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UMATILLA RIVER BASIN ANADROMOUS FISH HABITAT ENHANCEMENT PROJECT

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ANNUAL REPORT



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ABSTRACT

The Umatilla River Basin Anadromous Fish Habitat Enhancement Project continued to identify impacted stream reaches throughout the Umatilla River Basin for habitat improvements during the 2005-2006 contract period. Public outreach efforts, biological and physical monitoring assisted the project in fostering public cooperation, targeting habitat deficiencies, and determining habitat recovery measures. Instream improvements were made on Meacham Creek and required steps were taken towards eliminating salmonid passage barriers in the Birch Creek drainage. Both of these streams are tributary to the Umatilla River.

Previously obtained easements were maintained on 55 private properties, four new easements were secured, one new easement is in negotiation, and five new instream projects are in progress to enhance anadromous fish habitat. New project locations include Meacham Creek and Camp Creek, mainstem Birch Creek, and West Birch Creek, all of which are listed as priority streams for improvement in the Northwest Power & Conservation Council's Umatilla/Willow Subbasin Plan. Project implementation included: (1) placement of large trees (LWD) on Meacham and Iskuulpa Creek streambanks, (2) planting of some 3,000 willow cuttings along Meacham Creek, (3) mulch-stripping and planting of about 1,000 native trees and shrubs in the riparian area of the Peterson easement on Birch Creek (4) installing a trespass barrier on the B & G Resources easement, mid-Umatilla River, (5) weed burning on about 100 acres of the B & G Resources flood plain, and (6) final preparations for planting of 125 acres of native grass seed on B & G Resources and construction of a solar-powered well for livestock at B & G Resources to replace the Umatilla River as a watering source.

A total of $90,000 financial cost share funds was obtained from the Pacific Coastal Salmon Recoverty Fund for use in improving a box-culvert on the Cunningham Sheep Company easement and as partial funding of a fish ladder to be installed below the Hoeft Dam in 2007. The remainder of Hoeft dam ladder implementation will be funded by WHIP grant received from the U.S. Department of Agriculture's in the amount of $182,000. WHIP funds ($18,000) were also used for the vegetative plantings on the Peterson easement and Meacham Creek site. A major portion of project staff time was devoted to preparation for utilizing cost share funds to eliminate fish passage problems in the Birch Creek drainage. Activities included acquisition of easements, pre-project planning, preparation/submittal of environmental compliance documents, and coordination with other agencies and organizations that have an interest in Birch Creek improvements.

Monitoring continued to quantify baseline conditions and the effects of habitat restoration in Meacham and Birch Creeks and the mid-Umatilla River. Daily stream and ambient air temperatures were collected from May through mid-October at historic and new sites. Suspended sediment samples were obtained at three USGS gage stations during 2005/2006 to arrive at daily sediment load estimates. Macroinvertebrate surveys were conducted in upcoming Meacham Creek project areas to assist in assessing the effects of improvements implemented in 2006 and subsequent years.

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LIST OF ACRONYMS AND ABBREVIATIONS

BA	Biological Assessment
BCI	Biotic Condition Index
BIA	Bureau of Indian Affairs
BO	Biological Opinion
BPA	Bonneville Power Administration
cfs	cubic feet per second
cm	centimeters
COE	U.S. Army Corps of Engineers
CPUE	catch-per-unit-effort
CR	County Road
CRITFC	Columbia River Inter-Tribal Fish Commission
CRPP	Cultural Resources Protection Program
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
DBH	diameter at breast height
DNR	Department of Natural Resources
EPA	U.S. Environmental Protection Agency
EP/RP	Environmental Protection/Rights Protection
EPT	a count of the number of taxa belonging to the orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddis flies)
EQIP	Environmental Quality Incentive Program
ESA	Federal Endangered Species Act
ESD	Umatilla-Morrow County Educational Service District
ESU	Evolutionary Significant Unit
FFG	function feeding group
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
Forks	confluence of the North and South Forks of the Umatilla River
FY	fiscal year (refers to Bonneville Power Administration's October through September fiscal period)
GIS	Geographic Information Systems

GPS	Global Positioning Satellite
LWD	large woody debris
m	meters
mg/L	milligrams per liter; same as parts per million
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPPC	Northwest Power Planning Council
NRCS	Natural Resource Conservation Service
NTU	Nephelometric Turbidity Units
NWP	Nationwide Permit
ODEQ	Oregon Department of Environmental Quality
ODF&W	Oregon Department of Fish and Wildlife
ODSL	Oregon Department of State Lands
ORS	Oregon Revised Statute
OSU	Oregon State University
OWEB	Oregon Watershed Enhancement Board
OWRD	Oregon Water Resources Department
PCSRF	Pacific Coastal Salmon Recovery Fund
Project	Umatilla River Basin Anadromous Fish Habitat Enhancement Project
Reservation	Umatilla Indian Reservation
RM	river mile
SHPO	State Historic Preservation Office
SOW	Statement of Work
SWCD	Umatilla County Soil and Water Conservation District
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UBNPME	Umatilla Basin Natural Production Monitoring and Evaluation Project
UBWC	Umatilla Basin Watershed Council
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UNF	Umatilla National Forest
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
UTM	Universal Transverse Mercator
WHIP	Wildlife Habitat Incentive Program
WQMP	Water Quality Management Plan
WY	Water Year (October through September)

1. INTRODUCTION

The Umatilla River Basin Anadromous Fish Habitat Enhancement Project (hereafter referred to as project) is funded with Bonneville Power Administration (BPA) funds and is consistent with the 1994 Northwest Power & Conservation Council's (NPCC) Columbia River Basin Fish and Wildlife Program, Section 7.6 – 7.8, which targets the improvement of water quality and restoration of riparian areas, specifically the holding, spawning and rearing habitats of anadromous salmonids. This project is also compatible with the Habitat Strategies section of the 2000 NPPC Columbia River Basin Fish and Wildlife Program in that emphasis in the basin will depend "heavily on protection of, and improvements to, inland habitat as the most effective means of restoring and sustaining fish and wildlife populations". Funding of this project provides partial mitigation for losses of salmon and steelhead populations in the Columbia River Basin from the construction and operation of hydroelectric dams. This Umatilla River Basin Anadromous Fish Habitat Enhancement Project Annual Report covers work accomplished by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) from February 1, 2005 through January 31, 2007 as part of the Umatilla Basin Fisheries Restoration Program.

Significant effort has been directed at restoration of anadromous fish in the Umatilla River Basin. This habitat project is one element in the comprehensive Umatilla Basin Fisheries Restoration Program that also includes artificial production, adult and juvenile passage improvements (ladders, screens, and trap and haul), instream flow enhancement, riparian vegetation planting, and monitoring and evaluation. Emphasis on watershed-wide habitat is needed for protection and enhancement of the natural production capabilities in the basin.

The primary problems continuing to impact water quality and limit available habitat and natural fisheries production capabilities in the Umatilla River Basin include: non-point source pollution due to poor cropland tillage and rotation practices, livestock overgrazing of riparian and upland areas, over-appropriation of instream flows for irrigation, and stream channelization, constriction, and floodplain modification from agricultural operations and road/railroad building and maintenance.

During 2005-2006 the project focused on improving anadromous and resident salmonid passage on easements secured in the Birch and Meacham Creek drainages.. These efforts should result in providing several miles of channel spawning area and in facilitating passage of adult and juvenile salmonids.

In 1993, the project shifted emphasis from a site specific approach to an upland and riparian watershed-wide approach for identifying causative factors limiting anadromous fisheries habitat and natural fisheries production capabilities. Riparian and instream enhancement projects continued and were expanded to include tributaries outside of Reservation Boundaries. An additional three easements on private property outside the Reservation were secured in 2005/2006 for subsequent improvements to existing barriers and the attendant stream channel. Those new projects include Meacham Creek, mainstem Birch Creek, West Fork Birch Creek, and Wildhorse Creek. A total of 55 easements have been secured with private landowners since initial 1988 implementation efforts.

The project represents a continuation and evolution of existing efforts to improve natural production in the Umatilla River Basin. A subbasin plan (Umatilla/Willow Creek Subbasin Plan or Subbasin Plan) was completed in 2004 that incorporates a watershed assessment with prioritization of fisheries habitat needs and streamlining of project funding. Project planning and prioritization during 2005/2006 followed guidance presented in the Subbasin Plan. The project complements fish passage and artificial production projects in the basin by integrating existing on-the-ground management programs on private and public lands with restoration activities to better justify expenditure of funds and time. Biological and physical surveys, summaries of existing survey information, and follow up surveys are coordinated with CTUIR's Umatilla Basin Natural Production Monitoring and Evaluation (UBNPME) Project. Remedial measures will be implemented to reduce or eliminate detrimental land use activities where possible. Continued operations and maintenance of existing enhancement projects are included under this integrated approach.

The restoration of anadromous fisheries resources in the Umatilla River Basin has been a coordinated effort between CTUIR, state and federal agencies, and the local community. Examples include this project, the Umatilla Basin Watershed Council, the Department of Fish and Wildlife's Umatilla River Subbasin Fish Habitat Improvement Project, the Umatilla River Subbasin Salmon and Steelhead Production Plan, and development of the Umatilla Hatchery along with associated artificial production plans. This coordination has continued and expanded among stakeholder groups and technical committees, local landowners, sportsman clubs, special interest groups, and resource agencies, that strive to identify issues and develop creative solutions to land and water use problems in the basin.

2. DESCRIPTION OF PROJECT AREAS

The following CTUIR Habitat Enhancement Project Table illustrates enhancement project locations, number of stream miles enhanced, and number of landowner agreements secured in each drainage. Figure 1 shows the Umatilla River Basin.

TABLE 1 – CTUIR HABITAT ENHANCEMENT PROJECT TABLE.

STREAM	IMPROVEMENTS IMPLEMENTED	RIVER MILE LOCATIONS	NO. OF STREAM MILES IMPROVED	NO. OF LANDOWNER AGREEMENTS
Mid Umatilla River	Instream; bioengineering	37.3 – 37.4	0.1	1
Mid Umatilla River	Fencing; upland water development	43.0 – 46.5	3.5	3
Mid Umatilla River	Fencing; riparian vegetation	39.5-43	4.0	1
Upper Umatilla River	Fencing; instream bioengineering.	63.5	0.05	1
Upper Umatilla	Fencing; pool development	78.5 – 85.0	3.6	12

River				
Lower Meacham Creek	Fencing; instream; Veg. plantings	0 – 4.5	4.5	14
Boston Canyon Creek (Meacham tributary)	Fencing; instream; riparian veg. plantings	0 – 0.3	0.3	1
Camp Creek (Meacham tributary)	Dam removal	3	PASSAGE SITE	1
Mainstem Birch Creek	Dam removal	3, 10	PASSAGE SITE	3
West Birch Creek	Dam/culvert renovation	2.5, 3	Passage site	2
East Birch Creek	Fencing	10.3 – 10.5	0.2	1
Wildhorse Creek	Fencing; riparian veg. plantings; offstream water development; weed control	9.0 – 12.5	2.0	5
Greasewood Creek	Fencing; riparian veg. plantings	0 – 1.5	1.5	2
W. Fk. Greasewood Cr.	Fencing; riparian veg. plantings	0 – 0.3	0.3	2
Spring Hollow Creek	Fencing; riparian veg. plantings	3.4 – 4.0	0.6	1
Spring Hollow Creek	Instream rock veines; bank strabilization	3.1	Passage site	County right of way
Mission Creek	Instream rock vanes;	2.9 – 3.3	0.4	1
Mission Creek	Fencing; veg. plantings	@ 1.3 and 3.0	Passage site	1
Buckaroo Creek	Fencing; veg. plantings	1.0 – 2.6	1.6	6
Iskuulpa Creek	Fencing; veg. plantings	2.0 – 2.9 and 9.8 – 10.1 (Tribal land)	1.2	0 (Tribal Properties)
McKay Creek	Fencing; veg. plantings	21.5 – 22.25	0.4	2
Moonshine Creek	Instream bioengineering	@ 1.1	Passage site	0

Cottonwood Creek	Instream bioengineering	@ 0.5 and 1.3	Passage site	1
Sears Creek	Culvert removal; instream rock vanes	@ 0.25	Passage site	County right of way
TOTAL			24.25	61

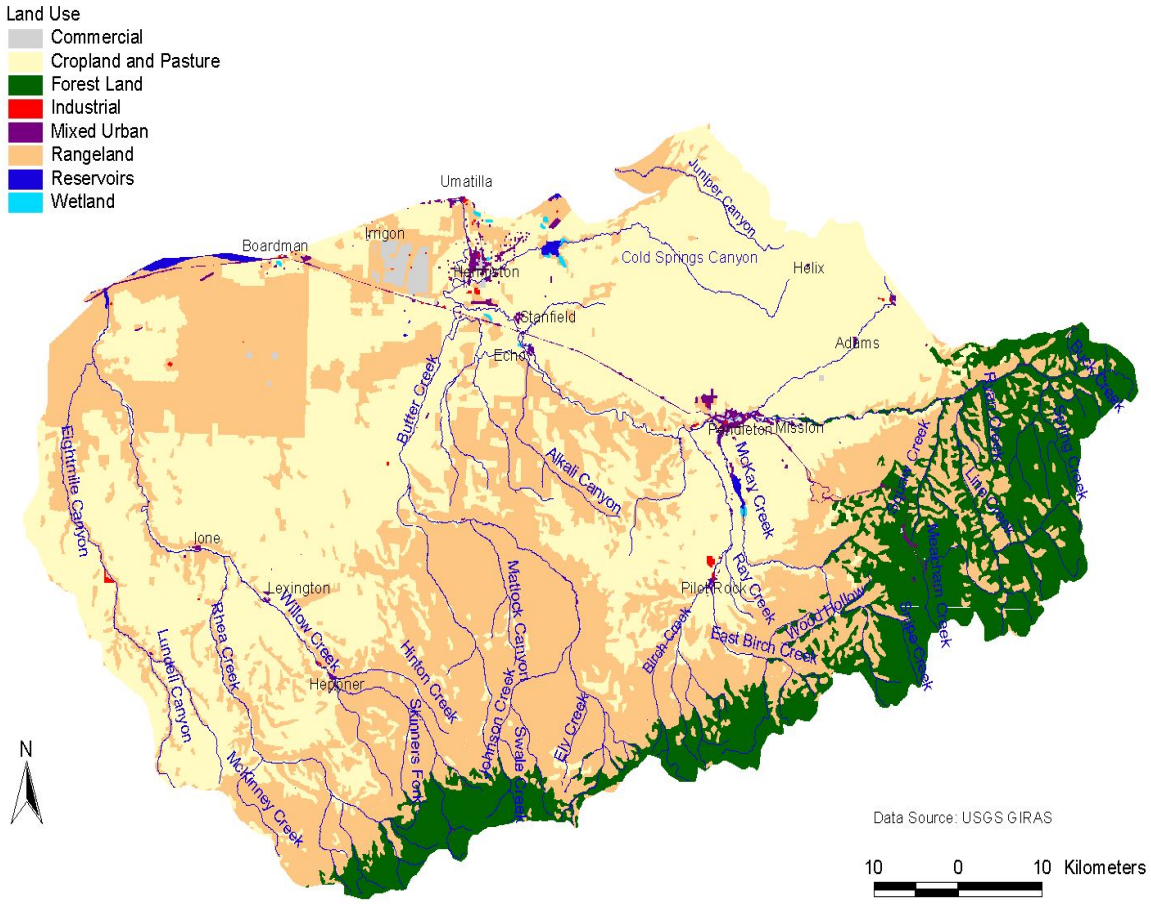


Figure 1. Umatilla River Basin

2.1 Upper Umatilla River System[1]

The Umatilla River (Figure 2) has a drainage basin of 2,290 square miles and is a tributary to the Columbia River at RM 289 (Gonthier and Harris, 1977). Elevations in the subbasin range from about 5,800 feet near Pole Springs on Thimbleberry Mountain to 260 feet at the mouth of the Umatilla River. After leaving the Blue Mountains, the North and South Fork of the Umatilla River merge to form the mainstem, a 90 mile reach of river which flows through a series of broad valleys that drain low rolling lands. All of the primary tributaries of the

[1] Only Umatilla River tributaries that received improvements during the reporting period are described in this report. Other tributaries in the basin have been characterized in past annual reports.

Umatilla River drain the Blue Mountains and enter the Umatilla River from the south. The North and South Forks (forks) of the Umatilla River and Meacham Creek account for approximately 14% of the Umatilla River subbasin drainage area, yet supply 40-50% of the average flow to the Umatilla River (Saul et al., 2001). The principle aquifer is quaternary alluvium composed of unconsolidated sand and gravel, and some silt. Alluvium may reach a depth of up to 12 feet (Gonthier and Harris, 1977).

The River upstream from RM 80 provides spawning and rearing for summer steelhead, fall chinook, and coho salmon as well as bull trout.

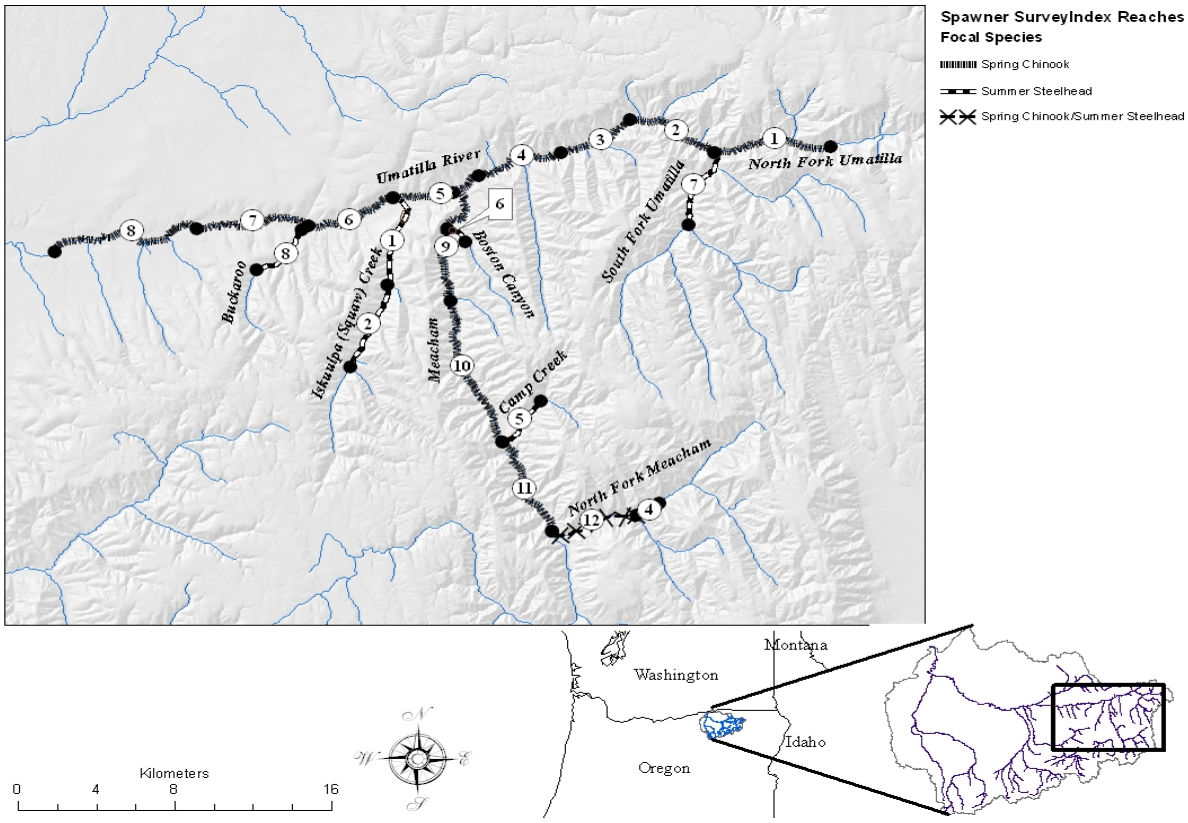


Figure 2. Upper Umatilla River System

2.2 Meacham Creek

Meacham Creek is a major tributary to the Umatilla River, entering at RM 79. It drains approximately 65 square miles and produces 145,000 acre-feet annually at RM 5 near the top of the project area. The average annual discharge for Meacham Creek is 193 cubic feet per second (cfs) (Saul et al., 2001).

The Creek provides spawning and rearing for summer steelhead, spring chinook, and bull trout as well as for resident trout.

2.3 Birch Creek

Birch Creek land use is primarily rural-residential, hay production and grazing with timber production predominating in the headwater reaches. Mid to lower portions of mainstem Birch are characteristically braided, very entrenched, and contain moderate to high

width/depth ratio channels that are highly dynamic and provide poor juvenile rearing habitat for salmonids. Many of these channels have lost connection with their historic floodplain and because of their degree of entrenchment are extremely erosive and unstable, producing excessive sediments, which fill in pools, embed spawning substrates and accelerate channel migration. A limiting factor for anadromous fish continues to be passage barriers throughout the drainage, mostly in the form of diversion dams. Amelioration of remaining passage barriers is a major subject of this report and is planned for continuance in future years.

East Birch Creek originates at 4,238 foot elevation in the southeast corner of Umatilla County and flows approximately 18 miles northwest to merge with West Birch Creek at the city of Pilot Rock. Gage station data collected near Pilot Rock by the U.S. Geological Survey) from 1967 through 1973 indicates that average monthly stream flows in East Birch Creek vary from a monthly average of 0.91 cfs in August to 76.8 cfs in April. East Birch provides spawning and rearing for summer steelhead and redband trout.

West Birch headwaters flow from some 4,000 foot elevation to join E. Birch. Monthly average flows are similar to East Birch. In combination the two tributaries provide an estimated 35 miles of spawning area for summer steelhead and redband trout.

Birch Creek is listed as water quality limited for temperature and habitat modification on Oregon's 1998 303(d) list. The listing for water temperature is based on exceedence of the statewide standard for salmonid rearing (64° F). The listing for habitat modification is based on habitat surveys conducted by the Oregon Department of Fish and Game (ODFW) in 1993 and deficiencies identified by comparison to ODFW habitat benchmarks for typical Eastern Oregon streams. A Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP) were written for the Umatilla River Basin, including Birch Creek, which should lead to water quality improvements over the long term (ODEQ et al 2000).

2.4 Mid-Umatilla River system

The Mid-Umatilla River has been highly altered by human development. Stream channel morphology and flows have been significantly altered by irrigation dams and pumps, channelization, and the development of farms, homes and industry in the riparian area and adjacent uplands (Contor et al, 1997). Modern human activities have loaded the river with agricultural fertilizers, sewage, pesticides, and suspended sediments, as well as urban and industrial pollution (Contor et al, 1997). However, stream temperatures in the Barnhart vicinity (RM 35.0 through 49.0) are positively influenced by cold water releases from McKay Reservoir. These releases elevate flows from about 45 to 250-325 cfs (Yoakum gage), increase turbidity and decrease water temperatures (Zimmerman and Duke, 1996). The gradient in this reach is constant, and the increased flows provided abundant fast water habitat types (Contor et al, 1997). Flows released from McKay Reservoir are from the cooler hypolimnion layer, providing suitable stream temperatures for salmonids. Stream temperatures from RM 35.0 through RM 49.0 of the Umatilla River are comparable to those found in its headwaters (RM 80.0 through 90.0) as shown in Figure 3.

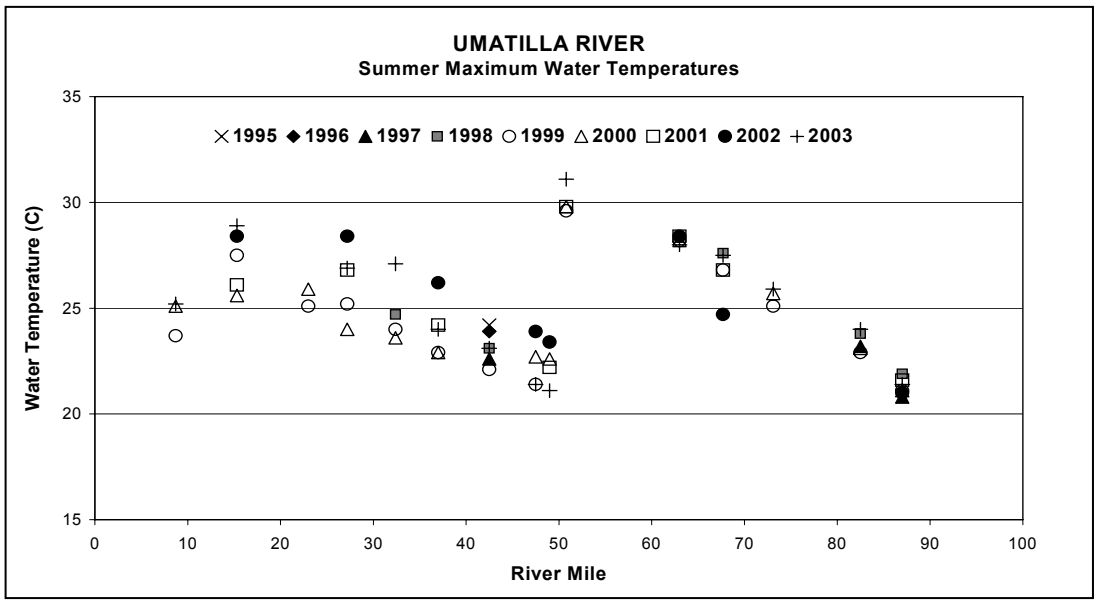


FIGURE 3 – MAXIMUM SUMMER WATER TEMPERATURES ALONG THE LENGTH OF THE UMATILLA RIVER.

3. METHODS AND MATERIALS

3.1 Maintenance Needs

The physical condition of habitat improvements are evaluated annually in existing project areas, following spring high flow events, to determine effectiveness and prescribe any maintenance to occur during the project funding period.

3.2 Project Cost Share

Cost share funds are solicited by CTUIR and combined with BPA funds for financial assistance. These efforts effectively forge partnerships between resource agencies and the public and allow BPA funds to go further. CTUIR's cost share ratio with agencies outside of BPA during the reporting period was about 50% from BPA and 50% from the other cost share entity(s).

3.3 Clearances and Land Owner Agreements

Various clearances and landowner agreements must be obtained before CTUIR can initiate habitat improvements on private properties.

The BIA may require a land survey of designated project area boundaries and do require acquisition of right-of-way agreements on private-owned, Indian Allotments (trust lands), prior to pursuit of riparian easements.

Riparian Conservation Agreements restrict landowners from certain land use activities, such as grazing, removal of vegetation, and use of weed or insect control measures within enhanced riparian corridor areas. The term of these agreements varies from 10 years to perpetuity with CTUIR attempting to secure as long an agreement as possible. The landowner(s) accepts the costs of all habitat improvements along with CTUIR's maintenance of these improvements as consideration for participating in project recovery efforts. An attempt is made to address landowner needs (such as livestock water gaps, stream crossing sites, and off-stream water developments) and incorporate these needs into the final agreement. Riparian easements protect habitat improvements and ensure an early recovery period within project areas.

Access, implementation and maintenance agreements are obtained for projects that involve strictly instream habitat enhancements. These agreements typically have a five-year term. As with the riparian conservation agreements, the landowner accepts the costs of all habitat improvements and CTUIR's maintenance of these improvements as consideration for participating in project recovery efforts. The purpose of these projects is to improve stream bank stability and increase in-stream habitat diversity. The five-year term provides a period in which to monitor project recovery and perform any necessary maintenance to in-stream structures.

Other necessary clearances may include obtaining permits from Umatilla County to

construct habitat improvements within county road right-of-way areas or burning permits to burn noxious weeds within existing project areas. Considerable effort and coordination is required to secure clearances and landowner agreements.

3.4 Removal/Fill Permits

Instream work activities on the Reservation require a CTUIR Tribal Stream Zone Alteration Permit (SZAP) and a U.S. Any instream work proposed within CTUIR's identified flood hazard sub-district or potential special flood hazard areas on the Reservation require a Tribal Development Permit from the CTUIR Planning Office.

Instream work activities off of the Reservation either require a General Authorization for Fish Habitat Enhancement Permit or a Removal/Fill Permit (dependent upon the scope of activities and scale of the proposed project) from the Oregon Department of State Lands (ODSL) in conjunction with a COE 404 Removal/Fill Permit. Applications for these permits should be completed and returned to the respective agencies a minimum of 90 days prior to anticipated instream work. Permitted instream work activities in the Umatilla River Basin are restricted to specific instream work periods. These instream work periods are based upon when migrating and spawning salmonids are least likely to be impacted by fill and removal activities. Work windows vary throughout the basin, but range from May-Oct.

3.5 Endangered Species Act Requirements

The Columbia River population of bull trout (*Salvelinus confluentus*) and mid-Columbia Evolutionary Significant Unit (ESU) summer steelhead (*Oncorhynchus mykiss*) are listed as threatened species under the federal Endangered Species Act (ESA). Any proposed instream work activities in areas within the Umatilla Basin, currently supporting these species or providing critical habitat for them, require ESA, Section 7 consultation when federal funding is utilized. Upon receiving a completed 404 Removal/Fill permit application, BPA initiates Section 7 consultation proceedings with the appropriate federal agencies. The U.S. Fish and Wildlife Service (USFWS) is consulted for potential resident fish species (such as bull trout) impacts. The National Marine Fisheries Service (NMFS) is consulted for potential anadromous fish species (such as summer steelhead) impacts. Instream work in critical bull trout and summer steelhead habitat areas generally requires the project proponent to develop Biological Assessments (BA's) to determine the extent of impact, if any, from proposed habitat enhancements. BA's are reviewed by USFWS and NMFS, during consultation proceedings, and assist in determining if an instream project will occur, as proposed, or if modification is necessary to limit potential impacts. Consultation proceedings can considerably delay obtainment of instream permits.

3.6 Cultural/Archeological Values

The project coordinates with CTUIR's Cultural Resource Protection Program (CRPP) at proposed habitat enhancement sites involving ground disturbance (fence construction, structures keyed into stream banks, etc.), prior to project implementation to obtain cultural clearances. CRPP Staff conduct file and literature searches, pedestrian surveys and/or archeological excavations to determine if cultural resources potentially eligible for inclusion to the National Register of Historic Places are present at proposed enhancement sites. Final reports, documenting their findings, are prepared and submitted to the BIA Umatilla Agency

Real Property Management Office (for implementation efforts on the Reservation) and to the State Historic Preservation Office (SHPO) (for implementation efforts, both on and off the Reservation). CRPP Staff may also conduct on-site monitoring of projects during implementation at culturally sensitive locations. All cultural clearances are obtained in compliance with Section 106 of the National Historic Preservation Act.

Section 106 also provides for cultural resource surveys of projects that are funded by the U.S. Dept. of Ag. WHIP program. Accordingly, TUIR projects using WHIP funding require cultural surveys by a Natural Resource Conservation Service (NRCS) archaeologist.

3.7 Project Design and Specifications

Design and layout of proposed projects consists of coordinating with the CTUIR Hydrologist to develop hydraulic designs, determining the quantity and type of materials required to build or repair fence and instream structures, and developing heavy equipment access sites, haul roads and boulder storage sites. Proposed fence lines, instream structure sites and stream bank areas are staked and flagged to provide assistance to subcontractors.

3.8 Contracts and Professional Services Agreements

Proposed implementation activities, requiring rental of operated heavy construction equipment, construction of fencing, and purchase and transport of rock or root wads, are advertised and pre-bid tours provided to potential subcontractors. Subcontracts are awarded to the lowest bidder.

Prior to commencement of a subcontract, the subcontractor meets with CTUIR Habitat Enhancement Project Personnel to discuss subcontract terms, work performance requirements, a work progress schedule, petroleum spill plans, and fire prevention and suppression plans. Notices to proceed are issued in writing to the subcontractor.

The subcontractor provides and maintains an inspection system acceptable to the CTUIR, covering the services under the subcontract. Complete records of all inspection work performed by the subcontractor are maintained and made available to the CTUIR during subcontract performance and for as long afterwards as the subcontract deems necessary.

Equipment is inspected at the work site at the time of delivery. All equipment must be in good working condition, free from excessive leaks in hydraulic, fuel and power systems and clean enough to allow close inspection of these systems. Any equipment that does not meet subcontract specifications and requirements is rejected.

CTUIR Habitat Enhancement Project Personnel monitor the subcontractor's progress and photo document various stages of project implementation.

