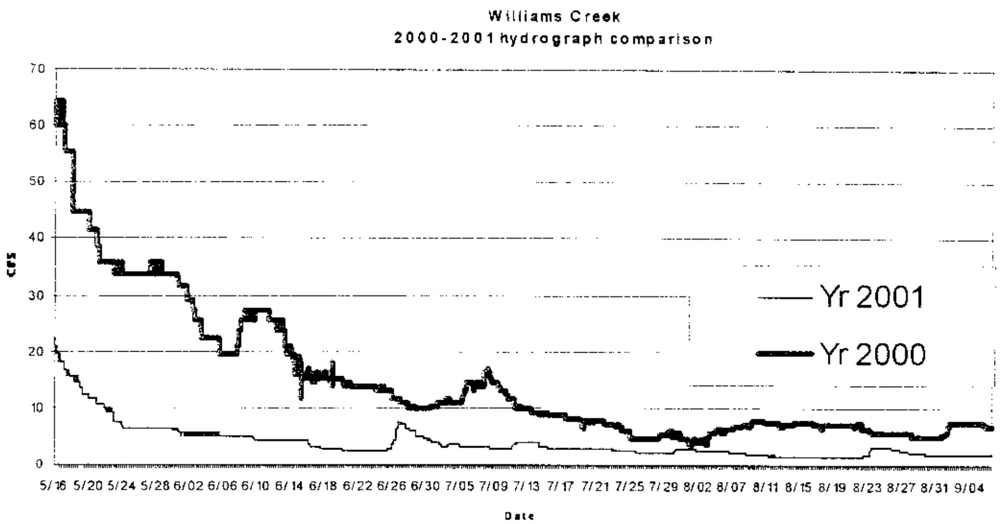


Figure 4. Williams Creek Hydrograph



2.2 Water Quality

2.2.1 Water Temperature

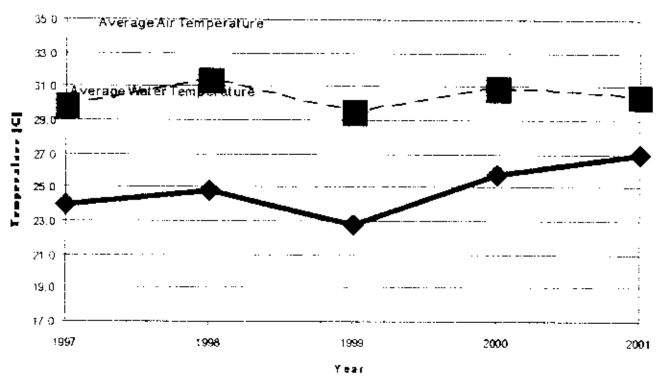
As of the writing of this document, DEQ and the Applegate River Watershed Council are completing a detailed water temperature assessments. These documents detail heat sources, heat budgets, and identification of cold and warm water reaches. This section does not duplicate these efforts. Rather, an over view of our temperature program and data is presented.

Summer water temperatures in the Applegate basin vary across the landscape. The influences of geography, flow regime, and riparian vegetation greatly affect water temperature. Continuous monitoring assists in identifying warm and cool water reaches and the causative factors that influence water temperature. By identifying locations of temperature impairment and causes, we can prioritize restoration and management strategies to restore aquatic habitat.

Summer stream temperatures were continuously recorded in the Applegate basin (Figure 1) during the years of 1997-2001 with *Onset Optic StowAway Temp* thermo-loggers. Selected sites were monitored from two to five years. Thermo-loggers recorded stream temperature on half-hour intervals. Water temperature values used in the analyses are the moving 7-day maximum average water temperature and the daily maximum change in temperature (ΔT). In addition, the number of days exceeding 17.8°C was assessed to determine duration of warm water conditions. DEQ established 17.8°C as the water temperature criteria for cold water fisheries.

Air temperature values used in the analyses are daily maximum and minimum temperatures recorded at the Medford, Oregon airport. Stream flow values used are daily discharge averages of Star Gulch.

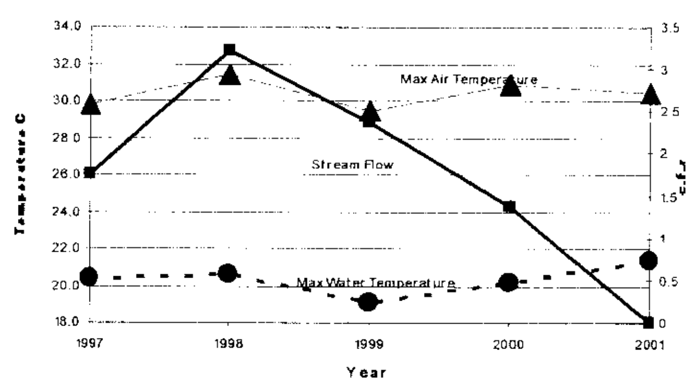
Figure 5. Average Water Temperature vs. Average Air Temperature



Yearly average of the daily maximum air temperatures values were compared to yearly 7-day maximum average water temperature to correlate the influence of air temperature on water temperature (Figure 5). From 1997-2001 water temperature closely correlated to air temperature; higher air temperatures resulted in higher water temperatures. This simple correlation supports earlier assessments (ARWC, 1999) in the Applegate basin of sunlight being the main factor for changes in water temperatures during the summer months.

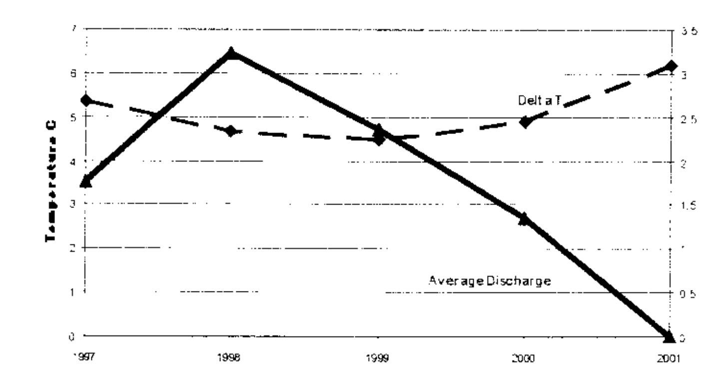
However, water temperature is also influenced by streamflow. 1998 had the highest air temperature recorded for this time-period yet water temperatures increased only slightly from 1997. 2001 had lower air temperature and higher water temperature value in comparison to 1998. The variance is the effect of stream flow.

Figure 6. Discharge, Air Temperature and Water Temperature



The influence of streamflow on water temperature is most evident in 1998 and 2001. (Figure 6). Tempering the high air temperatures in 1998 was the increase in discharge. Reduced flows in 2001, despite lower air temperatures, resulted in an increase in water temperature from 2000.

Figure 7. Diurnal variation vs. flow



Additionally, the average of each

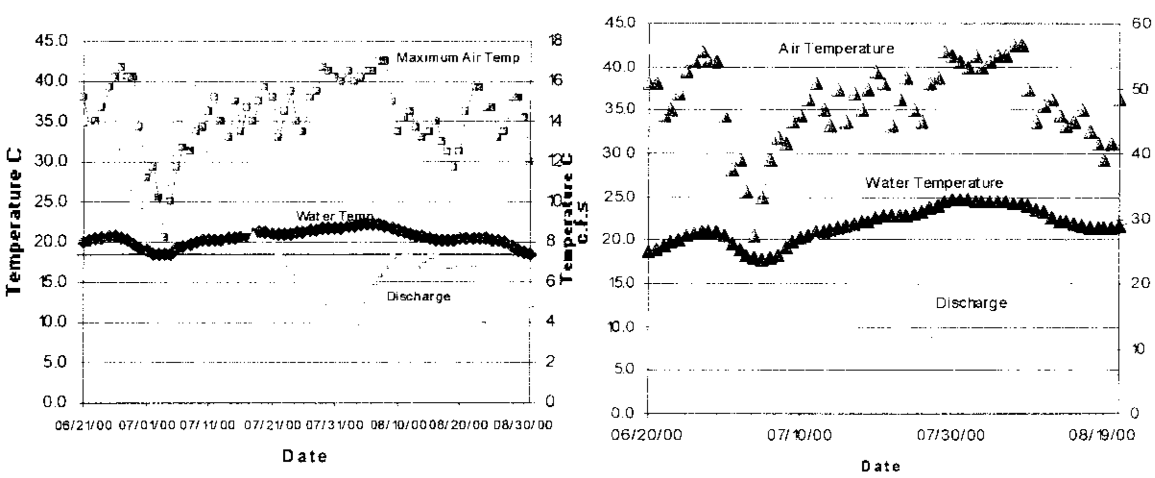
sites maximum diurnal fluctuation in water temperature (ΔT) was compared to the yearly average discharge. As evident, ΔT increased as average discharge decreased (Figure 7). This is evidence that lower volumes are more responsive to changes in air temperature.

Little shade on the River

To further examine the influence of flow on stream temperature, two sites with continuous temperature and discharge data for the years of 2000 and 2001 are compared. Williams Creek drains an area of 51,910 acres and flows in a south to north direction. The Little Applegate River watershed is 72,240 acres and displays an east to west orientation.

During the summer of 2000, water temperature clearly responded to changes in air temperature and volume of flow in both Williams Creek and the Little Applegate River (Figures 8 & 9). In 2001, the Little Applegate River had similar responsiveness to fluctuations in air temperature and stream flow as observed in 2000.

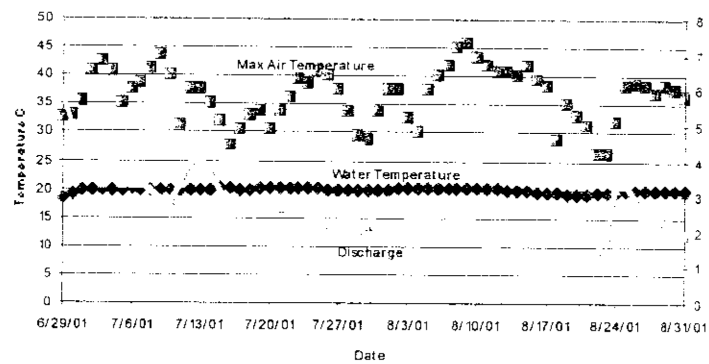
Figures 8&9. 2000 Flow, Air Temp. and Water Temp.—Williams and Little Applegate



Interestingly, 2001 water temperatures in Williams Creek displayed little variation regardless of air temperature and flow changes. (Figure 10). Dave Squires, BLM hydrologist, provided a possible explanation. The near constant temperature profile in Williams Creek during the summer of 2001 could be the effects of cool water input from a well shaded side-channel and from ground water. With the 2001 average summer flow less than half the summer average of 2000 (2.67 versus 8.60 CFS, *respectively*), there was a relatively larger contribution of cooler water emanating from ground and side channel sources producing a more pronounced cooling effect.

DEQ established 17.8°C as the water temperature criteria for cold water fisheries. Over 90 percent of sites monitored by ARWC over the last five years surpassed the water temperature criteria. There were three sites which consistently possess the greatest number of days over 17.8°C (see Appendix A.2): Slate Creek at the confluence with the Applegate River; the Little Applegate River near the mouth; and the Applegate River above the confluence of the Little Applegate River.

Figure 10. 2001 Flow, Air temp. and Water temp.--Williams Ck



Factors influencing warm water temperatures at these sites are the cumulative effects of lack of shade, low flow, and degraded stream channel morphology. Slate Creek and Little Applegate River (LA) drain two of the three largest basins in the Applegate watershed, increasing the opportunities for cumulative upstream warming. The Applegate River for three miles upstream of the confluence with LA has a high width to depth ratio and very little riparian canopy.

Continual temperature monitoring in the Applegate basin between the years of 1997-2001 provides the beginnings of base-line temperature monitoring. These five years of monitoring highlight the extent and severity of high water temperatures in the watershed. As a result, restoration activities are focusing on sites highlighted by this monitoring. With recent and future restoration projects focusing on improving water quality, additional monitoring is warranted to assess project effectiveness and track long-term water temperature trends in the Applegate watershed.

Jan Perttu helping crews with water quality and macroinvertebrate collection

2.2.2 Water Chemistry

Methods

Water chemistry monitoring involved collecting dissolved oxygen, alkalinity, conductivity, pH, and turbidity. Phosphorous and nitrates were also collected to assess nutrient loading.

We collected water chemistry data using two methods - grab samples and continuous sampling. Grab samples were collected bi-weekly. The methods used are described in the *Methods and Procedures Manual of the Applegate River Watershed Council.* Since 1997 ARWC collected grab samples at more than two dozen sites during the summer (Figure 1). Grab samples for determining these parameters are usually taken during mid-day through late afternoon and represent conditions at that time. The water quality parameters have a diurnal cycle responding to solar radiation, photosynthesis and respiration. These parameters are also influenced by weather and adjacent land use. Consequently, grab samples do not sufficiently characterize water quality over a range of conditions.

To obtain more comprehensive information, we deployed sondes to continuously monitor pH and dissolved oxygen; continuous monitoring allows the evaluation of selected parameters throughout the diurnal cycle. ARWC has two sondes (YSI model 600XLM, YSI model 6920) which records Dissolved Oxygen (DO), temperature, pH, and conductivity at 30 minute intervals.

Grab Sampling

Appendix A.3 provides water quality values for years 1997,1998,1999, and 2000, receptively. All data has been formatted to standard EPA format and delivered to DEQ.

All salmonids require high levels of *dissolved oxygen.* Reduced oxygen levels can impair embryo development, growth of fry, and adult movement. Oxygen values of 8-9 mg/L are required to assure normal growth and development; values of 6 mg/L begin to affect growth and efficiency of food conversion (Davis 1975). EPA's water quality criteria for DO is 9.5 mg/L for a 7-day mean and 8.0 mg/L for a 1-day minimum. Sites where DO values fell below 6mg/L include:

⇒ Sterling Thompson Williams Forest Little Applegate (LA)

⇒ Beaver Palmer Slate Humbug

The *pH* of water is a measure of relative acidity. A pH of 7 is neutral. Although pH level requirements depend on species and life stage, pH levels below 5.6 or above 8.5 adversely affects salmonids (Spence et al. 1996). pH values below 5.6 or above 8.5 were not recorded. The highest pH values were found in Applegate River, LA at Mouth, Slate Ck, Sterling, Yale Creeks. Except for Yale Creek these streams have relatively high levels of algae which during transpiration reduces hydrogen ions , resulting in higher pH.

Alkalinity is the ability of water to resist changes in pH. Alkalinity values in the Applegate basin ranged from 50 to 250. Sterling, Palmer, and Beaver Creeks have high values while Cheney and Munger Creeks have relatively low values. Streams with values lower than 50 are susceptible to rapid changes in pH. Thus, streams with a high alkalinity are protected against extreme variations in pH. Our data indicate that there is little change in alkalinity from year to year. The exception is Forest Creek where alkalinity varies by 30 percent. Alkalinity values greatly depend on the soils of the watershed and therefore, are expected to remain relatively constant. EPA has not set alkalinity value criteria.

Conductivity is a measure of the ability to water to conduct an electrical current. This in turn is dependent on the level of dissolved salts and minerals. EPA has not set conductivity value criteria. Palmer, Forest, Beaver, Sterling Creeks have the highest conductivities in the basin. Forest Creek is unusual due to the high variability in conductivity.

We analyzed streams for the *nutrients* of phosphate and nitrate. Nitrogen and phosphorus are the most important nutrients affecting biological processes (Spence et al. 1996). Fertilizers, septic effluent, and run-off from agricultural land are the most likely cause for increased nutrients in the Applegate. EPA's standard for nitrogen is less than 10mg/L. This is the limit for human health, values much less can have deleterious effects to aquatic habitat due to increased primary productivity. The highest nitrate level was .55 mg/L found in Forest Creek. Clearly our samples indicate that nitrogen levels are well below the EPA standard.

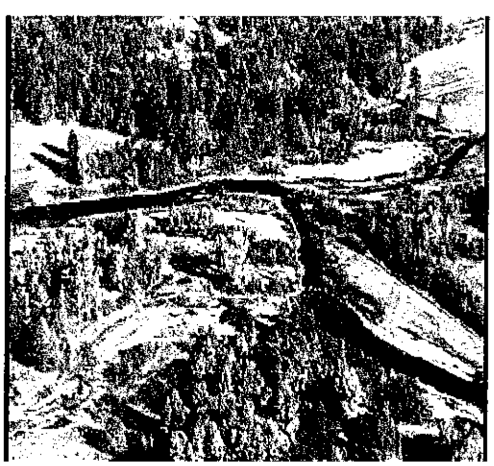


Photo Courtesy of Charles Rogers

Phosphates are generally considered non-toxic to aquatic vertebrates and invertebrates (Stumm and Morgan 1981). However, phosphates frequently limit primary productivity; a small increase can lead to a large increase in primary productivity. Minerals leached from rocks is the primary source of phosphate.

Grab samples, represent water quality at one particular time during the 2 week rotation. Immediate environmental factors such as time of day, weather pattern and land activity greatly influence individual readings. Due to the variability of these factors, developing statistically valid trends was not possible. However, a high degree of variability in conductivity, alkalinity, and nutrients within a year and from year to year indicates management influence. Natural factors influencing conductivity, alkalinity and nutrients are not expected to display high variability from year to year.

Forest Creek has the highest variability in these water quality parameters. This is particularly interesting when considering that perennial flow is limited to the lower 100 yards of Forest Creek at which point a spring generates surface flow. The adjacent land use is agriculture and leaching from the fields could be the cause for the water chemistry variability. Nitrate values in Forest Creek have increased steadily from .09 mg/L in 1997 to .53 mg/L in 2000. In 2001, the average value dropped to .15 mg/L. While trends are difficult to determine, the grab sample program indicates that other than DO, water chemistry condition is not jeopardizing beneficial uses.

Continuous Monitoring

A sonde is an instrument that continuously collects DO, pH, conductivity, temperature, and turbidity data. Since representative data can be obtained at a site in less than a week, the sondes were moved from site to site through the summer, during the critical time of the year. The locations for placement of the sondes are shown in (Figure 1). In analyzing our data, we have ignored the conductivity determinations, since these values are not relevant to water quality in the Applegate.

Dissolved Oxygen and pH are the focus of this evaluation. The Department of Environmental Quality (DEQ) has set a standard for cold water fisheries of 8 mg/L or 90% saturation, if the first value is not attained because of high stream temperatures. According to DEQ's standards, the pH of a stream for cold water fisheries should be between pH 6.5 and 8.5.

Representative results obtained by the sondes are shown in Figures 11-14. The data exhibit a diurnal variation in oxygen concentrations and pH, which is typical for all the streams. Closer examination of data reveals that there are two driving mechanisms for DO levels in our streams. The first is gas exchange. Dissolved oxygen is more soluble in cold water; ergo , as water temperature drops DO increases. Conversely, as temperatures increase, DO values decrease. The second driver is primary productivity. In this case, sunlight provides energy for aquatic vegetation which transpire during the day, producing oxygen. At night plants respire, consuming oxygen.

Inspecting the correlation between water temperature and DO, and the diurnal variation in pH identifies the DO driver. In data sets displaying a high positive correlation between temperature and DO, primary productivity drives DO values. Figures 13 and 14, WF Williams Creek and the Applegate River display DO positively tracking temperature, demonstrating transpiration and respiration cycles. In contrast, Beaver Creek and EF Williams (figures 11 and 12) DO and temperature are inversely correlated, signifying gas exchange processes. Associated with primary productivity are relatively large diurnal fluctuations in pH values. As algae photosynthesizes during the day, they take up carbon dioxide, resulting in a reduction in free hydrogen ions, increasing pH. Where primary productivity drives DO pH fluctuation averages 0.66. In contrast, the average pH fluctuation in gas exchange driven DO systems is 0.23.

Figures 11. DO, Water Temp., pH

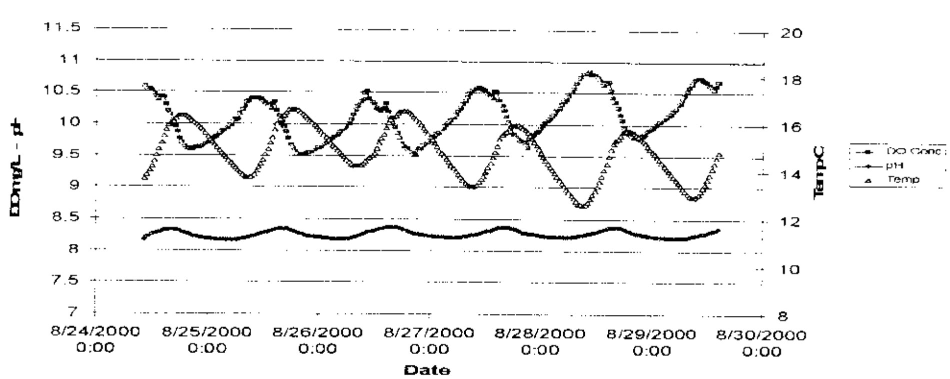


Figure 12. DO, Water Temp,

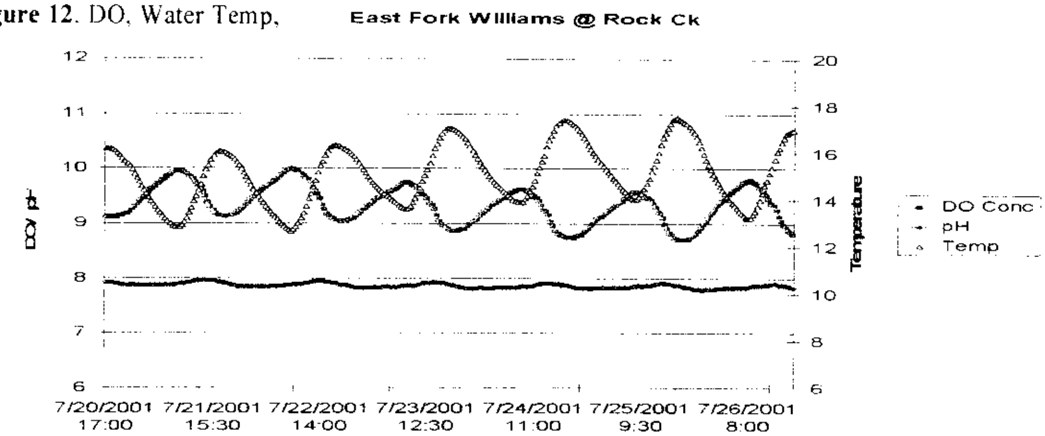


Figure 13. DO, Water Temp, pH

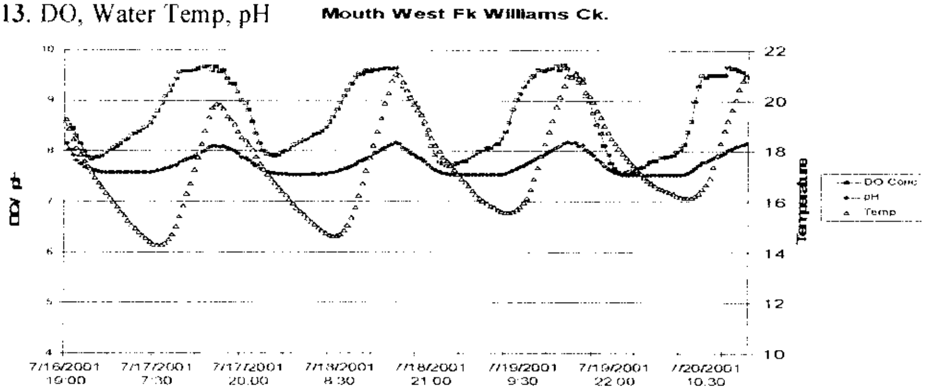


Figure 14. DO, Water Temp, pH

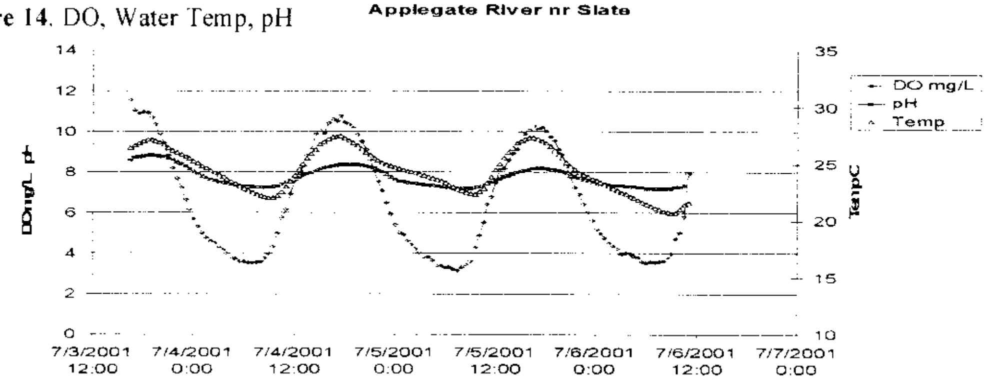


Table 1 displays date of deployment and percentage of reading exceeding DEQ standards. Sites with a high percentage (50%) of reading below standards are systems experiencing transpiration-respiration processes. Here, the low readings were recorded during the night as aquatic vegetation consumes oxygen.

Table 1. Percent time DO Exceeded Standards

Site	1999		2000		2001	
	Date	blw standard	Date	blw standard	Date	blw standard
AG @ Humbug					Jul 3-6	52
AG @ Slate					Jul 3-6	65
Applegate			Jul26-Aug2	18	Jun 14-21	0
Applegate			Au 31-Sep4	0	Aug 28- sep	56
Beaver Ck			Aug24-29	0		
Carolyn's	Jun 21-29	4				
E Fk Williams Ck			Aug14-18	19	Jul 16-26	51
EF Will @ Rock Ck					Jul 20-26	0
Forest Creek	Jun 6-19	36				
LA @ mile 2.6			Sep 5-20	3		
LA @ Mouth	May 18-28	0	Jul 7-14	0		
LA @ Mouth			Aug 24-29	32		
LA @ Mouth			Aug 30 -Sep 4	8		
LA abv Yale	Aug 4-14	9				
Little Applegate abv Yale					Aug 14-21	80
Little Applegate abv Yale			Sep 5-20	0	Jun 22-28	11
Yale			Jul17-24	26		
Slate @ Mouth					Aug 8-20	100
Thompson blw Tallowbox	Jul 17-29	44				
W Fk Williams Ck			Aug19-23	27	Jul 16-20	24
Will @ Wil Hwy	Aug 20-27	72	Jun16-23	33		
Will @ Wil Hwy			Aug 4-11	99		
Will @ Wil Hwy			Aug 14-22	79		
Yale @ Mouth	Jul 29-Aug 4	0	Jul 17-23	0	Jul 7-10	0
	Average	24		23		40

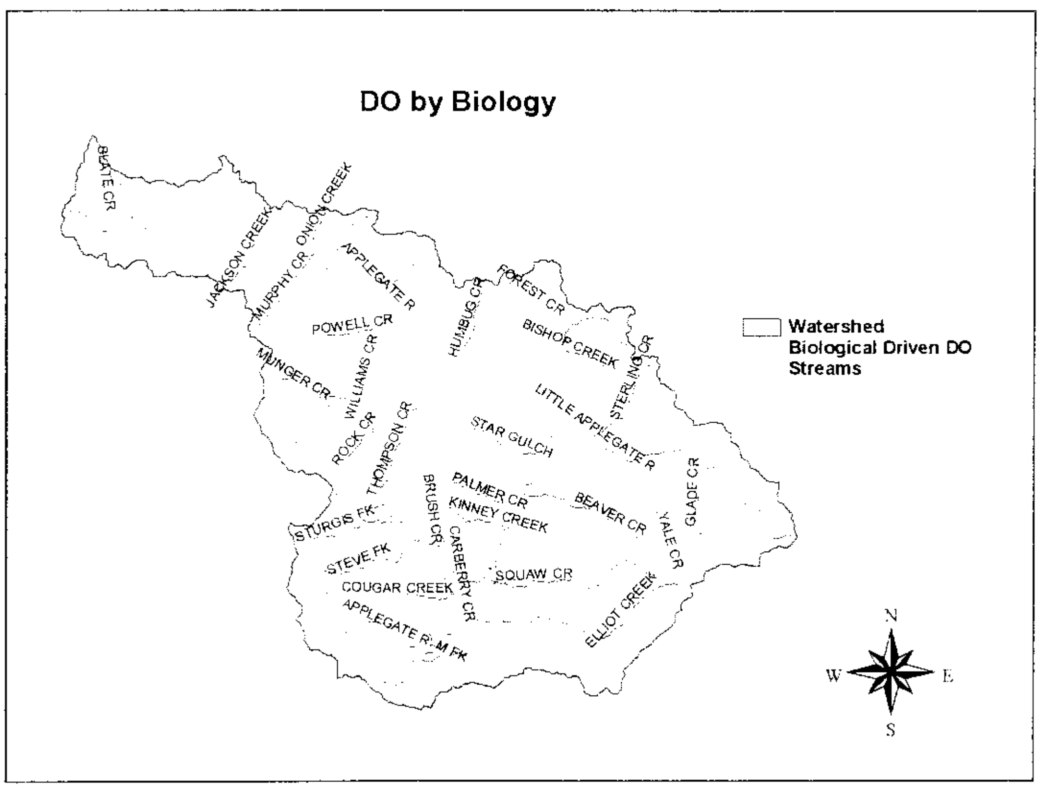
Year 2001 samples show a higher percentage of readings below standard. While water temperature was shown to be a function of air temperature and flow (see section 2.1) DO appears to be more directly related to flow. Number of days exceeding standards, min/max DO values, and diurnal fluctuations in DO and pH all correlate with baseflow. According to the Star Gulch gauging station, the summer of 1999 had the highest baseflow during our sampling period. Correspondingly, 1999 had the highest minimum and maximum DO values (table 2) and the least diurnal variability in DO and pH . The lowest baseflow, year 2001, corresponded with the lowest DO values and greatest daily fluctuation.

Figure 15 displays the distribution of river reaches with DO values driven by biological activity. Riparian site characterization and channel width is consistent within the identified reaches. In the biologically driven stream segments, riparian canopy cover is open and vegetation is fragmented. Furthermore, stream widths are generally greater than 30 feet. In contrast, riparian cover is greater and stream widths are less than 30 feet in the gas exchange driven system. These findings are in agreement with logic that states stream width and canopy cover determines solar radiation input; solar radiation input is the energy source for primary productivity. It must be noted that sampling did not occur at all locations, rather interpolation between sampling points created the distribution.

Table 2. Minimum and Maximum DO values

SITE	Minimum DO 1999	Minimum DO 2000	Minimum DO 2001	Maximum DO 1999	Maximum DO 2000	Maximum DO 2001
Applegate blw Fish Hatchery	8.1			9.3		
Applegate blw Little Applegate			8.3			9.9
Applegate nr Humbug			6.8			9.5
Applegate nr Slate			4.1			10.2
Beaver Ck nr Mouth		8.2			9.2	
EF Williams at Browns Rd		7.9	7.3		9.2	8.8
EF Williams at Rock Ck			8.9			9.7
Forest Creek nr Mouth	7.5			9.1		
Little Applegate abv Yale		7.9	7.2		8.6	8.3
Little Applegate blw Yale		8.4			9.7	
Little Applegate nr Mouth	9.9	8.7		11.0	10.9	
Little Applegate RM 2.6		8.4			10.3	
Slate nr Mouth			0.0			3.0
Thompson Ck blw Tallowbox	7.5			8.8		
WF Williams at Cedar Flat	12.3			13.2		
WF Williams nr Mouth	11.6	7.7	7.7	12.7	9.8	9.4
Williams Ck at Wil hwy	6.2	6.6		8.6	8.5	
Yale Ck nr Mouth	8.9	8.2	8.4	9.8	9.0	9.3
Average	**8.6**	**7.8**	**6.5**	**9.9**	**9.4**	**8.4**

Figure 15. Distribution of Biologic Driven DO values



Discussions with residents and examining historic flows indicate that water temperatures and DO values were historically limiting to salmonid use in the mainstem Applegate. However, historically, alcoves, side channels and near stream wetlands provided cold water seeps and springs creating cold water refugia. Sampling protocols by ARWC and Richard Nawa

(Siskiyou project, memo to John Renz, 2001) found steelhead and coho juveniles in isolated pockets near cold water seeps in lower Slate Creek and Williams Creek above Williams Highway. This highlights the importance of maintaining cold water refugia in our basin.

2.3 Sediment and Channel Morphology

ARWC permanently established more than 30 cross sections, to examine channel adjustment, scour fill cycles, fine sediment infiltration, and substrate particle size distribution. Several methods were used to characterize sediment in our basin and include:

- ⇒ Turbidity
- ⇒ Suspended sediment (USGS open file report 86-531, 1988)
- ⇒ Sour Chains (Nawa et al. 1993)
- ⇒ Infiltration Buckets (Lisle et al. 1991)
- ⇒ Pool Volume fine sediment accumulation (Hilton et al. 1993)
- ⇒ Cross sections (Harrelson et al. 1994)
- ⇒ ODFW habitat surveys

2.3.1 Sediment Sample Findings

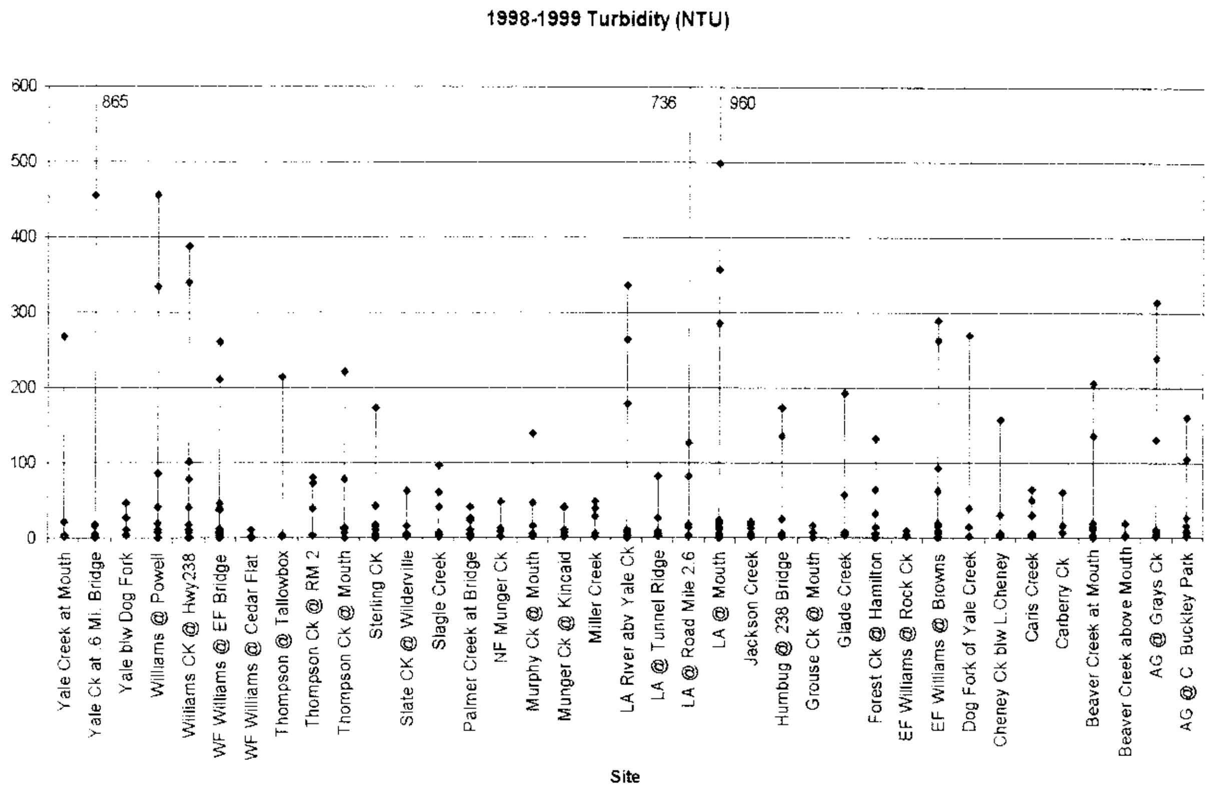
Turbidity

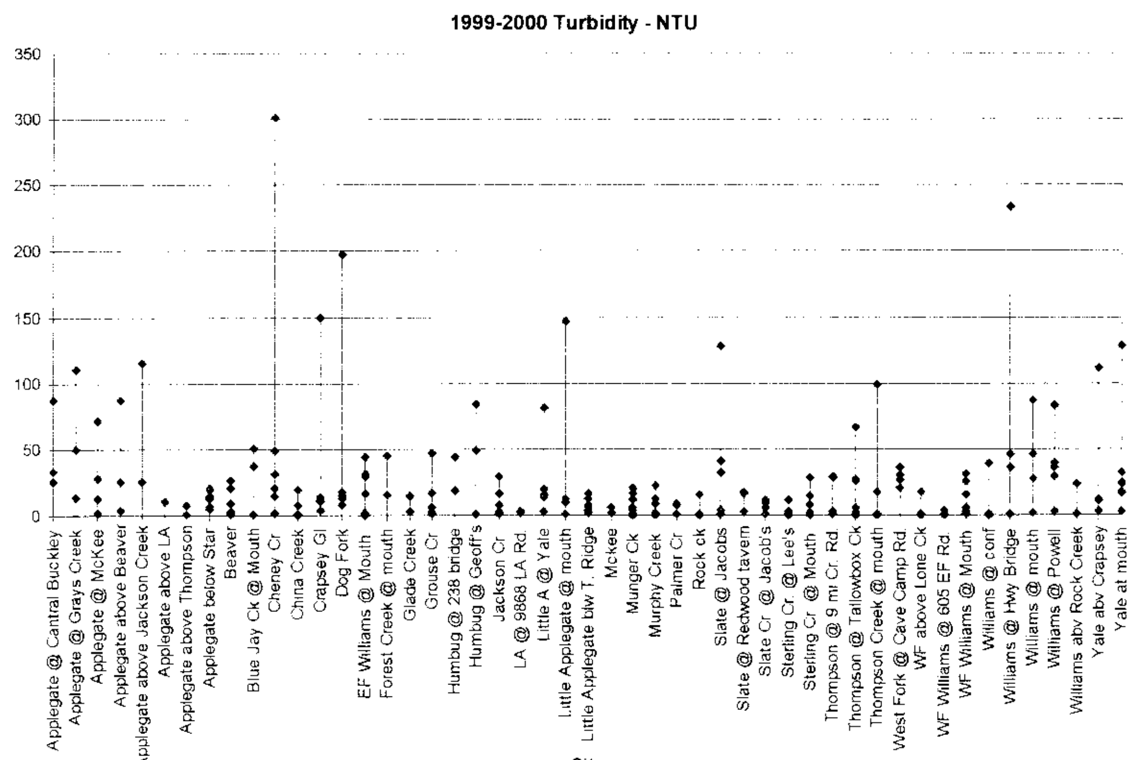
In 1998, ARWC established a network of volunteers to monitor stream turbidity. Applegate basin volunteers collected monthly samples during fall, winter, spring and during storm events. There were twenty volunteers in 1998-2001 who monitored over thirty sites. Samples were mailed to the ARWC office for processing. Additionally, staff gathered turbidity samples at locales not covered by volunteers. Figures 16 and 17 display sites and Turbidity values.

The data are reported in Nephelometric Turbidity Units (NTU) The Oregon Watershed Enhancement Board recommends 50 NTU as the upper level for fish bearing streams. Turbidity values of 50 NTU is not lethal to fish but can impair site feeding and create irritating particles in the gills.

Turbidity values are driven by rain intensity and stream flows. Chart 17 displays turbidity values for 1999 and 2000. Three distinct storms are evident (November 20-23, January 19-22, February 6-7). The November storm was associated with the highest precipitation intensity at 4.4 inches, but the event generated the lowest discharge. The January storm had a precipitation intensity of 2.05 inches and generated the highest flows. The February storm had a

Figures 16 and 17. Volunteer Turbidity Collection Sites and Values





precipitation intensity of 2.5 inches and fell between the November and January storm in discharge generation. In 2001, a very dry year elevated turbidity values were not observed.

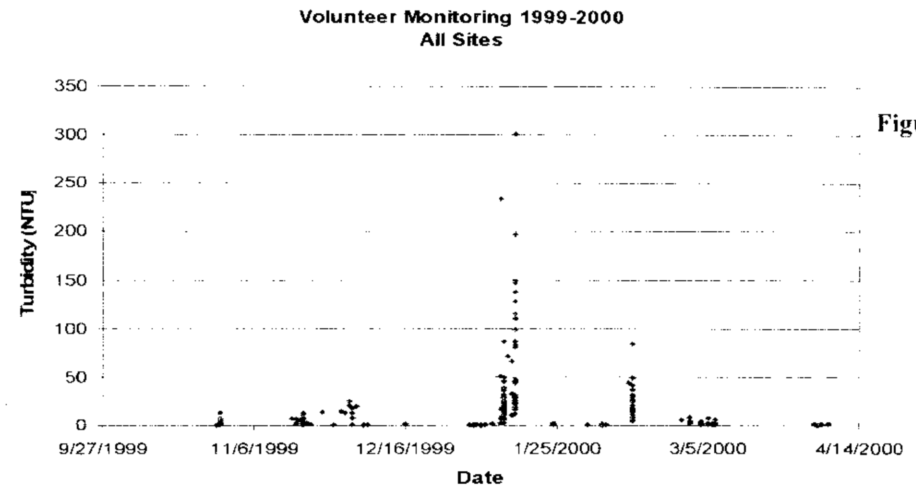


Figure 18. Turbidity Values

From the collected data, the Little Applegate River (LA) and Williams Creek, major tributaries to the Applegate River, are the most turbid during runoff events. Observations track high turbidity up to McDonald basin where bare granitic soils are eroding and delivering fine sediment to LA. Yale Creek, a tributary to the Little Applegate, is as turbid as the Little Applegate, while other tributaries, Grouse and Sterling Creeks, are relatively clean.

In the Williams Basin, the turbidity values for the East and West Fork were nearly equal but slightly less than the mainstem. Munger Creek is a clean stream. Thompson Creek was relatively turbid in the 1998 November and January storms. Slate Creek remained relatively clear at all times. All these streams are important steelhead and coho spawning streams.

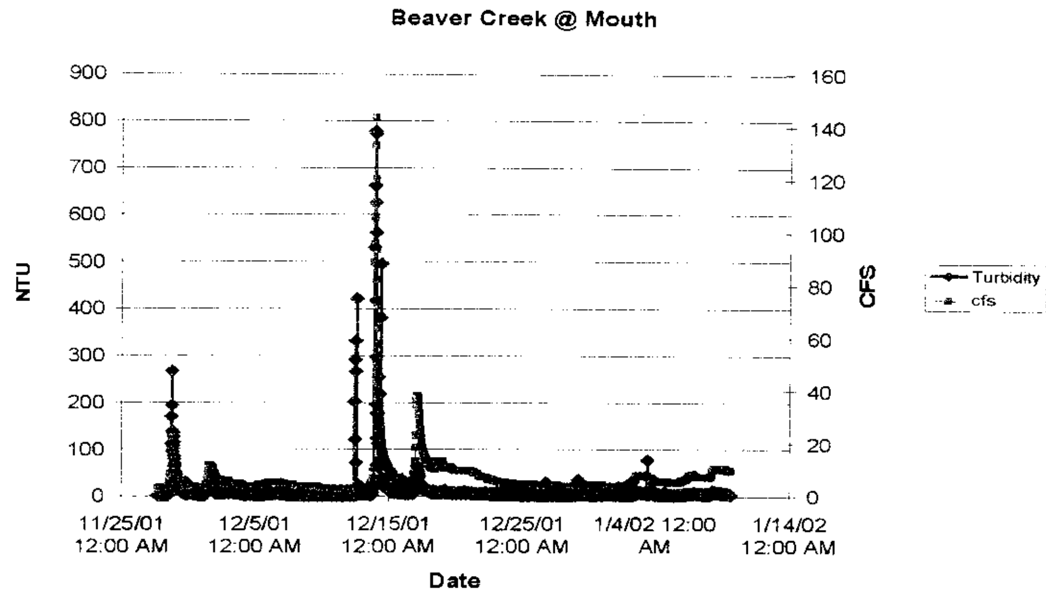
Limited sampling in Beaver Creek in 2002 revealed that Beaver Creek mainstem and small tributaries draining the northern aspect carry high levels of suspended sediment. A northern tributary in section 7 exceeded 1000 NTU's. Figure 19 displays continuous turbidity and discharge values. Final results of the Beaver Creek study are pending.

Suspended Sediment

Suspended sediment was measured in the mainstem of the Little Applegate River and Yale Creek. Tributaries to both Yale Creek and the Little Applegate River were also measured. A depth integrated suspended sediment sampler was used to determine sediment concentration (mg/L). Sediment concentration was multiplied by discharge to determine sediment discharge (grams/second).

Suspended sediment discharge is a function of supply, in-channel transport rates, storm intensity, and timing. The high flows that scour fines and the rains that wash sediment from

Figure 19. Beaver Creek Turbidity vs. Discharge



roads, fields and other sources are uneven with respect to time and space. Due to the variability of input and transport, caution should be used in interpreting sediment discharge data. Based on limited data only general interpretations can be made.

Upper Yale and Dog Fork, a tributary to upper Yale, appear to generate the greatest amount of sediment per drainage area Figure 20. This supposition is supported by the US Forest Service's investigations of slope stability. The investigations identify multiple unstable terrains including landslide activity, debris flow activity and earth flows in the Upper Yale Basin. Conversely, Grouse Creek data indicate that sediment discharge is relatively low. The US Forest Service identified few unstable terrains in Grouse Creek basin. In 2002, Beaver Creek was sampled and was found to carry as much suspended sediment as Little Applegate and Yale.

In terms of total sediment discharge, Little Applegate near Yale and Yale Creek at mouth rank as the highest sediment producers Figure 21. This is reasonable given that these locations also have the largest contributing watershed area.

Scour Chains and Sediment Buckets

Sediment transport following spawning can pose two major threats to developing embryos and emerging fry—stream bed scour and fine sediment infiltration.

Stream bed scour can cause high mortality to incubating eggs and developing alevins (Nawa et al 1993) as observed in the Applegate River and Butte Creek system following the 1997

Figure 20. Suspended sediment Concentration

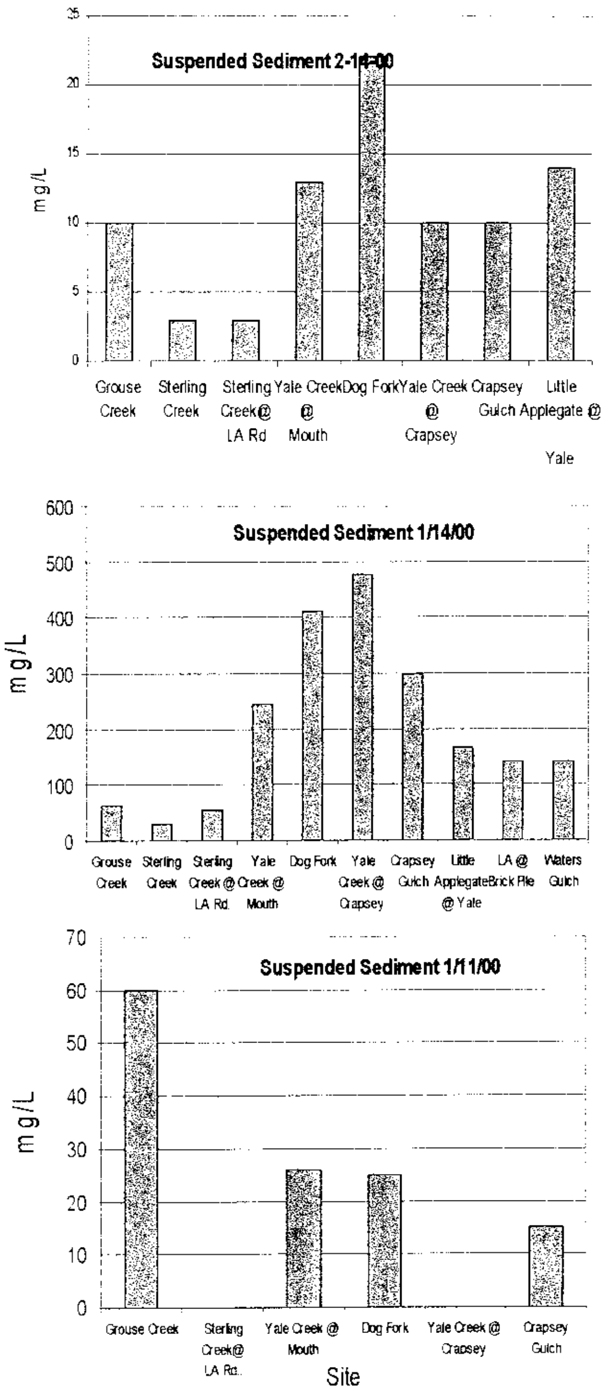
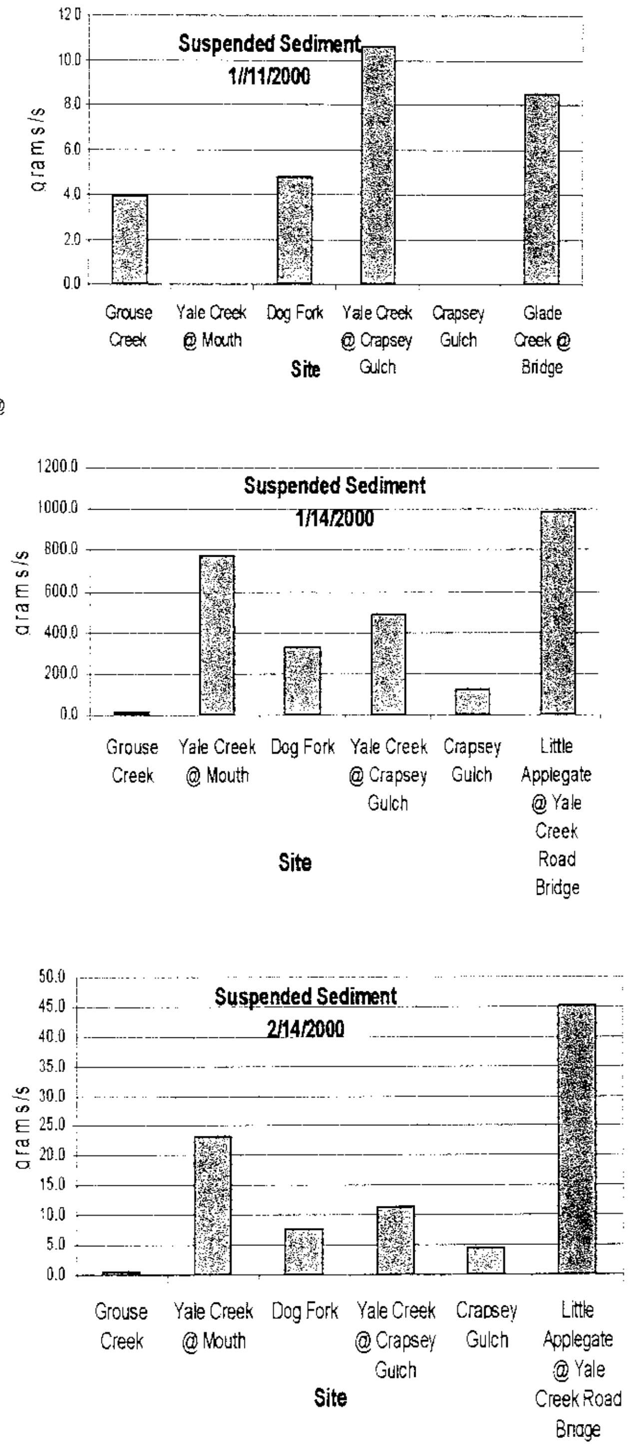


Figure 21. Sediment discharge rate



flood event. In this instance, Coho salmon spawned prior to the flood which subsequently scoured all redds. Levels of scour and fill can increase significantly following channel disturbances. Specifically, wood removal and channel straightening increase flow velocity and prevents lateral movement. This condition exists in nearly all low gradient floodplain reaches (see channel morphology). As a result, shear force along the channel bed increase. To evaluate scour and fill, scour chains were driven into the bed substrate to a depth of 2.5 feet. Scour chains were installed in the Little Applegate River, Yale Creek and Williams Creek. To date, the channel beds have shown no movement or scour. This is expected given the very low magnitude of peak flows over the last two winters. The study is on-going.

Fine sediment transport following spawning can infiltrate into the gravels reducing intergravel flow, reducing oxygen supply to developing embryos. Fine sediment can also plug interstitial spaces preventing fry emergence. Effects of fine sediment on biota depend on the tendency of particular grain size to deposit at certain levels in the bed where they may influence aquatic organisms (Lisle 1991). To document the process of fine sediment infiltration, sediment buckets were installed in Williams Creek, a stream with high fine sediment loads and a relatively strong coho spawning population.

Installation includes filling a bucket full of clean gravel, burying the bucket in the channel bed, and following peak flows, remove the bucket and measure the volume and size of the fine sediment. This is the first year of the sediment bucket study and results are pending.

Fine Sediment Pool Volume

Fine sediment pool volume is the fraction of pool filled with fine sediment, notated V*. Calculating sediment discharge in mountain streams is both difficult to measure during high flows and highly variable. V* estimates the sediment supply by measuring the amount of sediment accumulation in topographic low spots (pools) where sediment is likely to deposit. The study is conducted during the summer when flows are low and access good.

V* studies were conducted in Yale creek below the Quartz fire, and in Beaver and Palmer Creeks. Eight to ten pools were selected for assessment; sites were permanently monumented for follow up studies and effectiveness monitoring. Individual pool results were averaged, yielding V* for the reach. The percent of pool filling for Palmer, Yale, and Beaver creeks is 15, 19, and 35, respectively.

For comparative purposes, Lisle 1992 in the Trinity River system, found V* values ranging from 4-50 percent. A sediment budget was also calculated for the streams and was found to be highly correlated to the V* findings. The highest ranking sediment producer matched the highest V* rating and the lowest sediment producer matched the lowest V* value. Values for V* for the remaining watersheds fell in approximate order of sediment production.

Based on our V* studies and those conducted by Lisle, Beaver Creek carries the highest sediment load of the streams sampled. The assumption is consistent with limited bedload sampling conducted in year 2000 (Table 3). Beaver Creek, despite having a much lower discharge during sampling, had the highest bedload. Course granitic sand was found to be the bulk of the sediment captured in the Little Applegate, Yale, Beaver and Williams Creeks.

Table 3. 2000 Bedload sampling

date	site	Bed Load (gm.)
14-Feb	Yale @ mouth	61
14-Feb	yale @ Crapsey	99
14-Feb	Crapsey	20
14-Feb	Dog Fork	69
14-Feb	Palmer (broken bag)	5
29-Feb	Glade	19
29-Feb	Yale	9
29-Feb	Little A @ Brick pile	157
29-Feb	Beaver	344
29-Feb	Little A @ Yale	118
3-Mar	Williams at Mouth	63

2.3.2 Sediment Sources

ARWC's sediment study focused in the Little Applegate and Yale drainages. In 2001, a sediment study began in Beaver Creek. The sediment source assessment will, therefore, focus on these drainages. The assessment is by no means a comprehensive investigation of all sediment sources but rather provides information important to interpreting our sediment sampling findings.

Geology and Soils

Examining the geology of a basin provides the first step to identifying potential sediment sources. Geology in the Applegate is quite diverse. Correspondingly, natural sediment production varies greatly across the landscape. In the Applegate, the granitic plutons and the bench and earthflow landscape units are considered the most susceptible to accelerated erosion in the watershed. Granitic rock is highly susceptible to debris landslides and severe surface erosion (USDA, Rogue River National Forest 1994). Weathering of Granitic rock produces course grained sediment.

The earthflows associated with the bench and earthflow terrain are naturally occurring mass wasting features and can be very large. Soils are poorly drained as evident by the associated bogs and seeps. Large precipitation events can reactivate the earthflow, delivering large volumes of sediment directly to the stream. Earthflows are often found impinging on a stream course which undermines the toe, reactivating the flow. Much of the sediment in an earth-flow consists of fine grained silt to clay size particles.

Granitic rock types comprise 13 percent of the Applegate basin. Of the 33 subwatersheds, three in the Applegate contain over 80% of the granitic rock types—Little Applegate, Beaver Creek, and Williams Creek. Earthflows have been identified in the Glade, Yale and Upper Little Applegate.

Debris flow in Little Applegate

Roads

Roads and forest practices can greatly accelerate natural erosion rates. Roads pose a threat to increase sedimentation by routing surface runoff and sediment directly into the channel net-work, by impeding flow at crossings, and by fill slope failures. Table 4 provides basin-wide data on roads on slopes greater than 60%, road stream crossings, and roads in riparian areas. These indicators represent conditions with the highest potential for sediment delivery. The table is ranked from the most sensitive watershed in terms of sediment delivery potential, to the least.

Table 4. Watersheds and Road miles/Stream crossings

6th field watershed	Miles Rd slopes >60%	Miles Rd Riparian	Road/ Stream X-ing	Sum
Slate Creek	11.1	16.3	8	35.5
Carberry Creek	5.4	6.3	23	34.7
Lower William	3.8	8.0	15	26.8
Forest Creek	8.4	12.2	6	26.6
Steve Fork Creek	4.4	6.5	12	22.9
Lower Little Applegate River	5.3	11.0	6	22.2
Cheney/Jackson Creeks	10.6	4.6	7	22.2
Munger Creek	2.4	5.6	14	22.0
Star Gulch	7.1	9.2	5	21.3
Humbug	5.3	8.0	7	20.3
Beaver Creek	5.4	7.8	7	20.2
Thompson Creek	7.6	4.3	8	20.0
Palmer Creek	4.6	7.0	8	19.6
Middle Fork Applegate River	6.7	2.8	10	19.4
Slagle/Miller Creeks	2.3	8.1	8	18.4
Yale Creek	1.1	6.2	8	15.3
Murphy	8.1	4.2	3	15.3

6th field watershed	Miles Rd slopes >60%	Miles Rd Riparian	Road/ Stream X-ing	Sum
Upper Little Applegate River	2.8	3.5	5	11.3
Lower Elliott Creek	4.8	2.2	4	11.0
East Fork Williams Creek	0.6	4.0	6	10.6
Middle Little Applegate River	2.8	5.4	2	10.2
Squaw Creek	1.4	3.5	5	9.9
Bishop Creek	3.4	5.1	1	9.5
Upper Elliott Creek	3.7	1.7	4	9.4
Face Drainage	1.8	5.2	2	9.0
Sturgis Fork Creek	2.1	2.1	3	7.2
Joe Creek	4.3			4.3
Applegate Lakefront	0.7	2.5	1	4.2
Glade Creek	1.8	0.7	1	3.5
Dutch Creek	0.5	0.2	1	1.6
Obrien Creek	0.8	0.5		1.3
Butte Fork Applegate River	0.4	0.0		0.5
Face Drainage	1.4		1.4	

Beaver Creek

Thirty percent of the Beaver Creek drainage is comprised of granitic rock types. In the Haskins drainage, in section 13, numerous active road cuts were identified on Roads 2000907 and 2000908 (USDA forest Service 1994). South, in section 24, Rd. 2000900 has numerous areas of rills and gullies in the road prism. Also in section 24, old skid roads on very steep slopes (>60%) show rills, gullies and ravel. Additionally, clear-cut in the Haskins subwatershed have been slow to recover in numerous portions of section 13. Road 20 as it runs through the granitic belt in the mid- to upper- elevations is experiencing high levels of cut slope raveling. Haskins Gulch, also containing a high percentage of granitics has the highest road density in Beaver Creek at 4.6 miles of road per square mile.

In the northern part of the watershed, old roads in section 12 and 7 are interfering with stream courses resulting in fine sediment production. While not located in the granitics, these roads and streams may be running through an old earthflow which were identified just over the ridge in Yale Creek. While this formation has not been identified in the Beaver Creek drainage, the reddish color of the sediment is characteristic of the bench and earthflow formation.

In general, inadequate road drainage features such as water bars and dips on steep granitic roads is a leading factor of increased sediment production. Additionally, many culverts are undersized to convey a 100 year flood; several have initiated gullies at the outflow (USDA forest Service 1994).

Little Applegate River

Twenty percent of the Little Applegate River consists of granitic rock types. Granitics, including shallow and glaciated granitics comprise approximately 70 percent of the Upper Little Applegate and McDonald Creek subbasins. Thirty percent of Yale Creek contains granitic rock types. Earthflows comprise 23 percent of the Yale Creek watershed.

Mapped debris slides (USDA forest Service 1995) in the Little Applegate are concentrated in the upper watershed above Glade Creek and in Upper Yale Creek. A vast majority of slides were found in in the higher precipitation zone (above 4500 feet), and in the shallow granitic landscape. In this landscape, debris slide prone areas are characterized as having cohesionless sandy soil atop bedrock on steep slopes.

The single greatest contributor of accelerated erosion and sedimentation is roads (USDA Forest Service 1995). Photo comparisons of 1996 and 1998, bracketing the 1997 flood, show debris slides and flows originating from roads in the headwaters of Yale Creek and the Upper Little Applegate River. Steinfeld and Amaranthus (1999), in an Applegate-wide study, found ninety-eight percent of storm initiated landslides were related to management activities, primarily roads. ARWC staff field observations and road inventories indicate that much of the turbidity in the Little Applegate drainage originates from road systems. Roads identified as delivering chronic and episodic fine sediment include:

⇒ Dog Fork Road and spurs
⇒ Forest Service(FS) roads 581 and 1099

⇒ FS road 2040
⇒ Unidentified road (Township 40, Range 1 secs. 4,9,10,15,16,22,23)
⇒ Road 2030
⇒ Rush Creek Road

Grazing in the granitic areas of the upper subwatersheds, particularly McDonald Creek, have led to very large gullies. Removing vegetation and associated root mass from this cohesionless soil led to raveling and rill development. Concentration of runoff in the rills has lead to gully formation. Another major contributor of granitic sand to the system have been fill failures and gullies associated with the Talent Irrigation Ditch. In 2002, ARWC in cooperation with Oregon Water Trust and Talent Irrigation District initiated project development to identify alternatives to the McDonald Ditch system.

2.3.3 Channel Geometry

Over 30 cross sections were permanently established throughout the Applegate. Transects across the channel provide information on widths, depths, hydraulic radius, floodplain elevations, and channel area. This information provides insights to the conditions and functions of both the channel and the upslope environment. Moreover, cross sections are a valuable tool to monitor channel responses that may result from management activities, including restoration, or climatic events.

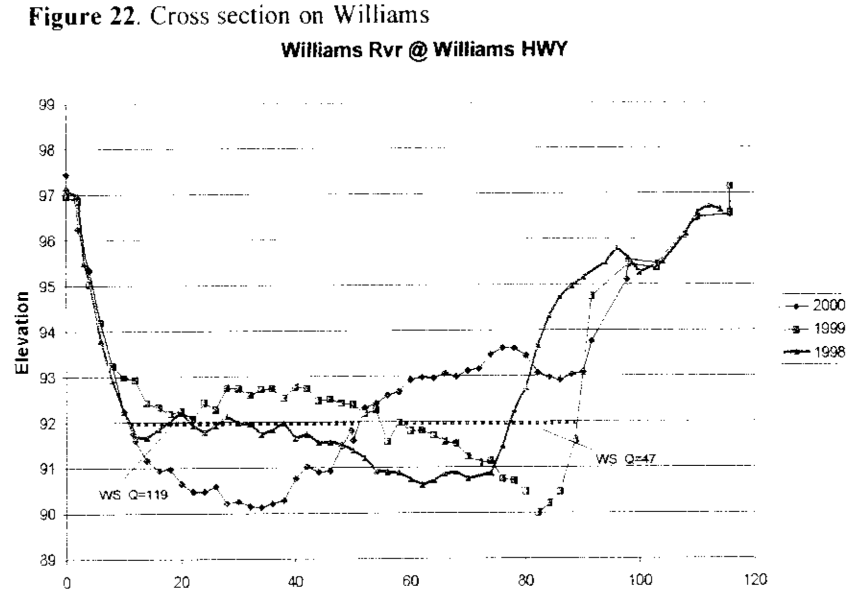
Channels, given their inherent characteristics, will respond uniquely to restoration and/or disturbances. To facilitate an understanding of channel adjustments and responses a summary of channel processes is presented:

> Channel morphology, or channel structure, is influenced by a number of variables including, width, depth, velocity, discharge, channel slope, roughness of channel materials, sediment load and sediment size (Leopold 1964). Although a number of variables determine channel structure, examining channel gradient and confinement provides a method to delineate between channel processes and response potential. Channel slope, gravity as the energy driver, determines sediment transport and deposition patters. Channel confinement, defined as the ratio of valley floor width to channel width, is the dominant structure determining flow width and floodplain development.
>
> Channel reaches can be broadly classified as source, transport and response reaches. Identification of potential source, transport, and response reaches provides a first step for assessing potential channel responses and recovery times (Montgomery and Buffington 1993). *Source reaches* with their steep position (>30% slope) in the watershed are susceptible to scouring, providing a sediment *source* to the channel environment. *Transport reaches* are high gradient confined channels capable of *transporting* sediment downstream. *Response reaches* occupy the lower watershed and have the lowest gradients. Commensurate with low gradient is low sediment transport capacities. These reaches *respond* to elevated sediment loads and other disturbances.

The majority of cross sections established in the Applegate fall into the *transport reach* classification. Given the resiliency to change of a transport reach and the low peak flow years following cross section establishment, very little change has been observed. The ability to resist change in the transport reaches is evident in the Yale Creek, Beaver Creek and the Upper Little Applegate River. The reaches have received a significant increase in sediment contribution from upslope sources (see sediment sources) but channel geometry has changed little. This can be attributed to the high sediment transport capacity of these channels; sediment entering these reaches is quickly transported downstream. While channel geometry has been little affected, fine sediment has deposited in and around cobbles, embedding the stream substrate.

A cross section in Williams Creek (Figure 22) displays channel adjustment in a response reach. The channel adjustments clearly reflect a "flashy" hydrologic regime and channel instability. Generally, channel instability can be attributed to an increase in sediment or discharge, a reduction in large wood, or channel straightening leading to a loss of floodplain connectivity. The Williams Creek Watershed Assessment (Williams Creek Watershed Council 2000) identified roads, grazing, agriculture and bank erosion as sources of increased sedimentation. The assessment also identified channel straightening, bank armoring and levee construction. These activities led to channel incision and loss of floodplain connectivity. Presence of large wood has also decreased, resulting from instream removal and riparian harvest.

Figure 22. Cross section on Williams



Williams Creek was an exception as most response reaches showed little change during our sampling time frame. However, channel cross section geometry does show adjustments to past disturbances. Figures 23 and 24 display channel adjustments from the 1997 flood. Prior to the flood, the channel form was created by channel straightening for agricultural practices, mining and infrastructure protection. Associated with these activities was an increase in channel gradient, as sinuosity decreased, and a loss of floodplain connectivity. The combination of increased gradient and loss of floodplain connection results in much higher in-channel energy. As a result, the 1997 flood scoured streambanks, created new channels and increased sinuosity. It is interesting to note that following the 1997 flood an increase in sinuosity was also observed in the Little Butte Creek system and the Illinois River system. Presumably, the increase in sinuosity was a process to reestablish channel grade and equilibrium.

At the watershed scale, nearly all low gradient reaches have lost connection with the floodplain. Incision, or channel confinement, occurs when the channel bed drops in elevation, also known as bed degradation. Figures 23 and 25 display cross sectional profiles of channels that have incised into the floodplain.

