Bonneville Power Administration
Fish and Wildlife Program FY98 Watershed Proposal Form

Section 1. General administrative information

Title Measure Mine Drainage Effects At Confluence Of Alder Creek And Methow River

Bonneville project number, if an ongoing project 8068

Business name of agency, institution or organization requesting funding
University of Washington

Business acronym (if appropriate) UW

Proposal contact person or principal investigator:

Name	Donald W. Allen, Director, Grant & Contract
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Subcontractors.

Organization	Mailing Address	City, ST Zip	Contact Name
Not Applicable			

NPPC Program Measure Number(s) which this project addresses.

NMFS Biological Opinion Number(s) which this project addresses.

Other planning document references.

Not Applicable

Subbasin.

Proposed sampling site is located in USGS Hyfrological Unit 17020008

Short description.

This project will measure the effects of acid mine drainage, which occurs in mountain headwater stream, from its source to its confluence with the Methow River.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction	X	Watershed
+	Resident fish		O & M		Biodiversity/genetics
	Wildlife		Production		Population dynamics
	Oceans/estuaries	+	Research	+	Ecosystems
	Climate	X	Monitoring/eval.		Flow/survival
+	Other		Resource mgmt		Fish disease
			Planning/admin.		Supplementation
			Enforcement		Wildlife habitat enhancement/restoration
			Acquisitions		

Other keywords.

>>>>>Macroinvertebrates, watershed ecology, acid mine drainage, heavy metals, bioconcentration, bioaccumulation, chemical criteria, biological response

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Measure Diversity and Abundance of Aquatic	a	Measure Diversity and Abundance of Benthic Macroinvertebrates

	Macroinvertebrates		
2	Chemically Analyze Ground and Surface Water	b	Install monitoring wells (piezometers)
		c	Measure Total Metals by ICP Atomic Emission Spectrophotometry in Water, Sediment, and Soil

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	07/1998	07/1999	33.34%
2	7/1998	7/1999	66.66%
			TOTAL 100.00%

Schedule constraints.
Not Applicable

Completion date.

The project may merit continuation and additional funding to measure the annual loading of heavy metal contaminants and the biological response at multiple sites to assist in the assessment of impacted waters and the restoration of impaired watersheds.

Section 5. Budget

FY99 budget by line item

Item	Note	FY98
Personnel	Salaries (Research Assistant, 9 mos.) Summer Hourly Work	$99,813,327
Fringe benefits	Research Assistant(s) @ 8.0% Hourly Assistance @ 13.0%	$798 $433
Supplies, materials, non-expendable property		$1500

Operations & maintenance		
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		
PIT tags	# of tags:	
Travel		$1000
Indirect costs		$5292
Subcontracts		
Other	Chemical Analysis Telecommunications, Copying	$3000 $5211
TOTAL		$30,542

Outyear costs

Outyear costs	**FY99**	**FY00**	**FY01**	**FY02**
Total budget				
O&M as % of total				

Section 6. Abstract

>>>>> Alder Creek is a tributary of the Methow River, which is the upper limit of naturally, produced spring salmon and summer steelhead (listed in 1997 as threatened) in the mid-Columbia River. The stream is also utilized by resident brook trout for habitat and spawning (Toal, 1990). A series of beaver ponds and cattail marshes originating from Alder Creek provide nesting sites for waterfowl, game and songbirds near its confluence with the Methow River. An abandoned gold, silver, copper and zinc mine is located east of Alder Creek near its source. The Alder mine produces acidic metal-rich effluent that affects the quality of water in Alder Creek. This study will measure the potential effects of mine drainage on the biological use of the stream at its confluence with the Methow River.

A preliminary study by the author in August 1997 indicates that the concentrations of heavy metals in the stream are above water quality standards and that the density and diversity of benthic macroinvertebrates were less below the mine than above.

Duplicate samples at predetermined sites will be analyzed to document pH and the presence of heavy metals and the abundance and diversity of benthic macroinvertebrates.

This study will assist in more accurate assessment of waters impacted by toxics and provide a better basis for determining how to restore impaired watersheds. This project may merit continuation and additional funding to measure the annual loading of contaminants and the biological response at multiple sites, develop models that will be

applicable to other watersheds, and to justify restoration. A final watershed analysis report will be developed and a thesis report will be provided to satisfy the requirements for a Master's of Science degree in Ecosystem Science at the University of Washington. The proposed date of field sampling will begin May 1998. A summary report and thesis based on the results will be completed in early 1999.