3.9 Maintain and Implement Habitat Enhancements

3.9.1 Instream and Stream Bank Improvements

Stream bank revetments, log and boulder weirs, log and boulder deflectors, rock vanes and grade control/sediment retention structures previously placed in the Umatilla River, Meacham Creek, Wildhorse Creek, Greasewood Creek, the West

Fork of Greasewood Creek and Spring Hollow Creek project areas are repaired annually as needed. These structures are designed to increase instream habitat diversity, increase pool frequency, stabilize stream banks/stream channels, and recruit and deposit sediments onto stream banks to provide for revegetation.

Newly proposed in-stream and stream bank project designs are determined and developed jointly by the CTUIR Hydrologist and CTUIR Habitat Enhancement Project Personnel. Project personnel place large woody debris (LWD) into areas where natural wood recruitment and habitat diversity is low. Placement of LWD provides additional instream cover for salmonids and organic material for aquatic organisms to feed upon, and assists in rebuilding stream banks by slowing water velocities and capturing sediments. Hydrological controls (root wad and rock revetments, deflectors, vanes, weirs, etc.) are used sparingly and restricted to stream reaches where benefits (grade control, sediment deposition, stream bank stability, growth of riparian vegetation and increased instream habitat) are immediate. More costly bio-engineering approaches are reserved for areas that will not recover in a timely or natural manner.

3.9.2 Fish Passage Improvements

Locations of numerous passage barriers have been identified through the ongoing Umatilla Subbasin/Willow Creek Subbasin Planning process. Project staff are currently coordinating closely with CTUIR's Monitoring and Evaluation Unit and the Oregon Department of Fish and Wildlife (DF&W) to verify and prioritize these passage concerns. Birch Creek system passage impediments will be the focus in 2005 and 2006 where removal or modification of passage barriers will provide access to currently unavailable or under-utilized stream reaches and improve migration for adult spawning, juvenile rearing, and adult and juvenile holding. The effects of such efforts, in conjunction with continued restoration of riparian and upland areas, will aid especially in increasing salmon and dwindling ESA listed summer steelhead populations.

3.9.3 Livestock Exclusion and Riparian Corridor Fencing

Fencing is constructed to exclude livestock from floodplain and riparian areas. Livestock exclusion provides stream bank protection and allows vegetative recovery to occur within project areas. The project constructs both, smooth-wire high tensile and barbed-wire fencing for livestock management. Smooth-wire high tensile fencing is utilized in areas where livestock are distributed over vast areas (open range) and tree blow-down is frequent. Barbed-wire fencing is useful when livestock pressure is significant, such as when large numbers of cattle are confined in pastures, there is high potential for fire damage, and tree density is low.

Fences, gates and cross fences in existing project areas are repaired by project personnel as needed. Frequent fence inspections are conducted to ensure continued exclusion of livestock and to allow for continued riparian recovery inside of project areas.

3.9.4 Off-stream Livestock Water Developments

Off-stream water sources are developed to prevent stream bank erosion from livestock trailing and eliminate high maintenance costs associated with water gaps in fenced riparian corridors. Existing springs are developed and shallow or deep wells drilled to provide a necessary water source for livestock.

Typically, these projects involve landowner financial and in-kind cost share assistance. The project funds any subcontracted services, electrical hook-ups and installations, and solar panels, pumps, pipe and associated hardware, water troughs and other material items. The landowner pays for electrical costs to operate pumps, and may provide equipment and labor to install plumbing and water troughs.

3.9.5 Revegetation

The CTUIR Habitat Enhancement Project utilizes heavy equipment and hand plants native riparian tree and shrub species along bank revetment structures, sediment retention structures and stream margins to improve bank stability, provide insect drop, shade streams and provide a future source of LWD. Stream banks, terraces and disturbed sites within project areas are seeded with native grasses and/or close equivalents of native grasses to improve bank stability and to capture and retain sediments during high flow events.

Native plants are acclimated to the local climate, provide natural forage for wildlife and are much more resistant to the area's disease and insect problems. Studies have found that exotic species may out-compete and displace native riparian vegetation (Gordon et al., 1993). In addition to historical and present impacts of disturbance on riparian vegetation connectivity and diversity, plantings of exotic riparian vegetation (e.g. Russian olive) and the potential of hybrid poplar monocultures could disrupt riparian processes (Li, 1998). In Europe, plantations of exotic monocultures have replaced the natural diversity of riparian vegetation along stream banks of various watersheds (Cortes et al., 1994). This has changed the trophic structure of affected streams and influenced the input of terrestrial invertebrates that form the bulk of drifting prey for surface feeding fishes in headwater streams. The timing and quality of litter inputs from single species plantings or exotic species may differ greatly from diverse systems and lead to reduced food resources for aquatic species (Li, 1998). There may also be concerns about pollution of the gene pool of existing plant populations when non-local plants are introduced to a site (Lambert et al., 1995).

Trees and shrubs planted in CTUIR Habitat Enhancement Project Areas are obtained locally and indigenous species grown out as bareroot stock or tublings. Native grass seed and close replicates of native grass seed are currently unavailable locally and continue to be purchased from various grass seed companies. CTUIR is collaborating with the USDA's CREP program to

facilitate riparian vegetation plantings. CREP contractors that have NRCS certification for CREP conservation plan preparation also use local or regional endemic species for planting riparian zones, i.e., in zone 1 (1st 15' from the stream) and zone 2 (from 15' to 180' from the stream). Typical zone 1 plantings are willows, cottonwood, blue elderberry, and alder. Zone 2 plantings generally consist of red ocher dogwood, wild rose, elderberry, Douglas hawthorne, golden current, and chokecherry.

3.9.6 Noxious Weed Control

CTUIR subcontracts with herbicide applicators to chemically treat noxious weeds in the spring and fall in existing project areas. Only the most invasive noxious weeds, identified as "A" Pest Weeds on Umatilla County's Noxious Weed List, are treated. All chemical applications are consistent with Oregon Revised Statute (ORS).570.505, Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) Regulations, and NMFS and USFWS recommendations regarding ESA concerns.

When other noxious weed species are identified as detrimental to project success or are of special concern to the landowner, CTUIR habitat enhancement project personnel or a designated agent treat these weeds as needed. In keeping with current regulations, herbicide types, rates, and location of use are reported annually to BPA's Environmental Unit.

3.9.7 Post-implementation Final Review

CTUIR personnel visit implementation sites immediately following final construction as indicated by the subcontractor. Subcontracted services are inspected to determine whether they conform to subcontract requirements. If subcontract services are not acceptable, CTUIR may (1) require the subcontractor to perform the services again in conformity with contract requirements, (2) reduce the contract price to reflect the reduced value of services performed, (3) hire another subcontractor to perform the services and charge the original subcontractor any cost incurred by the CTUIR, or (4) terminate the contract for default

3.10 Baseline Data Collection

Monitoring is carried out to assess pre-project conditions and to quantify short and long-term effects of habitat improvements in the Umatilla River Basin.

3.10.1 Geomorphologic and Hydraulic Data Monitoring

Geomorphologic and hydraulic data are collected to measure changes in channel morphology and vegetative response to habitat enhancements. This monitoring usually includes the following:

- **Longitudinal survey** - these data provides a graphical representation of the stream-bed contour. From this, stream habitat may be categorized into habitat unit types, such as pools, glides, riffles, rapids, or cascades. By comparing this information to "standards" developed in the literature, the project can better plan restoration strategies and quantify change over time.
- **Cross section survey** - this information is collected at two to ten (depending on total project length) permanent monitoring points at various locations in the stream reach being enhanced. Transects are taken perpendicular to the stream's thalweg and generally continue outward on each shoreline to a point above bank-full width. Transects are established at areas representative of different channel types. Among other things, cross-sectional data generates maximum widths and depths, bank-full widths, bank heights, width to depth ratios, entrenchment ratios, and discharge. By comparing this information to "standards" developed within the literature, the project is better able to plan restoration strategies and understand channel formation changes over time. A trend toward channel narrowing and deepening is most desirable for improvements in salmonid health, channel stability and water quality. These measurements may be repeated in out-years to measure changes in channel morphology and vegetative responses to habitat enhancements.
- **Habitat survey data** - literature searches are conducted and any available habitat inventory data previously collected at the stream reach level will be utilized for project planning purposes and to assist in analyzing recovery trends. In-field measurements of physical attributes, such as pool frequency, pool quality, available LWD, substrate types, water quality, stream flows and potential environmental impacts from current land uses and historical disturbances will be identified.
- **Photo points** - Permanent photo points are established prior to project implementation in conjunction with permanent transects. Standardized photos are taken to provide a visual record of changes in channel morphology and riparian recovery. Photos are cataloged and stored on computer hard drives and back up disks, maintained by the CTUIR Fisheries Habitat Enhancement Project. This information provides a very valuable visual source of restoration progress and public education.

3.10.2 Biological Inventories

Fisheries communities are good indicators of long-term effects and broad habitat conditions because they are relatively long-lived and mobile (Karr et al., 1986). However, the fish population at any location is influenced by activities throughout the stream length because fish use different habitats at various life stages and may migrate long distances (Bauer and Burton, 1993).

Project staff coordinate with CTUIR's Monitoring and Evaluation Project Unit to collect pre-project fish community data. Representative samples of fish species and size classes are collected with a backpack electrofisher in proposed project areas. A single pass with the electrofisher is made to evaluate community composition. All salmonids captured are counted, fork lengths measured and identified to species in the field. All other fish species numbers are visually estimated during sampling. Biological inventories are generally completed during the stable low flow period in mid-summer to avoid spawning migrations and seasonal fish movement (Karr et al., 1986).

Fish collection permits are required in the Umatilla River Basin because bull trout and summer steelhead are listed as threatened under the federal ESA. These permits specify sampling gear types and sampling periods. The UBNPME Project applies for and obtains all collection permits utilized by this project for fish sampling efforts.

Although fish collection did not occur during 2004, post-project biological inventories in 2005 and 2006 will occur in future project periods to assess fish utilization of instream enhancements and assist in evaluation of habitat recovery.

3.10.3 Aquatic Macroinvertebrate Sampling

Macroinvertebrates are components of the aquatic environment that provide a connecting link in the food chain between multicelled periphyton, detritus from terrestrial sources and the fish population. As a food source they are essential to the growth and production of fish and, because of their strict habitat requirements, are very useful as indicators of changes in aquatic habitat (USDA, Forest Service, 1985). The diet of immature chinook salmon has been shown to consist of 95% insects, and immature coho salmon consume about 99% insects (Johnson and Ringler, 1980). Steelhead diets are largely insect as well (Johnson and Ringler, 1980).

Aquatic macroinvertebrate communities can reveal the quality of habitat components essential to aquatic fauna, such as water quality, substrate composition, riparian habitat quality, ecosystem stability, and past history (U.S. Bureau of Land Management, 1988). Aquatic macroinvertebrate communities are useful for monitoring biological integrity of streams since they function as integrators of pollution over time and are a direct measure of beneficial uses (aquatic life support) (Meyers, 1987). According to Schoen (1991), macroinvertebrates cover the whole range of pollution sensitivity, from highly sensitive stoneflies and mayflies down to very tolerant aquatic worms, so the presence or absence of particular taxonomic groups provides a good yardstick of pollution. Unlike fish, macroinvertebrates are relatively immobile. So, if macroinvertebrates are absent from their normal habitat, it is likely that pollution drove them out. In a healthy stream, one should find a balanced population consisting of many different kinds of organisms. Adverse chemical or physical changes that disrupt any part of the stream ecosystem often decrease community diversity. Macroinvertebrate populations usually recover more quickly than fish populations in response to water quality improvements and thus, appear to provide better subjects for assessing habitat recovery.

The project annually hires entomologists with Oregon State University (OSU) to sample aquatic macroinvertebrate populations Umatilla tributary project areas. Their study design involves sampling invertebrates at two sites per project area. One site is located within downstream portions of CTUIR habitat enhancement projects (the "Restoration" site). Water quality is examined at these sites as flows exit the project areas. The second site is located upstream of project areas, within 300 m of the projects' upper boundaries. Water quality is examined at these sites as flows enter project areas (the "Control" site). The general hypothesis is, "restoration will have a positive influence on water quality as reflected by macroinvertebrate community structure".

Four benthic samples are obtained at each sampling site with a 30 cm, 250 micron mesh D-frame net. Samples are collected by firmly placing the net against substrate and disturbing the substrate in a 30 cm by 60 cm area in front of the net for a one minute period. An effort is made to disturb the substrate to a standard depth of 10 cm.

Macroinvertebrates are sorted from detritus, counted and identified to the lowest taxonomic level feasible in the laboratory. Samples are either completely sorted or sub-sampled when large amounts of sediment are present in the sample. Sub-sampling involves dispersing the sample evenly across a 20 cm diameter coffee filter, randomly choosing a quarter-section of the filter, cutting away that portion from the remainder of the filter and then sorting all macroinvertebrate from the quarter-section. Data from the four samples taken from a sampling site are pooled to provide a single measure of macroinvertebrate community structure at each site.

To examine the difference in community structure between the paired control and restoration sites for each stream, the following metrics are examined:

1) Taxa richness – a simple count of the number of taxa present at a site. This metric is predicted to decrease with decreasing water quality.
2) EPT richness – a count of the number of taxa belonging to the orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Most taxa within these orders are sensitive to pollution and therefore this metric is predicted to decrease with decreasing water quality.
3) Plecoptera richness – a count of the number of taxa belonging to the order Plecoptera. This metric is very similar to EPT; however, it has been found to perform better than EPT in the Pacific Northwest (Karr and Chu 1999). This metric is predicted to decrease with decreasing water quality.
4) Intolerant taxa richness – a count of the number of taxa considered to be intolerant or sensitive to pollution. This metric is expected to decrease with decreasing water quality.
5) Tolerant taxa richness – a count of the number of taxa considered to be tolerant or insensitive to pollution. This metric is expected to increase with decreasing water quality.
6) Sediment-tolerant taxa richness – a count of the number of taxa considered to be tolerant or insensitive to sediment. This metric is expected to increase with decreasing water quality.
7) % Predators – the proportion of predators found in a community. In general, this metric is expected to decrease with decreasing water quality.
8) Functional Feeding Group (FFG) structure – the proportion of taxa found within functional feeding groups. Other than the proportion of predators decreasing

with decreasing water quality (metric 8), there are few specific predictions about how FFG structure should change with changes in water quality. However, FFG structure can provide information on the diversity of basal resources at a site and in general this diversity is expected to increase with increasing water quality.

9) Shannon's Diversity Index – a measure that takes into account both the number of distinct taxa at a site and their relative abundances. This measure is expected to decrease with decreasing water quality.

10) Percent Dominance – a metric of the proportion of the community made up of the three most abundant taxa. This metric is expected to increase with decreasing water quality.

11) Hilsenhoff Biotic Index (HBI) – a metric of community structure that is especially sensitive to organic enrichment. Taxa are assigned an index score ranging from 0 (very sensitive taxa) to 10 (highly pollution tolerant). The index is an average score weighted by the abundance of each taxa. Scores ranging from 0-2 are considered indicative of clean water, 2-4 slightly enriched water, 4-7 enriched water, and 7-10 much polluted water (Hilsenhoff 1987).

12) Biotic Condition Index (BCI) – a metric of community structure indicative of pollution. This index measures a site's quality relative to a predicted quality based on physical and chemical parameters. Thus, each site is measured against its own "potential." Each taxa is assigned a score ranging from 2 (very sensitive taxa) to 108 (very tolerant taxa) and the weighted average of all scores are taken and then compared to the predicted score. BCI values greater than 90 are indicative of high quality conditions, 80-90 good conditions, 72-79 fair conditions, and less than 72 poor conditions (Platts et al. 1983).

13) Oregon Department of Environmental Quality's (ODEQ) Grande Ronde Multimetric Index – a single measure of water quality that is comprised of ten individual metrics: taxa richness, Ephemeroptera taxa richness, Plecoptera taxa richness, Trichoptera taxa richness, number of tolerant taxa, number of sediment - intolerant taxa, percent dominance of the three most abundant taxa, proportion of tolerant taxa, proportion of sediment-tolerant taxa, and HBI. Higher values of this index indicate better water quality. This metric was developed by Rick Hafele and Shannon Hubler of the ODEQ specifically for the Grande Ronde Subbasin. It has not been tested in the Umatilla Subbasin, but will be included in evaluating macroinvertebrates collected under this project.

In addition to the benthic macroinvertebrate samples, the following water quality measurements are made: turbidity, conductivity, pH, dissolved oxygen, and continuous water temperature. Turbidity is measured using a turbidimeter. Conductivity, pH and dissolved oxygen are measured using a WTW Multiline P4 meter. Temperature is taken using Hobo H8 data loggers. Macroinvertebrate surveys are repeated annually at project sites. Macroinvertebrate data will provide an additional element in comparatively detecting trends over time to assist in determining habitat enhancement effectiveness.

3.10.4 Water Temperature Monitoring

Vemco Minilog Thermographs are deployed within selected stream reaches (see Table and 3) in the upper Umatilla River Watershed. Several of these instruments are installed upstream,

downstream and/or within project areas in the Umatilla River, Meacham Creek, Wildhorse Creek, Greasewood Creek, Spring Hollow Creek, Mission Creek, Buckaroo Creek and Iskuulpa Creek to monitor the effectiveness of habitat improvements on water temperature cooling. The remaining thermographs are installed in Moonshine Creek, Coonskin Creek, Little Buckaroo Creek, Eagle Creek, and at additional Umatilla River and Wildhorse Creek sites to obtain data on potential habitat limiting factors and existing water quality conditions.

Thermographs are deployed in May. All instruments are recovered and downloaded into a computer program in November. The thermographs collect one temperature reading per hour. Water temperatures are graphed for warmer months (June, July, August and September) to determine if temperatures are reached which could prove detrimental to salmonids.

TABLE 2 – THERMOGRAPH LOCATIONS FOR 2005
1. Umatilla River – RM 40.4 (Downstream from B/G Resources)
2. Umatilla River - RM 56.0 (West Reservation Boundary)
3. Umatilla River – RM 76.5 (Downstream from Iskuulpa Cr.)
4. Umatilla River - RM 81.7 (USGS Gage Station No. 14020000)
5. Wildhorse Cr. - RM 0.1 (Upstream from confluence with Umatilla River)
6. Wildhorse Cr. – RM 1.4 (Oregon Water Resources Gage)
7. Wildhorse Cr. – RM 18.3 (Downstream from Athena)
8. Wildhorse Cr. - RM 26.0
9. Greasewood Cr. – RM 0.1 (upstream of confluence with Wildhorse Cr.)
10. Mission Cr. - RM 1.25 (upstream of Umatilla County Road 900 Bridge)
11. Mission Cr. - RM 3.7 (upstream of St. Andrew's Church)
12. Mission Cr.- RM 3.8 (downstream of stream forks)
13. Moonshine Cr. – RM 1.1 (upstream of Umatilla County Rd. 900 Bridge)
14. Coonskin Cr.– RM 0.2 (upstream of Umatilla County Road 900 Bridge)
15. Buckaroo Cr. – RM 2.0
16. Little Buckaroo Cr. – RM 0.04 (upstream from Buckaroo Cr.)
17. Mission Cr. – RM 1.25
18. Mission Cr. – RM 3.8
19. Birch Cr. – RM 3.0 (Peterson Dam)
20. West Birch Cr. – RM 3.0 (Hoeft Dam)
21. Umatilla River – RM 42.8 (Upstream from B/G Resources)
23. Wildhorse Cr. – RM 1.4

24. Spring Hollow Creek - RM 3.5
25. Meacham Cr. – RM 1.4 (USGS Gauge Station No. 14020300)
26. Meacham Cr. – RM 5.25 (East Reservation Boundary)

Legend: Water Air

TABLE 3 – THERMOGRAPH LOCATIONS FOR 2006

1. Umatilla River – RM 42.8 (Upstream from B/G Resources)
2. Birch Cr. – RM 10 (Broun Dam – sample 1)
3. Birch Cr. – RM 10 (Broun Dam – paired sample 2)
4. Birch Cr. – RM 10 (Broun Dam – paired sample 2a)
5. Birch Cr. – RM 10 (Broun Dam – paired sample 3)
6. Birch Cr. – RM 10 (Broun Dam – paired sample 3a)
7. Birch Cr. – RM 10 (Broun Dam – paired sample 4)
8. W. Birch Cr. – RM 2.9 (Hoeft Dam)
9. W. Birch Cr. – RM 3.0 (Hoeft Dam)
10. W. Birch Cr. – RM 3.25 (Cunningham Sheep)
11. Umatilla River RM 42.8 (Upstream from B/G Resources)
12. Birch Cr. RM 10 Broun Dam downstream
13. Birch Cr. RM 10 Broun Dam upstream
14. W. Birch Cr. RM RM 3 (Hoeft Dam)
15. W. Birch Cr. RM RM 3.25 (Cunningham)

Legend: Water Air

3.10.5 Suspended Sediment and Turbidity Monitoring

Siltation, a leading cause of non-point source pollution, is especially harmful to fish and aquatic ecosystems. Sediments harm fish by reducing dissolved oxygen levels and by smothering eggs and newly hatched fry. Sediment deposits also can eliminate aquatic plants that provide cover for fish and the invertebrates they consume (Trout Unlimited, 1994).

Three Isco Model 2700 Wastewater Samplers are deployed to obtain estimates of suspended sediments. These sampling sites include RM 81.7 Umatilla River, RM 56.0 Umatilla River and RM 2 Meacham Creek. Sampling sites are located at USGS Gage Stations (see Table) and near CTUIR thermographs.

Samples are taken year round at 6-hour intervals to create a composite daily sample. The samples are collected every 21 days and analyzed by Umatilla National Forest Service (UNF) Personnel at the United States Forest Service (USFS) Lab in Pendleton, Oregon to determine turbidity in Nephelometric Turbidity Units (NTU), specific conductivity and total suspended solids (TSS). CTUIR staff correlates suspended sediment data with stream flow data collected from the adjacent gage stations to calculate total sediment load (tons/day).

TABLE 4 – LOCATION OF SUSPENDED SEDIMENT AND TURBIDITY MONITORING SITES IN 2005 AND 2006.
Umatilla River – RM 56.0 @ USGS Gage Station No. 14020850 (West Reservation Boundary)
Umatilla River – RM 81.7 @ USGS Gage Station No. 14020000 (East Reservation Boundary)
Meacham Creek – RM 2.0 @ USGS Gage Station No. 14020300

4. RESULTS AND DISCUSSION

4.1 Coordination with other Agencies and Organizations (WE 118)

CTUIR staff collaborated with the owners, NRCS, and contractors to implement conservation plans for riparian vegetative planting on the Schmidtgall and Reynolds easements. In addition, staff arranged for a contractor to plant additional petroleum detoxification species on the Schmidtgall easement where a petroleum spill occurred in the riparian zone in the early 2000s.

CTUIR Habitat personnel participate in a technical coordinating committee that is chaired by the UBWC. The committee includes membership from federal, state, county and CTUIR units that are responsible for planning and implementation of projects affecting streams and their riparian zones. The committee normally meets at key times during the year to discuss present activities, future plans, and results of environmental monitoring.

Project staff coordinated informally during each year with NRCS, FSA, SWCD, UBWC and ODFW to identify future projects. Also, personnel met in September with other agency representatives to advise the U.S. Bureau of Reclamation concerning management of a 300-acre parcel owned by the Bureau. The parcel is located just northwest of Hermiston, Oregon and borders the Umatilla River for some two miles.

4.2 Provide Technical Review (WE 122)

Project staff responded to a request for a zoning variance for property on the mid-Umatilla River where a land owner wishes to build a shop in the riparian zone. The response to the Umatilla County Planning Department pointed out the potential hazards from such development, and recommended denial of the zoning request.

Staff informed the CTUIR Planning Department of a planned 30-acre residential development on Coyote Creek, tributary to the North Fork Umatilla River and the potential hazards of land disturbance and roads in these headwaters of the North Fork which is a prime chinook salmon and summer steelhead spawning and rearing area.

Staff commented on a description of a toxic cleanup project that was forwarded by the Dept. of Environmental Quality (DEQ) for an abandoned landfill that could leach to groundwater and thence the Umatilla River.

Staff also commented to DEQ concerning mitigation features for the aforementioned petroleum spill in the riparian zone of Wildhorse Creek.

Staff commented on the U.S. Bureau or Reclamation's "Draft Plan for Management of the Oxbow Unit" that was distributed in November 2006. The Plan reflected the recommendations of a multi-agency committee of which CTUIR is a member.

4.3 Outreach and Education (WE 99)

The following public outreach efforts occurred during the 2004 project period:

- Attended and provided input at the UBWC Technical Committee Meetings to rank and select projects to be funded by OWEB.
- Participated at an OWEB work shop that focused on CREP implementation by familiarizing agricultural interests with CTUIR's ongoing habitat enhancement efforts and to facilitate obtaining future cost share funding.
- Provided the McKay Creek Project Area, native willow cuttings and riparian habitat restoration/recovery instruction to elementary students participating in ESD Watershed Field Days. An additional 1,000 native willow cuttings were collected locally by project technicians and provided to students for planting in zone 1 at RM 21.5 of McKay Creek during the ESD Watershed Field Days in May 2005 and 2006. Zone 2 plantings of tree/shrub seedlings from Plants of the Wild Nursery also took place on the Cripes easement as shown in the photos below.





Pendleton Unified School District Students at Watershed Field Days

- Provided tours of the planned Birch Creek barrier amelioration projects for USCE, SLD, NOAA, and USF&WS staff.

4.4 Conduct Pre-Acquisition Activities (WE172)

Easements or agreements were obtained with seven new property owners in the Birch, Meacham, and Wildhorse Creek watersheds. Landowner names and the purpose/duration of these agreements are shown in Table 5.

Table 5. 2005-2006 Easements/ Agreements

LANDOWNER	PURPOSE	YRS. DURATION
Cliff Hoeft	Amelioration of fish passage barrier	20
Joyce Broun	Dam removal, fencing, livestock exclusion	20
Jim Whitney	Dam removal & flood plain vegetation	15
Brandon Benson	Dam removal	Two years after dam removed
Pendleton Country Club	Dam removal	Until dam removed
Robert/Darlene Hoskins	Dam removal	Until dam removed
Bruce Reynolds	Weed control/livestock exclusion	15

4.5 Preparation of Project Management Plans (WE 174)

4.5.1 McKay Creek

A conceptual plan was prepared for fencing and riparian/instream improvements in 2005, but landowner apathy in signing an easement with CTUIR and the Creek's low priority for habitat improvements resulted in abandonment of this project.

4.5.2 Birch Creek Watershed

- Cunningham Sheep Company Box Culvert

  This plan was completed in 2005 with concurrence in improvement concepts by USACE and NMFS. The stream gradient will be stabilized with rock weirs and the stream bank slope will be modified and revegetated to prevent sloughing and erosion.

- Hoeft Dam

  The conceptual plan for installation of a fish ladder at this site was concurred in by USACE, NMFS, and ODF&W upon completion of the alternatives evaluation by McMillen Engineering.

- Broun Dam

  A conceptual plan was prepared in 2005 that pertained to actions needed to prepare for and remove a diversion dam. The plan, which describes necessary water right transfers, was concurred in by the interested federal and state agencies as well as the six property owners that own water rights to the common diversion.

- Peterson Dam

  After site visits by environmental and regulatory control agencies, a conceptual plan was finalized for the dam that is located on the Peterson property, but that diverts irrigation water to two downstream properties, the Clear Creek Land and Cattle Company (spokesperson Jim Whitney) and Branden Benson. The plan, which is

concurred on by all parties, calls for provision of alternative water supplies (well or new pumped surface diversion) to each of the properties.

4.5.3 Meacham Creek Watershed

The Meacham Creek Watershed Analysis and Action Plan recommendations were followed in preparing actions plan for riparian and instream improvements, including levee removal, riparian plantings and large woody debris (LWD) placement, and channel morphology.

Appendix 1 is an example of a management plan that was prepared for Meacham Creek habitat restoration.

4.6 Produce Design or Specifications (WE 175)

4.6.1 Cunningham Sheep Company

Final engineering drawings and specifications were prepared by GeoEngineers, downstream from the culvert to eliminate the vertical drop from the downstream lip of the culvert and provide a fish jump height of not more than 0.7 feet.

4.6.2 Hoeft Dam

After an evaluation of alternatives by CTUIR's subcontractor, McMillen Engineering, the subcontractor then submitted final engineering drawings and specifications in September, 2006. Plans call for a full-channel concrete fish ladder with cells having no more than a 0.7 feet vertical drop. The channel area outside the ladder walls will be filled with rock/gravel and planted with native trees to establish vegetative cover. NMFS criteria will be followed to prevent erosion and fish loss.

4.6.3 Broun Dam

CTUIR's design/build subcontractor, Steve Lindley/Anderson-Perry Engineers, submitted final design drawings in December 2006. Plans specify the location and characteristics of rock weirs to be installed upstream and downstream of the removed dam in order to maintain a stabilized gradient throughout the channel affected by the dam.

4.6.4 Peterson Dam

CTUIR's design/build subcontractor, Steve Lindley/Anderson-Perry Engineers, submitted final design drawings in December 2006. Plans specify the locations and characteristics of rock weirs to be installed upstream and downstream of the removed dam in order to maintain a stabilized gradient throughout the channel affected by the dam.

4.6.5 Meacham Cr.

CTUIR's design/build subcontractor, Steve Lindley/Anderson-Perry Engineers, submitted final design drawings in December 2006. Plans describe: (1) the instream work to be carried out at RM 1.8 to ameliorate passage problems for summer steelhead and bull trout, (2) dam removal and stream channel stabilization to be implemented at RM 20.2, and (3) dam removal and

instream structures necessary at Camp Creek RM 0.3 to maintain a stabilized stream channel without head cutting.

4.7 Produce Environmental Compliance Documentation (WE 165)

4.7.1 Birch Creek Projects

- **Dredge/Fill Permits (Section 404 Permits)**

Preliminary permit applications were submitted to the U.S. Crops of Engineers (USACE) & Oregon Department of State Lands (DSL) in December 2004 for instream work planned for 2005 or 2006 in Birch Creek at the Peterson/Whitney, Broun, Hoeft, and Cunningham Sheep properties. A response to those applications from ODSL requested more detailed information on project design. That detail was provided for Cunningham Sheep and Hoeft projects in September 2006 when final engineering design plans were obtained. The revised permit applications rest with USACE/SLD awaiting the completion of ESA consultation with NMFS.

Final Section 404 permit applications were submitted to USACE/SLD in January 2007 for dam removal at the Broun and Peterson easements.

- Endangered Species Act Requirements (Biological Assessments and Essential Fish Habitat)

The "combined" biological assessment (BA) for the four Birch Creek projects submitted to BPA and environmental regulatory agencies in December 2004 was revised in September 2006, and forwarded to the regulatory and consulting parties mentioned above. An Essential Fish Habitat (EFH) addendum was attached to the BA.

- Cultural Resource Survey/Reports

The State Historical Preservation Office (SHPO) was notified in November 2004 of proposed instream improvement projects in the Birch Creek watershed. SHPO replied in December 2004 that no information was on record for the project sites and CTUIR's CRPP required that an on-site survey be done before the projects could proceed. CTUIR staff followed up on cultural requirements during the September of 2006 when a CTUIR subcontractor, Archaeological Investigations Northwest (AINW), who conducted an archaeological survey and prepared a report that covered all four of the passage barrier improvement sites.

4.7.2 Meacham Cr. Projects

- **Dredge/Fill Permits (Section 404 Permits)**

Final Section 404 permit applications were submitted to USACE/SLD in January 2007 for habitat improvement at the Meacham/Camp Creek sites.

- Endangered Species Act Requirements (Biological Assessments and Essential Fish Habitat)

A BA for the Meacham Creek LWD placement was submitted in September 2006. An Essential Fish Habitat (EFH) addendum was attached to the BA.

A BA for three Meacham Creek barrier improvement sites was submitted in January 2007. An Essential Fish Habitat (EFH) addendum was attached to the BA.

- Cultural Resource Survey/Reports

The riparian zone of Meacham Creek in Allotments 1138 and 1232 was surveyed and a report prepared by CTUIR's Cultural Resources Protection Program (CRPP) in connection with the zone 1 willow plantings done in December 2005. Approval for the project resulted when no significant resources were found.