Figures 23. Little Applegate Cross Section

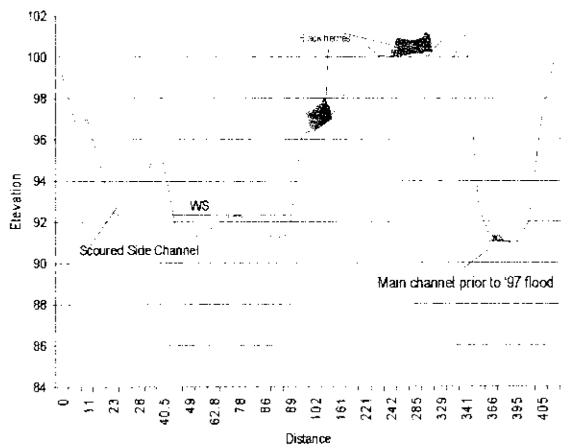


Figure 24. Forest Creek Cross Section

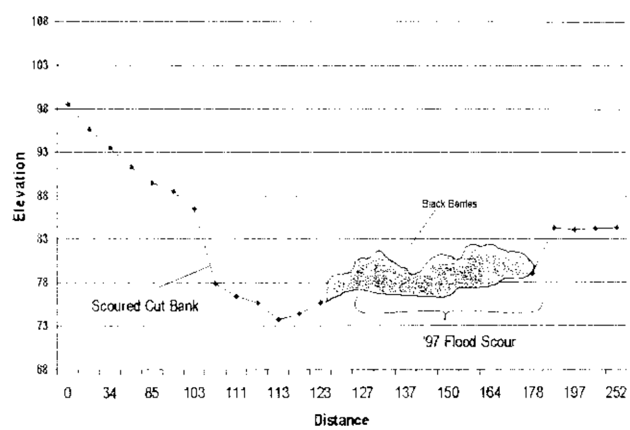
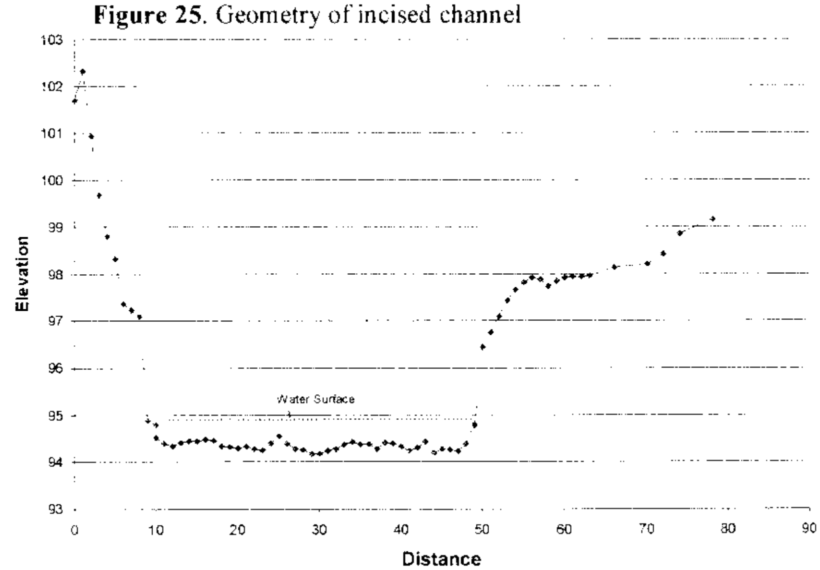


Figure 25. Geometry of incised channel



Additional information on channel entrenchment is provided by ODFW habitat surveys. Entrenchment is an index of channel confinement, defined as the terrace width divided by active channel width. Table 5 lists subwatersheds and percent loss of floodplain connection. The percent findings is based on those reaches with floodplain potential. In other words, channels with natural confinement where floodplain connection was never possible were exclude from analysis. Specifically, for inclusion in the assessment channel reaches met two criteria: 1) gradients less than 3 percent; 2) a valley width index greater than 2.2.

Table 5. Basin and % floodplain loss

Stream	Percent floodplain loss
Caris Creek	100
Cheney Creek	75
Little Applegate River	100
Murphy Creek	85
Slate Creek	90
Williams Creek	90

Channel incision on the Mainstem Applegate
Photo Courtesy of Charles Rogers

Floodplains function to dissipate energy, provide off channel habitat and wetlands, and provide water storage for late summer cold water releases. These functions are essential for channel stability, rearing salmonids and riparian diversity. The ability of the floodplains to provide these functions has been greatly reduced across the Applegate River Basin.

The mainstem Applegate is the largest response reach in the watershed. Accordingly, nearly all of the sediment entering the tributaries transport downslope to the mainstem. The Applegate itself has been directly modified by land clearing, levee development, side channel obliteration and instream gravel mining (ARWC 1999). Cumulatively, these activities have destabilized the mainstem river. Active channel widths in the mainstem have increased, up to 400 percent. From a cursory investigation, the sediment released from mainstem bank erosion overwhelms the sediment input from tributary sources. Although the mainstem has not incised into the floodplain as the contributing tributaries, floodplain function has been drastically reduced by the aforementioned management activities.

2.3.4 Physical Habitat

BLM, ODFW and ARWC provided data on aquatic habitat. Two survey protocols were used—Hankin and Reeves (1990) and ODFW (1989). Habitat data is collected along a stream reach; a series of reaches constitutes the surveyed stream length. Survey data from all sources were input into a GIS project.

Assessment of habitat conditions is a comparison of ODFW and National Marine Fisheries Service (NMFS—Klamath Province/Siskiyou Mountain Matrix) benchmarks to survey findings. In instances where benchmarks differ, ODFW's benchmarks were used. The assessment is at the 6th field watershed level. Results at the 6th field level derived from a length-weighted average of the surveyed reaches in the watershed. A series of figures displays habitat conditions as related to agency benchmarks across the Applegate and include:

Figure	Name	ODFW Benchmark	NMFS Benchmark
26	Fine Sediment	Desirable- % area <15	<20%
27	Pool habitat	Desirable- % area > 35	>30%
28	Residual Pool Depth	Desirable - >1 meter	> 3 feet
29	Complex Pools	Desirable - > 3/km	NA
30	Key Large Wood	Desirable - > 3/100m	25/mile
31	Spawning gravel	Desirable- % area ≥ 35	NA

The data serves to show that pool habitat and complexity are greatly lacking at the watershed scale. Instream large wood debris also greatly deficient across the Applegate is a primary reason. Channel incision and associated loss of floodplain connection has also led to pool loss and channel simplification in the lower gradient reaches. Spawning gravel is ample in all subwatersheds.

The fine sediment findings, which indicate little impairment is misleading. Ocular estimation was used to determine fine sediment. This method often misses fine sediment embedded around cobbles and gravels. Based on field reconnaissance sections of the Little Applegate River, Yale, Beaver, and EF Williams Creeks are adversely affected by fine sediment. In these reaches, granitic sand was the culprit.

3.0 Biological Monitoring

Biological monitoring provides information on how aquatic species respond to their habitat. ARWC conducted steelhead spawning, snorkeling and macroinvertebrate surveys. Biological sampling by ODFW was included to provide a more comprehensive biological picture of the watershed.

<u>Spawning surveys</u>

In 2000, ARWC in cooperation with the Rogue River National Forest conducted steelhead spawning surveys in the Little Applegate and Yale drainages. The study was initiated to provide pre-project monitoring associated with the Little Applegate Streamflow and Habitat Enhancement Project (LASHEP). Protocols followed ODFW's *Coastal Steelhead Spawning survey Procedural Manual.*

The study consisted of three reaches in the Little Applegate and two in Yale Creek. The reaches included:

- Farmers Ditch to Buck and Jones Ditch (Reach 1)
- Buck and Jones Ditch to Grouse Creek (Reach 2)
- FS boundary @ RM 14.2 to Waters Gulch (Reach 3)
- Yale Creek @ Mouth to First Waters Gulch
- Yale Creek – Unnamed tributary to Box Canyon

Figure 26. Percent fines

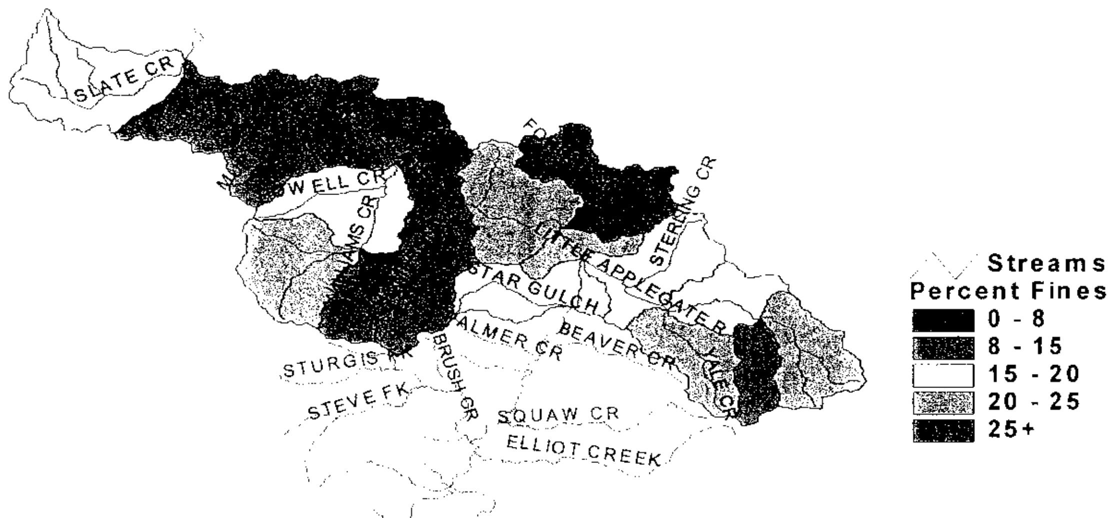


Figure 27. Percent Pool Habitat

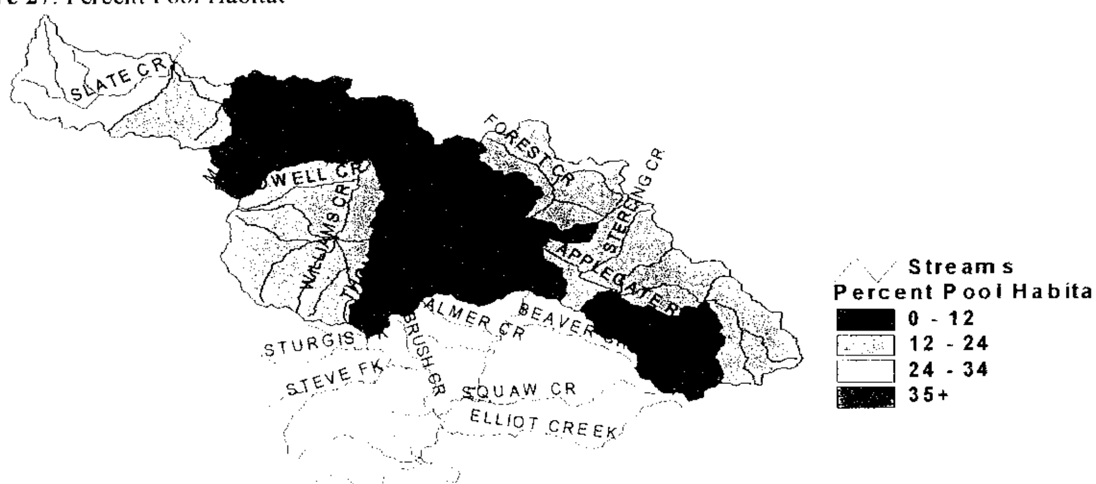


Figure 28. Number of Pools w/ residual pool depth >1m

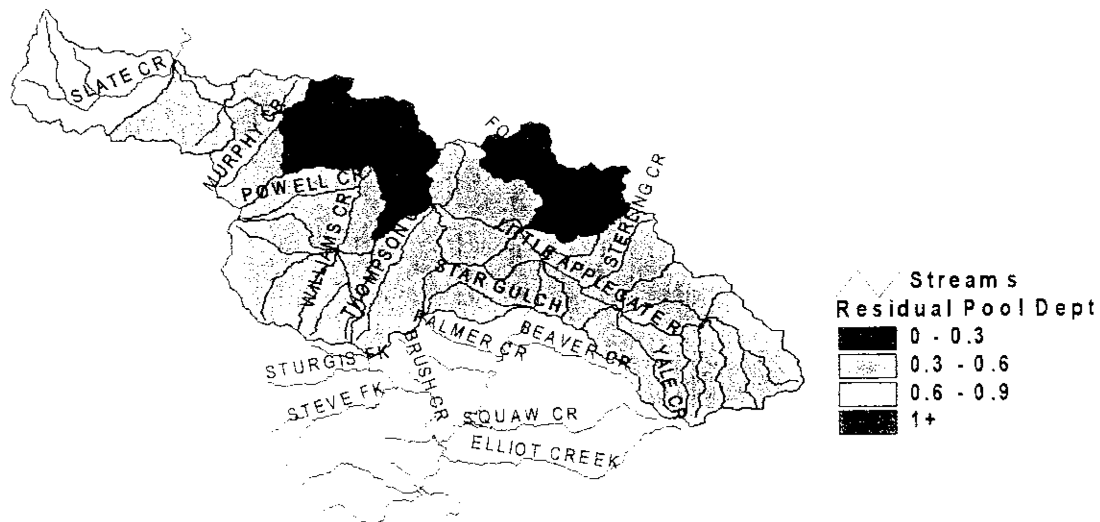


Figure 29. Number of complex pools

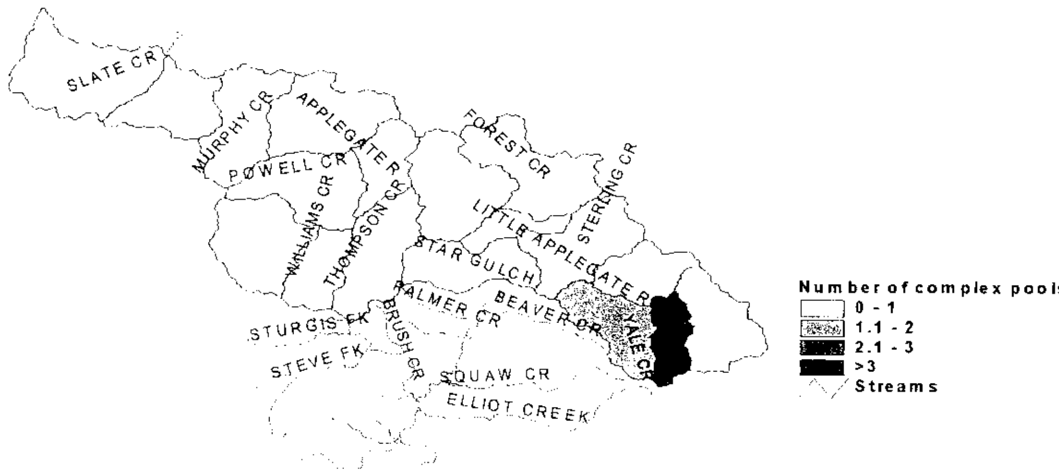


Figure 30. Pieces of LWD/Mile

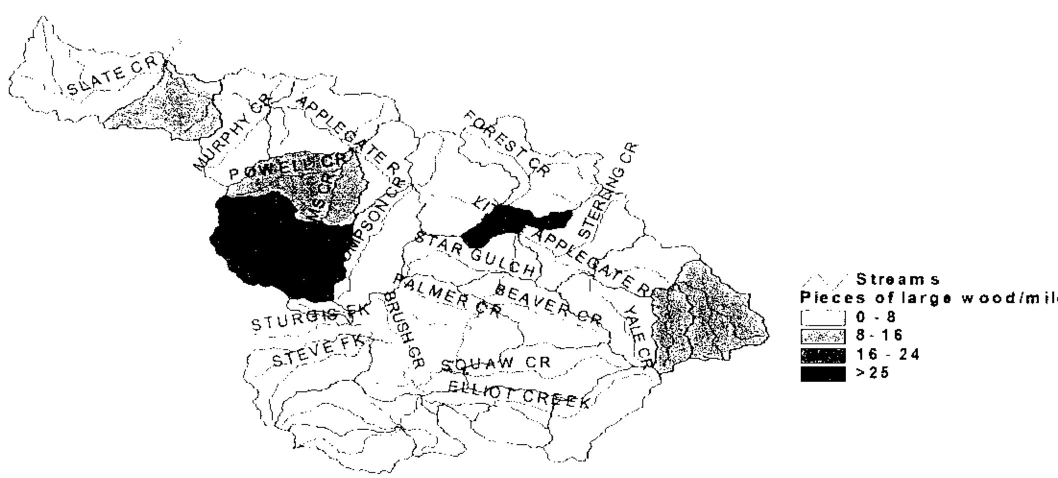


Figure 31. Percent Spawning gravel

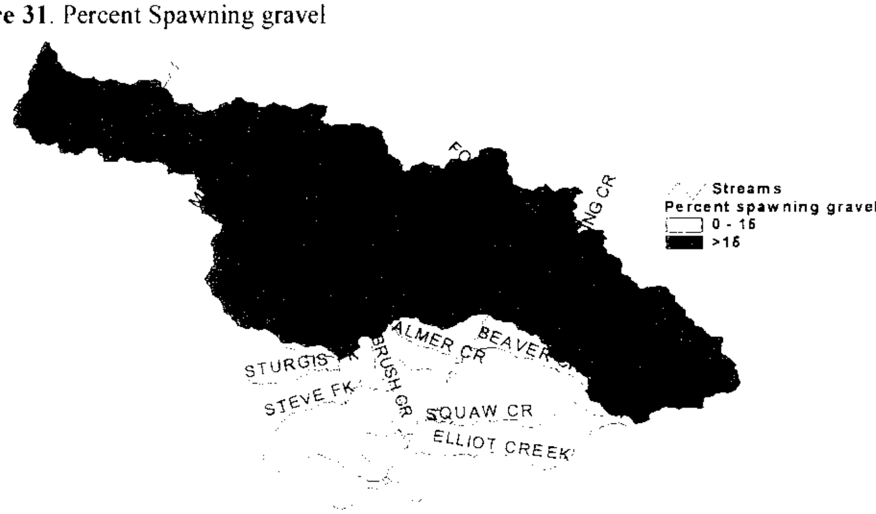
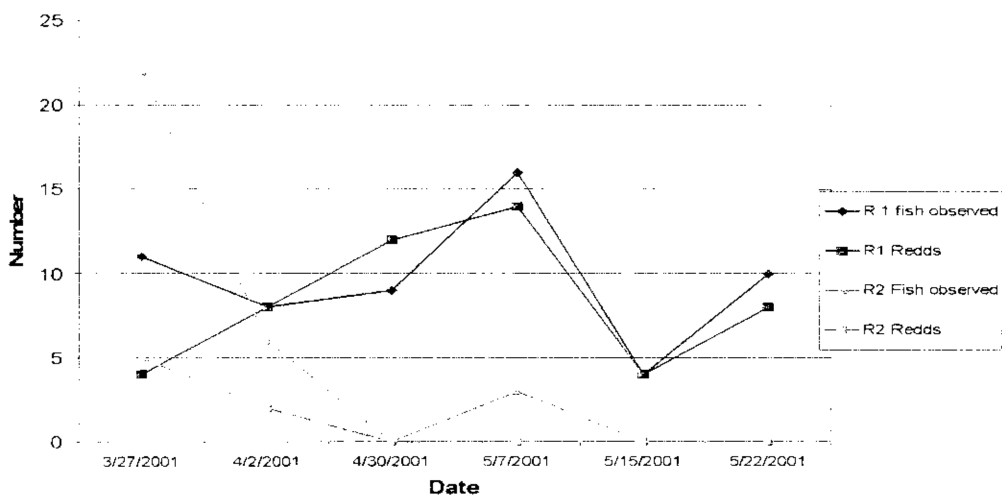


Figure 32 displays number of fish/redds observed and data. In the figure, R1 and R2 denotes the reach from Farmers Ditch to Buck and Jones Ditch and Buck and Jones Ditch to Grouse Creek, respectively. The drop in fish and redd observations in reach 2 coincides with flashboard installation at the Buck and Jones Diversion. Interestingly, in 2002, a flashboard board placed in late fall was removed in March after which dozens of steelhead were observed migrating over the structure. Removal of the Buck and Jones Diversion structure is planned as part of the LASHEP project.

Figure 32. Spawning observation in Reach 1&2

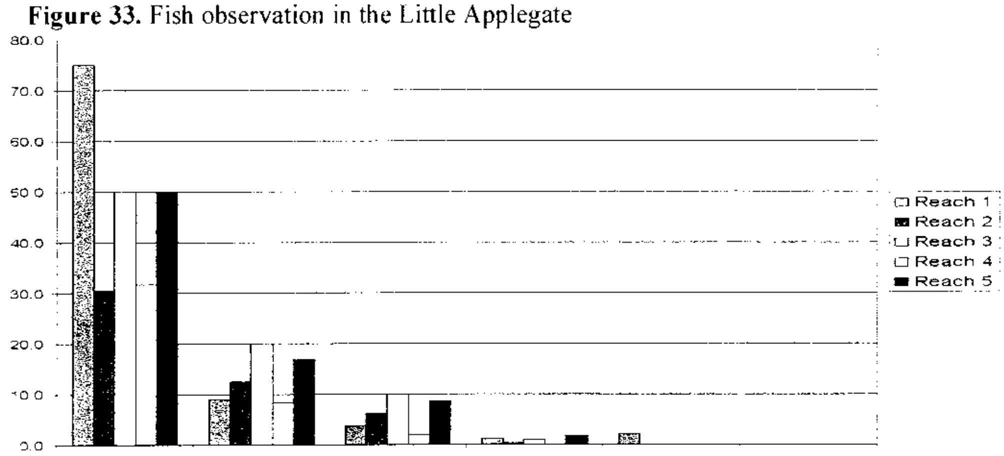


Snorkel Surveys

Little Applegate

Following a physical habitat survey in the Little Applegate a fish survey was conducted. Figure 33 displays reaches, species and count. Reach counts were determined by dividing the number of fish observed in the reach divided by units sampled. Appendix C contains detailed fish sampling findings.

Figure 33. Fish observation in the Little Applegate



From the chart, steelhead, particularly 0+ age, was the most frequent species-age class observed. Neither coho nor Chinook salmon were observed above the falls located near the end of reach 1.

While all reaches display a significant decline in numbers with increasing age class, reach 1 has the steepest decline. Habitat and water quality data may provide an explanation. Reach 1 maintains the lowest pool frequency, lowest large wood debris volumes, and the highest water temperatures. The absence of channel complexity created poor summer and winter habitat. Water temperatures in the lower LA ranks as one of the warmest reaches in the watershed. The drop may also reflect out migration as these fish have the best access to the Applegate River. Low water and diversion structures reduce mainstem accessibility to fish in reaches 2-5 reach. The relatively high numbers of 0+ steelhead in reach 1 may also indicate migration difficulty over the natural falls and Farmers Ditch which starts reach 2. The snorkeling protocol will be repeated following LASHEP project implementation.

Around the basin

During the drought of 2001, ARWC snorkeled several streams in the Applegate for fish use to identify reaches providing refugia during stressful drought conditions. Williams Creek above Williams Highway, Little Applegate River from Farmers Diversion Ditch to the Buck and Jones Diversion ditch and the mainstem Applegate River were sampled three times through the summer. Sampling locations on the mainstem included below the dam, at Jackson Picnic Grounds, Cantrell Buckley Park and below Humbug Creek. The EF and WF Williams, Slate Creek, and Waters Creek (tributary to Slate Creek) were sampled once late in the summer by snorkeling and ocular estimation.

Dave bravely looking for fish

A large reduction in salmonid numbers through the season was common to all streams surveyed. In the mainstem Applegate, number of salmonid observed decreased by 60% from our July to August surveys. The reach below the dam saw the largest decrease at 90%. In Williams Creek, we observed a 50% reduction from our June to July survey; coho numbers decreased by 90+%. All coho remaining in Williams Creek were found along cold water seeps and cool side channel inputs, which were 2-5 °C colder than the thalweg. The Little Applegate numbers display an increase in salmonid observations from our June to July survey but a decrease of 40% from July to September.

While migration may account for the changes in salmonid observations, very warm water reaches, dry reaches, and diversion dams greatly limited migration. In the mainstem Applegate, warm water and low DO levels below the town of Applegate limited downstream migration and low tributary input prevented moving into tributary streams. In Williams Creek, diversion structures and dry channels limited migration opportunities. In the Little Applegate, diversion dams prevented upstream migration and limited downstream migration.

In Waters Creek, we found coho schooling and a few steelhead in a 200 foot reach below the road 2200. No coho were observed above the culvert which is being replaced by the FS. Downstream of the 200 foot reach the channel was dry. In Slate Creek, we found coho schooling and a few steelhead from HWY 199 bridge downstream 300 yards. This reach flows through mature riparian forest on BLM land and contained several pieces of LWD. The lower reaches of EF and WF Williams supported coho and steelhead. Interestingly, higher on the East Fork, near Rock Creek, only a couple salmonids were observed despite favorable flow and water quality conditions. A diversion dam was identified as a possible migration barrier.

This limited survey indicates the importance of juvenile migration in our system. Coho generally spawn in lower gradient alluvial valley bottoms. The same locations have high summertime temperatures and concentrated water diversion activities. These reaches have also seen a significant decline in floodplain connectivity and associated loss of habitat (see channel morphology). Consequently, good spawning locations in our basin generally provide low quality rearing habitat. As fry emerge from the bed, migration is necessary to escape stressful rearing conditions. Without the ability to relocate, necessary habitat to complete the life cycle is limited.

Appendix A.4 provides a summary of species and distribution as identified by ODF.

Macroinvertebrates

ARWC, FS, and BLM have conducted macroinvertebrate sampling over the last 10 years. The assessment examines species richness and abundance to determine biotic health. The benthic community found at the sampling stations are compared with a reference model derived from a composite of benthic communities found in pristine or minimally disturbed Pacific Northwest streams. Three indices of biologic integrity are generated, corresponding to different habitat types: 1) Erosional habitat - riffle or fast water habitat 2) Marginal habitat—slack water habitat along channel margins 3) Detritus habitat—slow or slack water with ample detritus (leaves and organic debris). Scores for each habitat type are expressed as a percent of maximum potential score.

Table 6 lists the sampling sites and scores. The table is sorted from the highest average score to the lowest. Sites with scores above 80% have a high biotic integrity; scores below 65% have a low biotic integrity. Approximately 40 % of the samples fall into the low biotic integrity class.

The contractors (Bob Wisseman of Corvallis, Pete Schroeder Southern Oregon University) performing the assessment characterize the fauna at sites with scores below 65% as absence of cold water species, high embeddedness, few long lived taxa, and abundant high tolerant species. Long lived taxa indicates structural diversity; low levels of taxa indicate low habitat diversity.

Table 6. Macroinvertebrate Scores

SITE	EROSIONAL	MARGIN	DETRITUS	AVERAGE SCORE
LAKE CR. at MOUTH	87.0%	86.7%	91.7%	88.5
GLADE CR. blw. JACK CR.	87.8%	85.7%	n/a	86.8
McDONALD CR. at MOUTH	88.6%	79.6%	86.5%	84.9
YALE CR. blw. CRAPSEY	84.7%	88.9%	78.4%	84.0
TAMARACK CR.	88.7%	83.8%	79.4%	84.0
GLADE CR. at MOUTH	87.0%	80.6%	n/a	83.8
LITTLE APPLEGATE R. blw. BEAR GULCH	85.4%	77.6%	87.5%	83.5
YALE CR. at KENNEY MEADOWS	78.9%	84.7%	85.4%	83.0
YALE CR. abv. CRAPSEY GULCH	88.6%	77.6%	81.3%	82.5
YALE CR. (UPPER)	87.9%	79.8%	79.4%	82.4
YALE CR. at KENNEY MEADOWS	72.6%	84.7%	87.5%	81.6
GARVIN GULCH at MOUTH	81.3%	n/a	n/a	81.3
SILVER FORK CR.	79.8%	82.8%	79.4%	80.7
LAKE CR. (UPPER)	84.7%	79.8%	77.3%	80.6
GLADE CR. abv. GARVIN GULCH	84.7%	81.8%	73.2%	79.9
LITTLE APPLEGATE R. at TUNNEL RIDGE	70.2%	80.6%	84.4%	78.4
LITTLE APPLEGATE R. blw. McDONALD CR.	72.4%	82.7%	76.0%	77.0
LITTLE APPLEGATE R. at TUNNEL RIDGE	67.5%	81.6%	74.0%	74.4
McDONALD CR. (UPPER)	77.4%	76.8%	64.9%	73.0
LITTLE APPLEGATE R. abv. RUSH CR.	67.7%	79.8%	66.0%	71.2
STEVE'S FORK	80.0%	68.0%	64.0%	70.7
PALMER CR. abv. LIME GULCH	68.5%	67.7%	75.3%	70.5
THOMPSON CR. abv. 9-MILE CREEK	66.1%	66.3%	71.9%	68.1
YALE CR. at MOUTH	54.0%	70.4%	72.9%	65.8
ROCK CR. at MOUTH	54.0%	69.4%	72.9%	65.4
YALE CR. at MOUTH	49.6%	76.5%	68.8%	65.0
BEAVER CR. blw. ARMSTRONG GULCH	65.3%	70.7%	58.8%	64.9
ROCK CR. at MOUTH	66.1%	68.4%	59.4%	64.6
ELLIOTT CR. 37S-07W-15 NE SE	62.9%	62.6%	62.9%	62.8
LITTLE APPLEGATE R at BRICKPILE RANCH	80.0%	n/a	45.0%	62.5
YALE CR. at MOUTH	54.8%	61.2%	69.8%	61.9
WATERS CR. blw. BEAR CR.	53.2%	64.6%	64.9%	60.9
CHENEY CR.	57.3%	69.4%	55.2%	60.6
LITTLE APPLEGATE R. abv. YALE CR.	46.3%	71.4%	61.5%	59.7
LITTLE APPLEGATE R. abv. YALE CR.	50.0%	58.2%	61.5%	56.6
LITTLE APPLEGATE R. abv. YALE CR.	50.0%	58.2%	61.5%	56.6
W. FK. WILLIAMS CR. at MOUTH	44.4%	65.3%	59.4%	56.4
BEAVER CR.	75.0%	50.0%	41.0%	55.3
LITTLE APPLEGATE R. at MOUTH	46.3%	60.2%	57.3%	54.6
SLATE CR. at REDWOOD TAVERN	48.4%	60.2%	54.2%	54.3
E. FK. WILLIAMS CR. at Brown's RD.	43.5%	53.1%	58.3%	51.6
LITTLE APPLEGATE R. at MOUTH	44.4%	51.0%	53.1%	49.5
SLATE CR. at HWY. 199 BRIDGE	40.3%	49.5%	57.7%	49.2
LAKE CR. at MOUTH	34.7%	52.0%	45.8%	44.2
WILLIAMS CR. at HWY 238 BRIDGE	27.4%	42.9%	50.0%	40.1

Comparing the biotic scores with our temperature monitoring, sediment monitoring, and ODFW habitat data, reveals a high association . Namely, those sites with scores below 65 are generally the warmest reaches in the watershed, have the highest increased sediment input, and maintain low habitat complexity.

However, in describing Cold Water Biota Wisseman further states: *Summer water temperatures are high enough to be lethal to all cold water invertebrates. The absence of cold water invertebrate indicates that water temperatures are non-supportive of salmonid use.* While ARWC's temperature monitoring does indicate that temperatures are above optimum for fish, many of these sites maintain a salmonid population as supported by late summer observations. Apparently, Wisseman's reference model for benthic communities is not directly applicable to the Applegate. Wisseman acknowledges the fact by stating that "scoring criteria are not adjusted to individual watersheds or regions...they become better defined with greater comparative information from minimally disturbed watersheds in the region."

4.0 Project Monitoring

Stability of Constructed Alcoves

In 1998 Copeland Sand and Gravel implemented habitat improvement projects on their gravel operation sites. Specifically, the plan entailed construction of several off-channel alcove habitats. The intent of the alcoves was to provide high flow refugia in the winter and temperature refugia during the summer. Following project implementation ARWC conducted water quality, salmonid use, and vegetation surveys to assess project effectiveness. The final report in included in Appendix B.

Little Applegate Streamflow and Habitat Enhancement

The Applegate River Watershed Council together with numerous private and public entities are undertaking a project which changes a point of diversion from the Little Applegate River to the mainstem Applegate River. Pumps and pressurized pipes from the mainstem will replace two diversion structures in the Little Applegate.

The role of the monitoring plan is to identify and quantify the biological and physical effects from the Little Applegate Streamflow and Habitat Enhancement Project (LASHEP) . Key questions raised during project development and project expectations molded the monitoring study. The monitoring document outlines the technical evaluations in place to answer those key questions and verify expectations. Appendix C includes the monitoring plan.

5.0 Synthesis

The synthesis section integrates water quality, channel processes and physical habitat to describe summer and winter salmonid habitat suitability. Summer habitat suitability focuses on requirements for juvenile rearing; winter habitat suitability focuses on channel stability, spawning quality, and the ability to provide velocity refugia. Table 7 lists the specific indicators used to examine habitat suitability. Empirical data presented throughout this report compared to research findings on salmonid habitat requirements provides the basis for judgment of winter and summer habitat suitability. Some professional judgment and field observations were incorporated to interpolate between known condition locations.

Due to the large scale of the assessment and inconsistent data coverage, the assessment focuses on those reaches which clearly show an impairment to habitat suitability. Figures 34, impaired winter habitat, and 35, impaired summer habitat, display the identified reaches. The upstream and downstream extent of impairment is "fuzzy", meaning that depending on the year's environmental conditions, the longitudinal extent will expand or shrink.

Table 7. Indicators and Justification

Summer Suitability Indicators*	**Impairment threshold**—Justification
Dissolved Oxygen	**<6 mg/L**— initial symptoms of DO deprivation @ 6mg/L. (Davis et al. 1975; Alibaster et al. 1979)
Temperature	**>20° C**— Piper (1987) reported maximum growth with unlimited food occurred at 16-19C, but growth efficiency occurred at 10-16C. Most salmonids are at risk @ 23-25° C. (Bjorn and Reiser 1991)
Pool Frequency	**<10 channel widths/Pool**—Juvenile steelhead, coho, and cutthroat trout prefer pool habitat during low flow summer months. Reiser 1991 found higher densities of juvenile Chinook and steelhead in pool habitats. Pools offer fish a better chance of escaping predators, finding thermal refugia during summer months (Spence et al. 1996). National Marine Fisheries service determined that properly functioning channels maintained pool spacing between 4 to 6 channel widths. ODFW benchmark for desirable pool spacing is 5- 8 channel widths. In the Applegate, ODFW habitat surveys provide information on pool spacing. In examining the results, stream reaches with pool spacing greater than 10 channel widths were associated with mining activities, debris flows, loss of floodplain connectivity and very low wood levels.

Winter Suitability Indicators	Impairment threshold—Justification
Large wood debris	**<7 key Pieces of LWD/Mile**—Large stable wood in winter enhances the use of different habitats within a pool.... During floods quite water refuges are provided by wood (Maser and Sedell, 1994). LWD provides resting places for upstream migration (Spence et al. 1996). Pool area and spawning gravel retention is directly related to size of LWD (Bilby and Ward 1989). ODFW surveys of undisturbed watersheds calculated LWD/mile at the 25% percentile to be 7; 50% percentile was 28.
Floodplain connectivity	**>50% loss of connectivity** —Loss of floodplain interaction increases slope and water conveyance, leading to greater flow velocities and higher erosive forces. As a result, the channel will erode downward or outward (Gordon et al. 1992). The hydrologic storage function of floodplains is lost following channelization .... leads to a decrease in summer base flows because of a reduction in local groundwater tables (Wyrick 1968 in salmon conservation) In terms of biological habitat, channelization reduces the structural diversity of streams. Fish no longer have backwaters, pools or low velocity for refugia. Fish eggs may be swept downstream by the higher velocities (Lewis and Williams, 1984).
Pool Frequency	**<10 channel widths/Pool**—Adult salmonids migrating upstream rest in deeper pools; spring Chinook and summer steelhead may arrive at spawning sites several months before spawning and will hold in deep pools (Bjornn and Reiser 1991in salmonid conservation). Pools provide velocity refugia during winter floods. National Marine Fisheries service determined that properly functioning channels maintained pool spacing between 4 to 6 channel widths. ODFW benchmark for desirable pool spacing is 5- 8 channel widths. In the Applegate, ODFW habitat surveys provide information on pool spacing. In examining the results, stream reaches with pool spacing greater than 10 channel widths were associated with mining activities, debris flows, loss of floodplain connectivity and very low wood levels.
Spawning gravel	**% area < 15**— ODFW benchmark for undesirable levels of spawning gravel is less than 15%

Selected stream reaches, determined by data availability, were scored by comparing current conditions to the indicator threshold. Each indicator in the reach was scored as 1, not impaired, or 0 impaired. The sum of the indicator scores represent the reach condition. Cumulative scores are rated as: **suitable** if all indicators meet the criteria; **impaired** if one indicator does not meet criteria; **severely impaired** if 2 or more indicators do not meet the criteria.

It should be noted that impaired or severely impaired does not imply that the habitat does not support salmonid populations. Aquatic species are adaptable and diverse, capable of main-

Figure 34. Winter Habitat Suitability

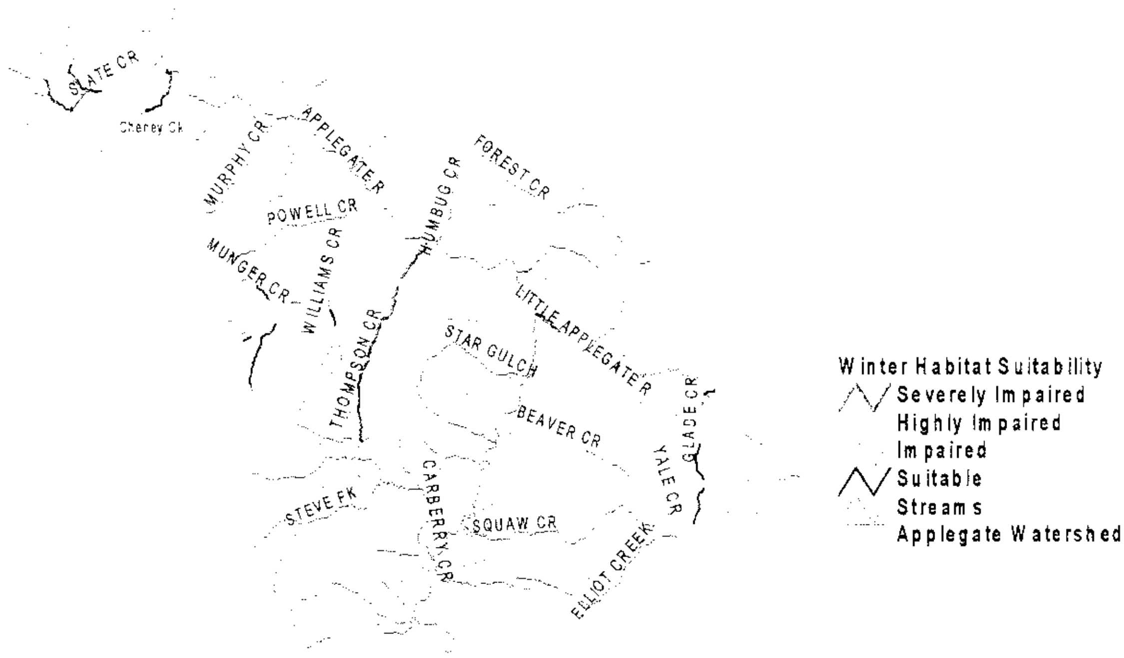
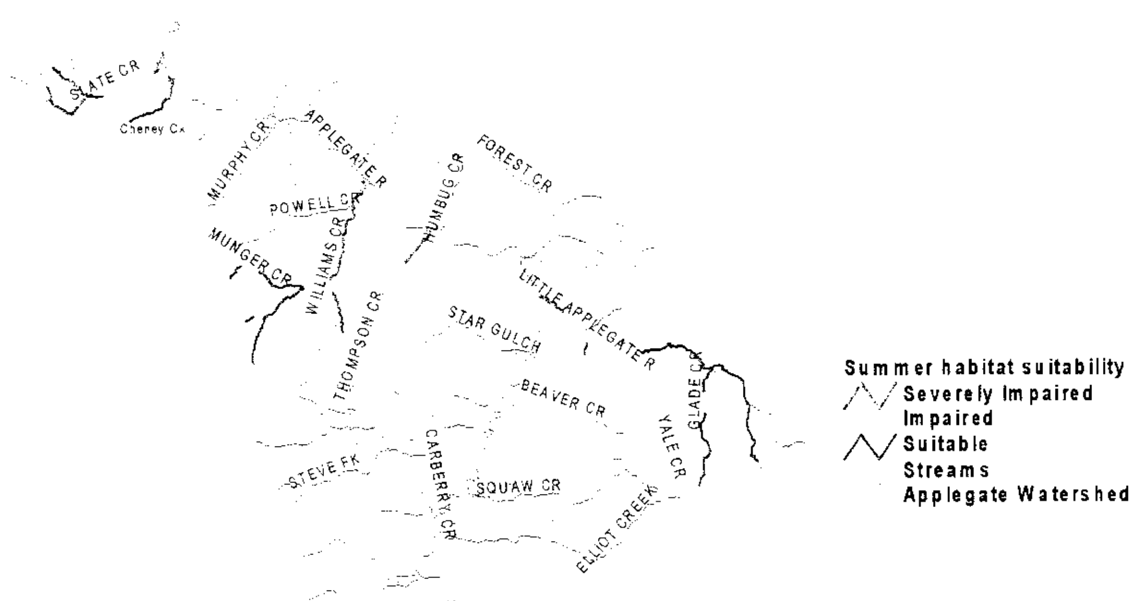


Figure 35. Summer Habitat Suitability



taining populations despite poor habitat. For example, Slate Creek identified as severely impaired, provided coho refugia during the drought of 2001.

The assessment identified two parameters most responsible for poor habitat suitability — water temperature and pool habitat. Lack of pool habit is directly liked to low wood volumes and loss of floodplain connectivity, also found to be limiting. Spawning gravel availability appears to be sufficient in all subwatersheds. Appendix A.5 provides stream reaches and scoring details.

6.0 Conclusions and Recommendations

This document emphasized landscape level conditions and functions. Recommendations, likewise, focus on the Applegate River Basin scale. The intent is not to develop a list of site specific projects, which is best accomplished following watershed assessment and in cooperation with landowners and management agencies. Rather, watershed enhancement opportunities presented are management recommendations intended to restore system wide functions responsible for most degraded aquatic conditions. Only through restoring function will allow our system incrementally and persistently improve through time.

Monitoring information identified two dominate conditions responsible for poor habitat suitability: High water temperatures and lack of Channel complexity. Loss of pool habitat, LWD, side channels and alcoves are responsible for poor channel complexity. Reduced streamflows and poor riparian vegetation conditions are responsible for elevated water temperatures.

Riparian zones including vegetation and associated floodplains function to provide shade, deliver large wood debris, and flood energy dissipation. Reduced riparian function, particularly in the low gradient valleys has been greatly reduced. Consequently, smaller scale process such as pool scouring, bed substrate sorting, and velocity refugia have also been reduced.

Management opportunities

Protection and Restoration

In the long term, our monitoring findings point to the need for instream flow enhancement and riparian zone restoration. Opportunities for streamflow enhancement and riparian zone restoration include:

1. Creation of riparian easements
2. Protection of properly functioning riparian areas
3. Creating riparian buffers in agricultural areas
4. Protection and stabilization, via planting, of existing side channels
5. Improve irrigation systems and practices
6. Water rights acquisition for instream flows
7. Education/outreach

Appendix A.1

Discharge Measurements

Applegate River Watershed Council Discharge Measurements

LOCATION	DATE	Discharge CFS
Beaver Ck nr Mouth	2/29/2000	36
Beaver Ck nr Mouth	2/17/2000	14
Beaver Ck nr Mouth	6/9/2000	4
Beaver Ck nr Mouth	6/13/2000	3
Beaver Ck nr Mouth	6/28/2000	3
Beaver Ck nr Mouth	7/19/2000	2
Beaver Ck nr Mouth	8/24/2000	1
Beaver Ck nr Mouth	11/29/2000	5
Beaver Ck nr Mouth	12/14/2000	4
Cheney	5/26/1999	6
Cheney	2/25/2000	36
Cheney	3/3/2000	52
Cheney	6/27/2000	2
Cheney	7/26/2000	1
EF Williams blw Rock Ck	5/26/1999	6
EF Williams blw Rock Ck	9/8/1999	4
EF Williams blw Rock Ck	5/12/2000	16
EF Williams blw Rock Ck	6/2/2000	12
EF Williams blw Rock Ck	6/15/2000	8
EF Williams blw Rock Ck	6/26/2000	5
EF Williams blw Rock Ck	7/19/2001	3
EF Williams nr Mouth	6/15/2000	9
EF Williams nr Mouth	6/2/2000	9
EF Williams nr Mouth	5/12/2000	13
EF Williams nr Mouth	3/14/2000	29
EF Williams nr Mouth	3/3/2000	44
EF Williams nr Mouth	2/24/2000	30
EF Williams nr Mouth	6/26/2000	6
EF Williams nr Mouth	7/19/2001	3
Glade @mouth	7/23/1999	12
Glade @mouth	10/14/1999	7
Glade @mouth	4/13/2000	66
Glade @mouth	6/8/2000	36
Glade @mouth	6/20/2000	18
Glade @mouth	6/26/2000	11
Glade @mouth	7/17/2000	7
Glade @mouth	8/23/2000	4
Glade @mouth	8/7/2000	4
Glade @mouth	7/6/2000	13
Glade @mouth	7/17/2001	7
LA @ Mouth	6/8/2000	118.2
LA @ Mouth	6/12/2000	80.7
LA @ Mouth	6/20/2000	54.6
LA @ Mouth	6/29/2000	29.5
LA @ Mouth	7/18/2000	18.1
LA @ Mouth	8/1/2000	12.45
LA @ Mouth	8/17/2000	8.07
LA @ Mouth	8/23/2000	3.3
LA @ Mouth	4/25/2001	56.5
LA @ Mouth	5/14/2001	34.7
LA @ Mouth	5/23/2001	22.1
LA @ Mouth	6/15/2001	4.8
LA @ Mouth	6/21/2001	3.5
LA @ Mouth	7/30/1999	28
LA @ tunnel Ridge	7/17/2000	13
LA @ tunnel Ridge	10/13/1999	4
LA @ Yale	12/1/1999	5
LA @ Yale	12/9/1999	5
LA @ Yale	7/29/1999	15
LA @ Yale	9/12/1999	4
LA @ Yale	1/11/2000	32
LA @ Yale	2/14/2000	63
LA @ Yale	2/29/2000	41
LA @ Yale	6/8/2000	24
LA @ Yale	6/12/2000	14
LA @ Yale	6/20/2000	12
LA @ Yale	6/26/2000	11
LA @ Yale	7/17/2000	6
LA @ Yale	8/2/2000	4
LA @ Yale	8/22/2000	2
LA @ Yale	5/14/2001	35
LA @ Yale	5/23/2001	7
LA @ Yale	6/21/2001	3
LA abv Glade	7/23/1999	15
LA abv Glade	10/4/1999	8
Palmer Ck	2/18/2000	7
Palmer Ck	6/8/2000	2
Palmer Ck	6/9/2000	1
Palmer Ck	6/9/2000	2
Palmer Ck	6/13/2000	2
Palmer Ck	6/26/2000	1
Palmer Ck	7/19/2000	1
Palmer Ck	8/1/2000	1
Palmer Ck	8/24/2000	0
Powell Ck	6/1/2701	1
Powell Ck	6/13/2001	1
Powell Ck	7/30/2001	1
Powell Ck	7/19/2001	1
Powell Ck	7/30/2001	1
Slate Ck	6/22/2000	6
Slate Ck	7/27/2000	2
Sterling nr Mouth	8/10/1999	1
Sterling nr Mouth	10/13/1999	0
Sterling nr Mouth	11/3/1999	0
Thompson Ck	7/15/1999	4
Thompson Ck	2/24/2000	38
Thompson Ck	6/14/2000	8
Thompson Ck	6/22/2000	3
Thompson Ck	7/27/2000	1
Thompson Ck	8/24/2000	1
WF Williams nr Mouth	5/12/2000	41
WF Williams nr Mouth	6/2/2000	19
WF Williams nr Mouth	6/15/2000	14
WF Williams nr Mouth	6/26/2000	9
WF Williams nr Mouth	7/19/2001	1
Williams Ck nr Mouth	3/3/2000	284
Williams Ck nr Mouth	5/12/2000	74
Williams Ck nr Mouth	6/2/2000	35
Williams Ck nr Mouth	6/15/2000	21
Williams Ck nr Mouth	2/24/2000	149
Williams Ck nr Mouth	6/26/2000	10
Williams Ck nr Mouth	8/4/2000	3
Williams Ck nr Wil Hwy	5/16/2000	56
Williams Ck nr Wil Hwy	6/2/2000	29
Williams Ck nr Wil Hwy	6/15/2000	21
Williams Ck nr Wil Hwy	6/26/2000	15
Williams Ck nr Wil Hwy	8/4/2000	5
Williams Ck nr Wil Hwy	8/17/2000	6

LOCATION	DATE	Discharge CFS	LOCATION	DATE	Discharge CFS
Williams Ck nr Wil Hwy	4/23/2001	24			
Williams Ck nr Wil Hwy	5/15/2001	23			
Williams Ck nr Wil Hwy	5/30/2001	5			
Williams Ck nr Wil Hwy	6/19/2001	3			
Williams Ck nr Wil Hwy	6/27/2001	9			
Williams Ck nr Wil Hwy	7/9/2001	3			
Williams Ck nr Wil Hwy	7/19/2001	2			
Williams Ck nr Wil Hwy	7/30/2001	2			
Williams Ck nr Wil Hwy	9/7/2001	2			
Yale	7/1/1999	63			
Yale	10/13/1999	10			
Yale	11/3/1999	13			

Appendix A.2

Water Temperature

Applegate River Watershed Council Water Temperature

SITE_NAME	MAX ΔT C	MAX ΔT Date	DAYS over 17.8 C	7-Day Max C	7-Day Max - Date
APPLEGATE R. AT THE MOUTH OF LITTLE APPLEGATE R.	8.4	13-Jul-01	101	25.6	9-Aug-01
APPLEGATE R. AT THE MOUTH OF LITTLE APPLEGATE R.	8.2	17-Jun-00	84	22.5	31-Jul-00
APPLEGATE R. AT THE MOUTH OF LITTLE APPLEGATE R.	6.7	5-Jul-99	61	21.2	10-Jul-99
APPLEGATE R. AT THE MOUTH OF LITTLE APPLEGATE R.	6.6	16-Jul-98	73	21.5	20-Jul-98
BEAVER CR. AT MOUTH	9.3	22-Jun-01	14	23.1	22-Jun-01
BEAVER CR. AT MOUTH	6.1	27-Jun-00	72	22.2	8-Aug-00
BEAVER CR. AT MOUTH	5.2	18-Jul-99	42	20.0	25-Aug-99
BEAVER CR. AT MOUTH	4.2	27-Jun-98	43	20.1	26-Jul-98
BEAVER CR. AT MOUTH	5.3	4-Aug-97	58	21.5	6-Aug-97
CHENEY CR. AT 2nd BRIDGE	3.3	27-Jun-01	0	14.9	29-Jun-01
CHENEY CR. AT 2nd BRIDGE	3.0	21-Jun-00	11	18.1	30-Jul-00
CHENEY CR. AT 2nd BRIDGE	3.6	5-Jul-99	0	17.7	3-Aug-99
CHENEY CR. AT 2nd BRIDGE	3.1	28-Jun-98	31	19.2	28-Jul-98
CHENEY CR. AT 2nd BRIDGE	3.3	24-Jun-97	25	18.4	6-Aug-97
CHENEY CR. AT MOUTH	6.5	20-Jun-01	11	19.2	4-Jul-01
CHENEY CR. AT MOUTH	4.8	25-Aug-00	59	21.8	8-Aug-00
EAST FORK WILLIAMS AT BROWN RD.	4.7	7-Jun-01	60	20.7	15-Aug-01
EAST FORK WILLIAMS AT BROWN RD.	4.7	27-Jun-00	42	20.9	31-Jul-00
EAST FORK WILLIAMS AT BROWN RD.	4.1	18-Jul-99	27	19.0	25-Aug-99
EAST FORK WILLIAMS AT BROWN RD.	3.7	2-Aug-98	55	20.3	27-Jul-98
EAST FORK WILLIAMS CR. AT ROCK CR.	3.6	2-Jul-01	8	18.4	10-Aug-01
EAST FORK WILLIAMS CR. AT ROCK CR.	3.6	24-Jul-00	4	18.2	8-Aug-00
FOREST CR. AT HAMILTON RD.	2.3	20-Jun-00	0	15.5	30-Jul-00
FOREST CR. AT HAMILTON RD.	2.0	9-Jul-99	0	15.4	13-Jul-99
FOREST CR. AT HAMILTON RD.	7.1	17-Jun-98	20	19.7	21-Jun-98
FOREST CR. AT HAMILTON RD.	8.1	3-Aug-97	50	19.8	1-Aug-97
GROUSE CR. AT MOUTH	6.2	17-Jun-01	42	24.5	6-Aug-01
GROUSE CR. AT MOUTH	6.1	5-Aug-00	28	21.3	8-Aug-00
GROUSE CR. AT MOUTH	4.4	15-Jul-99	3	18.1	25-Aug-99
GROUSE CR. AT MOUTH	4.8	31-Aug-98	42	20.6	27-Jul-98
GROUSE CR. AT MOUTH	9.9	13-Jul-97	42	19.8	21-Jul-97
LITTLE APPLEGATE R. AT MOUTH	10.5	2-Jul-01	92	27.0	9-Aug-01
LITTLE APPLEGATE R. AT MOUTH	8.1	7-Aug-00	88	25.4	30-Jul-00
LITTLE APPLEGATE R. AT MOUTH	4.2	16-Aug-99	0	17.4	25-Aug-99
LITTLE APPLEGATE R. AT MOUTH	6.3	3-Aug-98	69	22.7	26-Jul-98
LITTLE APPLEGATE R. AT ROAD MILE 2.6	6.1	20-Jul-00	69	22.3	31-Jul-00
LITTLE APPLEGATE R. AT ROAD MILE 2.6	6.1	18-Jul-99	44	20.8	4-Aug-99
LITTLE APPLEGATE R. AT ROAD MILE 2.6	5.8	12-Aug-98	61	21.8	26-Jul-98

SITE_NAME	MAX ΔT C	MAX ΔT Date	DAYS over 17.8 C	7-Day Max C	7-Day Max - Date
LITTLE APPLEGATE R. AT YALE CR.	7.8	26-Jul-01	74	23.8	9-Aug-01
LITTLE APPLEGATE R. AT YALE CR.	5.9	15-Aug-00	56	21.6	31-Jul-00
LITTLE APPLEGATE R. AT YALE CR.	4.9	22-Aug-99	24	19.5	25-Aug-99
LITTLE APPLEGATE R. AT YALE CR.	4.1	20-Jul-98	29	19.8	27-Jul-98
LITTLE APPLEGATE R. AT YALE CR.	5.2	20-Jul-97	2	18.3	6-Aug-97
MUNGER CR. AT KINCAID RD.	3.0	24-Jun-00	13	19.5	8-Aug-00
MUNGER CR. AT KINCAID RD.	2.6	18-Jul-99	0	17.6	28-Aug-99
MUNGER CR. AT KINCAID RD.	4.5	13-Jul-98	5	18.1	6-Aug-98
MUNGER CR. AT KINCAID RD.	2.4	27-Jun-98	13	18.5	27-Jul-98
MURPHY CR. AT BRIDGE	2.0	4-Jun-01	0	17.5	10-Aug-01
MURPHY CR. AT BRIDGE	2.4	28-Jun-00	0	17.1	8-Aug-00
MURPHY CR. AT BRIDGE	3.4	9-Jul-99	2	18.2	28-Aug-99
MURPHY CR. AT BRIDGE	2.9	27-Jun-98	20	19.5	27-Jul-98
MURPHY CR. AT BRIDGE	3.3	13-Jul-97	13	18.8	6-Aug-97
PALMER CR. AT PALMER CR. RD.	11.7	16-Jun-01	9	23.7	20-Jun-01
PALMER CR. AT PALMER CR. RD.	3.0	24-Jul-00	28	19.7	8-Aug-00
PALMER CR. AT PALMER CR. RD.	2.6	1-Aug-99	2	17.9	28-Aug-99
PALMER CR. AT PALMER CR. RD.	2.3	20-Jun-98	39	19.7	28-Jul-98
PALMER CR. AT PALMER CR. RD.	2.9	14-Aug-97	36	19.5	7-Aug-97
SLATE CR. AT MOUTH	4.96	7-Jun-01	98	22.48	13-Jul-01
SLATE CR. AT MOUTH	5.35	21-Jun-00	93	24.54	30-Jul-00
SLATE CR. AT MOUTH	4.99	23-Jun-99	89	22.81	12-Jul-99
SLATE CR. AT MOUTH	4.74	16-Jul-98	92	24.85	26-Jul-98
SLATE CR. AT MOUTH	4.54	4-Jul-97	89	22.82	21-Jul-97
SLATE CR. AT REDWOOD TAVERN	4.60	20-Jun-01	69	22.14	9-Aug-01
SLATE CR. AT REDWOOD TAVERN	4.58	21-Jun-00	46	21.48	31-Jul-00
SLATE CR. AT REDWOOD TAVERN	4.66	5-Jul-99	43	19.79	26-Aug-99
SLATE CR. AT REDWOOD TAVERN	4.21	27-Jun-98	69	22.58	26-Jul-98
SLATE CR. AT REDWOOD TAVERN	4.29	13-Jul-97	61	21.97	6-Aug-97
SLATE CR. AT ROAD MILE 1.6	4.93	21-Jun-01	54	20.88	9-Aug-01
SLATE CR. AT ROAD MILE 1.6	4.24	20-Jun-00	58	22.19	31-Jul-00
SLATE CR. AT ROAD MILE 1.6	4.62	30-Jul-99	54	21.10	28-Aug-99
SLATE CR. AT ROAD MILE 1.6	4.46	16-Jul-98	53	21.88	27-Jul-98
SLATE CR. AT ROAD MILE 1.6	4.71	3-Jul-97	50	20.89	6-Aug-97
STERLING CR. AT MOUTH	7.1	5-Jul-99	65	21.1	12-Jul-99
STERLING CR. AT MOUTH	6.8	27-Jun-98	78	22.0	26-Jul-98
STERLING CR. AT MOUTH	7.8	13-Jul-97	79	24.0	5-Aug-97
THOMPSON CR. AT TALLOWBOX CR.	9.6	1-Sep-01	31	21.6	1-Sep-01
THOMPSON CR. AT TALLOWBOX CR.	4.9	27-Jun-00	41	20.5	8-Aug-00
THOMPSON CR. AT TALLOWBOX CR.	5.7	5-Jul-99	47	19.8	25-Aug-99

SITE_NAME	MAX ΔT C	MAX ΔT Date	DAYS over 17.8 C	7-Day Max C	7-Day Max - Date
THOMPSON CR. AT TALLOWBOX CR.	4.4	2-Aug-98	65	21.3	27-Jul-98
WEST FORK WILLIAMS AT 2455 CEDAR FLATS RD.	4.3	19-Jun-01	28	20.3	10-Aug-01
WEST FORK WILLIAMS AT 2455 CEDAR FLATS RD.	3.6	28-Aug-00	13	19.2	31-Jul-00
WEST FORK WILLIAMS AT 2455 CEDAR FLATS RD.	3.7	8-Jul-99	0	17.3	28-Aug-99
WEST FORK WILLIAMS AT 2455 CEDAR FLATS RD.	3.4	2-Aug-98	19	18.9	27-Jul-98
WEST FORK WILLIAMS AT CAVES CAMP RD.	3.7	19-Jun-01	11	19.3	9-Aug-01
WEST FORK WILLIAMS AT CAVES CAMP RD.	3.5	27-Jul-00	12	18.7	30-Jul-00
WEST FORK WILLIAMS AT CAVES CAMP RD.	3.4	8-Jul-99	0	17.4	28-Aug-99
WEST FORK WILLIAMS AT CAVES CAMP RD.	2.9	3-Aug-98	8	18.6	27-Jul-98
WILLIAMS CR. AT CONFLUENCE OF E. & W. FORKS	6.3	13-Jun-01	91	23.0	10-Aug-01
WILLIAMS CR. AT CONFLUENCE OF E. & W. FORKS	5.6	27-Jun-00	74	22.3	8-Aug-00
WILLIAMS CR. BELOW POWELL CR.	6.7	16-Jul-98	72	23.5	26-Jul-98
WILLIAMS CR. BELOW POWELL CR.	6.7	3-Jul-97	88	21.7	4-Jul-97
WILLIAMS CR. WILLIAMS HWY. BRIDGE	6.0	7-Jun-01	95	20.5	5-Aug-01
YALE CR. AT MOUTH	4.9	8-Jul-01	25	20.6	9-Aug-01
YALE CR. AT MOUTH	4.7	12-Aug-00	11	18.8	8-Aug-00
YALE CR. AT MOUTH	4.2	16-Aug-99	0	17.4	25-Aug-99
YALE CR. AT MOUTH	4.5	27-Jun-98	7	18.5	27-Jul-98
YALE CR. AT MOUTH	4.1	13-Jul-97	10	19.0	6-Aug-97

Appendix A.3

Water Quality Values

Applegate River Watershed Council Water Quality Monitoring

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
APPLEGATE R. AT BEAVER CR.	28-Sep-01	9:05:00 AM	17.1	122.3	7.98	3	7.98	n/a	0.02	0.16
APPLEGATE R. AT BEAVER CR.	16-Aug-01	2:54:00 PM	22.1	107.1	8.29	2	9.04	56	0	0.01
APPLEGATE R. AT BEAVER CR.	11-Jul-01	4:11:00 PM	17.5	88.2	7.8	2	8.76	n/a	0.04	0.02
APPLEGATE R. AT BEAVER CR.	14-Jun-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
APPLEGATE R. AT BEAVER CR.	6-Sep-00	11:00:00 AM	14.7	83.0	8.27	1	9.4	n/a	n/a	0.03
APPLEGATE R. AT BEAVER CR.	24-Aug-00	10:55:00 AM	16.6	87.4	8.32	2	7.92	n/a	n/a	0.03
APPLEGATE R. AT BEAVER CR.	10-Aug-00	8:10:00 AM	14.6	79.3	8.31	2	8.3	n/a	n/a	0
APPLEGATE R. AT BEAVER CR.	26-Jul-00	8:05:00 AM	14.8	79.3	8.13	2	9.08	n/a	n/a	0
APPLEGATE R. AT BEAVER CR.	11-Jul-00	8:51:00 AM	15.0	75.3	8.29	1	9.18	n/a	n/a	0.01
APPLEGATE R. AT BEAVER CR.	23-Sep-99	11:15:00 AM	13.55	100	7.67	3	9.3	60	0.41	0.02
APPLEGATE R. AT BEAVER CR.	1-Sep-99	1:38:00 PM	16.8	104	8.47	3	8.14	84	0.03	0
APPLEGATE R. AT BEAVER CR.	16-Aug-99	9:50:00 AM	16	102	7.8	2	9.15	68	0.49	n/a
APPLEGATE R. AT BEAVER CR.	2-Aug-99	12:10:00 PM	17.2	87	8.04	2	9.19	64	0.28	0.01
APPLEGATE R. AT BEAVER CR.	20-Jul-99	2:40:00 PM	18.9	77	8.23	1	8.14	60	0.94	0.04
APPLEGATE R. AT BEAVER CR.	8-Jul-99	9:45:00 AM	14.3	178	7.89	1	8.82	148	0.23	0
APPLEGATE R. AT BEAVER CR.	17-Jun-99	10:35:00 AM	14	79	7.77	2	9.78	48	0.01	0.01
APPLEGATE R. AT BEAVER CR.	21-Sep-98	12:00:00 PM	11.4	112	8.34	1	10.32	72	0.43	0.01
APPLEGATE R. AT BEAVER CR.	12-Aug-98	11:30:00 AM	15.7	n/a	8.14	1	9.32	64	0.2	n/a
APPLEGATE R. AT BEAVER CR.	31-Jul-98	1:20:00 PM	17.8	105	8.50	1	9.00	72	0.17	0.01
APPLEGATE R. AT BEAVER CR.	23-Jul-98	12:45:00 PM	16.9	105	7.93	1	8.88	56	0.15	0.04
APPLEGATE R. AT BEAVER CR.	13-Jul-98	12:30:00 PM	15.6	98	8.09	1	9.32	54	0.05	0.05
APPLEGATE R. AT BEAVER CR.	2-Jul-98	11:20:00 AM	15.1	93	8.12	2	9.16	64	n/a	0.06
APPLEGATE R. AT BEAVER CR.	26-Jun-98	3:15:00 PM	14.8	n/a	8.35	n/a	8.53	n/a	n/a	0.06
APPLEGATE R. AT BEAVER CR.	4-Aug-97	11:10:00 AM	17.6	n/a	8.33	n/a	9.2	86	n/a	n/a
APPLEGATE R. AT BEAVER CR.	3-Jul-97	11:15:00 AM	16	n/a	7.89	n/a	10	62	n/a	n/a
APPLEGATE R. AT BEAVER CR.	24-Jun-97	10:30:00 AM	20	n/a	8.33	n/a	9.5	61	n/a	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	28-Sep-01	11:58:00 AM	18.1	125.3	8.02	2	8.82	n/a	0.01	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	16-Aug-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	11-Jul-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	14-Jun-01	2:39:00 PM	21.7	133.3	8.14	2	9.12	80	0.14	0.05

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
APPLEGATE R. AT CANTRALL BUCKLEY PARK	6-Sep-00	2:00:00 PM	17.4	98.0	8.66	2	10.8	n/a	n/a	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	24-Aug-00	12:30:00 PM	18.4	109.8	8.26	4	8.98	n/a	n/a	0.04
APPLEGATE R. AT CANTRALL BUCKLEY PARK	10-Aug-00	12:00:00 PM	17.4	96.4	8.53	1	9.32	n/a	n/a	0.02
APPLEGATE R. AT CANTRALL BUCKLEY PARK	26-Jul-00	11:25:00 AM	17.2	95.0	8.33	2	9.64	n/a	n/a	0.02
APPLEGATE R. AT CANTRALL BUCKLEY PARK	11-Jul-00	12:30:00 PM	17.2	102.4	8.21	1	9.06	n/a	n/a	0
APPLEGATE R. AT CANTRALL BUCKLEY PARK	22-Jun-00	9:20:00 AM	15.2	129.0	7.65	2	10.1	n/a	n/a	0.03
APPLEGATE R. AT CANTRALL BUCKLEY PARK	23-Sep-99	8:57:00 AM	12.55	111	7.6	2	8.28	70	0.47	0.08
APPLEGATE R. AT CANTRALL BUCKLEY PARK	1-Sep-99	2:10:00 PM	17.4	116	8.49	2	8.82	68	0.11	0
APPLEGATE R. AT CANTRALL BUCKLEY PARK	16-Aug-99	12:45:00 PM	18.2	117	8.1	2	9.72	65	0.2	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	2-Aug-99	11:05:00 AM	16.15	104	7.7	3	9.05	70	0.41	0.02
APPLEGATE R. AT CANTRALL BUCKLEY PARK	20-Jul-99	9:30:00 AM	16.3	92	7.59	2	8.18	n/a	0.59	0.03
APPLEGATE R. AT CANTRALL BUCKLEY PARK	8-Jul-99	1:10:00 PM	17.5	91	7.33	2	9.04	60	0.01	0
APPLEGATE R. AT CANTRALL BUCKLEY PARK	17-Jun-99	3:45:00 PM	15.9	93	7.91	4	9.38	n/a	0.16	0.03
APPLEGATE R. AT CANTRALL BUCKLEY PARK	12-Aug-98	8:55:00 AM	15.0	n/a	7.93	1	9.06	133	0.11	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	31-Jul-98	2:05:00 PM	19.6	127	8.36	1	9.00	168	n/a	0.02
APPLEGATE R. AT CANTRALL BUCKLEY PARK	23-Jul-98	1:30:00 PM	19.5	139	8.27	1	8.64	88	0.19	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	13-Jul-98	1:20:00 PM	17.5	130	8.15	1	9.00	80	0.16	0.05
APPLEGATE R. AT CANTRALL BUCKLEY PARK	2-Jul-98	9:30:00 AM	15.1	93	7.75	3	9.52	84	n/a	0.07
APPLEGATE R. AT CANTRALL BUCKLEY PARK	15-Jun-98	2:05:00 PM	16.0	118	8.43	4	8.50	76	n/a	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	4-Aug-97	9:00:00 AM	15.3	n/a	7.94	n/a	9.2	82	n/a	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	24-Jul-97	9:30:00 AM	16.2	n/a	8.06	n/a	9.3	76	n/a	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	14-Jul-97	11:10:00 AM	19.3	n/a	8.3	n/a	9.2	n/a	n/a	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	3-Jul-97	9:30:00 AM	13.5	n/a	8.15	n/a	7	67	n/a	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	24-Jun-97	9:30:00 AM	13.5	n/a	8.15	n/a	7	67	n/a	n/a
APPLEGATE R. AT CANTRALL BUCKLEY PARK	18-Jun-97	9:30:00 AM	14.4	n/a	7.83	n/a	9.5	70	n/a	n/a
APPLEGATE R. AT FISH HATCHERY PARK	28-Sep-01	1:44:00 PM	19.3	165.2	7.89	4	9.62	n/a	0.03	0.05
APPLEGATE R. AT FISH HATCHERY PARK	16-Aug-01	9:45:00 AM	23.3	199.6	8.22	3	6.9	78	0	0.17
APPLEGATE R. AT FISH HATCHERY PARK	11-Jul-01	10:15:00 AM	22.2	177.6	7.9	2	7.14	n/a	n/a	n/a
APPLEGATE R. AT FISH HATCHERY PARK	14-Jun-01	9:56:00 AM	20.2	177.6	7.83	2	8.52	n/a	n/a	n/a
APPLEGATE R. AT FISH HATCHERY PARK	23-Aug-00	1:00:00 PM	20.5	124.0	7.31	n/a	8.52	n/a	n/a	0.06
APPLEGATE R. AT FISH HATCHERY PARK	10-Aug-00	12:40:00 PM	22.3	108.9	7.74	2	8.5	n/a	n/a	0.05
APPLEGATE R. AT FISH HATCHERY PARK	26-Jul-00	3:15:00 PM	23.2	114.2	7.76	1	8.36	n/a	n/a	0.03