Section 7. Project description

a. Technical and/or scientific background.

>>>>> Wild anadromous fish runs in the Methow basin have declined significantly since the late 1800's (USFS, 1995). The Methow River basin (Columbia RM524) is now the upper limit of naturally produced spring Chinook salmon and summer steelhead (which was listed as threatened) in the mid-Columbia River. The effects of historically intensive commercial harvest levels, hatchery supplementation programs, catastrophic smolt and adult mortality at Columbia River hydropower projects and impoundments, and the loss of Columbia River estuary rearing areas for juvenile anadromous salmonids has been recognized. This study will measure the potential effects of mine drainage, which typically occurs in mountain headwater streams, on the biological use of larger rivers downstream from mining.

Although metals contribute to our standard of living and our national security, mining has left metal-rich mine wastes that produce acidic drainage that affects the quality of water in many streams throughout the United States and in many other countries of the world (USGS, 1994). The effects of mine drainage are often severe in mountain headwater streams and can limit the biological, recreational, industrial, and municipal use of larger rivers many miles downstream from mining.

More than 500,000 inactive and abandoned hard rock mines are estimated to exist in 32 states, with at least 50 billion tons of untreated, unreclaimed mining waste on private and public land (USGS, 1994). The possible cost of cleaning up environmental problems at these sites could exceed $70 billion. Scientific information that makes cleanup easier or less expensive would benefit everyone.

The semi-arid Alder Creek watershed is located approximately three miles south of Twisp, in Okanogan County, Washington. It is a small watershed that offers unique opportunities to answer questions related to impairment and restoration that are more difficult to answer at a larger scale. A third-order stream drains the watershed that is approximately eight square miles. Approximately three miles of the stream near the center of the reach flows under ground.

The stream is utilized by resident brook trout for habitat and spawning. A series of beaver ponds and cattail marshes originating from Alder Creek provide nesting sites for waterfowl, game and songbirds near its confluence with the Methow River. An abandoned gold, silver, copper and zinc production mine is located east of Alder Creek near its source. The mineral deposits were developed by three adits that total several hundred feet and a large open pit mine (Hunting, 1956). The mine was in production from before 1937 to 1953 (Okanogan County Health District, 1995). Over 23,276 tons of ore were shipped (Burnet 1976, and Huntting 1956).

In a preliminary study conducted by the author in August 1997, Alder Creek was paired with the adjacent Poorman Creek watershed located to the west. Both watersheds are third-order streams with similar hydrogeomorphic characteristics. Also, both watersheds appear to be impacted by similar land-use pressures that include logging, recreation, and grazing. Poorman Creek, however, has not been impacted by a mine as Alder Creek has.

The results from the study indicate that the concentration of heavy metals was above water quality standards and that the density and diversity of benthic macroinvertebrates was less below the mine. It was also observed that the evolution of carbon dioxide was elevated in soil and decomposing logs where groundwater was contaminated by acidic mine effluent. The pH of the mine effluent was two logs lower where it flowed into the ground, increased as it flowed towards the creek and reached normal levels when it eventually mixed with the water in the creek.

In a separate study by the Okanogan County Health District, the laboratory analysis of a water sample collected from mine tunnel effluent was analyzed for total Metals. The results indicated that cadmium, copper, and zinc exist at elevated levels but only cadmium existed at a level above the Model Toxics Control Act cleanup level (Okanogan County Health District, 1995). The study also determined that on June 28, 1995, the adit drainage flowed at approximately 15-20 gal/min. the water in the drainage flows into the ground within 80 to 100 feet from the adit. Groundwater flow is toward the west, eventually into Alder Creek approximately 0.2-mile downgradient.

Federal, state and local water quality standards, which are used to determine action limits for cleanup, are specific chemical limits identified as necessary to protect water for their designated use. The focus of the chemical criteria and the analysis of freshwater is on the concentration of toxic pollutants in the water column which is, in turn, aimed at controlling the release of “toxic pollutants in toxic amounts” (Adler, 1993). These criteria are based on levels suspected to cause human health risks. They assume an average human consumption rate of fish for risk assessments for carcinogens. The basis for establishing chemical criteria is related to the risk of cancer in humans due to the consumption of contaminated fish or to contact with contaminated water.