AINW surveyed the four barrier sites in January 2007 and prepared a report concerning the presence of significant cultural resources. The projects can be implemented with the understanding that work will stop and precautions taken to protect artifacts if found during excavation activities.

4.7.3 Mid-Umatilla River

- Cultural Resource Survey/Reports

A cultural resources survey was conducted by an NRCS archaeologist prior to CTUIR fence construction on the Adams and B & G easements in 2004. That survey, which occurred in September and December, respectively, found no cultural resources of concern that could be damaged by subsequent project activities, i.e., weed control and ground preparation for shrub, tree, and grass planting. However, BPA and CTUIR's CRPP required additional surveys before vegetative planting was undertaken, notwithstanding that any artifacts present historically would have been unearthed or eliminated by many years of plowing and weed/stubble burning. Performing an additional superfluous survey caused floodplain management activities at the easement to be delayed for one year.

4.8 Develop Alternative Water Source/Install Well (WEs 34 & 82)

4.8.1 Birch Creek

4.8.1.1 Broun Dam

The easement acquired for removal of the Broun dam requires that an alternative source of irrigation water be provided before the dam can be removed. This will be done by boring a well in the proximity of Birch Creek. To prepare for well development, CTUIR signed an agreement with Pacific Power and Light in 2006 for installation of a power pole and transformer to service the well. Then, CTUIR prepared a contract for installation of a well in January 2007.

In addition, transferring the point of diversion from the existing dam to a groundwater well requires approval by the Oregon Department of Water Resources (ODWR). A certified water rights examiner was subcontracted by CTUIR to prepare a transfer application for filing with ODWR. The application was submitted in January 2007 with the expectation of ODWR approval by the late summer of 2007. When the water right transfer is completed and the well

proves adequate to pump up to 70 gallons per minute (GPM), the dam will be removed during the instream window of 2007 as described in Section 4.12 below.

The Broun Dam diverts water to the Broun property and three other property owners. Following are those owners and a description of the necessary activities under CTUIR easements in order for the Dam to be removed:

- Hummell Easement

CTUIR's easement for the Hummell property calls for provision of either a water well or new surface diversion as an alternative to the Broun ditch which serves as a common purveyor of water for Broun, Hummell, the Pendleton Country Club, and the Peterson properties. As the same water rights requirements pertain to Hummells as with the Broun property, a certified water rights examiner was subcontracted by CTUIR to prepare a transfer application for filing with ODWR. The application was submitted in January 2007 with the expectation of ODWR approval during the late summer of 2007.

- Pendleton Country Club Agreement (PCC)

As PCC's existing point of diversion is common with the above properties, CTUIR negotiated an agreement with PCC wherein the former would pay the fee for transferring the existing point of diversion to a point on PCC property. A certified water rights examiner was subcontracted by CTUIR to prepare a transfer application for filing with ODWR. The application was submitted in January 2007 with the expectation of ODWR approval during the late summer of 2007.

- Peterson Agreement

Consistent with the above property owners, CTUIR negotiated an agreement with the owner/water right holder wherein the latter will convert to a new surface water diversion located on his property and not object to removal of the Broun dam if CTUIR pays the ODWR fee for transferring the point of diversion. A certified water rights examiner was subcontracted by CTUIR to prepare a transfer application for filing with ODWR. The application was submitted in January 2007 with the expectation of ODWR approval during the late summer of 2007.

4.8.1.2 Peterson Dam

- Whitney Easement

CTUIR's easement for the Whitney property calls for provision of either a water well or new surface diversion as an alternative to the ditch which originates at the Peterson Dam and serves as a common purveyor of water for Whitney and Benson, the two water right holders for the Dam diversion. As the same water rights requirements pertain to this diversion as with the Broun property, a certified water rights examiner was subcontracted by CTUIR to prepare a transfer application for both owners with subsequent submittal to ODWR. The application was submitted in January 2007 with the expectation of ODWR approval during the late summer of 2007.

- Benson Easement

CTUIR's easement for the Benson property calls for provision of either a water well or new surface diversion as with the Whitney property. A certified water rights examiner was subcontracted by CTUIR to prepare a transfer application for filing with ODWR. The application was submitted in January 2007 with the expectation of ODWR approval during the late summer of 2007.

4.8.2 Mid-Umatilla River

In acquiring an easement with B/G Resources, CTUIR agreed to provide a livestock well/pump/stock watering trough as part of the CREP conservation plan to exclude livestock from the River's riparian zone. CTUIR's subcontractor plans to install the well along with a solar pump and livestock troughs on the north side of the River outside of the CREP boundary in January, 2007.

4.9 Increase Instream Habitat Complexity (WE 29)

Meacham Creek in the reach between river mile 2 and 10 continues to be constrained by levees constructed previously within the railroad right-of-way. The levees prevent channel meander which is needed to reduce flow velocities and promote flood plain deposition and channel complexity. As described below, the Creek channel will benefit from placement of large woody debris (LWD) to promote pool habitat and to create/maintain point bars that will sustain riparian canopy. Also, passage barriers to spring chinook salmon and summer steelhead migration exist.

A total of 160 whole trees were placed in dry gravel bars of Meacham Creek between RM 4.6-8.3 in September 2005. The trees were arranged into groups of 2-8 (mean 4.4) in a total of 36 configurations.

Whole trees were 16-24 inches DBH and 60 to 100 feet in length. The size requirements were selected using the reference "A Guide to Placing Large Wood in Streams" (ODF&W 1995), and to provide stability of the wood complexes and limit movement during high flow events.

Representatives from the CTUIR Cultural Resource program conducted surveys and monitored project activities throughout the implementation period.

Areas disturbed in the project area were monitored for artifacts by CTUIR employees trained in cultural resource protection.

Appendix 2 provides additional details of the LWD project.

4.10 Plant Vegetation (WE 47)

4.10.1 Meacham Cr.

One stream mile in Allotments 1138 and 1232 of Meacham Creek stream was planted with 4,020 native willow cuttings in December 2005. Plants were placed in barren areas of the stream bank and adjacent riparian zone that lacked protection from bank cutting and where the stream is most subject to solar radiation. As shown in the photograph below, after one year the cuttings have good growth and have survived the spring runoff of 2006.

4.10.2 Peterson

Both stream banks of Birch Creek in the Peterson easement were planted with 1,000 native shrub and tree tubelings using 27,000 ft^2 of mulch fabric (tarps) at a rate of 30 ft^2 per stem. Planted species were Nootka rose, red osier dogwood, golden currant, Douglas hawthorn, and chokecherry.

Inspection of the plants during the fall of 2006 revealed that only some 10 percent of the tubelings survived. Accordingly, the tarps are to be replanted by the original subcontractor during January of 2007 with smooth sumac, black cottonwood, red osier dogwood, sage brush, snowberry, elderberry, and Woods rose.

4.10.3 Wildhorse Creek

CTUIR habitat staff coordinated and facilitated establishment of a CREP project on the Reynolds and Schmidtgall easements where sub-contractors planted 120 native shrubs and trees per acre (8 and 15 acres respectively) using mulch fabric with weed collars and deer/beaver guards. About 70 percent survival was realized after the first year. The planted acres in linear terms were about one mile on each side of Wildhorse Creek.

4.10.4 Mid-Umatilla River

About four lateral miles of zone 2 of the riparian zone of the B/G Resources easement were planted during the late fall of 2005 by a CREP contractor using mulch tarps and native trees and shrubs. Some 7,440 stems were planted at a rate of 120 stems per acre. Good growth and survival was recorded in the upstream tarps, but the furthest downstream tarps had relatively poor survival. CTUIR staff hand weeded the tarp borders during the summer of 2006. About a one-meter area bordering the tarps is subject to weed growth because of soil scarification prior to tarp installation. This problem appears common to all projects that use mulch fabric. Uncontrolled weed growth in the tarp border area shades the planted tubelings and takes moisture that would otherwise be used by the tubelings. An apparent counter to this problem would be to limit the ground preparation for tarp installation to the width of the tarp.

Zone 2 plantings were augmented with zone 1 plantings of coyote willow and black cottonwood at a rate of 120 stems per acre.



Riparian Planting with Mulch Fabric – B/G Resources

Overall benefits expected to be achieved with the B/G Resources project over the next few years include: (1) arresting bank undercutting and mass wasting on the north stream bank, (2) improving channel morphology through increasing channel sinuosity and reducing width to depth ratios, (3) improving floodplain connectivity by improving bank stability and reestablishing native vegetation communities, (4) improving wildlife habitat and promoting erosion control by planting of native grasses in the CREP zones and adjoining flood plain, and (5) controlling noxious weeds that have been a source of complaint from adjacent land owners and the County for several years.

Major activities at B/G Resources during 2005 and subsequent years were noxious weed control, grass planting in the flood plain adjacent to CREP units, and coordination with the CREP contractor for zones 1 and 2 shrub/tree planting.

4.11 Install Fence (WE 40)

- **B&G Resources - Trespass Barrier**

Riparian zone habitat has been damaged in past years by trespassers using 4-wheel vehicles to access the property. Access occurred at the upstream end of the easement where an access trail off Rieth Road allows for an easy stream crossing and entry into the eastern portion of the property. A natural block for access exists at t this location in the form of a steep cliff on one side of the trespass zone and a ditch with heavy vegetation on the other side. In 2005 CTUIR installed a 120-foot Jack fence between the two natural barriers that appears to have eliminated trespass to date.



Pipe-Type Fence Installed as Trespass Barrier at B/G Resources Easement

- **Baker Property**

A joint effort for installing a fence to exclude livestock along the border of a 5,000 acre parcel in the headwaters of E. Birch Creek was pursued during 2005 and 2006. During negotiations between CTUIR a large part of the fence was constructed with funding from the owner, the Rocky Mountain Elk Foundation, and ODF&W. The owner ultimately rejected CTUIR's proposed easement because of its 15-year restriction on land use. During the period when this report was being written, it became apparent that the fence will be completed without funding or materials assistance by CTUIR/BPA.

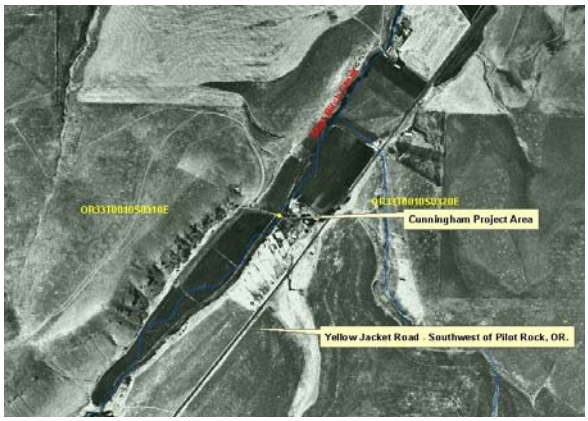
4.12 Install Fish Passage Structure (WE 184)

- **Meacham Cr. RM 1**

This migration impediment was evaluated in the fall of 2006 and determined to be amenable to removal by moving two large boulders. Movement of the boulders downstream by CTUIR staff is scheduled for the instream construction window of 2007. Relocation of the boulders will particularly benefit juvenile salmonids that need to move back upstream after freshets wash them past the barrier.

- **Cunningham Sheep – W. Birch Creek**

A preliminary application was filed with USACE and DSL (Oregon Dept. of State Lands) in December 2004 and a final application was filed in September 2005 for a dredge and fill permit. As of this reporting date, ESA consultation between USACE and NMFS was completed, but a Section 404 permit was not received. The USACE permit is the last step needed for project implementation which is now scheduled for construction within the July-October 2007 instream construction window using some $60,000 of Pacific Coastal Salmon Recovery Funds.



Aerial View of Cunningham Sheep Culvert


Cunningham Sheep Culvert Barrier

4.13 Remove/Modify Dam (WE 85)

- **Hoeft – W. Birch Creek**

Simultaneously with the Cunningham Sheep project, a preliminary application was filed with the USACE/SLD for improvements to the existing dam on the Hoeft property. That application included 90 percent-completed engineering design drawings and specifications for installation of a full-channel concrete fish ladder that would start at the dam face and continue downstream with the appropriate jump pools. Upon receipt of the application, USACE opined that the fish ladder alternative should be re-evaluated along with other alternatives such as a side-channel ladder or rock weirs to create jump pools. In response, CTUIR employed a sub-contractor, McMillen Engineering, to evaluate and recommend a chosen alternative. McMillen's report recommended and justified the full-channel fish ladder as the best alternative, given the channel gradient and the landowner's opposition to removal of the dam. With the anticipated approval of environmental compliance requirements, the $270,000 structure will be constructed in 2007 in partnership with ODF&W, UBWC, and the Birch Creek Water Conservation District. Major funding for implementation will come from the U.S. Dept. of Agriculture's Wildlife Habitat Improvement Program (WHIP) with additional contributions from the Blue Mountain Habitat Restoration Fund and PCSRF.


Hoeft Dam Showing Existing Inadequate Fish Passage

- **Broun – Mainstem Birch Creek**

CTUIR personnel met several times with the owner, renter, and neighbors of the landowner during 2005-2006 to discuss an agreement that would lead to removal of a diversion dam that serves an unscreened diversion. The diversion was used in the past by four water right holders, each of whom must approve removal of the dam and deactivation of the diversion. The improvement concept is for: (1) the owner to file with, and obtain a permit from, the Oregon Department of Water Resources (ODWR) for a change in the point of diversion, (2) CTUIR to acquire a subcontractor and oversee digging of a well and provision of an irrigation pump to replace the direct diversion, (3) CTUIR to provide irrigation lines from the new pump to the water right holders in lieu of their dependence on the diversion ditch, (4) removal of the existing dam, and (5) grading and stabilizing the stream channel upstream and downstream from the dam by means of rock weirs to create scour pools and jump heights amenable to salmonid passage. An easement was signed in 2005 and a water right transfer application was submitted to ODWR in January 2006. Along with environmental approval as discussed in Section 4.6.1, these steps will allow for project implementation during 2007.



- **Peterson – Mainstem Birch Creek**

By the end of 2004, pre-planning and pre-construction activities for the Peterson/Whitney project was followed with preparation of design and specifications for dam removal and channel restoration. Mr. Whitney, one of the property owners having a water right to the Peterson dam diversion, is negotiating an agreement with the Oregon Water Trust to lease a major part of his water right to the Trust for instream purposes. CTUIR's easement with Mr. Whitney will call for dam removal upon consummation of the aforementioned lease or – if the lease is not obtained – for installation of an alternative source of water to satisfy the Whitney water right. In the event that the latter alternative is exercised, preliminary applications for USACE and Oregon DSL dredge and fill permits were filed with the expectation of re-submitting the applications when the project design and specifications are completed.



- **Hoskins (Camp Creek RM 0.3)**

This concrete dam is a hold-over from the early 1900's that diverted irrigation water to the Umatilla River floodplain. Although the jump height appears amenable for adult steelhead and bull trout passage, it constitutes a block for juvenile salmonids that may be washed over the dam during freshets and that wish to return to the upstream rearing area. There are some three miles of spawning/rearing area upstream from the dam where, at that point, a natural falls prevents all salmonid passage. The land owners, Robert and Darlene Hoskins, have signed an agreement with CTUIR that allows for dam removal. Design drawings for removal and channel stabilization have been received from CTUIR's subcontractor. A Section 404 application is to be submitted to USACE/DSL and a cultural resource survey is to be conducted in January 2007. Dam removal is planned for the early fall of 2007.



Camp Creek Dam



Meacham Creek RM 20.2 Dam

- **Meacham Cr. RM 20.2**

This concrete dam is also a remnant from earlier days when the UP Railroad used water diverted from Meacham Creek for steam generation. The dam is located on U.S. Forest Service land. The USFS has given approval to CTUIR for dam breaching or removal. Design drawings for removal and channel stabilization have been received from CTUIR's subcontractor. A

Section 404 application is to be submitted to USACE/DSL and a cultural resource survey is to be conducted in January 2006. Dam removal is planned for the early fall of 2007.

4.14 Maintain Vegetation (WE 22)

Previously installed mulch tarps and plantings on CTUIR easements were visited periodically during the dry season to determine plant stress from drought. In addition, Adams and B/G Resources easement plants were watered during July and August.

An important part of riparian vegetation protection is livestock exclusion. Fence damage from winds, snow, and tree falling is identified and corrected in the spring along with water gap installation; water gaps are removed in the fall prior to high winter flows. Fence repairs and water gap maintenance were performed by CTUIR in active easements including Meacham Creek, Boston Canyon Creek, Mission Creek, Wildhorse Creek, Greasewood Creek, West Fork of Greasewood Creek, Spring Hollow Creek, Buckaroo Creek, Iskuulpa Creek and McKay Creek project areas.

4.15 Remove Vegetation (WE 53)

Weeds were treated on several CTUIR easements with the main noxious weed species being Scotch thistle, yellowstar thistle, dalmation toad flax, knapweed, and spurge. McLain Spraying was subcontracted to eradicate noxious weeds on 217 acres of stream corridor within the mid Umatilla River, McKay Creek, Wildhorse Creek, and Greasewood Creek, the West Fork of Greasewood Creek, Spring Hollow Creek and Mission Creek as well as Umatilla River project areas during the 2005 and 2006 project periods. An additional 106 acres of upland habitat was treated in the Wildhorse Creek and mid-Umatilla river easements.

Herbicide application occurred in the spring and, in some cases, the fall with 4-wheeler with tank, a backpack sprayer or hand wand during each growing season. The project prioritized eradicating weeds designated as "A" Pest Weeds on Umatilla County's Noxious Weed List because these weeds are much more evasive and ecologically considered to be more of a threat to native plant communities. Other invasive weed species were treated as deemed necessary.

In response to the magnitude of noxious weed on the B/G Resources easement, South County Helicopter Services was contracted to spray about 110 acres of mainly yellow star thistle and Scotch thistle in the upland portion of the easement. The project contracted with the Umatilla Weed Control Office to treat weeds inside the CREP riparian area including adjacent to the mulch fabric plantings.





B & G Resources before treatment – spring 2005 B & G Resources after treatment – summer 2005

Project personnel coordinated closely with these subcontractors and individual landowners to assure that nuisance weeds were adequately identified and eradicated. McLain Spraying provided annual descriptions and summaries of all noxious weeds identified and treated in historic project areas in Umatilla River tributaries.

Following completion of annual treatments, the project supplied BPA with a summary including acres treated, application methods employed, treatment dates, herbicides utilized, percent active ingredient in herbicides, type and percent of each adjuvant used and herbicide application rates per acre as shown in Table 4. All chemical applications were consistent with ORS.570.505, FIFRA Regulations, and NMFS and USFWS recommendations regarding ESA concerns.

4.16 Operate and Maintain Habitat/Passage (WE 186)

The physical condition and structural integrity of improvements within the upper and mid Umatilla River, Meacham Creek, Wildhorse Creek, Greasewood Creek, Spring Hollow Creek, Mission Creek, and McKay Creek project areas were evaluated in the spring of each year. CTUIR Habitat staff inspected all instream and stream bank improvements, including sloped stream banks, constructed point bars, root wad revetments, cross and J-vanes, constructed log jams and willow plantings in past project areas and made corrections when necessary.

4.17 Collect/Generate/Validate Field and Lab Data (WE 157)

4.17.1 Water and Air Temperature

Temperatures in excess of 65°F impair growth and survival in salmonids (USFWS and National Marine Fisheries Service, 1981). An abnormally high temperature condition during migration contributes to outbreaks of disease among adult Chinook salmon often resulting in pre-spawning mortality. Temperatures in excess of 68°F have been shown to result in impairment of Chinook salmon. High stream temperatures also stress juvenile steelhead during warm summer months. Temperatures exceeding 73°F result in direct mortality to Chinook salmon and steelhead (Bell, 1984).

Thermographs were deployed at 20 stream locations and six air stations throughout the Umatilla River Basin in 2005. Thermographs were deployed at 13 stream locations and six air stations in 2006. Deployment was from July until late September/early October. Results are shown in Appendix 3.

The number of stream stations monitored in 2006 was less than in 2005 recognizing that we have sufficient knowledge on temperature ranges at historic stations, and that the units could be better used upstream and downstream of projects that could influence water temperature. Air temperature was added to historic stream monitoring in order to evaluate the effects of solar energy on water temperature.

4.17.2 Suspended Solids and Turbidity

High levels of suspended solids and turbidity can adversely impact instream conditions. Results can be seen with increased depositional layers in the system. Increased turbidity and

suspended solids can impact feeding and respiration functions, and cause damage to spawning sites by limiting oxygen. Although the EPA and the State of Oregon don't have numeric water quality standards for suspended solids or streambed fines, excessive fine sediment is addressed through the applied narrative criteria.

CTUIR staff collected daily suspended sediment and turbidity data from three ISCO Model 2700 Wastewater Samplers. Data was obtained at RM 2.0 Meacham Creek (at USGS Gage Station No. 14020300), RM 56.0 Umatilla River (at USGS Gage Station No. 14020850) and RM 81.7 Umatilla River (at USGS Gage Station No. 14020000. These data are shown in Appendix 4.

4.17.3 Macroinvertebrates

OSU Hermiston Agricultural Research and Extension Center Entomologists, Drs. David Wooster and Sandra DeBano, were subcontracted by the project to conduct macroinvertebrate monitoring at Meacham Creek sites. Findings for 2005 are reported in the attached Appendix 5, "Assessment of Aquatic Macroinvertebrates in Meacham Creek, summer 2005". The main objective of the sampling was to provide pre-restoration data on the structure of the macroinvertebrate community in Meacham Creek. Nine sites were sampled in order to examine changes in stream quality after upcoming restoration consisting of large woody debris installation, levee removal, and instream improvements as discussed above in this report. Table 6 shows study locations and sampling dates.

Table 6. Study locations and sampling dates.

Study Site	UTM Location*	Elevation (m)	Sampling Date
1	11 0393772 5059911	554	8/16/2005
2	11 0393637 5058987	565	8/16/2005
3	11 0393501 5058583	570	8/25/2005
4	11 0393545 5058150	574	8/25/2005
5	11 0394246 5054877	603	8/26/2006
6	11 0394150 5054467	609	8/31/2005
7	11 0394114 5053720	621	8/31/2005
8	11 0394273 5053255	627	9/2/2005
9	11 0394395 5052384	630	9/2/2005

Correlation coefficients for the relationships between instream/riparian environmental variables were obtained for several orders of invertebrates; i.e., may fly, stone fly, and caddis fly. The results of this expressed as the Pearson correlation coefficients are shown in Table 7.

Table 7. Pearson correlation coefficients for the relationships between environmental variables and five metrics of community structure. Bold values are significant (based on a 2-tailed analysis with α = 0.05)

Environmental Variable	# of EPT	# of Plecoptera	Taxa Richness	Shannon Diversity	Shannon Evenness
Specific Conductance	-0.401	-0.131	-0.039	**-0.606**	**-0.906**
Turbidity	-0.356	-0.594	-0.351	-0.279	0.150
Dissolved Oxygen	0.119	0.212	0.235	0.616	0.456
Elevation	0.318	0.515	0.244	0.519	0.445
Slope	**-0.789**	**-0.797**	**-0.862**	-0.560	0.192
Aspect	0.295	0.257	0.514	0.461	0.346
% Riffle in Reach	-0.366	-0.249	-0.368	-0.433	-0.125
% Cover	-0.625	**-0.768**	-0.510	-0.118	0.296
Wetted Width	-0.008	0.112	-0.078	0.303	0.518
Pieces of Large Woody Debris	0.441	0.650	**0.674**	0.466	-0.237
Median Size Substrate	0.008	-0.178	-0.123	-0.125	-0.098
% Silt on Substrate	0.179	0.574	0.303	0.138	-0.359
% Filamentous Algae	0.143	-0.328	-0.048	0.183	0.577
Mean Depth	-0.477	-0.640	-0.342	-0.380	0.002
Mean Velocity	-0.020	-0.244	-0.292	0.005	0.119

4.18 Analyze/Interpret Data (WE 162)

4.18.1 Water and Air Temperature

Stream temperature data are summarized in tabular form, illustrating maximum and average daily Fahrenheit temperatures during thermograph deployment periods. Digital copies of these water temperature tables are maintained in the CTUIR Habitat Enhancement Project Office. Summer (June, July, August and September) stream temperatures were graphed to determine if temperatures exceeded limits detrimental to anadromous salmonids. Graphed data for 2005 and 2006 are shown in Appendix 3.

In 2005, Mission Creek and the upper Umatilla River (RM 81.7) continued to exhibit the temperatures most conducive for salmonid survival and rearing. The upper Umatilla River, however, maintains flows year round and surveyors found a moderate number of fish (0.45 salmonids/m^2) between RM 81.8 and RM 89.6 (Contor et al., 1996). Based on salmonids densities and low summer instream temperatures, this section of the Umatilla River appears to be the most important rearing area for salmonids. Stream temperatures were highest, exceeding 85° F on several days, at RM 56 Umatilla River.

The influence of hyporheic flow on stream temperature was again manifested at the Meacham Creek stations. Temperature decreased through the reach from RM 5.25 to RM 1.4 where the solar influence would be expected to increase temperatures from upstream to downstream. This factor demonstrates the importance of rock bars that allow interchange of water from the stream channel with waters in the adjacent gravels.

In 2006 monitoring, ambient air temperature was measured at Birch Creek and mid-Umatilla River stations. These data demonstrate the close correlation of air and water temperatures and that air temperature is the most important factor that determines both maximum and average water temperature. Water tends to buffer heating and cooling extremes that occur in ambient air. For example, the maximum daily variation in water temperature in Birch Cr. at the Broun dam was about 5° centigrade while the maximum daily variation in air temperature was 18° centigrade. Water temperature at paired duplicate stations was measured in the Broun dam area. These measurements showed only minute variation and verified that water temperatures that exceed salmonid tolerance occurred during July and August.

4.18.2 Suspended Solids and Turbidity

High levels of suspended solids and turbidity can adversely impact instream conditions. Results can be seen with increased depositional layers in the system. Increased turbidity and suspended solids can impact feeding and respiration functions, and cause damage to spawning sites by limiting oxygen. Although water quality standards for suspended solids or streambed fines have not been adopted by EPA or the State of Oregon, excessive fine sediment is addressed through narrative criteria.

CTUIR EP/RP Personnel collected daily suspended sediment and turbidity data from three ISCO Model 2700 Wastewater Samplers. Data was obtained at RM 2.0 Meacham Creek (at USGS Gage Station No. 14020300), RM 56.0 Umatilla River (at USGS Gage Station No. 14020850) and RM 81.7 Umatilla River (at USGS Gage Station No. 14020000. These data are prepared in graph form in Appendix 4.

Both TSS and turbidity levels were lower than historic levels at Umatilla River and Meacham Creek stations. Maximum TSSs were 340, 3,800, and 1440 mg/l, respectively, at the Meacham Cr, Umatilla River RM 87 and 53 stations. These levels occurred for only one day during April, 2006. Corresponding maximum turbidities were 37, 1025, and 690, respectively at the above stations. Accordingly, turbidity in the Umatilla system complied with Oregon Department of Environmental Quality water quality standards accept for brief (• 24-hour) periods.

4.18.3 Macroinvertebrates

Data analysis included a multivariate analysis (ordination) and an examination of five metrics commonly used in bioassessments. Ordination analyses allow an examination of the entire macroinvertebrate community in a manner that takes into account both the taxa of organisms and their relative abundance. Results show the most likely environmental variables that determine community structure.

The two most important variables affecting community structure in Meacham Creek appear to be geographic elevation and streambank canopy. Other important variables are: (1) amount of filamentous algae on the substrate, (2) channel slope, (3) amount of large woody debris, (4) substrate size, and (5) water velocity.

Monitoring results provide solid baselines for measuring changes in organism taxa and abundance after restoration activities are implemented.

Details of macroinvertebrate sampling are reported in Appendix 5.

4.19 Manage and Administer Projects (WE 119)

In addition to overview of the various work elements, preparation of budget mods and staff evaluations, and new-year PICES work element descriptions, project staff prepared a detailed proposal for the Northwest Power & Conservation Council (NPCC) for conduct of project activities during the years 2007-2009. The proposal was reviewed by the ISRP Committee and ultimately accepted by NCPP in October, 2006.

4.20 Produce Pisces Status Reports (WE 185)

Status reports were forwarded to the BPA COTR in June and October, 2006 and a year-end status report is scheduled for the end of January, 2007. The 2005 and 2006 reports were approved by the COTR.

4.21 Produce Annual Report (WE 132)

This report constitutes the annual report for the 2005 and 2006 project budget periods. The 2006 macroinvertebrate monitoring section that is incomplete will be submitted as an addendum when subcontractor data are received by CTUIR.

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APPENDIX 1

PROJECT MANAGEMENT PLANS – 2005

Meacham Creek

Situation

Salmonid productivity can be increased in Meacham Creek by both instream and riparian improvements. The Creek lacks riffle, glide, pool complexity as well as sinuosity. The railroad right-of-way compresses the stream in an artificial corridor that prevents attainment of meander. Flashy runoff in the months of snow/rainfall reduces summer base flows which allows for undesirable water temperature increase. Several passage impediments exist downstream from North Fork Meacham Creek

Purpose/Goal

Project is to: (1) improve the complexity of Birch Creek downstream from the North Fork, (2) increase channel meander, (3) reduce passage impediments, and (4) reduce water temperature in order to improve habitat for summer steelhead and spring chinook salmon.

Objectives

1. Add large woody debris (logs with rootwads) at appropriate locations.
2. Remove passage impediments where present.
3. Breach or remove selected dikes that prevent stream meander.
4. Plant stream bank and riparian vegetation.

Tasks/Schedule

Activity	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**
Select locations for improvement and type of improvement	---- 2005											
Obtain improvement design/specifications	--- 2005											
CWA/NEPA/ESA requirements	---- 2005											----
HR requirements	---- 2005											
Select subcontractor for vegetation planting	---- 2005											
Plant vegetation	---- 2005											
Select subcontractor for LWD placement	---- 2006											
Place LWD	------											
Select subcontractor for passage improvements	---- 2006											
Implement passage improvements	---- 2006											
Select dike breeching subcontractor	---- 2006											
Breech dikes	---- 2006											

APPENDIX 2

MEACHAM CREEK LARGE WOOD IMPLEMENTATION PROJECT

PROGRESS REPORT

Prepared by:

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The Confederated Tribes of the
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12/5/06

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INTRODUCTION

Meacham Creek is a major tributary of the Umatilla River at river mile (RM) 78.8 and contributes approximately half of the summer flow to the mainstem Umatilla River at the confluence. Historically, the Meacham watershed was a significant producer of salmonids and was an area of significant importance to tribal culture. Salmon were extirpated from the Umatilla Basin in the early 1900's due to seasonal passage issues in the lower Umatilla River. Meacham Creek still produces spring chinook salmon, summer steelhead and bull trout, but at reduced levels due to detrimental man-made impacts. The primary impacts to Meacham Creek are associated with the adjacent railway which was built in the early 1900's. Extensive diking, channel relocation or constrainment, and alteration of the vegetative component are impacts associated with construction and maintenance of railway operations. The railroad runs parallel and at close proximity to the mainstem of Meacham Creek for the majority of its 36 river miles. A significant secondary impact to Meacham Creek is the presence of livestock in the riparian area, where moderate to heavy grazing pressure occurs.

Many of the large trees in the Meacham watershed were likely removed to fuel steam locomotives during the early days of railroad and to supply the needs of a sawmill formerly located near RM 2 of the North Fork of Meacham Creek. Flood control structures and channel relocation activities have reduced the length of Meacham Creek by 1.4 miles, reduced habitat quality and quantity, and impacted the functional relationship between the floodplain and river channel. Large rock used in the construction of railway levees, have high solar energy absorption capacity, which can elevate water temperatures in addition to reducing habitat complexity. Subsequently, the effects of reduced channel sinuosity have resulted in an unstable hydrograph where extreme low and high flow scenarios are observed. Maximum flows peak at 8,800 cubic feet per second (cfs), while minimums of 7 cfs constitute summer base flows. Several vast dry channel reaches are located intermittently throughout Meacham Creek in the summer months as well. We theorize that substantial fish displacement, stranding, and mortality occurs in the system due to these hydrological disturbances.