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
APPLEGATE R. AT FISH HATCHERY PARK	10-Jul-00	12:00:00 PM	20.7	129.6	8.07	2	9.82	n/a	n/a	0.03
APPLEGATE R. AT FISH HATCHERY PARK	27-Jun-00	12:49:00 PM	21.5	131.1	8.24	2	8.46	n/a	n/a	0.07
APPLEGATE R. AT FISH HATCHERY PARK	14-Jun-00	2:10:00 PM	20.6	142.0	n/a	3	9.25	n/a	n/a	n/a
APPLEGATE R. AT FISH HATCHERY PARK	29-Sep-99	12:45:00 PM	13.1	132	8.19	1	10.4	86	0.21	0.01
APPLEGATE R. AT FISH HATCHERY PARK	24-Aug-99	11:30:00 AM	19.85	126	7.74	1	8.99	74	0.29	0.02
APPLEGATE R. AT FISH HATCHERY PARK	10-Aug-99	12:05:00 PM	21.4	129	8.04	1	8.98	60	0.18	0
APPLEGATE R. AT FISH HATCHERY PARK	28-Jul-99	11:40:00 AM	20.3	126	7.34	2	8.46	76	0.18	0
APPLEGATE R. AT FISH HATCHERY PARK	14-Jul-99	11:40:00 AM	18.1	107	7.15	1	8.78	n/a	0.28	0.03
APPLEGATE R. AT FISH HATCHERY PARK	29-Jun-99	1:55:00 AM	20.7	108	n/a	2	8.8	85	0.28	0.05
APPLEGATE R. AT FISH HATCHERY PARK	18-Jun-99	12:30:00 PM	15.4	107	7.57	3	9.34	n/a	0.21	0.01
APPLEGATE R. AT FISH HATCHERY PARK	28-Sep-98	12:57:00 PM	16.5	152	7.85	1	10.00	80	0.35	0.01
APPLEGATE R. AT FISH HATCHERY PARK	28-Aug-98	12:15:00 PM	19.9	152	8.13	1	8.72	89	n/a	n/a
APPLEGATE R. AT FISH HATCHERY PARK	17-Aug-98	3:30:00 PM	20.9	149	8.13	1	9.26	90	n/a	n/a
APPLEGATE R. AT FISH HATCHERY PARK	7-Aug-98	10:15:00 AM	19.8	154	n/a	1	8.40	82	0.10	0.03
APPLEGATE R. AT FISH HATCHERY PARK	28-Jul-98	10:10:00 AM	21.7	158	7.75	2	8.60	80	n/a	n/a
APPLEGATE R. AT FISH HATCHERY PARK	17-Jul-98	10:10:00 AM	20.2	156	7.95	3	8.56	76	0.17	0.1
APPLEGATE R. AT FISH HATCHERY PARK	8-Jul-98	3:00:00 PM	22.2	150	8.04	3	8.04	80	0.43	0.08
APPLEGATE R. AT FISH HATCHERY PARK	27-Jun-98	3:20:00 PM	17.3	139	8.17	4	9.14	90	0.30	0.05
APPLEGATE R. AT FISH HATCHERY PARK	18-Jun-98	1:00:00 PM	15.4	131	8.23	4	9.90	82	0.17	0
APPLEGATE R. AT FISH HATCHERY PARK	17-Sep-97	11:15:00 AM	16.5	n/a	7.42	n/a	9.6	95	n/a	n/a
APPLEGATE R. AT FISH HATCHERY PARK	21-Aug-97	12:42:00 PM	21.9	n/a	8.17	n/a	9.2	104	n/a	n/a
APPLEGATE R. AT FISH HATCHERY PARK	8-Aug-97	11:00:00 AM	21.6	n/a	8.05	n/a	8.8	98	n/a	n/a
APPLEGATE R. AT FISH HATCHERY PARK	14-Jul-97	10:40:00 AM	20.2	n/a	7.8	n/a	9.0	86	n/a	n/a
APPLEGATE R. AT FISH HATCHERY PARK	3-Jul-97	10:43:00 AM	20.1	n/a	8.09	n/a	9.2	104	n/a	n/a
APPLEGATE R. AT FISH HATCHERY PARK	24-Jun-97	9:45:00 AM	17.9	n/a	7.75	n/a	8.7	104	n/a	n/a
APPLEGATE R. AT GRAYS CR.	29-Sep-99	11:15:00 AM	12.8	130	7.82	2	11	88	0.16	0.02
APPLEGATE R. AT GRAYS CR.	24-Aug-99	12:55:00 PM	20.3	124	8.18	1	9.36	64	0.89	0.01
APPLEGATE R. AT GRAYS CR.	10-Aug-99	1:30:00 AM	21.6	126	8.37	1	9.38	80	0.5	0
APPLEGATE R. AT GRAYS CR.	28-Jul-99	12:45:00 PM	21	124	8.07	2	8.58	64	0.15	0
APPLEGATE R. AT GRAYS CR.	14-Jul-99	12:30:00 PM	19.1	107	7.25	1	8.96	n/a	0.16	0.03
APPLEGATE R. AT GRAYS CR.	29-Jun-99	3:40:00 AM	20.8	108	n/a	1	8.55	70	0.23	0.04
APPLEGATE R. AT GRAYS CR.	18-Jun-99	11:00:00 AM	14.8	106	7.5	3	9.87	n/a	0.07	0.01

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	28-Sep-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	16-Aug-01	3:17:00 PM	24	118.9	8.67	2	8.82	74	0.01	0.04
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	11-Jul-01	3:51:00 PM	20.5	110.7	8.09	2	8.84	n/a	0.03	0.04
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	14-Jun-01	4:43:00 PM	21.4	112.1	8.33	2	n/a	75	0.1	0.02
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	24-Aug-00	11:50:00 AM	17.0	95.1	8.34	2	8.34	n/a	n/a	0.03
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	10-Aug-00	10:20:00 AM	16.0	86.6	8.39	1	8.58	n/a	n/a	0.04
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	26-Jul-00	9:05:00 AM	14.7	79.5	8.17	1	9.54	n/a	n/a	0.04
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	11-Jul-00	9:24:00 AM	14.6	79.9	8.12	1	9.48	n/a	n/a	0.01
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	22-Jun-00	1:40:00 PM	18.0	110.0	8.29	1	9.24	n/a	n/a	0.01
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	23-Sep-99	9:40:00 AM	12.75	105	7.51	2	9.3	50	0.52	0.02
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	1-Sep-99	12:40:00 PM	16	108	8.38	3	7.96	96	0.12	0
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	16-Aug-99	1:20:00 PM	18.4	102	8.13	2	9.47	71	0.18	n/a
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	2-Aug-99	3:10:00 PM	19.5	92	8.52	2	8.84	n/a	0.23	0.02
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	20-Jul-99	1:10:00 PM	18.5	81	8.24	2	6.52	84	0.25	0.05
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	8-Jul-99	12:45:00 PM	17.3	76	7.92	2	9.38	34	0.08	0.05
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	21-Sep-98	9:15:00 AM	10.2	120	8.31	3	10.02	70	n/a	n/a
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	12-Aug-98	9:25:00 AM	14.9	n/a	8.04	1	9.70	65	0.13	n/a
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	31-Jul-98	12:30:00 PM	16.9	97	8.50	1	9.38	68	0.56	0.01
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	23-Jul-98	11:30:00 AM	18.0	116	7.51	1	8.48	72	0.32	0.08
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	13-Jul-98	11:15:00 AM	15.9	89	8.21	1	9.24	64	0.13	0.05
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	2-Jul-98	9:40:00 AM	15.2	90	8.06	1	7.46	70	0.27	0.04
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	4-Aug-97	12:00:00 PM	17.3	n/a	8.43	n/a	9.6	77	n/a	n/a
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	24-Jul-97	11:30:00 AM	16.3	n/a	8.46	n/a	9.5	64	n/a	n/a
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	14-Jul-97	11:50:00 AM	17.8	n/a	8.7	n/a	9.3	n/a	n/a	n/a
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	3-Jul-97	2:40:00 PM	15.7	n/a	8.28	n/a	8	75	n/a	n/a
APPLEGATE R. AT MOUTH LITTLE APPLEGATE R.	18-Jun-97	10:40:00 AM	14.4	n/a	8.2	n/a	9	65	n/a	n/a
BEAVER CR. AT MOUTH	28-Sep-01	8:45:00 AM	14.6	309.9	7.55	5	7.9	n/a	0.2	0.03
BEAVER CR. AT MOUTH	16-Aug-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BEAVER CR. AT MOUTH	11-Jul-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BEAVER CR. AT MOUTH	14-Jun-01	4:57:00 PM	18.8	386.5	7.96	1	n/a	250	0.21	0.06
BEAVER CR. AT MOUTH	6-Sep-00	10:50:00 AM	12.4	275.0	8.22	1	9.4	n/a	n/a	n/a
BEAVER CR. AT MOUTH	24-Aug-00	10:55:00 AM	16.3	307.4	8.25	3	8.78	n/a	n/a	0.05

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
BEAVER CR. AT MOUTH	10-Aug-00	7:55:00 AM	15.9	308.0	8.27	4	7.84	n/a	n/a	0.05
BEAVER CR. AT MOUTH	26-Jul-00	7:04:00 AM	14.7	297.0	8.18	1	6.84	n/a	n/a	0.05
BEAVER CR. AT MOUTH	11-Jul-00	8:31:00 AM	13.5	289.0	8.30	1	9.2	n/a	n/a	0.06
BEAVER CR. AT MOUTH	22-Jun-00	1:30:00 PM	19.4	339.0	8.17	2	8.28	n/a	n/a	0.03
BEAVER CR. AT MOUTH	23-Sep-99	11:00:00 AM	14.5	388	7.95	1	9.12	158	0.72	0.03
BEAVER CR. AT MOUTH	1-Sep-99	2:30:00 PM	16.4	387	8.21	1	6.66	196	0.13	0.02
BEAVER CR. AT MOUTH	16-Aug-99	9:40:00 AM	13.7	387	7.99	1	9.16	224	0.64	n/a
BEAVER CR. AT MOUTH	2-Aug-99	12:00:00 PM	16.8	380	7.97	3	8.92	185	0.84	0.02
BEAVER CR. AT MOUTH	20-Jul-99	2:40:00 PM	18.8	341	8.17	1	5.94	206	0.78	0.04
BEAVER CR. AT MOUTH	8-Jul-99	9:30:00 AM	12.4	290	7.94	1	9.38	182	0.32	0.04
BEAVER CR. AT MOUTH	17-Jun-99	10:03:00 AM	14.7	370	7.98	1	8.74	196	0.37	0.01
BEAVER CR. AT MOUTH	21-Sep-98	11:35:00 AM	12.5	379	8.66	1	9.66	210	0.65	0.02
BEAVER CR. AT MOUTH	12-Aug-98	11:15:00 AM	16.4	n/a	8.17	0	8.72	168	n/a	n/a
BEAVER CR. AT MOUTH	31-Jul-98	1:30:00 PM	18.2	361	8.59	1	9.40	180	0.32	0.04
BEAVER CR. AT MOUTH	23-Jul-98	12:30:00 PM	18.7	361	8.29	1	8.56	172	n/a	n/a
BEAVER CR. AT MOUTH	13-Jul-98	12:15:00 PM	15.7	341	8.24	1	8.94	190	0.38	0.07
BEAVER CR. AT MOUTH	2-Jul-98	11:15:00 AM	14.0	258	8.26	2	9.38	202	0.49	0.06
SLATE CR. AT MOUTH	15-Jun-00	1:45:00 PM	20.0	153.2	7.47	1	8.46			
BEAVER CR. AT MOUTH	26-Jun-98	3:40:00 PM	13.3	n/a	8.23	n/a	9.54	n/a	0.5	0.06
CHENEY CR. AT 2nd BRIDGE	14-Jun-01	9:07:00 AM	13.3	81.0	6.47	0	7.4	45	0.13	0.07
CHENEY CR. AT 2nd BRIDGE	23-Aug-00	11:55:00 AM	15.8	64.0	5.85	n/a	6.52	n/a	n/a	n/a
CHENEY CR. AT 2nd BRIDGE	10-Aug-00	12:15:00 PM	17.0	59.0	6.06	1	6.7	n/a	n/a	0.07
CHENEY CR. AT 2nd BRIDGE	26-Jul-00	1:30:00 PM	17.2	55.5	6.22	1	7.46	n/a	n/a	0.02
CHENEY CR. AT 2nd BRIDGE	10-Jul-00	12:15:00 PM	14.7	61.8	7.48	1	8.26	n/a	n/a	0.04
CHENEY CR. AT 2nd BRIDGE	27-Jun-00	11:31:00 AM	15.0	50.5	7.04	n/a	7.82	n/a	n/a	0.05
CHENEY CR. AT 2nd BRIDGE	14-Jun-00	1:50:00 PM	n/a	79.0	6.95	1	9.1	n/a	n/a	0.02
CHENEY CR. AT 2nd BRIDGE	29-Sep-99	1:35:00 PM	12.2	67	7.23	1	8.62	40	0.02	0.21
CHENEY CR. AT 2nd BRIDGE	24-Aug-99	11:00:00 AM	16	65	6.49	1	7.54	48	0.24	0.02
CHENEY CR. AT 2nd BRIDGE	10-Aug-99	11:25:00 AM	16.1	68	6.71	1	7.56	40	0.22	0.01
CHENEY CR. AT 2nd BRIDGE	28-Jul-99	11:00:00 AM	15.7	67	6.15	1	7.9	60	0.35	0
CHENEY CR. AT 2nd BRIDGE	14-Jul-99	11:05:00 AM	14.4	52	6.43	1	8.34	n/a	0.2	0.02
CHENEY CR. AT 2nd BRIDGE	29-Jun-99	1:10:00 AM	15.1	53	n/a	1	8.9	40	0.32	0

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
CHENEY CR. AT 2nd BRIDGE	18-Jun-99	1:11:00 AM	14.8	65	6.99	1	8.88	n/a	n/a	0
CHENEY CR. AT 2nd BRIDGE	28-Sep-98	1:48:00 PM	14.1	71	6.95	1	8.20	58	0.55	n/a
CHENEY CR. AT 2nd BRIDGE	28-Aug-98	11:45:00 AM	16.6	70	6.96	0	7.78	48	n/a	n/a
CHENEY CR. AT 2nd BRIDGE	17-Aug-98	3:00:00 PM	17.3	67	7.00	1	7.22	44	n/a	n/a
CHENEY CR. AT 2nd BRIDGE	7-Aug-98	9:00:00 AM	16.0	70	n/a	1	7.60	42	0.16	n/a
CHENEY CR. AT 2nd BRIDGE	28-Jul-98	11:00:00 AM	17.0	72	6.99	1	8.14	46	n/a	n/a
CHENEY CR. AT 2nd BRIDGE	17-Jul-98	11:15:00 AM	15.5	71	7.04	1	7.84	44	0.21	n/a
CHENEY CR. AT 2nd BRIDGE	8-Jul-98	3:45:00 PM	17.7	68	6.97	1	8.00	45	0.33	n/a
CHENEY CR. AT 2nd BRIDGE	27-Jun-98	4:30:00 PM	14.3	69	7.14	1	8.38	50	0.27	n/a
CHENEY CR. AT 2nd BRIDGE	18-Jun-98	3:00:00 PM	14.1	69	7.08	1	8.36	48	0.31	n/a
CHENEY CR. AT LITTLE CHENEY CR.	29-Sep-99	1:10:00 PM	13.4	108	7.22	1	7	60	0.2	0.03
CHENEY CR. AT LITTLE CHENEY CR.	24-Aug-99	10:40:00 AM	16.5	92	6.4	1	7.22	56	0.21	0.03
CHENEY CR. AT LITTLE CHENEY CR.	10-Aug-99	10:40:00 AM	16.8	85	6.925	1	7.53	40	0.31	0.01
CHENEY CR. AT LITTLE CHENEY CR.	28-Jul-99	10:50:00 AM	16.5	88	6.61	1	9.3	48	0.19	0
CHENEY CR. AT LITTLE CHENEY CR.	14-Jul-99	10:40:00 AM	14.9	67	6.75	1	8.24	n/a	0.25	0.02
CHENEY CR. AT LITTLE CHENEY CR.	29-Jun-99	12:45:00 PM	15.6	63	n/a	1	8.72	50	0.38	0.01
CHENEY CR. AT LITTLE CHENEY CR.	18-Jun-99	12:48:00 PM	14.9	74	7.05	1	8.96	n/a	0.25	0
CHENEY CR. AT MOUTH	23-Aug-00	11:30:00 AM	17.2	53.0	6.30	n/a	6.08	n/a	n/a	n/a
CHENEY CR. AT MOUTH	10-Aug-00	11:40:00 AM	18.9	88.0	6.77	1	7.58	n/a	n/a	n/a
CHENEY CR. AT MOUTH	26-Jul-00	12:30:00 PM	17.7	85.0	7.07	1	8.06	n/a	n/a	n/a
CHENEY CR. AT MOUTH	10-Jul-00	12:35:00 PM	15.8	74.1	7.55	1	9.34	n/a	n/a	n/a
CHENEY CR. AT MOUTH	27-Jun-00	11:08:00 AM	15.8	69.8	6.97	1	9.94	n/a	n/a	n/a
CHENEY CR. AT MOUTH	14-Jun-00	n/a	15.4	85.0	7.39	2	9.28	n/a	n/a	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	28-Sep-01	5:16:00 PM	15.4	128.7	7.66	3	8.18	n/a	0.06	0.04
EAST FORK WILLIAMS CR. AT BROWNS RD.	16-Aug-01	11:58:00 AM	19.1	131.0	7.94	1	8.16	76	1.2	0.09
EAST FORK WILLIAMS CR. AT BROWNS RD.	11-Jul-01	12:38:00 PM	16.9	141.5	7.39	3	7.54	n/a	0.16	0.07
EAST FORK WILLIAMS CR. AT BROWNS RD.	14-Jun-01	12:59:00 PM	16.1	152.5	7.64	2	8.76	40	0.09	0.02
EAST FORK WILLIAMS CR. AT BROWNS RD.	22-Aug-00	1:05:00 PM	16.2	111.0	7.92	n/a	8.6	n/a	n/a	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	9-Aug-00	1:00:00 PM	19.0	107.3	7.73	1	8.02	n/a	n/a	0.05
EAST FORK WILLIAMS CR. AT BROWNS RD.	25-Jul-00	1:20:00 PM	18.7	121.3	7.82	0	7.5	n/a	n/a	0.06
EAST FORK WILLIAMS CR. AT BROWNS RD.	10-Jul-00	10:05:00 AM	14.0	112.5	8.01	2	8.96	n/a	n/a	0.02
EAST FORK WILLIAMS CR. AT BROWNS RD.	27-Jun-00	3:00:00 PM	18.1	105.5	7.87	1	9.36	n/a	n/a	0.03

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
EAST FORK WILLIAMS CR. AT BROWNS RD.	15-Jun-00	10:17:00 AM	14.1	110.0	7.53	1	9.5	n/a	n/a	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	24-Sep-99	10:30:00 AM	14.5	164	7.7	3	8.68	98	0.72	0.08
EAST FORK WILLIAMS CR. AT BROWNS RD.	2-Sep-99	11:05:00 AM	13.4	158	7.26	2	9.12	92	0.37	0
EAST FORK WILLIAMS CR. AT BROWNS RD.	17-Aug-99	12:00:00 PM	16.6	150	7.5	1	7.26	100	0.63	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	4-Aug-99	10:47:00 AM	16.7	144	7.15	1	7.88	85	0.59	0.04
EAST FORK WILLIAMS CR. AT BROWNS RD.	22-Jul-99	10:20:00 AM	15.1	105	7.16	1	9.14	88	0.65	0.03
EAST FORK WILLIAMS CR. AT BROWNS RD.	9-Jul-99	9:25:00 AM	12.8	88	7.24	2	9.32	60	0.44	0.01
EAST FORK WILLIAMS CR. AT BROWNS RD.	21-Jun-99	1:40:00 PM	13.6	92	7.33	2	9.54	66	0.25	0.02
EAST FORK WILLIAMS CR. AT BROWNS RD.	31-Aug-98	12:18:00 PM	17.8	165	7.79	1	7.94	94	0.67	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	21-Aug-98	3:07:00 PM	18.9	151	7.64	1	8.12	96	n/a	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	11-Aug-98	12:00:00 PM	17.5	124	7.78	1	9.02	80	0.12	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	30-Jul-98	2:52:00 PM	20.1	131	7.79	1	7.98	84	n/a	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	20-Jul-98	11:26:00 AM	16.7	140	7.86	2	8.40	84	0.23	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	9-Jul-98	1:00:00 PM	16.9	84	7.94	1	9.14	84	0.15	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	26-Jun-98	12:00:00 PM	11.7	113	7.67	1	9.54	86	n/a	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	15-Sep-97	1:40:00 PM	14.7	n/a	7.99	n/a	9	80	n/a	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	26-Aug-97	3:55:00 PM	16.3	n/a	7.56	n/a	8.4	92	n/a	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	14-Aug-97	1:40:00 PM	20.3	n/a	7.86	n/a	8.2	n/a	n/a	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	1-Aug-97	2:27:00 AM	19.4	n/a	8	n/a	8.6	102	n/a	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	3-Jul-97	2:15:00 PM	17.2	n/a	7.9	n/a	8.8	87	n/a	n/a
EAST FORK WILLIAMS CR. AT BROWNS RD.	18-Jun-97	1:30:00 AM	17.1	n/a	7.94	n/a	8.5	84	n/a	n/a
FOREST CR. AT HAMILTON RD.	28-Sep-01	11:32:00 AM	15.5	236.5	7.41	2	5.62	n/a	0.23	0.06
FOREST CR. AT HAMILTON RD.	16-Aug-01	1:20:00 PM	16.7	261.4	7.63	1	6.02	136	0.4	0.15
FOREST CR. AT HAMILTON RD.	11-Jul-01	2:05:00 PM	15.3	330.8	6.38	2	6.58	n/a	0.06	0.03
FOREST CR. AT HAMILTON RD.	14-Jun-01	2:22:00 PM	15.4	346.0	6.89	1	8.12	200	0.17	0.24
FOREST CR. AT HAMILTON RD.	6-Sep-00	2:30:00 PM	15.1	225.0	6.95	1	7.2	n/a	n/a	0.55
FOREST CR. AT HAMILTON RD.	24-Aug-00	12:42:00 PM	16.6	239.5	6.94	1	7.56	n/a	n/a	0.55
FOREST CR. AT HAMILTON RD.	10-Aug-00	11:50:00 AM	15.7	240.4	7.22	1	7.1	n/a	n/a	0.46
FOREST CR. AT HAMILTON RD.	26-Jul-00	11:05:00 AM	15.8	236.0	7.24	1	7.82	n/a	n/a	0.55
FOREST CR. AT HAMILTON RD.	11-Jul-00	12:40:00 PM	15.3	241.4	7.09	1	8.52	n/a	n/a	0.55
FOREST CR. AT HAMILTON RD.	22-Jun-00	9:00:00 AM	13.9	348.0	6.92	1	7.48	n/a	n/a	0.54
FOREST CR. AT HAMILTON RD.	23-Sep-99	8:36:00 AM	13.9	297	6.9		6.16	110	0.62	0.34

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
FOREST CR. AT HAMILTON RD.	1-Sep-99	2:25:00 PM	16	147	7.15	3	4.04	128	0.35	0.33
FOREST CR. AT HAMILTON RD.	16-Aug-99	1:00:00 PM	17.9	298	7.07	1	10.2	138	0.47	n/a
FOREST CR. AT HAMILTON RD.	2-Aug-99	10:45:00 AM	15.6	305	6.75	2	7.44	158	0.98	0.33
FOREST CR. AT HAMILTON RD.	20-Jul-99	8:50:00 AM	14.5	248	7.1	1	7.18	148	0.57	0.31
FOREST CR. AT HAMILTON RD.	8-Jul-99	1:25:00 PM	15.8	248	6.52	3	8.42	178	0.21	0.24
FOREST CR. AT HAMILTON RD.	17-Jun-99	4:05:00 PM	15.8	328	7.07	1	8.8	n/a	0.27	0.15
FOREST CR. AT HAMILTON RD.	21-Sep-98	8:45:00 AM	13.5	313	7.20	1	7.96	172	0.45	0.16
FOREST CR. AT HAMILTON RD.	12-Aug-98	8:35:00 AM	14.0	n/a	6.95	0	7.10	172	n/a	0.08
FOREST CR. AT HAMILTON RD.	31-Jul-98	1:45:00 PM	17.0	335	7.08	1	8.00	168	0.43	0.15
FOREST CR. AT HAMILTON RD.	23-Jul-98	1:00:00 PM	17.5	353	7.07	1	8.68	182	0.54	0.45
FOREST CR. AT HAMILTON RD.	13-Jul-98	1:00:00 PM	17.4	339	7.33	0	8.74	184	0.4	0.16
FOREST CR. AT HAMILTON RD.	2-Jul-98	10:00:00 AM	15.5	281	7.30	1	8.60	200	0.53	0.15
FOREST CR. AT HAMILTON RD.	16-Jun-98	11:30:00 AM	14.7	333	7.80	2	8.38	170	0.39	0.04
GROUSE CR AT MOUTH	6-Sep-00	12:50:00 PM	12.3	209.0	8.38	1	9.6	n/a	n/a	n/a
GROUSE CR AT MOUTH	24-Aug-00	2:55:00 PM	17.0	273.0	8.23	1	7.48	n/a	n/a	0.05
GROUSE CR AT MOUTH	10-Aug-00	8:50:00 AM	15.5	194.7	8.39	4	8.1	n/a	n/a	0.05
GROUSE CR AT MOUTH	11-Jul-00	10:13:00 AM	14.7	197.6	8.36	2	9.34	n/a	n/a	0.02
GROUSE CR AT MOUTH	26-Jun-00	4:16:00 PM	18.4	222.6	8.24	4	6.5	n/a	n/a	0.02
GROUSE CR AT MOUTH	22-Jun-00	11:11:00 AM	14.7	202.0	7.68	4	8.7	n/a	n/a	0.03
GROUSE CR AT MOUTH	23-Sep-99	1:30:00 PM	14.95	441	8.22	1	8.63	175	0.51	0.09
GROUSE CR AT MOUTH	1-Sep-99	11:43:00 AM	11.7	283	8.21	3	5.9	n/a	0.29	0.02
GROUSE CR AT MOUTH	16-Aug-99	11:25:00 AM	13.8	278	7.95	1	9.14	158	0.56	n/a
GROUSE CR AT MOUTH	2-Aug-99	2:25:00 PM	16.5	395	7.4	2	6.76	200	0.92	0.03
GROUSE CR AT MOUTH	20-Jul-99	11:40:00 AM	15.2	242	8.1	2	8.82	154	0.43	0.01
GROUSE CR AT MOUTH	8-Jul-99	12:00:00 PM	12.5	180	7.8	4	8.18	156	0.28	0
GROUSE CR AT MOUTH	17-Jun-99	2:15:00 PM	13.9	184	7.93	4	9.14	n/a	0.25	0.06
GROUSE CR AT MOUTH	21-Sep-98	1:25:00 PM	11.9	226	8.35	3	9.39	175	0.76	0.03
GROUSE CR AT MOUTH	4-Sep-98	8:45:00 AM	15.7	297	7.94	3	8.46	172	0.44	0.01
GROUSE CR AT MOUTH	25-Aug-98	10:00:00 AM	13.6	307	8.34	3	8.94	184	0.37	0.08
GROUSE CR AT MOUTH	13-Aug-98	9:15:00 AM	16.2	303	8.17	3	6.84	164	0.86	0.06
GROUSE CR AT MOUTH	3-Aug-98	10:40:00 AM	16.2	236	8.15	4	8.10	160	0.31	0.05
GROUSE CR AT MOUTH	23-Jul-98	11:50:00 AM	17.4	260	8.36	5	8.28	172	0.94	0.13

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
GROUSE CR AT MOUTH	13-Jul-98	12:35:00 PM	14.8	171	8.24	5	8.42	136	0.45	0.07
GROUSE CR AT MOUTH	2-Jul-98	11:05:00 AM	13.1	162	8.06	3	9.20	130	0.19	0.05
GROUSE CR AT MOUTH	20-Jun-98	10:15:00 AM	10.3	192	8.21	6	9.76	124	0.35	0.02
GROUSE CR AT MOUTH	12-Sep-97	1:15:00 PM	15	n/a	7.81	n/a	9.0	160	n/a	n/a
GROUSE CR AT MOUTH	18-Aug-97	1:20:00 PM	17.9	n/a	8.52	n/a	8.2	210	n/a	n/a
GROUSE CR AT MOUTH	4-Aug-97	3:20:00 PM	19.6	n/a	8.17	n/a	8.4	198	n/a	n/a
GROUSE CR AT MOUTH	24-Jul-97	12:55:00 PM	17.9	n/a	8.06	n/a	7.8	174	n/a	n/a
GROUSE CR AT MOUTH	14-Jul-97	1:45:00 PM	16.9	n/a	8.45	n/a	8.8	n/a	n/a	n/a
GROUSE CR AT MOUTH	3-Jul-97	2:15:00 PM	15.6	n/a	8.14	n/a	8.0	144	n/a	n/a
GROUSE CR AT MOUTH	24-Jun-97	2:15:00 PM	15.6	n/a	8.14	n/a	n/a	n/a	n/a	n/a
HUMBUG CR. AT RT. 238	24-Sep-99	2:14:00 PM	18.3	143	8.29	5	8.42	128	0.49	0.1
HUMBUG CR. AT RT. 238	17-Aug-99	2:10:00 PM	20.9	227	8.4	8	7.88	156	0.7	n/a
HUMBUG CR. AT RT. 238	4-Aug-99	2:25:00 PM	22.6	217	8.13	5	7.4	128	0.64	0.04
HUMBUG CR. AT RT. 238	22-Jul-99	1:35:00 PM	20.2	208	7.97	5	8.48	120	0.32	0.05
HUMBUG CR. AT RT. 238	9-Jul-99	2:20:00 PM	20.7	284	8.12	4	7.82	196	0.7	0.09
HUMBUG CR. AT RT. 238	21-Jun-99	3:52:00 PM	17.7	346	8.11	3	7.38	184	0.77	0.09
JACKSON CR. AT MOUTH	29-Sep-99	12:25:00 PM	15.5	145	7.31	8	6.16	90	0.43	0.17
JACKSON CR. AT MOUTH	24-Aug-99	12:10:00 PM	17.75	137	6.915	1	4.8	84	0.51	0.05
JACKSON CR. AT MOUTH	10-Aug-99	12:25:00 PM	17.7	120	7.05	1	6.56	80	0.24	0.01
JACKSON CR. AT MOUTH	28-Jul-99	11:25:00 AM	18	131	6.64	1	7.7	76	0.29	0.08
JACKSON CR. AT MOUTH	14-Jul-99	11:30:00 AM	17	99	6.58	1	7.98	n/a	0.26	0.08
JACKSON CR. AT MOUTH	29-Jun-99	1:35:00 PM	16.4	87	n/a	1	8.76	60	0.42	0.02
JACKSON CR. AT MOUTH	18-Jun-99	12:20:00 PM	15.2	99	7.28	1	8.94	n/a	0.3	0
LITTLE APPLEGATE R. AT TUNNEL RIDGE	23-Sep-99	12:00:00 PM	13	221	8.05	2	8.82	140	0.58	0.03
LITTLE APPLEGATE R. AT TUNNEL RIDGE	1-Sep-99	10:00:00 AM	9.5	212	8.25	5	4.67	101	0.26	0
LITTLE APPLEGATE R. AT TUNNEL RIDGE	16-Aug-99	10:35:00 AM	12.3	195	8.09	1	9.6	115	0.28	n/a
LITTLE APPLEGATE R. AT TUNNEL RIDGE	2-Aug-99	1:25:00 PM	15.1	181	8.04	2	8.82	120	0.38	0.03
LITTLE APPLEGATE R. AT TUNNEL RIDGE	20-Jul-99	10:00:00 AM	13.1	141	8.13	3	6.68	94.5	0.92	0.02
LITTLE APPLEGATE R. AT TUNNEL RIDGE	8-Jul-99	10:40:00 AM	10.7	113	7.82	2	9.82	128	0.16	0
LITTLE APPLEGATE R. AT TUNNEL RIDGE	17-Jun-99	12:21:00 PM	10.7	107	7.81	4	9.4	n/a	0.18	0.04
LITTLE APPLEGATE R. AT TUNNEL RIDGE	12-Sep-97	2:40:00 PM	14.3	n/a	8.06	n/a	9.2	110	n/a	n/a
LITTLE APPLEGATE R. AT TUNNEL RIDGE	18-Aug-97	2:15:00 PM	16.6	n/a	8.3	n/a	9.5	150	n/a	n/a

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
LITTLE APPLEGATE R. AT TUNNEL RIDGE	24-Jul-97	1:55:00 PM	16.9	n/a	8.57	n/a	8.5	136	n/a	n/a
LITTLE APPLEGATE R. AT TUNNEL RIDGE	3-Jul-97	1:15:00 PM	14	n/a	8.24	n/a	9.5	120	n/a	n/a
LITTLE APPLEGATE R. AT TUNNEL RIDGE	18-Jun-97	2:00:00 PM	15.2	n/a	8.32	n/a	9	115	n/a	n/a
LITTLE APPLEGATE R. AT YALE CR.	28-Sep-01	10:53:00 AM	14.1	154.8	8.01	13	8.54	n/a	0.22	0.02
LITTLE APPLEGATE R. AT YALE CR.	16-Aug-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LITTLE APPLEGATE R. AT YALE CR.	11-Jul-01	2:36:00 PM	18.5	195.1	7.63	2	8.68	n/a	0.11	0.03
LITTLE APPLEGATE R. AT YALE CR.	14-Jun-01	3:30:00 PM	18.6	201.0	8.09	2	9.36	115	0.15	0.03
LITTLE APPLEGATE R. AT YALE CR.	6-Sep-00	12:23:00 PM	15.0	171.0	8.43	2	9.92	n/a	n/a	n/a
LITTLE APPLEGATE R. AT YALE CR.	24-Aug-00	3:15:00 PM	19.9	191.8	8.55	1	8.22	n/a	n/a	0.04
LITTLE APPLEGATE R. AT YALE CR.	10-Aug-00	9:20:00 AM	16.7	175.4	8.49	1	2.66	n/a	n/a	n/a
LITTLE APPLEGATE R. AT YALE CR.	26-Jul-00	1:10:00 PM	18.7	172.7	8.49	2	8.94	n/a	n/a	0.05
LITTLE APPLEGATE R. AT YALE CR.	11-Jul-00	10:30:00 AM	14.7	149.2	8.36	2	9.02	n/a	n/a	0.02
LITTLE APPLEGATE R. AT YALE CR.	26-Jun-00	3:30:00 PM	18.4	181.0	8.17	3	7.88	n/a	n/a	n/a
LITTLE APPLEGATE R. AT YALE CR.	22-Jun-00	12:35:00 PM	16.1	165.0	8.23	2	8.36	n/a	n/a	0.03
LITTLE APPLEGATE R. AT YALE CR.	23-Sep-99	12:55:00 PM	15.7	n/a	7.81	n/a	7.02	112	0.62	0.04
LITTLE APPLEGATE R. AT YALE CR.	1-Sep-99	11:05:00 AM	12.6	235	8.38	18	8.8	128	0.16	0.01
LITTLE APPLEGATE R. AT YALE CR.	16-Aug-99	11:10:00 AM	15.3	218	7.93	2	9.52	127	0.78	n/a
LITTLE APPLEGATE R. AT YALE CR.	2-Aug-99	2:00:00 PM	19.6	208	8.03	2	8.72	124	0.77	0.01
LITTLE APPLEGATE R. AT YALE CR.	20-Jul-99	11:07:00 AM	17.1	100	8.15	2	9.06	132	0.68	0.02
LITTLE APPLEGATE R. AT YALE CR.	8-Jul-99	11:15:00 AM	12.5	128	7.74	2	8.9	n/a	0.29	0
LITTLE APPLEGATE R. AT YALE CR.	17-Jun-99	1:15:00 PM	12.2	117	7.82	3	9.32	n/a	0.19	0.04
LITTLE APPLEGATE R. AT YALE CR.	21-Sep-98	2:45:00 PM	14.1	201	8.40	1	9.90	140	1.83	0.05
LITTLE APPLEGATE R. AT YALE CR.	4-Sep-98	9:15:00 AM	15.8	268	8.22	1	7.40	172	0.26	0.06
LITTLE APPLEGATE R. AT YALE CR.	25-Aug-98	9:15:00 AM	13.9	280	8.22	1	9.34	164	0.31	0.11
LITTLE APPLEGATE R. AT YALE CR.	13-Aug-98	9:40:00 AM	17.0	268	8.06	1	8.78	146	0.73	0.04
LITTLE APPLEGATE R. AT YALE CR.	3-Aug-98	11:15:00 AM	17.3	240	8.23	4	8.40	128	0.27	0.05
LITTLE APPLEGATE R. AT YALE CR.	23-Jul-98	12:50:00 PM	18.9	228	8.28	1	8.26	146	0.32	0.1
LITTLE APPLEGATE R. AT YALE CR.	13-Jul-98	12:20:00 PM	14.8	149	8.33	2	8.94	122	0.29	0.08
LITTLE APPLEGATE R. AT YALE CR.	2-Jul-98	11:55:00 AM	12.2	112	8.17	2	9.78	92	0.25	0.05
LITTLE APPLEGATE R. AT YALE CR.	20-Jun-98	9:20:00 AM	9.0	128	8.21	5	10.24	88	0.3	0.01
LITTLE APPLEGATE R. AT YALE CR.	12-Sep-97	1:57:00 PM	16.1	n/a	7.16	n/a	8.5	102	n/a	n/a
LITTLE APPLEGATE R. AT YALE CR.	28-Aug-97	12:43:00 PM	16.7	n/a	8.12	n/a	9	164	n/a	n/a

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
LITTLE APPLEGATE R. AT YALE CR.	18-Aug-97	1:55:00 PM	19.6	n/a	8.35	n/a	9.5	164	n/a	n/a
LITTLE APPLEGATE R. AT YALE CR.	4-Aug-97	2:25:00 PM	22.5	n/a	8.25	n/a	8.2	154	n/a	n/a
LITTLE APPLEGATE R. AT YALE CR.	24-Jul-97	1:31:00 PM	19.4	n/a	8.37	n/a	7.6	160	n/a	n/a
LITTLE APPLEGATE R. AT YALE CR.	14-Jul-97	12:45:00 PM	18.5	n/a	8.43	n/a	8.4	n/a	n/a	n/a
LITTLE APPLEGATE R. AT YALE CR.	3-Jul-97	2:00:00 PM	18	n/a	8.27	n/a	9.5	140	n/a	n/a
LITTLE APPLEGATE R. AT YALE CR.	24-Jun-97	1:57:00 PM	15.9	n/a	8.31	n/a	8.5	120	n/a	n/a
LITTLE APPLEGATE R. AT YALE CR.	18-Jun-97	11:15:00 AM	16	n/a	8.02	n/a	9.6	110	n/a	n/a
LITTLE APPLEGATE R. AT MOUTH	28-Sep-01	9:48:00 AM	15.8	213.5	7.78	3	6.78	n/a	0.12	0.01
LITTLE APPLEGATE R. AT MOUTH	16-Aug-01	1:40:00 PM	24.6	260.1	8.25	1	7.64	116	0.9	0.6
LITTLE APPLEGATE R. AT MOUTH	11-Jul-01	3:30:00 PM	20.8	250.9	7.77	2	8.8	n/a	0.19	3.1
LITTLE APPLEGATE R. AT MOUTH	14-Jun-01	4:24:00 PM	22.5	234.3	8.32	2	8.4	140	0.22	0.04
LITTLE APPLEGATE R. AT MOUTH	6-Sep-00	11:30:00 AM	15.8	214.0	8.54	1	10.1	n/a	n/a	n/a
LITTLE APPLEGATE R. AT MOUTH	24-Aug-00	11:30:00 AM	17.7	230.8	8.57	1	10.7	n/a	n/a	n/a
LITTLE APPLEGATE R. AT MOUTH	10-Aug-00	10:10:00 AM	17.7	217.7	8.58	2	8.8	n/a	n/a	0.11
LITTLE APPLEGATE R. AT MOUTH	26-Jul-00	8:33:00 AM	15.4	192.6	8.28	1	9.02	n/a	n/a	0.07
LITTLE APPLEGATE R. AT MOUTH	11-Jul-00	2:35:00 PM	20.0	202.1	8.61	2	8.1	n/a	n/a	0.04
LITTLE APPLEGATE R. AT MOUTH	26-Jun-00	5:13:00 PM	20.6	216.0	8.23	3	8.74	n/a	n/a	n/a
LITTLE APPLEGATE R. AT MOUTH	22-Jun-00	10:00:00 AM	15.5	207.0	7.93	3	8.66	n/a	n/a	0.04
LITTLE APPLEGATE R. AT MOUTH	23-Sep-99	9:23:00 AM	14.4	289	7.83	2	8.88	106	0.53	0.01
LITTLE APPLEGATE R. AT MOUTH	1-Sep-99	12:27:00 PM	15.2	268	8.41	2	8.52	153	0.22	0
LITTLE APPLEGATE R. AT MOUTH	16-Aug-99	1:15:00 PM	19	258	8.45	1	9.82	152	0.54	n/a
LITTLE APPLEGATE R. AT MOUTH	2-Aug-99	3:25:00 PM	22	246	8.51	2	8.55	n/a	0.9	0.03
LITTLE APPLEGATE R. AT MOUTH	20-Jul-99	12:55:00 PM	19.2	210	8.34	2	8.16	144	0.52	0.01
LITTLE APPLEGATE R. AT MOUTH	8-Jul-99	12:45:00 PM	16.1	169	7.86	6	8.72	n/a	0.39	0
LITTLE APPLEGATE R. AT MOUTH	17-Jun-99	3:20:00 PM	15.7	145	7.95	5	9.54	n/a	0.31	0.04
LITTLE APPLEGATE R. AT MOUTH	21-Sep-98	9:15:00 AM	11.7	307	8.38	2	9.98	184	0.77	0.04
LITTLE APPLEGATE R. AT MOUTH	12-Aug-98	9:15:00 AM	16.3	n/a	8.40	1	9.70	164	n/a	n/a
LITTLE APPLEGATE R. AT MOUTH	31-Jul-98	12:00:00 PM	18.4	268	8.62	1	8.44	132	0.29	0.03
LITTLE APPLEGATE R. AT MOUTH	23-Jul-98	11:15:00 AM	18.9	203	8.32	1	8.30	136	n/a	0.06
LITTLE APPLEGATE R. AT MOUTH	13-Jul-98	11:00:00 AM	16.6	194	8.46	5	9.54	118	0.28	0.06
LITTLE APPLEGATE R. AT MOUTH	2-Jul-98	9:24:00 AM	13.1	134	8.12	3	9.44	100	0.77	0.06
LITTLE APPLEGATE R. AT MOUTH	16-Jun-98	12:45:00 PM	10.0	145	8.34	9	9.56	96	n/a	n/a

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
LITTLE APPLEGATE R. AT MOUTH	12-Sep-97	11:30:00 AM	16.5	n/a	8.31	n/a	7	170	n/a	n/a
LITTLE APPLEGATE R. AT MOUTH	28-Aug-97	12:15:00 PM	18.1	n/a	8.35	n/a	8.7	184	n/a	n/a
LITTLE APPLEGATE R. AT MOUTH	18-Aug-97	12:30:00 PM	20.8	n/a	8.43	n/a	8.5	170	n/a	n/a
LITTLE APPLEGATE R. AT MOUTH	4-Aug-97	11:40:00 AM	20.8	n/a	8.4	n/a	8.9	185	n/a	n/a
LITTLE APPLEGATE R. AT MOUTH	24-Jul-97	12:45:00 PM	19.3	n/a	8.4	n/a	8.6	176	n/a	n/a
LITTLE APPLEGATE R. AT MOUTH	14-Jul-97	11:40:00 AM	18.1	n/a	8.58	n/a	9	n/a	n/a	n/a
LITTLE APPLEGATE R. AT MOUTH	3-Jul-97	12:00:00 PM	16.8	n/a	8.19	n/a	8.4	155	n/a	n/a
LITTLE APPLEGATE R. AT MOUTH	18-Jun-97	10:30:00 AM	15.5	n/a	8.18	n/a	7.5	127	n/a	n/a
LITTLE APPLEGATE R. AT RD. MI. 2.6	28-Sep-01	10:14:00 AM	15	199.1	8	1	9.02	n/a	0.13	0.01
LITTLE APPLEGATE R. AT RD. MI. 2.6	14-Jun-01	4:04:00 PM	18.7	229.4	8.28	2	n/a	125	0.19	0.08
LITTLE APPLEGATE R. AT RD. MI. 2.6	6-Sep-00	1:30:00 PM	14.8	202.0	8.61	1	10.5	n/a	n/a	n/a
LITTLE APPLEGATE R. AT RD. MI. 2.6	24-Aug-00	2:35:00 PM	18.7	230.2	8.61	1	8.58	n/a	n/a	0.03
LITTLE APPLEGATE R. AT RD. MI. 2.6	10-Aug-00	8:35:00 AM	16.1	206.5	8.40	2	8	n/a	n/a	n/a
LITTLE APPLEGATE R. AT RD. MI. 2.6	26-Jul-00	11:45:00 AM	16.4	192.0	8.46	1	8.82	n/a	n/a	n/a
LITTLE APPLEGATE R. AT RD. MI. 2.6	11-Jul-00	9:41:00 AM	13.7	179.9	8.36	2	9.36	n/a	n/a	0.04
LITTLE APPLEGATE R. AT RD. MI. 2.6	26-Jun-00	4:49:00 PM	20.0	209.5	8.16	2	8.42	n/a	n/a	0.03
LITTLE APPLEGATE R. AT RD. MI. 2.6	22-Jun-00	10:30:00 AM	14.8	192.0	8.04	2	8.96	n/a	n/a	0.03
LITTLE APPLEGATE R. AT RD. MI. 2.6	23-Sep-99	2:10:00 PM	17.15	283	8.52	1	7.24	146	0.64	0.02
LITTLE APPLEGATE R. AT RD. MI. 2.6	1-Sep-99	12:10:00 PM	13	268	8.4	3	5.46	124	0.62	0
LITTLE APPLEGATE R. AT RD. MI. 2.6	16-Aug-99	12:10:00 PM	15.9	253	8.21	1	9.52	156	0.43	n/a
LITTLE APPLEGATE R. AT RD. MI. 2.6	2-Aug-99	2:55:00 PM	19.5	235	8.32	1	7.94	n/a	n/a	n/a
LITTLE APPLEGATE R. AT RD. MI. 2.6	20-Jul-99	12:35:00 PM	17.1	197	8.28	1	8.8	155	0.57	0.02
LITTLE APPLEGATE R. AT RD. MI. 2.6	8-Jul-99	12:30:00 PM	14.4	161	7.94	5	8.52	136	0.21	0
LITTLE APPLEGATE R. AT RD. MI. 2.6	17-Jun-99	3:00:00 PM	14.4	135	7.98	4	9.5	n/a	0.42	0.04
LITTLE APPLEGATE R. AT RD. MI. 2.6	21-Sep-98	12:45:00 PM	13.0	305	8.26	1	9.64	188	0.42	0.04
LITTLE APPLEGATE R. AT RD. MI. 2.6	4-Sep-98	8:00:00 AM	15.9	303	7.78	2	9.36	156	0.51	0.02
LITTLE APPLEGATE R. AT RD. MI. 2.6	25-Aug-98	11:00:00 AM	14.7	310	8.35	1	8.94	176	0.37	0.06
LITTLE APPLEGATE R. AT RD. MI. 2.6	13-Aug-98	8:50:00 AM	16.4	287	8.09	1	8.62	160	n/a	0.08
LITTLE APPLEGATE R. AT RD. MI. 2.6	3-Aug-98	10:15:00 AM	15.9	228	8.32	4	8.62	138	0.28	0.07
LITTLE APPLEGATE R. AT RD. MI. 2.6	23-Jul-98	11:00:00 AM	17.8	255	8.16	1	8.24	160	0.87	0.13
LITTLE APPLEGATE R. AT RD. MI. 2.6	13-Jul-98	1:30:00 PM	16.5	143	8.30	2	8.04	136	0.29	0.07
LITTLE APPLEGATE R. AT RD. MI. 2.6	2-Jul-98	10:32:00 AM	13.1	134	8.12	3	9.60	110	0.5	0.07

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
LITTLE APPLEGATE R. AT RD. MI. 2.6	20-Jun-98	11:20:00 AM	10.8	110	8.33	6	9.66	96	n/a	n/a
LITTLE APPLEGATE R. AT RD. MI. 2.6	12-Sep-97	12:15:00 PM	15.9	n/a	7.68	n/a	7.5	160	n/a	n/a
LITTLE APPLEGATE R. AT RD. MI. 2.6	18-Aug-97	12:55:00 PM	19.1	n/a	8.27	n/a	9	n/a	n/a	n/a
LITTLE APPLEGATE R. AT RD. MI. 2.6	4-Aug-97	12:55:00 PM	23.8	n/a	8.35	n/a	8.6	185	n/a	n/a
LITTLE APPLEGATE R. AT RD. MI. 2.6	24-Jul-97	12:00:00 PM	17.3	n/a	8.39	n/a	8.6	184	n/a	n/a
LITTLE APPLEGATE R. AT RD. MI. 2.6	14-Jul-97	2:30:00 PM	n/a	n/a	n/a	n/a	8.7	n/a	n/a	n/a
LITTLE APPLEGATE R. AT RD. MI. 2.6	3-Jul-97	2:20:00 PM	20	n/a	8.2	n/a	7.5	260	n/a	n/a
LITTLE APPLEGATE R. AT RD. MI. 2.6	24-Jun-97	1:00:00 PM	17.8	n/a	8.4	n/a	6.8	220	n/a	n/a
MUNGER CR. AT KINCAID RD.	22-Aug-00	11:25:00 AM	14.9	73.0	8.03	n/a	8.8	n/a	n/a	0.07
MUNGER CR. AT KINCAID RD.	9-Aug-00	2:20:00 PM	18.5	87.2	7.48	1	8.12	n/a	n/a	0.06
MUNGER CR. AT KINCAID RD.	25-Jul-00	2:00:00 PM	16.2	89.1	8.22	0	8.66	n/a	n/a	0.04
MUNGER CR. AT KINCAID RD.	10-Jul-00	8:45:00 AM	13.0	86.5	8.00	1	8.96	n/a	n/a	0.03
MUNGER CR. AT KINCAID RD.	27-Jun-00	3:20:00 PM	16.3	79.7	7.80	1	8.86	n/a	n/a	n/a
MUNGER CR. AT KINCAID RD.	19-Jun-00	12:40:00 PM	13.5	104.0	8.31	1	9.36	n/a	n/a	n/a
MUNGER CR. AT KINCAID RD.	24-Sep-99	11:26:00 AM	14.4	118	7.75	1	9	90	1.33	0.04
MUNGER CR. AT KINCAID RD.	2-Sep-99	10:15:00 AM	12.2	115	7.1	2	9.4	62	0.25	0
MUNGER CR. AT KINCAID RD.	17-Aug-99	10:25:00 AM	14.6	112	7.26	0	8.78	76	0.42	n/a
MUNGER CR. AT KINCAID RD.	4-Aug-99	10:00:00 AM	15.6	107	7.25	1	8.7	70	0.42	0.02
MUNGER CR. AT KINCAID RD.	22-Jul-99	11:03:00 AM	15	85	7.06	1	8.8	60	0.46	0.02
MUNGER CR. AT KINCAID RD.	9-Jul-99	12:00:00 PM	13.8	78	6.94	0	9.54	60	0.72	0.02
MUNGER CR. AT KINCAID RD.	21-Jun-99	2:05:00 PM	13.1	91	7.19	1	8.8	60	0.43	0.01
MUNGER CR. AT KINCAID RD.	24-Sep-98	1:02:00 PM	13.2	93	7.86	1	8.86	60	0.27	0.04
MUNGER CR. AT KINCAID RD.	31-Aug-98	12:43:00 PM	16.2	111	7.77	0	9.06	56	n/a	n/a
MUNGER CR. AT KINCAID RD.	21-Aug-98	3:30:00 PM	15.8	114	7.59	0	8.62	56	0.33	0.08
MUNGER CR. AT KINCAID RD.	11-Aug-98	1:15:00 PM	16.5	112	7.87	0	8.80	60	n/a	0.04
MUNGER CR. AT KINCAID RD.	30-Jul-98	3:18:00 PM	17.0	123	7.65	1	8.32	72	0.45	n/a
MUNGER CR. AT KINCAID RD.	20-Jul-98	10:33:00 AM	14.9	83	7.52	1	9.18	60	0.15	0.04
MUNGER CR. AT KINCAID RD.	9-Jul-98	1:56:00 PM	15.3	86	7.83	1	9.04	60	0.13	0.05
MUNGER CR. AT KINCAID RD.	26-Jun-98	12:40:00 PM	11.5	97	7.64	1	9.64	60	0.14	0.05
MUNGER CR. AT KINCAID RD.	17-Jun-98	5:00:00 PM	12.4	81	7.70	0	8.80	70	0.21	0
MUNGER CR. AT KINCAID RD.	15-Sep-97	11:44:00 AM	13.8	n/a	8.00	n/a	10	90	n/a	n/a
MUNGER CR. AT KINCAID RD.	26-Aug-97	2:45:00 PM	14.8	n/a	7.81	n/a	8.7	68	n/a	n/a

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
MUNGER CR. AT KINCAID RD.	14-Aug-97	1:10:00 PM	17.9	n/a	7.97	n/a	9.4	n/a	n/a	n/a
MUNGER CR. AT KINCAID RD.	1-Aug-97	12:55:00 PM	15.8	n/a	7.3	n/a	8.8	64	n/a	n/a
MUNGER CR. AT KINCAID RD.	24-Jul-97	3:15:00 PM	15.9	n/a	7.36	n/a	8.5	70	n/a	n/a
MUNGER CR. AT KINCAID RD.	14-Jul-97	3:00:00 PM	15.2	n/a	7.65	n/a	9.5	62	n/a	n/a
MUNGER CR. AT KINCAID RD.	3-Jul-97	11:00:00 AM	12.6	n/a	7.8	n/a	9.4	60	n/a	n/a
MUNGER CR. AT KINCAID RD.	18-Jun-97	3:30:00 PM	14.5	n/a	6.85	n/a	9.4	78	n/a	n/a
MURPHY CR. AT BRIDGE	28-Sep-01	1:21:00 PM	14.3	138.5	7.94	2	8.6	n/a	0.03	0.02
MURPHY CR. AT BRIDGE	16-Aug-01	10:12:00 AM	17.1	185.2	8.33	2	81	108	0.3	0.04
MURPHY CR. AT BRIDGE	11-Jul-01	10:43:00 AM	16.7	190.1	7.75	1	8.28	n/a	0.05	0.07
MURPHY CR. AT BRIDGE	14-Jun-01	10:32:00 AM	12.8	171.1	7.89	2	8.76	110	0.11	0.06
MURPHY CR. AT BRIDGE	23-Aug-00	1:20:00 PM	15.7	162.0	7.41	n/a	8.86	n/a	n/a	0.06
MURPHY CR. AT BRIDGE	10-Aug-00	1:10:00 PM	17.3	143.8	7.41	1	8.1	n/a	n/a	0.05
MURPHY CR. AT BRIDGE	27-Jul-00	3:50:00 PM	16.5	136.4	7.54	1	8.56	n/a	n/a	0.03
MURPHY CR. AT BRIDGE	10-Jul-00	2:15:00 PM	14.8	136.5	8.07	1	9.1	n/a	n/a	0.02
MURPHY CR. AT BRIDGE	27-Jun-00	1:13:00 PM	15.7	123.8	8.38	1	9.06	n/a	n/a	0.02
MURPHY CR. AT BRIDGE	14-Jun-00	2:42:00 PM	14.5	154.0	7.50	1	9.68	n/a	n/a	n/a
MURPHY CR. AT BRIDGE	29-Sep-99	11:45:00 AM	9.6	181	7.96	3	10.3	82	0.38	0.01
MURPHY CR. AT BRIDGE	24-Aug-99	12:30:00 PM	16.5	182	7.73	0	8.64	110	0.3	0.02
MURPHY CR. AT BRIDGE	10-Aug-99	12:55:00 PM	16.7	173	7.92	0	8.66	120	n/a	0
MURPHY CR. AT BRIDGE	28-Jul-99	12:05:00 PM	16.3	169	7.645	1	8.21	99.5	0.32	0
MURPHY CR. AT BRIDGE	14-Jul-99	12:05:00 PM	14.2	126	7.24	1	9.1	n/a	0.2	0.04
MURPHY CR. AT BRIDGE	29-Jun-99	3:10:00 AM	14.9	119	n/a	1	9.5	85	0.37	0.01
MURPHY CR. AT BRIDGE	18-Jun-99	11:50:00 AM	12.7	139	6.83	1	9.54	n/a	0.21	0
MURPHY CR. AT BRIDGE	28-Sep-98	12:23:00 PM	12.6	181	8.22	1	9.34	110	0.92	0.05
MURPHY CR. AT BRIDGE	28-Aug-98	12:50:00 PM	15.8	172	8.04	0	8.14	92	n/a	n/a
MURPHY CR. AT BRIDGE	17-Aug-98	1:00:00 PM	15.4	171	7.74	0	8.82	96	n/a	n/a
MURPHY CR. AT BRIDGE	7-Aug-98	10:45:00 AM	16.2	171	n/a	0	8.70	88	0.25	0.06
MURPHY CR. AT BRIDGE	28-Jul-98	9:20:00 AM	17.2	168	7.53	1	8.22	89	n/a	n/a
MURPHY CR. AT BRIDGE	17-Jul-98	9:30:00 AM	14.9	160	7.85	0	8.86	96	0.18	0.09
MURPHY CR. AT BRIDGE	8-Jul-98	2:15:00 PM	16.5	155	7.97	1	8.84	105	0.45	0.06
MURPHY CR. AT BRIDGE	27-Jun-98	2:00:00 PM	13.3	142	8.08	1	9.30	98	0.38	0.04
MURPHY CR. AT BRIDGE	18-Jun-98	12:00:00 PM	12.3	137	8.04	2	9.36	96	0.37	0.01

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
MURPHY CR. AT BRIDGE	17-Sep-97	10:15:00 AM	12	n/a	7.64	n/a	9.8	90	n/a	n/a
MURPHY CR. AT BRIDGE	21-Aug-97	12:25:00 PM	16.3	n/a	7.91	n/a	8.8	101	n/a	n/a
MURPHY CR. AT BRIDGE	8-Aug-97	10:30:00 AM	16.7	n/a	7.98	n/a	9.0	110	n/a	n/a
MURPHY CR. AT BRIDGE	3-Jul-97	10:00:00 AM	14.7	n/a	7.04	n/a	9.5	104	n/a	n/a
MURPHY CR. AT BRIDGE	24-Jun-97	9:17:00 AM	11	n/a	8.2	n/a	9.9	100	n/a	n/a
PALMER CR. AT PALMER CR. ROAD	14-Jun-01	5:08:00 PM	19.4	438.1	7.86	1	8.68	225	0.14	0.02
PALMER CR. AT PALMER CR. ROAD	24-Aug-00	8:50:00 AM	14.8	317.0	7.86	1	8.54	n/a	n/a	0.02
PALMER CR. AT PALMER CR. ROAD	10-Aug-00	7:35:00 AM	15.9	335.8	8.21	1	7.56	n/a	n/a	0.08
PALMER CR. AT PALMER CR. ROAD	11-Jul-00	8:10:00 AM	14.1	307.1	8.13	1	8.02	n/a	n/a	0.04
PALMER CR. AT PALMER CR. ROAD	22-Jun-00	3:10:00 PM	16.8	411.0	8.15	1	8.52	n/a	n/a	0.01
PALMER CR. AT PALMER CR. ROAD	13-Jun-00	2:00:00 PM	14.6	397.0	8.39	1	9.85	n/a	n/a	0.03
PALMER CR. AT PALMER CR. ROAD	23-Sep-99	10:28:00 AM	15.2	414	7.55	2	8.6	190	0.79	0.03
PALMER CR. AT PALMER CR. ROAD	1-Sep-99	1:20:00 PM	16.5	409	8.22	3	5.62	200	0.28	0
PALMER CR. AT PALMER CR. ROAD	16-Aug-99	9:20:00 AM	15.3	421	7.95	1	8.83	242	0.92	n/a
PALMER CR. AT PALMER CR. ROAD	2-Aug-99	11:45:00 AM	18.6	412	7.84	2	9.63	200	0.78	0.02
PALMER CR. AT PALMER CR. ROAD	20-Jul-99	1:55:00 PM	18.2	356	8.03	2	8.86	224	0.66	0.03
PALMER CR. AT PALMER CR. ROAD	8-Jul-99	9:00:00 AM	13.65	318	7.895	1	9.08	198	0.52	-0.02
PALMER CR. AT PALMER CR. ROAD	17-Jun-99	9:03:00 AM	14.45	400	7.885	1	8.59	219	0.26	0.02
PALMER CR. AT PALMER CR. ROAD	21-Sep-98	10:40:00 AM	14.4	425	8.26	1	8.88	200	0.41	0.04
PALMER CR. AT PALMER CR. ROAD	12-Aug-98	10:50:00 AM	18.7	n/a	8.15	0	8.76	228	n/a	n/a
PALMER CR. AT PALMER CR. ROAD	31-Jul-98	1:00:00 PM	18.7	423	8.20	0	8.80	200	0.26	0.03
PALMER CR. AT PALMER CR. ROAD	23-Jul-98	12:00:00 PM	19.5	421	8.02	1	8.50	228	n/a	n/a
PALMER CR. AT PALMER CR. ROAD	13-Jul-98	11:45:00 AM	17.2	396	8.20	0	8.50	240	0.38	0.06
PALMER CR. AT PALMER CR. ROAD	2-Jul-98	10:50:00 AM	15.3	308	8.09	0	8.94	220	0.48	0.07
PALMER CR. AT PALMER CR. ROAD	26-Jun-98	3:00:00 PM	14.0	n/a	8.37	n/a	9.3	n/a	0.41	0.07
SLATE CR. AT SLATE CR. RD. MILE 1.6	28-Sep-01	3:10:00 PM	15.2	234.6	8.38	2	8.72	n/a	0	0.01
SLATE CR. AT SLATE CR. RD. MILE 1.6	16-Aug-01	8:45:00 AM	16.7	246.1	8.14	1	7.5	144	0	0.03
SLATE CR. AT SLATE CR. RD. MILE 1.6	11-Jul-01	9:48:00 AM	17.8	281.2	8.26	1	8.52	n/a	0.05	1.9
SLATE CR. AT SLATE CR. RD. MILE 1.6	14-Jun-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SLATE CR. AT SLATE CR. RD. MILE 1.6	26-Aug-00	10:05:00 AM	15.5	213.6	8.25	0	9	n/a	n/a	0.02
SLATE CR. AT SLATE CR. RD. MILE 1.6	23-Aug-00	9:45:00 AM	15.0	241.0	8.36	n/a	8.4	n/a	n/a	0.04
SLATE CR. AT SLATE CR. RD. MILE 1.6	10-Aug-00	10:40:00 AM	17.6	215.8	8.40	1	8.66	n/a	n/a	0.01

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
SLATE CR. AT SLATE CR. RD. MILE 1.6	10-Jul-00	1:05:00 PM	16.1	217.5	8.43	1	9.08	n/a	n/a	0.02
SLATE CR. AT SLATE CR. RD. MILE 1.6	14-Jun-00	12:00:00 AM	13.6	244.0	8.46	1	9.8	n/a	n/a	0
SLATE CR. AT SLATE CR. RD. MILE 1.6	29-Sep-99	2:10:00 PM	11.2	284	8.665	1	10.2	129	0.26	0
SLATE CR. AT SLATE CR. RD. MILE 1.6	24-Aug-99	9:20:00 AM	15.9	280	8.13	0	8.7	152	0.4	0.05
SLATE CR. AT SLATE CR. RD. MILE 1.6	10-Aug-99	9:15:00 AM	16.4	274	8.31	1	9.1	110	n/a	0
SLATE CR. AT SLATE CR. RD. MILE 1.6	28-Jul-99	9:55:00 AM	15.8	272	8.16	1	8.68	160	0.33	0
SLATE CR. AT SLATE CR. RD. MILE 1.6	14-Jul-99	9:15:00 AM	14.1	207	8.36	1	9.32	n/a	0.25	0
SLATE CR. AT SLATE CR. RD. MILE 1.6	29-Jun-99	10:15:00 AM	14.85	199	n/a	1	9.77	147.5	0.63	0
SLATE CR. AT SLATE CR. RD. MILE 1.6	18-Jun-99	2:00:00 AM	16.2	238	8.25	2	8.96	n/a	1.65	0
SLATE CR. AT SLATE CR. RD. MILE 1.6	28-Sep-98	2:45:00 PM	14.0	293	8.35	0	9.70	150	0.95	0.02
SLATE CR. AT SLATE CR. RD. MILE 1.6	28-Aug-98	9:50:00 AM	15.2	276	8.41	0	8.86	164	n/a	n/a
SLATE CR. AT SLATE CR. RD. MILE 1.6	17-Aug-98	4:45:00 PM	17.1	267	8.46	0	8.98	158	n/a	n/a
SLATE CR. AT SLATE CR. RD. MILE 1.6	7-Aug-98	9:30:00 AM	15.9	279	n/a	0	8.68	142	0.45	0.07
SLATE CR. AT SLATE CR. RD. MILE 1.6	28-Jul-98	11:30:00 AM	19.1	271	8.46	1	8.32	164	n/a	n/a
SLATE CR. AT SLATE CR. RD. MILE 1.6	17-Jul-98	11:30:00 AM	16.8	263	8.52	0	8.84	160	0.22	0.07
SLATE CR. AT SLATE CR. RD. MILE 1.6	8-Jul-98	4:15:00 PM	19.3	248	8.60	0	8.14	148	0.39	0.06
SLATE CR. AT SLATE CR. RD. MILE 1.6	27-Jun-98	5:10:00 PM	16.0	186	8.28	1	9.32	145	0.32	0.03
SLATE CR. AT SLATE CR. RD. MILE 1.6	18-Jun-98	3:30:00 PM	15.3	229	8.60	1	8.90	164	0.25	0
SLATE CR. AT SLATE CR. RD. MILE 1.6	17-Sep-97	12:25:00 PM	12.9	n/a	7.83	n/a	8.8	167	n/a	n/a
SLATE CR. AT SLATE CR. RD. MILE 1.6	21-Aug-97	2:20:00 PM	20.2	n/a	8.27	n/a	8.7	169	n/a	n/a
SLATE CR. AT SLATE CR. RD. MILE 1.6	8-Aug-97	12:10:00 PM	19.6	n/a	8.45	n/a	9.4	190	n/a	n/a
SLATE CR. AT SLATE CR. RD. MILE 1.6	14-Jul-97	12:00:00 PM	16.3	n/a	8.34	n/a	9.3	156	n/a	n/a
SLATE CR. AT SLATE CR. RD. MILE 1.6	3-Jul-97	1:14:00 PM	15.8	n/a	8.12	n/a	9.6	152	n/a	n/a
SLATE CR. AT SLATE CR. RD. MILE 1.6	24-Jun-97	12:30:00 PM	13.4	n/a	8.38	n/a	9.7	164	n/a	n/a
SLATE CR. AT MOUTH	28-Sep-01	2:30:00 PM	17.4	196.9	7.9	1	2.2	n/a	0.08	0.19
SLATE CR. AT MOUTH	16-Aug-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SLATE CR. AT MOUTH	11-Jul-01	9:10:00 AM	19	230.6	7.21	3	6.56	n/a	0.18	1.8
SLATE CR. AT MOUTH	14-Jun-01	8:24:00 AM	15.3	127.5	7.49	1	7.3	110	0.13	0.16
SLATE CR. AT MOUTH	23-Aug-00	10:50:00 AM	18.7	172.0	6.84	n/a	7.6	n/a	n/a	0.07
SLATE CR. AT MOUTH	10-Aug-00	11:20:00 AM	20.2	157.0	7.05	1	8.08	n/a	n/a	0.08
SLATE CR. AT MOUTH	26-Jul-00	11:00:00 AM	20.1	155.8	7.16	1	7.34	n/a	n/a	0.05
SLATE CR. AT MOUTH	10-Jul-00	1:50:00 PM	19.4	158.3	7.78	1	8.22	n/a	n/a	0.04