A fundamental question is how well chemical criteria contribute to the ultimate objective of the Clean Water Act: do they act to restore and maintain the chemical, physical and biological integrity of the nation’s waters? According to Adler (1993) the traditional measures of water quality, which include changes in water chemistry, are only surrogate measurers of ecosystem health.

Other indicators of how well the Clean Water Act has worked to protect human health and aquatic ecosystems have been developed. Traditional measurers of water quality, including changes in water chemistry, are being supplemented with biological water quality criteria which compare the benthic macroinvertebrates in a water body with those in control waters that are in a relatively natural state (Karr, 1981). For example, the Index of Biological Integrity (Karr, 1981) relies on the direct assessment of the populations, diversity, and community structure of fish, invertebrates, and other groups of species within an aquatic ecosystem.

Adler (1993), however, comments that biocriteria are only snapshots of ecosystem health, they do not measure the ability of a system to resist or recover from stress, and they do not measure the secondary effects of chemical pollution such as long-term accumulations or threats to humans or wildlife that consume contaminated species.

b. Proposal objectives.

>>>>> The objective of this study is to evaluate ground and surface waters along Alder Creek from the mine at its headwaters to its confluence with the Methow River using chemical methods to test the hypothesis that community-level measures respond predictably to varying concentrations of measured pollutants. There are several assumptions necessary for this hypothesis to be true. First, chemical criteria address all identifiable effects on human health and welfare. Criteria that address human health but do not address aquatic life, or cancer but not other human health effects, do not meet this standard. Second, criteria that apply only to the water column address the concentration and dispersal of toxic pollutants through chemical, physical, and biological systems. Criteria that fail to account for the accumulation and concentration of toxic contaminants in sediments and the tissues of plants and animals do not meet this standard. Third, chemical criteria assume that people, fish, and wildlife are exposed only to individual pollutants, from water sources alone. Criteria that ignore simultaneous, additive or synergistic effects from multiple pollutants and multiple sources such including food as well as water fail this standard.

c. Rationale and significance to Regional Programs.

>>>>> The EPA and the states have been working to identify stream reaches impaired by toxics (including metals as part of the Clean Water Act reporting requirement. Often such information is lacking for watersheds impacted by historic mining. This project will help to establish an understanding of considerations appropriate for evaluating the aquatic ecosystem impacts of mine sites on small watersheds, and how these impacts may be evaluated in the context of larger watersheds impacted by historic mining. Ultimately, studies of this kind will assist in more accurate assessment of waters impacted by toxics and provide a better basis for determining how to restore impaired watersheds.

d. Project history

>>>>> Not Applicable

**e.	Methods**.

<u>Biological Monitoring (objective 1, task a)</u>

>>>>> The fieldwork for this study will be carried out at a headwater stream impaired by an abandoned mine near Twisp, Washington in Okanogan County. Four sites in the Alder Creek basin have been selected for study. Each site represents different impacts due to acid mine drainage and waste rock leachate. Two additional sites will be studied in the adjacent Poorman Creek drainage, which will serve as a reference for the Alder Creek study.

At each of the six sites, three modified surber samples will be taken and sorted following forest Service procedures for the analysis of benthic macroinvertebrates. Samples will be sorted and specimens will be identified and used in metrics analyses. The following ten metrics will be analyzed from surber samples: 1) Total Taxa Richness, 2) Ephemoptera, Plecoptera, and Trichoptera (EPT) Index, 3) Ratio of EPT to EPT plus chironomidae, 4) Percent Contribution of the Dominant Taxon, 5) Ratio of Shredders to all other individuals collected, 6) Ration of Collectors-Filterers to all other individuals collected, 7) Ratio of Scrapers to all other individuals collected, 8) Ratio of scrapers to scrapers plus filterers-Collectors, 9) Forest Service Biotic Index (FSBI), 10) Hilsenhoff Biotic Index (HBI).

Total taxa richness is a general measure of the health of a community. Richness usually increases with increasing water quality and habitat diversity.

The ratio of EPT to EPT plus chironomidea is a measure of community balance. Good biotic conditions should be reflected by an even distribution among these four groups with a more substantial representation of the more sensitive, Ephemoptera, Plecoptera, and Trichoptera (EPA, 1989).

The EPT index summarizes richness for these orders that are known to be sensitive to pollution and other habitat impairment. The EPT index generally decreases in response to habitat impairment.

The percent contribution of the dominant taxon is another indicator of community balance. Where a community is dominated by only a few taxa, it is assumed that there is some type of environmental stress that reduces the number of sensitive taxa.