Much of the Meacham watershed is not in compliance with salmonid temperature requirements and corresponding state and federal water quality standards. Thermal guidelines for bull trout state that water temperatures above 15^{o}C limit distribution. This benchmark is consistently exceeded in the majority of the Meacham Basin. However limited, Meacham Creek is classified as critical habitat for bull trout due to its historical importance, knowledge of inhabitance, and potential for connectivity with the core population located in the North Fork of the Umatilla River. Population levels of sexually mature, adult bull trout in the Meacham Creek drainage are estimated to be less than 50 individuals. Year-round hospitable habitat is found in only a minority of the Meacham watershed, generally near cold water inflows or relatively deep pools with additional desirable qualities such as shade and cover. Therefore a migratory life stage component is present in much of Meacham's bull trout population. The low numbers and concentrated distribution pattern of bull trout in the Meacham Basin categorizes the population as "increasing threat" and "high risk" of extinction. Not surprisingly a report on the status of Oregon's bull trout (Buchanan & Gregory 1997) classified the small bull trout population in Meacham Creek as "high risk". Protecting the Meacham sub-population of bull trout is important to preserve the genetic integrity of the species as well as enhance the migratory corridor from a connectivity standpoint with the primary core population located in the North Fork Umatilla River. The potential for connectivity improves the odds of species preservation over time,

especially during catastrophic events and diversifies evolutionary genetic exchange between populations when conditions dictate the necessity for such.
Meacham Creek's suitability for salmonids is currently classified as marginal, but the restoration potential is good despite limitations imposed by the fixed presence of the railway. Currently, high stream temperatures, lack of summer flow, limited quantity of pools, lack of overall habitat complexity and shortages of large woody debris are considered as primary factors limiting salmonid carrying capacity and production in Meacham Creek.

In the 1980's, a successful, hatchery-based salmonid reintroduction effort was instituted using neighboring strains of various salmonid species. A plethora of management strategies have been successfully applied in effort to reestablish the salmonids to self sustaining levels. Juvenile abundance is substantially increasing in the basin and adult returns have also risen. We expect exponential response of salmonid populations once habitat deficiencies are addressed and improved. We believe a positive correlation between habitat improvement, salmonid density, and fitness levels will shift the status of listed species towards a safer level of sustainability in the Umatilla Basin.

Based upon the recovery potential of the system, CTUIR has initiated a restoration project to compensate for existing shortages of in-channel large woody debris and to approach natural historic channel morphology and facilitate improved function of the Meacham Creek floodplain. The importance of large woody debris is recognized as a major sculptor and component of pools and offers a structural entity which creates a mechanism for vegetative establishment and succession. The formation of deep, complex pools are beneficial in that they offer important hiding cover and thermal refuge for salmonids. The addition of large wood was identified as the top priority in the current Meacham Creek Action Plan (Andrus, Midel, 2003). The Meacham Creek Action plan identifies priority actions that will occur in phases to improve salmonid productivity in Meacham Creek. Initially large woody debris will be incorporated into the active channel, then channel morphology work and in-stream woody debris work will occur, grazing will be managed and riparian plantings will follow.

The goals identified in the Action Plan aim at promoting hyporheic exchange, increase channel sinuosity, improve vegetative conditions in the riparian, and improve fish passage. Restoration strategies for Meacham Creek are designed to improve fish habitat by trapping sediment, stabilizing stream banks, creating pool habitat, and providing micro-sites for riparian vegetation establishment. CTUIR natural resource professionals expect favorable response and increased carrying capacity of salmonids as well as improvements in watershed health. The project is designed to provide large wood sources until the floodplain and adjacent forest mature. We theorize that any adverse impacts associated with the implementation will be temporary and insignificant when compared to the expected long-term benefits to the Meacham Creek Watershed ecosystem. Key objectives of the project are:

- reduce stream-flow energy and erosion during over-bank discharge events
- increase fine sediment retention in key areas, bank building process
- create holding pools for salmonids
- promote the development of sites for vegetation establishment

Expected cumulative benefits of improving floodplain function are:

- immediate increase in roughness elements in the active channel and floodplain
- eventual self sustaining development of the vegetative component
- subsequent improvement in terrestrial nutrient contribution
- improved channel form, sinuosity, complexity, geomorphic, hydrograph stability
- decreased width:depth, active:wetted channel ratios, reduced cross-sectional surface area

- increased base flow, shallow-groundwater capacity, capability of functional interaction
- A reduction of de-watering, fish mortalities, improve passage, availability of habitat
- Increased salmonid population dynamics and carrying capacity of preferred species

METHODS

Tree sources for implementation were obtained from timber stands located on hill slopes located adjacent to Meacham Creek near RM 0.3 and 2.0. Tree selection was based upon improving long term health of the timber stand. Trees selected for harvest had visual imperfections such as double tops, insect damage, signs of disease or were taken from areas in need of thinning to promote the growth of dominant, robust trees (Figure 1).

Figure 1. Selective harvest of an individual tree from an overgrown stand meeting preferred requirements. Tree source used for implementation stage of restoration project, Meacham Creek.



Whole trees were 16-24 inches DBH and 60 to 100 feet in length. The size requirements were selected using the reference “A Guide to Placing Large Wood in Streams” (ODF and ODFW 1995), and to provide stability of the wood complexes and limit movement during high flow events.

Representatives from the CTUIR Cultural Resource program conducted surveys and monitored project activities throughout the implementation period (Figure 2).

Figure 2. Areas disturbed in the project area were monitored for artifacts by CTUIR employees trained in cultural resource protection.



Harvested trees were transported by helicopter from the source site to the active channel of Meacham Creek for implementation (Figure 3).

Figure 3. Trees were transported via helicopter from hill slope to the active channel.



Whole trees were placed in pre-selected, marked areas on dry gravel bars located in the active channel of Meacham Creek (Figure 4).

Figure 4. Helicopter placement of trees into strategic, pre-selected areas.



Placement areas were marked on ground with high visibility flagging and spray paint. Crews directed helicopter operators by radio and used hand signals to guide tree placement into specific locations. Trees placed by helicopter into clusters of 2-8 per configuration (Figure 5).

Figure 5. Tree configurations intertwined, overlaid to maximize complexity, anchoring capacity.



To reduce and minimize potential impacts from implementation, no heavy equipment was used on the ground and work was conducted within the designated in-stream work period (July-October). Trees were not anchored or attached by any unnatural means. Tree configurations were designed to be intertwined to maximize self-anchoring ability. Configurations were numbered 1-36. The locations were marked with cattle ear tags with corresponding numbers on trees located beyond the high water mark.

A Trimble Geo XT Geo Explorer Series Pocket PC hand held computer with a backpack receiver with extended dome antennae, manufactured by Trimble Inc was used to document GPS coordinates for each site (Figure 6).

Figure 6. Trimble instrumentation used to document GPS coordinates of each tree configuration.



Terra Synch version 2.5 software was used for data collection on the field PC. Microsoft ActiveSync was used to transfer field data from the Geo XT to a desktop PC. GPS Pathfinder Office version 3.00-02 was used to run differential corrections to calibrate and improve the accuracy of GPS readings. Arc Map GIS 9 was used to present data in the form of maps, tables and figures and has the capability to overlay data with digital aerial photo backdrops, offering the capability to monitor the location of tree configurations over time.

Photographs were also taken of each configuration and correlated to flow data derived from a USGS internet web site (figure 7).

Figure 7. Photographic documentation of vegetative succession, hydraulic conditions at sites.



In the future, additional photographs will be used to document evolving conditions at a variety of flow regimes.

The monitoring plan instituted for Meacham Creek restoration activities is designed to provide a comprehensive measurement of effectiveness of the actions implemented using a range of physical and biological parameters. Parameters include suspended sediment and turbidity, stream temperature at specific points throughout the project reach and, monumented cross-sections, longitudinal profiles, stream habitat surveys, macro invertebrate sampling, and fish sampling. Permanent photo points, repeated on an annual basis, will also be used to show project changes. A portion of the temperature and suspended sediment characteristics have been monitored since the mid-1990's and will continue for the purpose of long-term trend analysis. Additional forms of monitoring will also be used, such as the experimental design regimen of Before-After, Control-Influence or BACI (Smith 2002).

HABITAT SURVEYS

Years prior to the tree implementation phase, CTUIR collected habitat data for Meacham Creek on two separate occasions to document the status of habitat conditions. Methods developed by ODFW (Moore et al. 2002) were used to inventory both aquatic and riparian habitat. Field surveys were conducted by one or two persons walking upstream, dividing the stream into a series of individual habitat quadrates. The identification of quadrate boundaries were identified by significant differences in the hydraulic component of the wetted channel as defined in the ODFW methods. (Figure 8).

Figure 8. Identification of quadrate boundaries was based on distinct differences in hydraulic features of the wetted channel.



Quadrates were numbered sequentially. The specific type of wetted habitat comprising a quadrate was identified as either riffle, rapid, glide, scour pool, or off-channel/sub-unit pool. In addition the following data was recorded for each quad; habitat type, latitude, longitude, mean length, wetted and high-flow width, depth, shade, canopy, wood rating, substrate composition, bed scour, embeddedness, channel type, percent flow, land use, bank class, undercut bank, dominant and secondary vegetation. Blackberries and young deciduous growth were classified as shrub cover. Bed scour, embeddedness and spawning fines were categorical and had ascending values associated with each of the five categories to describe the degree of each variable in spawning locations (Mobrand et al. 1997). Wood ratings were also categorical and were useful for quantifying the value of in-river woody debris habitat for fish. In addition, pieces of woody debris and boulders were tallied if they met minimum size requirements, and were located within the high water channel. Shade values were taken when standing in the middle of a quadrate, while canopy estimates were made from each adjacent shoreline. Notes were taken to supplement the standard entry requirements.

Dimensions of quadrates were measured in the field by a Bushnell Yardage Pro laser rangefinder. Site length was later recorded more accurately by accessing differentially-corrected GPS information. A 2.4 meter (m) Crain Inc. measuring rod was used to take river widths and depths. A Suunto Inc. clinometer was used for obtaining stream shade values. Habitat information was analyzed using the associated summarization macro to ODFW's Aquatic Habitat Inventory. Additional summaries were generated using Principal Components Analysis.

FISH SURVEYS

Fish surveys were conducted on two occasions prior to the implementation period by a crew of four to six persons. The surveys were extensive, density-driven efforts. One or two backpack electroshockers manufactured by Smith Root Inc. were used to collect fish.

Site selection was generated randomly and a variety of habitat-types were sampled as to represent the complexity of the system. If a randomly selected site was determined to be too deep etc. to effectively sample then an adjacent section was substituted. To facilitate statistical analysis, sites were selected within designated in treatment areas where management actions

are planned, as well as in non treatment reference reaches. A spatially-balanced line-linear randomization routine was used to select points in the tributary network based on a GIS platform (EPA 2002, Stevens & Olsen 2003, 2004).

Site dimensions were variable and had maximum lengths of 313 meters. Navigating to the general area of the sites was accomplished by reviewing documentation of physical landmarks in close proximity and GPS coordinates were used to refine the search and hone-in on the specific location.

Blocknets were used at the lower and upper ends to isolate the site for sampling. Care was taken not to displace fish from the section as nets were being set. Fish species were captured with dip nets and removed on successive electrofishing passes. Electrofishers were operated in a similar manner for at least the same number of seconds as the previous pass. Electroshocker settings (i.e. volts, pulse) remained constant for each removal pass.

Captured fish were temporarily held in buckets, and then placed in a flow-through livewell upstream from the uppermost blocknet. A portion of the fish were identified to species, measured and weighed. Differentiation between anadromous steelhead and resident rainbow trout was not determined and therefore all were classified generically as rainbow trout. After examination, fish were released back into site where captured, or in some cases relocated just up or downstream from the sampled reach if conditions appeared significantly better. A minimum of five sculpin spp. were collected from each site for taxonomic identification to be conducted later. The majority of sculpin samples were mortalities associated with electrofishing activity.

Scale samples were taken from a portion of salmonids of various sizes to be used for determining age, life history and genetic composition. Approximately 6-12 scales were removed from an area two rows above the lateral line, posterior to the dorsal fin, and anterior to the adipose fin. Scale samples were taken from all salmonid mortalities. Scales were placed in clear mylar envelopes labeled with stream, site, date, species and fork length information.

In addition to the density-driven fish sampling, CTUIR conducted relative abundance sampling and used catch per unit effort to express fish quantity. This form of sampling was conducted up to three times per year at three index sites on the mainstem of Meacham Creek from 1994-1999. Site locations were marked on trees with numbered cattle ear tags to ensure that the same sites were sampled annually. Sampling was conducted in the summer, spring and fall periods to study species abundance, variability and seasonal movement patterns. No blocknets were used and catch was divided by time of effort to derive estimates of fish abundance.

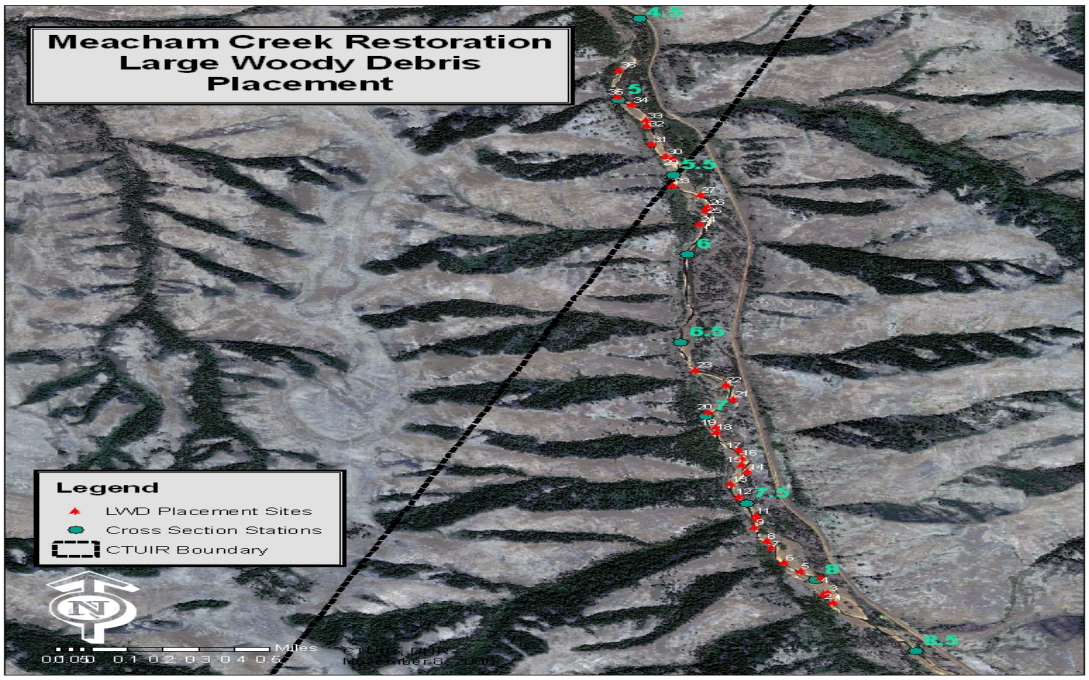
Estimates of species abundance and density were derived using a maximum-likelihood model (Van Deventer and Platts 1989) which is based on the number of a species captured per electrofishing pass. Densities were estimated by dividing fish abundance by the total area of the wetted channel sampled. Lengths and weights were summarized based on mean frequency distributions. The length-weight relationships were analyzed using a generalized linear model by software ABEE (http://filaman.ifm-geomar.de/Download/index.htm). Fish diversity was calculated using the inverse of Simpson's D. Relationships among the covariates were explored using a generalized linear model-base neural network analysis and multiple regression. All statistical analyses were conducted using JMP version 5.2.

RESULTS

Whole Tree Placement

A total of 160 whole trees were placed onto dry gravel bars of Meacham Creek, between RM 4.6-8.3. The trees were arranged into groups of 2-8 (mean 4.4) in a total of 36 configurations. Tree placement sites are shown in **Error! Reference source not found.** 9.

Figure 9. Aerial photograph of Meacham Creek showing locations of whole tree configurations.



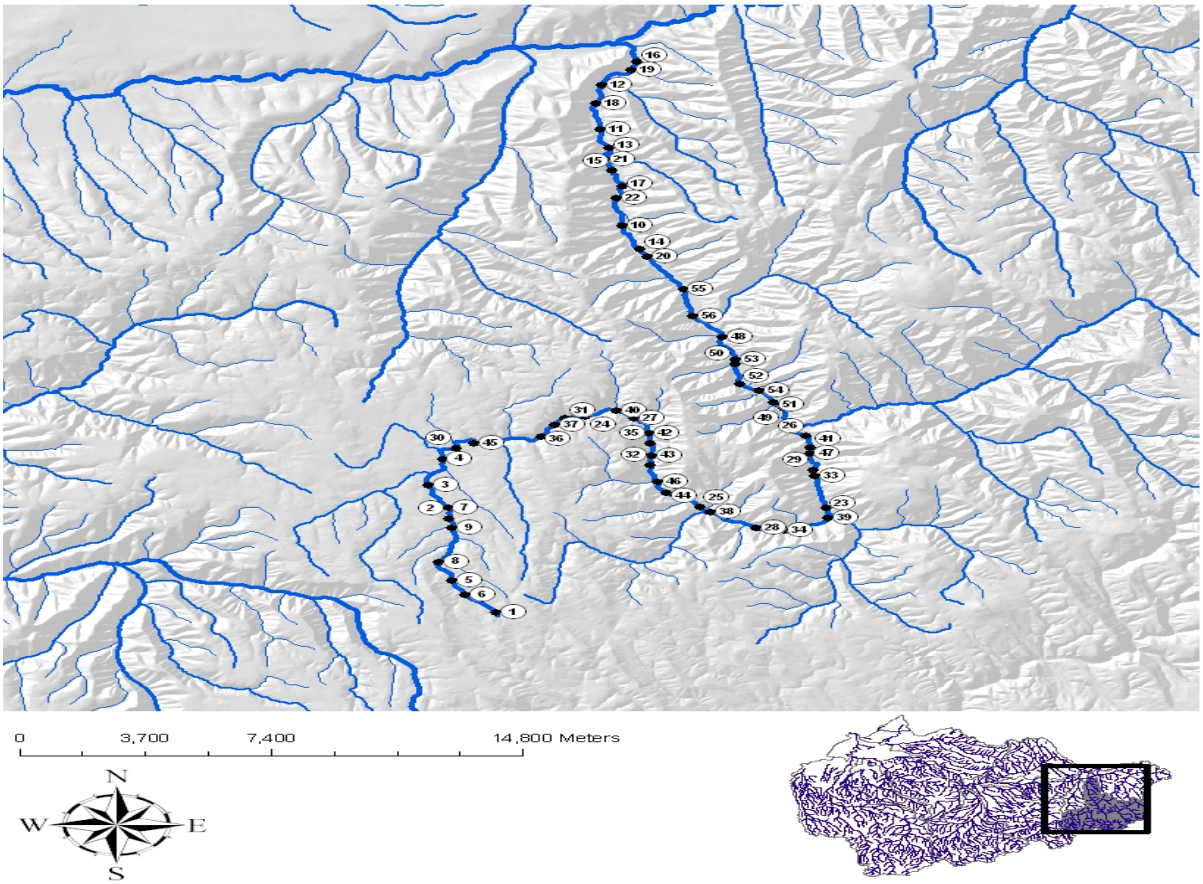
1993 Habitat Surveys

In July 1993, the CTUIR Natural Production Monitoring and Evaluation Project collected baseline, pre-treatment and reference habitat information from the mainstem of Meacham Creek, RM 0-15.3. Results of the survey were as follows: (1) maximum stream temperature was 74°F, (2) 14% of the quadrates surveyed were dry, (3) wetted braided channels made up 20% of the stream length and 10% of stream area, (4) 45% of habitat units was classified as riffle, (5) 45% of stream banks were actively eroding, (6) 1% of bank length was undercut, (7) open sky value of the wetted channel averaged 60%, (8) 1.6 pieces of large woody debris per 100m, (9) wood complexity score averaged 1.2, (10) average stream gradient was 1.3%, (11) width of the wetted channel was 25 times the depth, (12) substrate was dominated by gravels (43%) and cobbles (40%) and 200 boulders (>20") per mile provided important cover and microhabitat for fish (CTUIR 1994).

2005 Habitat Surveys

A total of 56 potential sites on the mainstem of Meacham Creek were made available to the random generator program for selection of sampling sites. Of which only 11 sites were selected for field sampling. The following sites were sampled for fish; 12, 13, 14, 17, 18, 22, 26, 49, 50, 54, 56 and are shown in Figure 9.

Figure 9. Location of potential sites, selected sites sampled for fish by CTUIR, 2005.



The dimensions of sample-sites varied. Widths ranged from 1.8-10.5 meters wide and lengths were 177-313 meters. Sampling was conducted September 7 and October 3, 2005.
There were only 135 pieces (12.3 mean per site) of wood tallied that met size and location criteria and the wood rating as it pertained to fish cover ranked only 2.0. A good portion of the woody debris either lacked complexity or was located beyond the wetted channel where it was of little value to fish at the time of survey. This phenomenon was the direct result of the flashy flow nature of the system as supported by active channel widths measuring 7.4 times as wide as wetted widths (Table 1).

Table 1. Summary of stream habitat metrics collected at 11 sites, Meacham Creek, 2005.

Site	Hab	Lgth (m)	Ave w (m)	Bfl (m)	Av d (m)	Snd%	Grv%	Cbl%	Bld%	Wd (#)	Wd Rt
18	glide	39	8.5	26	0.1	20	55	20	5	0	1
18	pool	45	4.0	25	0.2	20	55	10	15	0	1
18	riffle	69	7.5	27	0.1	15	65	15	5	0	1
18	pool	20	11.5	22	0.3	35	45	5	15	0	1
18	glide	30	6.5	33	0.3	35	40	10	15	0	1
total		**202**	**7.6**	**27**	**0.2**	**25**	**52**	**12.5**	**11**	**0**	**1**
13	riffle	99	8.5	63	0.1	15	65	20	0	7	2
13	pool	39	7.0	69	0.4	30	45	25	0	1	3

Site	Hab	Lgth (m)	Ave w (m)	Bfl (m)	Av d (m)	Snd%	Grv%	Cbl%	Bld%	Wd (#)	Wd Rt
13	riffle	56	6.5	65	0.2	15	40	30	15	6	2
total		**193**	**7.3**	**65**	**0.2**	**20**	**50**	**25**	**5**	**4.7**	**2.3**
14	glide	66	6.5	100	0.3	30	50	20	0	4	1
14	riffle	44	2.5	83	0.1	15	35	50	0	5	1
14	riffle	46	1.0	11	0.1	20	40	40	0	0	1
14	pool	23	2.0	9	0.3	20	55	25	0	3	3
14	glide	58	2.0	10	0.1	35	40	25	0	0	1
14	glide	78	7.0	100	0.4	35	35	30	0	3	1
total		**313**	**3.5**	**52**	**0.2**	**26**	**43**	**32**	**0**	**2.5**	**1.3**
50	riffle	191	3.0	37	0.1	20	40	40	0	1	1
total		**191**	**3.0**	**37**	**0.1**	**20**	**40**	**40**	**0**	**1**	**1**
54	glide	81	2.0	35	0.2	15	60	25	0	12	3
54	riffle	105	1.5	67	0.1	10	40	50	0	10	2
total		**186**	**1.8**	**51**	**0.2**	**13**	**50**	**38**	**0**	**11.0**	**2.5**
22	riffle	21	11.0	30	0.3	15	25	40	20	0	1
22	pool	36	6.5	34	0.4	15	50	25	10	0	1
22	riffle	73	14.0	63	0.1	15	45	35	5	2	1
22	glide	48	10.5	50	0.5	25	45	25	5	4	1
total		**177**	**10.5**	**44**	**0.3**	**18**	**41**	**31**	**10**	**1.5**	**1.0**
56	riffle	177	5.0	80	0.2	10	50	40	0	11	1
total		**177**	**5.0**	**80**	**0.2**	**10**	**50**	**40**	**0**	**11.0**	**1.0**
26	glide	43	6.0	13	0.2	25	30	45	0	1	2
26	riffle	164	7.5	14	0.1	0	35	55	10	6	2
total		**207**	**6.8**	**13**	**0.2**	**13**	**33**	**50**	**5**	**3.5**	**2.0**
49	riffle	49	4.0	64	0.1	15	40	45	0	5	1
49	glide	17	2.5	69	0.3	20	45	35	5	1	2
49	riffle	92	4.0	60	0.2	10	35	40	15	2	2
49	glide	10	4.5	50	0.2	20	40	40	0	1	1
49	riffle	27	3.0	67	0.1	10	50	40	0	2	2
total		**195**	**3.6**	**62**	**0.2**	**15**	**42**	**40**	**4**	**2.2**	**1.6**
17	riffle	92	9.0	27	0.2	15	50	30	5	1	1
17	glide	30	7.0	32	0.3	20	50	20	10	0	1
17	riffle	63	12.5	31	0.1	10	55	30	5	0	1
total		**184**	**9.5**	**30**	**0.2**	**15**	**52**	**27**	**7**	**0.3**	**1.0**
12	pool	18	8.0	40	0.6	10	55	30	5	2	3
12	glide	35	10.5	63	0.3	15	55	30	0	1	2
12	riffle	127	7.5	60	0.2	5	40	45	10	4	1
total		**179**	**8.7**	**54**	**0.4**	**10**	**50**	**35**	**5**	**2.3**	**2.0**
TOTAL		**2203**	**221**	**1625**	**7.8**	**640**	**1600**	**1090**	**175**	**135**	**68.7**

The average values per sample-site for bed scour, spawning fines, and Embeddedness were 4.6, 2.1 and 2.1 respectively. The results indicated very high bed scour with moderate to low amounts of fine substrate in potential spawning areas. Generally, these values met criteria

associated with moderately favorable spawning conditions. Undercut values averaged only 10.5% per quadrate sampled, which indicated a low quantity of overhead cover, essential for providing shading and hiding areas for fish.

Mean riparian canopy was estimated at 31%, while mid channel shade values averaged 39% (35 degrees) per quad. There were intermittent concentrations of mature tree growth that received solid habitat rankings, but generally the distance from the wetted channel was too great to provide adequate shading or the width of the riparian strip was rather thin, and flanked by cleared land. Average channel shade values were 37 degrees and riparian canopy open sky values averaged 33% (Table 2).

Table 2. Summary of stream and riparian metrics for 11 sites, Meacham Creek, 2005.

Bad Sc	Emb	Spn Fin	Ucut L	Ucut R	Bnk L	Bnk R	Prm Vg L	Sec Vg L	Prm Vg R	Sec Vg R	Ch Sd R	Ch Sd L	Rip Cn L	Rip Cn R
3	2	2	0	5	BC	BC	D	G	C	G	20	45	10	35
3	2	2	0	25	BC	BC	G	S	C	S	15	45	10	35
4	2	2	5	5	BC	NE	S	G	C	G	20	40	15	35
4	3	3	20	30	BC	NE	D	S	G	C	25	35	35	20
4	3	3	0	15	BC	NE	D	G	G	S	15	35	40	20
3.6	**2.4**	**2.4**	**5**	**16**							**19**	**40**	**22**	**29**
5	2	2	5	5	BC	NE	C	G	C	S	25	45	30	55
5	3	3	35	5	AE	NE	C	S	C	S	50	40	45	70
5	2	2	10	10	BC	NE	C	N	S	G	45	35	60	65
5.0	**2.3**	**2.3**	**17**	**7**							**40**	**40**	**45**	**63**
5	3	2	5	0	BC	AE	D	C	C	S	20	30	0	10
5	2	1	15	10	AE	AE	D	C	C	S	20	40	0	5
5	1	2	10	5	AE	AE	N	G	C	S	20	60	20	60
4	2	3	5	40	AE	AE	N	G	C	S	20	55	15	35
3	3	3	0	5	BC	AE	N	N	S	G	20	40	0	15
5	3	2	5	5	BC	AE	C	S	S	G	20	30	0	5
4.5	**2.3**	**2.2**	**7**	**11**							**20**	**43**	**6**	**22**
5	2	2	15	10	BC	BC	C	G	D	G	20	30	15	35
5.0	**2.0**	**2.0**	**15**	**10**							**20**	**30**	**15**	**35**
5	2	2	20	15	NE	BC	D	C	D	C	45	20	55	30
4	2	2	5	10	NE	BC	D	C	D	C	40	30	35	20
4.5	**2.0**	**2.0**	**13**	**13**							**43**	**25**	**45**	**25**
5	2	2	20	15	NE	NE	C	N	C	S	40	35	30	45
5	2	2	30	5	NE	NE	C	N	C	S	40	45	30	45
5	2	3	5	10	AE	NE	C	S	C	S	20	50	40	50
5	3	2	5	0	BC	NE	C	S	C	S	30	55	25	60
5.0	**2.3**	**2.3**	**15**	**8**							**33**	**46**	**31**	**50**
5	2	3	20	15	VS	AE	C	S	D	C	40	25	20	35
5.0	**2.0**	**3.0**	**20**	**15**							**40**	**25**	**20**	**35**
4	3	2	15	10	BC	BC	S	D	C	S	30	50	15	55
4	2	2	15	15	BC	VS	D	C	D	C	55	65	55	70
4.0	**2.5**	**2.0**	**15**	**13**							**43**	**58**	**30**	**63**
5	2	2	15	10	BC	BC	C	S	D	C	25	65	10	75

5	2	2	0	20	VS	BC	C	D	D	C	30	65	15	65
5	2	2	15	10	VS	BC	C	D	D	C	25	35	10	25
5	2	2	5	15	VS	VS	C	S	D	C	20	35	15	25
4	2	2	10	5	BC	VS	C	S	D	S	35	25	30	10
4.8	**2.0**	**2.0**	**9**	**12**							**27**	**45**	**16**	**45**
5	2	2	10	5	BC	VS	C	D	C	D	35	65	35	60
5	2	2	0	10	BC	NE	C	N	C	S	30	60	35	70
5	2	2	5	5	BC	NE	C	N	C	S	25	40	30	20
5.0	**2.0**	**2.0**	**5**	**7**							**30**	**55**	**33**	**50**
4	1	1	0	30	BC	VS	N	G	D	G	25	50	0	45
5	2	2	10	0	BC	BC	N	D	D	S	15	30	5	30
5	1	1	10	10	VS	VS	D	S	C	D	20	40	10	30
4.7	**1.3**	**1.3**	**7**	**13**							**20**	**40**	**5**	**35**
160	**75**	**74**	**345**	**390**							**980**	**1490**	**795**	**1365**

The upland land use classification generally consisted of levees, timber, shrubs and grasses (Table 3).

Table 3. Summary of land use habitat metrics for eleven survey sites, Meacham Creek, 2005.

Landuse Classification	Primary, Left Side%	Secondary, Left Side%	Primary, Right Side%	Secondary, Right Side%
Timber	45	20	51	34
Diked	36	3	43	3
Cleared	9	6	0	0
Grassland	6	11	0	17
Shrubs	3	45	6	43
Grazing	0	6	0	3
Commercial	0	6	0	0
Wetland	0	3	0	0
Total	**100**	**100**	**100**	**100**

Habitat variable covariance was high among channel, riparian, and substrate metrics. The PCs loaded heavily on covariance in substrate and riparian conditions. The quantitative variables were reduced to three Principle Components, which explained ~85% of the variance in the habitat data. Fish diversity did improve the relationship between salmonid abundance and habitat information considerably (Table 4).