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
SLATE CR. AT MOUTH	14-Jun-00	n/a	16.8	179.0	7.49	1	8.88	n/a	n/a	0.06
SLATE CR. AT MOUTH	29-Sep-99	3:10:00 PM	16	195	7.63	1	8.44	100	0.89	0
SLATE CR. AT MOUTH	24-Aug-99	10:10:00 AM	19	192	7.01	1	7	100	0.43	0.01
SLATE CR. AT MOUTH	10-Aug-99	10:10:00 AM	19	196	7.26	1	6.94	90	0.15	0.03
SLATE CR. AT MOUTH	28-Jul-99	10:30:00 AM	18.7	179	6.77	1	8.92	85	0.2	0.03
SLATE CR. AT MOUTH	14-Jul-99	10:10:00 AM	17.7	152	7.06	1	7.32	n/a	0.15	0.02
SLATE CR. AT MOUTH	29-Jun-99	12:15:00 PM	17.9	146	n/a	1	8.42	80	0.24	0.01
SLATE CR. AT MOUTH	18-Jun-99	2:45:00 AM	19.5	164	7.1	3	8.8	n/a	0.17	0
SLATE CR. AT MOUTH	28-Sep-98	3:17:00 PM	17.7	219	7.41	n/a	8.06	105	0.29	0.06
SLATE CR. AT MOUTH	28-Aug-98	9:20:00 AM	17.4	195	7.42	1	6.60	92	n/a	n/a
SLATE CR. AT MOUTH	17-Aug-98	2:30:00 PM	20.7	198	7.29	1	7.96	96	n/a	n/a
SLATE CR. AT MOUTH	7-Aug-98	10:00:00 AM	19.4	195	n/a	1	7.36	92	0.3	0.07
SLATE CR. AT MOUTH	28-Jul-98	12:10:00 PM	22.3	198	7.27	1	7.06	104	n/a	n/a
SLATE CR. AT MOUTH	17-Jul-98	12:30:00 PM	20.1	185	7.35	1	7.38	102	0.2	0.09
SLATE CR. AT MOUTH	8-Jul-98	4:45:00 PM	22.4	180	7.36	1	7.92	84	0.98	0.07
SLATE CR. AT MOUTH	27-Jun-98	4:55:00 PM	18.1	170	7.66	1	8.22	120	0.31	0.05
SLATE CR. AT MOUTH	18-Jun-98	4:10:00 PM	18.4	164	7.63	1	7.92	94	0.33	0
SLATE CR. AT MOUTH	17-Sep-97	1:32:00 PM	16.9	n/a	6.99	n/a	7.9	99	n/a	n/a
SLATE CR. AT MOUTH	21-Aug-97	3:20:00 PM	21.2	n/a	7.07	n/a	7.3	104	n/a	n/a
SLATE CR. AT MOUTH	8-Aug-97	1:00:00 PM	20.8	n/a	7.47	n/a	7.4	n/a	n/a	n/a
SLATE CR. AT MOUTH	14-Jul-97	1:34:00 PM	19.5	n/a	7.69	n/a	8.0	108	n/a	n/a
SLATE CR. AT MOUTH	3-Jul-97	2:43:00 PM	19.9	n/a	6.8	n/a	8.3	108	n/a	n/a
SLATE CR. AT MOUTH	24-Jun-97	11:15:00 AM	15.8	n/a	7.7	n/a	8.6	104	n/a	n/a
SLATE CR. AT REDWOOD TAVERN	28-Sep-01	2:50:00 PM	15.1	233.0	8.02	2	8.2	n/a	0.04	0.01
SLATE CR. AT REDWOOD TAVERN	16-Aug-01	9:09:00 AM	17.6	253.8	7.84	1	6.54	140	0.5	0.06
SLATE CR. AT REDWOOD TAVERN	11-Jul-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SLATE CR. AT REDWOOD TAVERN	14-Jun-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SLATE CR. AT REDWOOD TAVERN	23-Aug-00	10:25:00 AM	15.8	223.0	7.86	n/a	8.7	n/a	n/a	n/a
SLATE CR. AT REDWOOD TAVERN	10-Aug-00	11:00:00 AM	18.2	207.2	7.78	1	8.94	n/a	n/a	0.02
SLATE CR. AT REDWOOD TAVERN	26-Jul-00	10:25:00 AM	16.2	199.1	8.01	1	9.04	n/a	n/a	0.02
SLATE CR. AT REDWOOD TAVERN	10-Jul-00	1:30:00 PM	16.4	193.4	8.32	1	9.34	n/a	n/a	0.03
SLATE CR. AT REDWOOD TAVERN	27-Jun-00	10:41:00 AM	16.0	224.2	7.80	1	9.4	n/a	n/a	0.03

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
SLATE CR. AT REDWOOD TAVERN	14-Jun-00	10:55:00 AM	13.8	222.3	8.02	0	9.14	n/a	n/a	0.01
SLATE CR. AT REDWOOD TAVERN	29-Sep-99	2:45:00 PM	11	273	8.35	1	10.4	120	0.55	0.01
SLATE CR. AT REDWOOD TAVERN	24-Aug-99	9:45:00 AM	16.7	262	7.72	0	8.4	174	0.43	0.03
SLATE CR. AT REDWOOD TAVERN	10-Aug-99	9:40:00 AM	17.1	253	8	1	8.04	110	0.31	0.01
SLATE CR. AT REDWOOD TAVERN	28-Jul-99	10:10:00 AM	16.4	249	7.78	1	8.7	152	0.37	0.04
SLATE CR. AT REDWOOD TAVERN	14-Jul-99	9:35:00 AM	15.15	193	8.005	1	9.07	n/a	0.57	0.01
SLATE CR. AT REDWOOD TAVERN	29-Jun-99	11:50:00 AM	15.6	181	n/a	1	9.8	90	0.43	0
SLATE CR. AT REDWOOD TAVERN	18-Jun-99	2:20:00 AM	16.5	215	7.93	2	9.38	n/a	n/a	0
SLATE CR. AT REDWOOD TAVERN	28-Sep-98	2:27:00 PM	13.8	272	8.02	0	9.14	144	0.57	0.03
SLATE CR. AT REDWOOD TAVERN	28-Aug-98	10:20:00 AM	15.6	270	7.93	0	8.56	154	n/a	n/a
SLATE CR. AT REDWOOD TAVERN	17-Aug-98	2:00:00 PM	17.2	263	8.14	0	8.74	140	n/a	n/a
SLATE CR. AT REDWOOD TAVERN	7-Aug-98	9:45:00 AM	16.7	264	n/a	0	8.30	144	0.4	0.01
SLATE CR. AT REDWOOD TAVERN	28-Jul-98	11:50:00 AM	19.3	245	8.08	0	8.14	142	n/a	n/a
SLATE CR. AT REDWOOD TAVERN	17-Jul-98	12:00:00 PM	17.4	242	8.20	0	9.02	142	0.22	0.06
SLATE CR. AT REDWOOD TAVERN	8-Jul-98	4:30:00 PM	19.6	229	8.27	1	8.24	140	0.43	0.06
SLATE CR. AT REDWOOD TAVERN	27-Jun-98	5:30:00 PM	16.4	178	8.09	1	8.44	130	0.41	0.05
SLATE CR. AT REDWOOD TAVERN	18-Jun-98	3:30:00 PM	15.7	207	8.31	1	8.66	120	n/a	n/a
SLATE CR. AT REDWOOD TAVERN	17-Sep-97	12:49:00 PM	13.7	n/a	7.67	n/a	9.4	132	n/a	n/a
SLATE CR. AT REDWOOD TAVERN	21-Aug-97	2:45:00 PM	19.5	n/a	8.05	n/a	8.8	142	n/a	n/a
SLATE CR. AT REDWOOD TAVERN	8-Aug-97	12:20:00 PM	18.1	n/a	8.03	n/a	9.0	164	n/a	n/a
SLATE CR. AT REDWOOD TAVERN	14-Jul-97	12:30:00 PM	18.6	n/a	8.2	n/a	9.3	144	n/a	n/a
SLATE CR. AT REDWOOD TAVERN	3-Jul-97	1:45:00 PM	16	n/a	7.6	n/a	9.6	145	n/a	n/a
SLATE CR. AT REDWOOD TAVERN	24-Jun-97	11:50:00 AM	13.5	n/a	8.25	n/a	9.9	133	n/a	n/a
STERLING CR. AT LITTLE APPLEGATE RD.	24-Aug-00	2:45:00 PM	19.5	404.9	8.18	1	8.38	n/a	n/a	0.05
STERLING CR. AT LITTLE APPLEGATE RD.	10-Aug-00	12:20:00 PM	19.5	405.4	8.30	2	7.02	n/a	n/a	0
STERLING CR. AT LITTLE APPLEGATE RD.	26-Jul-00	12:10:00 PM	15.2	357.3	8.22	1	8.68	n/a	n/a	0
STERLING CR. AT LITTLE APPLEGATE RD.	11-Jul-00	10:00:00 AM	15.0	354.9	8.32	1	8.68	n/a	n/a	0.01
STERLING CR. AT LITTLE APPLEGATE RD.	26-Jun-00	4:36:00 PM	19.7	464.2	8.14	4	7.8	n/a	n/a	0.02
STERLING CR. AT LITTLE APPLEGATE RD.	23-Sep-99	1:50:00 PM	18	468	8.14	1	8.27	226	0.82	0.03
STERLING CR. AT LITTLE APPLEGATE RD.	1-Sep-99	11:55:00 AM	15.3	490	8.25	4	4.84	248	0.31	0.01
STERLING CR. AT LITTLE APPLEGATE RD.	16-Aug-99	11:40:00 AM	17.6	468	8.18	1	8.71	272	0.66	n/a
STERLING CR. AT LITTLE APPLEGATE RD.	2-Aug-99	2:45:00 PM	20.5	458	8.2	1	8.44	n/a	0.82	0.01

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
STERLING CR. AT LITTLE APPLEGATE RD.	20-Jul-99	12:00:00 PM	18.8	406	8.15	2	7.38	246	0.77	0.01
STERLING CR. AT LITTLE APPLEGATE RD.	8-Jul-99	12:20:00 PM	17.5	388	8.1	1	8.92	200	0.45	0
STERLING CR. AT LITTLE APPLEGATE RD.	17-Jun-99	2:40:00 PM	18.8	435	8.16	1	8.26	n/a	0.78	0.05
STERLING CR. AT LITTLE APPLEGATE RD.	21-Sep-98	1:00:00 PM	16.4	489	8.26	1	8.22	276	1.07	0.02
STERLING CR. AT LITTLE APPLEGATE RD.	4-Sep-98	8:20:00 AM	16.1	487	8.24	1	8.08	280	0.28	0
STERLING CR. AT LITTLE APPLEGATE RD.	25-Aug-98	10:35:00 AM	16.5	471	8.39	1	8.25	270	0.29	0.03
STERLING CR. AT LITTLE APPLEGATE RD.	13-Aug-98	11:00:00 AM	18.5	428	8.30	1	8.28	236	0.62	0.05
STERLING CR. AT LITTLE APPLEGATE RD.	3-Aug-98	12:30:00 PM	20.1	458	7.02	1	7.76	228	0.45	0.05
STERLING CR. AT LITTLE APPLEGATE RD.	23-Jul-98	11:25:00 AM	18.7	453	8.53	1	8.26	256	0.66	0.08
STERLING CR. AT LITTLE APPLEGATE RD.	13-Jul-98	1:00:00 PM	18.6	390	8.47	1	7.96	260	0.62	0.07
STERLING CR. AT LITTLE APPLEGATE RD.	2-Jul-98	10:50:00 AM	14.8	350	8.34	1	9.00	240	0.4	0.07
STERLING CR. AT LITTLE APPLEGATE RD.	20-Jun-98	10:50:00 AM	13.9	332	8.58	1	9.04	252	0.32	0.02
STERLING CR. AT LITTLE APPLEGATE RD.	12-Sep-97	1:03:00 PM	17.8	n/a	7.87	n/a	7	280	n/a	n/a
STERLING CR. AT LITTLE APPLEGATE RD.	18-Aug-97	1:10:00 PM	20.8	n/a	8.29	n/a	n/a	n/a	n/a	n/a
STERLING CR. AT LITTLE APPLEGATE RD.	4-Aug-97	1:55:00 PM	23.2	n/a	8.26	n/a	7.6	319	n/a	n/a
STERLING CR. AT LITTLE APPLEGATE RD.	24-Jul-97	12:45:00 PM	22.3	n/a	8.36	n/a	7.9	280	n/a	n/a
STERLING CR. AT LITTLE APPLEGATE RD.	3-Jul-97	n/a	20	n/a	8.2	n/a	7.5	260	n/a	n/a
STERLING CR. AT LITTLE APPLEGATE RD.	24-Jun-97	n/a	17.8	n/a	8.4	n/a	6.8	220	n/a	n/a
THOMPSON CR. AT MOUTH	28-Sep-01	12:23:00 PM	16.5	171.8	7.4	2	8	n/a	0.04	0.02
THOMPSON CR. AT MOUTH	16-Aug-01	12:55:00 PM	18	180.1	7.69	1	7.94	104	0.8	0.15
THOMPSON CR. AT MOUTH	11-Jul-01	1:35:00 PM	15.9	212.9	6.99	1	8.06	n/a	0.11	3.3
THOMPSON CR. AT MOUTH	14-Jun-01	1:53:00 PM	15.4	248.9	7.35	1	9.16	n/a	n/a	n/a
THOMPSON CR. AT MOUTH	24-Aug-00	2:08:00 PM	17.6	170.5	7.59	1	8.24	n/a	n/a	0.95
THOMPSON CR. AT MOUTH	10-Aug-00	11:25:00 AM	16.5	173.8	7.74	1	8.32	n/a	n/a	0.19
THOMPSON CR. AT MOUTH	26-Jul-00	10:45:00 AM	15.3	183.1	7.20	1	8.6	n/a	n/a	0.13
THOMPSON CR. AT MOUTH	11-Jul-00	1:36:00 PM	16.2	197.8	7.62	1	8.14	n/a	n/a	0.14
THOMPSON CR. AT MOUTH	14-Jun-00	4:24:00 PM	n/a	260.0	7.58	1	8.62	n/a	n/a	n/a
THOMPSON CR. AT MOUTH	24-Sep-99	1:55:00 PM	17.1	234	7.26	2	8.04	103	0.46	0.14
THOMPSON CR. AT MOUTH	2-Sep-99	12:40:00 PM	16.1	258	7.395	2	6.67	156	0.31	0.01
THOMPSON CR. AT MOUTH	17-Aug-99	1:40:00 PM	17.2	256	7.56	2	7.93	150	0.49	n/a
THOMPSON CR. AT MOUTH	4-Aug-99	2:00:00 PM	16.9	240	7.21	0	7.42	130	0.74	0.03
THOMPSON CR. AT MOUTH	22-Jul-99	12:30:00 PM	16	209	7.21	2	7.72	80	0.5	0.18

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
THOMPSON CR. AT MOUTH	9-Jul-99	1:23:00 PM	15.8	208	6.86	0	8.12	120	0.53	0.17
THOMPSON CR. AT MOUTH	21-Jun-99	8:55:00 AM	14.05	284	7.28	1	8.66	148	0.69	0.17
THOMPSON CR. AT TALLOWBOX CR.	24-Aug-00	1:11:00 PM	17.4	225.6	7.96	1	8.74	n/a	n/a	n/a
THOMPSON CR. AT TALLOWBOX CR.	10-Aug-00	11:10:00 AM	17.3	228.0	8.02	1	8.68	n/a	n/a	0.04
THOMPSON CR. AT TALLOWBOX CR.	27-Jul-00	9:00:00 AM	14.7	225.0	7.54	0	8.72	n/a	n/a	0.05
THOMPSON CR. AT TALLOWBOX CR.	26-Jul-00	10:23:00 AM	15.2	207.5	7.80	1	8.56	n/a	n/a	0.05
THOMPSON CR. AT TALLOWBOX CR.	11-Jul-00	1:20:00 PM	15.8	209.4	7.76	1	8.68	n/a	n/a	0.08
THOMPSON CR. AT TALLOWBOX CR.	10-Jul-00	4:15:00 PM	16.2	252.8	7.59	1	8.68	n/a	n/a	0.15
THOMPSON CR. AT TALLOWBOX CR.	14-Jun-00	1:20:00 PM	16.3	212.0	7.59	1	9.35	n/a	n/a	n/a
THOMPSON CR. AT TALLOWBOX CR.	24-Sep-99	1:28:00 PM	15.9	297	7.94	2	8.64	147	0.86	0.06
THOMPSON CR. AT TALLOWBOX CR.	2-Sep-99	1:10:00 PM	14.5	292	8.05	1	9.38	168	0.52	0
THOMPSON CR. AT TALLOWBOX CR.	17-Aug-99	1:20:00 PM	17.2	286	8.02	1	8.28	152	0.68	n/a
THOMPSON CR. AT TALLOWBOX CR.	4-Aug-99	1:30:00 PM	18	290	7.84	1	8.19	160	0.65	0.04
THOMPSON CR. AT TALLOWBOX CR.	22-Jul-99	1:10:00 PM	16.8	246	7.95	1	8.94	152	0.52	0.02
THOMPSON CR. AT TALLOWBOX CR.	9-Jul-99	1:55:00 PM	17	251	7.84	1	8.7	172	0.41	0.06
THOMPSON CR. AT TALLOWBOX CR.	21-Jun-99	10:10:00 AM	13.5	248	7.74	1	9.4	136	0.72	0.03
THOMPSON CR. AT TALLOWBOX CR.	24-Sep-98	3:32:00 PM	15.2	170	8.07	n/a	8.86	8.86	0.34	0.06
THOMPSON CR. AT TALLOWBOX CR.	31-Aug-98	10:12:00 AM	15.6	156	7.74	n/a	8.32	8.32	n/a	0.09
THOMPSON CR. AT TALLOWBOX CR.	21-Aug-98	12:00:00 PM	16.0	132	7.78	n/a	8.46	8.46	0.43	n/a
THOMPSON CR. AT TALLOWBOX CR.	11-Aug-98	9:30:00 AM	15.8	156	7.80	n/a	8.32	8.32	n/a	n/a
THOMPSON CR. AT TALLOWBOX CR.	30-Jul-98	9:42:00 AM	16.2	164	8.01	n/a	8.74	8.74	0.37	0.08
THOMPSON CR. AT TALLOWBOX CR.	20-Jul-98	2:28:00 PM	18.2	160	7.98	n/a	7.94	7.94	0.27	0.16
THOMPSON CR. AT TALLOWBOX CR.	9-Jul-98	9:18:00 AM	15.2	168	8.07	n/a	9.10	9.10	0.56	0.12
THOMPSON CR. AT TALLOWBOX CR.	26-Jun-98	2:45:00 PM	14.3	144	8.18	n/a	9.90	9.90	0.5	0.09
UPPER MUNGER CR.	24-Sep-99	11:54:00 AM	12.75	82	7.56	3	9.18	52	0.04	0
UPPER MUNGER CR.	17-Aug-99	10:45:00 AM	12.8	87	7.23	1	9.52	56	0.42	n/a
UPPER MUNGER CR.	22-Jul-99	11:40:00 AM	12.5	60	7.17	1	9	60	0.5	0.01
UPPER MUNGER CR.	21-Jun-99	2:40:00 PM	11.5	72	7.02	1	9.82	48	0.31	0.01
WEST FORK WILLIAMS CR. AT CAVES CAMP RD.	22-Aug-00	11:00:00 AM	13.6	106.0	8.10	n/a	9.56	n/a	n/a	0.05
WEST FORK WILLIAMS CR. AT CAVES CAMP RD.	9-Aug-00	3:00:00 PM	17.6	101.8	7.55	1	8.3	n/a	n/a	0.04
WEST FORK WILLIAMS CR. AT CAVES CAMP RD.	25-Jul-00	2:30:00 PM	16.3	106.9	8.00	1	8.5	n/a	n/a	0.06
WEST FORK WILLIAMS CR. AT CAVES CAMP RD.	10-Jul-00	8:15:00 AM	12.7	100.8	8.27	1	9.12	n/a	n/a	0.05

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
WEST FORK WILLIAMS CR. AT CAVES CAMP RD.	27-Jun-00	3:50:00 PM	16.7	98.8	8.05	1	9.35	n/a	n/a	n/a
WEST FORK WILLIAMS CR. AT CAVES CAMP RD.	16-Jun-00	11:30:00 AM	12.2	114.0	2.00	2	10.2	n/a	n/a	n/a
WEST FORK WILLIAMS CR. AT CAVES CAMP RD.	24-Sep-99	11:07:00 AM	13.5	147	7.82	3	8.68	94	0.8	0
WEST FORK WILLIAMS CR. AT CAVES CAMP RD.	2-Sep-99	10:40:00 AM	11.8	146	7.16	2	9.6	88	0.35	0.01
WEST FORK WILLIAMS CR. AT CAVES CAMP RD.	17-Aug-99	11:15:00 AM	14.5	138	7.46	1	8.86	84	0.45	n/a
WEST FORK WILLIAMS CR. AT CAVES CAMP RD.	4-Aug-99	10:22:00 AM	14.9	131	7.52	1	8.74	80	0.38	0.03
WEST FORK WILLIAMS CR. AT CAVES CAMP RD.	22-Jul-99	11:15:00 AM	14.1	96	7.29	1	6.4	80	0.49	0.02
WEST FORK WILLIAMS CR. AT CAVES CAMP RD.	9-Jul-99	12:30:00 PM	13.5	92	7.4	1	9.16	84	0.74	0.02
WEST FORK WILLIAMS CR. AT CAVES CAMP RD.	21-Jun-99	3:00:00 PM	13.6	103	7.19	1	9.4	52	0.24	0.01
WEST FORK WILLIAMS CR. AT MOUTH	28-Sep-01	5:27:00 PM	16.4	123.5	7.47	2	8.24	n/a	1.29	0.04
WEST FORK WILLIAMS CR. AT MOUTH	16-Aug-01	11:36:00 AM	18.4	131.4	8	2	8.2	78	0.1	0.01
WEST FORK WILLIAMS CR. AT MOUTH	11-Jul-01	1:01:00 PM	17.4	142.4	7.4	3	8.4	n/a	0.09	0.07
WEST FORK WILLIAMS CR. AT MOUTH	14-Jun-01	12:41:00 PM	16.8	144.2	7.85	1	9.8	100	0.16	0.08
WEST FORK WILLIAMS CR. AT MOUTH	22-Aug-00	1:25:00 PM	17.4	95.0	8.07	n/a	9.14	n/a	n/a	n/a
WEST FORK WILLIAMS CR. AT MOUTH	9-Aug-00	12:00:00 PM	18.7	100.5	7.79	1	8.06	n/a	n/a	0.03
WEST FORK WILLIAMS CR. AT MOUTH	25-Jul-00	1:00:00 PM	18.2	111.2	8.06	0	8.4	n/a	n/a	0.03
WEST FORK WILLIAMS CR. AT MOUTH	10-Jul-00	9:15:00 AM	13.9	105.3	8.01	2	9.14	n/a	n/a	0.03
WEST FORK WILLIAMS CR. AT MOUTH	27-Jun-00	2:40:00 PM	19.6	104.5	7.67	1	9.11	n/a	n/a	0.01
WEST FORK WILLIAMS CR. AT MOUTH	15-Jun-00	9:25:00 AM	13.9	122.1	7.93	1	9.8	n/a	n/a	n/a
WEST FORK WILLIAMS CR. AT MOUTH	24-Sep-99	10:45:00 AM	15.2	144	7.33	3	8.24	76	0.78	0.05
WEST FORK WILLIAMS CR. AT MOUTH	2-Sep-99	11:20:00 AM	15.1	138	6.95	4	8.82	92	0.47	0.09
WEST FORK WILLIAMS CR. AT MOUTH	17-Aug-99	12:35:00 PM	16.8	137	7.44	1	8.02	84	0.58	n/a
WEST FORK WILLIAMS CR. AT MOUTH	4-Aug-99	11:10:00 AM	17.8	133	7.13	1	7.76	84	0.68	0.02
WEST FORK WILLIAMS CR. AT MOUTH	22-Jul-99	10:05:00 AM	15.6	102	6.76	1	7.62	92	0.37	0.02
WEST FORK WILLIAMS CR. AT MOUTH	9-Jul-99	9:36:00 AM	14.1	94	7.06	1	9.78	55	0.47	0.03
WEST FORK WILLIAMS CR. AT MOUTH	21-Jun-99	1:10:00 PM	14.4	105	7.67	1	8.58	72	0.53	0.01
WEST FORK WILLIAMS CR. AT MOUTH	24-Sep-98	3:32:00 PM	15.2	258	8.07	0	8.86	170	0.39	n/a
WEST FORK WILLIAMS CR. AT MOUTH	31-Aug-98	10:12:00 AM	15.6	327	7.74	1	8.32	156		n/a
WEST FORK WILLIAMS CR. AT MOUTH	21-Aug-98	12:00:00 PM	16.0	282	7.78	1	8.46	132	0.4	0.06
WEST FORK WILLIAMS CR. AT MOUTH	11-Aug-98	9:30:00 AM	15.8	325	7.80	1	8.32	156		n/a
WEST FORK WILLIAMS CR. AT MOUTH	30-Jul-98	9:42:00 AM	16.2	322	8.01	1	8.74	164	0.2	0.04
WEST FORK WILLIAMS CR. AT MOUTH	20-Jul-98	2:28:00 PM	18.2	320	7.98	0	7.94	160	0.18	0.07

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
WEST FORK WILLIAMS CR. AT MOUTH	9-Jul-98	9:18:00 AM	15.2	4	8.07	1	9.10	168	0.23	0.04
WEST FORK WILLIAMS CR. AT MOUTH	26-Jun-98	2:45:00 PM	14.3	297	8.18	1	9.90	144	0.41	0.04
WEST FORK WILLIAMS CR. AT MOUTH	17-Jun-98	11:50:00 AM	14.9	116	7.78	1	9.00	90	n/a	n/a
WEST FORK WILLIAMS CR. AT MOUTH	15-Sep-97	1:30:00 PM	14.8	n/a	7.57	n/a	9.00	70	n/a	n/a
WEST FORK WILLIAMS CR. AT MOUTH	26-Aug-97	3:45:00 PM	16.7	n/a	7.81	n/a	9.10	84	n/a	n/a
WEST FORK WILLIAMS CR. AT MOUTH	14-Aug-97	1:40:00 PM	22	n/a	7.89	n/a	9.00	n/a	n/a	n/a
WEST FORK WILLIAMS CR. AT MOUTH	1-Aug-97	2:10:00 AM	19.8	n/a	8.15	n/a	9.10	78	n/a	n/a
WEST FORK WILLIAMS CR. AT MOUTH	24-Jul-97	5:00:00 PM	21.1	n/a	7.63	n/a	8.10	84	n/a	n/a
WEST FORK WILLIAMS CR. AT MOUTH	3-Jul-97	2:30:00 PM	19.4	n/a	7.90	n/a	8.90	82	n/a	n/a
WEST FORK WILLIAMS CR. AT MOUTH	18-Jun-97	1:30:00 AM	17	n/a	7.52	n/a	8.60	85	n/a	n/a
WILLIAMS CR. AT POWELL CR.	24-Sep-99	9:37:00 AM	15.2	177	7.05	2	7.34	110	0.68	0.07
WILLIAMS CR. AT POWELL CR.	2-Sep-99	9:20:00 AM	14.3	167	7.01	2	5.66	120	0.29	0.02
WILLIAMS CR. AT POWELL CR.	17-Aug-99	9:32:00 AM	16.1	160	7.08	1	7.88	80	0.31	n/a
WILLIAMS CR. AT POWELL CR.	4-Aug-99	12:15:00 PM	18.45	178	6.7	2	7.58	87.5	0.86	0.13
WILLIAMS CR. AT POWELL CR.	22-Jul-99	8:56:00 AM	15.9	124	6.61	1	8.39	91	0.41	0.1
WILLIAMS CR. AT POWELL CR.	9-Jul-99	11:00:00 AM	15.5	109	6.98	1	9.23	76	1.1	0.06
WILLIAMS CR. AT POWELL CR.	21-Jun-99	11:35:00 AM	15	117	7.08	1	9	66	0.31	0.04
WILLIAMS CR. AT POWELL CR.	15-Sep-97	10:40:00 AM	15.6	n/a	8.04	n/a	9.00	80	n/a	n/a
WILLIAMS CR. AT POWELL CR.	28-Aug-97	9:53:00 AM	16.9	n/a	7.58	n/a	9.20	108	n/a	n/a
WILLIAMS CR. AT POWELL CR.	14-Aug-97	12:00:00 PM	22.3	n/a	7.85	n/a	10.00	98	n/a	n/a
WILLIAMS CR. AT POWELL CR.	1-Aug-97	11:14:00 AM	18.1	n/a	7.75	n/a	9.20	98	n/a	n/a
WILLIAMS CR. AT POWELL CR.	24-Jul-97	1:00:00 PM	20.2	n/a	7.71	n/a	8.25	99	n/a	n/a
WILLIAMS CR. AT POWELL CR.	14-Jul-97	12:30:00 PM	18.1	n/a	7.00	n/a	9.00	98	n/a	n/a
WILLIAMS CR. AT POWELL CR.	3-Jul-97	4:30:00 PM	24	n/a	7.70	n/a	9.00	92	n/a	n/a
WILLIAMS CR. AT POWELL CR.	18-Jun-97	10:30:00 AM	17.5	n/a	7.89	n/a	9.40	86	n/a	n/a
WILLIAMS CR. AT RT. 238 BRIDGE	28-Sep-01	3:56:00 PM	18.4	151.9	7.77	2	7.52	n/a	0.1	0.02
WILLIAMS CR. AT RT. 238 BRIDGE	16-Aug-01	10:44:00 AM	20.4	162.2	7.87	2	6.3	86	0.4	0.07
WILLIAMS CR. AT RT. 238 BRIDGE	11-Jul-01	11:16:00 AM	20.5	176.8	6.74	2	7.36	n/a	0.05	0.07
WILLIAMS CR. AT RT. 238 BRIDGE	14-Jun-01	11:13:00 AM	18.1	175.3	7.27	2	9.28	115	0.19	0.05
WILLIAMS CR. AT RT. 238 BRIDGE	22-Aug-00	2:41:00 PM	20.7	99.0	6.96	n/a	9.72	n/a	n/a	n/a
WILLIAMS CR. AT RT. 238 BRIDGE	9-Aug-00	11:15:00 AM	19.7	128.5	7.09	1	6.74	n/a	n/a	0.05
WILLIAMS CR. AT RT. 238 BRIDGE	25-Jul-00	3:00:00 PM	22.0	129.2	7.47	1	8.8	n/a	n/a	0.04

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
WILLIAMS CR. AT RT. 238 BRIDGE	10-Jul-00	11:05:00 AM	18.6	137.2	7.61	1	9.04	n/a	n/a	0.02
WILLIAMS CR. AT RT. 238 BRIDGE	27-Jun-00	1:50:00 PM	21.3	141.0	7.67	2	9.46	n/a	n/a	0.02
WILLIAMS CR. AT RT. 238 BRIDGE	24-Sep-99	12:55:00 PM	18.6	150	7.15	3	6.66	88	0.93	0.06
WILLIAMS CR. AT RT. 238 BRIDGE	2-Sep-99	9:15:00 AM	16.6	148	7.01	1	7.58	96	0.25	0.03
WILLIAMS CR. AT RT. 238 BRIDGE	17-Aug-99	9:15:00 AM	17.9	155	6.705	1	7.84	90	0.36	n/a
WILLIAMS CR. AT RT. 238 BRIDGE	4-Aug-99	12:48:00 PM	20.7	147	6.96	1	7.04	80	0.51	0.05
WILLIAMS CR. AT RT. 238 BRIDGE	22-Jul-99	8:30:00 AM	17.5	125	6.33	2	5.6	84	0.52	0.08
WILLIAMS CR. AT RT. 238 BRIDGE	9-Jul-99	1:00:00 AM	19.5	122	6.71	1	9.88	76	0.58	0.06
WILLIAMS CR. AT RT. 238 BRIDGE	21-Jun-99	11:00:00 AM	15.9	122	7.02	1	8.52	80	0.43	0.07
WILLIAMS CR. AT RT. 238 BRIDGE	24-Sep-98	9:14:00 AM	14.8	74	7.30	1	7.60	100	0.26	n/a
WILLIAMS CR. AT RT. 238 BRIDGE	31-Aug-98	10:59:00 AM	18.9	168	7.21	1	8.72	82	n/a	n/a
WILLIAMS CR. AT RT. 238 BRIDGE	21-Aug-98	1:00:00 PM	18.1	169	7.27	1	8.90	88	0.33	n/a
WILLIAMS CR. AT RT. 238 BRIDGE	11-Aug-98	10:15:00 AM	19.6	166	7.25	1	8.12	88	n/a	0.02
WILLIAMS CR. AT RT. 238 BRIDGE	30-Jul-98	10:22:00 AM	19.6	177	7.61	0	7.82	68	0.31	0.07
WILLIAMS CR. AT RT. 238 BRIDGE	20-Jul-98	1:55:00 PM	21.1	165	7.49	1	8.20	110	0.48	0.1
WILLIAMS CR. AT RT. 238 BRIDGE	9-Jul-98	9:59:00 AM	18.3	154	7.40	1	8.00	80	0.27	0.06
WILLIAMS CR. AT RT. 238 BRIDGE	26-Jun-98	9:15:00 AM	13.8	134	7.73	1	7.72	100	0.25	0.05
WILLIAMS CR. AT RT. 238 BRIDGE	17-Jun-98	1:00:00 PM	16.0	125	7.83	1	8.86	76	0.29	0.01
WILLIAMS CR. AT RT. 238 BRIDGE	15-Sep-97	10:20:00 AM	15	n/a	7.81	n/a	8.2	80	n/a	n/a
WILLIAMS CR. AT RT. 238 BRIDGE	28-Aug-97	9:30:00 AM	17.5	n/a	7.05	n/a	7.7	104	n/a	n/a
WILLIAMS CR. AT RT. 238 BRIDGE	14-Aug-97	11:45:00 AM	22.4	n/a	7.49	n/a	10.5	n/a	n/a	n/a
WILLIAMS CR. AT RT. 238 BRIDGE	1-Aug-97	10:23:00 AM	19.3	n/a	7.73	n/a	8.3	105	n/a	n/a
WILLIAMS CR. AT RT. 238 BRIDGE	18-Jun-97	9:30:00 AM	16.5	n/a	7.79	n/a	8.89	99	n/a	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	28-Sep-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	16-Aug-01	11:15:00 AM	19.9	143.7	7.92	1	5.94	76	0.4	0.04
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	11-Jul-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	14-Jun-01	1:25:00 PM	18.3	144.5	7.28	2	7.68	100	0.19	0.07
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	22-Aug-00	2:00:00 PM	19.5	109.0	7.44	n/a	8.18	n/a	n/a	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	9-Aug-00	10:30:00 AM	19.3	111.9	7.49	1	7.4	n/a	n/a	0.02
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	25-Jul-00	3:30:00 PM	20.6	109.6	7.35	0	6.8	n/a	n/a	0.04
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	10-Jul-00	10:45:00 AM	15.6	111.6	7.72	2	9.22	n/a	n/a	0.03
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	27-Jun-00	2:26:00 PM	20.2	111.8	7.39	1	9.14	n/a	n/a	0.03

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	19-Jun-00	1:25:00 PM	17.1	128.0	7.53	n/a	8.74	n/a	n/a	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	16-Jun-00	12:45:00 PM	15.7	126.0	7.43	1	8.04	n/a	n/a	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	24-Sep-99	10:05:00 AM	15.4	153	7.36	3	7.74	100	0.38	0.07
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	2-Sep-99	10:00:00 AM	14.6	146	6.55	3	8.44	100	0.35	0
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	17-Aug-99	9:48:00 AM	16.4	142	6.87	1	n/a	88	0.58	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	4-Aug-99	11:42:00 AM	18.7	138	6.9	1	7.68	70	0.54	0.01
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	22-Jul-99	9:30:00 AM	16	106	6.47	1	7.72	84	0.72	0.02
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	9-Jul-99	10:25:00 AM	14.8	95	6.8	1	8.8	56	0.47	0.03
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	21-Jun-99	12:25:00 PM	14.3	103	7.125	1	8.56	70	0.49	0.02
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	24-Sep-98	11:05:00 AM	14.9	121	7.56	0	6.56	95	0.31	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	31-Aug-98	11:40:00 AM	18.6	150	7.69	1	8.98	82	n/a	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	21-Aug-98	2:10:00 PM	20.0	148	7.66	0	8.44	76	0.47	0.05
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	11-Aug-98	11:00:00 AM	18.3	145	7.62	1	8.84	72	n/a	0.01
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	30-Jul-98	1:30:00 PM	20.3	144	7.90	1	8.66	76	0.29	0.05
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	20-Jul-98	12:12:00 PM	18.3	138	7.62	1	8.26	84	0.3	0.08
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	9-Jul-98	10:54:00 AM	16.4	108	7.77	1	8.70	70	0.27	0.06
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	26-Jun-98	11:00:00 AM	12.7	119	7.50	1	8.86	84	0.5	0.06
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	17-Jun-98	3:00:00 PM	15.3	111	7.49	1	8.60	55	0.49	0.02
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	15-Sep-97	11:08:00 AM	15.9	n/a	7.55	n/a	8.60	80	n/a	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	26-Aug-97	4:10:00 PM	17.5	n/a	7.33	n/a	8.70	84	n/a	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	14-Aug-97	12:30:00 PM	19.7	n/a	7.02	n/a	9.00	n/a	n/a	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	1-Aug-97	12:02:00 PM	19.6	n/a	7.67	n/a	8.90	85	n/a	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	24-Jul-97	6:00:00 PM	21.6	n/a	7.11	n/a	7.20	97	n/a	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	3-Jul-97	3:30:00 PM	20.9	n/a	7.80	n/a	8.30	81	n/a	n/a
WILLIAMS CR. AT WILLIAMS HWY. BRIDGE	18-Jun-97	12:04:00 PM	16.1	n/a	7.76	n/a	8.70	88	n/a	n/a
ALE CR. AT MOUTH	28-Sep-01	10:34:00 AM	13.4	200.4	7.93	1	8.24	n/a	n/a	0.07
ALE CR. AT MOUTH	16-Aug-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ALE CR. AT MOUTH	11-Jul-01	2:48:00 PM	16.4	243.4	7.48	3	8.46	n/a	0.11	0.06
ALE CR. AT MOUTH	14-Jun-01	3:45:00 PM	14.4	208.0	8.03	2	8.76	110	0.18	0.06
ALE CR. AT MOUTH	6-Sep-00	12:14:00 PM	12.2	231.0	7.99	2	10.2	n/a	n/a	n/a
ALE CR. AT MOUTH	10-Aug-00	9:10:00 AM	14.9	220.7	8.32	2	8.12	n/a	n/a	0.08
ALE CR. AT MOUTH	26-Jul-00	1:06:00 PM	16.7	230.3	8.17	4	8.8	n/a	n/a	0.08

Site	Date	Time	T; C	Cond	pH	Turb	D.O.	CaCO3	PO4	NO3
YALE CR. AT MOUTH	11-Jul-00	10:30:00 AM	12.9	182.0	8.39	2	9.76	n/a	n/a	0.03
YALE CR. AT MOUTH	26-Jun-00	2:36:00 PM	16.0	214.0	8.36	2	8.84	n/a	n/a	0.03
YALE CR. AT MOUTH	22-Jun-00	11:55:00 AM	13.6	208.0	8.08	2	7.44	n/a	n/a	0.07
YALE CR. AT MOUTH	23-Sep-99	12:35:00 PM	14.4	334	8.23	1	8.88	174	0.76	0.03
YALE CR. AT MOUTH	1-Sep-99	10:55:00 AM	11	314	8.26	3	6.22	172	0.32	0.01
YALE CR. AT MOUTH	16-Aug-99	11:00:00 AM	13.4	292	8.07	1	9.63	176	0.53	n/a
YALE CR. AT MOUTH	2-Aug-99	1:53:00 PM	15.7	270	7.95	4	9.94	132	0.39	0.05
YALE CR. AT MOUTH	20-Jul-99	10:50:00 AM	13.8	198	8.08	2	8.82	148	0.91	0.05
YALE CR. AT MOUTH	8-Jul-99	11:00:00 AM	11.2	176	7.8	3	10	n/a	0.39	0.01
YALE CR. AT MOUTH	17-Jun-99	1:35:00 PM	13.5	167	8.02	3	9.72	n/a	0.21	0.04
YALE CR. AT MOUTH	21-Sep-98	2:40:00 PM	12.3	258	8.39	3	9.44	195	0.58	0.04
YALE CR. AT MOUTH	4-Sep-98	9:40:00 AM	14.8	329	8.25	1	8.00	192	0.4	0.03
YALE CR. AT MOUTH	25-Aug-98	9:40:00 AM	12.6	123	8.28	2	9.50	176	0.29	0.08
YALE CR. AT MOUTH	13-Aug-98	9:40:00 AM	15.1	292	8.18	2	9.52	176	0.79	0.05
YALE CR. AT MOUTH	3-Aug-98	11:10:00 AM	15.3	278	8.28	1	8.94	160	0.26	0.06
YALE CR. AT MOUTH	23-Jul-98	12:15:00 PM	16.7	256	8.47	2	8.14	144	1.02	0.09
YALE CR. AT MOUTH	13-Jul-98	11:45:00 AM	13.2	173	8.30	2	9.10	132	0.29	0.08
YALE CR. AT MOUTH	2-Jul-98	11:37:00 AM	11.8	148	8.26	2	9.84	110	0.22	0.05
YALE CR. AT MOUTH	20-Jun-98	8:30:00 AM	8.8	175	8.25	6	10.16	118	0.2	0.02
YALE CR. AT MOUTH	12-Sep-97	1:40:00 PM	14.9	n/a	7.91	n/a	9.0	190	n/a	n/a
YALE CR. AT MOUTH	28-Aug-97	12:35:00 PM	15.1	n/a	8.12	n/a	8.9	200	n/a	n/a
YALE CR. AT MOUTH	18-Aug-97	1:40:00 PM	17.4	n/a	8.44	n/a	n/a	200	n/a	n/a
YALE CR. AT MOUTH	4-Aug-97	2:20:00 PM	19.4	n/a	8.42	n/a	8.5	198	n/a	n/a
YALE CR. AT MOUTH	24-Jul-97	1:15:00 PM	16.2	n/a	8.4	n/a	9.3	199	n/a	n/a
YALE CR. AT MOUTH	14-Jul-97	1:05:00 PM	15.6	n/a	8.56	n/a	9.0	n/a	n/a	n/a
YALE CR. AT MOUTH	3-Jul-97	1:50:00 PM	14.3	n/a	8.21	n/a	9.0	158	n/a	n/a
YALE CR. AT MOUTH	24-Jun-97	1:50:00 PM	12.5	n/a	8.44	n/a	7.4	150	n/a	n/a
YALE CR. AT MOUTH	18-Jun-97	11:00:00 AM	15	n/a	8.1	n/a	9.4	120	n/a	n/a

ODFW Fish Presence Surveys

Stream	Tributary to	ChF Miles	ChF Use	Co Miles	Co Use	StS Miles	StS Use	StW Miles	StW Use	Trout Miles	Trout Use	Comments
Squaw Creek	Applegate Lake	0		0		0		0		8	s,m,r	
Elliot Creek	Applegate Lake	0		0		0		0		14	s,m,r	
Mule Creek	Applegate River	0		0		0.3	s,m,r	0		2.5	s,m,r	St seen up to RM 0.3 (P&B survey 1970)
Slagle Creek	Applegate River	0		0		1.2	s,m,r	0		1.2	s,m,r	ODFW survey 1998; fish found up to 20 yds below
Star Gulch	Applegate River	0		0		4	s,m,r	0		6.5	s,m,r	St and CT use verified to RM 4 (BLM survey 1976),
Slate Creek	Applegate River	8.1	s,m	11	s,m,r	12.9	s,m,r	12.9	s,m,r	13.3	s,m,r	coho use confirmed (USFS 1997)
Onion Creek	Applegate River	0		0		0.8	s,m,r	0				ODFW survey 1998; Pond at mouth of stream
Jackson Creek	Applegate River	0		1	s,m,r	1.5	s,m,r	0		1.5	s,m,r	CT, St confirmed use confirmed (ODFW 1997); coho
Chapman Creek	Applegate River	0		0		0		0		2.4	s,m,r	CT; BLM survey 1980 and 1997
Oscar Creek	Applegate River	0		0		0.1	s,m,r	0				ODFW survey 1998
Palmer Creek	Applegate River	0		1.5	s,m,r	3.7	s,m,r	0		7	s,m,r	*St verified up to RM 1.75; assumed up to RM 3 (P&B
Iron Creek	Applegate River	0		0.6	s,m,r	0.25	s,m,r	0.25	s,m,r			Coho presence determined by BLM; St use confirmed
Williams Creek	Applegate River	7.1	s,m	7.1	s,m,r	7.1	s,m,r	7.1	s,m,r	7.1	s,m,r	St use verified (P&B survey 1965), Co use verified
Murphy Creek	Applegate River	2	s,m	4.5	s,m,r	4.5	s,m,r	0		6.5	s,m,r	Co, St, CT confirmed to RM 0.25, St confirmed to RM 3
Thompson Creek	Applegate River	1	s,m	8.6	s,m,r	8.6	s,m,r	8.6	s,m,r	10.5	s,m,r	St use verified (P&B survey 1969); CO use confirmed
Board Shanty Creek	Applegate River	0		0		1.4	s,m,r	0		2	s,m,r*	*StS found up to RM 1.4 in 1998 (ODFW); no fish found
Grays Creek	Applegate River	0		0.6	s,m,r	3	s,m,r	0		3	s,m,r	coho presence determined by BLM; St, CT confirmed to
Butte Fork Applegate River	Applegate River	0		0		0		0		8	s,m,r	
Cheney Creek	Applegate River	1.5	s,m	3.5	s,m,r	5	s,m,r	5	s,m,r	5	s,m,r	Co confirmed to RM 3.5 (ODFW 1998);
Caris Creek	Applegate River	0		0		2.8	s,m,r*	0		3	s,m,r*	StS and CT found only up to RM 2.5 in 1998 (ODFW
Beaver Creek	Applegate River	0		1.2	s,m,r	5	s,m,r	0		6.8	s,m,r	trout use confirmed (Medite 1995); St confirmed to RM
Bull Creek	Applegate River	0		0		0		0		2	s,m,r	CT use confirmed (BLM 1988)
Little Applegate River	Applegate River	5	s,m	6	s,m,r	6	m,r	19	s,m,r*	19	s,m,r	Steelhead fry observed at RM 12.25; suitable habitat to
Humbug Creek	Applegate River	0		0		1.3	s,m,r*	0		2.5	s,m,r	St redds seen to RM 0.5; habitat suitable to RM 1.3
Miller Creek	Applegate River	0		0		0.8	s,m,r	0		2	s,m,r*	*Trout and steelhead only found up to RM 0.8 in 1998
Middle Fork Applegate River	Applegate River	0		0		0		0		6	s,m,r	
Carberry Creek	Applegate River (Lake)	0		0		0		0		6.3	s,m,r	P&B survey 1970
Petes Camp Creek	Beaver Creek	0		0		0		0		1	s,m,r	Visual survey 1995 (Medite)
Bear Wallow Creek	Bill Creek	0		0		0.2	s,m,r	0		0.2	s,m,r	St, CT use confirmed (ODFW fish presence survey,
Knight Creek	Butcherknife Creek	0		0.5	s,m,r	0		0				Coho presence determined by BLM
Steve's Fork Carberry Creek	Carberry Creek	0		0		0		0		11.1	s,m,r	
Sturgis Fork Carberry Creek	Carberry Creek	0		0		0		0		8.5	s,m,r	
Cougar Creek	Carberry Creek	0		0		0		0		1.5	s,m,r	
Brush Creek	Carberry Creek	0		0		0		0		4	s,m,r	
Rocky Creek	Caris Creek	0		0		0		0		0.1	s,m,r	CT; ODFW survey 1998
Miners Creek	Caris Creek	0		0		0.1	s,m,r	0		0.1	s,m,r	ODFW survey 1998
Little Cheney Creek	Cheney Creek	0		0.8	s,m,r	0.8	s,m,r	0		0.8	s,m,r	Co and St use determined by BLM; trout use assumed.
Sugarloaf Gulch	Clapboard Gulch	0		0		0		0		0.75	s,m,r	CT; ODFW survey 1995
Rock Creek	East Fork Williams Creek	0		0		1	s,m,r	0		1.5	s,m,r	
Clapboard Gulch	East Fork Williams Creek	0		0		0		0		0.8	s,m,r	CT; ODFW survey 1995
Dutch Creek	Elliot Creek	0		0		0		0		2	s,m,r	
Silver Fork	Elliot Creek	0		0		0		0		1.75	s,m,r	
Poormans Creek	Forest Creek	0		0		0		0		1	s,m,r	
Trib GL - A	Glade Creek	0		0		0		0		0.1	s,m,r	T40S, R1W, Sec. 6; CT - ODFW survey 1996
Hendricks Creek	Glade Creek	0		0		0		0		0.1	s,m,r	CT; ODFW survey 1996
Garvin Gulch	Glade Creek	0		0		0		0		0.9	s,m,r	CT use confirmed (ODFW survey 1996)
Trib GL-C	Glade Creek	0		0		0		0		0.1	s,m,r	T40S, R1W, Sec. 18; CT - ODFW survey 1996
Wrangle Creek	Glade Creek	0		0		0		0		0.1	s,m,r	CT - ODFW survey 1996
Trib A	Little Applegate River	0		0		0		0		0.6	s,m,r	visual survey 1995 (Medite)

Appendix A.4

ODFW reach habitat summaries

ODFW Fish Presence Surveys

Stream	Tributary to	ChF Miles	ChF Use	Co Miles	Co Use	StS Miles	StS Use	StW Miles	StW Use	Trout Miles	Trout Use	Comments
Squaw Creek	Applegate Lake	0		0		0		0		8	s,m,r	
Elliot Creek	Applegate Lake	0		0		0		0		14	s,m,r	
Mule Creek	Applegate River	0		0		0.3	s,m,r	0		2.5	s,m,r	St seen up to RM 0.3 (P&B survey 1970)
Slagle Creek	Applegate River	0		0		1.2	s,m,r	0		1.2	s,m,r	ODFW survey 1998; fish found up to 20 yds below
Star Gulch	Applegate River	0		0		4	s,m,r	0		6.5	s,m,r	St and CT use verified to RM 4 (BLM survey 1976),
Slate Creek	Applegate River	8.1	s,m	11	s,m,r	12.9	s,m,r	12.9	s,m,r	13.3	s,m,r	coho use confirmed (USFS 1997)
Onion Creek	Applegate River	0		0		0.8	s,m,r	0				ODFW survey 1998; Pond at mouth of stream
Jackson Creek	Applegate River	0		1	s,m,r	1.5	s,m,r	0		1.5	s,m,r	CT, St confirmed use confirmed (ODFW 1997); coho
Chapman Creek	Applegate River	0		0		0		0		2.4	s,m,r	CT; BLM survey 1980 and 1997
Oscar Creek	Applegate River	0		0		0.1	s,m,r	0				ODFW survey 1998
Palmer Creek	Applegate River	0		1.5	s,m,r	3.7	s,m,r	0		7	s,m,r	*St verified up to RM 1.75; assumed up to RM 3 (P&B
Iron Creek	Applegate River	0		0.6	s,m,r	0.25	s,m,r	0.25	s,m,r			Coho presence determined by BLM; St use confirmed
Williams Creek	Applegate River	7.1	s,m	7.1	s,m,r	7.1	s,m,r	7.1	s,m,r	7.1	s,m,r	St use verified (P&B survey 1965), Co use verified
Murphy Creek	Applegate River	2	s,m	4.5	s,m,r	4.5	s,m,r	0		6.5	s,m,r	Co, St, CT confirmed to RM 0.25, St confirmed to RM 3
Thompson Creek	Applegate River	1	s,m	8.6	s,m,r	8.6	s,m,r	8.6	s,m,r	10.5	s,m,r	St use verified (P&B survey 1969); CO use confirmed
Board Shanty Creek	Applegate River	0		0		1.4	s,m,r	0		2	s,m,r*	*StS found up to RM 1.4 in 1998 (ODFW); no fish found
Grays Creek	Applegate River	0		0.6	s,m,r	3	s,m,r	0		3	s,m,r	coho presence determined by BLM; St, CT confirmed to
Butte Fork Applegate River	Applegate River	0		0		0		0		8	s,m,r	
Cheney Creek	Applegate River	1.5	s,m	3.5	s,m,r	5	s,m,r	5	s,m,r	5	s,m,r	Co confirmed to RM 3.5 (ODFW 1998);
Caris Creek	Applegate River	0		0		2.8	s,m,r*	0		3	s,m,r*	StS and CT found only up to RM 2.5 in 1998 (ODFW
Beaver Creek	Applegate River	0		1.2	s,m,r	5	s,m,r	0		6.8	s,m,r	trout use confirmed (Medite 1995); St confirmed to RM
Bull Creek	Applegate River	0		0		0		0		2	s,m,r	CT use confirmed (BLM 1988)
Little Applegate River	Applegate River	5	s,m	6	s,m,r	6	m,r	19	s,m,r*	19	s,m,r	Steelhead fry observed at RM 12.25; suitable habitat to
Humbug Creek	Applegate River	0		0		1.3	s,m,r*	0		2.5	s,m,r	St redds seen to RM 0.5; habitat suitable to RM 1.3
Miller Creek	Applegate River	0		0		0.8	s,m,r	0		2	s,m,r*	*Trout and steelhead only found up to RM 0.8 in 1998
Middle Fork Applegate River	Applegate River	0		0		0		0		6	s,m,r	
Carberry Creek	Applegate River (Lake)	0		0		0		0		6.3	s,m,r	P&B survey 1970
Petes Camp Creek	Beaver Creek	0		0		0		0		1	s,m,r	Visual survey 1995 (Medite)
Bear Wallow Creek	Bill Creek	0		0		0.2	s,m,r	0		0.2	s,m,r	St, CT use confirmed (ODFW fish presence survey,
Knight Creek	Butcherknife Creek	0		0.5	s,m,r	0		0				Coho presence determined by BLM
Steve's Fork Carberry Creek	Carberry Creek	0		0		0		0		11.1	s,m,r	
Sturgis Fork Carberry Creek	Carberry Creek	0		0		0		0		8.5	s,m,r	
Cougar Creek	Carberry Creek	0		0		0		0		1.5	s,m,r	
Brush Creek	Carberry Creek	0		0		0		0		4	s,m,r	
Rocky Creek	Caris Creek	0		0		0		0		0.1	s,m,r	CT; ODFW survey 1998
Miners Creek	Caris Creek	0		0		0.1	s,m,r	0		0.1	s,m,r	ODFW survey 1998
Little Cheney Creek	Cheney Creek	0		0.8	s,m,r	0.8	s,m,r	0		0.8	s,m,r	Co and St use determined by BLM; trout use assumed.
Sugarloaf Gulch	Clapboard Gulch	0		0		0		0		0.75	s,m,r	CT; ODFW survey 1995
Rock Creek	East Fork Williams Creek	0		0		1	s,m,r	0		1.5	s,m,r	
Clapboard Gulch	East Fork Williams Creek	0		0		0		0		0.8	s,m,r	CT; ODFW survey 1995
Dutch Creek	Elliot Creek	0		0		0		0		2	s,m,r	
Silver Fork	Elliot Creek	0		0		0		0		1.75	s,m,r	
Poormans Creek	Forest Creek	0		0		0		0		1	s,m,r	
Trib GL - A	Glade Creek	0		0		0		0		0.1	s,m,r	T40S, R1W, Sec. 6; CT - ODFW survey 1996
Hendricks Creek	Glade Creek	0		0		0		0		0.1	s,m,r	CT; ODFW survey 1996
Garvin Gulch	Glade Creek	0		0		0		0		0.9	s,m,r	CT use confirmed (ODFW survey 1996)
Trib GL-C	Glade Creek	0		0		0		0		0.1	s,m,r	T40S, R1W, Sec. 18; CT - ODFW survey 1996
Wrangle Creek	Glade Creek	0		0		0		0		0.1	s,m,r	CT - ODFW survey 1996
Trib A	Little Applegate River	0		0		0		0		0.6	s,m,r	visual survey 1995 (Medite)

Yale Creek	Little Applegate River	0		0		6	s,m,r*	0		8	s,m,r	Fry (assumed StS) observed to RM 4; suitable habitat to
Glade Creek	Little Applegate River	0		0		0		0.5	s,m,r	6	s,m,r*	Trout observed to RM 1.75 (P&B survey 1968)
Sterling Creek	Little Applegate River	0		0		3	s,m,r	0		4.5	s,m,r	
Cinnabar Gulch	Little Applegate River	0		0		0		0		0.1	s,m,r	Visual survey 1995 (Medite)
Grouse Creek	Little Applegate River	0		0		0.6	s,m,r	0.6	s,m,r	0.6	s,m,r	St use confirmed (BLM 1985); trout use assumed
McDonald Creek	Little Applegate River	0		0		0		0		3	s,m,r	
Tree Branch Creek	Lone Creek	0		0		0		0		0.1	s,m,r	CT; ODFW survey 1995
Trib A	Lone Creek	0		0		0		0		0.1	s,m,r	CT; ODFW survey 1995
Split Rock Creek	McDonald Creek	0		0		0		0		0.6	s,m,r	Visual survey 1995 (Medite)
Bean Gulch	Middle Fork Applegate	0		0		0		0		0.1	s,m,r	
Whiskey Creek	Middle Fork Applegate	0		0		0		0		2.5	s,m,r	
Cook and Green Creek	Middle Fork Applegate	0		0		0		0		5	s,m,r	
Swamp Creek	Munger Creek	0		0		0		0		0.25	s,m,r	CT; ODFW survey 1995
Trib M	Murphy Creek	0		0		0.2	s,m,r	0		0.2	s,m,r	T37S, R6W, Sec. 36; ODFW survey 1998
Spencer Creek	Murphy Creek	0		0.4	s,m,r	0		0				Coho presence determined by BLM
Trib 1	Pete's Camp Creek	0		0		0		0		0.1	s,m,r	CT use confirmed (Medite visual 1995)
Unnamed trib	Petes Camp Creek	0		0		0		0		0.2	s,m,r	T40S, R2W, Sec. 18; visual survey 1995 (Medite)
Wallow Creek	Powell Creek	0		0		0		0		0.75	s,m,r	CT; ODFW survey, 1995
Honeysuckle Creek	Powell Creek	0		0		0		0		0.5	s,m,r	CT; BLM survey, 1983
Trib G	Rock Creek	0		0		0		0		0.25	s,m,r	CT; ODFW survey 1995
Applegate River	Rogue River	47	s,m	47	s,m,r	47	m,r	47	s,m,r	47	s,m,r	
South Fork Round Prairie Creek	Round Prairie Creek	0.5	s,m	0.2	s,m,r	0.3	s,m,r	0		0.3	s,m,r	ChF use verified (P&B survey 1974); Co, St use
Bill Creek	Rt. Hand Fk. West Fk.	0		0		1	s,m,r	0		1	s,m,r	St, CT confirmed to mouth of Bear Wallow (ODFW
Butcherknife Creek	Slate Creek	1	s,m	1.5	s,m,r	1	s,m,r	0		2	s,m,r	Coho use determined by BLM; St verified to RM 0.5
Elliot Creek	Slate Creek	1.5	s,m	2.2	s,m,r	2.4	s,m,r	0		2.4	s,m,r	Co, St and CT use confirmed (ODFW 1997); ChF use
Round Prairie Creek	Slate Creek	0.5	s,m	0.3	s,m,r	1.3	s,m,r	0		0.3	s,m,r	Co and St use determined by BLM; ChF up to RM 0.5
Cedar Log Creek	Slate Creek	0		0.5	s,m,r	0.7	s,m,r	0.7	s,m,r	0.7	s,m,r	Coho use confirmed (USFS 1997)
Welter Creek	Slate Creek	0		0		0		0		0.25	s,m,r	CT use to RM 0.25 (P&B survey 1974)
Ramsey Creek	Slate Creek	0		0		1.9	s,m,r	0		1.9	s,m,r	
Waters Creek	Slate Creek	2	s,m	2.5	s,m,r	3	s,m,r	0		3	s,m,r	ChF use verified (P&B survey 1974); Co verified
Buckeye Creek	Slate Creek	0		0		0		0		0.2	s,m,r	
Benson Gulch	Star Gulch	0		0		0		0		0.25	s,m,r	trout use confirmed (BLM 1982)
Alexander Gulch	Star Gulch	0		0		0		0		0.4	s,m,r	CT; BLM survey 1982
Ladybug Gulch	Star Gulch	0		0		0		0		0.9	s,m,r	trout use confirmed (BLM 1982)
Lightning Gulch	Star Gulch	0		0		0.6	s,m,r	0.6	s,m,r	0.6	s,m,r	CT, St use confirmed (BLM 1984)
Right Hand Fork Steve's Fork	Steve's Fork Carberry	0		0		0		0		1	s,m,r	
O'Brien Creek	Sturgis Fork Carberry	0		0		0		0		1	s,m,r	
Bigelow Creek	Sturgis Fork of Carberry	0		0		0		0		1	s,m,r	
Ninemile Creek	Thompson Creek	0		0		1	s,m,r	0		2.5	s,m,r	Residents reported St use reported by landowners
Trib A	Wallow Creek	0		0		0		0		0.1	s,m,r	CT; ODFW survey, 1995
Salt Creek	Waters Creek	0.3	s,m	0.5	s,m,r	0.5	s,m,r	0				Co, St presence determined by BLM; ChF verified (P&B
Bear Creek	Waters Creek	0.3	s,m	0.3	s,m,r	0.8	s,m,r	0		0.1	s,m,r	coho presence determined by BLM; ChF use verified
Right Fork Waters Creek	Waters Creek	0		1	s,m,r	0		0				Coho use confirmed (USFS 1997)
Sulphur Gulch	Waters Gulch	0		0		0		0		0.3	s,m,r	CT - ODFW survey 1996
Trib B	West Fork Williams	0		0		0		0		0.5	s,m,r	CT; ODFW survey 1995
Right Hand Fork West Fork	West Fork Williams	0		0		0.5	s,m,r	0.5	s,m,r	2	s,m,r	St use confirmed (P&B 1965); Trout use assumed
Mungers Creek	West Fork Williams	1	s,m	2.5	s,m,r	2.5	s,m,r	2.5	s,m,r	4.5	s,m,r	St use confirmed (P&B survey 1965)- 12' falls;CT use
Lone Creek	West Fork Williams	0		0		0		0		1.5	s,m,r	CT; BLM survey 1988
Goodwin Creek	West Fork Williams	0		0		0.1	s,m,r	0		0.1	s,m,r	ODFW survey 1995
Winter Creek	West Fork Williams	0		0		0		0		0.7	s,m,r	CT; ODFW survey 1995
Powell Creek	Williams Creek	0.5	s,m	0.8	s,m,r	4	s,m,r	0		6	s,m,r	CT use verified (ODFW survey 1995); St use verified
Banning Creek	Williams Creek	0		0		0.25	s,m,r	0		0.5		ODFW survey, 1995

Butcher Creek	Williams Creek	0		0		0		0		0.7	s,m,r	CT; ODFW survey 1995
West Fork Williams Creek	Williams Creek	2.5	s,m	4.5	s,m,r	4.5	s,m,r	4.5	s,m,r	6.5	s,m,r	St use confirmed (P&B survey 1965);CT confirmed to
East Fork Williams Creek	Williams Creek	1	s,m	3.2	s,m,r	4.5	s,m,r	4.5	s,m,r	6	s,m,r	Co and St use confirmed to RM 3.2 (ODFW 1992); St
Pennington Creek	Williams Creek	0		0		1	s,m,r	0				ODFW survey, 1995
Crapsey Gulch	Yale Creek	0		0		0		0		0.4	s,m,r	CT; ODFW survey 1996
Waters Gulch	Yale Creek	0		0		0		0		1.5	s,m,r	CT - ODFW survey 1996
Trib CY-A	Yale Creek	0		0		0		0		0.1	s,m,r	T40S, R2W, Sec. 15; CT - ODFW survey 1996

Appendix A.5
Reaches and Suitability Scoring

Winter and Summer Habitat suitability

Basin	Stream	Reach	Temperature	DO	CWPool	Summer Suitability Score	LWD	FP	Gravel	Winter Suitability Score
Slate Creek	Slate	1	0	0	1	1	1	0	1	3
		2	0	1	1	2	0	0	1	2
		3	0	1	0	1	0	0	1	1
		4	0	1	0	1	0	0	1	1
		5	0	1	0	1	0	0	1	1
	Waters	1	0	1	0	1	0	0	1	1
		2	1	1	0	2	0	0	1	1
	Bear	1	1	1	1	3	0	#NA	1	2
	Butcherknife	1	1	1	0	2	0	1	1	2
Cheney Creek	Cheney	1	0	1	0	1	0	0	1	1
		2	1	1	1	3	1	1	1	4
		3	1	1	1	3	0	1	1	3
Williams	Williams	1	0	0	1	1	0	0	1	2
		2	0	0	1	1	0	0	1	2
		3	0	0	1	1	0	0	1	2
	EF Williams	1	0	1	1	2	1	0	1	3
		2	0	1	0	1	1	1	1	3
		3	1	1	1	3	1	1	1	4
		4	1	1	1	3	1	0	1	3
		5	1	1	0	2	1	1	1	3
		6	1	1	0	2	1	1	1	3
	Glade fork	1	1	1	0	2	1	1	1	3
		2	1	1	0	2	1	1	1	3
	West Fork	1	1	1	1	3	0	0	1	2
		2	1	1	1	3	0	0	1	2
		3	1	1	1	3	0	1	1	3
		4	1	1	1	3	1	1	1	4
		5	1	1	0	2	0	1	1	2
		6	1	1	0	2	1	1	1	3
	Rt hand Fork	1	1	1	1	3	1	1	1	4
		2	1	1	1	3	1	1	1	4
	Bill Ck	1	1	1	0	2	0	1	1	2
		2	1	1	0	2	1	1	1	3
	Bear Wallow	1	1	1	0	2	1	1	1	3
	Munger	1	1	1	1	3	1	0	1	3
		2	1	1	1	3	1	1	1	4
		3	1	1	0	2	1	1	1	3
		4	1	1	0	2	1	1	1	3
	NF Munger	1	1	1	0	2	1	1	1	3
		2	1	1	0	2	0	1	0	1
	Trib to NFMun	1	1	1	1	3	1	1	1	4
Thompson Creek	Thompson Ck	1	0	1	1	2	0	1	1	3
		2	0	1	0	1	0	0	1	1
		3	0	1	0	1	0	0	1	1
		4	0	1	0	1	0	0	1	1
		5	0	1	0	1	0	0	1	1
		6	0	1	0	1	0	0	1	1
		7	0	1	1	2	0	1	1	3
		8	0	1	1	2	0	1	1	3
		9	1	1	0	2	0	0	1	1
		10	1	1	0	2	0	0	1	1

Basin	Stream	Reach	Temperature	DO	CWPool	Summer Suitability Score	LWD	FP	Gravel	Winter Suitability Score
		11	1	1	0	2	0	0	1	1
		12	1	1	0	2	0	0	1	1
		13	1	1	0	2	0	0	1	1
	Nine mile	1	1	1	0	2	0	1	1	2
		2	1	1	0	2	0	1	1	2
Little Applegate River	Little Applegate	1	0	1	0	1	0	0	1	1
		2	0	1	1	2	0	0	1	2
		3	0	1	1	2	0	0	1	2
		4	1	1	1	3	0	1	1	3
		5	1	1	1	3	1	1	1	4
		6	1	1	1	3	0	1	1	3
		7	1	1	1	3	0	1	1	3
		8	1	1	1	3	0	1	1	3
		9	1	1	1	3	0	1	1	3
	Glade Ck	1	1	1	1	3	0	1	1	3
		2	1	1	1	3	0	1	1	3
		3	1	1	1	3	0	1	1	3
		4	1	1	0	2	0	1	1	2
		5	1	1	1	3	1	1	1	4
		6	1	1	1	3	0	1	1	3
		7	1	1	1	3	1	1	1	4
	Yale	1	1	1	0	2	0	1	1	2
		2	1	1	0	2	0	1	1	2
		3	1	1	0	2	0	1	1	2
		4	1	1	0	2	0	1	1	2
	Grouse	1	0	1	1	2	0	1	1	3
		2	0	1	1	2	0	1	1	3
		3	1	1	1	3	0	1	1	3
		4	1	1	0	2	0	1	1	2
Beaver Creek	Beaver	1	0	1	0	1	0	1	1	2
		2	1	1	0	2	0	1	1	2
		3	1	1	0	2	0	1	1	2
		4	1	1	0	2	0	1	1	2
		5	1	1	0	2	0	1	1	2
		6	1	1	0	2	0	1	1	2
		7	1	1	0	2	0	1	1	2

An Assessment of the Suitability of Constructed Alcoves as Salmonid Habitat: The Alcoves in the Applegate River at River Mile 16

A Project of the Applegate River Watershed Council
1999

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This project was supported by Grant 149-99 from the Department of Environmental Quality and Grant 98-275 from the Governor's Watershed Enhancement Board.