The ration of shredders to the total number of individuals collected can be sued to evaluate potential impairment to the course particulate matter dependent shredder community. Shredders may be negatively impacted by alterations to the riparian zone and by toxicants that are readily adsorbed to organic matter.

The ratio of collectors-filterers to the total number of individuals collected can be used as an indicator of organic enrichment. Organic enrichment often increases the availability of fine particulate organic matter, which is the primary food resource of collectors-filterers.

The ratio of scrapers to the total number of individuals collected can be used as an indicator of organic and nutrient enrichment. Scrapers are adapted to utilizing periphyton which increase in availability due to organic and nutrient enrichment and sparse canopy cover. The ratio of scrapers to scrapers-plus-collectors-filterers can be used as an indicator of community-intolerance resulting from an overabundance of particular food resource. Scraper densities increase due to increased periphyton availability while collector-filterer densities increase in response to increased availability of fine particulate matter.

The Forest Service Biotic Index and Helsenhoff Biotic Index use tolerance values for each taxon to summarize the overall pollution tolerance of the community with a single value.

Results will be analyzed based on two-factor ANOVA test for significant differences in metric scores between stations.

Qualitative collections will be made at each of the study sites using kick nets, aerial nets, beating sheets and nets, and hand picking. Emergence traps will be placed near the regular sampling sites. Emergence specimens will be removed at two-week intervals. These traps are designed for continuous collecting of emerging adults.

<u>Monitoring well Installation (objective 2, task b)</u>

The controlling assumption concerning the effects of mine drainage and waste rock leachate is that dissolved metals enter and mix with ground water, move from an upgradient source and flow downgradient into Alder Creek according to the normal laws of ground water flow. In order to verify ground water flow and the migration of heavy metal contaminants, five piezometers will be installed. Each piezometer will be configured to permit sampling for total metals.

<u>Sampling and Chemical Analysis (objective 2, task c)</u>

Sampling and sample preservation protocols recommended by the EPA will be used. All chemical analyses for heavy metals will be performed using assays for total metals by ICP atomic emission spectrophotometry and graphite furnace atomic absorption spectrophotometry. Chemical assays will be performed at Cascade Analytical in Wenatchee, WA.

f. Facilities and equipment.

>>>>> The University of Washington College of Forest Resources in Seattle, Washington will provide all field equipment and laboratory space. Chemical analysis of water samples for total metals will be performed by the Analytical Services Laboratory at the University of Washington, College of Forest Resources.

g. References.

Adler, W. A., J. C. Landman, and D. M. Caameron. 1993. *The Clean Water Act 20 Years Later,* Island Press, Washington, D.C.

Alpers, C. N. 1994. Responsibilities and Activities of the U.S. Geological Survey Related to Mining and the Environment, *Workshop Report – Mine Waste Technical Forum,* USGS.

Burnet, F.W. 1976. Felsic volcanic rocks and mineral deposits in the Buck Mountain Formation andesites, Okanogan County, Washington: University of Washington Master of Science thesis, 26 p., 1 pl.

EPA. 1989. Rapid bioassessment protocols for use in streams and rivers. Benthic macroinvertebrates and fish. (EPA/444/4-89-001). Washington, D.C.: U.S. Environmental Protection Agency.

Huntting, M. T. 1956. Inventory of Washington minerals – Part II, Metallic minerals: Washington Division of Mines and Geology Bulletin 37, v. 1, 428 p; v. 2, 67p.

Margalef, Ramon. 1968. *Perspectives in Ecological Theory*, The University of Chicago Press, Chicago.

Karr, J. R. 1981. Assessment of Biotic Integrity Using Fish Communities, *Fisheries 6*, no. 6:21-27.

Okanogan County Health District. 1995. *Washington Department of Ecology Toxic Cleanup Program, Initial Investigation Report/Data Collection.*

Peplow, D. P. 1997. Alder Creek Watershed Initial Investigation Report. Unpublished Data.

U.S.F.S. 1995. Twisp Watershed Analysis. Okanogan National Forest, Methow Valley Ranger District, United States Department of Agriculture, Washington, D. C.

Section 8. Relationships to other projects

>>>>> Not Applicable

Section 9. Key personnel

Key Personnel

1. Dan Peplow
   Masters student, University of Washington, College of Forest Resources, Division of Ecosystems, Horticulture, and Conservation.