Table 4. Meacham Creek Habitat variables and loadings in Principle Components Analysis

VARIABLE	PC1	PC2	PC3
Eigenvalue	378.6333	214.0958	145.2810
Percent	43.5278	24.6125	16.7015
Cum Percent	43.5278	68.1403	84.8419
Snd%	-0.09116	-0.13871	-0.26350
Grvl%	0.07543	0.28329	0.11728
Cobl%	0.10215	0.18125	0.73528
Bldr%	0.04795	-0.18109	-0.15888
#Wood	0.03906	0.24083	0.04543
WoodRt	0.01194	0.01287	0.00420

VARIABLE	PC1	PC2	PC3
BdSc	0.00453	0.00887	0.01054
Emb	0.00620	-0.00516	-0.00903
SpFn	0.00254	0.00845	-0.00817
UcutL	0.12985	0.18999	0.12884
UcutR	-0.07270	0.04932	0.03027
ChSdL	0.41711	0.32278	0.08762
ChSdR	0.20714	-0.62821	0.10553
RpCnL	0.57795	0.29185	-0.52168
RpCnR	0.63125	-0.39240	0.20027

1993 Fish Surveys

Biological Surveys of Meacham Creek and major tributaries were conducted in June, 1993 for determining juvenile steelhead/rainbow location and abundance. Approximately 87,432 naturally produced rainbow/steelhead trout juveniles were estimated within the lower 15.3 miles and were the most abundant salmonid species. This is primarily due to timing of life cycle characteristics which have proven to be best suited for conditions in the Umatilla Basin and have given the species a competitive advantage over other salmonids. Mean density in the study area was estimated at 20 individuals per100m^2. Estimates of rainbow/steelhead in the main tributaries adjacent to the Meacham Creeks restoration zone had densities 2-4 times higher than in the mainstream of Meacham Creek. Salmonid densities on the mainstem Umatilla River within the boundary of the Umatilla Indian Reservation (RM 56.1-81.8) were only 36/100meter. In fact there were more than twice as many salmonids estimated in the 15.3 miles of Meacham creek that in the lower 81.8 miles of the Umatilla River. To compound the significance of this finding, Meacham Creek has considerably less water volume than the Umatilla River. This illustrates the importance of Meacham Creek in terms of salmonid production and potential.

No results will be presented at this time for the relative abundance sampling that was conducted by CTUIR during the summer, spring and fall periods from 1994-1999. CTUIR may choose to resume sampling of the index sites in the future as a means of determining fish population trends as well as strengthening pre and post implementation monitoring capabilities. If CTUIR resumes this form of monitoring on Meacham Creek, then results will be presented as applicable opportunities arise.

2005 Fish Surveys

Crews electrofished 11 sites, averaging 200 meters in length, from RM 2.2 to 15.5 of Meacham Creek between September 7 and October 3, 2005. The cumulative area sampled was 13,452.5m2. Between 132 and 1088 rainbow trout were captured at each site. Approximately 99% of captured trout were unmarked, naturally produced fish. A total of 3303 rainbow trout were captured. Densities for rainbow trout ranged from 0.0881-2.9755/m2 and averaged 0.3524/m2. Between 0 and 33 juvenile chinook salmon were captured at each site. A total of 88 Chinook were captured. Densities for juvenile Chinook salmon ranged from 0.0000-.0412/m2 and averaged 0.0109/m2. Between 117 and 642 speckled dace were captured at each site. A total of 3997 speckled dace were captured. Densities for speckled dace ranged from .0295-.2.8418/m2 and averaged 0.7839/m2. Between 40 and 372 sculpin spp. salmon were captured at each site. A total of 2105 sculpin spp. were captured. Densities for sculpin spp. ranged from 0.0433-.2.2485/m2 and averaged .4903/m2 (Table 5).

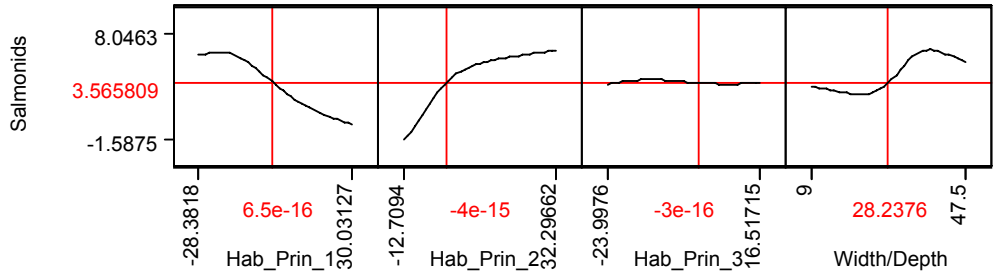
Table 2. Summary of fish capture information collected from eleven survey sites on Meacham Creek. Site numbers correspond to Figure 1.

Site	RBT	RBT	RBT	CHS	CHS	CHS	Dace	Dace	Dace	Scul	Scul	Scul
	Catc	Exp	Dens	Ctch	Exp	Dens	Ctch	Exp	Dens	Ctch	Exp	Dens
18	233	416	0.289	15	19	0.013	454	655	0.454	257	414	0.287
13	212	372	0.253	33	38	0.026	253	493	0.335	304	609	0.414
14	284	355	0.276	5	5	0.004	232	378	0.030	128	207	0.161
50	1088	1699	2.976	1	1	0.002	541	1612	2.821	257	1285	2.249
54	160	266	0.834	1	1	0.003	117	201	0.63	148	166	0.520
22	187	234	0.118	13	14	0.007	321	1605	0.809	142	432	0.218
56	332	429	0.485	1	1	0.001	503	2515	2.842	249	1245	1.407
26	205	252	0.169	0	0	0.000	480	575	0.386	40	43	0.289
49	317	346	0.472	0	0	0.000	203	421	0.575	153	272	0.371
17	132	160	0.088	7	8	0.004	251	1255	0.085	372	1860	1.024
12	153	212	0.146	12	60	0.041	642	836	0.574	55	63	0.043
Total	**3303**	**4741**	**0.352**	**88**	**147**	**0.011**	**3997**	**10546**	**0.784**	**2105**	**6596**	**0.490**

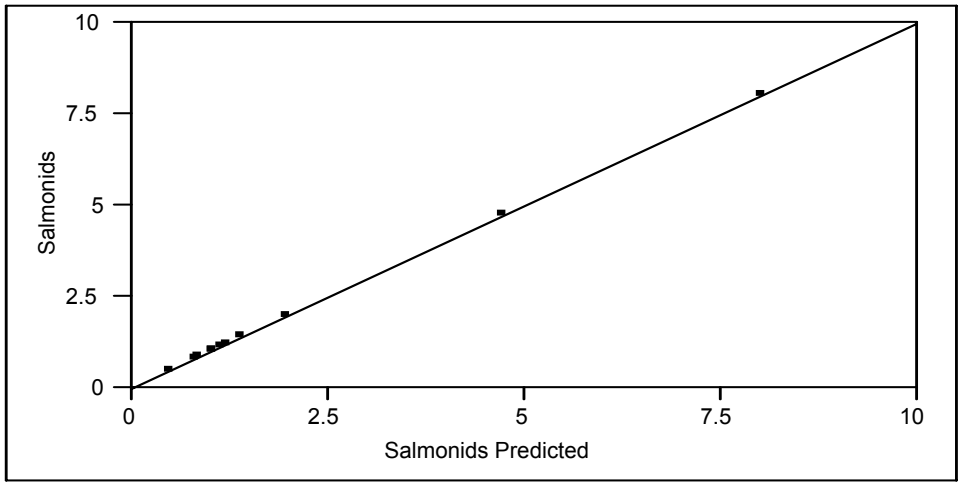
We used a Generalized Linear Model Neural Network Analysis to explain fish information based on habitat conditions. Width-to-depth ratios and the first three habitat PCs were predictive of salmonid abundance virtually 100% of the time. Results of length-weight analysis using mean frequency distributions and the ABEE generalized linear model software/neural network and multiple regression are show in Figure 10 (a-c).

Figure 10. Contour profiler (a), predicted values (b), and residuals (c) from a neural network analysis of three habitat principle components, width-to-depth ratios, and estimates of salmonid abundance at 11 sites on Meacham Creek, 2005.

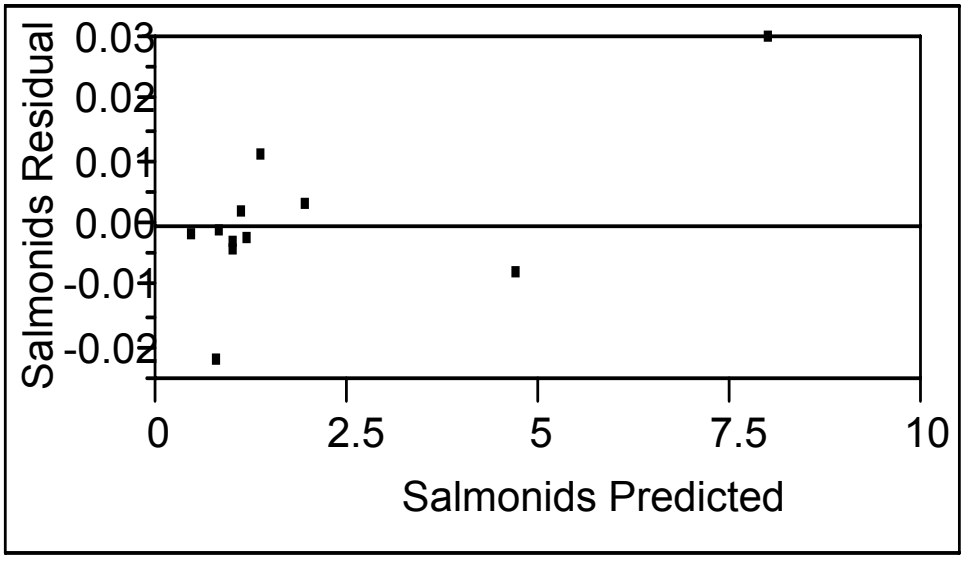
(a)



(b)



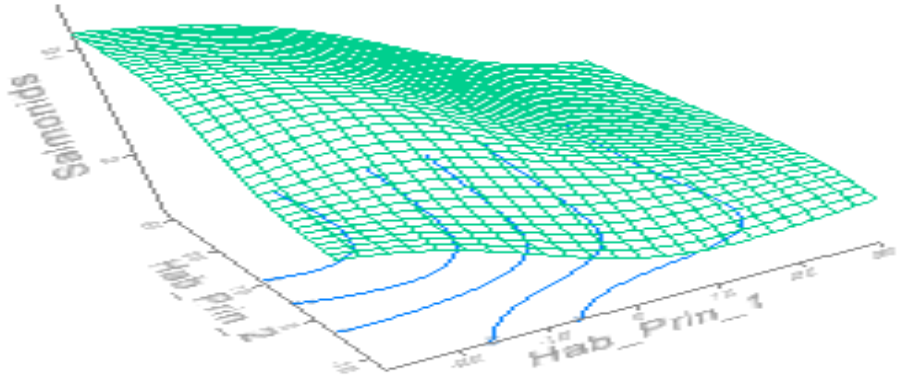
(c)



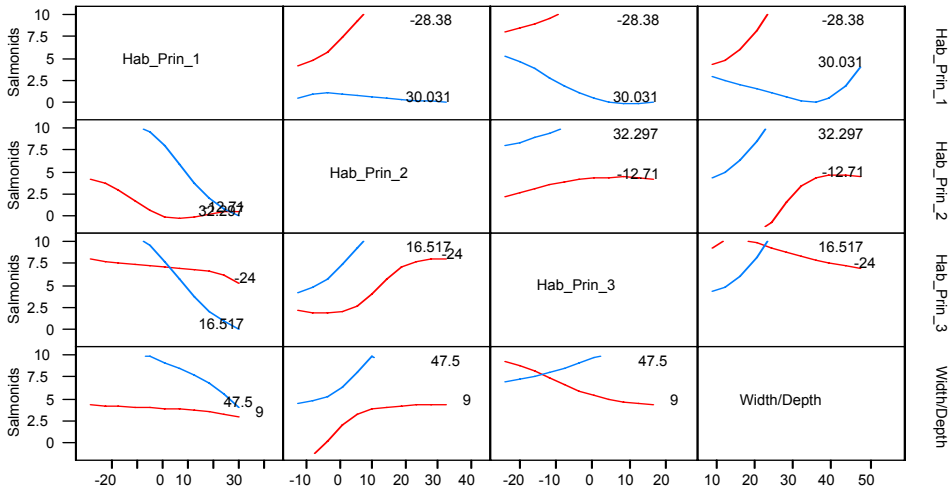
The GLM was sensitive to all metrics (Figure 11). This analytical technique has been criticized as oversensitive to covariance in predictors, and should be substantiated using more traditional techniques.

Figure 11. Response surface (a) and response profiler (b) among the principle components of habitat, width-to-depth ratios, and salmonid abundance at 11 sites, Meacham Creek, 2005.

(a)

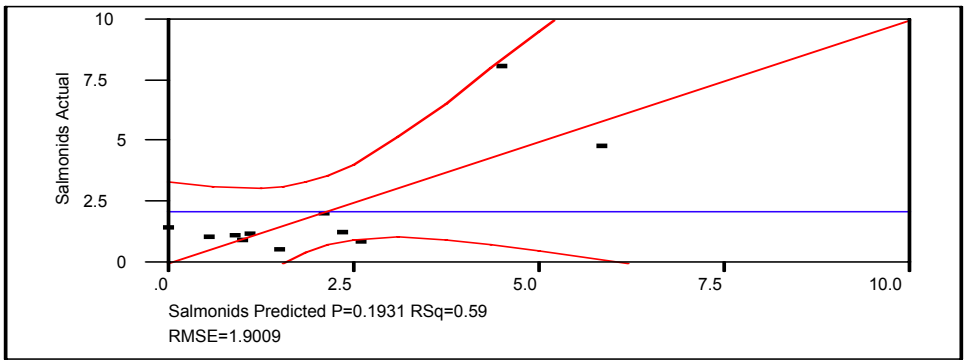


(b)



Based on multivariate regression, salmonid abundance was strongly related to habitat information (Figure 12, Rsq=0.59, p<0.05), suggesting the fish-habitat correlations are real.

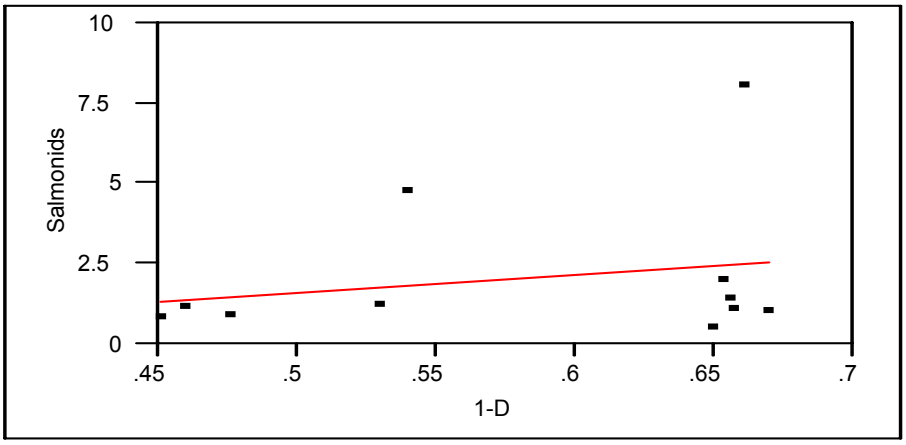
Figure 112. Salmonid abundance predicted in multi-variate regression of three principle components of habitat information and width-to-depth ratios, 11 sites, Meacham Creek, 2005.



Fish diversity alone was not predictive of salmonid abundance (Figure 13), suggesting that salmonid limiting factors are at least partially non-biological ones.

Figure 123. Simple regression (a), observed vs. predicted (b) salmonid abundance using inverse of Simpson's D, 11 sites, Meacham Creek.

(a)



(b)

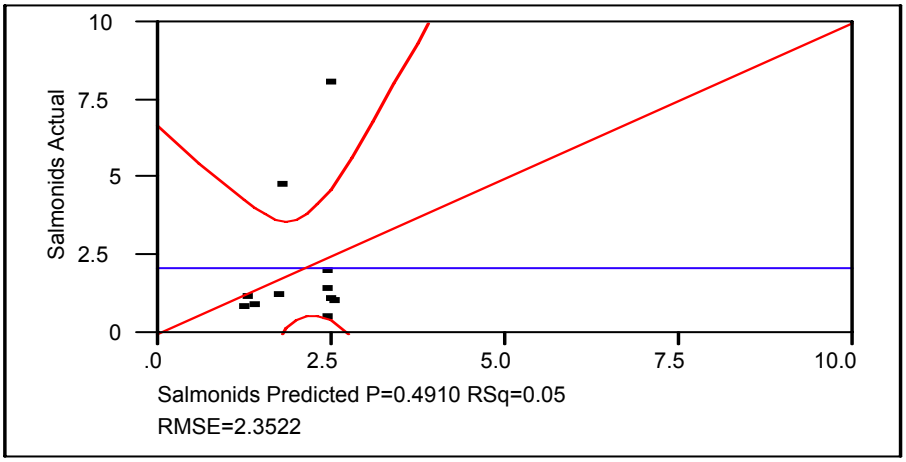
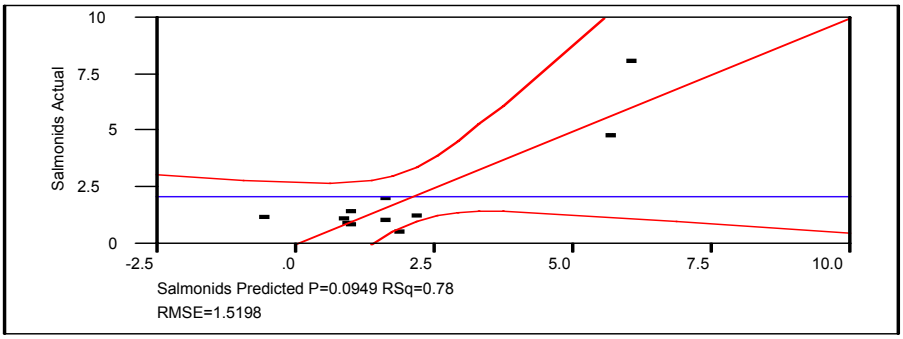


Figure 13. Observed versus predicted estimates of salmonid abundance, 11 sites, Meacham Creek, 2005, based on multivariate regression between three principle components of habitat data, width-to-depth ratios, inverse of Simpson's D.



It is probable that both ecological and physical forces currently limit salmonid production in Meacham Creek. We hypothesize that the relationship between physical habitat conditions, ecological conditions, and salmonid abundance will improve in sites that receive habitat treatments, and to a lesser extent in sites that are downstream from the treatment areas. We expect the steepness of the curves depicted in Figure 10 and Figure 11 to increase over time at all sites due to broad-scale restoration efforts implemented by the Agencies and Authorities. However, we expect their steepness to increase more dramatically in sites receiving habitat treatments. Post-treatment surveys will be conducted pending resources to quantify the "improved" state of physical, biological, and ecological information. Methods, approach, and technical details associated with that survey work will be developed during 2006 in collaboration with the US EPA, ODFW, BPA, and NOAA.

The general purpose of the fish survey work was to support the evaluation of habitat action effectiveness based on salmonid performance. Various post-implementation monitoring strategies will be utilized in the future. Results of the monitoring efforts will be used to evaluate the impacts of habitat actions on biological performance metrics, and to guide future decisions in regard to fish and habitat management strategies in the Umatilla Basin.

LIST OF ABBREVIATIONS

AvDp(m)	Average depth in meters
AE	Actively eroding
Area(m2)	Area in meters
AvWd(m)	Average width in meters
BC	Boulder/cobble
BdSc	Bedscour
Bkfl(m)	Bankful measurement in meters
Bldr%	Percentage of substrate comprised by boulder
BnkL	Bank classification, left
BnkR	Bank classification, right
C	Conifer
Chnnl	Channel type
CHS	Spring Chinook
ChSdL	Channel shade, left side
ChSdR	Channel shade, right side
Cobl%	Percentage of substrate comprised by cobble

D	Deciduous
Emb	Embeddedness
G	Grass
Grvl%	Percentage of substrate comprised by gravel
Hab	Habitat type
Lat	Latitude
Len(m)	Length in meters
Longit	Longitude
N	None
NE	Non eroding
RBT	Rainbow Trout
RpCnL	Riparian canopy. Left riparian
RpCnR	Riparian canopy. Right riparian
Scul	Sculpin
Snd%	Percentage of substrate comprised by sand
SpFn	Spawning fines
UcutL	Undercut, left bank
UcutR	Undercut, Right bank
VS	Vegetated, stable
WoodRt	Wood rating as it pertains to fish habitat
#Wood	Number of pieces of wood meeting criteria
1VgL	Primary vegetation, left side riparian
2VgL	Secondary vegetation, left side riparian
1VgR	Primary vegetation, right side riparian
2VgR	Secondary vegetation, right side riparian

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APPENDIX 3

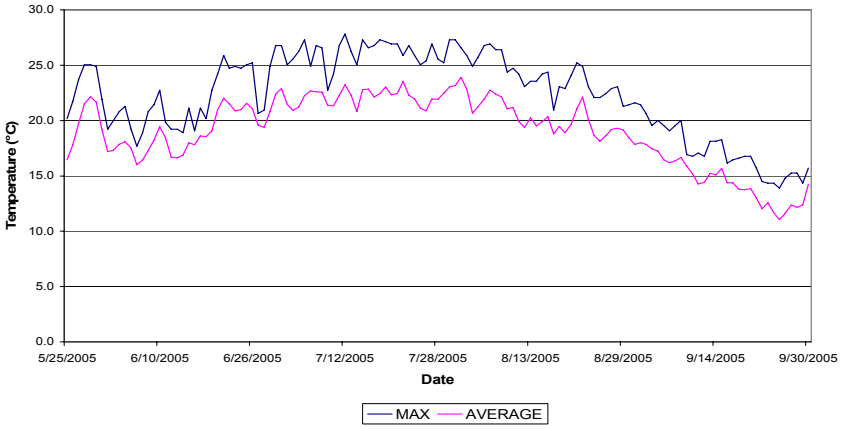
TEMPERATURE MONITORING DATA

UMATILLA HABITAT PROJECT STATIONS – 2005

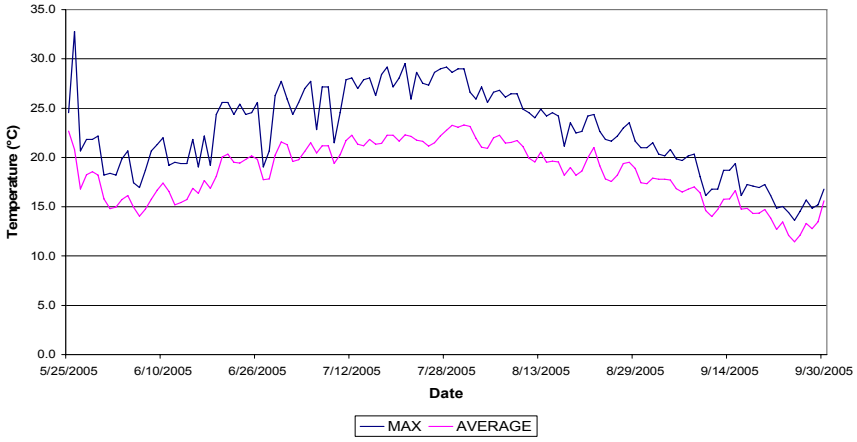
UNIT TYPE	SERIAL / WRP #	STREAM LOCATION	LATITUDE/ LONGITUDE	PLACEMENT / PURPOSE
VEMCO	2123	Wildhorse Crk RM 14	45°44'27.14"N 118°36'18.51"W	Static/Water
VEMCO	2125	Wildhorse Crk RM 26.0 Gentry Res	45°45'01.99"N 118°24'08.77W	Static/Water
VEMCO	2126	Wildhorse Crk RM 18.3 d-s Athena	45°48'31.44"N 118°29'49.90W	Static/Water
VEMCO	2127	Wildhorse Crk RM 0.0 u-s of Confluence	45°40'45.58"N 118°45'400.14"W	Static/Water
VEMCO	**2129**	Wildhorse Crk Rm 1.4 @ New Gauge	45°41'08.35"N 118°44'49.89"W	Static/Water
VEMCO	**2128**	Umatilla River RM 56.0 @ ODFW	45°40'09.77"N 118°46'30.42"W	Static/Water
VEMCO	2130	Umatilla River RM 76.5 d-s of Iskuulpa Crk	45°41'54.01"N 118°24'26.37"W	Static/Water
VEMCO	2131	Umatilla River RM 81.7	45°43'04.93"N 118°19'29.72"W	Static/Water
VEMCO	2132	Umatilla River RM 42.8 B&G Upstream	45°39'33.58"N 118°59'04.37W	Static/Water
VEMCO	2133	Umatilla River RM 40.4 B&G Downstream	45°40'20.76"N 119°00'35.15"W	Static/Water
VEMCO	2134	Meacham Crk RM 1.4 @ Gauge Station	45°41'18.89"N 118°21'24.48"W	Static/Water
VEMCO	2135	Meacham Crk RM 5.25	45°38'09.66"N 118°21'28.42"W	Static/Water
VEMCO	2136	Coonskin Crk RM 0.2 d-s of Cayuse Rd.	45°40'36.33"N 118°32'46.23"W	Static/Water
VEMCO	2137	Mission Crk RM 1.25	45°39'36.01"N 118°38'30.34"W	Static/Water
VEMCO	2138	Mission Crk RM 3.8	45°37'35.91"N 118°37'03.37"W	Static/Water
VEMCO	2139	Moonshine Crk RM 1.1 u-s of Cayuse Rd.	45°39'36.27"N 118°33'58.17"W	Static/Water
VEMCO	2141	Greasewood Crk RM 0.1 Lower project area	45°44'23.13"N 118°36'51.37"W	Static/Water
VEMCO	2142	Spring Hollow Crk RM 3.5	45°45'19.63"N 118°30'22.22"W	Static/Water
VEMCO	2143	Buckaroo Crk RM RM 2.0	45°39'55.11"N 118°28'26.70"W	Static/Water
VEMCO	2144	Little Buckaroo Crk RM 0.04	45°40'03.50"N 118°28'14.50"W	Static/Water
ONSET Tidbit-wr	1	West Fork of Birch Crk RM 3 Hoeft Dam	45°27'24.40"N 118°52'10.92"W	Static/Water

ONSET Tidbit-wr	2	Birch Crk RM (Petersons)	45°37'38.79"N 118°51'00.19"W	Static/Water
ONSET Tidbit-wr	3	Wildhorse Crk Rm 1.4 @ New Gauge	45°41'08.35"N 118°44'49.89"W	Static/Air
ONSET Tidbit-wr	4	Umatilla River RM 42.8 B&G Upstream	45°39'33.58"N 118°59'04.37W	Static/Air
ONSET Tidbit-wr	5	West Fork of Birch Crk RM 3 Hoeft Dam	45°27'24.40"N 118°52'10.92"W	Static/Air
ONSET Tidbit-wr	7	Meacham Crk RM 1.4 @ Gauge Station	45°41'18.89"N 118°21'24.48"W	Static/Air
ONSET Tidbit-wr	8	Meacham Crk RM 5.25	45°38'09.66"N 118°21'28.42"W	Static/Air
ONSET Tidbit-wr	9	Spring Hollow Crk RM 3.5	45°45'19.63"N 118°30'22.22"W	Static/Air

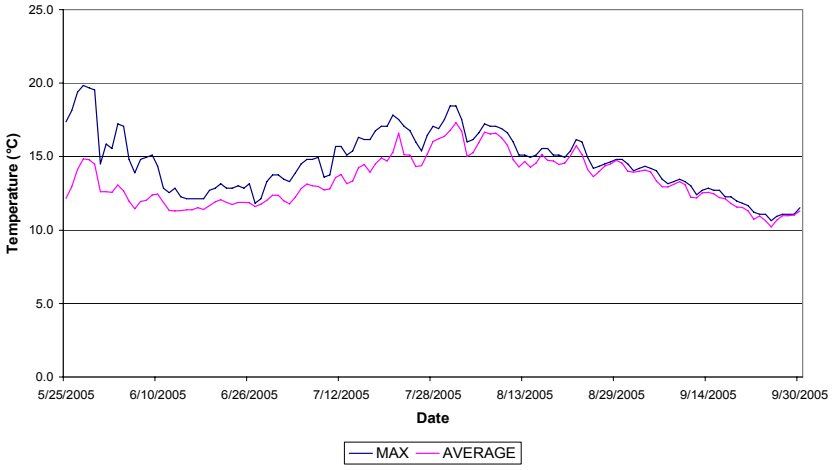
Wildhorse Creek
River Mile 0.0 u-s of Confluence



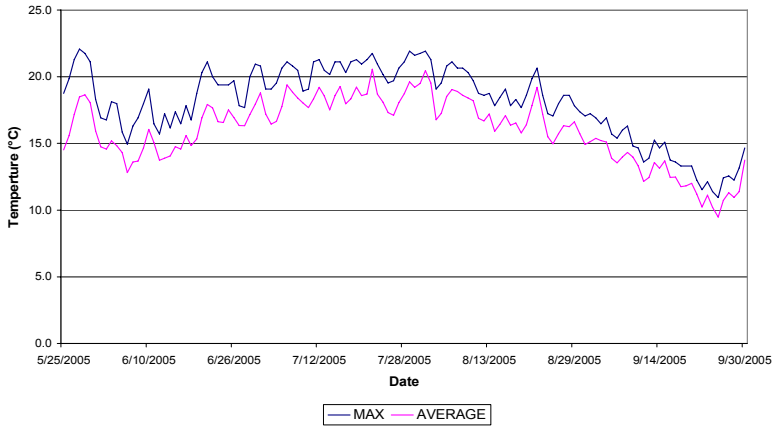
Birch Creek, Mainstem
River Mile xx Peterson Property



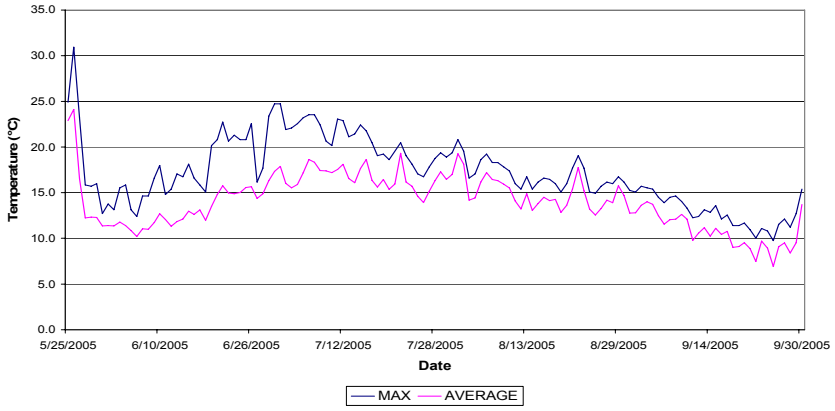
Coonskin Creek
River Mile 0.2 d-s of Cayuse Rd.