Appendix B

Copeland Sand and Gravel Alcove Study

ABSTRACT

Several species of anadromous salmonids including coho and chinook salmon and steelhead trout inhabit the Applegate Basin. Warm summer stream temperatures and simplified stream habitat along the lower river, however, may inhibit salmonid survival, and the lack of complex, off-channel rearing habitat along the mainstem Applegate likely limits rearing success.

In 1997 Copeland Sand and Gravel, Inc. began exploring options through which aggregate extraction operations could enhance or restore off-channel habitat, effectively linking aggregate extraction with watershed restoration. As a result, several experimental off-channel alcoves were constructed during the summer of 1998. These alcoves were intended to provide high-flow refugia for juvenile salmonids during winter; in summer alcoves were planned to provide cool, hyporheic water inputs to benefit mainstem rearing juveniles. Additional proposed benefits included: increased spawning area, increased bank stability, and increased area for fry to rear in interstitial spaces.

Throughout the spring and summer of 1999, the Applegate River Watershed Council evaluated water quality and fish use in constructed alcoves in an effort to appraise the success of this project. Most water quality data were collected during July and August, while fish surveys were conducted between March and September. High flows precluded monitoring during the winter to assess the alcoves as winter refugia.

We found the constructed and natural off-channel units provided habitat for chinook salmon and rainbow/steelhead trout. Redside shiners and juvenile northern pikeminnow, however, were the most commonly observed species within constructed habitat units. Juvenile salmonids utilized constructed off-channel habitat for summer rearing, but natural, flowing off-channel reaches appeared most important, and juvenile salmonids utilized pool and riffle with pocket habitat more often than alcove habitat.

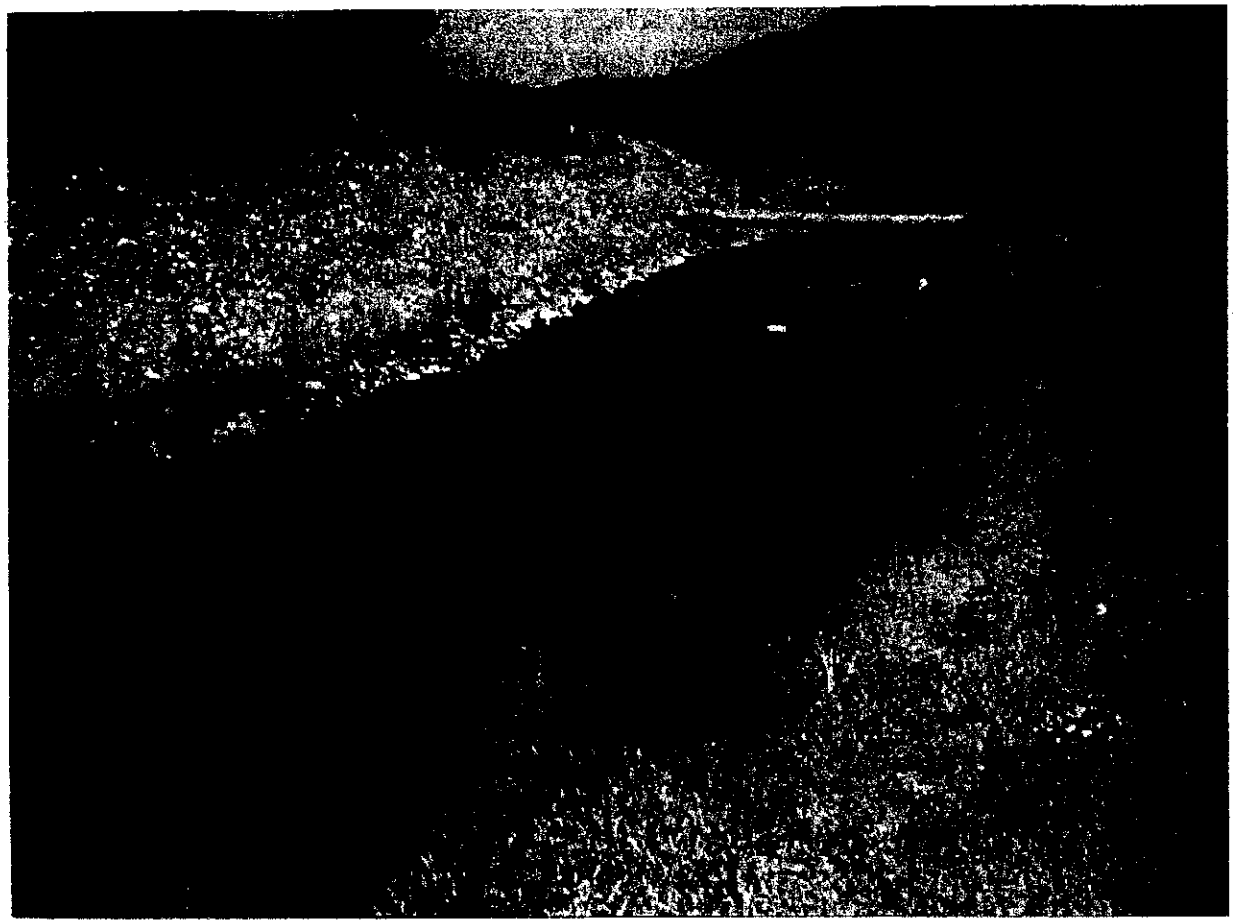
During summer, constructed alcoves and glides provided habitat most suitable for warm water fish species. Redside shiners and northern pikeminnow were the most commonly observed fishes in the constructed areas, and adult bluegill were observed to have spawned along the banks of the alcoves. The presence of newly emerged minnows and redside shiners suggested that other warm water fish spawned and reared in constructed alcove areas as well. The lack of flowing water and suitable substrate, however, likely precludes the use of the alcoves for salmonid spawning.

On a daily average, constructed alcoves did not provide significantly cooler conditions than the mainstem Applegate. Nonetheless, during short periods of time (~6-15 hours) when mainstem temperatures approached summer maximums, localized areas of cooler water appeared to exist at several alcove locations.

Continuous temperature data demonstrated that most alcoves were stratified (*i.e.* warmer at the surface). Stratification was also obvious in longitudinal profiles of pH and dissolved oxygen levels. The stratification of dissolved oxygen levels and pH likely reflected poor vertical mixing in combination with significant plant and algal growth (eutrophication).

Based on our observations, the constructed alcoves did not provide critical salmonid habitat during daylight hours between March and September. Rather, alcoves appeared to enhance habitat for compeditory (redside shiner) and predatory (northern pikeminnow) species to salmonid fishes. In addition, water quality parameters in both the mainstem river and constructed alcove areas were below recommended standards for salmonid health.

This project was supported by Grant 149-99 from the Department of Environmental Quality and Grant 98-275 from the Governor's Watershed Enhancement Board.



Alcove F

The photograph was taken from near the closed end of the alcove and looks northwest to the mouth of the alcove and the Applegate River

Introduction

Copeland Sand and Gravel Inc. is the major producer of aggregates for industrial and domestic construction in Josephine County, OR. The company realized that their work in the Applegate River, if appropriately designed, might improve aquatic habitat for salmonids, and initiated a program to integrate gravel extraction with fish habitat enhancement. Working with Pacific Habitat Services, Oregon Department of Fish and Wildlife, and David Newton and Associates, Copeland Sand and Gravel devised a novel plan that entailed the construction of several experimental, off-channel alcoves in areas of aggregate extraction on the lower Applegate River (Pacific Habitat Services 1997).

Permits for the project were obtained at the county, state, and federal levels. Copeland Sand and Gravel and the Applegate River Watershed Council submitted a fill and removal permit application to the Army Corps of Engineers and Division of State Lands which was also reviewed by all state and federal agencies with regulatory authority over fish, water quality, and fill and removal.

Alcoves were constructed near river mile 16 of the Applegate River in 1998. As a co-applicant on this project, the Applegate River Watershed Council recognized the need to ascertain if the goals had been met. In an effort to determine salmonid and non-salmonid use, as well as suitability for use, of the constructed off-channel sites, we monitored fish populations, water chemistry, and stream temperature in intact alcoves during the spring and summer of 1999.

Background

Historically, the lower Applegate River maintained complex aquatic habitat that included perennial multiple channel sections, high-flow flood channels, sloughs, alcoves, and large woody debris complexes. A complex mosaic of mature floodplain and riparian tree species stabilized the river channel, and historical flooding maintained many off-channel features. Stable and complex low-gradient river and stream reaches provided important off-channel rearing habitat for native salmonids (Bjornn and Reiser, 1991). Throughout settlement history, however, land use practices, residential development, aggregate mining, dam release schedules, and channelization projects have destabilized the Lower Applegate River channel and reduced the complexity of off-channel habitat areas.

Three species of anadromous salmonids, coho and chinook salmon and steelhead trout, inhabit the Applegate basin. Each of these species utilizes the lower Applegate River during some stage of their life history, and portions of the mainstem Applegate provide essential habitat for salmonid spawning, holding, migration, and rearing. However, warm summer stream temperatures and simplified stream habitat along the lower river may inhibit salmonid survival, and the lack of complex, off-channel rearing habitat in the Applegate may limit rearing success.

During winter, the alcoves were intended to provide high-flow refugia for juvenile salmonids, while in the summer they were planned to provide cool, hyporheic water inputs for mainstem rearing juveniles. Additional proposed benefits of constructed alcoves included increased areas for spawning fish to deposit eggs, increased bank stability, and increased area for fry to rear in interstitial spaces (Van Staveren *et. al.*, 1997).

The alcoves are in an unconstrained, low gradient reach (.032-.039 slope) of the Applegate River. The floodplain width at this site approaches 1000m, and the project area is underlain by fluvial deposits of unconsolidated sand, silt, gravel, and cobble. Figure 1 shows the topography and general location of the site; Figure 2 displays the proposed locations of constructed alcoves. Winter flows reconfigured many of the constructed alcoves, yet several alcoves, located along the west side of the Applegate, remained intact throughout 1999 (Figure 2).

Monitoring Site Selection

Monitoring sites were selected to compare and contrast the different off-channel conditions created by natural stream processes and alcove excavation (Figure 3). Sites D, C, and F are constructed alcoves. Site H, a constructed channel, has visible hyporheic flow entering from the Applegate River through a gravel bar, and site I, the junction of the two constructed alcoves, is where a natural alcove, present before construction, terminated. Site G, near the mouth of the long alcove system, was chosen to determine if conditions near the alcove mouth were similar to those of the Applegate River. Site B is a constructed channel, and Sites A and J represent natural off-channel habitat that was present prior to alcove construction.

Objectives

This project set out to determine if the constructed alcoves provided improved summer habitat for Applegate salmonids. We recorded fish use of constructed and natural off-channel areas and monitored the following water quality parameters: temperature, conductivity, pH, turbidity, alkalinity, dissolved oxygen, and the nutrients, nitrate and phosphate. Biological oxygen demand was checked and the presence of aquatic plants and or algae at each monitoring site was noted. Additionally, longitudinal water chemistry profiles (pH, temperature, and dissolved oxygen at the surface and the bottom) were measured in the alcoves. The methods used are described in the Appendix.

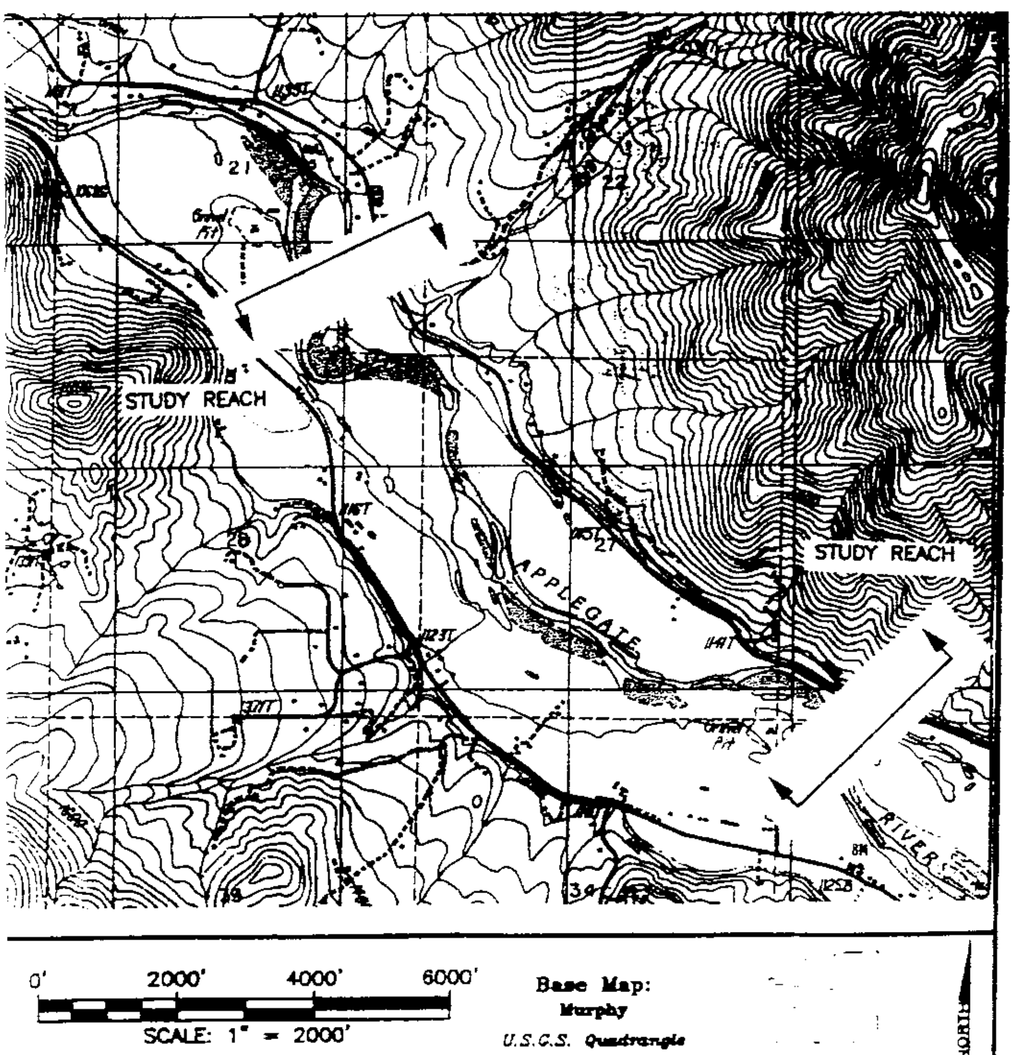


Figure 1. Vicinity Map taken from the plan prepared by David J. Newton Associates, inc (David J. Newton Associates 1997)

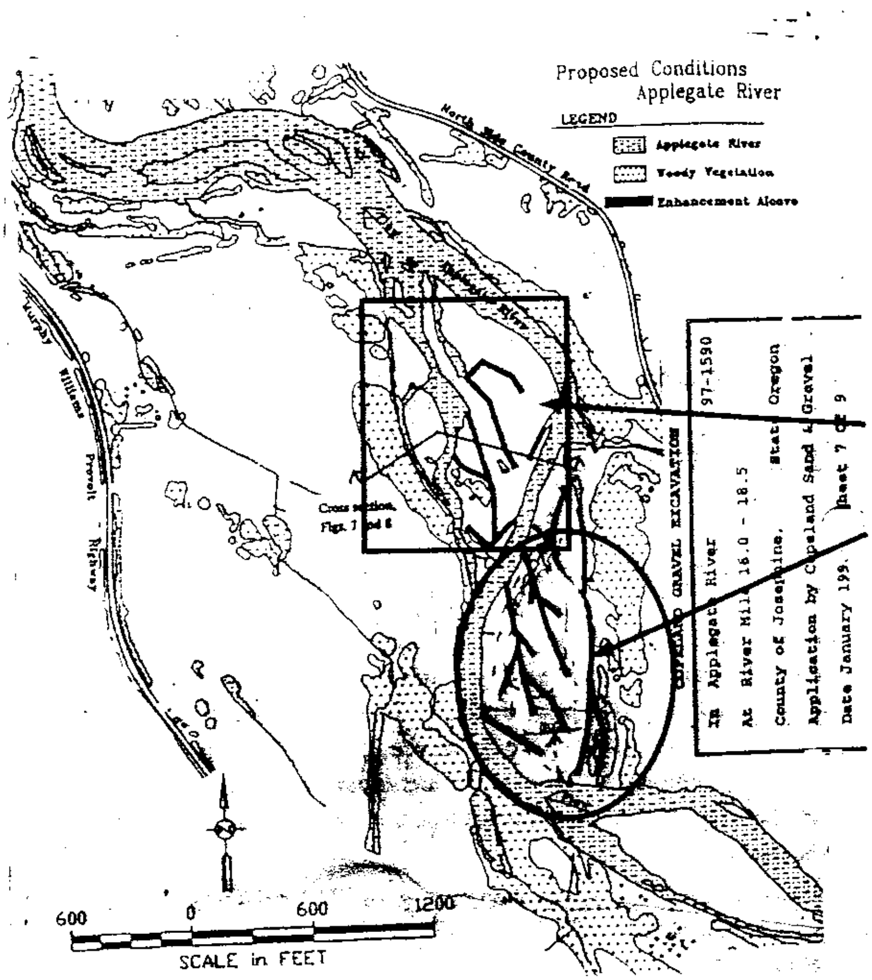


Figure 2.
Proposed locations of alcoves. Taken from the plan submitted by Copeland Sand and Gravel. The inset box is the area shown in Figure 3 and contains the monitoring sites. The alcoves in the oval area filled with sediment during the winter of '98-99.

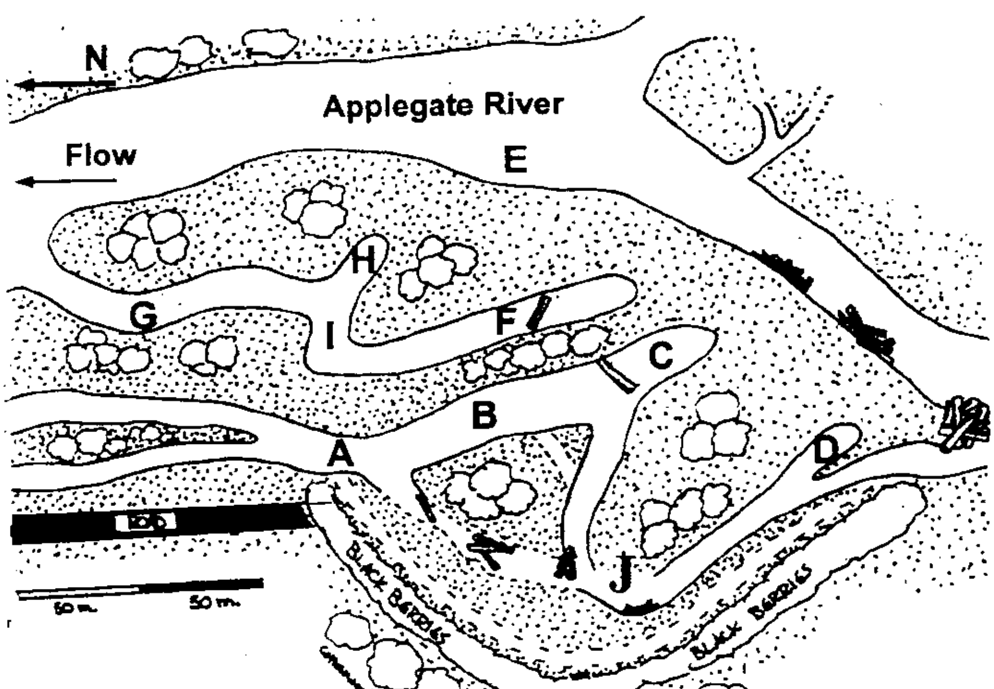


Figure 3.
Location of ARWC monitoring sites. Sites are identified by letters.

Table 1. List and numbers of fish species or group observed in an off-channel complex of the Applegate River, April to September, 1999.

common name	scientific name	total number of observations
Unidentified salmonids	*Oncorhynchus spp.*	49
Chinook salmon	*Oncorhynchus tshwytscha*	300
Steelhead and rainbow trout	*Oncorhynchus mykiss*	736
Redside shiners	*Richardsonius balteatus*	2385
Northern pikeminnow	*Ptychocheilus oregonensis*	1152
Bluegill	*Lepomis macrochirus*	7
Mosquito fish	*Gambusia affinis*	1
Sculpin	*Cottus spp.*	7
Unidentified minnows	*Family Cyprinidae*	1126
		5763

Results

Fish Surveys

A total of 5763 fish observations were made during six snorkeling surveys conducted roughly monthly from 30 March to 22 September. No species were observed during the 30 March survey. Water temperature at this time was below 7° C and visibility was poor due to turbidity and high flows. During the remaining surveys, however, a total of seven fish species were observed in the off-channel survey area (Table 1), including two species of the family Salmonidae: *Oncorhynchus tshawytscha* and *O. mykiss*. The most abundant species present were redside shiners and northern pikeminnow (a.k.a. northern squawfish) followed by steelhead trout and chinook salmon.

The total number of fish observations and fish types varied between habitat units (Table 2). Of 4622 total fish observations for the major species observed, 36.6% were in glide, 27.5% in alcove, 24.3% in pool, and 11.7% in riffle with pocket habitat.

Table 2. Number of fish observations within each habitat unit type of the off-channel study site.

Fish	alcove	glide	pool	riffle	total
salmonids	23	187	541	341	1092
redside shiners	743	1056	394	192	2385
n. pikeminnow	500	448	188	16	1152
total	1266	1691	1123	549	4629

Salmonids were most often observed in pool (50%) and riffle with pocket habitat (31%), and least often in the constructed alcove habitat (2%). In contrast, northern pikeminnow and redside shiners were most commonly observed in the constructed alcove (44 and 31%) and glide habitat (39 and 44%), and least often observed in the riffle with pocket habitat (1 and 8%).

The timing and relative abundance of different species changed during the study period and are shown in Figure 3. Redside shiners were observed throughout the survey period, and the number of redside shiner observations generally increased over the summer. Northern pikeminnow were observed during August and September and may have been present as early as 2 June, as recently hatched young of the year minnows (family Cyprinidae) were observed on 2 June and believed to be northern pikeminnows. No northern pikeminnow of piscivorous size (>10 in. Poe *et. al.*, 1991) were observed. The most common size class noted was 1.5-3.0 in., however most appeared to be approximately 3 in. in length.

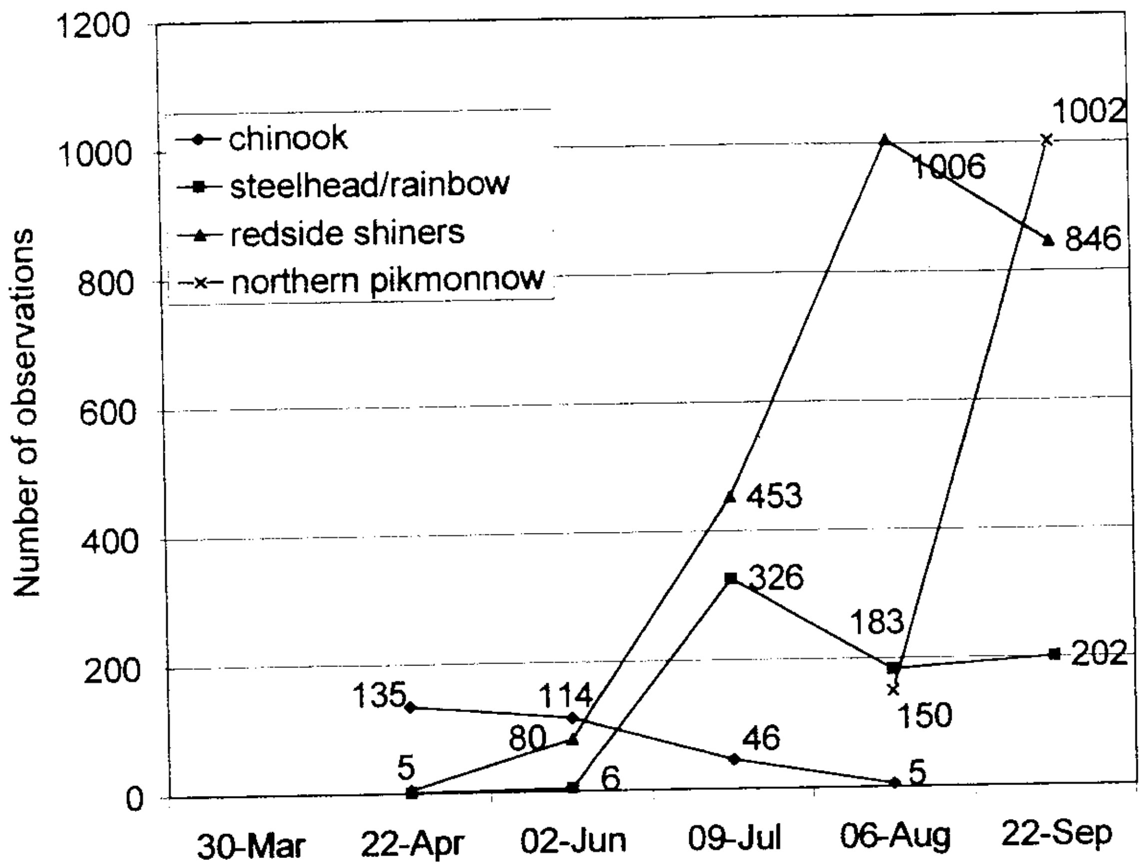


Figure 4. Number of fish observed during snorkel surveys at the off-channel complex along the main-stem Applegate River.

Steelhead trout were first noted on 22 April and were not found in considerable numbers until 9 July. The number of observations was similar during July, August, and September. Chinook salmon were the most abundant species noted during the 22 April survey. Numbers of observations consistently decreased during subsequent surveys and chinook were last noted on 6 August.

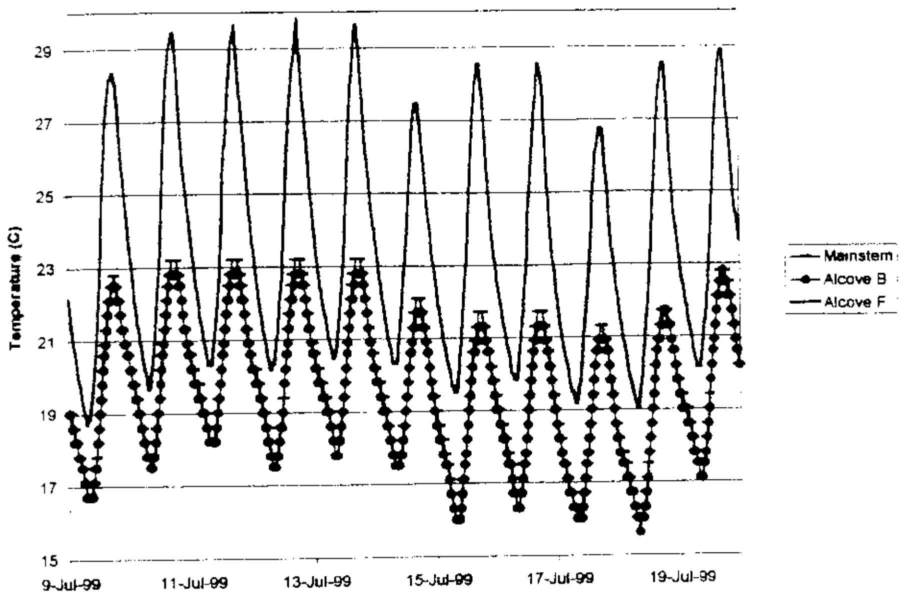
Water Chemistry

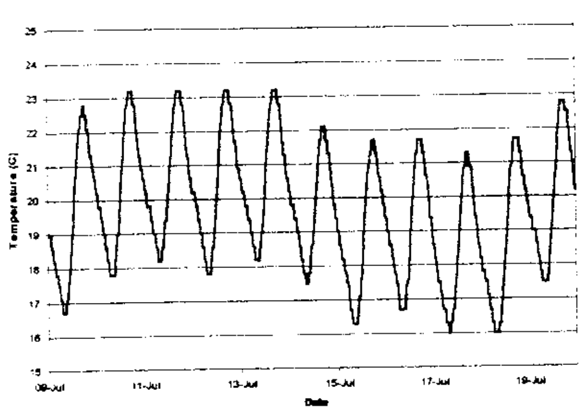
Temperature

Continuous temperature dataloggers were used to monitor alcove and main channel temperatures throughout the summer. Dataloggers were deployed in the mainstem Applegate and in constructed alcoves near the bottom and the surface in order to obtain comparative temperature data and to detect any cool subrheic flow entering the alcoves. These data are presented in Figures 5-7 and Table 3. Temperature data loggers are accurate to ±0.5°C, and temperature differences between locations within this range should not be considered significant.

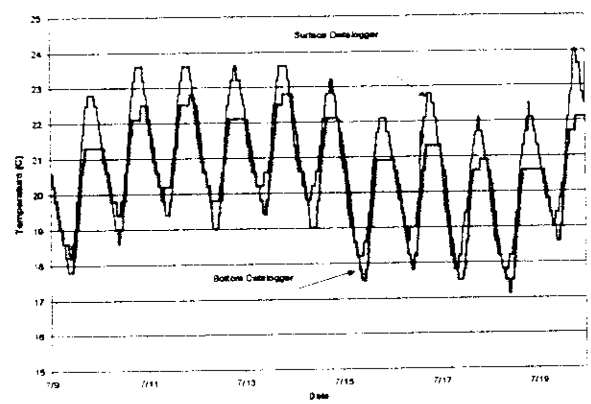
Mainstem temperatures for the Applegate follow a diurnal warming and cooling pattern with a 24-hour average daily fluctuation of approximately 4 to 5 °C (Figures 5-7). The mainstem temperature data in these figures provide a baseline with which to compare alcove data.

Temperature data graphs from alcove monitoring sites are also shown in Figures 5-7.





Mainstem

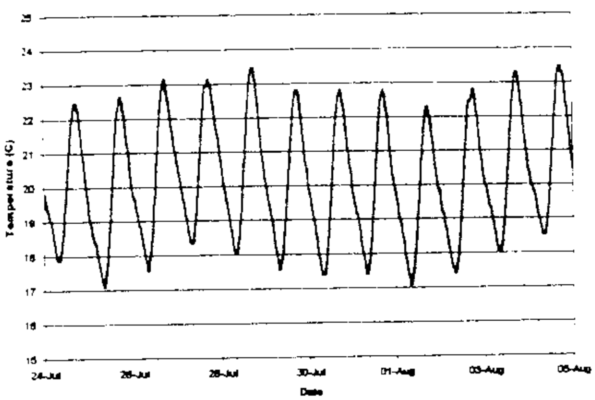


Alcove D

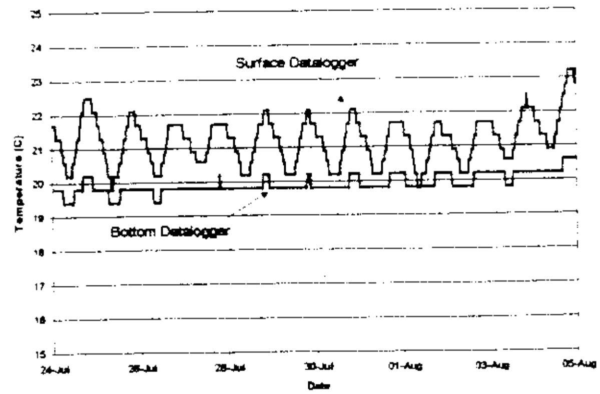
Figure 5. Continuous Temperature data for July 9 through 20.

Temperatures obtained from the surface and bottom of Alcove D indicate that surface and bottom temperatures of this alcove have a marked diurnal fluctuation. The surface temperature closely follows that of the mainstem, but is about 1 degree warmer. The bottom datalogger indicates a slightly cooler range of temperatures with a diurnal fluctuation that is damped (Figures 5 and 7).

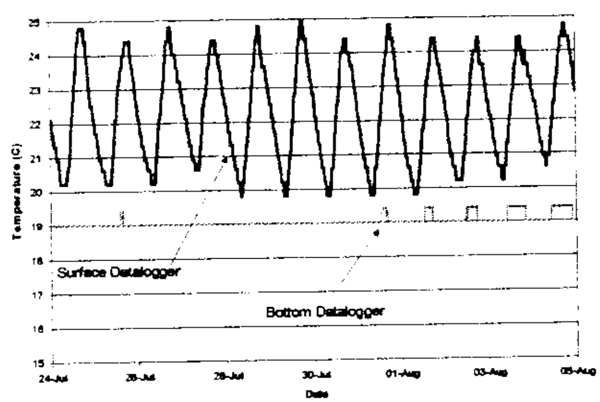
The data shown in Figure 6 show a very different pattern for Alcove F. The temperature patterns near the surface of alcove F resemble the diurnal fluctuations found in the mainstem. The maximum temperatures at the surface at the upper end were somewhat cooler than the mainstem; while at the lower end the surface is warmer than the mainstem. However, the average temperatures are warmer and the diurnal change at the upper end of the alcove is about a third that of the mainstem. More remarkable is that at both ends of this alcove, temperatures found near the bottom exhibit a negligible diurnal change. This observation indicates poor mixing between the surface and lower levels. Temperatures near the bottom of the alcove, however, remain relatively constant and maintain an average temperature similar to the



Mainstem



Upper End of Alcove



Lower End of Alcove

Figure 6. Continuous Temperature Data for the Mainstem and Alcove F. July 24 through August 5.

mainstem Applegate.

Continuous temperature data, summarized in Table 3, suggest that alcoves often maintain warmer temperatures both at the surface and the bottom than the mainstem Applegate River. However, when maximum temperatures in the Applegate are near their peak, select sites near the bottom of alcoves D, C, F, and I maintain lower temperatures than the adjacent mainstem river.

Longitudinal Profiles of Water Chemistry

Other water quality parameters reflected the temperature stratification found in the alcoves. Longitudinal profiles of surface and bottom water layers were conducted in three alcoves (C, D, and F). Temperature, pH, and dissolved oxygen were measured in grab samples taken from the two water levels at regular intervals along the alcoves. Figure 8 on page 10 shows the results obtained in alcove F. In this data set, the values of all parameters were greatest near the surface. This observation conforms with the expected as mid-day sample collection occurs during maximum surface heating and peak photosynthesis. Levels of dissolved oxygen were higher at the surface than at the bottom. Observed dissolved oxygen values of 150% to 210% of saturation are indicative of heavy plant growth, and the abundant vegetation

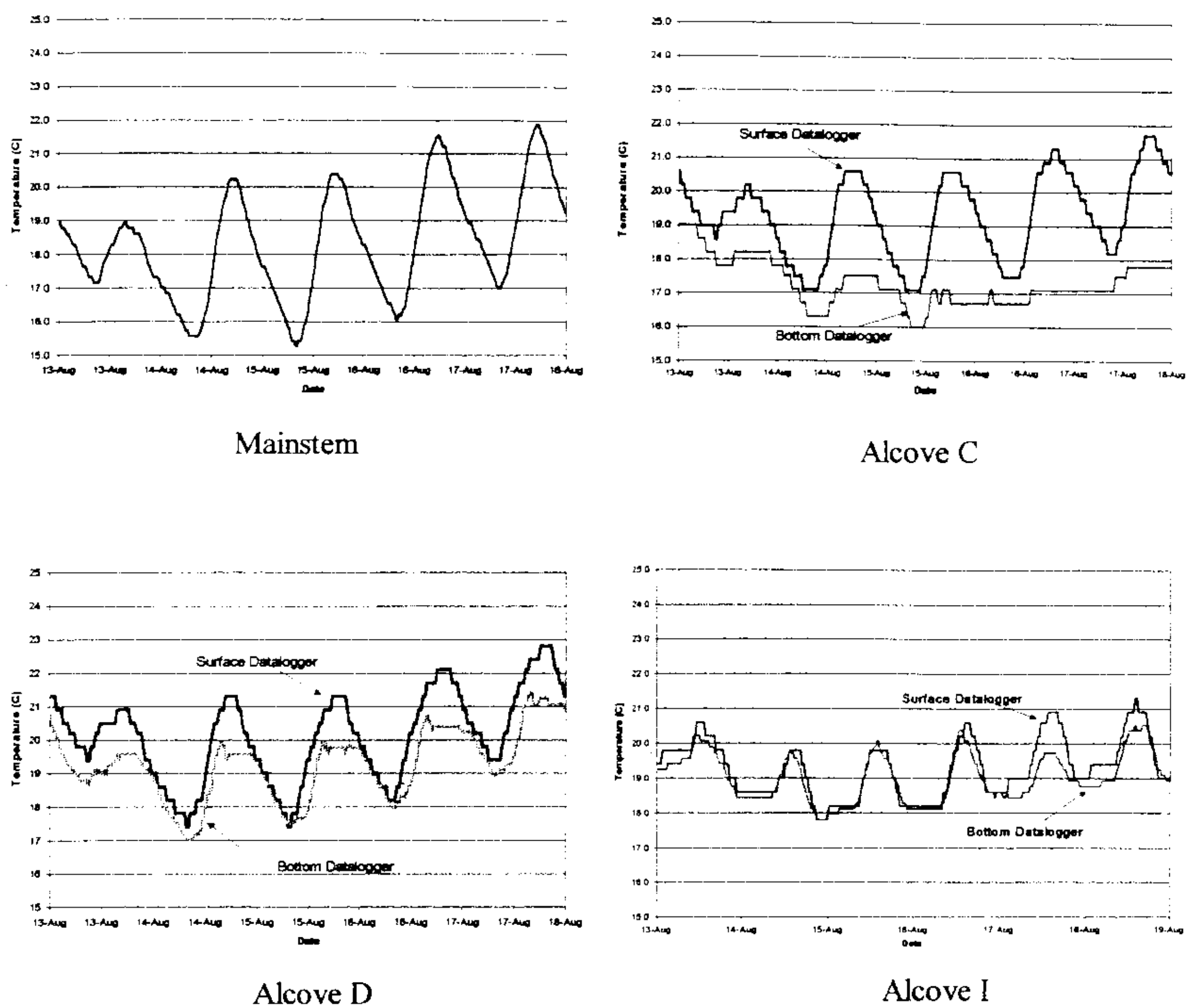


Figure 7. Continuous Temperature Data for the Period August 13 through 18.

within alcoves suggests that photosynthesis near the surface contributes to high daytime dissolved oxygen levels. Lower oxygen levels found at the bottom of alcove F may reflect a lower rate of photosynthesicaused by shading from surface level vegetation. There may also be an excess of respiration at the lower level due to the accumulation of large amounts of detritus. In addition to oxygen producion, photosynthesis increases the pH of water. This is reflected in the higher pH values found at the surface. A pH value of 10 was recorded for the upstream end of alcove F. This value is significantly higher than normal pH values for the area, and pH values in excess of 8.5 are considered to be detrimental to salmonids (Oregon Plan Water Quality Monitoring Guide Book). Nearly all surface pH values in Alcove F exceed this level.

The data collected from Alcove C resembled values from Alcove F. In this instance, however, neither the pH nor the levels of dissolved oxygen were as great as those observed for Alcove F, but stratification was again obvious except near the mouth of the alcove (data shown in appendix). Here, interaction with water flowing past the mouth of the alcove may have provided sufficient mixing to eliminate stratification. Temperature in this alcove was also stratified (Figure 6).

Table 3. Summary of Continuous temperature data from locations in the alcoves.

Dates	Average Temperatures (C) for the Period Studied			
July 25 through Aug. 5	Minimum	Maximum	Average	Daily change
Mainstem	17.7	22.9	20.2	5.2
Surface Upper End*	20.3	22.1	21.2	1.8
Bottom at Upper End*	19.7	20.2	19.9	0.4
Surface Lower End*	20.1	24.6	22.3	4.5
Bottom at Lower End*	19	19.2	19	0.2
* Data from Alcove F				
Aug. 13 through Aug. 18				
Mainstem	16.3	20.8	18.5	4.4
Alcove C Surface	16.9	17.9	17.4	1
Alcove C Bottom	17.8	21.1	19.4	3.3
Alcove D Surface	18.5	21.9	20.3	3.5
Alcove D Bottom	18.2	21.3	19.8	3.2
Alcove I Surface	18.4	20.5	19.3	2.1
I Lower	18.2	20.1	19	1.9
July 9 through July 19				
Mainstem	17.2	22.4	19.7	5.3
Alcove D Surface	18.9	23.1	21	4.1
Alcove D Bottom	18.3	21.8	20.3	3.4
Surface Alcove B	16.7	22.3	19.5	5.6
Surface Alcove F	19.8	28.7	23.6	8.9

Results from Alcove D differed from both alcove F and C (data shown in the appendix). While the stratification of temperature was similar to alcoves F and C, the stratification of pH and dissolved oxygen was reversed; values for these parameters were greatest at the lower level. Plant and algal growth was also different in this alcove, as there was little plant material near the surface but significant growth near the bottom. This observation may account for the difference in pH stratification. Temperature stratification was evident in the continuous temperature data obtained for this alcove (Figures 5 and 7).

A summary of the data obtained by the longitudinal surveys of the alcoves is given in a table in the appendix.

<u>Continuous Monitoring of pH, Dissolved Oxygen and Temperature</u>

A data sonde was deployed in Alcove F during the second week of July. The sonde was located near the alcove midpoint, approximately one foot above the bottom. pH was found to have a diurnal cycle with maxima and minima of 8.8 and 6.7 respectively. Dissolved oxygen varied from 58% to near 0 % saturation during the first two days. A figure in the appendix displays this data.

<u>Water Chemistry</u>

Water chemistry was monitored on alternate weeks from early July until mid-August. Water from the alcoves and mainstem was analyzed for pH, dissolved oxygen, temperature, conductivity, alkalinity, turbidity, and the nutrients nitrate and phosphate. Detailed monitoring data and nutrient analyses are provided in the appendix.

Conductivity monitoring can pinpoint groundwater intrusion into surface water by showing the

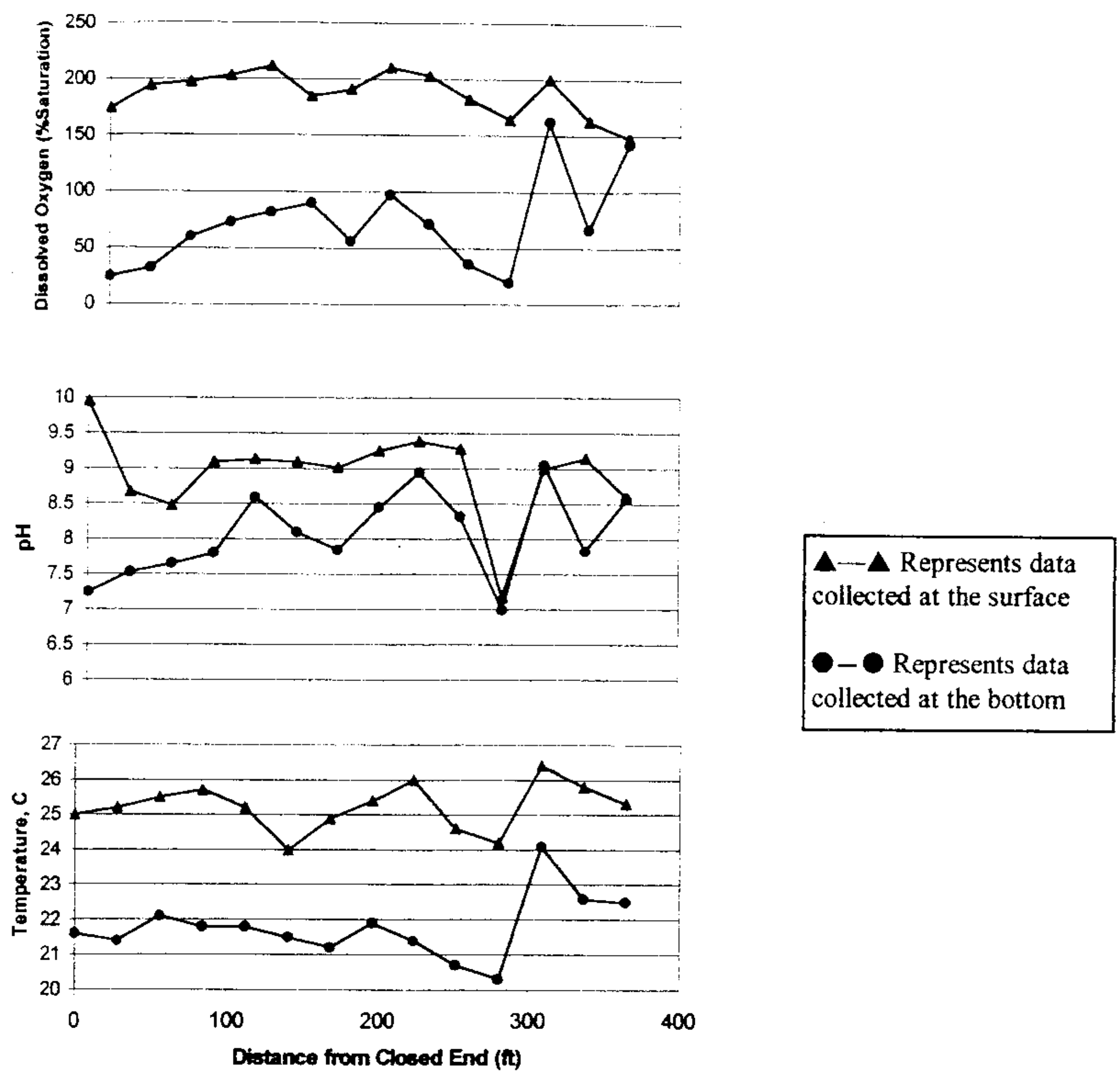


Figure 8. Longitudinal Chemical Parameters for Alcove F. Data obtained on 8/5/99

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enhanced concentration of dissolved salts and minerals in subsurface water. The average conductivity for all sites over time was 118±17 µS. The only value exceeding this range was found in an alcove with obvious ground water intrusion (site H).

Turbidity values ranged from 1 turbidity unit (NTU) at most locations to 9 NTU in Alcove F, which consistently had the highest turbidity readings. Alcove F maintained abundant algae and aquatic vegetation throughout the summer, and often, a bluish-gray film was on the water surface near the bank. These factors likely contributed to the higher turbidity.

Alkalinity is a measure of water's ability to resist changes in pH. The average value, 74 mg/L (as $CaCO_3$), represents the capacity for a modest resistance to change in pH. The range of alkalinity in constructed alcove areas (60 to 90 mg/L) did not vary significantly from day to day at individual sites. Alcoves, side-channels, and mainstem Applegate channels maintained similar alkalinity values throughout the study period.

Nitrate concentrations were found to be between 0.01 and 0.06 mg/L. These concentrations are low and do not suggest nitrogen loading at any location. Phosphate levels were also low, ranging from 0.12 to 0.74 mg/L. These values are typical of those found at ARWC's water quality monitoring stations throughout the Applegate Basin (Summer Program: Water Quality, Stream Ecology; 1998). Alcove C had the highest phosphate level. The amount of algae and plant growth observed in alcoves C, D, and F indicated eutrophication, a result of excess plant or algae growth, and reflected excess nutrient levels. Since plants and algae utilize nutrients for growth and assimilate the nutrients as they enter the system, a system may be eutrophied even though low nutrient levels are found.

Biological oxygen demand (BOD) was determined and found to be representative of clean or, moderately clean water.

Relative Abundance of Aquatic Plants and Algae.

The presence of plants and or algae was estimated in the alcoves on several occasions. At each longitudinal monitoring station, the presence of algae or aquatic vegetation was noted when sampling procedures encountered algae or vascular plant material. In Alcove F (August 5), all 13 samplings of water at the bottom of the alcove contacted either plant or algal material, and on the surface 11 of 13 locations supported plant or algal material. In Alcoves C and D (August 12), all samplings from the bottom level (6 per site) reflected plants or algae. In contrast, sampling surface areas within Alcove C found 3 of 6 sites with algal or plant growth, while Alcove D maintained only 2 of 6 such sites. These quantitative observations substantiate visual estimates of plant and algal growth. In fact, by September 1, Alcove F was virtually filled with aquatic plants, and cattails were occupying marginal areas.

Discussion

These alcoves in the Applegate River were constructed as part of an aggregate mining operation. The hope and expectation was that constructed alcoves would provide off-channel habitat for salmonids. As such, the alcove project could effectively link aggregate extraction with watershed restoration. We evaluated water quality and summertime fish use in constructed alcoves in an effort to evaluate the success of this project. Most water quality data were collected during July and August 1999, while fish surveys took place between March and September 1999.

The constructed and natural off-channel habitat surveyed along the mainstem Applegate River during summer 1999 provided habitat for several species of fish, including chinook salmon and steelhead/ rainbow trout. Redside shiners and juvenile northern pikeminnow, however, were the most commonly observed species within constructed habitat units (alcoves and glides).

Off-channel habitat for juvenile salmonid rearing in summer was provided in the area surveyed, however pre-existing, flowing off-channel reaches appeared most important, and juvenile salmonid fishes utilized pool and riffle with pocket habitat more often than glide and alcove habitat.

Alcoves provide little concentration of drifting macroinvertebrates for juvenile salmonid feeding, and this may partly explain the lack of daytime usage of these areas. During summer, juvenile salmonids in fresh water streams typically occupy areas of low to moderate velocity, where food, cover, and suitable water quality are present. Moreover, the most important food source for juvenile salmonids in streams is aquatic macroinvertebrates, and as some juvenile salmonids grow, they select stream areas with increased stream velocities, in order to improve access to passing drift (Chapman and Bjornn, 1969). In comparison to other stream habitats, riffles and heads of pools appear to provide the greatest concentration of drifting macroinvertebrates. Alcoves, in contrast, have essentially no velocity and consequently provide little concentration of drift.

Water quality may also explain the limited use of alcoves by salmonids. Water temperatures in the

Applegate can reach levels critical for survival of salmonid fishes (chinook >26.2°C., coho >26.0°C., steelhead >23.9°C. Brett 1952; Bell 1986). One proposed benefit of this project was to provide thermal refugia for native fish during summer months. This was to be achieved through construction of dendritic alcoves that would promote delivery of cool, sub-surface flow to the off-channel area. There is evidence that this occurred in isolated pockets, but warmer alcove waters (maximum 28.7°C) in the immediate vicinity of cool water inputs may have restricted cool temperature benefits. Extreme pH and dissolved oxygen values may have also reduced the benefits of cool water input into alcove areas. Salmonid growth and survival, for example, appear to be limited in stream environments with less than 6mg/l dissolved oxygen, and 3mg/l is the limit to avoid acute mortality (MacDonald *et. al.,* 1991). Dissolved oxygen values recorded for an alcove location remained below 3mg/l for an extended period (>12 hours). The pH of the alcoves also varied in space and time, and high pH values (9.95 maximum) may also interfere with salmonid use of alcove areas.

Nonetheless, as mainstem Applegate temperatures increased throughout the summer to above 22.9°C, salmonids were observed in non-flowing constructed alcove areas. During the 6 August survey, in fact, over 50 juvenile steelhead/rainbow were observed in a constructed alcove area with visible hyporheic flow (Alcove H). This alcove remained a part of the mainstem wetted channel throughout June, but as river levels dropped during July and August this site lost surface water inputs and took on alcove characteristics. As a result, this habitat unit was only sampled during August and September. Because this area evolved from a mainstem river reach into an alcove over the course of our survey period, related snorkel data are not included in summary tables or figures.

During summer, constructed alcoves and glides seemed to provide the most suitable habitat for warm water fish species. Redside shiners and northern squawfish were the most commonly observed fishes in constructed areas, and adult bluegill were observed to have spawned along the banks of the alcoves, where temperatures ranged from 19.8-28.7°C. Moreover, the presence of newly emerged minnows and redside shiners suggests that other warm water fish spawned and reared in constructed alcove areas as well. The lack of flowing water and suitable substrate, however, likely precludes their use for salmonid spawning.

One projected outcome of the alcove construction was that the alcove trenches would receive an influx of cooler ground water. Indeed, small seeps of cooler water were detected during fish surveys, and salmonids were observed in the vicinity of cool water inputs. Although surface alcove temperatures were consistently warmer than the mainstem Applegate, temperatures recorded near the bottom of Alcove C and at the bottom near the open end of Alcove F were less than those found for the average maximum of the mainstem Applegate. Data suggest that during a 24-hour period, alcoves do not provide significantly cooler conditions than the mainstem Applegate.

Alcove water surface elevations are approximately one foot lower than the adjacent mainstem (Figure in the appendix). This difference may not generate sufficient hydrostatic pressure to promote subrheic through the tightly packed sands, gravels and cobbles present in the study site. As a result, hyporheic water input is not sufficient to offset warm alcove temperatures. None-the-less, during short periods of time, when mainstem Applegate temperatures reach summer maximums, localized areas of cooler water appear to exist at several alcove locations.

Salmonid health is considered to be impaired if the 7-day average maximum temperature exceeds 17.8°C (Oregon Plan Water Quality Monitoring Guide Book). The average maximum temperatures observed for the mainstem Applegate and constructed alcoves were above this value. However, average water temperature near the bottom of Alcove F remained close to the maximum acceptable level.

Constructed lentic alcove areas appear to promote both algal and vascular aquatic plant growth. Alcove areas are unshaded and apparently maintain sufficient nutrient levels to support luxuriant vascular plant communities. As a result, aquatic vegetation virtually filled several alcoves and contributed to stratification and eutrophication.

Continuous temperature data clearly demonstrated this stratification. Temperature data collected at two depths in Alcoves F and C showed marked differences between surface and bottom levels (Figures 5 and 6). Lesser, but distinct, stratification was found in Alcove D and there was minor stratification in Alcove I (Figures 5 and 7). Stratification results from poor mixing and it is not surprising that a long alcove such as Alcove F remains isolated from the mixing effects of the river. In addition, heavy aquatic plant growth shades the deeper areas and serves to dampen vertical mixing by wind. While Alcove C is short, flowing water appears to bypass its mouth and little mixing was observed. In contrast, the mouth of Alcove D is deep and mixing between side-channel and alcove water is apparent.

Stratification was also obvious in the longitudinal profiles of temperature, pH and dissolved oxygen (Figure 8 and figures in the appendix). Alcoves F and C had similar patterns of stratification, with temperature, pH and dissolved oxygen greatest at the surface. The plants and algae near the surface absorb sunlight and photosynthesis seems to be greatest in this zone. Photosynthesis is also an alkalization process and it follows that the pH at the surface should be and, indeed, was greater than at the bottom.

Alcove D showed temperature stratification in the longitudinal profile of a magnitude that was not apparent from temperature dataloggers. This may simply reflect that grab samples were collected nearer the surface and the bottom. The stratification of pH and dissolved oxygen, which was inverted—when compared to Alcove F—was most likely a result of the location of plant and algal growth in this alcove. There was little surface plant life; most plants were on the bottom, making that the primary locus of photosynthesis.

Eutrophication of the alcoves appeared to have two consequences. One was that pH values well outside of the range considered to be safe for salmonids (pH 6.5 to 8.5) were observed in the lateral profiles of Alcoves D and F. These extremes undoubtedly resulted from sampling at the upper and lower most levels, and hence, represent extreme values within the alcoves. This pH range was rarely exceeded in the grab samples collected at intermediate levels during monitoring visits (table in the appendix).

The additional consequence was that surface and bottom levels of dissolved oxygen contrasted significantly. Longitudinal profiles displayed super-saturation in the zones of high photosynthesis and low levels of oxygen in the shaded regions. The continuous dissolved oxygen data obtained by the sonde indicate nearly anoxic conditions during the night in Alcove F (data in the appendix). Oxygen concentrations considered detrimental to salmonid survival (<6 mg/l or approximately 70% of saturation at 21°C) were found within the lower layer of Alcove F at approximately half (n=14) of the data collection points.

Alcove temperatures were uniformly above the level recommended for salmonid health, and the extremes of pH and dissolved oxygen were also outside of the preferred range. Nonetheless, salmonids were found in and around the alcoves during several snorkel surveys, with roughly 2% of salmonid observations in constructed alcove habitat (Table 2).

Based on observations collected during summer 1999, alcoves did not provide significant salmonid habitat, and they appeared to enhance habitat for compeditory (redside shiner) and predatory (northern pikeminnow) species to salmonid fishes. An alternative restoration approach, providing off-channel flowing water habitat with complex structure and cover might provide summer and winter rearing habitat for juvenile salmonids, while limiting the use of these areas by other predatory or compeditory fishes.

The importance of these alcoves as a velocity refuge for salmonids during winter high flows is not known and should be examined. Furthermore, nocturnal surveys may also document different patterns of alcove use.

As constructed off-channel habitat units evolve, habitat parameters, including cover, stability, temperature, and algal and aquatic plant productivity will likely change, and the importance of these areas for summer salmonid use may increase. At present, vegetation from plantings and natural colonization of constructed off-channel areas is growing rapidly. Willow, cottonwood, and alder are stabilizing the study area, and in the absence of a 15-20 year flood event in the near future, mature vegetation will begin to stabilize off-channel areas, trap passing woody debris and sediment, and provide shade to constructed alcove habitat. Copeland Sand and Gravel Inc.'s commitment to set this site aside and allow revegetation may see the entire area evolve into a stable and complex off-channel lotic and wetland area. Future fish and wildlife benefits could be significant.

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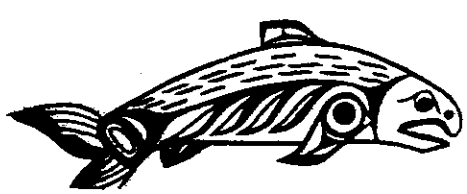

Appendix

Methods

Most of the methods used are described in the *Methods and Procedures Manual of ARWC* . Other methods were as follows.

Biological oxygen demand (BOD) was estimated by determining the difference in oxygen concentration in a fresh sample of water and one that had incubated in the dark for 5 to 7 days at 20°C. The difference between the initial value and the dissolved oxygen at the fifth day is called BOD_5. Biological oxygen demand shows the presence of organic material that bacteria can oxidize (Baron 1997). During incubation the sample temperature was kept at approximately 20°C.

Temperature was continuously recorded by temperature dataloggers (Hobos® or OpticStow-Aways®) at several locations in the alcoves and in the mainstem. Temperature monitors placed in the alcoves were stratified. The lower device was weighted to hold it near the bottom, while the upper temperature datalogger was held within a foot of the surface by a piece of Styrofoam. A short length of cord connected the dataloggers. These devices recorded the temperature every 30 minutes.

Dissolved oxygen, pH temperature, and conductivity were continuously determined by a sonde, which was deployed in Alcove F from July 9 to 14. The sonde was calibrated by procedures provided by YSI Inc. Yellow Springs, OH .

Longitudinal profiles of water chemistry were determined at the surface and at the bottom of the alcoves at regular increments from the end of the alcove to its mouth. Distances between measurements were approximated by strides. For this study dissolved oxygen was measured with a YSI Model 95 Dissolved Oxygen and Temperature Meter. With this unit oxygen is detected by a Clark type voltametric microelectrode array. The instrument was calibrated by procedures provided by YSI Inc.

Fish use and relative abundance were monitored monthly at the study site from March to September 1999. During day light hours, two people snorkeled through waterways of the study site beginning at the downstream end of the study reach and continued upstream to the southern-most alcove. Surveys included pre-existing side channel areas, constructed side channel, and constructed alcoves. Number of fish per species and size class was recorded for each of 11 pre-designated habitat units. Notes were also made of fish behavior and location relative to cover, velocity, and other factors. Fish species present in the mainstem Applegate River was observed by snorkeling around two large woody debris accumulations south and upstream of the off-channel survey area during each survey.