2. Robert L. Edmonds
   Professor, College of Forest Resources, Graduate Committee Chairman

Resume´

Robert L. Edmonds
Professor, College of Forest Resources
University of Washington, Seattle, 98195

Ph.D.	1971	University of Washington (Forest Pathology)
M.S.	1968	University of Washington (Forest Pathology)
B.S.	1964	Sydney University, Australia (Forestry)

1993 – 1997	Chairman, Ecosystem Science and Conservation Division, University of Washington
1984 – 1986	Vice Chairman, forest Resources Management division, University of Washington
1982 – Present	Professor, University of Washington
1979 – 1982	Associate Professor, University of Washington
1976 – 1979	Assistant Professor and Director Pack Forest, University of Washington
1973 – 1976	Associate Director, US/IBP Coniferous Forest Biome Program and Research Assistant Professor
1971 – 1973	Program Coordinator to Director, US/IBP Aerobiology Program, Botany Department, University of Michigan

(Robert L. Edmonds, continued)

1966 – 1970	Research Assistant, College of Forest Resources, University of Washington
1965 – 1966	Research Assistant, Department of Forestry, Australian National University, Canberra, Australia
1964 – 1965	Research Forestry Officer, Forest Research Institute, Canberra, Australia

Robert Edmonds has 35 years experience conducting research in forest biology, nutrient cycling, soil microbiology and ecosystem and watershed studies. He has expertise in stream chemistry and has been involved with students and postocs in invertebrate studies. Five pertinent publications are listed below from a list of 135 publications.

Edmonds, R.L. and R.D. Blew. 1997. Trends in Precipitation and Stream Chemistry in a Pristine Old-Growth forest Watershed, Olympic National Park, Washington. J. Am. Water Res. Assoc. 33:781-793.

Edmonds, R.L., T.B. Thomas, and R.D. Blew. 1995. Biogeochemistry of an Old-Growth forested Watershed, Olympic National Park, Washington. Water Res. Bull. 31:409-419.

Edmonds, R.L., D. Brinkley, M.C. Feller, P. Sollins, A. Abee, and D.D. Myrold. 1989. Nutrient Cycling:Effects on Productivity of Northwest Forests, pages 17-35. In: D.A. Perry, R. Neurisse, B. Thomas, r. Miller, J. Boyle, J. Means, C.R. Perry, and R.F. Powers. (Eds.) Maintaining the Long-Term Productivity of Pacific Northwest forest Ecosystems. Timber Press, Portland, OR.

Edmonds, R.L. (Ed.) 1982. Analysis of Coniferous Forest Ecosystems in the Western United States. US/IBP Synthesis Series. Hutchinson Ross, Stoudsburg, Pennsylvania. 419 P.

Dan Peplow
Bachelor of Science, Zoology, University of Washington, 1997
Bachelor of Science, Bacteriology and Public Health, Washington State University, 1977

1997 to Present	Masters Student, University of Washington, College of Forest Resources, Division of Ecosystem Science and Conservation, Seattle, Washington.
1996 to 1997	Undergraduate, University of Washington, Zoology Department, Seattle, Washington.
1984 to 1996	Manager, Vertebrate Cell Culture Process Development and Manufacture of Recombinant Human Therapeutics, Amgen Inc., Thousand Oaks, California.
1981 to 1984	Research Associate, Invertebrate Cell Culture Process Development, Southwest Foundation for Biomedical Research, San Anotonio, Texas.

1978 to 1981 Parasitologist, National Institute for Agricultural Research (Peace Corps), Ecuador, South America.

Dan Peplow has approximately 17 years experience in biology. Three years as a Peace Corps volunteer participating in public health projects and conducting basic research on the incidence of parasitosis in people and cattle in Ecuador. Three years were spent as a research associate developing process for the large-scale production of insect cells and baculoviruses and the expression of heterologous proteins in culture. Eleven years were dedicated to vertebrate cell culture process development and manufacturing of recombinant human therapeutics. The last two years have been dedicated to the completion of a second degree in zoology and the beginning of graduate studies in forestry focusing on the effects of acid mine drainage and waste rock leachate on watershed ecology.

Section 10. Information/technology transfer

>>>>> A final watershed analysis report will be developed to provide pertinent project findings to the Pacific Power Planning Council (the Bonneville Power Administration), to state and to federal water quality management officials, as well as industry, in an effort to better understand mine site impacts on water quality and biological receptors. A summary report will be prepared to summarize initial findings in early 1999.