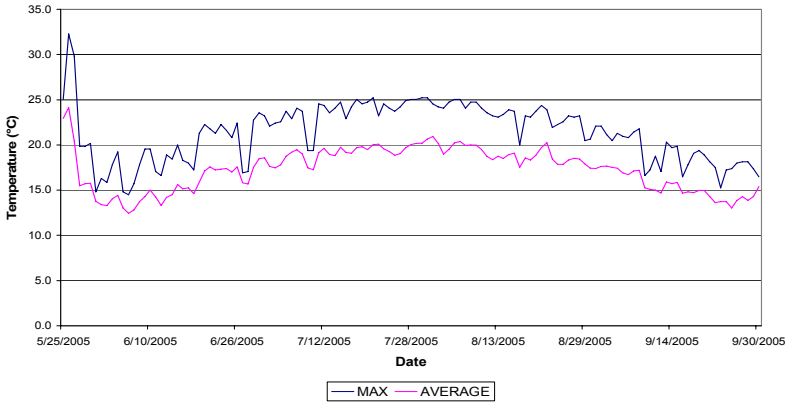
Greasewood Creek
River Mile 0.1 Lower Project Area



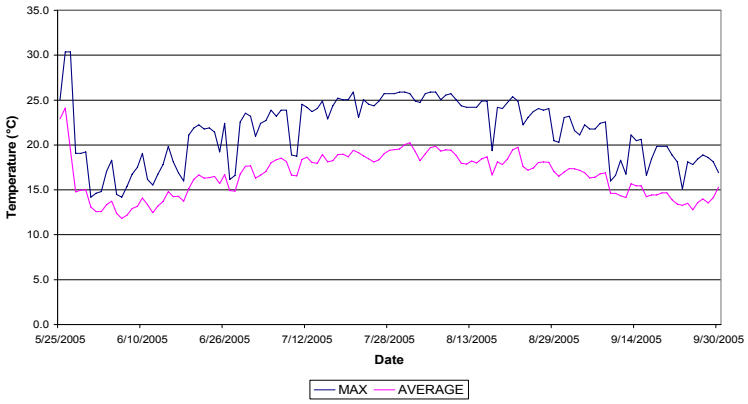
Little Buckaroo Creek
River Mile 0.04



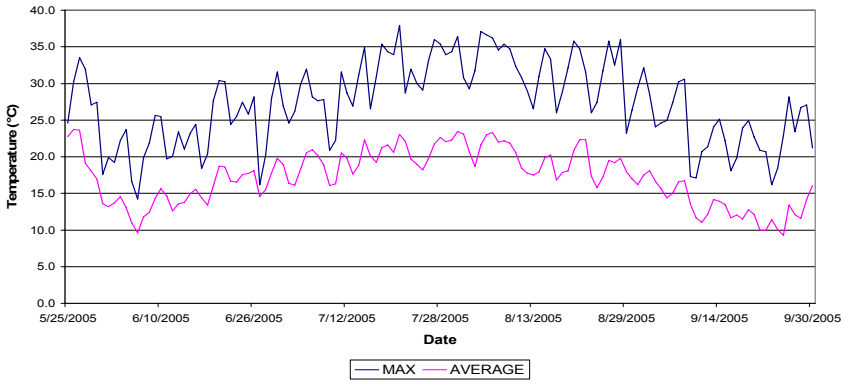
Meacham Creek
River Mile 1.4 @ Gauge Station



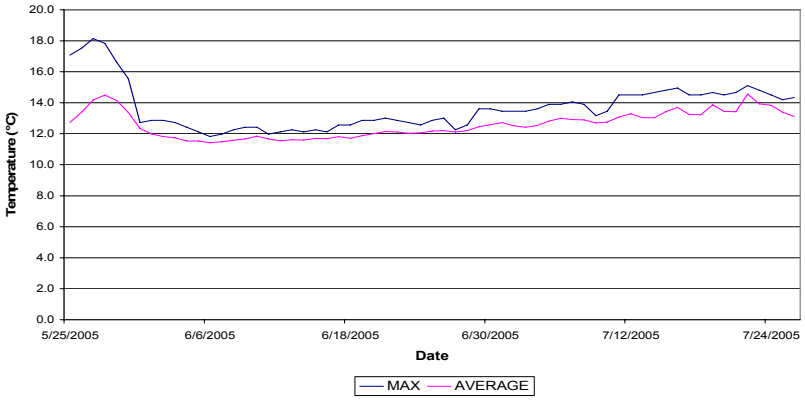
Meacham Creek
River Mile 5.25



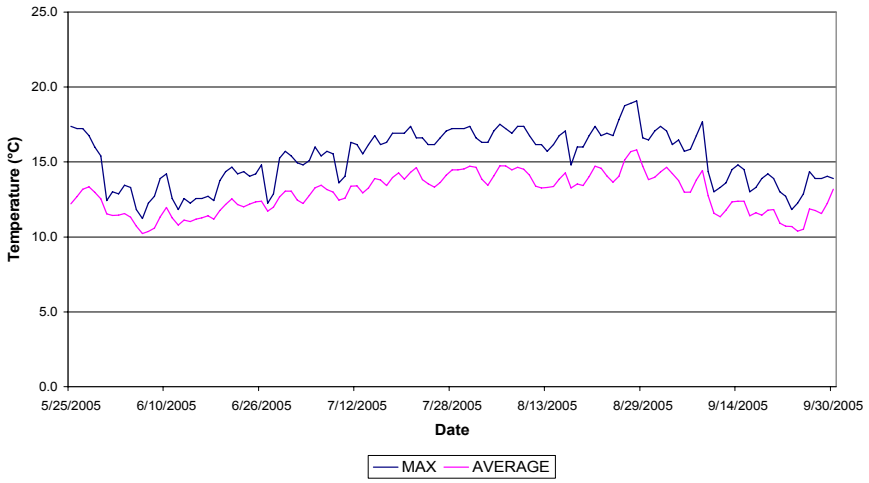
Meacham Creek
Static Air
River Mile 1.4 @ Gauge Station



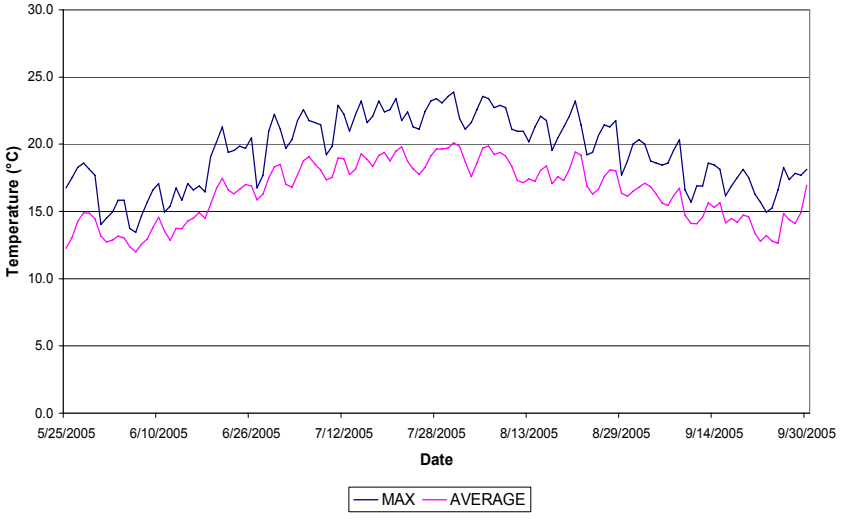
Mission Creek
River Mile 1.25



Mission Creek
River Mile 3.8



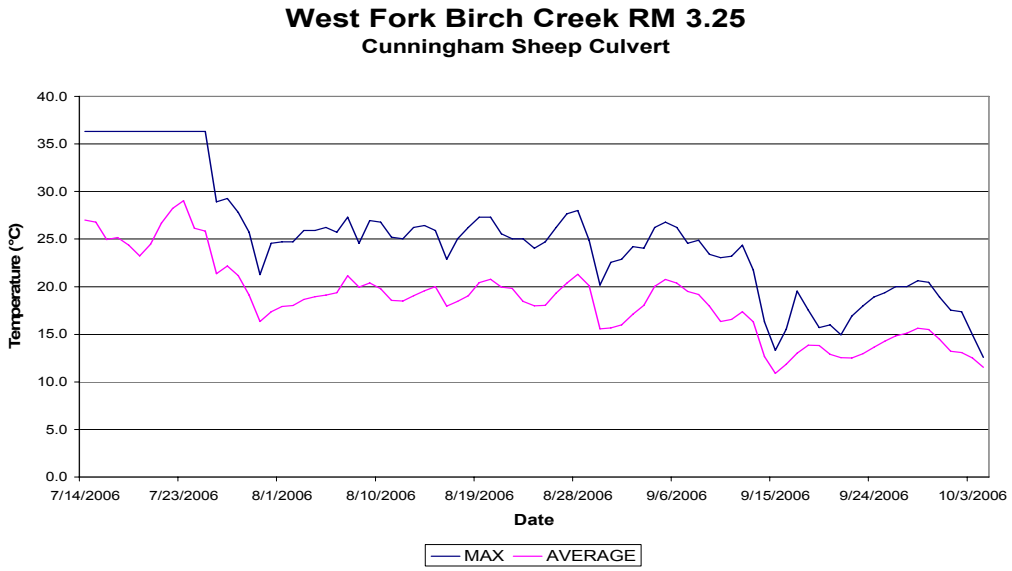
Moonshine Creek
River Mile 1.1

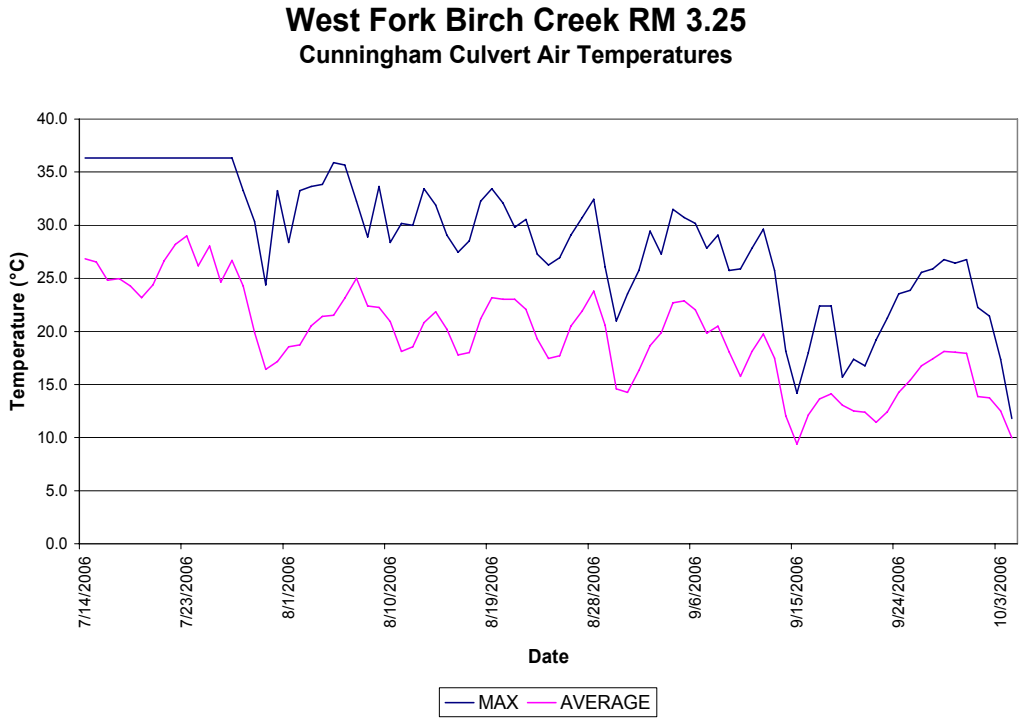


UMATILLA HABITAT PROJECT STATIONS - 2006

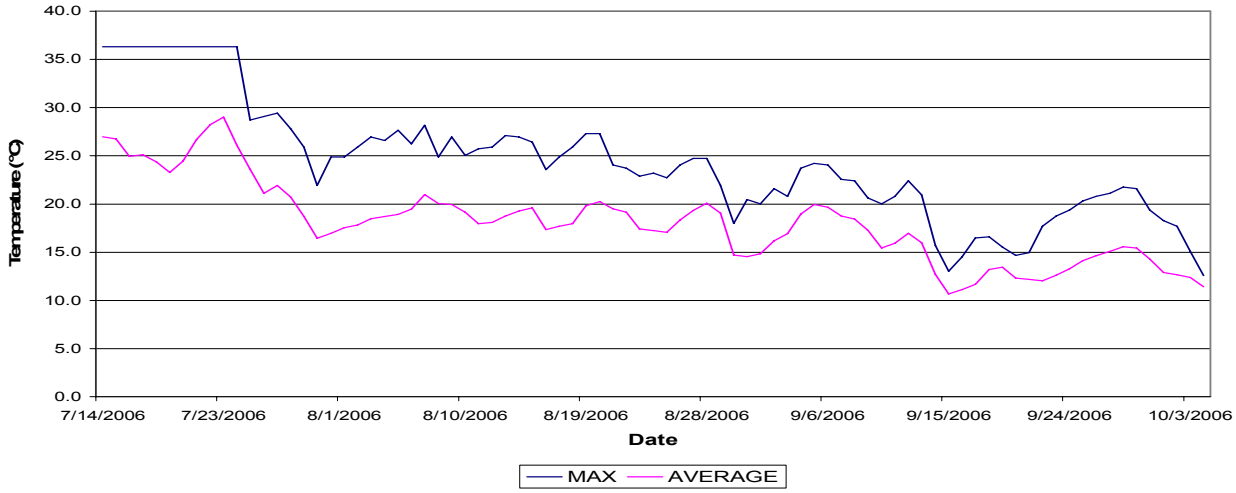
UNIT TYPE	SERIAL / WRP #	STREAM LOCATION	LATITUDE/ LONGITUDE GENERAL AREA	PLACEMENT / PURPOSE
VEMCO	2123	Broun Hummel Property 1 Birch		Static/Water
VEMCO	2125	Broun Hummel Property 1 Birch		Static/Water
VEMCO	2144	Broun Hummel Property 2 Birch		Static/Water
VEMCO	2127	Broun Hummel Property 2 Birch		Static/Water
VEMCO	2129	Broun Hummel Property 3 Birch		Static/Water
VEMCO	2128	Broun Hummel Property 3 Birch		Static/Water
VEMCO	2132	Broun Hummel Property 4 Birch		Static/Water
VEMCO	2133	Broun Hummel Property 4 Birch		Static/Water
VEMCO	10	*Broun Hummel Property Birch*		Static/Air
VEMCO	7	*Broun Hummel Property Birch*		Static/Air
VEMCO	2130	Umatilla River RM 42.8 B&G Upstream	45°39'33.58"N 118°59'04.37W	Static/Water
VEMCO	2131	Umatilla River RM 40.4 B&G Downstream	45°40'20.76"N 119°00'35.15"W	Static/Water
VEMCO	2136	Umatilla River RM 42.8 B&G Upstream	45°39'33.58"N 118°59'04.37W	Static/Air
VEMCO	2137	Umatilla River RM 40.4 B&G Downstream	45°40'20.76"N 119°00'35.15"W	Static/Air
VEMCO	2138	West Fork of Birch Cunningham Culvert		Static/Water
VEMCO	2139	West Fork of Birch Cunningham Culvert		Static/Air
VEMCO	2141	West Fork of Birch Crk RM 3 Hoeft Dam	45°27'24.40"N 118°52'10.92"W	Static/Water
VEMCO	2142	West Fork of Birch Crk RM 2.9 Hoeft Dam		Static/Water

VEMCO	2143	West Fork of Birch Crk RM 3 Hoeft Dam	45°27'24.40"N 118°52'10.92"W	Static/Air

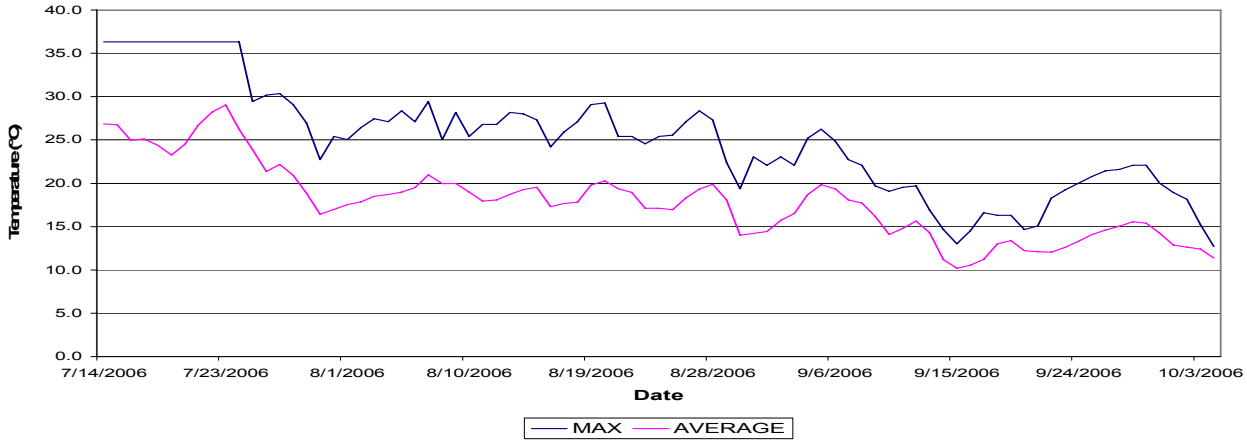


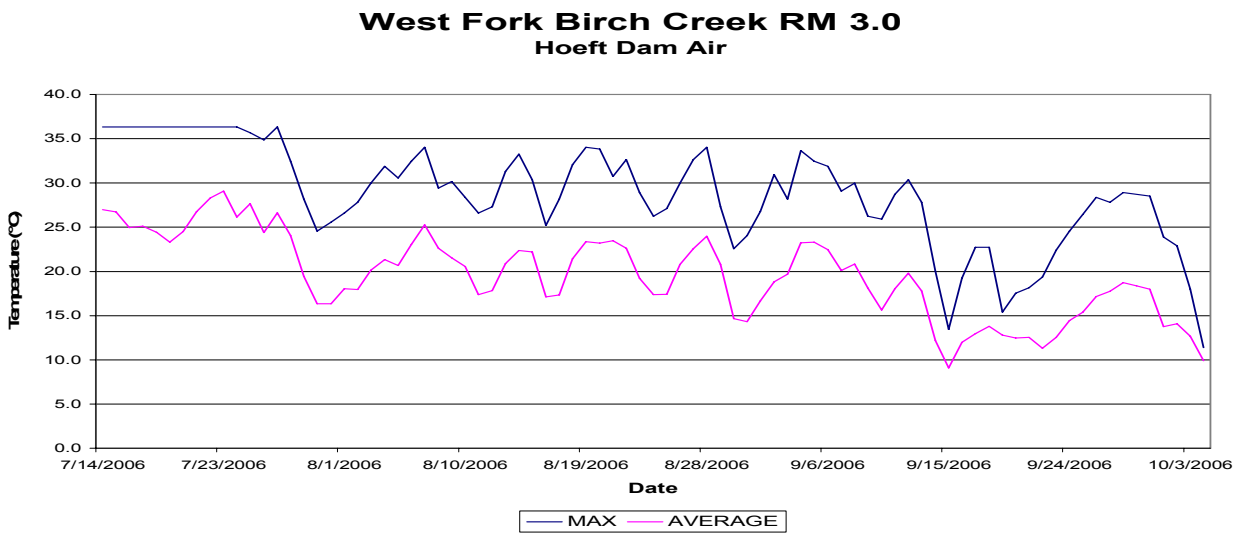


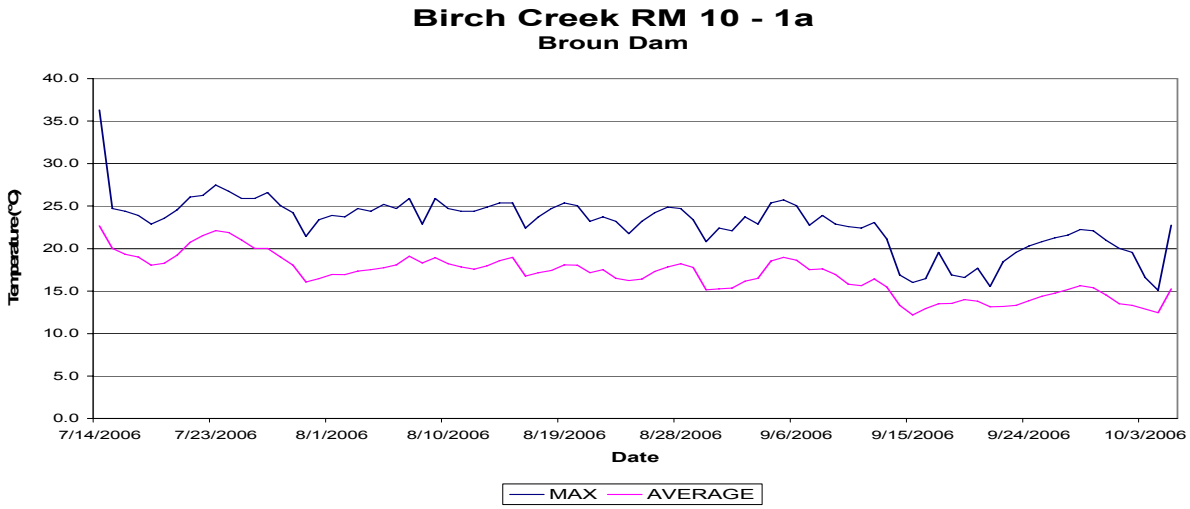
West Fork Birch Creek RM 2.9
Hoeft Dam



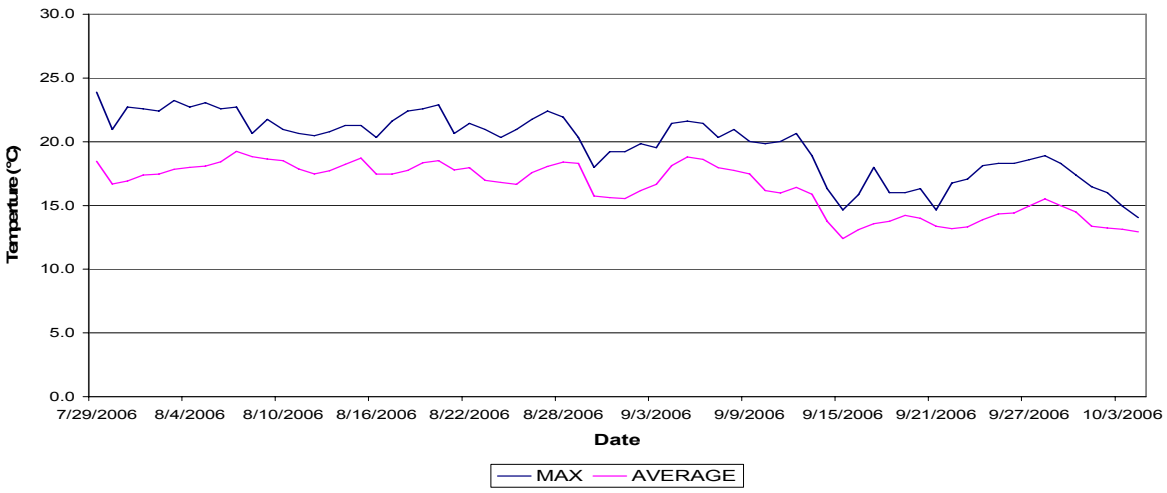
West Fork Birch Creek
Hoeft Dam RM 3



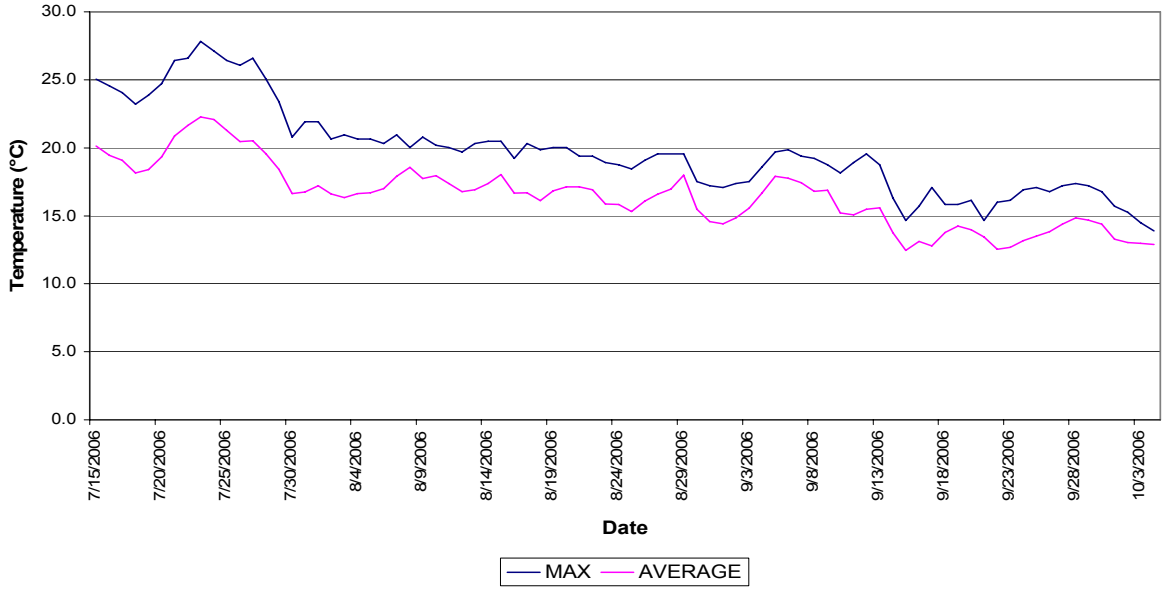

West Fork Birch Creek RM 3.0
Hoeft Dam Air
Temperature(°C)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
7/14/2006
7/23/2006
8/1/2006
8/10/2006
8/19/2006
8/28/2006
9/6/2006
9/15/2006
9/24/2006
10/3/2006
Date
MAX
AVERAGE


Birch Creek RM 10 - 1a
Broun Dam
Temperature(°C)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
7/14/2006
7/23/2006
8/1/2006
8/10/2006
8/19/2006
8/28/2006
9/6/2006
9/15/2006
9/24/2006
10/3/2006
Date
MAX
AVERAGE

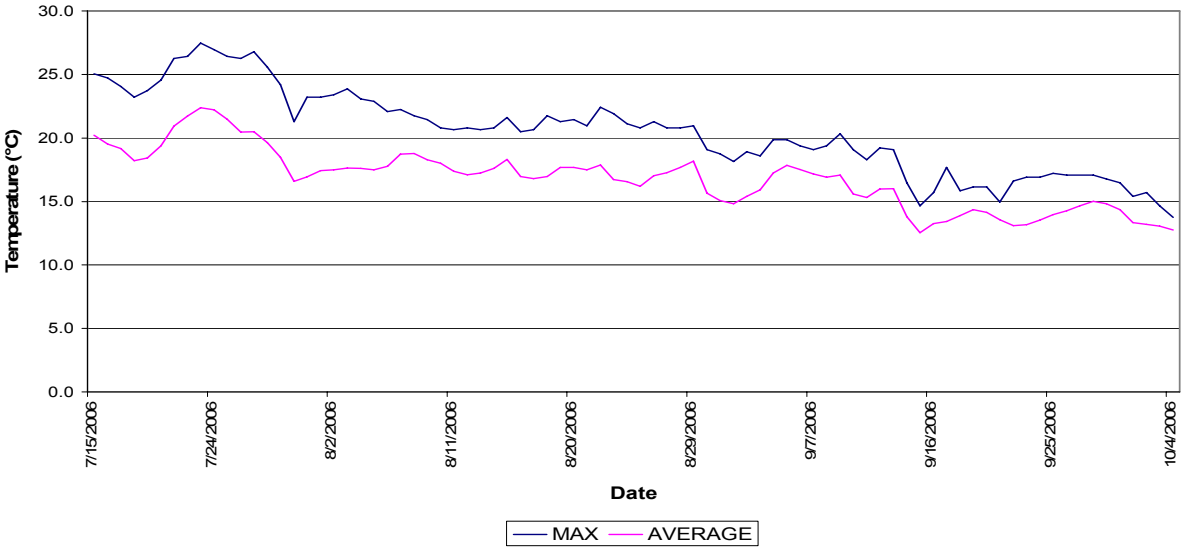
Birch Creek RM10
Broun Dam 2



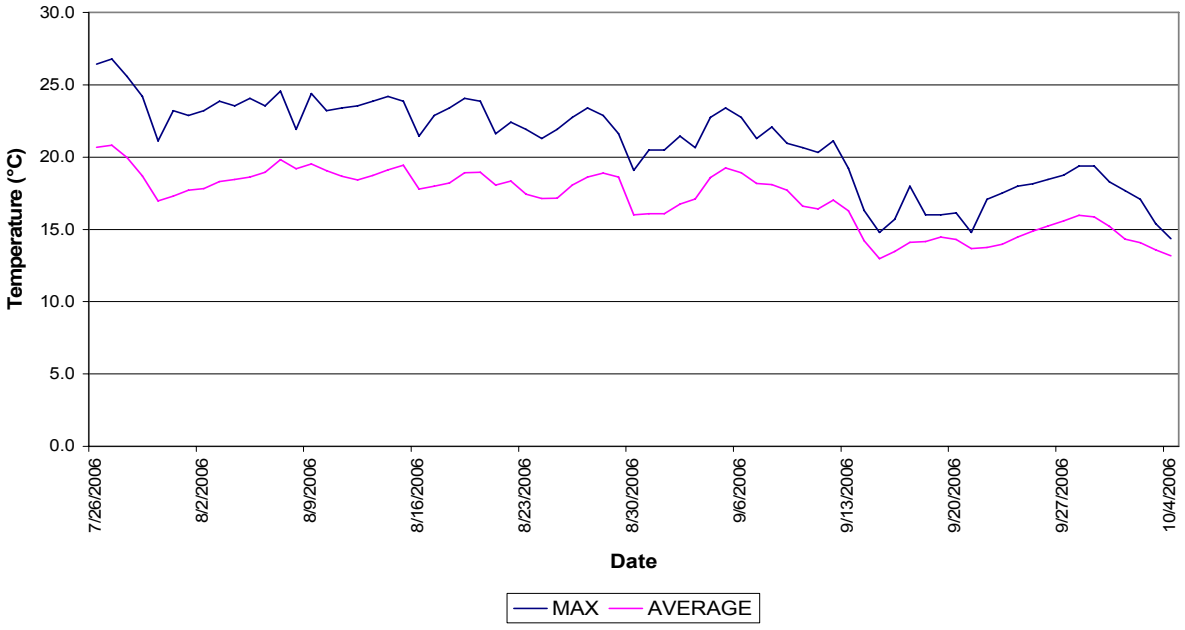
Birch Creek RM10
Broun Dam 2a

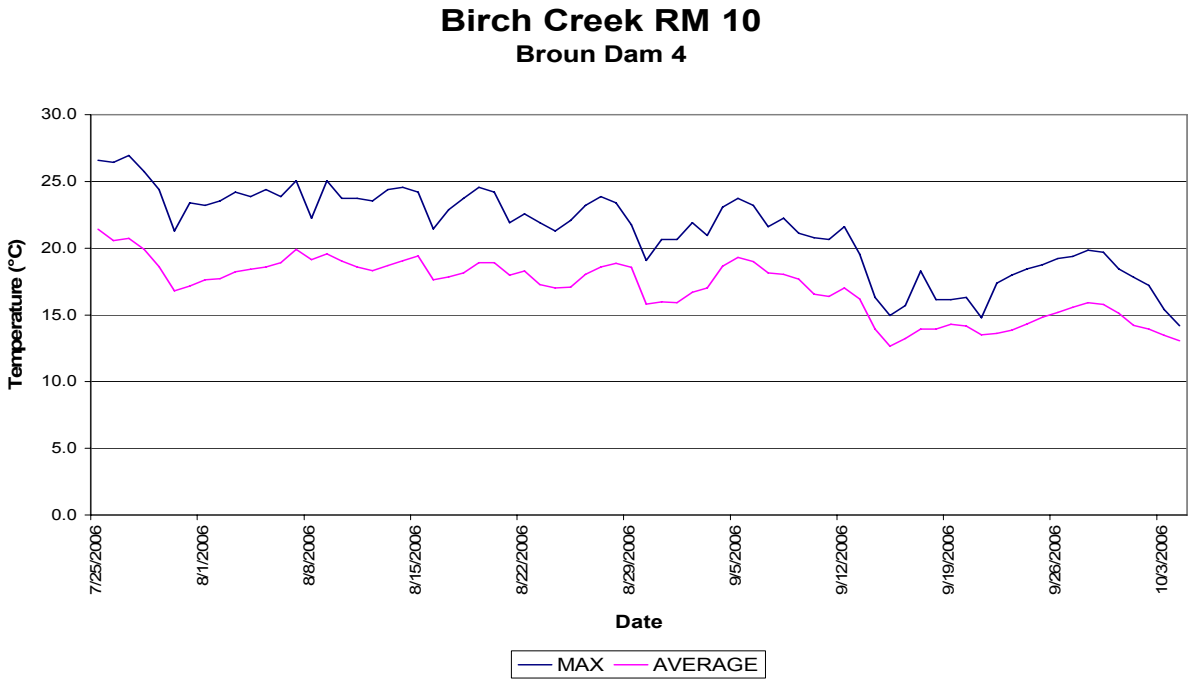


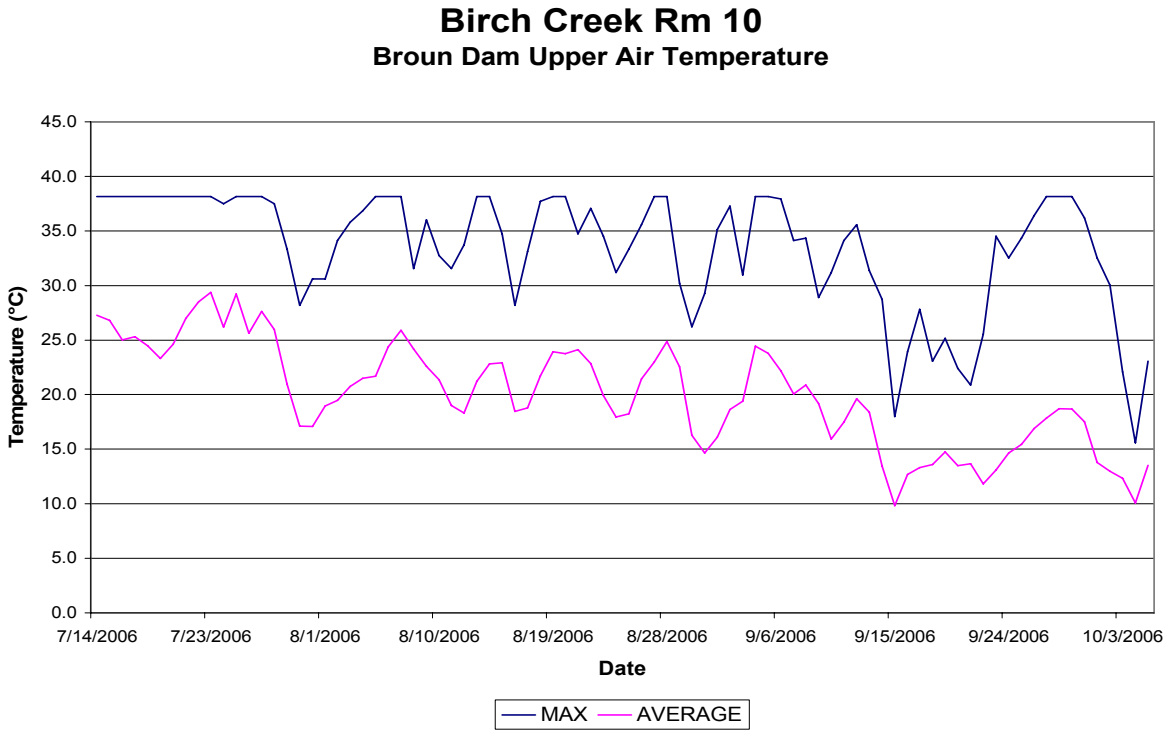
Birch Creek RM 10
Broun Dam 3



Birch Creek RM 10
Broun Dam 3A

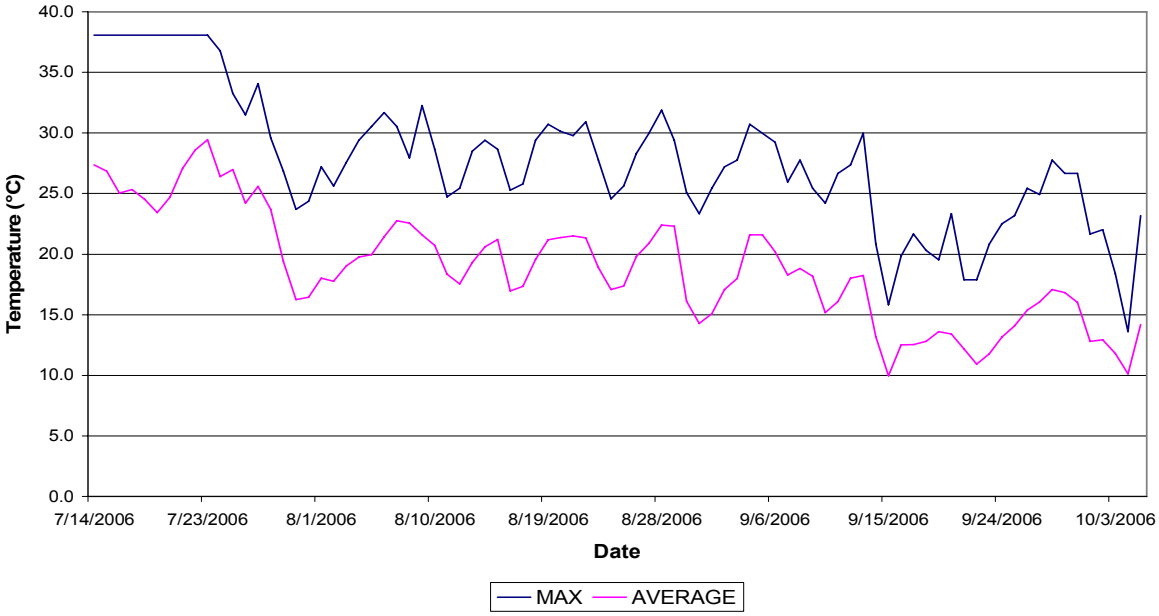



Birch Creek RM 10
Broun Dam 4
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (°C)
7/25/2006
8/1/2006
8/8/2006
8/15/2006
8/22/2006
8/29/2006
9/5/2006
9/12/2006
9/19/2006
9/26/2006
10/3/2006
Date
MAX
AVERAGE