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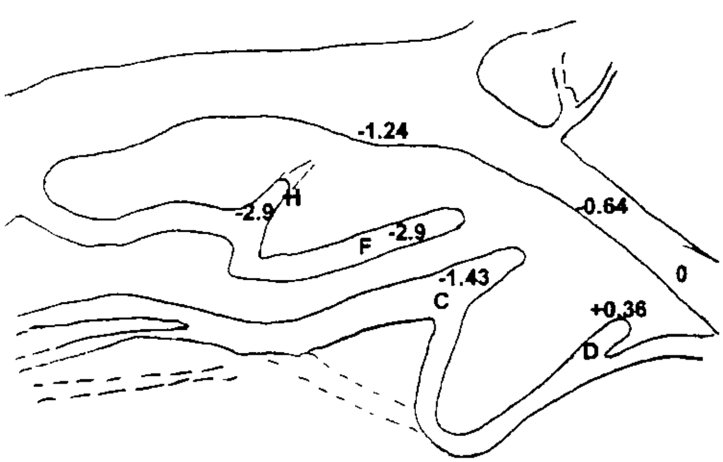
Site	location	Date	Time	Temp.	Cond.	pH	Turb.	Alk.	DO mg/L	Oxygen % Sat.
A	end of road	7/8	10:40	16.3		8.27			10.3	108.8
		7/16	9:06	17*	100*	7.03*	1	56*	8.45*	90.5*
		7/23	10:11	18.5*	104*	7.69*	2*	84*		
		8/5	9:42	18.5	119	6.66	1	80	7.36	81
B	side channel up from road	7/8	11:00	16.8		8.36			8.48	90.9
		7/16	9:43	17.0	101	7.08	2	68	7.84	84.1
		7/23	10:23	18.8	106	7.89	2	60		
		8/5	9:54	18.6	119	6.86	1	80	8.15	89.7
C	alcove above bend	7/8	11:08	16.7		8.49			8.76	92.5
		7/16	9:50	17.2	103	6.53	3	72	6.58	70.5
		7/23	10:32	18.5	105	7.89	2	70		
		8/5	10:10	19.5	123	6.7	7	70	5.64	63.1
D	alcove nearest pump	7/8	11:15	17.2		9.93			9.9	106.1
		7/16	10:08	18.3	104	6.81	2	68	6.58	72.4
		7/23	10:40	20.3	107	7.94	1	94		
		8/5	10:25	19.7*	121*	7.31*	5*	75*	7.32*	82.3*
E	Applegate River	7/8	12:07	18.0		8.38			9.1	99.6
		7/16	11:18	20.4	109	7.39	1	70	6.12	70
		7/23	11:15	19.6	107	8.18	1	65		
		8/5	11:06	18.4	118	7.6	2	80	8.64	95.1
F	long alcove, up from trunk	7/8	11:40	19.4		7.61			8.34	93.3
		7/16	10:25	20.0	120	6.45	7	68	7.34	83
		7/23	10:51	20.9	123	7.65	8	80		
		8/5	10:50	21.2	131	6.38	9	70	6.54	75.6
G	Mouth of long alcove	7/8	12:40	20.6		9.15			7.76	88.7
		7/16	11:35	22.1	115	7.53	1	76	6.62	78.2
		7/23	11:27	21.1	114	7.98	3	70		
		8/5	11:40	21.1	122	7.34	1	70	6.66	77
H	Side alcove with gr. Water	7/8	12:50	18.7		8.12			6.74	74.2
		7/16	11:00	20.3	188	7.7	2	72	7.34	83.9
		7/23	11:12	20.9	113	8.06	1	70		
		8/5	11:24	20.5	122	7.17	2	80	6.24	71.3
I	junction of two alcoves	7/8	1:10	21.3*		8.36*			8.21*	95.4*
		7/16	10:42	20.7	115	7.24	2	76	7.64	87.3
		7/23	11:00	21.7	117	7.78	3	80		
		8/5	11:55	21.3	138	7.3	2	85	5.94	69.4
	Overall Average				118		2.7	74		
	Standard Deviation				17		2.4	7		

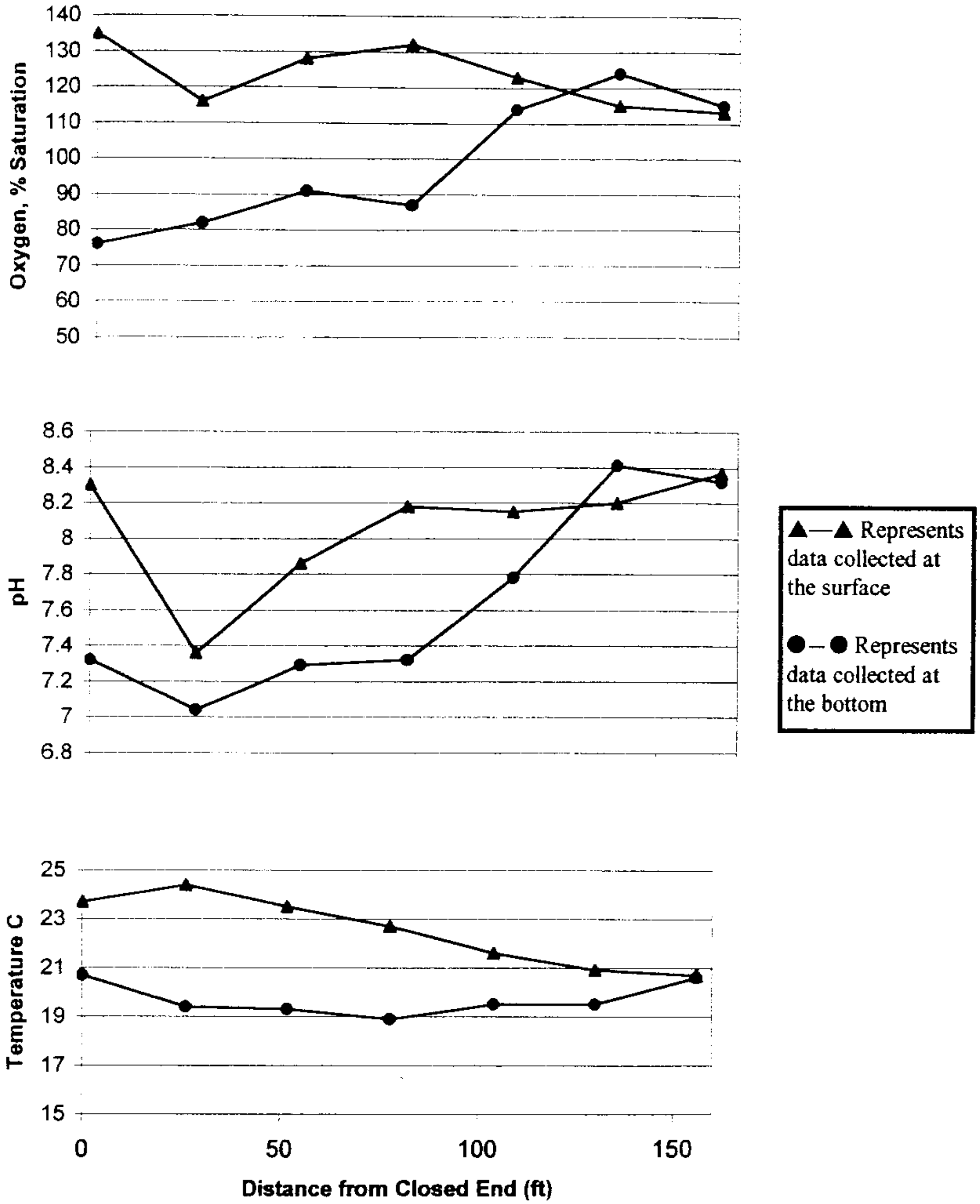
Monitoring Data for the Alcoves. An * indicates the number is the average of two determinations

Site	location	Nitrate mg/L	Phosphate mg/L
A	end of road	0.04* 0.01	0.23* 0.18
B	side channel up from road	0.05 0.02	0.4 0.33
C	alcove above bend	0.03 0.02	0.54 0.74
D	alcove nearest pump	0 0.02*	0.12 0.27*
E	Applegate River	0.03 0.02	0.25 0.4
F	long alcove, up from trunk	0.01 0.01	0.53 0.64
G	Mouth of long alcove	0.03 0.02	0.18 0.52
H	Side alcove with gr. Water	0.06 0.05	0.41 0.66
I	junction of two alcoves	0.01 0	0.23 0.42
	Overall Average	0.02	0.41
	Standard Deviation	0.02	0.19

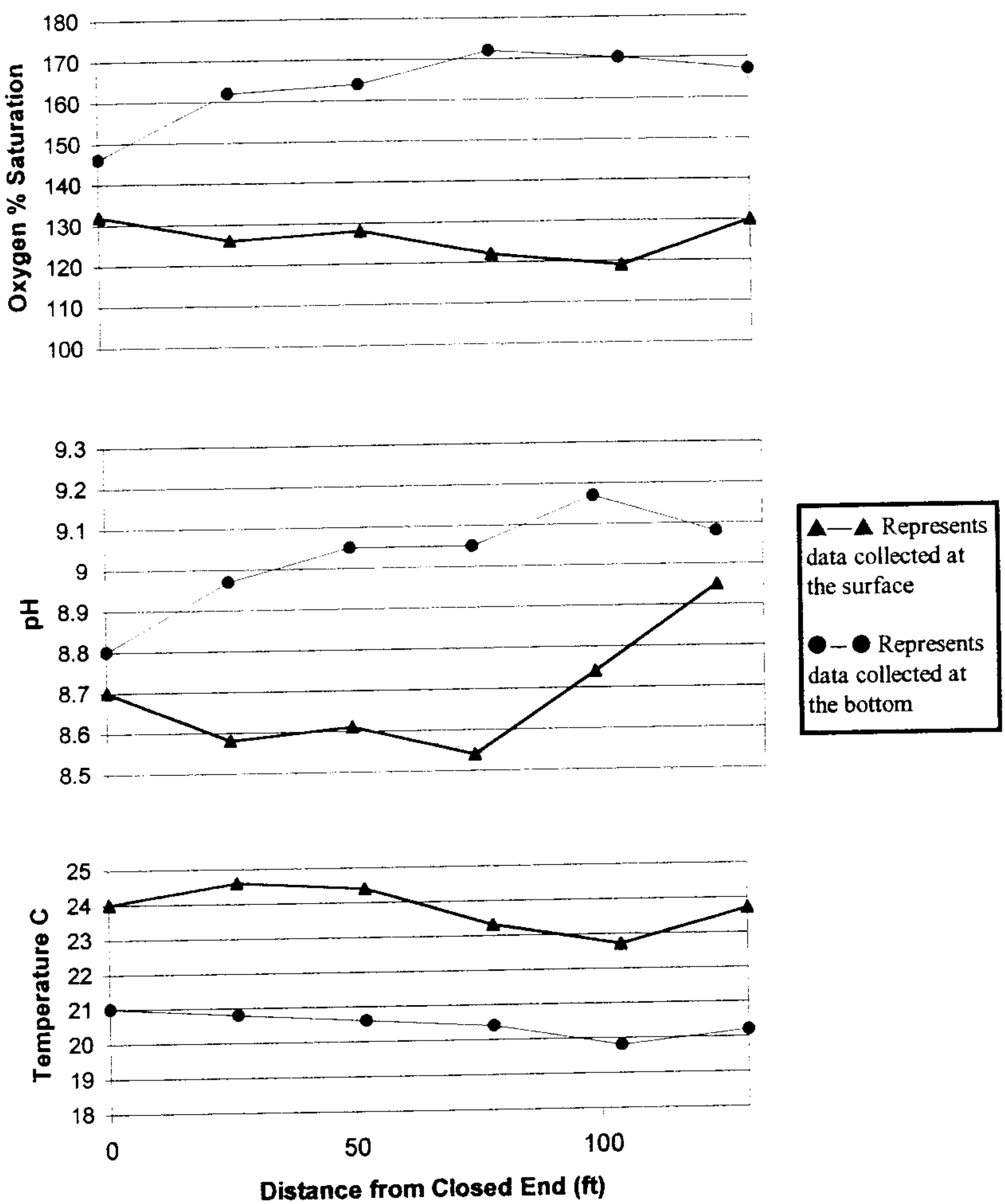
Nutrient Analysis of Water Samples from the Alcoves.
For each monitoring location the top number is data for samples collected on July 23, the lower number is for samples from August 5.
An * indicates the number is the average of two determinations



Relative Elevation of the Monitoring Sites. All sites are relative to the edge of the Mainstem of the Applegate just above Alcove D. The units are in feet.



Longitudinal Chemical Parameters for Alcove C. Data obtained on 8/12/99



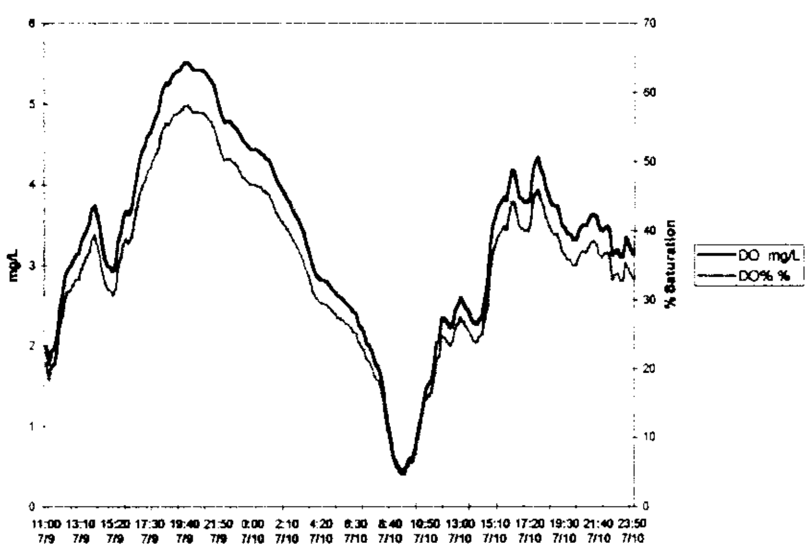
Longitudinal Chemical Parameters for Alcove D. Data obtained on 8/12/99

Alcove	C	D	F
Date	8/12/99	8/12/99	8/5/99
Average Δ T (°C)[1]	3.6	3.3	3.5
Range of T Extremes[2]	19-24	20-25	20-26
Average Δ pH[1]	0.6	-0.4	0.9
Range of pH Extremes[2]	7.0-8.3	8.5-9.2	7.0-10.0
Average Δ % DO[1]	37	-39	115
Range of % DO Extremes[2]	76-135	132-172	19-212

1 Represents surface values minus bottom values.

2 Represents the smallest and largest values. These values may or may not occur at the same point. In determining the range, one value was taken from the surface and the other from the bottom.

A Summary of the Variations in Values of Chemical Parameters Found for the Longitudinal Profiles of Alcoves C, D and F.



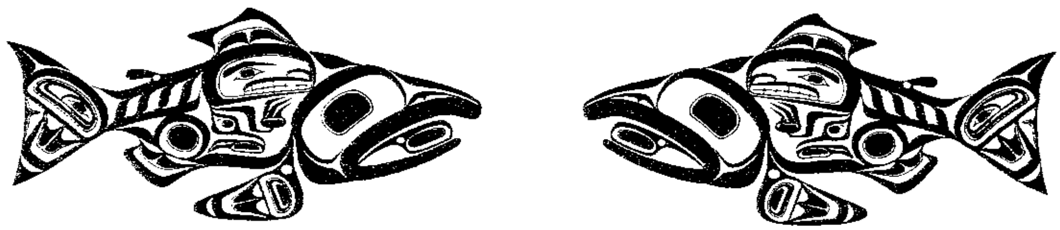
Dissolved oxygen as mg/L and % saturation found in Alcove F.

Date	Parameter	Minimum	Maximum	Mean
10-Jul	pH	7.00	8.25	7.48
	DO, mg/L	0.43	4.44	2.91
	Temp C	17.50	18.00	17.80
11-Jul	pH	6.97	7.76	7.30
	DO, mg/L	0.36	3.52	2.44
	Temp C	17.70	18.20	18.00

Summary of data obtained by the sonde in Alcove F

Appendix C

Little Applegate Streamflow and Habitat Enhancement Monitoring



Little Applegate Streamflow and Habitat Enhancement Project
Monitoring Activities Summary

I. Introduction

The Applegate River Watershed Council together with numerous private and public entities are undertaking a project which changes a point of diversion from the Little Applegate River to the mainstem Applegate River. Pumps and pressurized pipes from the mainstem will replace two diversion structures in the Little Applegate.

The role of the monitoring plan is to identify and quantify the biological and physical effects from the Little Applegate Streamflow and Habitat Enhancement Project (LASHEP) . Key questions raised during project development and project expectations molded the monitoring study. This document outlines the technical evaluations in place to answer those key questions and verify expectations.

Data explanations and investigations are on-going. Therefore, procedures and data summaries, rather than findings and conclusions are presented. Each section contains an issue statement, monitoring tool, and representative data.

It is the hope of this program that information and lessons learned will assist others working on similar projects or confronted with similar issues.

II. Issues and Design

A. Streamflow

Proposition: Streamflows will increase in the lower 3 miles of the Little Applegate River.

In May 2000, a continuous water stage recorder and staff plate were installed near the mouth of the Little Applegate River. The instrument records water surface elevations every 1/2 hour. The staff plate has been "rated", establishing the relationship between water surface elevation and discharge. Together we are able to determine flows for any time period, as well as observationally, via the staff plate. Year 2000 and 2001 data will provide two seasons of low flow record prior to project implementation. Equipment will remain following implementation. The before and after set of information will allow us to quantify flow and yield benefits from the project. Chart 1 compares hydrographs above and below the project location during the 2000 irrigation season. Chart 2 displays the 2000 and 2001 hydrographs near the mouth of the Little Applegate River.

Chart 1 Hydrograph upstream and downstream of project site

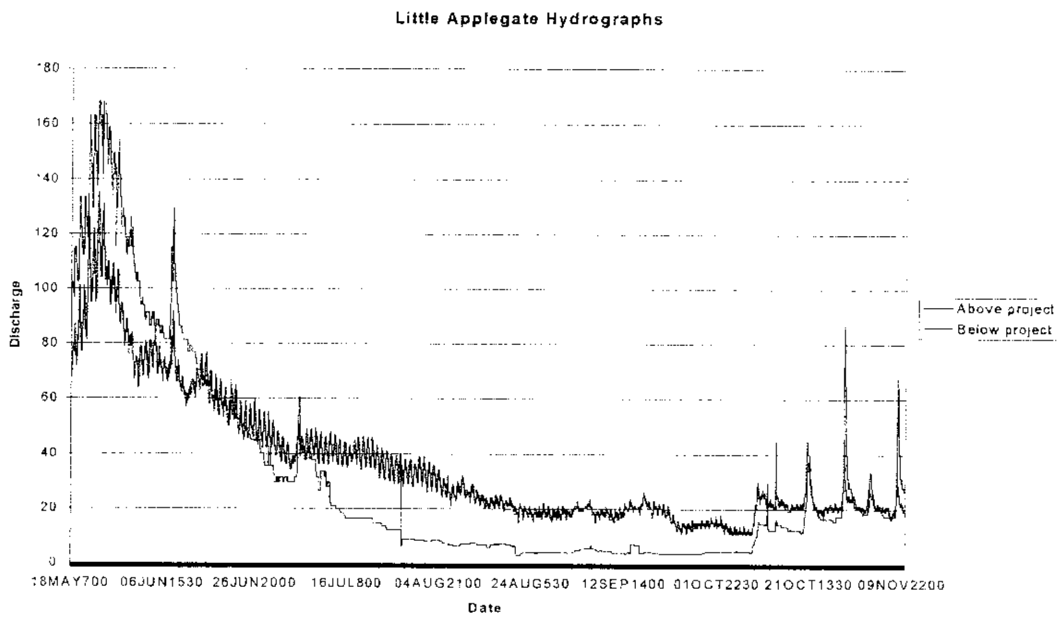
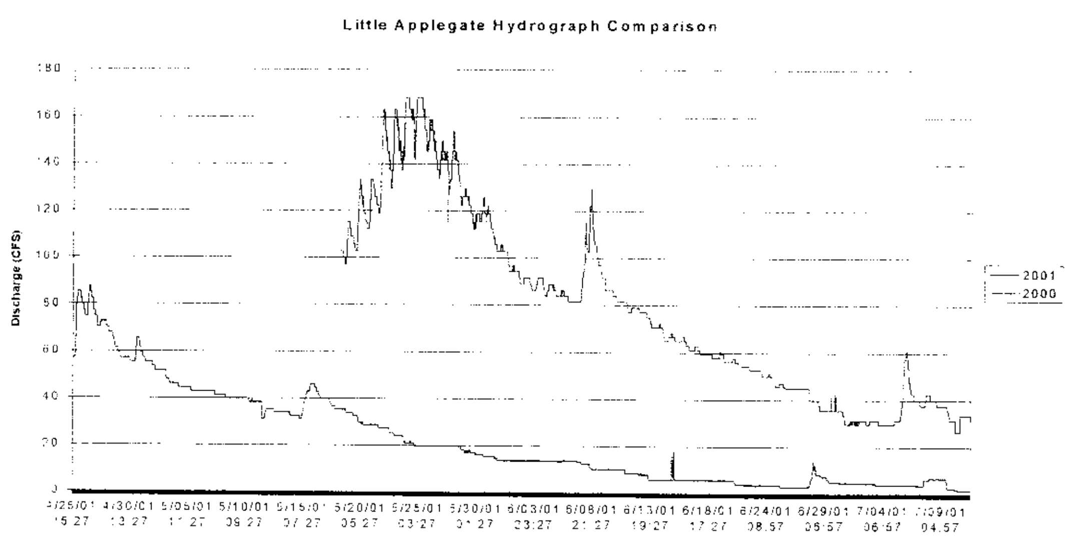


Chart 2 2000 and 2001 hydrographs



B. Fish Habitat

Proposition: Increased streamflows will increase available aquatic habitat.

During the summer of 2000. crews conducted a physical habitat survey from the mouth of the Little Applegate River upstream to Yale Creek. The Protocol followed the Oregon Department of Fish and Wildlife (ODFW) stream habitat survey. The survey provides pool-riffle, width to depth, substrate, instream wood, and riparian vegetation information(see appendix 1). The survey will be repeated following project implementation. The comparison will depict the change in habitat quality and composition.

C. Fish Use and Passage

Proposition: Increased streamflows and the removal of obstructions to fish migration will increase available spawning and rearing habitat.

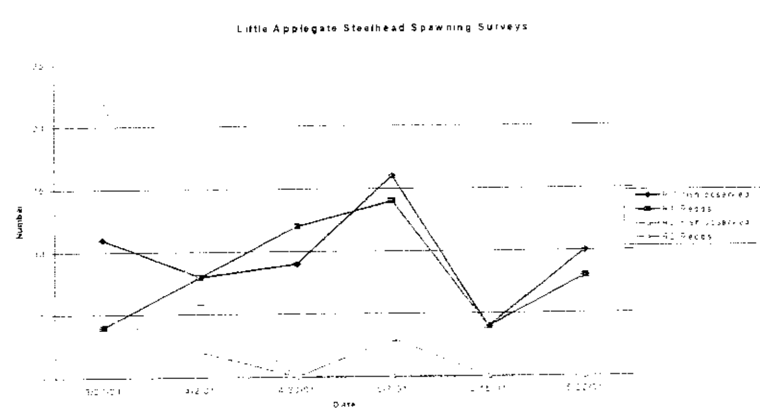
Following the aforementioned ODFW habitat survey, crews snorkeled every fifth pool and every tenth riffle. Appendix 1a presents findings. Fish surveys will be repeated in 2001 and following project implementation.

Additionally, nearly every two weeks in the spring of 2001, field personnel conducted steelhead spawning surveys. The survey followed established ODFW protocols. Five reaches were surveyed and include:

- Farmers Ditch to Buck and Jones Ditch (Reach 1)
- Buck and Jones Ditch to Grouse Creek (Reach 2)
- FS boundary @ RM 14.2 to Waters Gulch (Reach 3)
- Yale Creek @ Mouth to First Waters Gulch
- Yale Creek – Unnamed tributary to Box Canyon

Assembly and collation of data is underway; ergo, all data is not available at this time. Chart 3 displays comparative data between reach 1 and reach 2. The drop in fish observation in reach 2 is attributed to flashboard installation at the Buck and Jones Diversion.

Chart 3 Spawning surveys results of Reach 1 and 2



D. Water Quality

Proposition: Increased streamflows will improve water quality

The Applegate River Watershed Council maintains a very active water quality monitoring program. The program, established seven years ago, tracks water temperature and chemistry in over 25 sites throughout the Applegate. From a water quality perspective, temperature is the most limiting factor to the aquatic system. The lower Little Applegate is consistently one of the warmest stream reaches in the Applegate watershed; every year ranking in the top five reaches in number of days exceeding 17.8 C (temperature harmful to fish) (Table 2).

Table 1 Dissolved Oxygen and pH Summary

Date	Min of pH	Max of pH	delta	Min DO mg/l	Max DO mg/l	delta
24-Aug-00	8.59	8.81	0.22	7.1	11.1	4.0
25-Aug-00	7.97	8.83	0.86	7.1	11.3	4.2
26-Aug-00	7.96	8.81	0.85	7.3	11.0	3.7
27-Aug-00	7.97	8.8	0.83	7.7	10.7	3.0
28-Aug-00	7.98	8.73	0.75	7.8	10.4	2.6
29-Aug-00	7.96	8.7	0.74	7.7	10.1	2.3
30-Aug-00	8.05	8.78	0.73	7.6	11.3	3.7
31-Aug-00	8.02	8.74	0.72	7.7	11.1	3.4
01-Sep-00	8.03	8.73	0.7	8.0	11.6	3.6
02-Sep-00	8.04	8.71	0.67	8.8	11.7	2.9
03-Sep-00	8.05	8.71	0.66	9.0	11.6	2.6
04-Sep-00	8.06	8.43	0.37	9.2	11.5	2.3

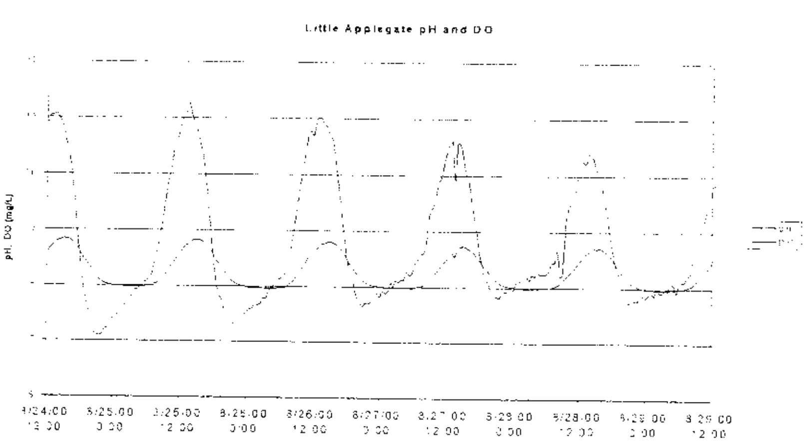
Through our routine grab sample protocol we found no indication of DO problems anywhere in the basin. In 2000, we deployed a continuous dissolved oxygen (DO) and pH probe (Sonde). The sonde data indicated that DO in many streams "bottoms out" between midnight and 6 am. Little Applegate is included in this list (Table 1, Chart 4). Photosynthesis – respiration cycles of algae are responsible for the day-time high and night-time low DO values.

Temperature and water quality data collection continues and will continue following project implementation. The pre- and post-project data will be used to determine how increased flows influence water quality.

Table 2 Temperature Summary

Year	Days >17.8
1997	78
1998	69
1999	72
2000	88

Chart 4 Continuous Dissolved Oxygen and pH

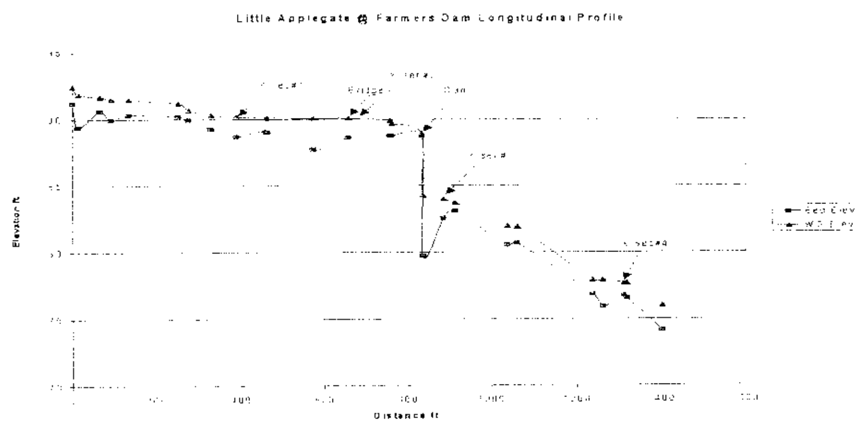


E. Sediment and Channel Morphology

Key Question: How will the removal of two dams, and release of stored sediment, change upstream and downstream channel condition.

To identify changes in channel morphology, pre– project longitudinal and cross sectional profiles were established. The surveys documented water surface and streambed profile elevations above, through, and below Farmer's Dam (Chart 5). Cross sections are indicated on the longitudinal survey. The cross sections detail width, depth and water surface elevations at various flows. Cross sections are also permanently surveyed downstream, near the mouth. The channel bed above the dam will lower in the vicinity of the private bridge shown in chart 5. The destabilization of the bridge abutments is being evaluated.

Chart 5 Longitudinal survey



Surveys will be repeated following project implementation. Comparing the two surveys, ARWC will be able to quantify changes in channel structure due to the release of stored sediment.

Pool filling, by the release of stored sediment, is another sediment related issue. Several pools, spaced between the dam location and the mouth, have been identified. At each pool site, pool-bottom topography was recorded using a grid of cross sections. The surveying of pools through the lower mile is designed to track the movement of sediment downstream. Upstream pools are also being surveyed as a control population. Topographic surveys will be repeated following project implementation to determine level of pool filling.

Appendix 1
Aquatic Habitat Inventory

ODFW AQUATIC INVENTORY PROJECT

STREAM: Little Applegate River
BASIN: Applegate River
DATES: August 9-21, 2000
CREW: David M. Livingston / Stephen Sagmiller
REPORT PREPARED BY: David M. Livingston w/ assistance ODFW Corvallis R&D
STREAM ORDER: 5
BASIN AREA: 300 km^2
USGS MAPS: Ruch, Sterling Creek
ECOREGION: Klamath Siskiyou

GENERAL DESCRIPTION:
The Little Applegate River survey began at the confluence with the Applegate River. The survey proceeded 9.6 km ending at the confluence with Yale Creek. The entire length of the survey is contained within a broad valley with constraining terraces. The land use within this survey is predominately rural residential.

Reach Descriptions:

Reach 1:(T39S-R3W-10NW) Reach 1 begins at the confluence with the Applegate River and ends at the Farmer's Ditch dam. The channel is constrained within a broad valley. The valley width index is > 5. The dominant riparian vegetation is shrub and deciduous (1-3cm DBH) with land use being rural residential. The average gradient is 2.2%. Scour pools comprise the greatest number of habitat type in reach 1. Large woody debris is 1.3m^3 / 100m within this reach.

Reach 2:(T39S-R3W-11SE) Reach 2 begins at the Farmer's Ditch dam and continues to the Buck & Jones Dam. The channel is constrained with in a broad valley. The valley width index is > 5. The dominant riparian vegetation is shrub followed by a deciduous component (3-15cm DBH). The land use is rural residential. The average gradient is 1.3 %. Riffles comprise the greatest number of habitat type in reach 2. Large woody debris is 2.4m^3 / 100m.

Reach 3:(T39S-R3W-13NW) Reach 3 begins at the Buck & Jones dam and continues to the confluence with Sterling Creek. The channel is constrained with in a broad valley. The valley width index is >5. The dominant riparian vegetation is mix of conifer and deciduous (30-50cm DBH) with a shrub under story. Land use is predominately agriculture. The average gradient is 0.5%. Riffles comprise the largest number of habitat type in reach 3. Large woody debris is 10.3m^3 / 100m.

Reach 4:(T39S-R3W-13SE) Reach 4 begins at the confluence of Sterling Creek and ends at Grouse Creek. The valley width index is >5. The dominant riparian vegetation is grass dominant with a sub-dominant deciduous component (1-3cm DBH). Land use is rural residential. Scour pools along with riffles both comprise the greatest number of habitat type in reach 4.

Reach 5: (T39S-R3W-24SE) Reach 5 begins at the confluence with Grouse Creek and ends at the confluence with Yale Creek. The channel is constrained with in a broad valley. The valley to width index is > 5. The dominant riparian vegetation is grass with a sub-dominant component of deciduous (30-50cm DBH). Land use is predominately rural residential. The average gradient is 1.1%. Scour pools comprise the greatest number of habitat types in reach 5. Large woody debris is 3.7m^3 / 100m.

REACH SUMMARY

REACH 1 T39S-R3W-10NW REACH 1

Valley and Channel Summary

Valley Characteristics (Percent Reach Length)

Narrow Valley Floor		Broad Valley Floor	
Steep V-shape	0	Constraining Terraces	100
Moderate V-shape	0	Multiple Terraces	0
Open V-shape	0	Wide Floodplain	0

Valley Width Index avg: 5.0 range: 5.0-5.0

Channel Morphology (Percent Reach Length)

Constrained		Unconstrained	
Hillslope	0	Single Channel	0
Bedrock	0	Multiple Channel	0
Terrace	100	Braided Channel	0
Alt. Terrace/Hill	0		
Landuse	0		

Channel Characteristics

Type	Length(m)	Area (m2)	Dry Units
Primary	2,779	20,396	0
Secondary	122	725	0

Channel Dimensions(m)

Wetted		Active			Floodprone	First Terrace
Width	7.3	Width	9.2		15.4	51.3
Depth	0.67	Height	1.9		3.3	6.3
		W:D ratio	10.1	Entrenchment	8.3	

Stream Flow Type: LF Water Temp: 70.0-70.0°C
Avg. Unit Gradient: 2.2% Habitat Units/100m: 2.9

Riparian, Bank, and Wood Summary

	Primary	Secondary
Land Use:	RR	NU
Riparian Vegetation:	S	D1

Bank Condition and Shade

Bank Status	Percent Reach Length	Shade (% of 180)	
Actively Eroding	0%	Reach avg:	56%
Undercut Banks	0%	Range:	0- 94

Large Woody Debris

	Total	Total/100m
All pieces (≥3m x 0.15m)	116	4.2
Volume (m^3)	36	1.3
Key pieces (≥10m x 0.6m)	0	0.0

REACH SUMMARY

REACH 2 T39S-R3W-11SW REACH 2

Valley and Channel Summary

Valley Characteristics (Percent Reach Length)

Narrow Valley Floor		Broad Valley Floor	
Steep V-shape	0	Constraining Terraces	100
Moderate V-shape	0	Multiple Terraces	0
Open V-shape	0	Wide Floodplain	0

Valley Width Index avg: 5.0 range: 5.0-5.0

Channel Morphology (Percent Reach Length)

Constrained		Unconstrained	
Hillslope	0	Single Channel	0
Bedrock	0	Multiple Channel	0
Terrace	0	Braided Channel	0
Alt. Terrace/Hill	100		
Landuse	0		

Channel Characteristics

Type	Length(m)	Area (m2)	Dry Units
Primary	1,825	17,775	0
Secondary	331	1,107	1

Channel Dimensions(m)

Wetted		Active		Floodprone		First Terrace
Width	8.4	Width	9.1		14.3	283.0
Depth	0.48	Height	0.7		1.4	3.0
		W:D ratio	13.5	Entrenchment	1.7	

Stream Flow Type: LF Water Temp: 58.0-58.0°C
Avg. Unit Gradient: 1.3% Habitat Units/100m: 2.7

Riparian, Bank, and Wood Summary

	Primary	Secondary
Land Use:	RR	ST
Riparian Vegetation:	S	D3

Bank Condition and Shade

Bank Status	Percent Reach Length	Shade (% of 180)	
Actively Eroding	0%	Reach avg:	66%
Undercut Banks	1%	Range:	19-100

Large Woody Debris

	Total	Total/100m
All pieces (≥3m x 0.15m)	108	5.9
Volume (m^3)	44	2.4
Key pieces (≥10m x 0.6m)	1	0.1

REACH SUMMARY

REACH 3 **T39S-R3W-13NW** **REACH 3**

Valley and Channel Summary

Valley Characteristics (Percent Reach Length)

Narrow Valley Floor		Broad Valley Floor	
Steep V-shape	0	Constraining Terraces	100
Moderate V-shape	0	Multiple Terraces	0
Open V-shape	0	Wide Floodplain	0

Valley Width Index avg: ***.* range: 999.0-0.0

Channel Morphology (Percent Reach Length)

Constrained		Unconstrained	
Hillslope	0	Single Channel	0
Bedrock	0	Multiple Channel	0
Terrace	100	Braided Channel	0
Alt. Terrace/Hill	0		
Landuse	0		

Channel Characteristics

Type	Length(m)	Area (m2)	Dry Units
Primary	217	2,586	0
Secondary	156	1,340	0

Channel Dimensions(m)

Wetted		Active		Floodprone		First Terrace
Width	11.6	Width	***.*		***.*	0.0
Depth	0.74	Height	**.*		**.*	0.0
		W:D ratio	***.*	Entrenchment	**.*	

Stream Flow Type: LF Water Temp: 64.0-64.0°C
Avg. Unit Gradient: 0.5% Habitat Units/100m: 2.1

Riparian, Bank, and Wood Summary

	Primary	Secondary
Land Use:	AG	RR
Riparian Vegetation:	M30	S

Bank Condition and Shade

Bank Status	Percent Reach Length	Shade (% of 180)	
Actively Eroding	8%	Reach avg:	75%
Undercut Banks	0%	Range:	53- 81

Large Woody Debris

	Total	Total/100m
All pieces (≥3m x 0.15m)	43	19.8
Volume (m^3)	22	10.3
Key pieces (≥10m x 0.6m)	0	0.0

REACH SUMMARY

REACH 4 T39S-R3W-13SE **REACH 4**

Valley and Channel Summary

Valley Characteristics (Percent Reach Length)

Narrow Valley Floor		Broad Valley Floor	
Steep V-shape	0	Constraining Terraces	0
Moderate V-shape	0	Multiple Terraces	0
Open V-shape	0	Wide Floodplain	0

Valley Width Index avg: 5.0 range: 5.0-5.0

Channel Morphology (Percent Reach Length)

Constrained		Unconstrained	
Hillslope	0	Single Channel	0
Bedrock	0	Multiple Channel	0
Terrace	0	Braided Channel	0
Alt. Terrace/Hill	0		
Landuse	0		

Channel Characteristics

Type	Length(m)	Area (m2)	Dry Units
Primary	0	0	0
Secondary	1,174	11,450	0

Channel Dimensions(m)

Wetted		Active		Floodprone		First Terrace
Width	10.3	Width	10.6		47.0	216.7
Depth	0.50	Height	0.8		1.6	1.8
		W:D ratio	13.3	Entrenchment	4.5	

Stream Flow Type: LF Water Temp: 55.0-55.0°C
Avg. Unit Gradient: **.*% Habitat Units/100m: 2.0

Riparian, Bank, and Wood Summary

	Primary	Secondary
Land Use:	RR	NU
Riparian Vegetation:	G	D1

Bank Condition and Shade

Bank Status	Percent Reach Length	Shade (% of 180)	
Actively Eroding	0%	Reach avg:	70%
Undercut Banks	0%	Range:	21-100

Large Woody Debris

	Total	Total/100m
All pieces (≥3m x 0.15m)	54	***.*
Volume (m^3)	22	***.*
Key pieces (≥10m x 0.6m)	0	0.0

REACH SUMMARY

REACH 5 T39S-R3W-24SE **REACH 5**

Valley and Channel Summary

Valley Characteristics (Percent Reach Length)

Narrow Valley Floor		Broad Valley Floor	
Steep V-shape	0	Constraining Terraces	100
Moderate V-shape	0	Multiple Terraces	0
Open V-shape	0	Wide Floodplain	0

Valley Width Index avg: 5.0 range: 5.0-5.0

Channel Morphology (Percent Reach Length)

Constrained		Unconstrained	
Hillslope	0	Single Channel	0
Bedrock	0	Multiple Channel	0
Terrace	100	Braided Channel	0
Alt. Terrace/Hill	0		
Landuse	0		

Channel Characteristics

Type	Length(m)	Area (m2)	Dry Units
Primary	3,493	26,543	0
Secondary	546	4,918	0

Channel Dimensions(m)

Wetted		Active			Floodprone	First Terrace
Width	7.4	Width	9.3		16.7	211.4
Depth	0.60	Height	0.9		1.7	3.9
		W:D ratio	11.2	Entrenchment	1.8	

Stream Flow Type: LF Water Temp: 60.0-60.0°C
Avg. Unit Gradient: 1.1% Habitat Units/100m: 2.7

Riparian, Bank, and Wood Summary

	Primary	Secondary
Land Use:	RR	NU
Riparian Vegetation:	G	D30

Bank Condition and Shade

Bank Status	Percent Reach Length	Shade (% of 180)	
Actively Eroding	0%	Reach avg:	75%
Undercut Banks	2%	Range:	8-100

Large Woody Debris

	Total	Total/100m
All pieces (≥3m x 0.15m)	182	5.2
Volume (m^3)	129	3.7
Key pieces (≥10m x 0.6m)	1	0.0

HABITAT UNIT SUMMARY

REACH 1 T39S-R3W-10NW REACH 1

HABITAT DETAIL

Habitat Type	Number Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Total Area (m^2)	Large Boulders (#>0.5m)	Substrate Percent Wetted Area S/O	Snd	Grvl	Cbbl	Bldr	Bdrk
CASCADE/BEDROCK	4	61	4.4	0.30	245	2	1	2	4	4	13	77
GLIDE	1	24	10.0	0.30	242	3	2	26	34	13	9	17
POOL-DAMMED	3	71	10.7	1.07	859	4	3	15	14	16	26	26
POOL-LATERAL SCOUR	8	293	6.7	1.03	2,057	17	2	21	22	21	3	31
POOL-PLUNGE	2	42	12.9	1.65	539	5	20	29	6	5	3	37
POOL-STRAIGHT SCOUR	24	827	7.3	0.87	5,881	31	2	23	18	16	6	35
POOL-TRENCH	4	205	5.6	1.03	1,274	4	2	18	17	10	3	50
RAPID/BOULDERS	1	24	5.8	0.30	140	40	5	25	25	25	20	0
RIFFLE	25	1,069	7.3	0.37	7,909	485	1	18	21	24	14	21
RIFFLE W/ POCKETS	8	229	7.8	0.31	1,810	66	1	19	28	18	10	23
STEP/BEDROCK	1	50	2.5	1.20	125	0	0	0	5	5	0	90
STEP/STRUCTURE	2	4	8.8	0.40	39	0	0	0	0	8	93	0
Total:	83	2,900	7.3	0.67	21,121	657	**Avg:** 2	19	19	18	11	31

HABITAT SUMMARY

Habitat Group	No. Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Wetted Area (m^2)	Wetted Area Percent	Large Boulders Number	Large Boulders #/100m^2
Dammed & BW Pools	3	71	10.7	1.07	859	4.07	4	0.5
Scour Pools	38	1,367	7.3	0.96	9,751	46.17	57	0.6
Glides	1	24	10.0	0.30	242	1.15	3	1.2
Riffles	33	1,298	7.4	0.36	9,719	46.02	551	5.7
Rapids	1	24	5.8	0.30	140	0.66	40	28.5
Cascades	4	61	4.4	0.30	245	1.16	2	0.8
Step/Falls	3	54	6.7	0.67	164	0.78	0	0.0
Dry	0	0	-	-	0	0.00	0	0.0

POOL SUMMARY

	Total	#/Km
All Pools	41	14.1
Pools ≥1m deep:	16	5.5
Complex pools (LWD pieces≥3):	7	2.4
Pool Frequency (channel widths/pool):	10.2	
Residual pool depth (avg)	0.71m	

HABITAT UNIT SUMMARY

REACH 2 T39S-R3W-11SW REACH 2

HABITAT DETAIL

Habitat Type	Number Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Total Area (m^2)	Large Boulders (#>0.5m)	Substrate Percent Wetted Area S/O	Snd	Grvl	Cbbl	Bldr	Bdrk
CASCADE/BEDROCK	6	143	6.3	0.41	638	20	0	3	5	1	5	86
DRY UNITS	1	28	3.3	0.10	93	4	0	0	20	60	5	15
POOL-DAMMED	2	142	13.4	1.05	1,912	6	2	41	41	10	5	0
POOL-LATERAL SCOUR	5	208	9.7	0.94	2,245	14	1	36	30	17	7	8
POOL-STRAIGHT SCOUR	17	613	8.0	0.66	5,128	35	0	20	32	22	4	22
RAPID/BEDROCK	1	45	5.0	0.30	225	7	0	11	11	0	22	56
RIFFLE	22	867	8.7	0.24	7,895	124	1	11	31	37	13	6
RIFFLE W/ POCKETS	3	109	6.5	0.52	741	52	0	28	23	18	15	17
STEP/STRUCTURE	1	0	16.7	0.00	5	0	0	0	0	0	0	0
Total:	58	2,156	8.4	0.48	18,882	262	**Avg:** 1	17	27	24	9	21

HABITAT SUMMARY

Habitat Group	No. Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Wetted Area (m^2)	Wetted Area Percent	Large Boulders Number	Large Boulders #/100m^2
Dammed & BW Pools	2	142	13.4	1.05	1,912	10.12	6	0.3
Scour Pools	22	821	8.4	0.73	7,373	39.05	49	0.7
Glides	0	0	-	-	0	0.00	0	0.0
Riffles	25	976	8.4	0.27	8,636	45.73	176	2.0
Rapids	1	45	5.0	0.30	225	1.19	7	3.1
Cascades	6	143	6.3	0.41	638	3.38	20	3.1
Step/Falls	1	0	16.7	0.00	5	0.03	0	0.0
Dry	1	28	3.3	0.10	93	0.49	4	4.3

POOL SUMMARY

	Total	#/Km
All Pools	24	11.1
Pools ≥1m deep:	5	2.3
Complex pools (LWD pieces≥3):	5	2.3
Pool Frequency (channel widths/pool):	9.8	
Residual pool depth (avg)	0.53m	

HABITAT UNIT SUMMARY

REACH 3 T39S-R3W-13NW REACH 3

HABITAT DETAIL

Habitat Type	Number Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Total Area (m^2)	Large Boulders (#>0.5m)	Substrate Percent Wetted Area S/O	Snd	Grvl	Cbbl	Bldr	Bdrk
POOL-DAMMED	1	167	12.5	1.70	2,084	3	5	30	20	35	10	0
POOL-STRAIGHT SCOUR	2	50	11.7	0.65	610	0	1	35	7	24	7	25
RIFFLE	4	156	9.5	0.30	1,230	19	0	8	25	43	9	14
STEP/STRUCTURE	1	0	19.2	1.70	2	0	0	0	0	0	0	0
Total:	8	373	11.6	0.74	3,925	22	**Avg:** 1	17	17	32	8	13

HABITAT SUMMARY

Habitat Group	No. Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Wetted Area (m^2)	Wetted Area Percent	Large Boulders Number	Large Boulders #/100m^2
Dammed & BW Pools	1	167	12.5	1.70	2,084	53.09	3	0.1
Scour Pools	2	50	11.7	0.65	610	15.54	0	0.0
Glides	0	0	-	-	0	0.00	0	0.0
Riffles	4	156	9.5	0.30	1,230	31.33	19	1.5
Rapids	0	0	-	-	0	0.00	0	0.0
Cascades	0	0	-	-	0	0.00	0	0.0
Step/Falls	1	0	19.2	1.70	2	0.05	0	0.0
Dry	0	0	-	-	0	0.00	0	0.0

POOL SUMMARY

	Total	#/Km
All Pools	3	8.1
Pools ≥1m deep:	1	2.7
Complex pools (LWD pieces≥3):	2	5.4
Pool Frequency (channel widths/pool):	***.*	

Residual pool depth (avg) 0.82m

HABITAT UNIT SUMMARY

REACH 4 **T39S-R3W-13SE** **REACH 4**

HABITAT DETAIL

Habitat Type	Number Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Total Area (m^2)	Large Boulders (#>0.5m)	Substrate Percent Wetted Area S/O	Snd	Grvl	Cbbl	Bldr	Bdrk
CASCADE/BOULDERS	1	20	9.2	0.40	184	19	0	0	10	20	40	30
POOL-DAMMED	1	68	13.3	1.20	908	0	5	38	43	14	0	0
POOL-LATERAL SCOUR	1	28	20.8	0.65	589	0	0	20	25	35	20	0
POOL-STRAIGHT SCOUR	10	346	9.8	0.65	3,730	24	0	13	24	30	12	21
RIFFLE	11	712	9.6	0.29	6,039	90	0	10	20	38	19	13
Total:	24	1,174	10.3	0.50	11,450	133	**Avg:** 0	12	22	33	16	16

HABITAT SUMMARY

Habitat Group	No. Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Wetted Area (m^2)	Wetted Area Percent	Large Boulders Number	Large Boulders #/100m^2
Dammed & BW Pools	1	68	13.3	1.20	908	7.93	0	0.0
Scour Pools	11	374	10.8	0.65	4,319	37.72	24	0.6
Glides	0	0	-	-	0	0.00	0	0.0
Riffles	11	712	9.6	0.29	6,039	52.74	90	1.5
Rapids	0	0	-	-	0	0.00	0	0.0
Cascades	1	20	9.2	0.40	184	1.61	19	10.3
Step/Falls	0	0	-	-	0	0.00	0	0.0
Dry	0	0	-	-	0	0.00	0	0.0

POOL SUMMARY

	Total	#/Km
All Pools	12	10.2
Pools ≥1m deep:	3	2.6
Complex pools (LWD pieces≥3):	3	2.6
Pool Frequency (channel widths/pool):	9.3	
Residual pool depth (avg)	0.43m	

HABITAT UNIT SUMMARY

REACH 5 T39S-R3W-24SE REACH 5

HABITAT DETAIL

Habitat Type	Number Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Total Area (m^2)	Large Boulders (#>0.5m)	Substrate Percent Wetted Area S/O	Snd	Grvl	Cbbl	Bldr	Bdrk
CASCADE/BEDROCK	7	117	7.5	0.46	951	27	0	4	4	6	19	68
DEBRIS JAM	1	121	3.3	0.05	399	0	0	15	30	30	25	0
POOL-ALCOVE	1	4	3.3	0.75	14	0	0	55	10	35	0	0
POOL-DAMMED	3	140	5.8	0.78	773	1	2	24	30	35	8	0
POOL-ISOLATED	1	8	2.5	0.50	21	0	20	80	0	0	0	0
POOL-LATERAL SCOUR	7	185	6.1	0.99	1,114	4	0	23	23	22	11	22
POOL-PLUNGE	3	87	10.5	1.27	887	15	0	13	30	11	14	32
POOL-STRAIGHT SCOUR	40	1,616	8.1	0.81	14,734	94	0	21	25	25	11	18
POOL-TRENCH	1	18	2.1	0.60	37	0	0	5	5	0	0	90
RAPID/BEDROCK	2	48	3.4	0.38	147	5	0	8	12	28	34	18
RAPID/BOULDERS	1	29	9.2	0.30	269	30	0	11	21	26	37	5
RIFFLE	35	1,621	7.1	0.30	11,741	477	0	13	20	29	24	13
RIFFLE W/ POCKETS	1	33	8.3	0.45	276	20	0	15	5	40	40	0
STEP/BEDROCK	4	12	7.3	0.24	89	7	0	1	0	4	5	90
STEP/STRUCTURE	3	1	10.0	1.00	11	0	0	0	0	0	0	0
Total:	110	4,039	7.4	0.60	31,462	680	**Avg:** 0	16	20	23	16	22

HABITAT SUMMARY

Habitat Group	No. Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Wetted Area (m^2)	Wetted Area Percent	Large Boulders Number	Large Boulders #/100m^2
Dammed & BW Pools	5	153	4.7	0.72	808	2.57	1	0.1
Scour Pools	51	1,905	7.9	0.85	16,771	53.31	113	0.7
Glides	0	0	-	-	0	0.00	0	0.0
Riffles	36	1,654	7.1	0.30	12,017	38.20	497	4.1
Rapids	3	77	5.3	0.35	416	1.32	35	8.4
Cascades	7	117	7.5	0.46	951	3.02	27	2.8
Step/Falls	7	13	8.5	0.56	100	0.32	7	7.0
Dry	0	0	-	-	0	0.00	0	0.0

POOL SUMMARY

	Total	#/Km
All Pools	56	13.9
Pools ≥1m deep:	16	4.0
Complex pools (LWD pieces≥3):	10	2.5
Pool Frequency (channel widths/pool):	7.8	
Residual pool depth (avg)	0.60m	

STREAM SUMMARY **LITTLE APPLEGATE**

Number Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Total Area (m^2)	Substrate Percent Wetted Area S/O	Sand	Grvl	Cbbl	Bldr	Bdrk	Total Large Boulder
283	10,641	7.9	0.59	86,841	1	17	21	23	13	23	1,754

Habitat Group	Wetted Area (m^2)	Percent
Scour Pool	38,825	44.7
Backwater Pools	6,571	7.6
Glide	242	0.3
Riffle	37,641	43.3
Rapid	781	0.9
Cascade	2,018	2.3
Step	271	0.3
Dry	93	0.1

Appendix 1a
Little Applegate Fish Survey

Little Applegate Fish Survey Data

Survey Date: August 9-21, 2000

REACH	HABITAT TYPE	SPECIES	AGE CLASS 0	1+	2+	3+
1	SP5	ONMY	16	3	6	
		ONTS	1			
	SP10	ONMY	120	7		
		ONTS	4			
	R10	ONMY	40			
	SP15	ONMY	55	3	1	
		ONTS	1			
	SP20	ONMY	90	5	2	4
		ONTS	2			
	R20	ONMY	90			
		ONTS	3			
	SP25	ONMY	70	7	1	
		ONTS	3			
	SP30	ONMY	140	4	3	1
	R30	ONMY	5			
	SP35	ONMY	100	20	8	3
		ONTS	6			
	SP40	ONMY	100	50	20	5
		ONTS	3			
		ONKI	1			
2	SP45	ONMY	35	10	15	1
	R40	ONMY	50	12	2	
	SP50	ONMY	35	30	12	1
	SP55	ONMY	20	20	15	
	R50	ONMY	20	7	5	
	P60	ONMY	20	20	2	
	R60	ONMY	40			
	SP65	ONMY	35	7	3	
	R70	ONMY	20	7	2	1
3	SP70	ONMY	50	20	10	1
4	SP75	ONMY	35	5	2	
	R80	ONMY	15	5	2	
	SP80	ONMY	45	15	2	
5	P85	ONMY	113	20	8	
	R90	ONMY	100	3	4	
	P95	ONMY	32	6	12	1
	R100	ONMY	12	12	2	1
	P100	ONMY	17	4	1	
	P105	ONMY	35	15	10	5
	P110	ONMY	17	10	35	8
	R110	ONMY	56	25	7	
	P115	ONMY	15	25	5	4
	P120	ONMY	30	13	3	
	R120	ONMY	35	16	4	
	P125	ONMY	160	45	17	4
	P130	ONMY	47	27	5	
	R130	ONMY	29	15	7	1

Reach Totals

Reach	ONMY 0	ONMY 1+	ONMY 2+	ONMY 3+	ONTS 0	ONKI 0
1	826	99	41	13	23	1
2	275	113	56	3		
3	50	20	10	1		
4	95	25	6			
5	698	236	120	24		

Key

Species

ONMY	Steelhead/Rainbow Trout
ONTS	Chinook Salmon
ONKI	Coho Salmon

Age Class

0	< 1 year old; length= 1-3"
1+	~ 1 year old; length= 3-6"
2+	~2 years old; length=6-8"
3+	~3 years old; length >8"

Sizes vary depending on local conditions

OREGON 319 PROGRAM *MIDYEAR/FINAL REPORT*			
Project name: All Season Monitoring	***Project Number: OR-99-35-319***	***DEQ Contract No. 149-99***	***Amendment No.***
Contractor: Applegate River Watershed Council			

Start Date: 6/99 **End Date:** 12/31/00 **Date of report**: 1/12/01

Reporting Period: 6/99-12/31/01

Abstract

The Applegate River Watershed Council's monitoring program has collected water quality data since 1997. Monitoring activities include temperature, turbidity, conductivity, pH, DO, and nutrients. Thirty sites have been monitored bi-weekly. A network of volunteers has been established across the Applegate Valley to collect turbidity samples during rain events throughout the winter/spring months. The program also tracks project effectiveness of riparian restoration in feedlots.

Project Status

Two years of summer water quality data, on thirty sites, have been completed during the report period. Turbidity, with the help of numerous volunteers, has been collected over the last two winters. Water quality monitoring capturing flows from the feedlots on Forest and Bishop Creeks was completed. In 1999 and 2000, a continuous multi-parameter water quality instrument was placed in several locations to monitor diurnal and season changes in DO, pH and temperature.

Permanent cross sections on Forest and Bishop creeks riparian planting sites have been established. Baseline channel geometry, and shade values were recorded. The sites will be revisited each year to quantify changes in shade, water quality and channel condition.

DEQ Contact Brad Prior **Phone** 541-776-6010x242

Project Contact Mike Mathews

Status of planned outputs and milestones for this report period based on tasks in workplan

1. **PLANNED:** Establish a network of volunteers to collect turbidity samples throughout the year.
STATUS: A coordinated network of volunteers has been established. Twenty volunteers covered over 30 sites. Sample bottles are mailed to each volunteer complete with a self-addressed, postage paid envelope. Samples were mailed to our lab for processing. Sampling occurred on a time schedule and during rain events (when turbidity is likely highest). The two-year project will again be initiated in early winter. **Attachment A** – *Winter turbidity* includes findings and data summary.

2. **PLANNED:** Water Quality monitoring in the Applegate

STATUS: Since 1997 Applegate River Watershed Council (ARWC) has monitored water quality throughout the Applegate Valley. Water quality attributes include dissolved oxygen, alkalinity, conductivity, pH, temperature, and turbidity. In 1999 and 2000 ARWC deployed a multiparameter continuous monitoring device (Sonde) at several locations. The Sonde continuously recorded pH, dissolved oxygen, and temperature. These parameters undergo a diurnal cycle of which the extremes can stress salmonids and other aquatic life. **Attachment B** — *Water quality in the Applegate* includes findings and data summary.

PLANNED: Conduct project effectiveness monitoring at riparian planting sites on Forest and Bishop Creeks. Track water quality on Forest and Bishop Creeks.
STATUS: Water quality monitoring capturing flows from Forest and Bishop Creeks have been completed. Permanent cross sections on Forest and Bishop creeks have been established. Baseline channel geometry and shade values were recorded. The sites will be revisited each year to quantify changes in shade, water quality and channel condition. **Attachment C** — *Riparian Monitoring* includes findings and data summary.

Additional Information

Support information, such as maps, photographs, notices of meetings, etc.
Data, cross section profiles, and charts are included in the Appendices.

Evaluation of Project Implementation and Effectiveness TO DATE

On-the-ground Protection Improvement (if applicable): Water quality and turbidity data collected over the last two years is very useful in directing future data collection efforts. The data also identified high priority areas for ARWC's restoration program.

Public Involvement and Education (if applicable): Numerous volunteers assisted with turbidity and discharge collection. Through these efforts, volunteers gained a basic understanding of watershed processes and conditions. The data results and findings have been presented to the public and land management agencies.

Research (if applicable):

Monitoring (if applicable): Monitoring procedures and locations have been established for riparian planting sites. Determining project effectiveness will require consecutive years of monitoring; hence, effectiveness of project not yet known.

Institutionalization (if applicable):

Possible Improvements:

The monitoring program examines the physical (channel geometry), the chemical (nutrients), and the biological components of the basin. In 1999, continuous water quality data supplemented our grab sample program. The continuous data indicate large diurnal fluctuations, which is missed with routine grab samples (details in Attachment B). In the future, an increase in continuous data will improve our understanding of water quality cycles and the mechanisms driving water quality.

Success of riparian planting will not be known for several years. Therefore, possible improvements have not been identified.

ATTACHMENT A

Winter Turbidity

Prepared by
Applegate River Watershed Council
6941 Upper Applegate Rd
Jacksonville, OR 97503


I. Introduction

Sediment is a natural component of streambeds. However, excessive sediment can fill pore spaces between gravels and cobbles. Salmon lay their eggs in gravel, and salmon fry hide and feed in these spaces. Insects and insect larvae also live here and provide food for fish. Large increases in sediment can impair or eliminate fish and aquatic macroinvertebrate habitat and can even alter the structure of the stream.

In winter and spring, rains and snowmelt introduce new sediment into streams, and high stream flows mobilize instream sediment. In summer, the most likely causes of increased turbidity are human activities or animal disturbances.

In 1998, the Applegate River Watershed Council (ARWC) established a network of volunteers to monitor stream turbidity. The suspended fines that constitute turbidity may move some distance before settling. Therefore, turbidity can reveal zones of active upslope erosion. Applegate Basin volunteers collected monthly samples during fall, winter, and spring and during exceptionally high flow events. There were twenty volunteers in 1998-2001 who monitored over thirty sites (Figure 1). Although the grant expired in November of 2000, the volunteer turbidity program will continue through, at least, the winter of 2000-2001. Samples are mailed to ARWC for determination of turbidity. In addition, ARWC staff collected samples from areas not covered by volunteers.

The data are reported in Nephelometric Turbidity Units (NTU). The Oregon Watershed Enhancement Board recommends 50 NTU as the upper level for fish bearing streams. Turbidity above 50 NTU is not lethal for fish but can impair sight feeding and small particles may damage gill tissue.

II. Discussion

Turbidity values are driven by rain intensity and stream flows. Chart 2, displays turbidity values and date for winter '99-'00. Three distinct storms are evident (November 20-23rd, January 19-22nd, February 6-7th). The November storm was associated with the highest precipitation intensity at 4.44 inches, but the event generated the lowest discharge. The January storm had a precipitation intensity of 2.05 inches, but generated the highest flows. The February storm had a precipitation intensity of 1.21 inches and fell between the November and January storm in discharge generation. Turbidity values in 1999 (chart 4) were considerably lower. In 1999, both rainfall intensity and discharge values were below those observed in 1998.

Due to the variability of sedimentation and transport, caution should be used in interpreting turbidity data. The high flows that scour out fines and the rains that bring sediment in from roads, cultivated fields and other disturbed areas are uneven with respect to time and space. Nonetheless, with a sufficient number of samples from each site and a few storms to track, our data provide some quite useful information.

From the collected data, the Little Applegate River and Williams Creek, major tributaries of the Applegate River, carry high loads of suspended sediment during peak flow events. The Little Applegate River seems to be the most turbid. Our data serve to show that the Little Applegate River has high turbidity for as far up as river mile 13. Yale Creek, a major tributary, is as turbid as the Little Applegate, while another major tributary, Sterling Creek, is relatively clean. Grouse Creek, which is quite small, runs clean.

In the Williams Basin, the East and West Fork turbidity values were nearly equally, but are slightly less turbid than the mainstem. Munger Creek is a clean stream.

Thompson Creek was quite turbid in 1998 during the November and February storms. This stream was not sampled during the January storm. Slate Creek remained relatively clean at all times. Both these streams are important anadromous spawning tributaries of the Applegate River.

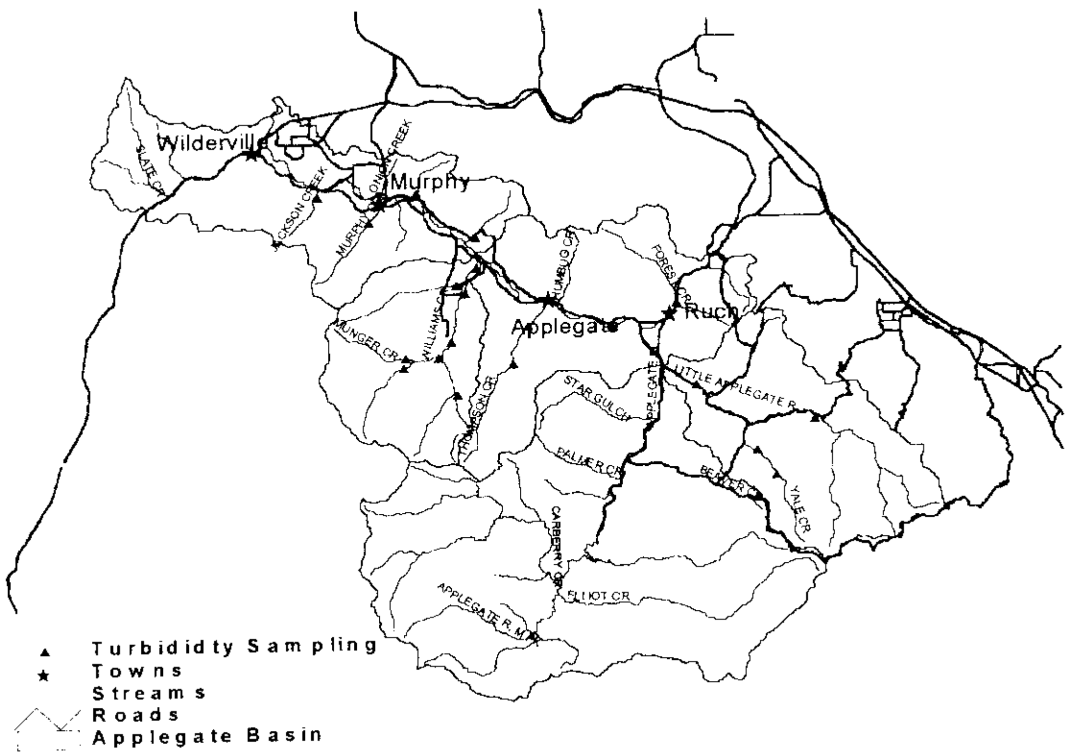
What Next...

One of the goals of monitoring is to enable us to locate areas where restoration projects could have maximum benefit. Preliminary findings point to high priority subbasins needing further investigation. With more detailed and refined data combined with existing assessments, it will be possible to localize sediment sources, enabling us to pinpoint project sites.

In the winter of 2000-2001, based on past turbidity findings, ARWC will focus sediment studies in the Little Applegate River and Williams Creek basins. Four sites, in both the Little Applegate and Yale creeks, will be monitored for suspended sediment. Depth integrated suspended sediment sampling will allow us to identify geographic areas contributing the greatest amount of sediment. The information will be used as a monitoring tool for the Pilot Integration Team (PIT) and for restoration prioritization.

In the East Fork of Williams creek, a combination of road inventories, turbidity measurements, and suspended sediment measurements will further help us identify sediment sources.