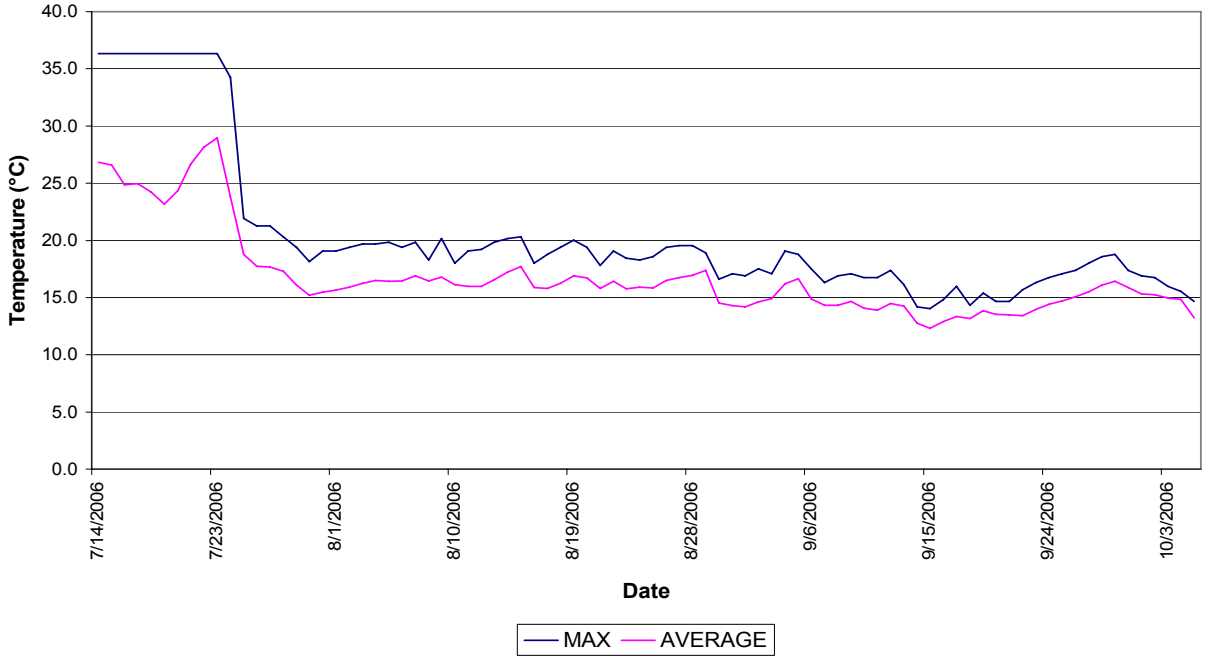

Birch Creek Rm 10
Broun Dam Upper Air Temperature
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (°C)
7/14/2006
7/23/2006
8/1/2006
8/10/2006
8/19/2006
8/28/2006
9/6/2006
9/15/2006
9/24/2006
10/3/2006
Date
MAX
AVERAGE

Birch Creek RM 10

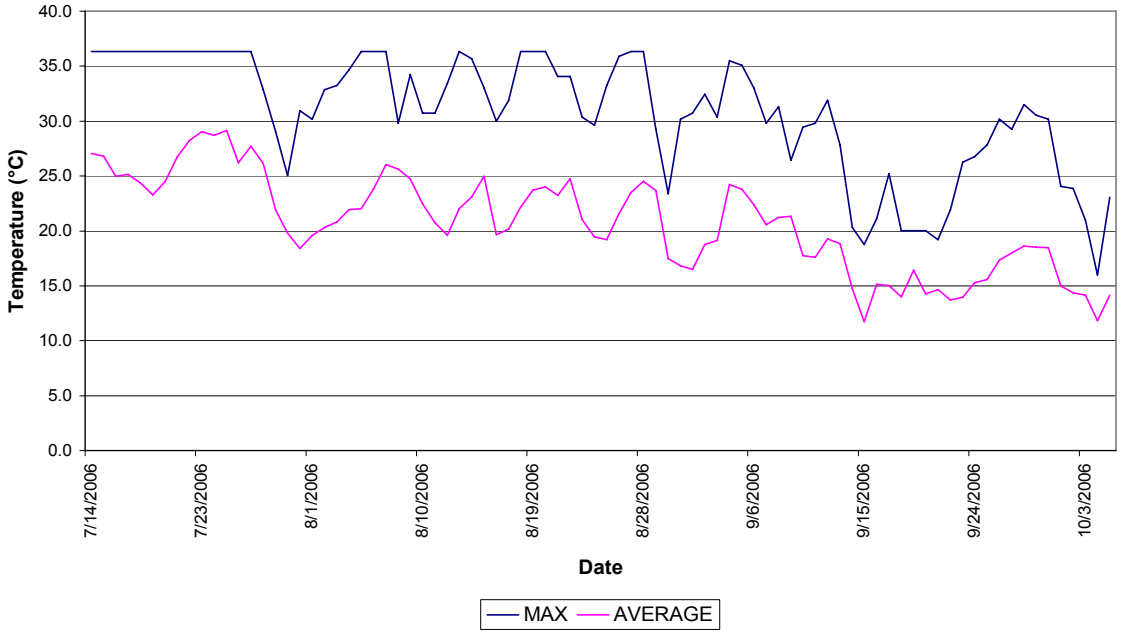
Broun Dam Downstream Air Temperature



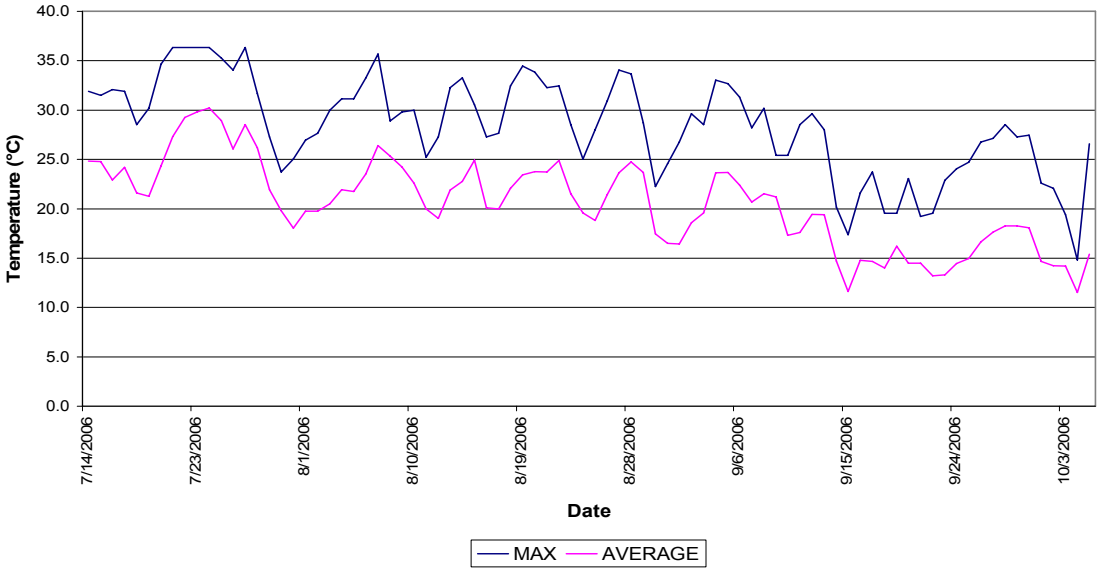
Umatilla River RM 42.8
B&G Upstream



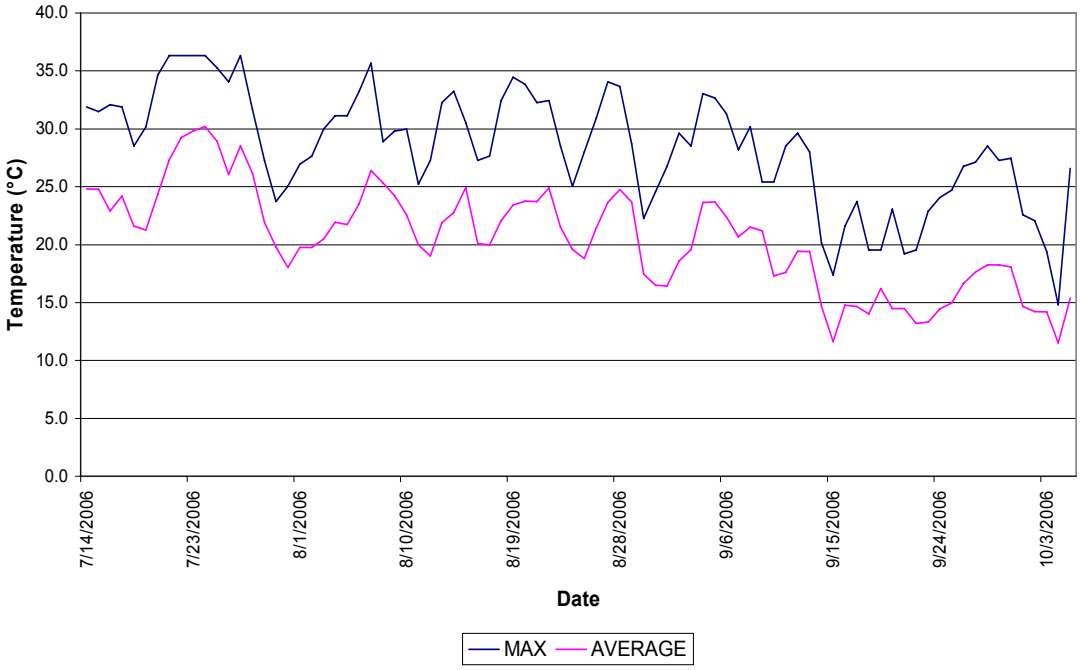
Umatilla River Rm42.8
B&G Upstream Air Temperature



Umatilla River RM 40.4
B&G Down Stream Air Temperature

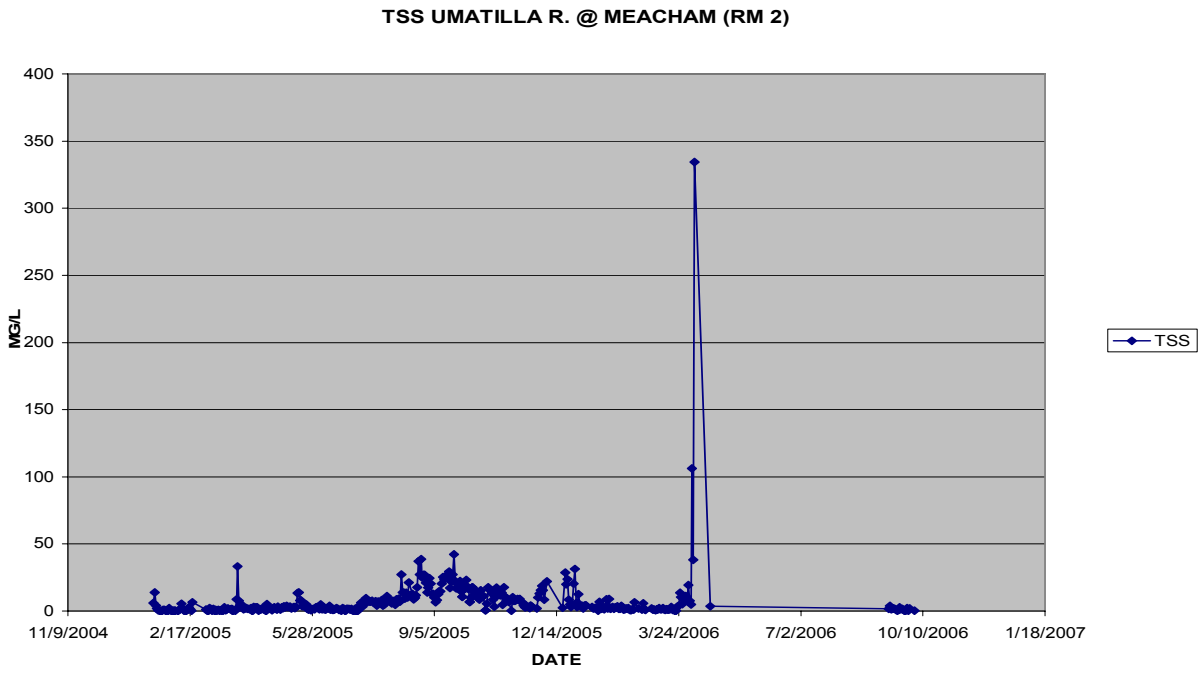


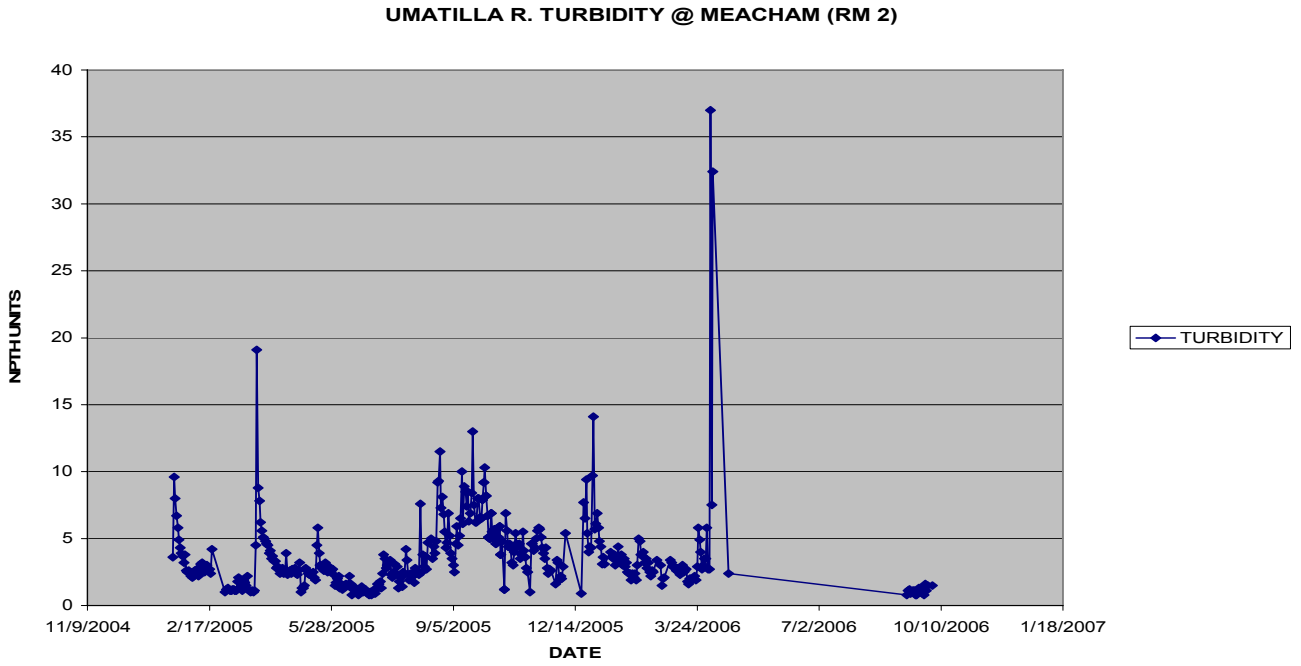
Umatilla River RM 40.4
B&G Down Stream Air Temperature

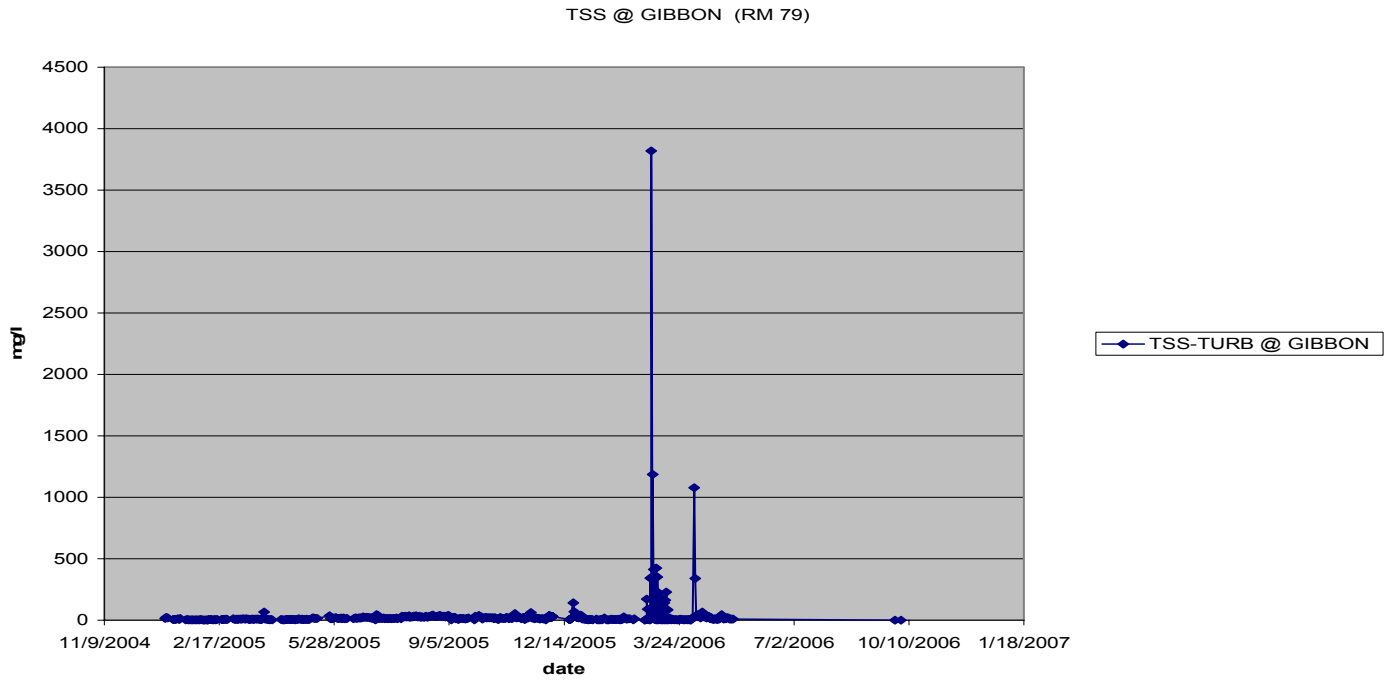


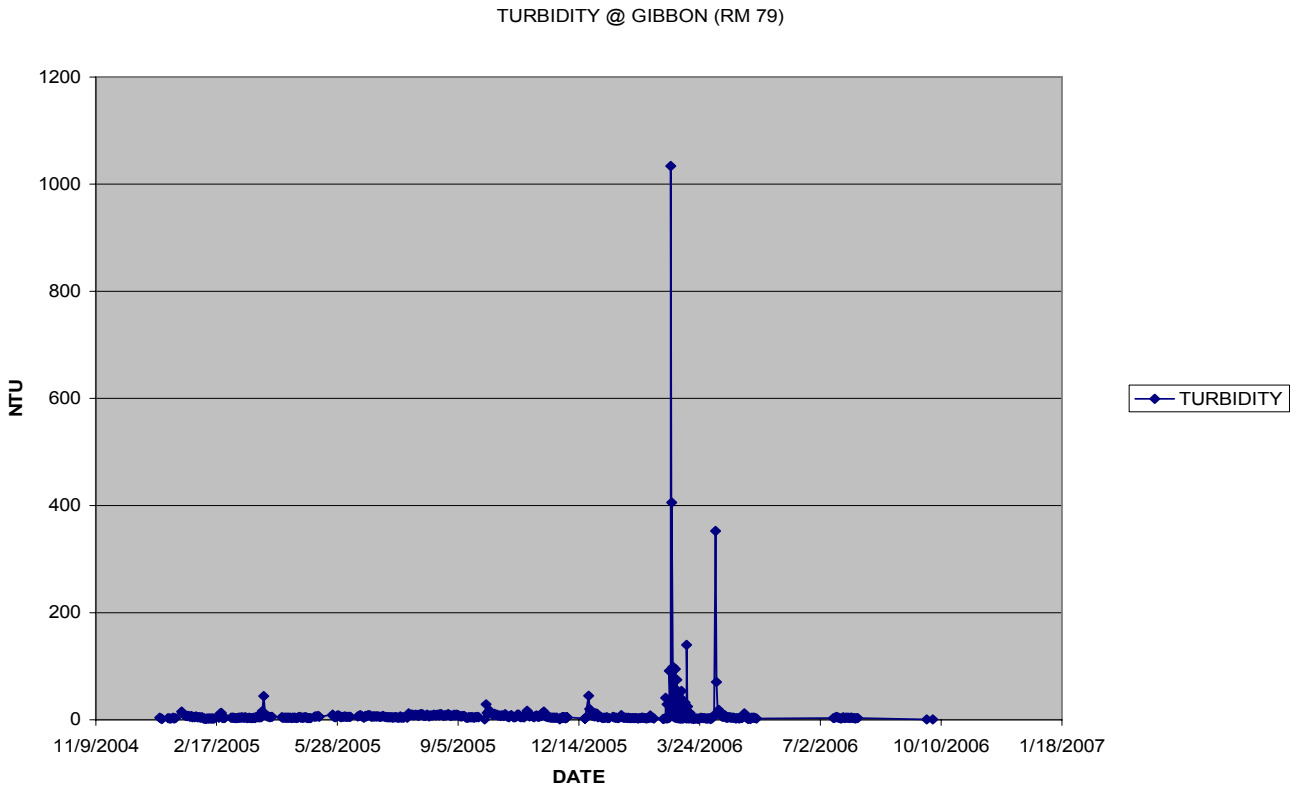
APPENDIX 4

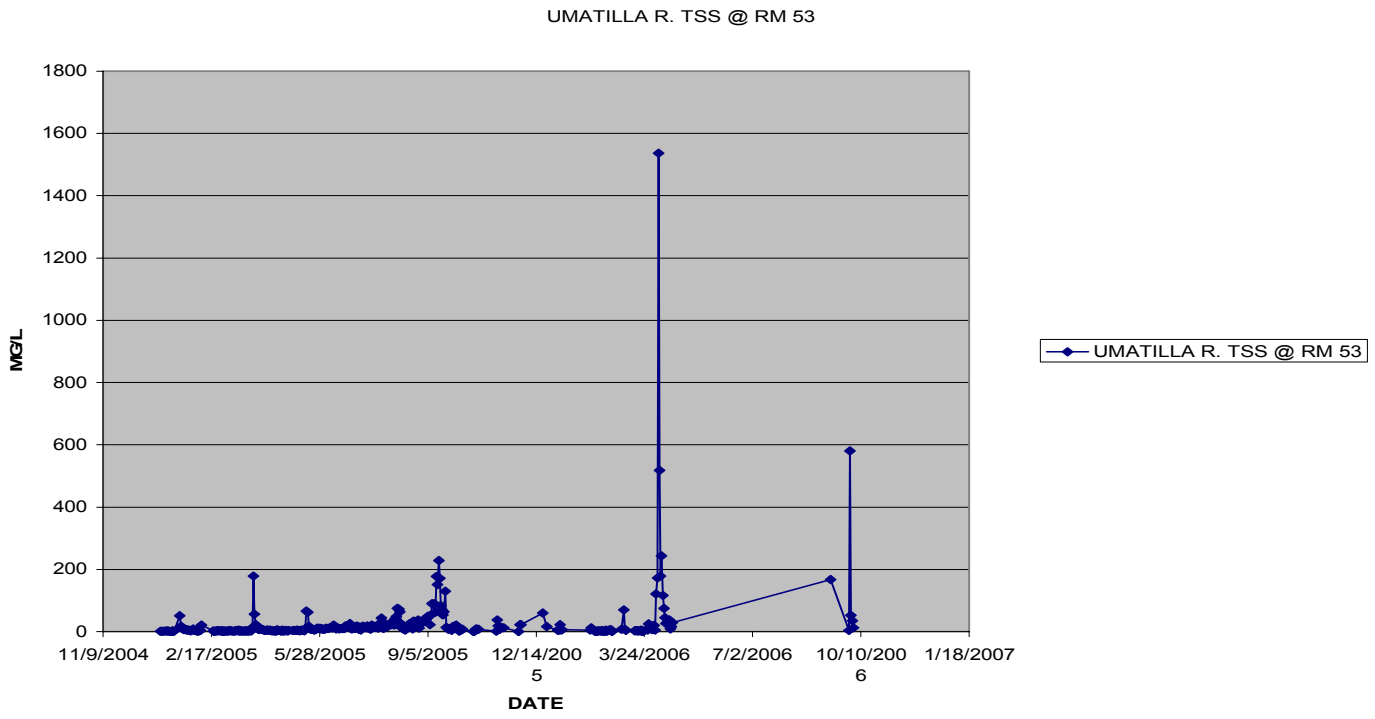
TOTAL SUSPENDED SOLIDS & TURBIDITY MONITORING
MEACHAM CREEK AND UMATILLA RIVER

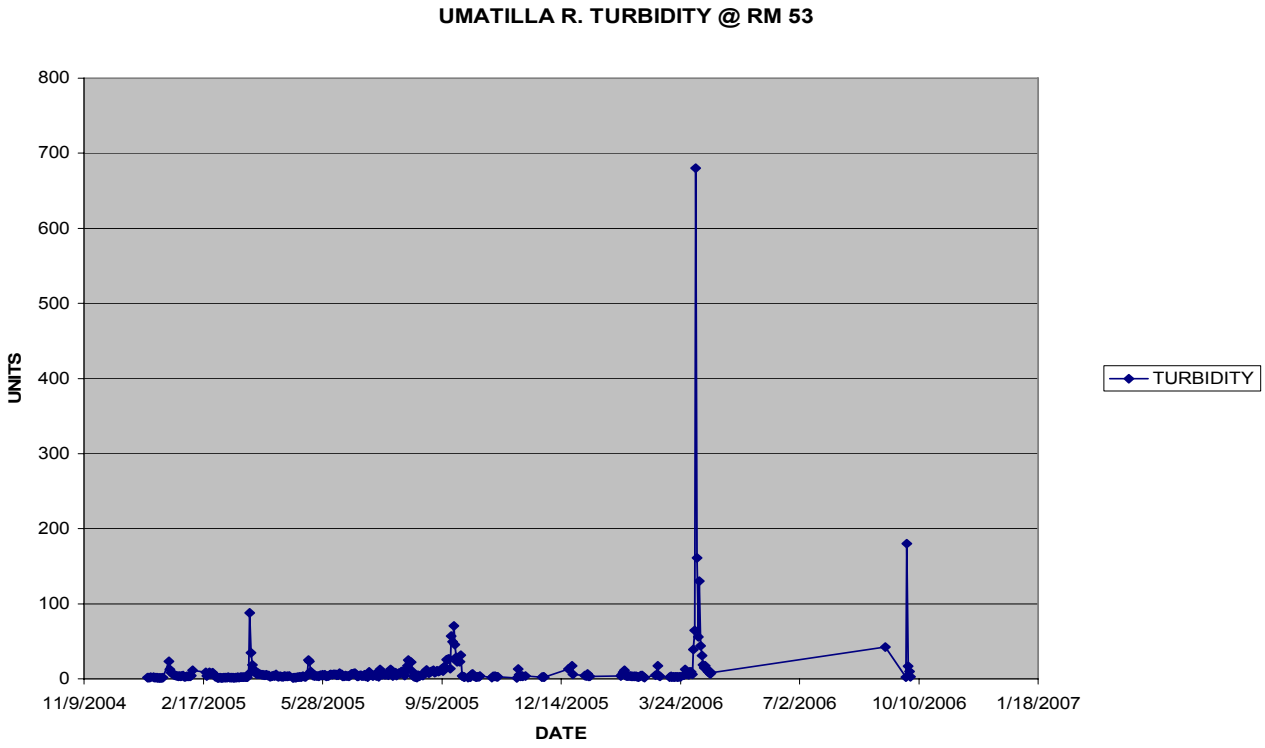





TSS @ GIBBON (RM 79)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
mg/l
11/9/2004
2/17/2005
5/28/2005
9/5/2005
12/14/2005
3/24/2006
7/2/2006
10/10/2006
1/18/2007
date
TSS-TURB @ GIBBON


TURBIDITY @ GIBBON (RM 79)
1200
1000
800
600
400
200
0
NTU
11/9/2004
2/17/2005
5/28/2005
9/5/2005
12/14/2005
3/24/2006
7/2/2006
10/10/2006
1/18/2007
DATE
TURBIDITY


UMATILLA R. TSS @ RM 53
1800
1600
1400
1200
1000
800
600
400
200
0
MG/L
11/9/2004
2/17/2005
5/28/2005
9/5/2005
12/14/2005
3/24/2006
7/2/2006
10/10/2006
1/18/2007
DATE
UMATILLA R. TSS @ RM 53


UMATILLA R. TURBIDITY @ RM 53
800
700
600
500
400
300
200
100
0
UNITS
11/9/2004
2/17/2005
5/28/2005
9/5/2005
12/14/2005
3/24/2006
7/2/2006
10/10/2006
1/18/2007
DATE
TURBIDITY

APPENDIX 5

Assessment of Aquatic Macroinvertebrates in Meacham Creek Summer 2005

Technical Memorandum



Prepared for:
The Confederated Tribes of the Umatilla Indian Reservation
DNR EPRP Program
P.O. Box 638
Pendleton, Oregon 97801

Prepared by:
David Wooster and Sandra DeBano
Department of Fisheries & Wildlife
Hermiston Agricultural Research and Extension Center
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Introduction/Objectives

This report summarizes the findings of macroinvertebrate sampling that occurred in August of 2005 in Meacham Creek. The main objective of the sampling was to provide pre-restoration data on the structure of the macroinvertebrate community in Meacham Creek. The proposed restoration will involve re-activating historic channels that will increase the sinuosity of the creek and improve creek – floodplain connectivity. This data will provide a point of reference for tracking changes in stream quality after the proposed restoration projects have taken place.