Figure 1


Wilderville
Murphy
Applegate
Ruch
SLATE CR
ONION CREEK
MUNGER CR
STAR GULCH
PALMER CR
LITTLE APPLEGATE R
YALE CR
CARBERRY CR
ELLIOT CR
Turbididty Sampling
Towns
Streams
Roads
Applegate Basin

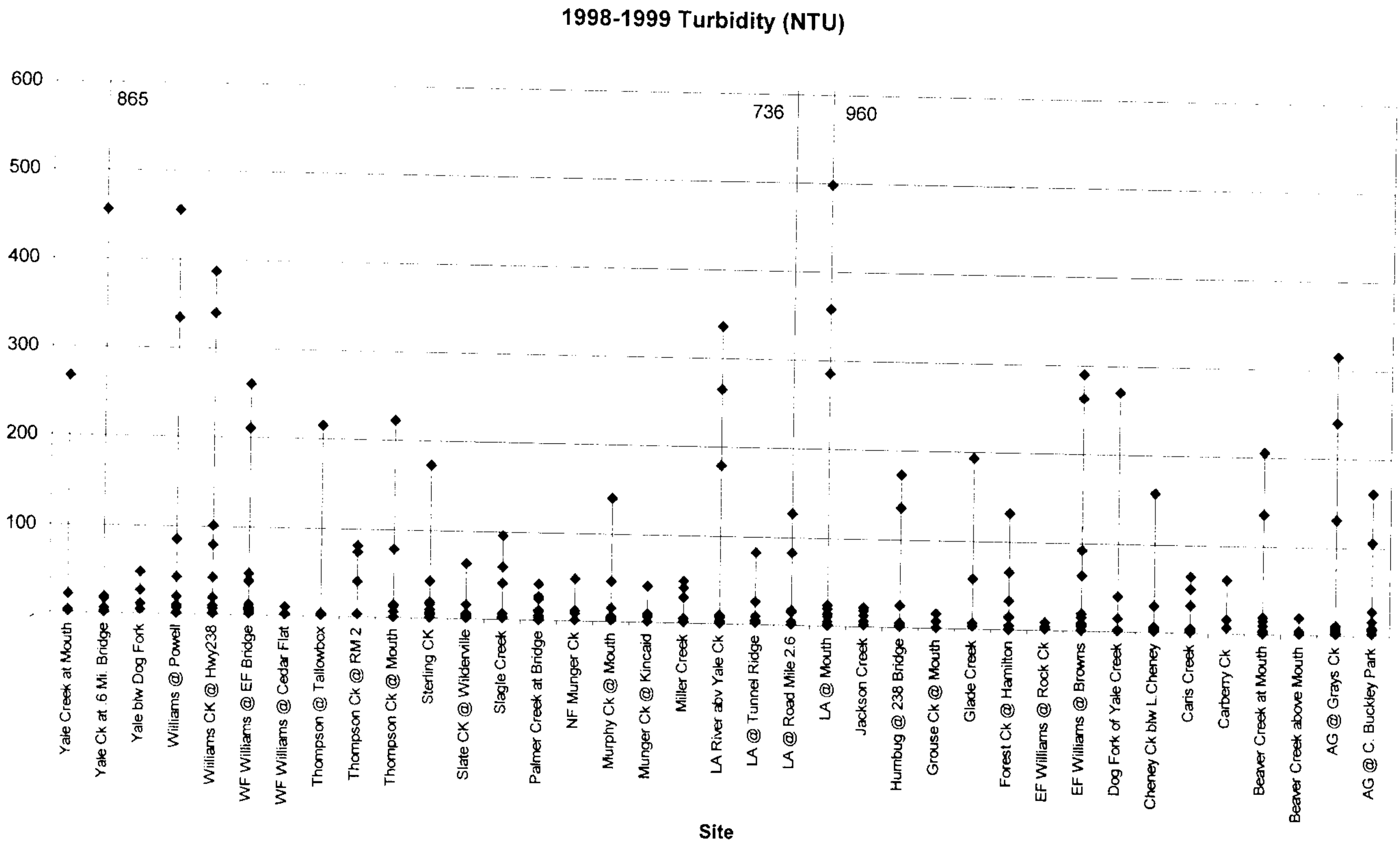

1998-1999 Turbidity (NTU)
600
500
400
300
200
100
865
736
960
Yale Creek at Mouth
Yale Ck at .6 Mi. Bridge
Yale blw Dog Fork
Williams @ Powell
Williams CK @ Hwy238
WF Williams @ EF Bridge
WF Williams @ Cedar Flat
Thompson @ Tallowbox
Thompson Ck @ RM 2
Thompson Ck @ Mouth
Sterling CK
Slate CK @ Wilderville
Slagle Creek
Palmer Creek at Bridge
NF Munger Ck
Murphy Ck @ Mouth
Munger Ck @ Kincaid
Miller Creek
LA River abv Yale Ck
LA @ Tunnel Ridge
LA @ Road Mile 2.6
LA @ Mouth
Jackson Creek
Humbug @ 238 Bridge
Grouse Ck @ Mouth
Glade Creek
Forest Ck @ Hamilton
EF Williams @ Rock Ck
EF Williams @ Browns
Dog Fork of Yale Creek
Cheney Ck blw L.Cheney
Caris Creek
Carberry Ck
Beaver Creek at Mouth
Beaver Creek above Mouth
AG @ Grays Ck
AG @ C. Buckley Park
Site

Chart 1

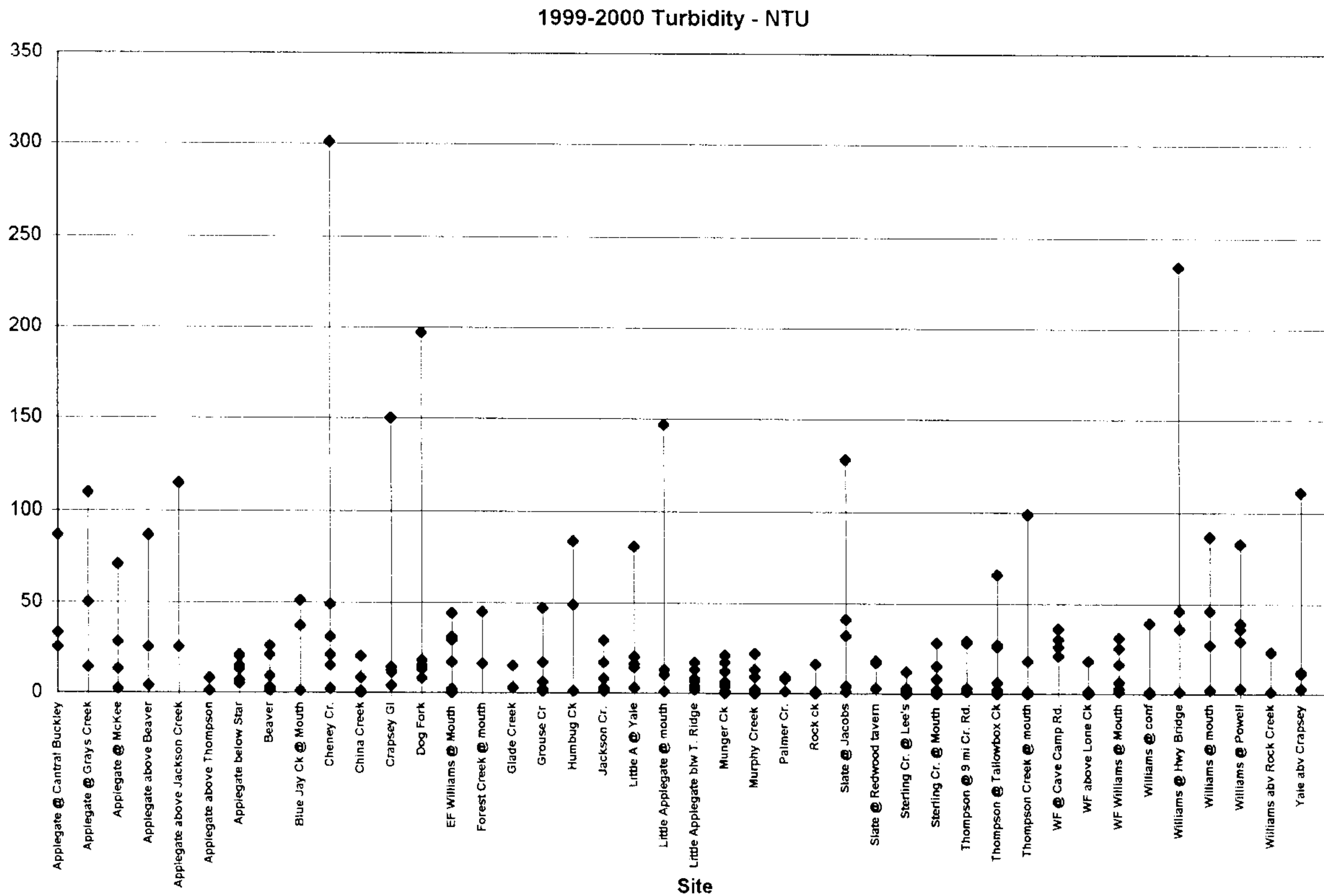
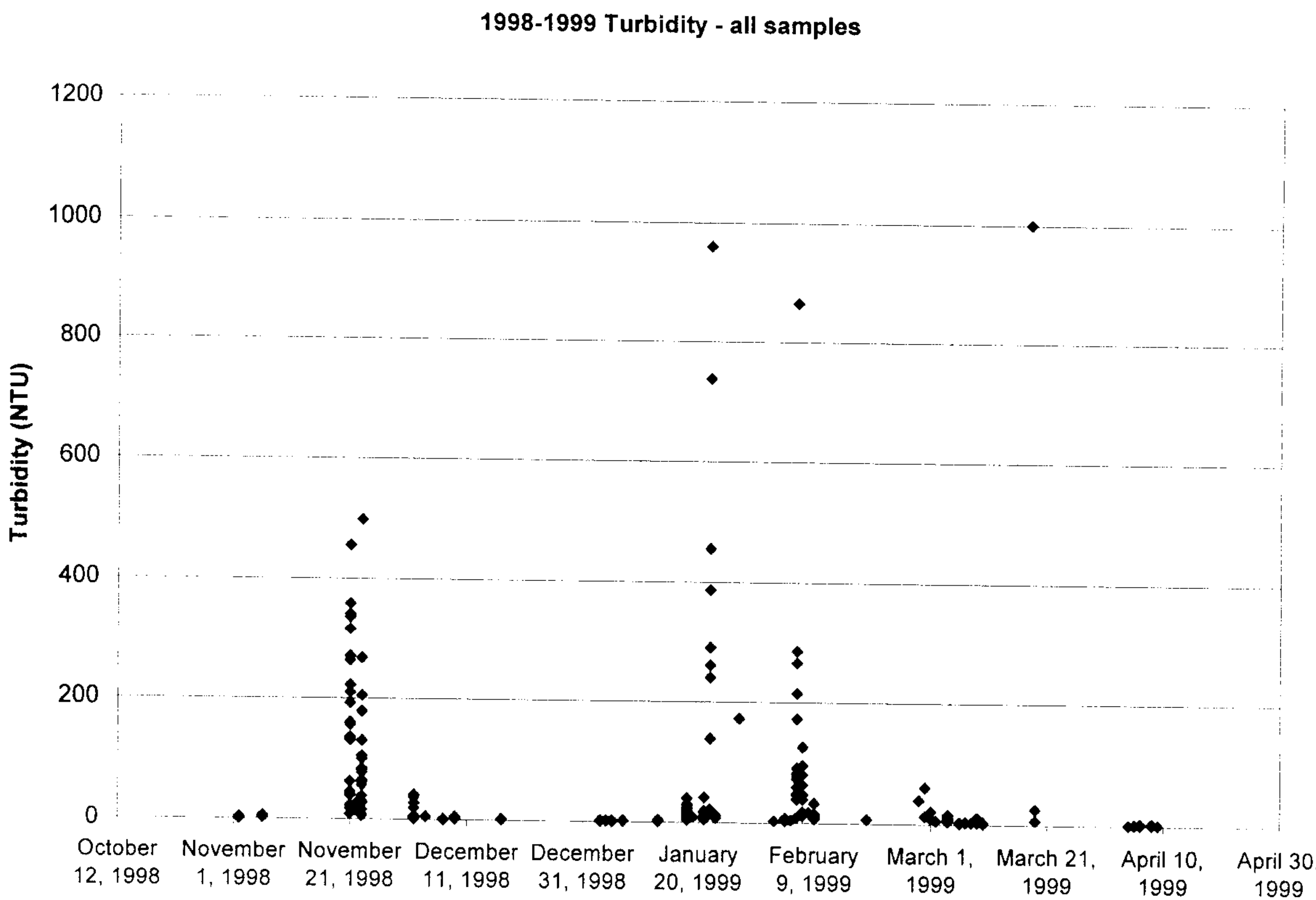
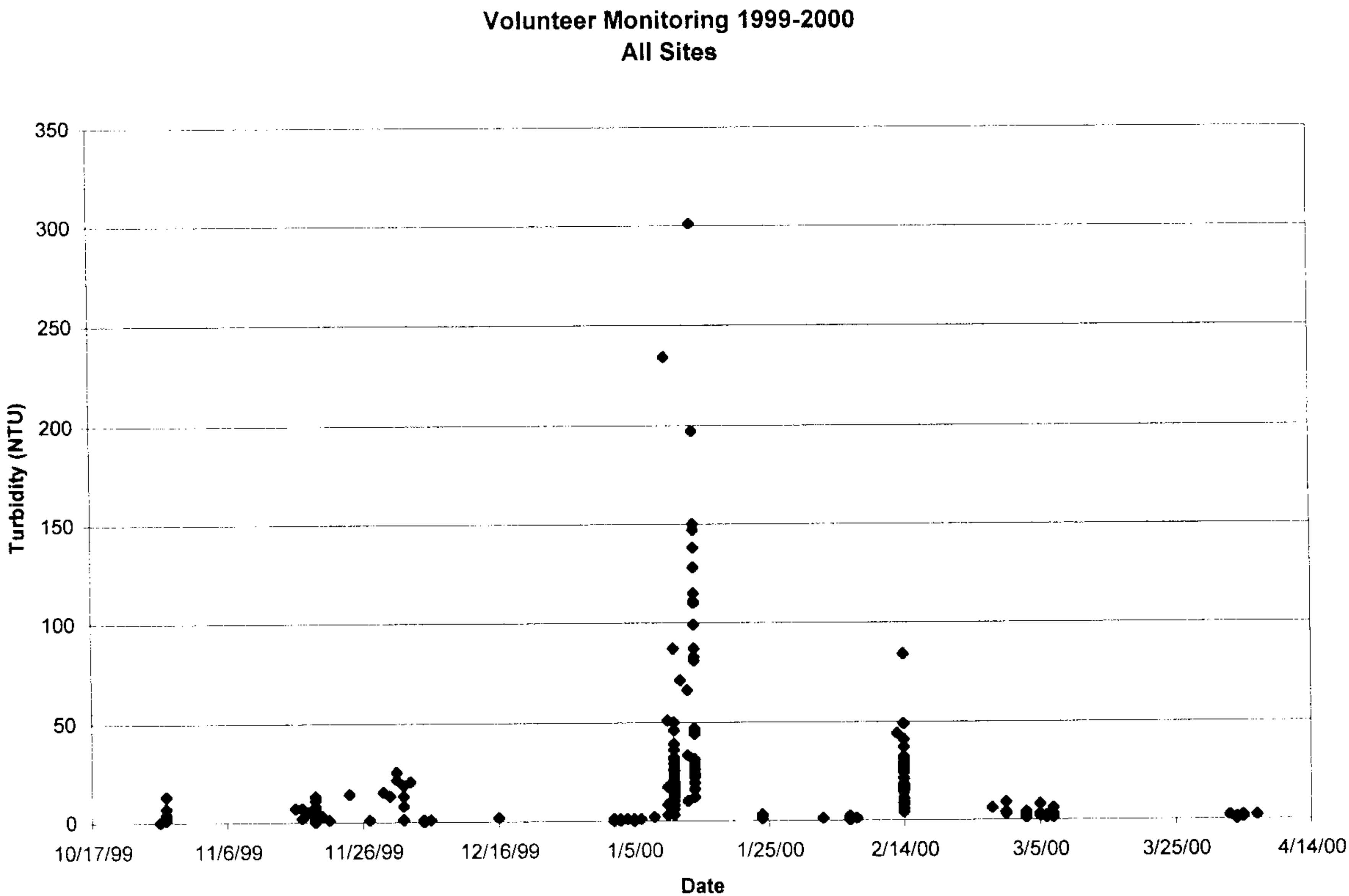

1999-2000 Turbidity - NTU
350
300
250
200
150
100
50
0
Applegate @ Cantral Buckley
Applegate @ Grays Creek
Applegate @ McKee
Applegate above Beaver
Applegate above Jackson Creek
Applegate above Thompson
Applegate below Star
Beaver
Blue Jay Ck @ Mouth
Cheney Cr.
China Creek
Crapsey Gl
Dog Fork
EF Williams @ Mouth
Forest Creek @ mouth
Glade Creek
Grouse Cr
Humbug Ck
Jackson Cr.
Little A @ Yale
Little Applegate @ mouth
Little Applegate blw T. Ridge
Munger Ck
Murphy Creek
Palmer Cr.
Rock ck
Slate @ Jacobs
Slate @ Redwood tavern
Sterling Cr. @ Lee's
Sterling Cr. @ Mouth
Thompson @ 9 mi Cr. Rd.
Thompson @ Tallowbox Ck
Thompson Creek @ mouth
WF @ Cave Camp Rd.
WF above Lone Ck
WF Williams @ Mouth
Williams @ conf
Williams @ Hwy Bridge
Williams @ mouth
Williams @ Powell
Williams abv Rock Creek
Yale abv Crapsey
Yale at mouth
Site

Chart 3



1998-1999 Turbidity - all samples
Turbidity (NTU)
1200
1000
800
600
400
200
0
October 12, 1998
November 1, 1998
November 21, 1998
December 11, 1998
December 31, 1998
January 20, 1999
February 9, 1999
March 1, 1999
March 21, 1999
April 10, 1999
April 30, 1999

CHART 2



Volunteer Monitoring 1999-2000
All Sites
Turbidity (NTU)
350
300
250
200
150
100
50
0
10/17/99
11/6/99
11/26/99
12/16/99
1/5/00
1/25/00
2/14/00
3/5/00
3/25/00
4/14/00
Date

CHART 4

ATTACHMENT B
Water Quality in the Applegate River

Prepared by
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I. Introduction

The Applegate River Watershed Council (ARWC) has an ongoing water quality-monitoring program that involves collecting dissolved oxygen, alkalinity, conductivity, pH, and turbidity. Phosphorous and nitrates were also collected to assess nutrient loading. Since 1997 ARWC has collected biweekly grab samples at more than two dozen sites during the summer (Figure 1). Grab (instantaneous) samples for determining these parameters are usually taken during mid-day through late afternoon and, only represent conditions at that time. The water quality parameters have a diurnal cycle responding to solar radiation, photosynthesis and respiration. These parameters are also influenced by weather (air temperature or precipitation) and adjacent land use. Consequently, grab samples do not sufficiently characterize water quality over a range on conditions.

In order to obtain more comprehensive information, we have deployed sondes to continuously monitor pH and dissolved oxygen; continuous monitoring allows the evaluation of selected parameters throughout the day. ARWC has two sondes. One (YSI model 600XLM) records DO, temperature, pH, and conductivity; the second sonde (YSI model 6920) additionally determines turbidity at set intervals (30 minutes is the time interval used in these studies). In 2001, the continuous turbidity data will assist with a sediment TMDL study currently underway in Beaver Ck. Sonde information could be used to evaluate TMDLs for pH, DO and, indirectly, nutrient load.

II. Results

Grab Sampling

Tables 1-4 in appendix A display average water quality values for years 1997,1998,1999, and 2000 receptively. Table 4 in appendix A displays 2000 water quality data in EPA's standard format.

Samples were collected on a bi-weekly interval. The methods used are described in the *Methods and Procedures Manual of the Applegate River Watershed Council*. The samples are considered grab samples; the sample represents water quality at one particular time during the 2 week rotation. The grab sample technique greatly limits the ability to establish trends. Immediate environmental factors such as time of day, weather pattern and land activity greatly influence individual readings. Due to the variability of these factors developing a statistically valid trend is not possible. However, nitrate levels in Forest Creek have been steadily climbing. Nitrate values have increased from .09 mg/L in 1997 to .53 mg/L in 2000 with values of .17 and .28 in 1998 and 1999 respectively.

Our grab sampling program indicates that water chemistry and nutrient values are within DEQ standards.

Continuous Sampling

Since representative data can be obtained at a site in less than a week, the sondes can be moved from site to site during the critical time of the year so that a number of sites can be covered. The locations for placement of the sondes are shown in the map on the following (Figure 1). A sonde is an instrument that continuously collects DO, pH, conductivity, temperature, and turbidity data. In analyzing our data, we have ignored the conductivity determinations, since these values are not relevant to water quality in the Applegate. While the temperature data could be useful in locating warm or cool locations, the sondes were usually placed at locations already covered by temperature dataloggers placed for ARWC's temperature monitoring program. The temperature data will appear in our comprehensive temperature monitoring report as well as in BLM's data for the Applegate.

Dissolved Oxygen and pH is the focus of this report. The Department of Environmental Quality (DEQ) has set a standard for cold water fisheries of 8 mg/L or 90% saturation, if the first value is not attained because of high stream temperatures. According to DEQ's standards, the pH of a stream for cold water fisheries should be between pH 6.5 and 8.5.

Representative results obtained by the sondes are shown in Figures 2--5. Figure 2 shows the DO levels found for Yale Creek near its mouth from July 17th to the 23rd. The data exhibit a diurnal variation in oxygen concentrations and pH, which is typical for all the streams. Oxygen levels are maximal from midday till late in the day and then drop at night. This simply reflects oxygen production by photosynthesis during the day and utilization at night by respiration. Oxygen varied in concentration from about 8.2 to 9.2 mg/L. Expressed as percent saturation this would be from 80 to 90. This figure also shows the daily changes in pH obtained at this location during this time. The pH shows a diurnal variation ranging from about pH 8.0 to 8.3. Clearly, during this time, Yale Creek was in good shape with respect to both pH and oxygen levels.

Figure 3 shows data obtained in Williams Creek during the middle of August. While the pH values were all in the safe range, the concentration of DO rarely rose above the minimal level required for salmonid health. Figure 4 displays data collected in the Little Applegate River near its mouth during the last week of August. Approximately 25 percent of DO observations fell below 8 mg/l and about 1/3 of the pH values recorded at the site were greater than 8.5.

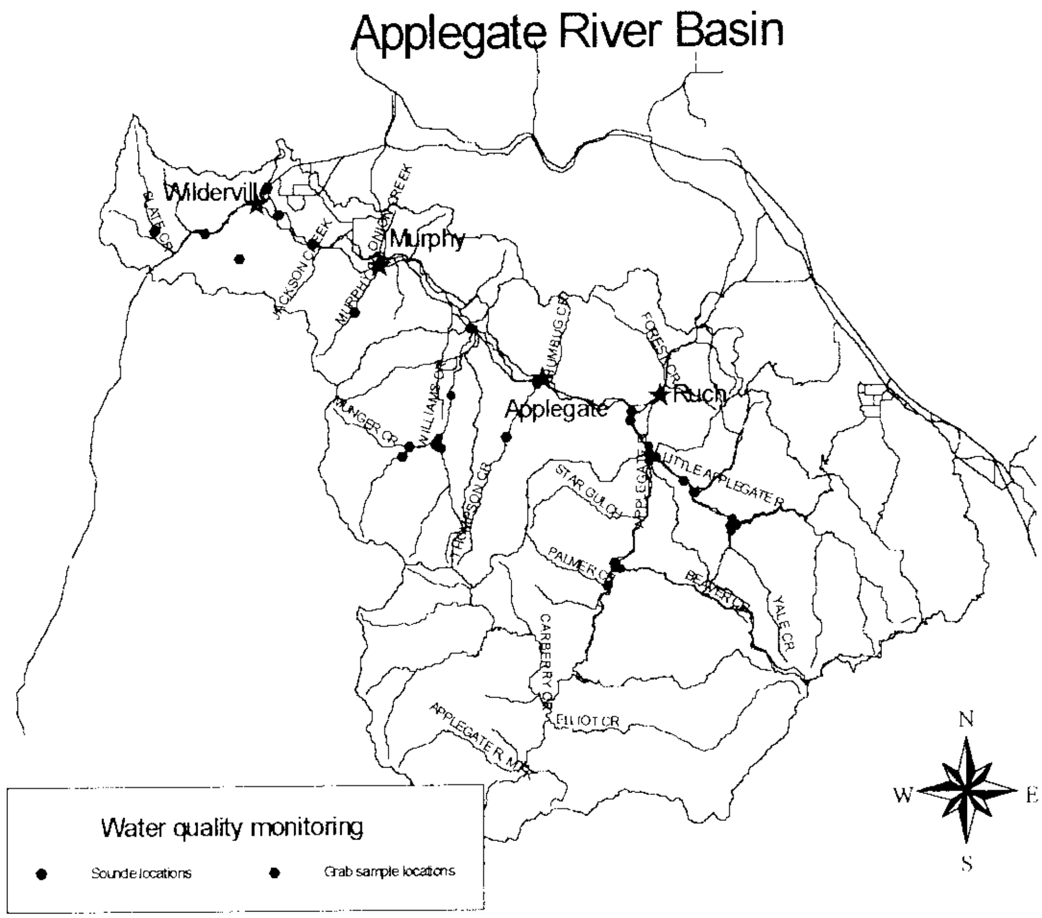
Figure 5 shows data obtained on the Applegate River below the mouth of the Little Applegate River. The DO levels spike in the afternoon of nearly all the days. On the first two days, the spike is marked and occurs early in the afternoon. The last four days display lesser spikes and these occur at 6:00 in the afternoon. The location of the sonde was on the east bank of a south north—flowing, relatively wide, river. Thus it seems doubtful that a brief exposure to full sunlight would be responsible for the burst in oxygen production. The sonde was located near the intake of an irrigation pump, which was not run daily. At this time we are at a loss to account for this spike in levels of DO.

Table I shows all the 2000 data collected for all sites. Columns "percent of DO Measurements <8 mg/l" and "Percent of pH measurements > 8.5" describe the percentage of time the parameters were measured out of compliance. Additionally, in the columns of table I entitled "minimum DO observed and maximum pH observed" values that exceed DEQ standards are in **bold** type.

We have selected six criteria to present as indicators of water quality: fraction of data points that exceed limits set by DEQ, i.e., pH greater than 8.5 and DO less than 8 mg/L, the maximum pH and minimum DO found and the average daily change for DO and pH. The reasons for choosing the first four criteria are obvious. The last two were selected because large fluctuations of DO and pH indicate increased photosynthesis, and hence potential eutrophication.

The data from the individual sites were ranked with respect to these parameters, with the sites with the "least detrimental" data being awarded the lowest score. Tables II and III show the results

Figure 1 Monitoring locations



with the sites listed in increasing average score.

Table 1 displays sites with moderate fluctuation in DO also had moderate fluctuation in pH. Examination of data reveals that there are two driving mechanisms for DO levels in our streams. One is temperature and the other is primary productivity. In data sets displaying a high positive correlation between temperature and DO, primary productivity drives DO values. Figure 6, Little Applegate at Mouth is an example of a system where primary productivity drives DO. In this case, as sunlight increases transpiration also increases, generating high DO values; at night respiration consumes oxygen decreasing dissolved oxygen. Conversely, Beaver Creek (figure 7) is a systems where temperature is the primary driver of DO. This is evident in the high negative correlation between temperature and DO; as temperature increases DO decreases. In the first case DO is biologically driven, in the latter gas exchange. In Beaver, Yale, East Fork Williams and Slate(Slate Creek Rd.) creeks DO values are temperature driven. While the West Fork and mainstem Williams and the Little Applegate DO values are biologically driven. Associated with a biological DO driver is large diurnal fluctuations in pH values; pH fluctuation averages 0.66. In contrast, the average pH fluctuation in temperature driven DO systems is 0.23. This study demonstrates that pH values indicate primary productivity.

Riparian site characterization is consistent within the two groups. In the biologically driven systems riparian canopy cover is open and vegetation is fragmented. In contrast, riparian cover is greater and less fragmented in the temperature driven system. This is in agreement with logic that states solar radiation is the energy source for primary productivity.

The sonde data has greatly increased our understanding of water quality and restoration needs. With this information we are better able to target high priority stream reaches for restoration. While temperature is stressful to salmonids in nearly all stream segments, we have identified reaches which are also stressful in regards to DO and pH. Riparian planting that improves not only temperature but also water chemistry will generate greater restoration success.

Deploying the sonde in 2001 will help us further identify specific reaches sensitive to DO and pH fluctuations.

Figure 2 **Yale Creek**

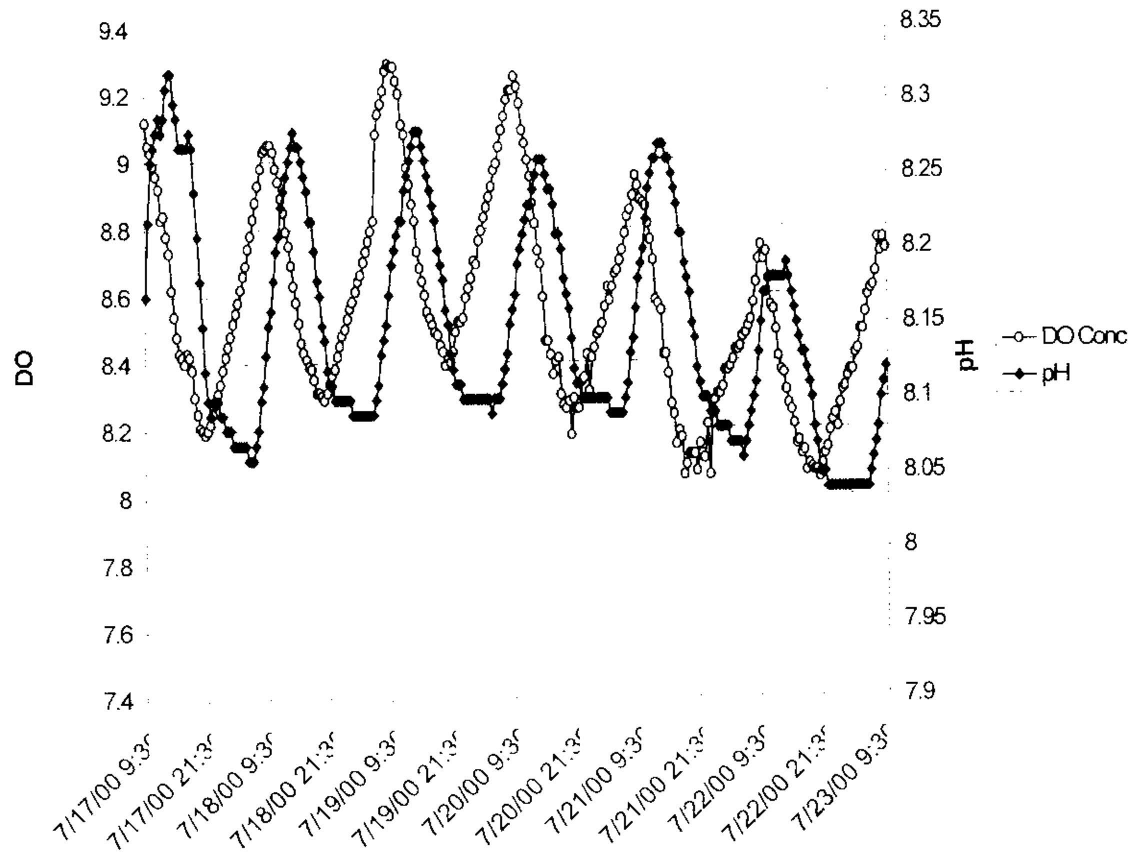


Figure 3 **Williams Ck. above Williams Hwy Br.**

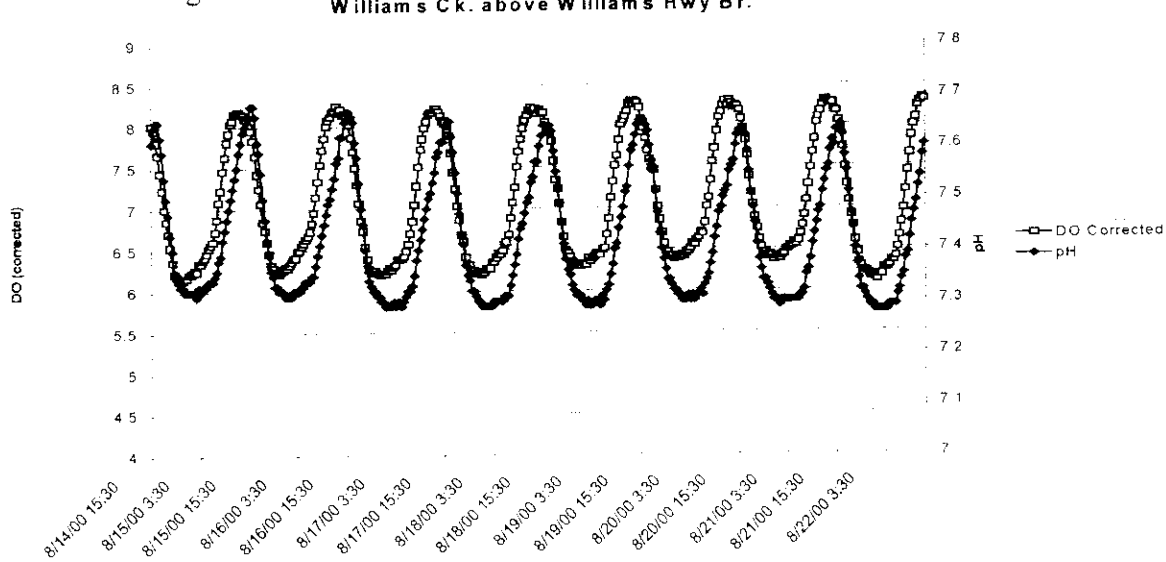


Figure 4 Little Applegate River @ Mouth

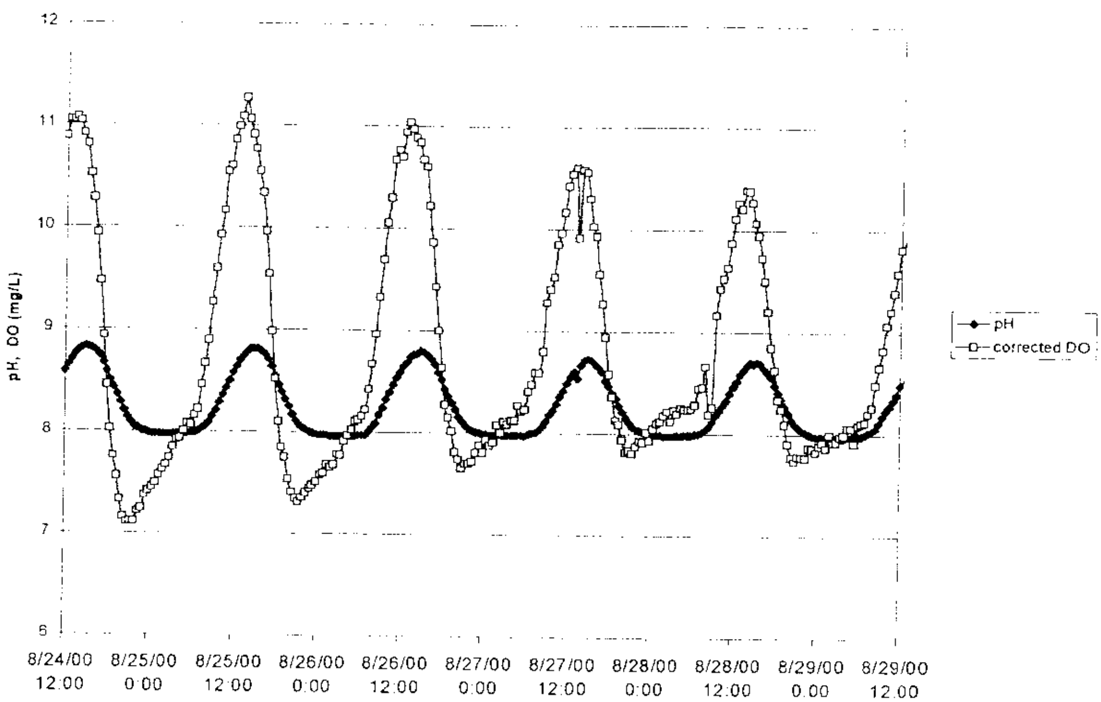


Figure 5 **Applegate River below the Little Applegate**

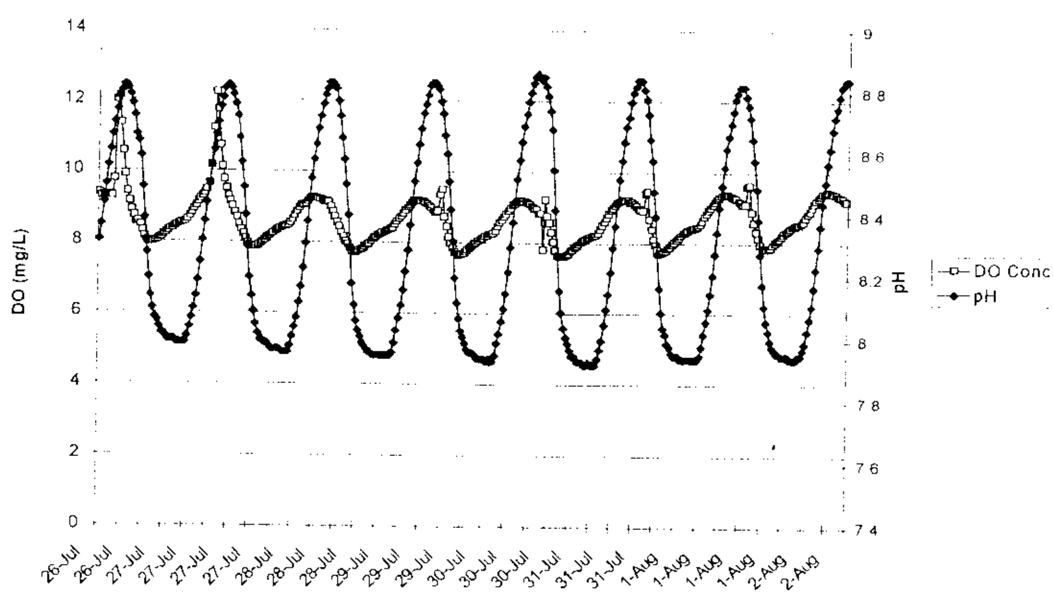


Figure 6

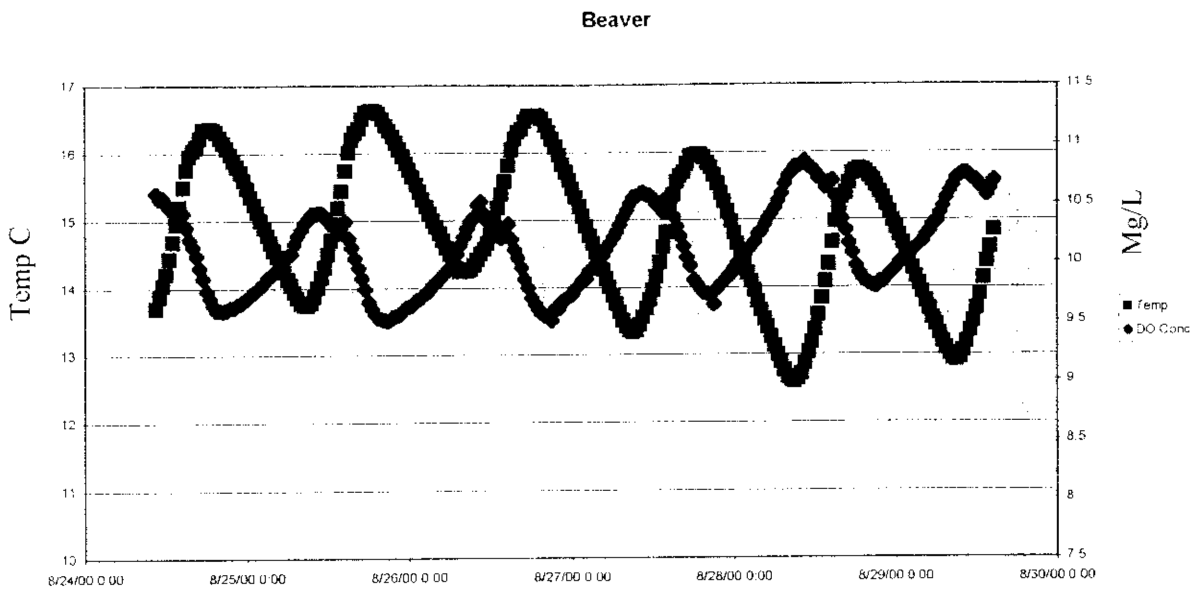


Figure 7

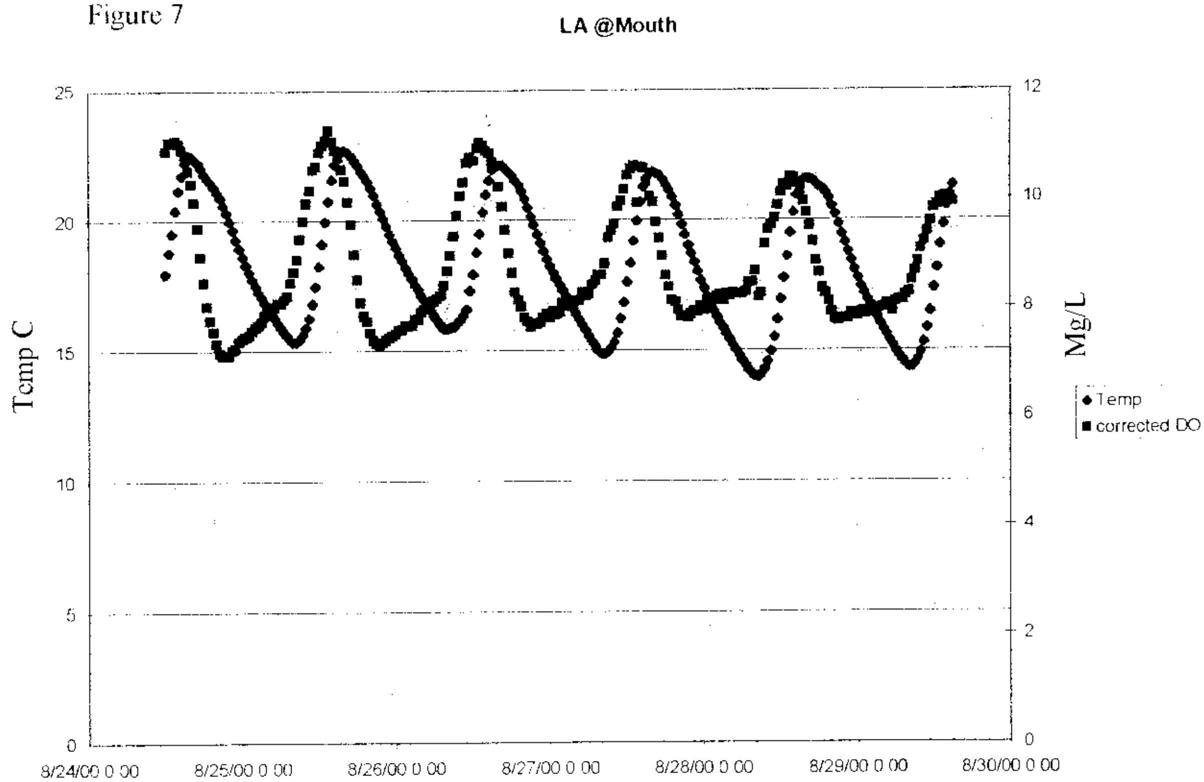


Table I

Location	Start Date	End Date	Sonde	Corrections to observed DO (mg/L)	Corrections to observed pH	Percent of DO measurements < 8 mg/L	Minimum DO observed	Average Daily DO Change	Percent of pH measurements > pH 8.5	Maximum pH observed	Average Daily pH Change	Notes
Williams Ck at Williams Hwy Br	16-Jun	23-Jun	600 XLM	-1.58 and for slope	none	33	**6.9**	1.5	0	7.75	0.26	
Slate Ck at Road mile 1.6	27-Jun	02-Jul	600 XLM	no data	none	NA	NA	NA	8	**8.52**	0.33	
Mouth of Little Applegate	07-Jul	14-Jul	600 XLM	none	none	0	8.5	1.6	1	**8.52**	0.38	
Little Applegate Below Yale	17-Jul	24-Jul	600 XLM	-0.7	none	26	**7.7**	0.7	6	**8.6**	0.26	
Yale Creek	17-Jul	23-Jul	600XLM	none	none	0	8.1	0.8	0	8.32	0.17	see graph
Applegate above Little Applegate	26-Jul	29-Jul	600 XLM	no data	none	NA	NA	NA	30	**8.72**	0.79	Data after 7/29 discarded
Applegate below Little Applegate	26-Jul	02-Aug	6920	none	none	18	**7.6**	2.3	35	**8.8**	0.88	see graph
Williams Ck at Williams Hwy Br	04-Aug	11-Aug	6920	-0.8	none	99	**5.2**	2.1	0	7.72	0.34	
E Fk Williams Ck	14-Aug	18-Aug	600 XLM	-1	none	19	**7.7**	1.3	0	7.66	0.27	
W Fk Williams Ck	19-Aug	23-Aug	600 XLM	-1	none	27	**7.7**	2.0	0	8.09	0.69	
Williams Ck at Williams Hwy Br	14-Aug	22-Aug	6920	-1	none	79	**6.1**	2.2	0	7.65	0.35	
Beaver Creek	24-Aug	29-Aug	600 XLM	-1.45	none	0	8.1	1.0	0	8.38	0.17	
Mouth of Little Applegate	24-Aug	29-Aug	6920	-.7 as well as slope	none	32	**7.1**	2.6	27	**8.83**	0.71	see graphs
Mouth of Little Applegate	30-Aug	04-Sep	6920	none	none	8	**7.6**	3.0	28	**8.78**	0.64	
Applegate below Little Applegate	31-Aug	04-Sep	600 XLM	none	none	0	8.7	1.7	24	**8.6**	0.82	
Little Applegate Below Yale	05-Sep	20-Sep	6920	none	none	0	8.1	1.3	0	8.34	0.34	
Little Applegate @ Road mile 2.6	05-Sep	20-Sep	600XLM	none	none	3	**7.8**	1.8	13	**8.75**	0.53	DO data after 9/11 discarded

Table II

Location	Start Date	Average Rank for Dissolved Oxygen
Yale Creek	17-Jul	1.3
Beaver Creek	24-Aug	1.7
Little Applegate Below Yale	05-Sep	2.0
Mouth of Little Applegate	07-Jul	2.0
Applegate below Little Applegate	31-Aug	2.0
Little Applegate Below Yale	17-Jul	3.0
E Fk Williams Ck	14-Aug	3.3
Little Applegate @ Road mile 2.6	05-Sep	3.3
Applegate below Little Applegate	26-Jul	4.3
Williams Ck at Williams Hwy Br	16-Jun	4.7
W Fk Williams Ck	19-Aug	4.7
Mouth of Little Applegate	30-Aug	4.7
Mouth of Little Applegate	24-Aug	5.7
Williams Ck at Williams Hwy Br	14-Aug	6.0
Williams Ck at Williams Hwy Br	04-Aug	6.7

Table III

Location	Start Date	Average Rank for pH
E Fk Williams Ck	14-Aug	1.3
Williams Ck at Williams Hwy Br	16-Jun	1.7
Williams Ck at Williams Hwy Br	14-Aug	1.7
Yale Creek	17-Jul	2.0
Williams Ck at Williams Hwy Br	04-Aug	2.0
Beaver Creek	24-Aug	2.3
Little Applegate Below Yale	05-Sep	2.7
W Fk Williams Ck	19-Aug	3.7
Little Applegate Below Yale	17-Jul	4.0
Mouth of Little Applegate	07-Jul	4.0
Slate Ck at Road mile 1.6	27-Jun	4.3
Little Applegate @ Road mile 2.6	05-Sep	6.0
Mouth of Little Applegate	30-Aug	7.3
Applegate below Little Applegate	31-Aug	7.3
Mouth of Little Applegate	24-Aug	8.0
Applegate above Little Applegate	26-Jul	8.0
Applegate below Little Applegate	26-Jul	9.3

Methodology

The sondes were calibrated for DO determinations by two methods. The first is the manufacturer suggestion and entails exposing the DO probe to air saturated with water. The elevation is entered into the sonde's internal program and after a 15 minute wait for the probe to equilibrate the instrument is calibrated. This method assumes that the film of water on the probe is saturated with oxygen at its partial pressure in air. ARWC also has a DO meter (YSI model 95) which is calibrated in the same manner. The sondes and DO meter gave similar DO results. The second method is Winkler titration. The results obtained by Winkler titration were about 10% lower. In attempting to resolve this difference, a large volume (~ 1 gallon) of water was saturated by sparging with air with a fritted tube and a "fish tank" air pump. In this instance, the DO level in the water should have been 8.6 mg/L (after making a +2% correction for using air that was not saturated with water. This is a correction for partial pressure of water in air saturated with water). The DO concentration in this sample by Winkler titration was 8.1 mg/L and by the 600XLM sonde was 9.2 mg/L. Similar results were obtained in several such trials.

Winkler titration using different lots of sodium thiosulfate from HACH Chemical Co. were compared to Winkler titration by Karen Williamson from Oregon Department of Environmental Quality. The results were very similar. Although sodium thiosulfate is not suitable as a primary standard for oxygen determinations, the values obtained by the Winkler method were assumed to be correct. Therefore, The DO data collected by the sondes were corrected to values obtained by Winkler titrations. Using Winkler titration, our data would be consistent with field determinations and at other locations in the state. The corrections used are indicated in Table 1. The corrected sonde data are within a few percent of DO levels found by Winkler titration of grab samples from this site at this time.

The sensor on the sondes' DO probes consists of a pair of electrodes that are covered by a drop of KCL electrode solution. This, in turn, is covered by a Teflon membrane that is held in place by an O ring. The electrode solution is replaced periodically and the assembly of the membrane with its retaining ring can be tricky. Over time, results obtained with a probe with aged electrode solution or with a micro-leak in the assembly will give a steadily decreasing signal. If this is slow enough, the results can be normalized by correcting for the slope of this decay, which was determined by DO levels (Winkler titration) before and during deployment. The table indicated indicates the two instances in which this correction was made. If the leak is too great, no useful data are collected. This is also noted in Table 1.

The sondes were calibrated for pH by using standard buffers in the range of pH 7 to 10. Field audits and post deployment determinations indicated little or no drift in the values recorded by the sondes. Consequently, no corrections to the data obtained were necessary.

The sondes were set to record DO, temperature, pH, conductivity and turbidity every 15 minutes and placed at sites for approximately one week intervals. Sondes were calibrated in the "laboratory" prior to deployment and with grab samples taken in the field. In analyzing our data, we have ignored the conductivity determinations, since these values are not relevant to water quality in the Applegate. While the temperature data could be useful in locating warm or cool locations, the sondes were usually placed at locations already covered by temperature dataloggers placed for ARWC's temperature monitoring program. The temperature data will appear in our comprehensive monitoring report as well as in BLM's data for the Applegate.

Appendix A
1997 – 2000 Average Water Quality Values

Water Quality 1997 - Average Values

Site	pH	DO	Alk	Nutrients- mg/L Phosphate	Nitrate
Applegate River above Grays Ck.	7.90	8.90	98	0.40	0.03
Applegate River above Little Applegate	8.41	9.08	70		
Applegate River at Beaver Creek	8.18	9.57	70	0.32	0.03
Applegate River at Cantrall Buckly Park	8.07	8.53	72	0.46	0.04
Applegate River at Fish Hatchery Park	7.88	9.08	99	0.41	0.04
Beaver Creek	8.20	8.89	207	1.04	0.05
Cheney Ck below little Cheney					
Cheney Creek at 2nd br.	6.99	8.22	50	0.53	0.06
East Fork Williams at Confluence	7.88	8.58	89	1.00	0.10
Forest Creek at mouth	7.27	6.57	164	0.75	0.09
Grouse Creek at mouth	8.18	8.37	177	0.66	0.07
Humbug Creek at Rt. 238					
Jackson Creek at mouth					
Little Applegate River at mouth	8.36	8.33	167	0.87	0.04
Little Applegate River at Road Mile 2.6	8.22	8.10	202	0.87	0.10
Little Applegate River at Tunnel Ridge	8.30	9.14	126	1.02	0.05
Little Applegate River at Yale Creek	8.14	8.76	139	0.78	0.06
Munger Creek at Kincaid Rd.	7.59	9.21	70	0.68	0.05
Murphy Creek at Bridge	7.75	9.40	101	0.49	0.04
Palmer Creek at mouth	8.06	9.14	239	0.62	0.03
Slate Creek at mouth	7.29	7.92	105	0.68	0.09
Slate Creek at Redwood Tavern	7.97	9.33	143	0.71	0.05
Slate Creek at road mile 1.6	8.23	9.25	166	0.79	0.05
Sterling Creek at mouth	8.23	7.36	272	0.89	0.06
Thompson Creek at mouth					
Thompson Creek below Tallowbox	7.55	8.24	166	0.68	0.07
Upper Munger Ceek	7.62	9.10	50	0.38	0.02
West Fork Williams Ck. at Caves Camp Rd.					
West Fork Williams Creek at confluence	7.78	8.87	81	0.56	0.03
Williams Creek at Powell Ck.	7.69	9.13	96	0.39	0.04
Williams Creek at Rt. 238 bridge	7.57	8.72	97	0.64	0.37
Williams Creek at Williams Hwy	7.46	8.45	86	0.51	0.05
Yale Creek at Mouth	8.29	8.81	177	0.92	0.08

Table 1

Water Quality Average Values 1998

Site	pH	DO %	Alkalinity	Conductivity	Turbidity	NumberVisits	Nutrients - mg/L Phosphate	Nitrate	number
Applegate River at Fish hatchery Park	8.03	100	83	149	2	9	0.25	0.05	6
Applegate River above Grays Ck.	8.02	101	81	150	2	8	0.22	0.05	5
Applegate River at Cantrall Buckley Pk.	8.15	98	105	121	2	6	0.15	0.05	3
Applegate River above Little Applegate	8.11	94	68	102	1	6	0.29	0.05	4
Applegate River at Palmer Ck	8.21	96	64	103	1	7	0.20	0.04	6
Forest Creek	7.25	86	178	326	1	7	0.45	0.17	7
Palmer Creek	8.18	93	219	395	0	7	0.39	0.05	5
Beaver Creek	8.35	96	187	340	1	7	0.50	0.05	5
Mouth of Little Applegate River	8.38	96	133	209	3	7	0.53	0.06	4
Little Applegate River at 2.6 miles	8.19	92	147	231	2	9	0.49	0.07	7
Little Applegate River at Yale Ck.	8.24	94	133	208	2	9	0.43	0.06	8
Little Applegate River at Tunnel Ridge	8.30	95	118	177	2	8	0.39	0.04	7
Sterling Creek	8.24	90	255	429	1	9	0.51	0.04	8
Grouse Creek	8.20	88	157	239	4	9	0.49	0.06	8
Yale Creek at mouth	8.30	93	156	226	2	9	0.48	0.06	8
Mouth Slate Creek	7.42	85	99	189	1	9	0.42	0.06	6
Slate Creek at Redwood Tavern	8.13	91	140	241	0	9	0.41	0.04	5
Slate Creek at 1.6 mi. Slate Ck. Rd.	8.46	94	155	257	0	9	0.43	0.04	6
Cheney Creek at 2nd Br.	7.02	83	47	70	1	9	0.31	0.05	6
Cheney Creek at 380 Cheney Ck. Rd.	7.12	82	53	90	1	9	0.29	0.05	5
Murphy Creek at bridge	7.93	91	97	162	1	9	0.31	0.06	7
Williams Creek at Rt. 238 bridge	7.45	89	88	148	1	9	0.30	0.05	7
Williams Creek at Powell Ck.	7.61	84	94	152	1	9	0.33	0.05	7
Williams at Williams Hwy. Br.	7.65	91	77	132	1	9	0.38	0.07	4
East Fork Williams Creek	7.78	93	84	127	1	8	0.30	0.05	6
Munger Ck at Kincaid Rd.	7.71	92	62	100	1	9	0.24	0.04	8
Upper Munger Ck.	7.60	89	50	78	1	8	0.30	0.03	3
West Fork Williams at Confluence	7.68	93	75	126	1	8	0.43	0.05	6
Thompson Creek at 3905 Thompson	7.95	91	156	267	1	8	0.41	0.10	6

Table 2

Water Quality Average Values 1999

Site	PH	DO%	Alkalinity	Turbidity	Visits	Nutrients - mg/L Phosphate	Nitrate	number analyses
Applegate above Grays Creek	7.9	102.7	73	2	7	0.31	0.02	7
Applegate at Cantrall Buckley Park	7.8	94.5	67	2	7	0.28	0.03	6
Applegate at the mouth of Little Applegate	8.1	92.2	67	2	6	0.23	0.03	5
Applegate River at Beaver Creek	8.0	94.3	76	2	7	0.34	0.01	6
Applegate River at Fish Hatchery Park	7.7	99.2	76	2	7	0.22	0.02	5
Beaver Creek at Mouth	8.0	85.1	192	1	7	0.54	0.03	6
Cheney Creek at 2nd Bridge	6.7	84.4	46	1	7	0.23	0.04	7
Cheney Creek below Little Cheney Ck.	6.8	83.7	51	1	7	0.25	0.01	7
East Fork Williams Creek at Browns Rd.	7.3	88.7	84	2	7	0.52	0.03	6
Forest Creek at Hamilton Road	6.9	77.9	143	2	7	0.52	0.28	6
Grouse Creek at mouth	7.9	81.5	169	2	7	0.46	0.04	6
Humbug Creek at Rt. 238	8.2	90.1	152	5	6	0.60	0.07	5
Jackson Creek at mouth	7.0	76.9	78	2	7	0.35	0.06	7
Little Applegate River at Mouth	8.2	95.9	139	3	7	0.49	0.02	6
Little Applegate River at Road Mile 2.6	8.2	84.5	143	2	7	0.48	0.02	5
Little Applegate River at Tunnel Ridge	8.0	83.1	116	3	7	0.41	0.02	6
Little Applegate River at Yale Creek	8.0	92.0	125	5	7	0.50	0.02	6
Munger Creek at Kincaid Rd.	7.2	91.6	68	1	7	0.58	0.02	6
Murphy Creek at Bridge	7.6	92.7	99	1	7	0.28	0.01	7
Palmer Creek at Bridge	7.9	88.8	210	2	7	0.60	0.01	6
Slate Creek at mouth	7.1	86.2	91	1	7	0.31	0.02	7
Slate Creek at Redwood Tavern	8.0	93.6	129	1	7	0.42	0.01	7
Slate Creek at road mile 1.6	8.3	94.4	140	1	7	0.59	0.01	7
Sterling Creek at Little Applegate Rd.	8.2	86.4	238	2	7	0.64	0.02	6
Thompson Creek at mouth	7.3	82.1	127	1	7	0.54	0.12	6
Thompson Creek at Tallowbox Ck.	7.9	92.7	155	1	7	0.62	0.04	6
Upper Munger Creek	7.2	93.2	54	1	4	0.32	0.01	3
West Fork Williams Ck. at Caves Camp Rd.	7.4	87.8	80	1	7	0.49	0.02	6
West Fork Williams Creek at Confluence	7.2	87.2	79	2	7	0.55	0.04	6
Williams Creek at Powell Ck.	6.9	82.2	90	1	7	0.56	0.07	6
Williams Creek at Rt. 238 Bridge	6.8	83.3	85	1	7	0.51	0.06	6
Williams Creek at Williams Hwy. Bridge	6.9	72.6	81	1	7	0.50	0.02	6
Yale Creek at mouth	8.1	90.5	160	2	7	0.50	0.03	6
Average	7.6	88.2	112	2		0.45	0.04	

Table 3

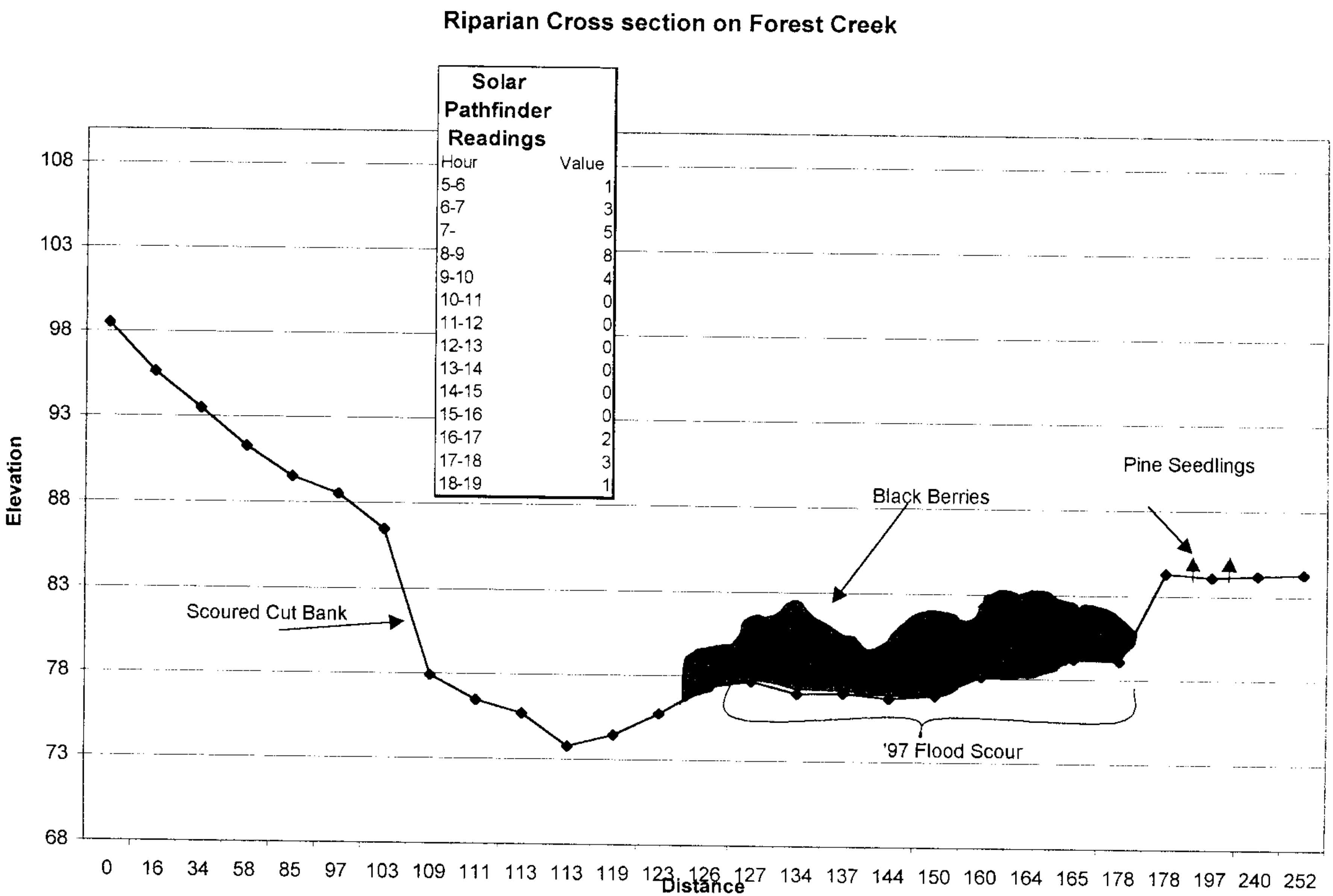
Water Quality 2000 - Average Values

Site	Conductivity	pH	Turbidity	% DO	Nutrients - mg/L Nitrate	Phosphate
Applegate River at Fish Hatchery Park	124.97	7.82	2.00	0.94	0.05	0.37
Applegate at Cantrall Buckley Park	105.10	8.27	2.00	0.94	0.02	0.38
Applegate at the mouth of Little Applega	90.22	8.26	1.20	0.87	0.03	0.40
Applegate @ Beaver Creek	80.86	8.26	1.60	0.81	0.01	0.34
Slate Creek at mouth	164.42	7.26	1.00	0.83	0.06	0.43
Slate Creek at Redwood Tavern	211.53	7.97	0.80	0.88	0.02	0.49
Slate Creek at road mile 1.6	226.38	8.38	0.75	0.85	0.02	0.67
Cheney @ Mouth	75.82	7.01	1.20	0.81	0.04	0.47
Cheney Creek at 2nd Bridge	61.63	6.60	1.00	0.70	0.04	0.42
Murphy Creek at Bridge	142.75	7.72	1.00	0.84	0.03	0.43
Williams Creek at Rt. 238 Bridge	131.35	7.38	1.20	0.91	0.08	0.47
Williams at Williams Hwy. Bridge (Care	115.41	6.56	1.00	0.86	0.03	0.50
West Fork Williams @ Renz (mouth)	106.43	7.92	1.00	0.87	0.03	0.35
West Fork Williams @ Caves Camp	104.72	7.00	1.20	0.86	0.05	0.54
Munger Creek @ Kincaid	86.58	7.97	0.80	0.83	0.05	0.52
East Fork Williams at Browns Rd.	111.27	7.81	1.00	0.84	0.04	0.72
Thompson Ck at mouth	197.04	7.55	1.00	0.82	0.35	0.41
Thompson Creek at Tallowbox Ck. (JD's	222.90	7.75	0.86	0.83	0.07	0.78
Little Applegate at Mouth	211.46	8.39	1.86	0.89	0.07	0.56
Little Applegate at Road Mile 2.6	201.73	8.38	1.57	0.84	0.03	0.57
Little Applegate at Yale Creek	172.30	8.39	1.86	0.74	0.04	0.52
Sterling Creek at LA Rd.	397.34	8.23	1.80	0.80	0.02	0.67
Grouse Creek at mouth	216.48	8.21	2.67	0.77	0.03	0.76
Yale at Mouth	214.33	8.22	2.33	0.81	0.06	0.68
Forest Creek at Hamilton Road	255.05	7.06	1.00	0.72	0.53	0.64
Beaver Creek at Mouth	302.57	8.23	2.00	0.79	0.05	0.76
Palmer at Bridge	345.98	8.16	1.00	0.82	0.04	0.44

Table 4

ATTACHMENT C
Riparian Monitoring

Prepared by
Applegate River Watershed Council
6941 Upper Applegate Rd
Jacksonville, OR 97503



Riparian Cross section on Forest Creek
Solar Pathfinder Readings
Hour Value
5-6 1
6-7 3
7- 5
8-9 8
9-10 4
10-11 0
11-12 0
12-13 0
13-14 0
14-15 0
15-16 0
16-17 2
17-18 3
18-19 1
Elevation
108
103
98
93
88
83
78
73
68
Scoured Cut Bank
Black Berries
Pine Seedlings
'97 Flood Scour
0 16 34 58 85 97 103 109 111 113 113 119 123 126 127 134 137 144 150 160 164 165 178 178 197 240 252
Distance

Forest Creek Water Quality

Forest Creek at Hamilton Road Water Quality 2000

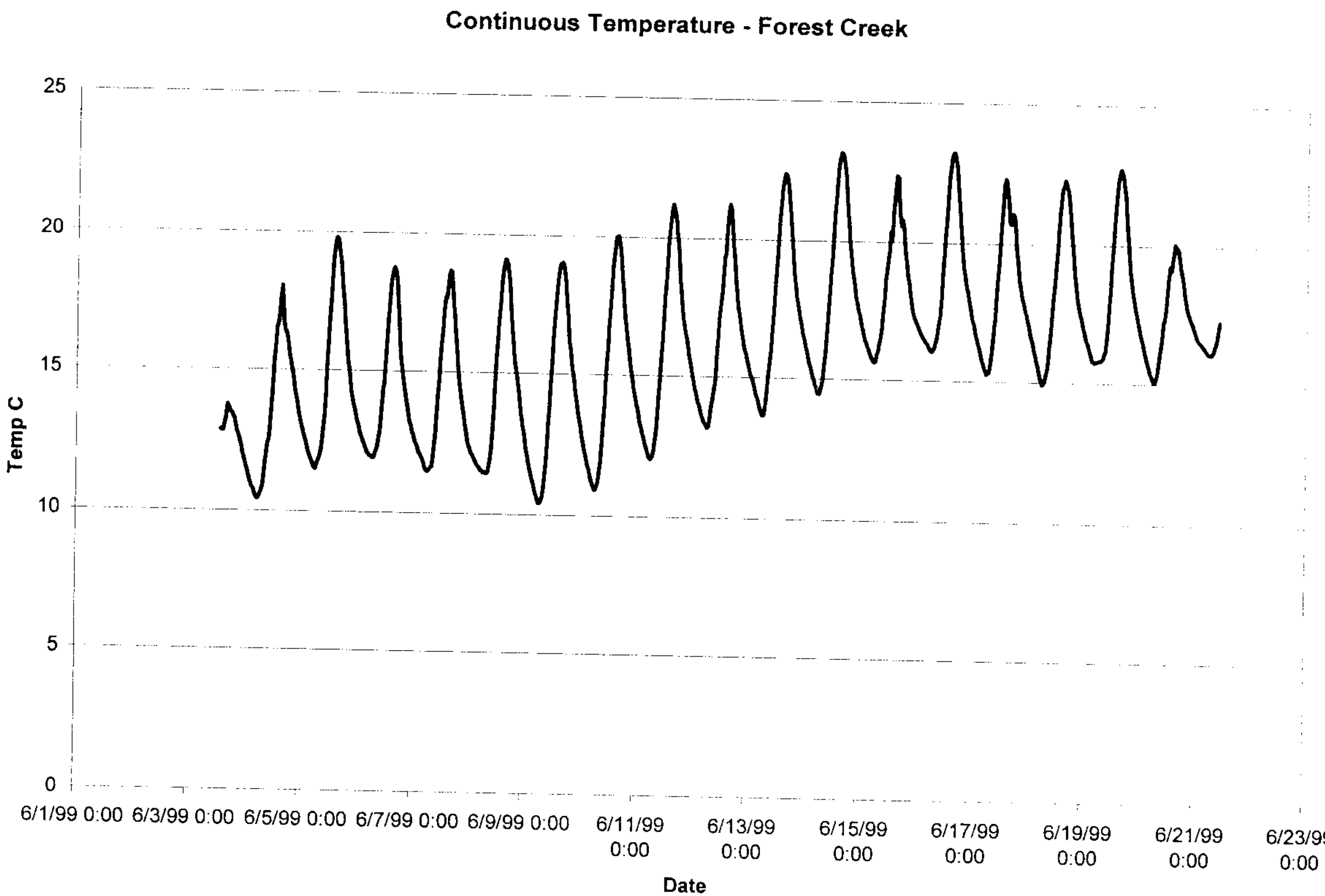
Site	Date	Time	T; C	Cond	pH	Turb	% DO	D.O.	NO3	PO4
Forest Creek at Hamilton Road	06/22/00	9:00	13.9	348.0	6.92	1	68	7.48	0.54	1.05
Forest Creek at Hamilton Road	07/11/00	12:40	15.3	241.4	7.09	1	80	8.52	0.55	0.51
Forest Creek at Hamilton Road	07/26/00	11:05	15.8	236.0	7.24	1	74	7.82	0.55	0.56
Forest Creek at Hamilton Road	08/10/00	11:50	15.7	240.4	7.22	1	68	7.1	0.46	0.57
Forest Creek at Hamilton Road	08/24/00	12:42	16.6	239.5	6.94	1	74	7.56	0.55	0.23
Forest Creek at Hamilton Road	09/06/00	14:30	15.1	225.0	6.95	1	67	7.2	0.55	0.9

Forest Creek at Hamilton Road Water Quality 1999

Site	Date	Temp.	Cond.	pH	Turb.	Alk.	DO %	DO mg/L	NO3	PO4
Forest Creek at Hamilton Road	06/17/99	15.8	328	7.07	1		91.5	8.8	0.15	0.27
Forest Creek at Hamilton Road	07/08/99	15.8	248	6.52	3	178	87.5	8.42	0.24	0.21
Forest Creek at Hamilton Road	07/20/99	14.5	248	7.1	1	148	73.2	7.18	0.31	0.57
Forest Creek at Hamilton Road	08/02/99	15.6	305	6.75	2	158	77.3	7.44	0.33	0.98
Forest Creek at Hamilton Road	08/16/99	17.9	298	7.07	1	138	111.8	10.22		0.47
Forest Creek at Hamilton Road	09/01/99	16	147	7.15	3.14	128	42.4	4.04	0.33	0.35
Forest Creek at Hamilton Road	09/23/99	13.9	297	6.9		110	61.6	6.16	0.34	0.62

Forest Creek at Hamilton Road Water Quality 1998

Site	Date	T., °C	Cond.	pH	Turb.	Alk.	% DO	DO mg/L		NO3		PO4
Forest Ck.	6/16/98	14.7	333	7.80	1.9	170	78.24463	8.38	7/3/97	0.09	7/3/97	1.14
Forest Ck.	7/2/98	15.5	281	7.30	0.6	200	81.09382	8.60	7/5/97	..	7/5/97	0.31
Forest Ck.	7/13/98	17.4	339	7.33	0.4	184	85.81247	8.74	7/14/97	0.13	7/14/97	0.38
Forest Ck.	7/23/98	17.5	353	7.07	0.5	182	86.11111	8.68	8/4/97	0.07	8/4/97	0.56
Forest Ck.	7/31/98	17.0	335	7.08	0.5	168	78.54688	8.00	8/18/97	0.08	8/18/97	1.51
Forest Ck.	8/12/98	14.0		6.95	0.4	172	65.01832	7.10	9/12/97	0.08	9/12/97	0.62
Forest Ck.	9/21/98	13.5	313	7.20	0.7	172	72.19955	7.96				


Continuous Temperature - Forest Creek
Temp C
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20
15
10
5
0
6/1/99 0:00
6/3/99 0:00
6/5/99 0:00
6/7/99 0:00
6/9/99 0:00
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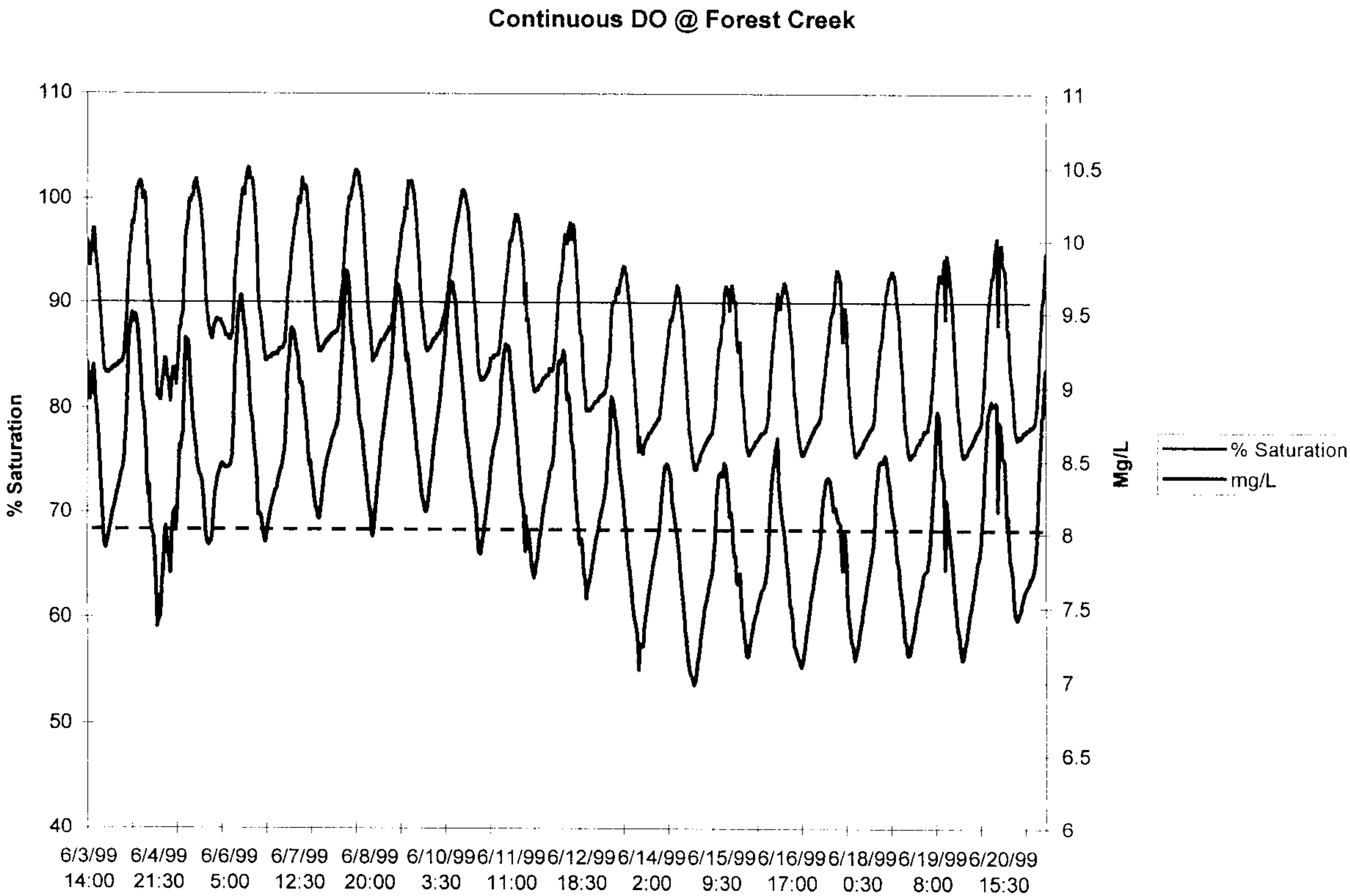
Date


Continuous DO @ Forest Creek
% Saturation
Mg/L
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100
90
80
70
60
50
40
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
6/3/99 14:00
6/4/99 21:30
6/6/99 5:00
6/7/99 12:30
6/8/99 20:00
6/10/99 3:30
6/11/99 11:00
6/12/99 18:30
6/14/99 2:00
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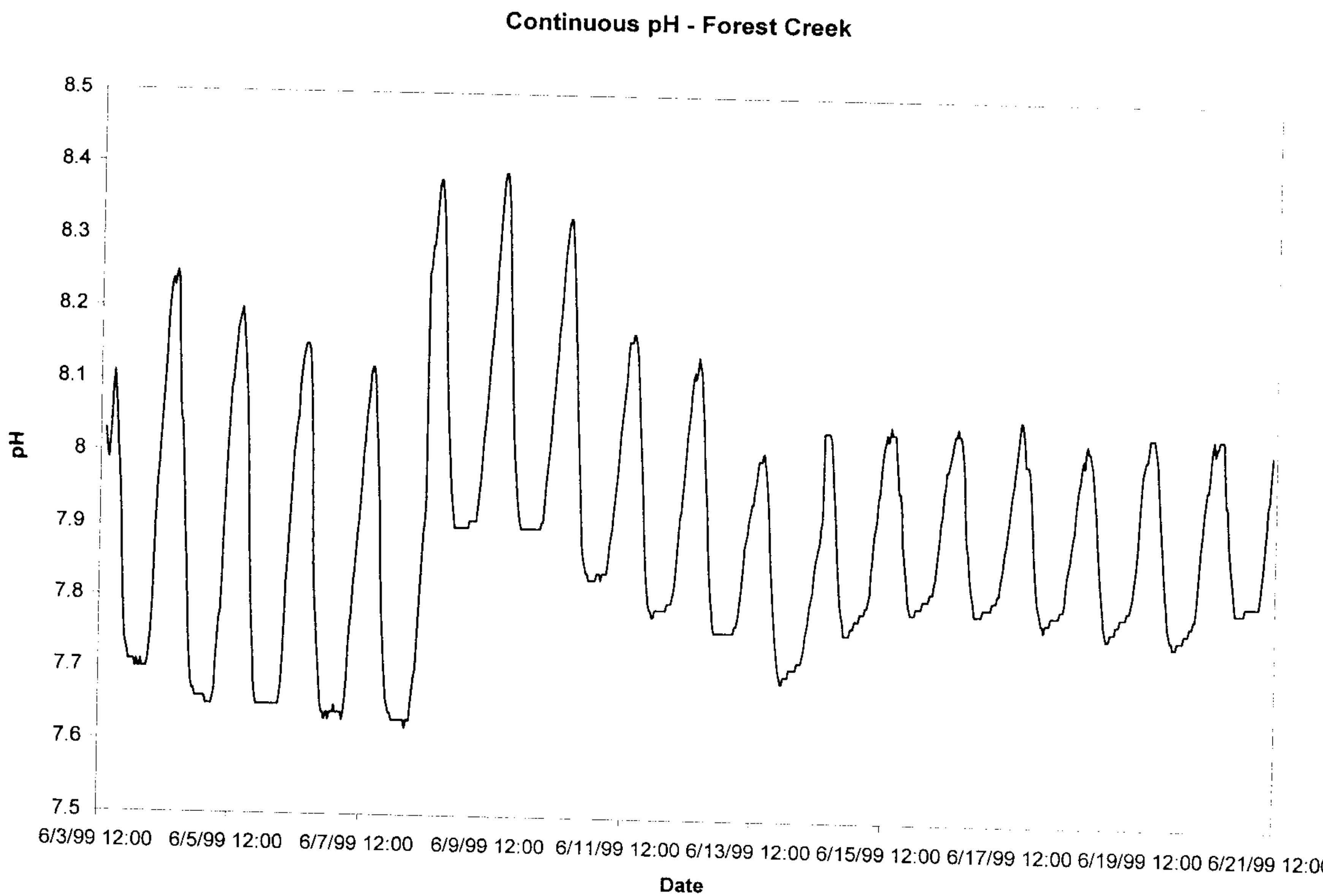
% Saturation
mg/L


Continuous pH - Forest Creek
8.5
8.4
8.3
8.2
8.1
8
7.9
7.8
7.7
7.6
7.5
pH
6/3/99 12:00
6/5/99 12:00
6/7/99 12:00
6/9/99 12:00
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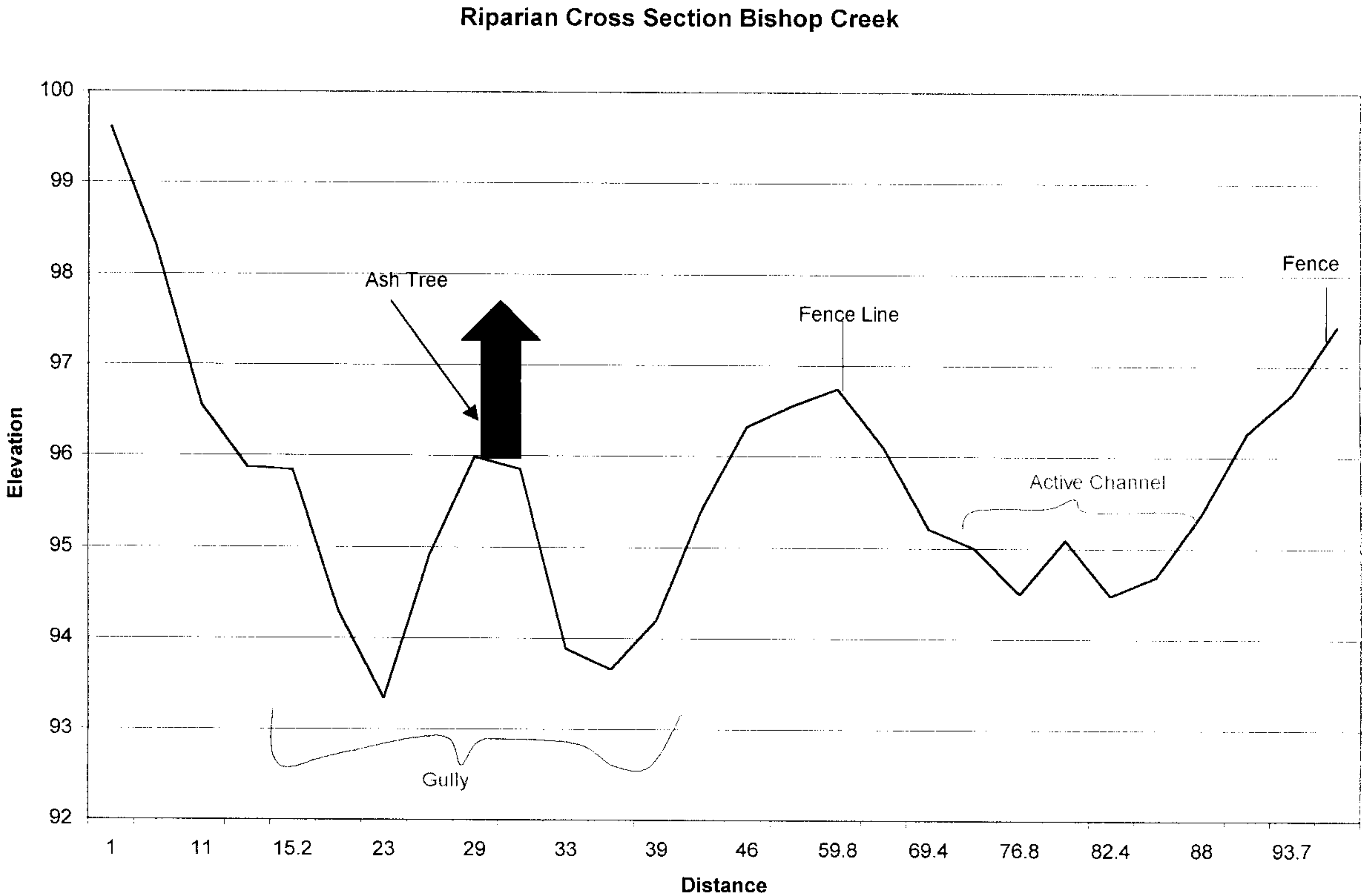
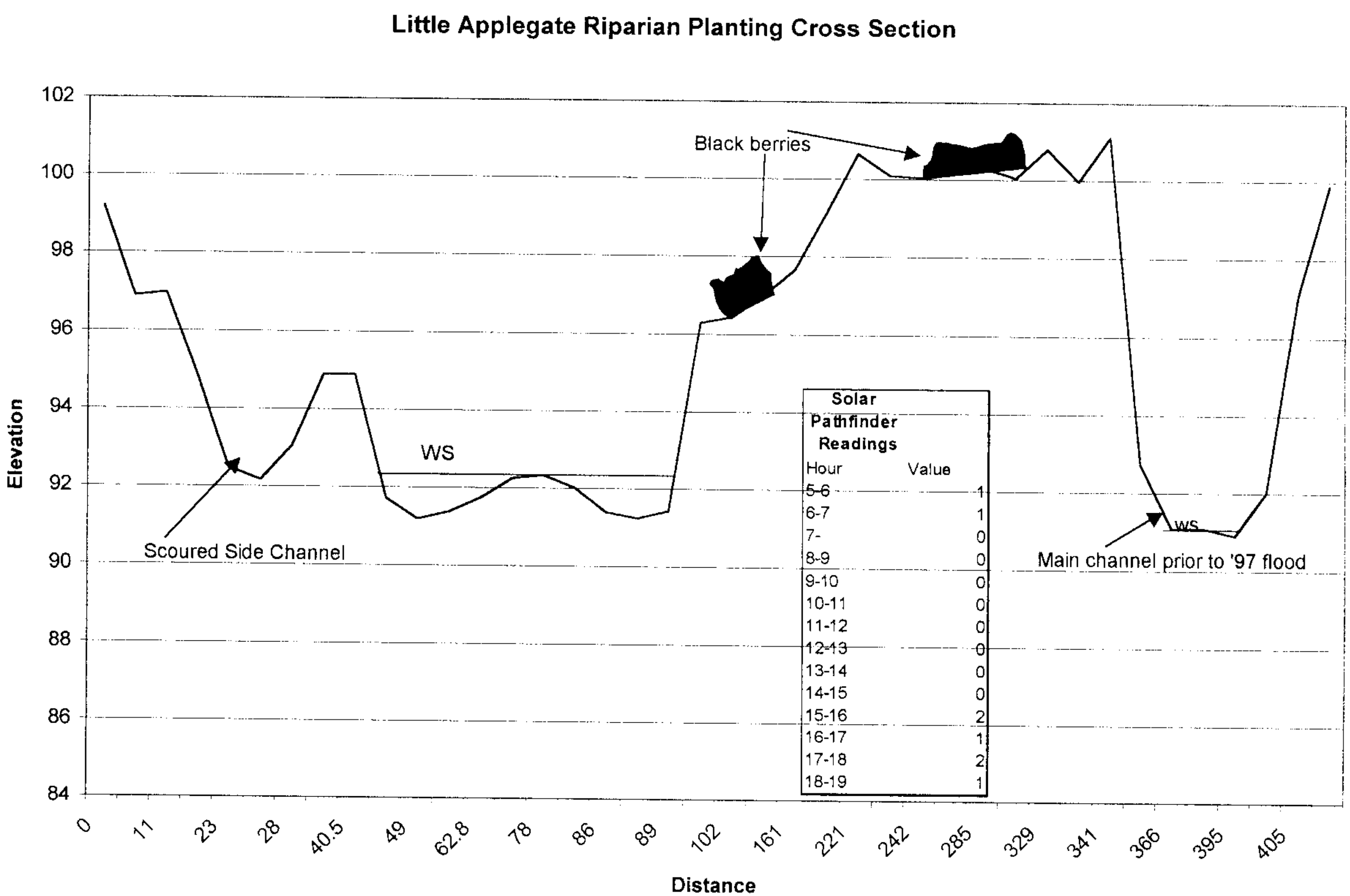
6/21/99 12:00
Date


Riparian Cross Section Bishop Creek
Elevation
100
99
98
97
96
95
94
93
92
Ash Tree
Fence Line
Fence
Active Channel
Gully
1
11
15.2
23
29
33
39
46
59.8
69.4
76.8
82.4
88
93.7
Distance


Little Applegate Riparian Planting Cross Section
Elevation
Distance
102
100
98
96
94
92
90
88
86
84
0
11
23
28
40.5
49
62.8
78
86
89
102
161
221
242
285
329
341
366
395
405
Black berries
WS
Scoured Side Channel
ws
Main channel prior to '97 flood
Solar Pathfinder Readings
Hour Value
5-6 1
6-7 1
7- 0
8-9 0
9-10 0
10-11 0
11-12 0
12-13 0
13-14 0
14-15 0
15-16 2
16-17 1
17-18 2
18-19 1

Winter Monitoring

Site	Date	Time	Storm?	T., °C	pH	pH Dup	DO	DO Dup	% Sat.	% Sat Dup	Cond.	Turbidity	Nutrients Pi	Pi Dup	NO3	N03 Dup	TPO4	Duplicate
Bishop Creek at Rt 238	03/18/99	9:50	No										0.47		0.03			
Bishop Creek at BLM Rd	03/18/99	9:30	No	7.4	7.46		10.96		96		258	4	0.48		0.02			
Forest Creek at 238 Bridge	03/18/99	10:50	No	8.7	8.02		10.98		98		276	4	0.48		0.05			
Forest Creek at 238 Bridge	04/21/99	9:55	No	9.8	7.8		10.5		98		307	3	0.57		0.04		0.62	
Forest Creek at 238 Bridge	05/19/99	10:50	No	12.2	8.02		10.4		101		327	1	0.51		0.01			
Forest Creek at 238 Bridge	06/03/99	2:00	No	12.8	7.66		9.92		98		354	3	0.5		0.02			
Forest Creek at 6480 Hwy 238	03/18/99	9:00	No	6.9	7.33		10.7		92		265	3	0.68		0.02			Yes
Forest Creek at 6480 Hwy 238	04/21/99	10:20	No	9.5	7.7		10.2		94		307	2	0.37		0.01			
Forest Creek at 6480 Hwy 238	05/19/99	11:40	No	11.6	7.62		10		97		333	1	0.51		0.01			
Forest Creek at 6480 Hwy 238	06/03/99	3:00	No	11.9	7.81		9.5		93		351	2	0.36		0			
Forest Creek at Billie's (Dam)	04/21/99	10:10	No	9.8	8		10.88		101		305	8	0.53		0.03		0.2	
Forest Creek at Billie's (Dam)	05/19/99	11:05	No	11.8	8.2		11.2		109		324	2	0.47		0.02			
Forest Creek at Billie's (Dam)	06/03/99	2:15	No	12.4	8.01		10		98		355	2	0.33		0.04			
Forest Creek at Mouth	03/18/99	10:30	No	8.4	8		9.24		83		271	3	0.58		0.12			
Forest Creek at Mouth	04/21/99	9:45	No	9.8	7.7		10.36		96		304	3	0.51		0.08		0.31	
Forest Creek at Mouth	05/19/99	10:30	No	11.7	7.55		11.1		107		324	1	0.6	0.64	0.08	0.08		Yes
Forest Creek at Mouth	06/03/99	1:10	No	12.9	7.94		9.68		96		350	2	0.37	0.41	0.02	0.01		Yes
Forest Creek at ODOT	04/21/99	10:55	No	9.1	8.1		10.3		94		309	2	0.41		0.02			
Forest Creek at ODOT	05/19/99	11:55	No	11.2	7.86	7.8	9.48	9.34	91	89	334	1	0.49	0.58	0.01	0.01		Yes
Forest Creek at ODOT	06/03/99	2:35	No	11.7	7.77	7.82	9.1	9.1	88	88	350	3	0.46	0.3	0.01	0.01		Yes
Poormans Creek at Longernecker	04/21/99	10:45	No	9.8	7.6		9.8		92		285	2	0.42		0.02			
Poormans Creek at Longernecker	05/19/99	12:15	No	12.3	7.71		9.54		95		311	0	0.37		0.01			

Notes

Access very difficult through Forest Ck

DO samples rushed, due to Christov.

Sod clumps from church scarttered around @ 238 bridge
Large school of fingerling slamonids

Margins covered by filamentous green algae.
100% algae covered, appears to be decaying
100% covered in algae (some decaying).

Brown and green algae covering 65% of reach

No algae present @ mouth; weather overcast and drizzle
Water clear, no algae present
Large school of fingerling slamonids

No algae present.

Very low flow

JAN 3 1 2000

TURBIDITY MONITORING IN THE APPLEGATE RIVER BASIN: WINTER 1998-99

A PROJECT OF THE APPLEGATE RIVER WATERSHED COUNCIL
1999

Eric Miller

Hans Rilling

Summary

During the winter of 1998-99 the Applegate River Watershed Council (ARWC) established a network of volunteers to assist in monitoring stream turbidity. Turbidity is the cloudy or murky look that water can have and is an indicator of suspended sediment. The suspended fines that constitute turbidity are slow to settle and move some distance before settling, making it possible to detect disturbances downstream from the site of erosion. High turbidity is anticipated in winter, since high flows scour and remove sediment from streambeds and banks and rains wash sediment from roads.

Sediment is a factor that contributes to the impairment of salmonid habitat in the Applegate. Too much fine sediment in the stream or streambed degrades aquatic invertebrate and fish habitats. Excess sediment can also alter the structure and width of stream channels and adjacent riparian zones. Monitoring the sources of sediment, its transportation by streams, and deposition trends can provide important information for better management decisions. Monitoring turbidity addresses one component of the erosional cycle, the transport of fine sediment.

The volunteers, 16 in all, collected samples monthly from early November till early April and during exceptionally high flow events. ARWC staff collected samples from areas not covered by volunteers. A total of 273 samples from 41 sites were analyzed.

The data that was collected provided useful information. We found that the Little Applegate River and Williams Creek, major tributaries of the Applegate River, had high turbidity during high flows. The Little Applegate River was apparently the worst and had high turbidity as far as 13 miles from its mouth. Two major tributaries to the Little Applegate River had widely differing turbidities. Yale Creek was as turbid as was the Little Applegate River, while turbidity values of Sterling Creek were low. Grouse Creek, a small tributary, was very clear.

In the Williams Basin the East and West Forks of Williams Creek were nearly equally turbid, but were slightly clearer than the mainstem. Munger Creek was a clear stream.

Thompson Creek was quite turbid during the first of the three major storms, while Slate Creek remained relatively clean at all times. Both are important tributaries of the Applegate River.

The primary goal of monitoring turbidity is to locate areas where restoration projects could have maximum benefit. This study identifies the Little Applegate River, and Williams and Thompson Creeks as sub-basins where sediment reduction projects should have high priority. More detailed and refined data should enable us to more closely localize sediment sources and, consequently, restoration project sites.

Acknowledgements

We are indebted to the volunteers whose efforts provided the major portion of the data that are the backbone of the report.

This Work was supported by Grant 98-275 from the Governor's Watershed Enhancement Board and Grant 149-99 from the Department of Environmental Quality

Introduction

Sediment is composed of clay, sand, small gravel, and decomposing leaves and is a natural component of streambeds. However, excessive sediment can clog the spaces between the larger gravels and cobble, spaces that are important for the health of the stream. Salmon lay their eggs in gravel, and salmon fry hide and feed in these spaces. Insects and insect larvae also live here and provide food for fish.

In winter and spring, rains and melting snows bring new sediment into streams, and high stream flows wash sediment downstream. If sediment input is greater than that flushed out, our streams may suffer. Large increases in sediment can impair or eliminate fish and aquatic macroinvertebrate habitat and can even alter the structure of the stream.

Last year, the Applegate River Watershed Council (ARWC) established a network of volunteers to monitor stream turbidity. Turbidity or suspended sediment can be measured easily. The suspended fines that constitute turbidity may move some distance before settling, thus making it possible to detect disturbances downstream from the site of erosion. High turbidity is anticipated in winter, since high flows scour and remove sediment from streambeds and banks. Rains wash sediment from roads and can reveal zones of active erosion. In summer, the most likely causes of increased turbidity are human activities or animal disturbances.

Applegate Basin volunteers collected samples monthly during fall, winter, and spring and during exceptionally high flow events. There were sixteen volunteers in 1998-99 who monitored twenty-two sites. Samples were mailed to ARWC for determination of turbidity. In addition, ARWC staff collected samples from areas not covered by volunteers. A total of 273 samples from 41 sites were analyzed.

The data are reported in Nephelometric Turbidity Units (NTU). The Oregon Watershed Enhancement Board recommends 50 NTU as the upper level for fish bearing streams. Turbidity above 50 NTU is not lethal for fish but can impair sight feeding and small particles at that level may damage gill tissue.

A more comprehensive discussion of streams, sediment and turbidity can be found in the appendix. Methods and a complete listing of the data are also in that section of the report.

Results

Data were collected from early November through early April. In addition to volunteers, ARWC staff collected samples, especially during high flow events. A map showing the location of the forty-one monitoring sites is given in Figure 1. Figure 2 shows the turbidity of these sites (273 samples) graphed as a function of the date of sample collection. This graph shows quite clearly that there were three brief periods in the fall and winter of '98-'99 that had high levels of stream turbidity. Not surprisingly, each event was associated with a storm. The inset on this graph shows the precipitation recorded in Medford during the same period: 4.44 inches for November 20-23; 2.05 inches for January 19-22; and 1.21 inches for February 6-7. The latter two storms were rain-on-snow events.

<u>Turbidity During Storms</u>

The turbidity data can be utilized to locate sources of sediment in the system as well as locations where turbidity seems not to be a problem. Figures 3A-3C show turbidity of the three different storms graphed to show the location (site) of sample collection. The vertical lines in this graph are used to delineate the sub-basin or area from which the data were collected. The names and locations for the various sites are given in the legend of Figure 1. Figures 3A-3C show that the streams of the Williams and Little Applegate sub-basins had high turbidities during all three storms.

Table 1 shows the data from the different sites in Little Applegate and Williams Basins for these storms. These data show that the turbidity generally increases as the Little Applegate River progresses towards its mouth. (It should be noted that turbidity values are not additive as two bodies of water mix. For

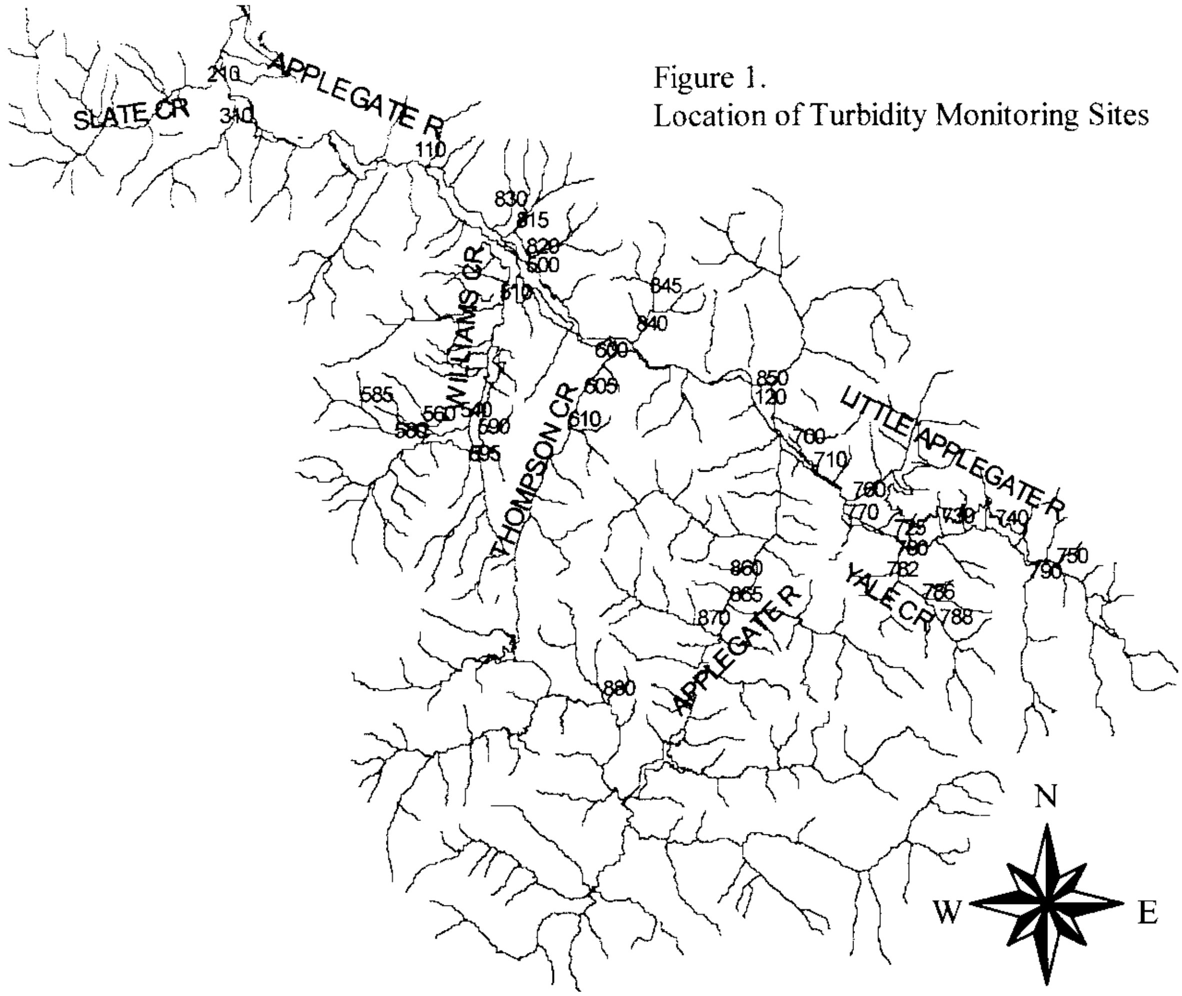


Figure 1.
Location of Turbidity Monitoring Sites

List of Sites and Site Numbers

Applegate above Grays Creek	110	Little Applegate at Tunnel Ridge	740
Applegate at Cantrall Buckley Park	120	Little Applegate at Brickpile Ranch	750
Slate Creek at Wilderville	210	Sterling Creek at Little Applegate Rd.	760
Cheney Creek below Little Cheney	310	Grouse Creek at mouth	770
Murphy Creek at Mouth	400	Yale Creek at Mouth	780
Williams Creek at Rt. 238 Bridge	500	Yale Creek at .6 mile bridge	782
Williams Creek at Powell Ck.	510	Yale Creek below Dog Fork	786
West Fork Williams at E. Fk. Bridge	540	Dog Fork of Yale Creek	788
West Fork Williams at 2455 Cedar Flat Rd	560	Glade Creek	790
Munger Creek at Kincaid Rd.	580	Jackson Creek	810
Upper Munger Creek	585	Caris Creek	815
East Fork Williams at Browns Rd.	590	Slagle Creek	820
East Fork Williams at Browns Rd.	590	Miller Creek	830
East Fork Williams below Rock Ck.	595	Humbug Creek at Rt. 238 Bridge	840
Thompson Creek at mouth	600	Humbug Creek at 4099 Humbug Ck. Rd.	845
Thompson Creek at Mile 2	605	Forest Creek at Hamilton Road	850
Thompson Creek at Tallowbox Ck.	610	Beaver Creek at Mouth	860
Little Applegate River at Mouth	700	Beaver Creek above mouth	865
Little Applegate at road mile 2.6	710	Palmer Creek at Bridge	870
Little Applegate at Yale (Bridge)	725	Carberry Creek at 4 mile mark	880
Little Applegate at 9868 Little Applegate Rd.	730		

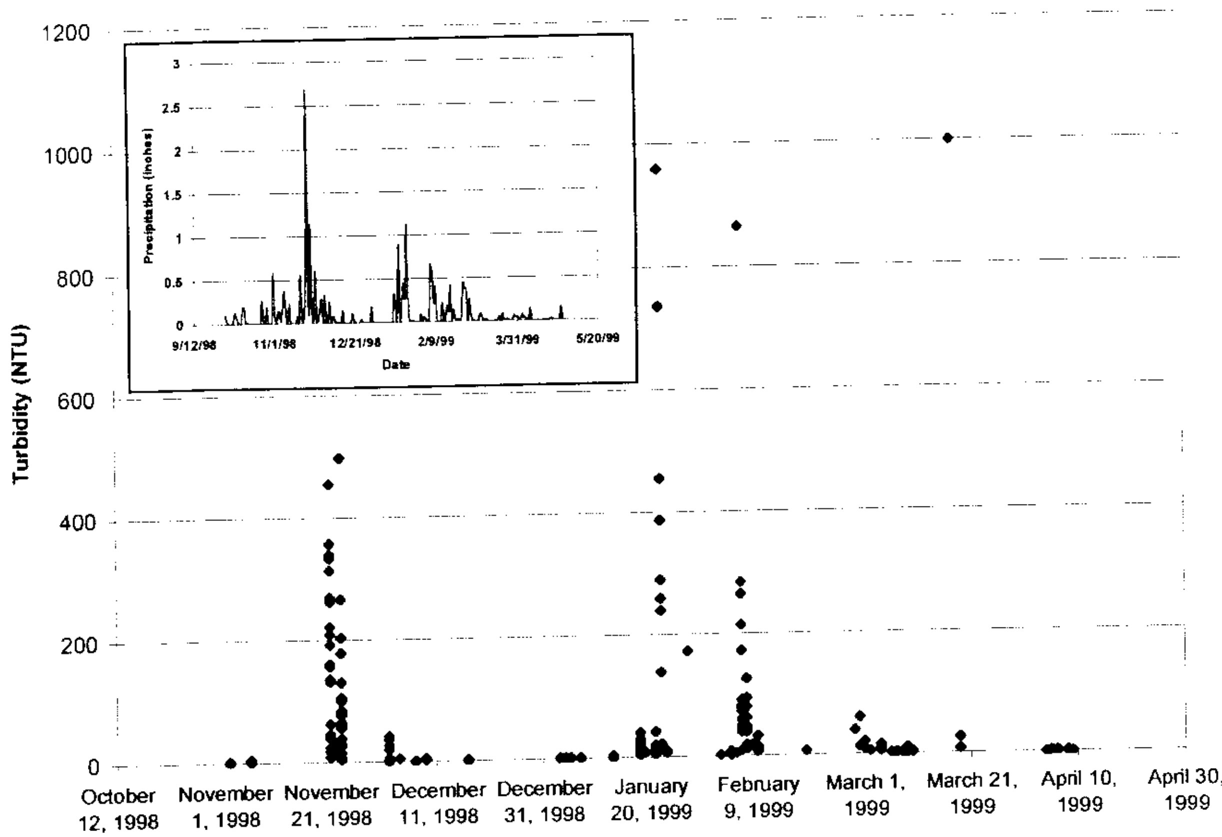


Figure 2. Levels of turbidity at all sites during the Winter of 1998-99.
The inset shows precipitation (inches) recorded in Medford, OR during this period.

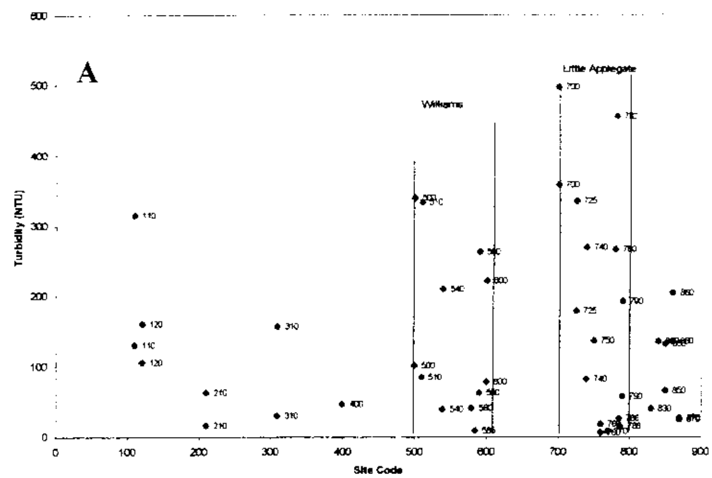
example, if two streams of similar discharge and identical turbidities converge, the resulting stream should have the same turbidity as each of the tributaries.) From this table, it is apparent that Yale Creek's turbidity is similar to that of the Little Applegate where they converge; and that Sterling and Grouse Creeks are usually not major contributors of suspended sediment.

Table 1 also shows a similar analysis for the Williams Basin. Here the mainstem had higher turbidity than the East and West Forks, its major tributaries, for nearly all determinations for these three storms. The data in these tables show that for the first day of the November storm the Little Applegate River and Williams Creek had comparable turbidity levels. For the second day of that storm as well as for the January and February storms the Little Applegate River was considerably more turbid than Williams Creek.

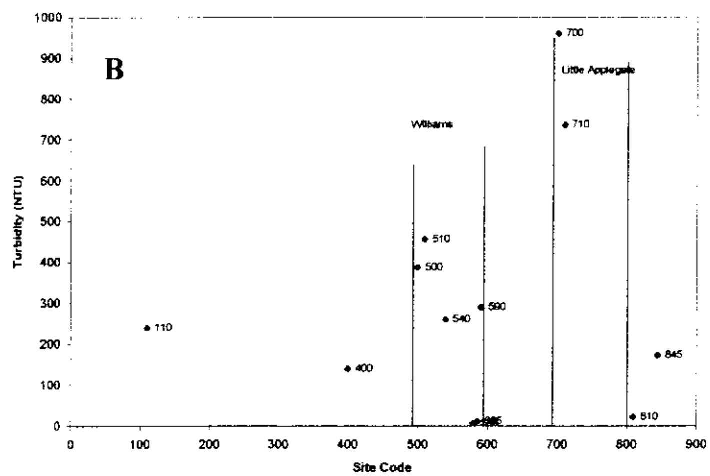
Turbidity During Storm-Free Periods

Locating streams with low suspended sediment is just as important as finding those with a high output. Table 2 lists sites where the turbidity was 50 or less during the three storm events of last winter. Very important primary drainages did not have high levels of turbidity. These were Slate, Murphy, Sterling, Beaver, and Palmer Creeks. Tributaries in the sub-basins or smaller tributaries with low turbidity were, in the Williams Basin West Fork of Williams Creek and Munger Creek; in the Little Applegate Basin, Grouse Creek, and the upper Yale Creek area; and on the Mainstem, Jackson Creek, and the north-side streams, Caris and Miller Creeks.

A final look at the turbidity data is given in Figures 4A and B. All non-storm data are depicted in

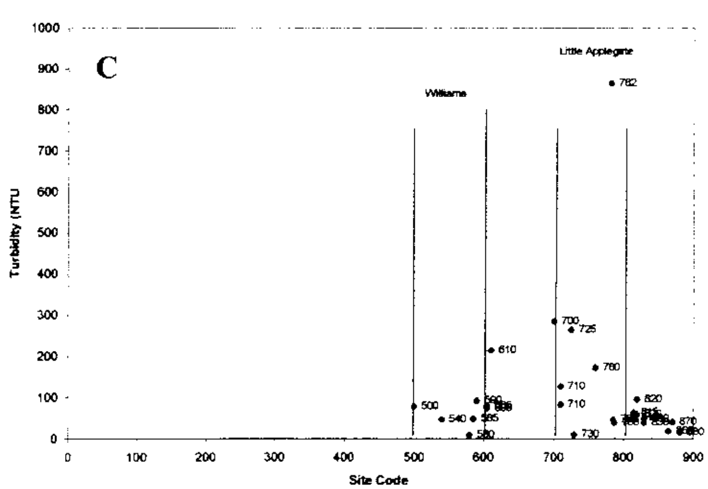


Turbidity during the November Storm



Turbidity during the January Storm

Figure 3
Turbidity at all sites for which data was collected during the three storms.



Turbidity during the February Storm

Table 1. Turbidity (NTU) During Storms

Little Applegate Basin

Little Applegate	21-Nov	23-Nov	22-Jan	06-Feb
at Mouth	358	498	960	285
at Road Mile 2.6			736	83
above Yale Creek	336	179		265
at Tunnel Ridge	270	82		
at Brickpile Ranch	137			
Tributaries				
Yale Creek		267		865
Sterling Creek	18	6		173
Grouse Creek		8		

Williams Basin

Williams Creek	21-Nov	23-Nov	22-Jan	06-Feb
at Rt. 238 Bridge	340	101	387	79
below Powell Ck.	334	85	456	
Tributaries				
W. Fk. At Confluence	210	39	260	47
E. Fk. At Confluence	263	63	290	92
Munger at Kincaid	41			10
Upper Munger	9			48

Table 2. Sites with turbidity of 50 NTU or less during storms

Site	Code	November Storm	January Storm	February Storm
Slate Creek at Wilderville	210	16		
Cheney Creek below Little Cheney	310	30		
Murphy Creek at mouth	400	46		
West Fork Williams at confluence	540	39		47
Munger Creek at Kincaid Rd.	580	41	7	10
Upper Munger Ck.	585	9	12	48
Little Applegate at 9868 Little Applegate Rd.	730			12
Sterling Creek at Little Applegate Rd.	760	6, 18		
Grouse Creek at mouth	770	8		
Yale Creek below Dog Fork	786	26		47
Dog Fork, Yale Creek	788	15		40
Jackson Creek	810		22	
Caris Creek	815			50
Miller Creek	830	40		40, 48
Beaver Creek near mouth	865			19
Palmer Creek at Bridge	870	24, 27		41
Carberry Creek at 4 mile mark	880			16

these figures. Turbidity values are on a logarithmic scale so that the lower values can be spread for easier viewing. The data are divided into two graphs for the same reason. It is possible to identify virtually all of the data points by a quick inspection of these figures. A line at fifty NTU, which represents the upper "safe" turbidity level for salmonids, is projected on both graphs. Most turbidity values in these figures are below 50, and sites 110 (Applegate River above Grays Creek) and 210 (Slate Creek at its mouth) never had values greater than 10 NTU. Three high turbidities stand out. The 1000 NTU was obtained for the

Little Applegate River at a site nearly ten miles upstream from its mouth. The extremely high turbidity was a result of a large landslide on Rush Creek Road, which resulted in the delivery of a large volume of muddy water to the Little Applegate River (Figure 5). The sediment plume was clearly visible all the way to the mouth of the Little Applegate River. The other two high values were of 173 NTU at the mouth of Humbug Creek on January 27th and of 61 NTU found for Carberry Creek on February 28th. The reasons for these high turbidities are not known.

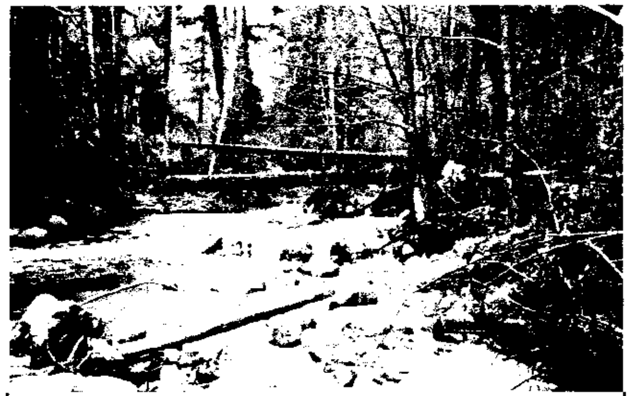


Figure 5. Sediment entering the Little Applegate River from the Rush Creek road landslide (3/19/99).

The Influence of the Applegate Dam

The Applegate Dam acts as a huge settling pond for the upper Applegate River, so that the water discharged from the dam is relatively clean during winter flows. We did not sample the Applegate River above Cantrall Buckley Park, so we do not have a direct measure of the effectiveness of the dam in removing fines. Figure 6 shows that the mainstem is considerably cleaner than Beaver Creek, one of the streams with consistent low turbidity. In addition, one can estimate from data that we collected. Samples taken from the Applegate River at Cantrall Buckley Park include contributions from the Little Applegate River and Beaver and Palmer Creeks. During the November storm the turbidity at Cantrall Buckley Park was 161 and 106 NTU, while the Little Applegate was contributing water with turbidities of 358 and 498 NTU to the mainstem just a few miles upstream. This dilution in turbidity indicates that the river above the Little Applegate was relatively clean.

During the summer the Applegate River is clear below the dam. Average turbidity at the monitoring site above Palmer Creek in 1998 was 1 NTU. In 1999, turbidity above Beaver Creek ranged from 1 to 3 NTU. Consequently, it was a surprise that in mid-October of 1999 that we noticed that the Applegate River below the dam was turbid. For several weeks the turbidity was found to be in the 15 to 25 NTU range. At that time the Little Applegate and Palmer Creek had turbidities of 1 or less NTU. Quite obviously the water collected behind the dam was more turbid than other streams. What may have happened was that the water level of Applegate Lake was so low that the dam was no longer efficiently trapping sediment. Disturbances such as rain or increased inflow from tributaries to the lake were probably stirring up fines that had been collected behind the dam. The level of the lake was so low that it was now contributing fine sediment rather than removing it. This is unfortunate, since this is the time that coho salmon wold be spawning or would have spawned and the fines would infiltrate the gravels of new redds.

Figure 6.The mouth of Beaver Creek (2/18/99) during a 1.2 inch period of precipitation

Consultation with the Corps of Engineers, operators of the dam, revealed the lake inadvertently had been drawn too far down late in the summer. Since it was necessary to maintain sufficient flow in the Applegate River to cover redds, it was not possible to decrease the outflow so that the lake could rise to a level at which it could function as a sediment trap.

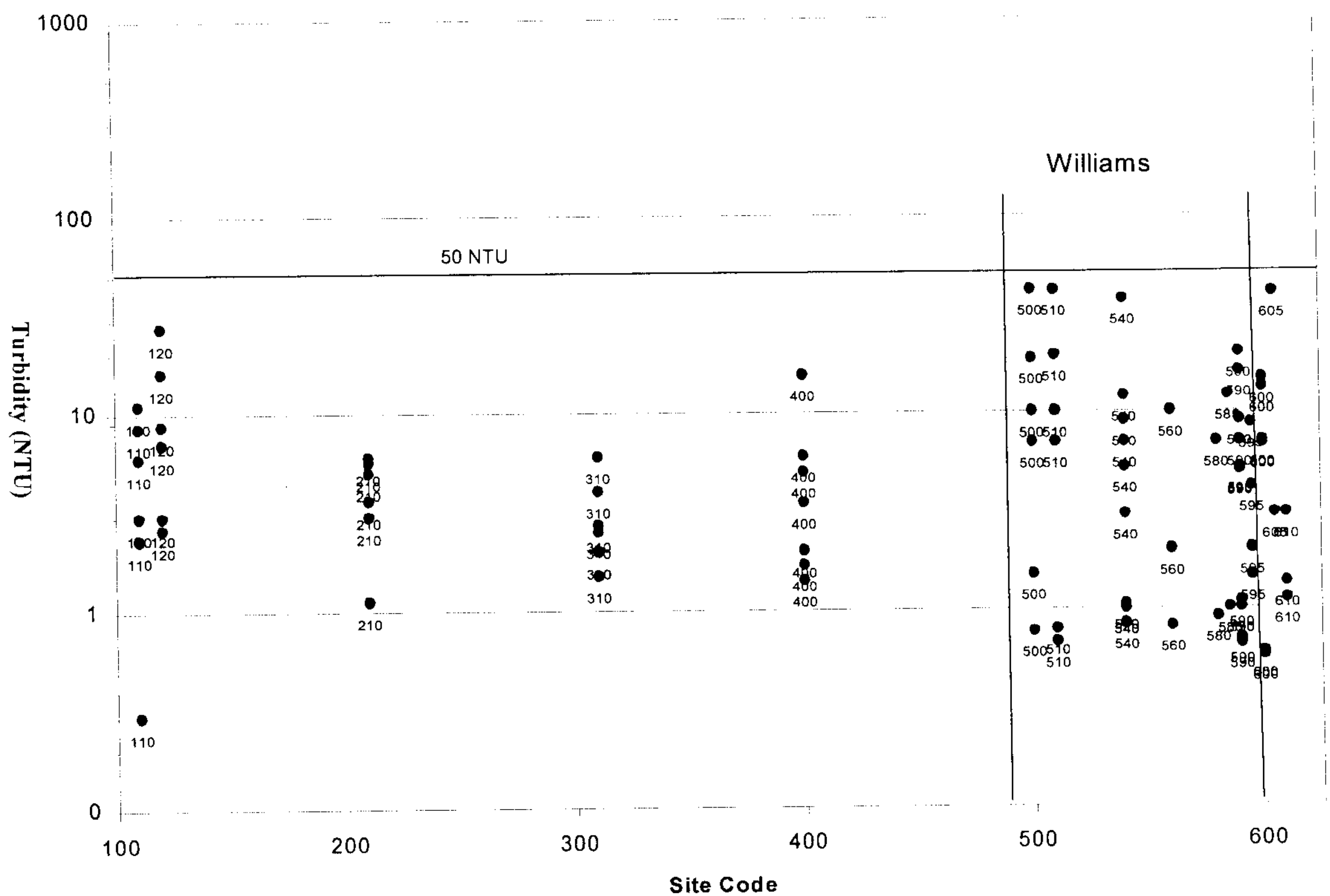


Figure 4A. Non-Storm Data, Sites 110 to 690

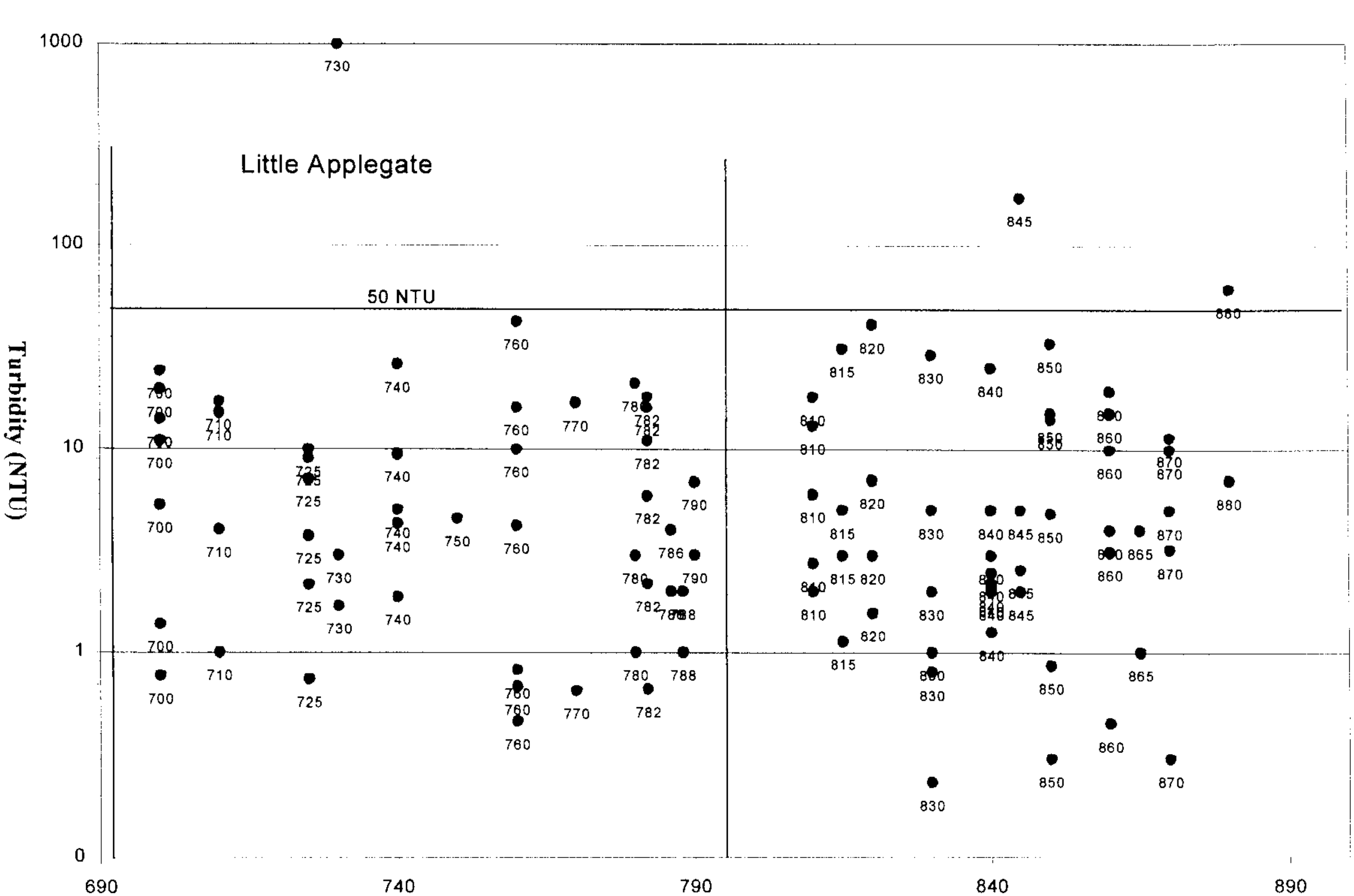


Figure 4B. Non-Storm Data, Sites 700 to 870

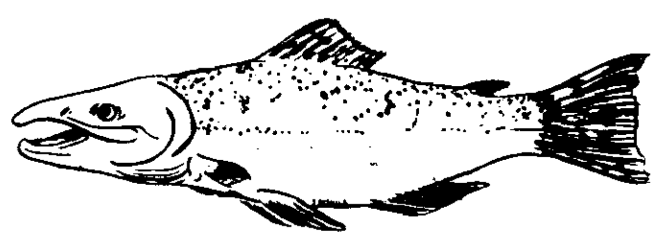
Discussion

Caution should be used in interpreting turbidity data. The fines that cause turbidity can settle in a matter of hours or days. The high flows that scour out fines and the rains that bring sediment in from roads, cultivated fields and other disturbed areas are uneven with respect to time and space. Ideally the streams should be sampled near the top of a rising hydrograph. Since we cannot anticipate this time and since we lack the number of samplers necessary to cover the Applegate Basin in a few hours, our data are but an approximation. Nonetheless, with a sufficient number of samples from each site and a few storms to track, our data provide some quite useful information. Clearly the Little Applegate River and Williams Creek, major tributaries of the Applegate River, carry high loads of suspended sediment during high flow events. The Little Applegate River seems to be the most turbid. Our data serve to show that the Little Applegate River has high turbidity for as far up as river mile 13. Yale Creek, a majortributary, is as turbid as the Little Applegate, while another major tributary, Sterling Creek, is relatively clean. Grouse Creek, which is quite small, runs clean.

In the Williams Basin the East and West Fork contribute nearly equally, but are slightly less turbid than the mainstem. Munger Creek is a clean stream.

Thompson Creek was quite turbid during the November and February storms. This stream was not sampled during the January storm. Slate Creek remained relatively clean at all times. Both these streams are important tributaries of the Applegate River.

One of the goals of monitoring is to enable us to locate areas where restoration projects could have maximum benefit. This study clearly points out areas where sediment reduction projects should have a high priority. With more detailed and refined data it should be possible to more closely localize sediment sources and consequently enable us to pinpoint project sites.



APPENDIX

Background

Sediment is the product of erosional and fluvial processes. Erosion involves detachment of sediment particles, transporting them from the original site with eventual deposition elsewhere. Site characteristics such as geology, soils, slope and length, vegetation, precipitation, channel and stream flow characteristics all influence erosion rates. Erosion and the delivery of sediment to stream systems are complex and naturally occurring processes in all watersheds. However, by modifying the landscape, human activities can increase rates of erosion.

Sediment is a factor that contributes to the impairment of salmonid habitat in the Applegate. Too much fine sediment in the stream or streambed degrades aquatic invertebrate and fish habitats. Excess sediment also alters the structure and width of stream channels and adjacent riparian zones (MacDonald et al. 1991). Increased sediment input may elevate suspended sediment concentrations and turbidity. Excess fine sediments fill intergravel spaces used by aquatic insects and young fish. Pool frequency and depth may diminish, and channel sinuosity and other channel characteristics can be appreciably changed. Land management activities contribute to these impacts by affecting watershed processes and altering sediment delivery to a stream network.

Monitoring the sources of sediment, its transportation by streams, and deposition trends can often provide important information for better management decisions. Monitoring turbidity addresses one component of the erosional cycle—the transport of fine sediment.

Sediment particles are characterized by their size. They range from the finest clays and silt particles to sand, pebbles, gravels, and boulders. Once sediment particles have been introduced to a stream system, the smaller particles (silts and clays) are typically transported as suspended sediment in the water column before eventually settling out and depositing. Suspended sediment is difficult and expensive to measure. Turbidity, which is relatively easy and inexpensive to measure, is frequently used as an indirect measure of suspended sediment and is often a basis for determining water quality. Monitoring turbidity provides valuable information to help us understand baseline trends as well as the effects of specific projects on water quality.

Turbidity varies with the number and size of particles present in the water column. Turbidity is the optical property of a sample that causes light to be scattered and absorbed. Clays and silts are primarily responsible for light scatter. The relationship between suspended sediment and turbidity varies greatly between sites. For example, a watershed with coarse soils may have large fluctuations in suspended sediment with little change in turbidity. A watershed with fine clay soils may have high turbidity with low concentrations of other suspended sediment.

Turbidity levels are generally influenced by the same factors as suspended sediment and, in general, turbidity can be expected to increase during high stream flow events, but this will vary within a given storm and between storms.

For example, the first storm of the year may produce higher turbidity than a storm of the same magnitude later in the season. Likewise, as stream flow initially rises during a storm event, turbidities may be high. The equivalent flow as the stream recedes may produce lower turbidity levels. Because of these characteristics, the variability in turbidity between sites and over time can make it difficult to establish background levels and trends. It is important to use caution when drawing conclusions with turbidity data.

Information taken from L. H. MacDonald et.al. (1991), *Monitoring Guidelines to Evaluate the Effects of Forestry Activities on Streams of the Pacific Northwest and Alaska*, EPA 910/9-91-001. and *Water Quality Monitoring; Technical Guidebook* (1999), The Oregon Plan for Salmon and Watersheds.

A Complete List of Data by Site and Date

Site	Code	Date	Storm?	Turbidity
Applegate above Grays Creek	110	06-Nov-98		2
		21-Nov-98	storm	315
		23-Nov-98	storm	131
		09-Dec-98		6
		07-Jan-99		2
		22-Jan-99	storm	240
		04-Feb-99		9
		09-Mar-99		11
		06-Apr-99		3
Applegate at Cantrall Buckley Park	120	02-Nov-98		3
		21-Nov-98	storm	161
		23-Nov-98	storm	106
		02-Dec-98		27
		05-Jan-99		3
		18-Jan-99	storm	9
		09-Feb-99		16
		04-Mar-99		16
		19-Mar-99		7
Slate Creek at Wilderville	210	06-Nov-98		6
		21-Nov-98	storm	63
		23-Nov-98	storm	16
		09-Dec-98		4
		07-Jan-99		1
		04-Feb-99		5
		09-Mar-99		6
		06-Apr-99		3
Cheney Creek below Little Cheney	310	06-Nov-98		3
		21-Nov-98	storm	157
		23-Nov-98	storm	30
		09-Dec-98		3
		07-Jan-99		2
		04-Feb-99		4
		09-Mar-99		6
		06-Apr-99		2
Murphy Creek at Mouth	400	06-Nov-98		2
		21-Nov-98	storm	46
		09-Dec-98		4
		07-Jan-99		1
		18-Jan-99	storm	16
		22-Jan-99	storm	140
		04-Feb-99		5
		09-Mar-99		6
		06-Apr-99		2
Williams Creek at Rt. 238 Bridge	500	02-Nov-98		2
		21-Nov-98	storm	340
		23-Nov-98	storm	101
		02-Dec-98		42
		05-Jan-99		1
		18-Jan-99	storm	19
		22-Jan-99	storm	387

Site	Code	Date	Storm?	Turbidity
		06-Feb-99	storm	79
		09-Feb-99		10
		04-Mar-99		7
Williams Creek at Powell Ck.	510	02-Nov-98		1
		21-Nov-98	storm	334
		23-Nov-98	storm	85
		02-Dec-98		41
		05-Jan-99		1
		18-Jan-99	storm	19
		22-Jan-99	storm	456
		09-Feb-99		10
		04-Mar-99		7
West Fork Williams at E. Fk. Bridge	540	02-Nov-98		1
		21-Nov-98	storm	210
		23-Nov-98	storm	39
		02-Dec-98		37
		04-Dec-98		5
		05-Jan-99		1
		07-Jan-99		1
		18-Jan-99	storm	12
		22-Jan-99	storm	260
		06-Feb-99	storm	47
		09-Feb-99		7
		04-Mar-99		9
		09-Mar-99		3
		09-Apr-99		1
West Fork Williams at 2455 Cedar Flat Rd	560	03-Jan-99		1
		01-Mar-99	storm	10
		05-Apr-99		2
Munger Creek at Kincaid Rd.	580	21-Nov-98	storm	41
		23-Jan-99		7
		06-Feb-99	storm	10
		17-Dec-98		1
Upper Munger Creek	585	21-Nov-98	storm	9
		23-Jan-99		12
		06-Feb-99	storm	48
		17-Dec-98		1
East Fork Williams at Browns Rd.	590	02-Nov-98		1
		21-Nov-98	storm	263
		23-Nov-98	storm	63
		02-Dec-98		20
		04-Dec-98		5
		05-Jan-99		1
		07-Jan-99		1
		18-Jan-99	storm	16
		22-Jan-99	storm	290
		06-Feb-99	storm	92
		09-Feb-99		9
		04-Mar-99		7
		09-Mar-99		5

Site	Code	Date	Storm?	Turbidity
East Fork Williams at Browns Rd.	590	09-Apr-99		1
		07-Dec-98		1
East Fork Williams below Rock Ck.	595	13-Jan-99		4
		19-Jan-99		9
		06-Mar-99		2
Thompson Creek at mouth	600	02-Nov-98		1
		21-Nov-98	storm	222
		23-Nov-98	storm	78
		02-Dec-98		7
		05-Jan-99		1
		18-Jan-99	storm	15
		09-Feb-99		13
		04-Mar-99		7
Thompson Creek at Mile 2	605	06-Feb-99	storm	74
		07-Feb-99	storm	81
		27-Feb-99	storm	40
		07-Mar-99		3
Thompson Creek at Tallowbox Ck.	610	07-Dec-98		1
		04-Jan-99		1
		06-Feb-99	storm	215
		08-Mar-99		3
Little Applegate River at Mouth	700	02-Nov-98		1
		21-Nov-98	storm	358
		23-Nov-98	storm	498
		02-Dec-98		5
		05-Jan-99		1
		18-Jan-99	storm	24
		21-Jan-99	storm	20
		22-Jan-99	storm	960
		06-Feb-99	storm	285
		09-Feb-99		14
		04-Mar-99		11
Little Applegate at road mile 2.6	710	18-Jan-99	storm	15
		21-Jan-99	storm	17
		22-Jan-99	storm	736
		06-Feb-99	storm	83
		07-Feb-99	storm	127
		07-Mar-99		4
		04-Apr-99		1
Little Applegate at Yale (Bridge)	725	02-Nov-98		1
		21-Nov-98	storm	336
		23-Nov-98	storm	179
		02-Dec-98		4
		05-Jan-99		2
		21-Jan-99	storm	7
		06-Feb-99	storm	265
		09-Feb-99		10
		04-Mar-99		9

Site	Code	Date	Storm?	Turbidity
Little Applegate at 9868 Little Applegate Rd.	730	05-Jan-99		2
		07-Feb-99	storm	12
		06-Mar-99		3
		18-Mar-99		1000
Little Applegate at Tunnel Ridge	740	21-Nov-98	storm	270
		23-Nov-98	storm	82
		02-Dec-98		4
		05-Jan-99		2
		18-Jan-99	storm	9
		21-Jan-99	storm	5
		19-Mar-99		26
Little Applegate at Brickpile Ranch	750	21-Nov-98	storm	137
		02-Dec-98		5
Sterling Creek at Little Applegate Rd.	760	02-Nov-98		0
		21-Nov-98	storm	18
		23-Nov-98	storm	6
		02-Dec-98		1
		05-Jan-99		1
		18-Jan-99	storm	4
		21-Jan-99	storm	42
		06-Feb-99	storm	173
		09-Feb-99		16
		04-Mar-99		10
Grouse Creek at mouth	770	23-Nov-98	storm	8
		02-Dec-98		1
		21-Jan-99	storm	17
Yale Creek at Mouth	780	23-Nov-98	storm	267
		02-Feb-99		3
		01-Mar-99	storm	21
		05-Apr-99		1
Yale Creek at .6 mile bridge	782	02-Nov-98		1
		21-Nov-98	storm	456
		02-Dec-98		6
		05-Jan-99		2
		21-Jan-99	storm	18
		06-Feb-99	storm	865
		09-Feb-99		16
		04-Mar-99		11
Yale Creek below Dog Fork	786	22-Nov-98	storm	26
		13-Jan-99		2
		07-Feb-99	storm	47
		10-Mar-99		4
Dog Fork of Yale Creek	788	22-Nov-98	storm	15
		13-Jan-99		1
		07-Feb-99	storm	40
		10-Mar-99		2

Site	Code	Date	Storm?	Turbidity
Glade Creek	790	21-Nov-98	storm	193
		23-Nov-98	storm	57
		02-Dec-98		3
		18-Jan-99	storm	7
Jackson Creek	810	04-Jan-99		3
		22-Jan-99	storm	22
		08-Feb-99	storm	18
		28-Feb-99	storm	13
		02-Mar-99		6
		06-Apr-99		2
Caris Creek	815	03-Jan-99		1
		18-Jan-99	storm	31
		06-Feb-99	storm	50
		07-Feb-99	storm	64
		09-Mar-99		5
		08-Apr-99		3
Slagle Creek	820	03-Jan-99		2
		18-Jan-99	storm	41
		06-Feb-99	storm	60
		07-Feb-99	storm	96
		09-Mar-99		7
		08-Apr-99		3
Miller Creek	830	21-Nov-98	storm	40
		09-Dec-98		2
		03-Jan-99		0
		07-Jan-99		1
		18-Jan-99	storm	29
		04-Feb-99		5
		06-Feb-99	storm	40
		07-Feb-99	storm	48
		09-Mar-99		5
		06-Apr-99		1
		08-Apr-99		1
Humbug Creek at Rt. 238 Bridge	840	06-Nov-98		2
		21-Nov-98	storm	136
		09-Dec-98		2
		03-Jan-99		2
		07-Jan-99		1
		18-Jan-99	storm	25
		04-Feb-99		3
		09-Mar-99		5
		06-Apr-99		2
Humbug Creek at 4099 Humbug Ck. Rd.	845	03-Jan-99		2
		27-Jan-99	storm	173
		05-Feb-99		5
		17-Dec-98		3

Site	Code	Date	Storm?	Turbidity
Forest Creek at Hamilton Road	850	02-Nov-98		0
		21-Nov-98	storm	132
		23-Nov-98	storm	65
		02-Dec-98		5
		05-Jan-99		1
		18-Jan-99	storm	14
		09-Feb-99		33
		04-Mar-99		15
Beaver Creek at Mouth	860	21-Nov-98	storm	136
		23-Nov-98	storm	205
		02-Dec-98		3
		05-Jan-99		0
		21-Jan-99	storm	19
		09-Feb-99		15
		04-Mar-99		10
		10-Mar-99		4
Beaver Creek above mouth	865	04-Jan-99		1
		07-Feb-99	storm	19
		10-Mar-99		4
		04-Apr-99		1
Palmer Creek at Bridge	870	21-Nov-98	storm	24
		23-Nov-98	storm	27
		02-Dec-98		3
		07-Dec-98		0
		05-Jan-99		0
		21-Jan-99	storm	11
		06-Feb-99	storm	41
		09-Feb-99		10
		04-Mar-99		5
Carberry Creek at 4 mile mark	880	07-Feb-99	storm	16
		18-Feb-99	storm	7
		28-Feb-99	storm	61

Methods

Turbidity was determined with a HACH Model 2100P turbidimeter. Samples collected by ARWC staff were measured on site. Volunteers mailed their samples to ARWC for analysis. These were usually measured within two days of collection. Cool temperatures and low levels of nutrients made it unlikely that bacterial growth could have effected turbidity levels.

Some turbid samples were retained for more than a week and their turbidity checked periodically. If these samples were thoroughly shaken before reading, the turbidity values did not change over this time period.