An examination of macroinvertebrate communities is important in understanding the quality of stream reaches for a variety of reasons. Macroinvertebrates form an important part of stream communities; they are important in nutrient cycling, they act as a linkage between riparian areas and streams, and they are the primary component of the diet of many fish (Williams and Fetlmate 1992, Hershey and Lamberti 1998). Therefore, the ecosystem functioning of a stream can be greatly influenced by the abundance and type of macroinvertebrates present. Macroinvertebrate communities are also sensitive to human disturbances and because of their rapid generation times and relatively small home ranges they are particularly well suited for bio-assessments of stream reach quality (Rosenberg and Resh 1993).

In Meacham Creek macroinvertebrates and a suite of environmental variables were sampled during the summer of 2005 at nine sites (Table 1). As stated above, the primary objective of the macroinvertebrate sampling was to provide pre-restoration data on the macroinvertebrate community of Meacham Creek that can be used to examine changes in stream quality after restoration. Secondary objectives include: a) an examination of environmental variables that correlate with macroinvertebrate community structure. This provides insights into the variables that are important in driving macroinvertebrate community structure in Meacham Creek, and b) a comparison of the macroinvertebrate community in Meacham Creek to that in the North Fork of the Umatilla River. The North Fork drains a 32 square mile wilderness area that was established by the Forest Service in 1984. The North Fork is considered a relatively pristine drainage in the Umatilla Subbasin and is at approximately the same elevation (715m) as the sites studied in Meacham Creek (Table 1). Thus, the North Fork is potentially a good reference site to gauge the quality of Meacham Creek both before restoration and after restoration.

Study Sites

Meacham Creek flows into the Umatilla River at river mile 79 at an elevation of 535m. At their confluence the discharge of Meacham Creek is approximately equal to that of the Umatilla River. Meacham Creek is an important drainage for steelhead and spring Chinook production and also harbors one of the few remaining populations of bull trout in the Umatilla Subbasin.

Macroinvertebrate sampling in Meacham Creek was conducted at nine study locations that span the area in which the proposed restoration practices will take place. The locations of these sites and dates of sampling are shown in Table 1.

Table 1. Study locations and sampling dates.

Study Site	UTM Location*	Elevation (m)	Sampling Date

1	11 0393772 5059911	554	8/16/2005
2	11 0393637 5058987	565	8/16/2005
3	11 0393501 5058583	570	8/25/2005
4	11 0393545 5058150	574	8/25/2005
5	11 0394246 5054877	603	8/26/2006
6	11 0394150 5054467	609	8/31/2005
7	11 0394114 5053720	621	8/31/2005
8	11 0394273 5053255	627	9/2/2005
9	11 0394395 5052384	630	9/2/2005

*WGS 84 datum

Methods

Macroinvertebrates were sampled in the field following modified EPA EMAP protocols for targeted riffle sampling (Peck et al. 2001). Study reaches were defined as 100m long stretches of stream with the downstream end at the UTM location. Along a study reach 8 sampling locations were randomly located in riffle habitat. Macroinvertebrates were collected at each of these locations by placing a D-frame net firmly against the substrate and scrubbing by hand all cobble sized and larger rocks in an $0.09m^2$ area just upstream of the net. After these rocks had been scrubbed and set aside the same area was agitated by foot for 30 seconds. Each of the 8 samples was composited in the field into a single large sample for each study site and preserved in 75% ethanol. In the laboratory samples were spread over a 20cm diameter sieve and subsamples were taken using a 5cm diameter template. Invertebrates were picked from subsamples until at least 500 organisms had been counted from the subsamples. These invertebrates were identified to genus (for most insects) and order or family (for most non-insect invertebrates) using published keys (Merritt and Cummins 1996, Thorpe and Covich 1991, Wiggins 2000).

A suite of environmental variables was measured at each site at the time of macroinvertebrate sampling. These variables included habitat metrics. Slope of the study reach was estimated using a clinometer. Substrate composition was estimated at each macroinvertebrate sampling point using a 20cm x 30cm grid and determining the percent coverage of standard substrate size classes (Kaufmann 2001). Percent filamentous algal coverage on the substrate was also estimated within the 20cm x 30cm grid. At each macroinvertebrate sampling location water depth and water velocity (using a Marsh-McBirney electromagnetic flow meter) was measured. Five uniformly spaced transects perpendicular to streamflow were established along the 100m study reaches and at each of these transects stream aspect (i.e., compass direction facing downstream and read from the middle of the stream), wetted width, and cover (measured at each bank and in the middle of the stream using a densiometer) were measured. Along the

entire transect the length of riffle habitat was measured and the number of pieces of large woody debris (defined as pieces at least 10cm in diameter and 1m long) was counted. Other environmental variables measured included three water quality metrics. These metrics were measured once at each study site and included turbidity (using a LaMotte 2020 Turbidimeter), specific conductance (using a YSI Model 30 handheld meter), and dissolved oxygen (measured as percent saturation using a YSI Model 550 handheld meter).

Data Analysis

Data analysis included a multivariate (ordination) analysis and an examination of five metrics commonly used in bioassessments.

To examine the entire community at each site in Meacham Creek in a single analysis a non-metric multidimensional scaling (NMS) ordination was conducted (using PC-Ord Version 4.0, McCune and Mefford 1999). This analysis was conducted such that the nine study sites were plotted in "species space." Thus, sites close together in the ordination have similar communities and sites farther apart are increasingly dissimilar in macroinvertebrate community structure. NMS ordination is a robust ordination technique that avoids assumptions regarding linear relationships among variables and does not truncate data at zero as do many other ordination techniques (McCune and Grace 2002). Distance measures are used in ordination analyses to quantify the similarity of sites in community composition. For the analysis presented here a relative Sorenson distance measure was used. This measures distance between sites in a "city block" fashion (as opposed to a Euclidean or straight line fashion) and it relativizes the data such that proportions of each taxa within each site are analyzed and not absolute abundances. Thus, this analysis is based on the relative importance of each taxa within each site.

To understand which environmental variables were potentially important in driving community structure the 15 environmental variables measured at each site were correlated with each axis of the ordination. A significant correlation suggests that the environmental variable is important in structuring the macroinvertebrate community. In addition, to understand which taxa were important in driving differences in community structure among the nine sites, the abundance of each taxa was correlated with each axis.

Ordination analyses allow an examination of the entire community in a fashion that takes into account both the taxa present and their relative abundance. Thus, in contrast to many "metrics" of community composition, no taxa were ignored in the ordination analysis and the community is described in a manner that allows:

a) A determination of whether clusters of sites or "outlier sites" (based on community structure) occur. Understanding prior to restoration whether these clusters or outliers exist is important to understanding how we might predict the community to change with restoration and how this change might differ among areas within Meacham Creek.
b) A determination of environmental variables that appear to be driving community structure.
c) A determination of the taxa that are important in driving differences in community structure among sites.
d) Most importantly ordination will allow the tracking of changes in community structure at each site over time. By tracking community composition at all sites before restoration and at a subset of sites outside the restoration area the natural year to year variability in macroinvertebrate community composition can be quantified. By

tracking changes in macroinvertebrate community composition within the restoration project the response of the community to restoration can be quantified.

In addition to multivariate analyses of the whole community the following metrics were examined for each site and compared to a sampling site on the North Fork of the Umatilla River (macroinvertebrates were sampled at this site on 6/30/2005):

- Number of EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa
  This is perhaps the most common macroinvertebrate metric of water quality. Taxa in these orders are generally considered to be intolerant of human disturbances and thus higher numbers are considered indicative of higher stream quality. However, the main weakness of this metric is that many of the common Ephemeropterea and Trichoptera taxa are actually fairly tolerant of human disturbances and thus changes in numbers of these taxa do not necessarily correspond to changes in water quality.
- Number of Plecoptera taxa
  This metric has been suggested as a substitute for the EPT metric because very few, if any, Plecoptera (stoneflies) taxa appear to be tolerant of human disturbances (Karr and Chu 1999). Higher numbers are considered to be indicative of higher stream reach quality. The main weakness of this metric is simply that it takes into account only a very small proportion of the macroinvertebrate community and thus ignores other taxa that can be important determinants of water quality. In addition, low numbers of stonefly taxa do not necessarily indicate poor water quality but can simply result from natural attributes of streams and rivers that create poor conditions for stoneflies (e.g., rivers with naturally sandy substrates will have few stoneflies because they prefer gravel/cobble substrates).
- Taxa Richness
  A simple count of the number of macroinvertebrate taxa present is also a common metric of water quality. The theory is that higher taxa richness represents higher water quality. However, the author's experiences with the Umatilla River indicate that while the type of taxa might change across areas that differ in water quality, taxa richness does not necessarily change (i.e., there are simply a lot of tolerant taxa present in the Umatilla Subbasin).
- Shannon Diversity and Evenness
  As with taxa richness, community diversity and evenness are expected to increase with increasing water quality. The main weakness of these metrics is that communities can have moderate to high diversity and evenness values and be composed completely of a fairly low number of highly tolerant taxa.

Results

A total of 5502 individual invertebrates were sorted and 69 taxa were identified from the nine sites (Appendix 1). The number of taxa per site ranged from 32 at site 2 to 47 at site 9. The average number of taxa per site was 39.

NMS Ordination Analysis

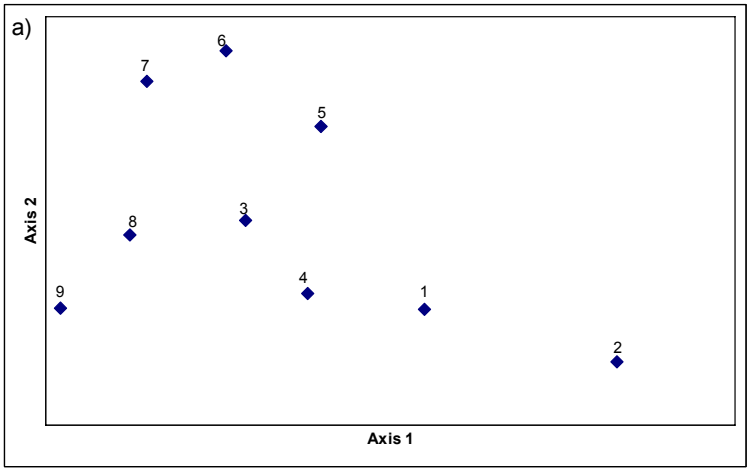
A 3-dimensional ordination solution was found for the community data. The total amount of variance in community structure explained by the three ordination axes was 96.3%. The first

axis explained the overwhelming majority (64.7%), while axes 2 and 3 explained substantially less of the variation (12.0% and 19.6%, respectively).

Figure 1 shows the nine sites in species space along the three ordination axes. No obvious clusters of sites occurred along axes 1 and 3. However, the mid-elevation sites (sites 5, 6, and 7) formed a cluster along axis 2.

Of the three axes, axis 1 explained most of the variation in community structure. Increasing values on this axis corresponded significantly to decreased elevation and increased amount of cover (Table 2). An important group of taxa neagatively associated with this axis are the Plecoptera or stoneflies, a group known to be sensitive to many human disturbances (Karr and Chu 1999). Eight of nine stonefly taxa found in Meacham Creek were negatively correlated with axis 1; however, this relationship was significant for only two of the taxa (Appendix 1).

Axes 2 and 3 explained relatively little variation in community structure among the nine study sites. Axis 2 was negatively correlated with mean substrate size and water velocity (Table 2). Very few taxa were significantly correlated with axis 2; however, the few EPT taxa significantly associated with axis 2 were all negatively correlated with the axis and oligochaetes (a taxa known to be tolerant of human impacts) were positively correlated with axis 2. This result suggests that axis 2 represents a gradient in decreasing water quality. In a similar vein, axis 3 also appears to show a gradient in water quality. A total of nine Plecoptera taxa were found in Meacham Creek; of these, four were significantly correlated with axis 3 and all of these correlations were positive suggesting an increase in water quality with increasing values along axis 3. Environmental variables associated with axis 3 were turbidity, % filamentous algae, and slope (all negatively correlated with axis 3) and the number of pieces of large woody debris (positively correlated) (Table 2).



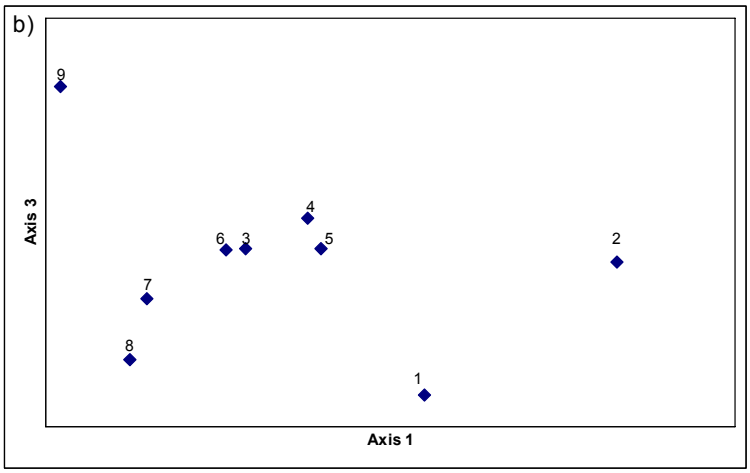


Figure 1. Results of a non-metric multidimensional scaling ordination showing Meacham Creek study sites in species space. Numbers next to data points correspond to study site numbers.

Metric Analysis

The number of EPT taxa varied from 13 to 24 across the nine Meacham Creek sites (Fig. 2a). The only environmental variable associated with the number of EPT taxa was slope, which was negatively correlated with EPT number (Table 3). The North Fork site had 23 EPT taxa, one less than found at Site 9. Site 9 and the North Fork had many more EPT taxa than any other site at Meacham Creek (site 8 had 19 EPT taxa, which was the next highest number).

The number of Plecoptera taxa ranged from 3 to 8 across the nine Meacham Creek sites (Fig 2b). Site 9 had the highest number of Plecoptera taxa and had one less than found in the North Fork. Both slope and percent cover were negatively correlated with the number of Plecoptera taxa (Table 3).

Table 2. Pearson correlation coefficients for environmental variables and the three axes of the NMS ordination. Bold values are significant (based on a 2-tailed analysis with α = 0.05).

Environmental Variable	**Axis 1**	**Axis 2**	**Axis 3**
Specific Conductance	0.229	0.202	0.212
Turbidity	0.598	-0.105	**-0.785**
Dissolved Oxygen	-0.270	0.153	0.235
Elevation	**-0.812**	0.487	0.321
Slope	0.393	0.382	**-0.810**
Aspect	-0.525	0.403	-0.031
% Riffle in Reach	-0.075	0.554	-0.247
% Cover	**0.790**	-0.105	-0.411
Wetted Width	-0.471	0.378	-0.421
Pieces of Large Woody Debris	-0.383	-0.114	**0.693**
Median Size Substrate	0.487	**-0.677**	-0.455
% Silt on Substrate	-0.414	0.057	0.135
% Filamentous Algae on Substrate	0.330	-0.438	**-0.748**
Mean Depth	0.606	0.117	-0.570

Mean Velocity	0.607	**-0.757**	0.006

Taxa richness ranged from 32 to 47 taxa (Fig. 2c). Within Meacham Creek, site 9 had the highest value for this metric. The North Fork community was not particularly rich with only 39 taxa. Slope was also negatively correlated with taxa richness; while the number of pieces of large woody debris was positively correlated (Table 3).

Shannon diversity varied little across the nine Meacham Creek sites (from 2.6 to 3.1) and the North Fork Umatilla River site fell within the range of diversity values found in Meacham Creek (Fig. 2d). Finally, Shannon's evenness index also showed little variation among the sites in Meacham Creek (Fig. 2e). However, the North Fork had a particularly high evenness value indicating that most taxa present were found in similar abundance. Diversity and evenness were both negatively correlated with specific conductance (Table 3).

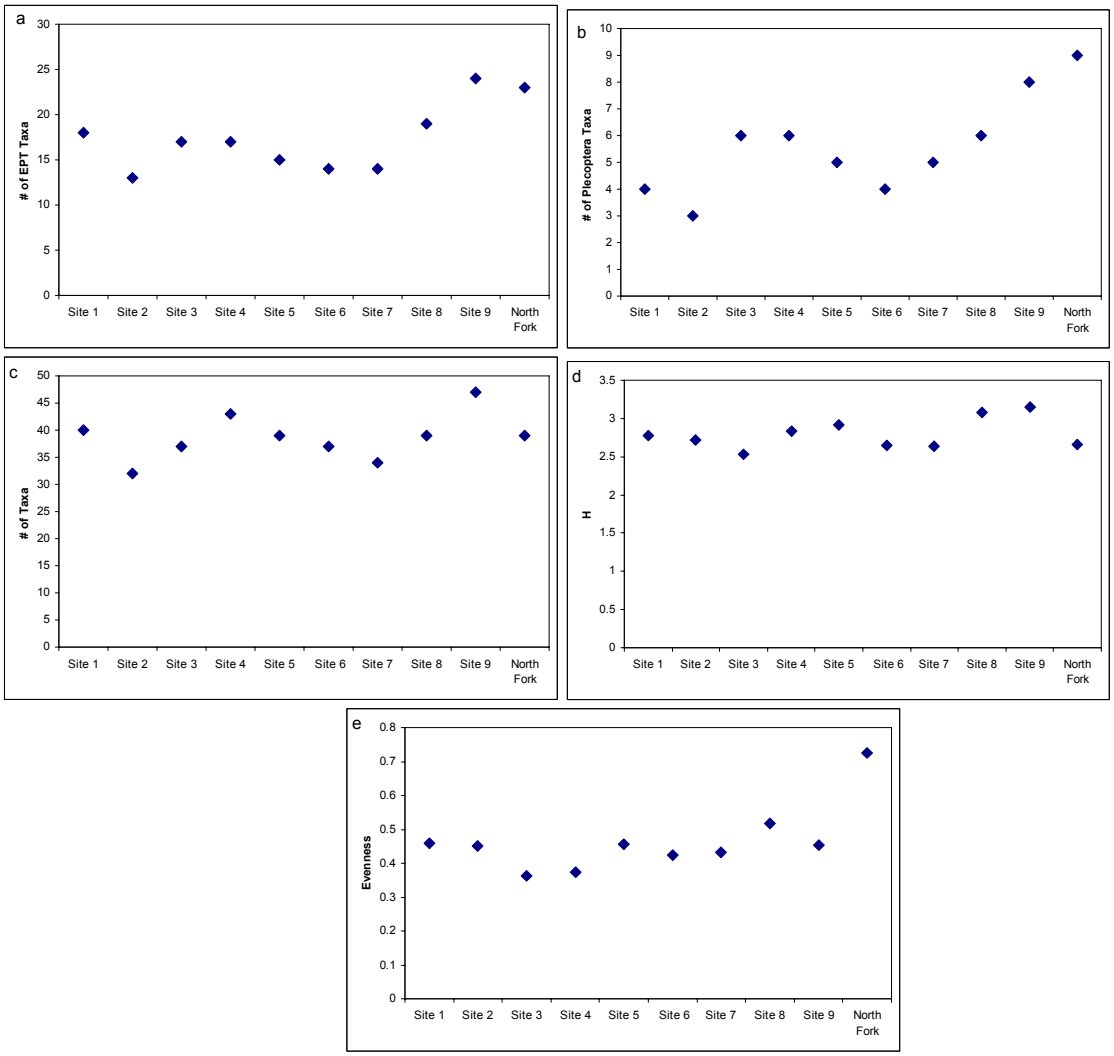


Figure 2. Metric values for the nine sites on Meacham Creek and one site on the North Fork. a) # of EPT taxa, b) # of Plecoptera taxa, c) taxa richness, d) Shannon diversity, e) Shannon evenness.

Discussion

The main purpose of this study was to provide pre-restoration data on macroinvertebrate community structure in Meacham Creek. These data are important in tracking any changes in community structure after restoration.

In addition, these data provide some initial insights into the quality of Meacham Creek before implementation of the restoration project, how that varies among sites, and environmental variables that are potentially important in driving community structure.

Table 3. Pearson correlation coefficients for the relationships between environmental variables and five metrics of community structure. Bold values are significant (based on a 2-tailed analysis with $\alpha = 0.05$)

Environmental Variable	# of EPT	# of Plecoptera	Taxa Richness	Shannon Diversity	Shannon Evenness
Specific Conductance	-0.401	-0.131	-0.039	**-0.606**	**-0.906**
Turbidity	-0.356	-0.594	-0.351	-0.279	0.150
Dissolved Oxygen	0.119	0.212	0.235	0.616	0.456
Elevation	0.318	0.515	0.244	0.519	0.445
Slope	**-0.789**	**-0.797**	**-0.862**	-0.560	0.192
Aspect	0.295	0.257	0.514	0.461	0.346
% Riffle in Reach	-0.366	-0.249	-0.368	-0.433	-0.125
% Cover	-0.625	**-0.768**	-0.510	-0.118	0.296
Wetted Width	-0.008	0.112	-0.078	0.303	0.518
Pieces of Large Woody Debris	0.441	0.650	**0.674**	0.466	-0.237
Median Size Substrate	0.008	-0.178	-0.123	-0.125	-0.098
% Silt on Substrate	0.179	0.574	0.303	0.138	-0.359
% Filamentous Algae	0.143	-0.328	-0.048	0.183	0.577
Mean Depth	-0.477	-0.640	-0.342	-0.380	0.002
Mean Velocity	-0.020	-0.244	-0.292	0.005	0.119

The ordination analysis revealed that a majority of the variance (over 60%) in community structure could be explained along a single axis. Elevation was strongly correlated with this axis. While elevation gradients in community structure are often found in studies of stream macroinvertebrates (Vannote et al. 1980; Finn and Poff 2005), finding such a gradient in this study was somewhat surprising given that the total change in elevation across the nine sites was only 80m. It is possible that community structure was driven more by the amount of riparian cover, which was also correlated with axis 1. Therefore, a further examination of the influence of cover and elevation on macroinvertebrate communities in Meacham Creek is warranted.

An examination of the macroinvertebrate taxa correlated with axis 1 reveals that a possible gradient in water quality exists along that axis, with site quality decreasing with increasing values along that axis. This water quality gradient is suggested mostly by patterns in stonefly abundance. Of 9 stonefly taxa 8 showed a decreasing trend in abundance along axis 1. This

also suggests that monitoring changes in stonefly abundance and distribution should be a good metric for monitoring changes in stream quality with restoration.

Axis 2 and 3 accounted for relatively little of the variation in community structure. Substrate size and water velocity both decreased with increasing values on axis 2. Thus, the cluster of mid-elevation sites on axis 2 were sites with relatively small substrate and low water velocity. These sites also had high abundance of oligochaete worms, a taxa known to be sediment and temperature tolerant (Soster and McCall 1990).

Sites with higher values along axis 3 tended to have more large woody debris, lower turbidity, lower amounts of filamentous algae, and lower slopes. The first three of these environmental variables suggests an increase in stream quality. This pattern in environmental data is consistent with the macroinvertebrate data. Four Plecoptera taxa showed significant increases in abundance along axis 3 and four additional Plecoptera taxa showed an increasing, but nonsignificant, trend.

The overall conclusions from the ordination are that elevation appears to play a role in macroinvertebrate community structure in Meacham Creek as does the amount of riparian cover. To a somewhat lesser degree turbidity, amount of filamentous algae on the substrate, slope, amount of large woody debris, substrate size, and water velocity also appear to play a role. In addition, sites differed in quality based upon the macroinvertebrates present. Because both axis 1 and 3 reveal potential trends in water quality, site 9 (which had a value indicating high quality on both axes) appears to be a reach that has the highest quality of those studied. Therefore, this site, which is located above the restoration areas, should serve as a good reference point and potential source of colonists for the areas that will be directly affected by the restoration. Finally, stoneflies were associated with both axes 1 and 3 indicating that this group of taxa should be an important one to follow during future monitoring efforts.

The metric analysis also suggested that differences in water quality occurred among the nine Meacham Creek sites and that site 9 was of the highest quality. Site 9 had the highest value of the nine sites for four of the five metrics examined. The North Fork of the Umatilla River was used as a reference site and was predicted to have a higher quality than the Meacham Creek sites based on the metrics. However, this was not the case. While the North Fork had the greatest number of Plecoptera taxa and evenness, the other three metrics did not indicate higher water quality than site 9 in Meacham Creek. This comparison is based on only one site in the North Fork and during only one sampling period that was earlier in the summer than the sampling in Meacham Creek. Therefore, this comparison must be interpreted somewhat cautiously.

Future Monitoring

If the proposed restoration activities occur, macroinvertebrate monitoring should continue at Meacham Creek. This monitoring should be conducted at the same nine sites or areas at the same elevation within recharged channels after restoration. Stonefly taxa richness and abundance should be given careful examination, as the abundance of this group of insects varies among sites and they are potentially good indicators of stream reach quality. Multivariate analyses, especially ordination, should also continue to be conducted to track changes in entire community composition at each site.

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Appendix 1 – Macroinvertebrates identified from summer 2005 Meacham Creek samples and their correlation coefficients with the axes of an NMS ordination.

Phylum	Class	Order	Family	Genus	Pearson r		
					Axis 1	Axis 2	Axis 3
Arthropoda	Insecta	Plecoptera	Perlidae	Calineuria	-.45	-.16	**.81**
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	**-.86**	.48	.26
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcella	-.32	-.05	-.41
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcys	-.02	-.13	.23
Arthropoda	Insecta	Plecoptera	Perlodidae	Perlinodes	.00	-.63	.75
Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	-.48	.03	.25
Arthropoda	Insecta	Plecoptera	Perlodidae		-.47	-.20	**.79**
Arthropoda	Insecta	Plecoptera	Nemouridae	Malenka	-.48	-.30	**.75**
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	**-.71**	-.16	.37
Arthropoda	Insecta	Ephemeroptera	Ameletidae	Ameletus	-.48	-.30	**.75**
Arthropoda	Insecta	Ephemeroptera	Baetidae	Acentrella	.47	**-.69**	.03
Arthropoda	Insecta	Ephemeroptera	Baetidae	Diphetor	**-.69**	.01	**.72**
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	.56	-.53	.03
Arthropoda	Insecta	Ephemeroptera	Baetidae	Centroptilum	.24	.06	-.48
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	-.39	-.37	.59
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	-.54	.30	-.30
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	-.56	-.42	.55
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Seratella	-.48	-.30	**.75**
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorous	**.67**	**-.77**	.05
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	-.30	-.47	.50
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Ecdyonurus	-.54	.34	.19
Arthropoda	Insecta	Ephemeroptera	Heptageniidae		**-.77**	.21	.52
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	-.32	-.05	-.41
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	-.03	**-.69**	.57
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptila	-.17	-.17	-.63
Arthropoda	Insecta	Trichoptera	Hydroptilidae pupa		.65	-.12	.05
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	-.63	.15	.63
Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus	-.06	-.34	-.55
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosma	**.89**	**-.69**	-.26
Arthropoda	Insecta	Trichoptera	Philopotamidae	Wormaldia	**.76**	-.48	.00
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosma pupa	**.69**	-.43	.24
Arthropoda	Insecta	Trichoptera pupa			-.50	-.01	**.74**
Arthropoda	Insecta	Diptera	Athericidae	Atherix	.14	.43	**-.67**
Arthropoda	Insecta	Diptera	Athericidae	Atherix pupa	.10	.32	.06
Arthropoda	Insecta	Diptera	Chironomidae	Diamisinae	-.24	-.44	.36
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladinae	.10	-.64	-.12
Arthropoda	Insecta	Diptera	Chironomidae	Tanytarsini	-.63	.03	**.77**
Arthropoda	Insecta	Diptera	Chironomidae	Chironomini	-.56	-.13	**.71**
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	-.46	-.40	.62

Arthropoda	Insecta	Diptera	Chironomidae pupa		.01	-.42	.38
Arthropoda	Insecta	Diptera	Ceratopogonidae		-.07	.00	.06
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	.45	**-.75**	.00
Arthropoda	Insecta	Diptera	Empidae	Hemerodromia	-.05	-.51	**.80**
Arthropoda	Insecta	Diptera	Empidae	Chelifera	.47	.03	.03
Arthropoda	Insecta	Diptera	Empidae	Clinocera	.38	.21	-.06
Arthropoda	Insecta	Diptera	Empidae pupa		-.21	.15	**.77**
Arthropoda	Insecta	Diptera	Psychodidae pupa		-.11	.58	.06
Arthropoda	Insecta	Diptera	Tipulidae	Antocha	.19	**-.80**	.23
Arthropoda	Insecta	Diptera	Tipulidae	Antocha pupa	-.56	-.10	.58
Arthropoda	Insecta	Diptera	Tipulidae	Dicranota	-.11	.58	.06
Arthropoda	Insecta	Diptera	Tipulidae	Limnophilia	-.01	-.16	.18
Arthropoda	Insecta	Diptera	Tipulidae	Tipula	.33	-.30	-.57
Arthropoda	Insecta	Coleoptera	Psephenidae	Psephenus	.52	-.26	-.18
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservous larvae	-.60	.14	.52
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservous adults	**-.76**	.34	.49
Arthropoda	Insecta	Coleoptera	Elmidae	Ordobrevia larvae	-.48	-.30	**.75**
Arthropoda	Insecta	Coleoptera	Elmidae	Ordobrevia adults	-.48	-.30	**.75**
Arthropoda	Insecta	Coleoptera	Elmidae	Zaitzevia larvae	-.49	.49	.57
Arthropoda	Insecta	Coleoptera	Elmidae	Zaitzevia adults	-.40	.57	**.74**
Arthropoda	Insecta	Coleoptera	Haliplidae	Brychius	.07	-.25	.19
Arthropoda	Insecta	Lepidoptera	Pyralidae	Petrophila larvae	.34	.23	-.18
Arthropoda	Insecta	Lepidoptera	Pyralidae	Petrophila pupa	.09	-.38	**-.66**
Arthropoda	Arachnida	Hydracarina			**-.78**	.10	.46
Nematoda					.10	.32	.06
Annelida	Lumbriculidae				.08	.44	.16
Annelida	Oligochaeta				-.33	**.81**	-.25
Annelida	Branchiobdellida				**-.77**	.64	.29
Mollusca	Gastropoda	Basommatophora	Ancylidae	Ferrissia	.06	.04	-.47
Arthropoda	Crustacea	Decapoda			-.45	.52	.64