Instructions: USGS specifies the following format exactly as it appears. Please complete each section. Should you need additional space, attach a separate piece of paper and note the letter appropriate to the section being addressed in the upper right-hand corner. Do not deviate from the format provided and address only the area which is specified in each section. Please do not consolidate section areas.

PROJECT SYNOPSIS

1. PROJECT NUMBER _____ (to be completed by IWRRI)

2. TITLE Limnology of High Mountain Lakes in the Bighorn Crags Region of the Frank Church - River of No Return Wilderness

3. COWRR CATEGORY _____ (to be completed by IWRRI)

4. KEYWORDS Mountain Lakes, Limnology, Wilderness

5. DURATION June 1, 1995 through May 31, 1996
(month/year to month/year use actual beginning and estimated ending month/year for projects continuing from earlier grants or expected to continue beyond the 1991 grant)

6. FISCAL YEAR 1995 FEDERAL FUNDS $14,964 (Total) $ 11,449 (Direct) $ 3,515 (Indirect)

7. FISCAL YEAR 1995 NON-FEDERAL FUNDS $_____ (Total) $_____ (Direct) $_____ (Indirect)

8. NAME(S) DEPARTMENT(S) AND UNIVERSITY OF PRINCIPAL INVESTIGATOR(S)

Kirk Lohman, Dept. of Range Resources/Fish and Wildlife Resources

9. CONGRESSIONAL DISTRICT OF UNIVERSITY PERFORMING RESEARCH 1

C:\wp51\forms\synopsis.pro

10. STATEMENT OF PROPOSED RESEARCH ROLE IN ADDRESSING CRITICAL LOCAL, STATE OR REGIONAL WATER PROBLEMS **10%**

[Include explanation of need for research, who wants it and why. (2 paragraphs minimum)]

The proposed research would investigate limnological conditions of lakes in the Bighorn Crags area of the Frank Church-River of No Return Wilderness and provide basic data on nutrient levels, trophic status, and buffering capacity. There is presently no information available on the water chemistry of these lakes.

Knowledge of the basic limnological conditions would provide land managers from the U.S. Forest Service and the Idaho Division of Environmental Quality with baseline data for assessing future changes in lake water quality. Many of the lakes within the Bighorn Crags region receive heavy recreational use and are probably susceptible to cultural eutrophication. Without data on present nutrient conditions, the extent of nutrient enrichment that results from recreational use will be impossible to determine. In addition to nutrient enrichment, high mountain lakes are often sensitive to acid deposition. This research would determine the buffering capacity of lakes within the area.

On a broader scale, the results of this research will add to a growing, but still incomplete body of knowledge concerning the limnology of high mountain lakes. Because of the logistical problems that generally hinder water sampling of high altitude waters, relatively little data has been collected on mountain lakes. Work that has been done on these lakes suggests that high elevation, cold temperature, small drainage area, and the relatively recent origin of high mountain lakes make them unique aquatic environments. This research would contribute to our understanding of mountain lakes by providing additonal information on water chemistry and trophic status from lakes in the Northern Rockies, an area from which there is surprisingly little data.

11. STATEMENT OF RESULTS, USES AND POTENTIAL BENEFITS OF THE RESEARCH TO IWRRI PRIORITIES (refer to attached list) **10%**

[What is expected to be gained by use of the grant during the performance period or by the end of the project, if of longer durarion, and how will the results be used. (2 paragraphs maximum)]

The results of this research will identify current water quality conditions in lakes of the Bighorn Crags region. This study will report nutrient (nitrogen and phosphorus) and chlorophyll *a* concentrations which can be used to characterize trophic status. Measurements of alkalinity and pH will be used to assess the buffering capacity of lakes within the region. These results, together with measurements of other water quality variables (temperature, Secchi disk transparency, specific conductance, total suspended solids), will help describe water chemistry and trophic conditions within the Bighorn Crags lake district.

Water quality data collected on the lakes of the Bighorn Crags region will provide baseline information which can be used to assess future changes in lake water quality. Lakes in the area may be affected by nutrient additions originating from nonpoint sources such as recreational use. These lakes may also be sensitive to changes in pH and the effects of acidic deposition. Baseline data on current conditions will provide essential information for assessing future changes in water quality.

12. NATURE, SCOPE AND OBJECTIVES OF PROPOSED RESEARCH 15%

The proposed research would investigate limnological conditions in lakes of the Bighorn Crags region of the Frank Church-River of No Return Wilderness. This work would describe water chemistry in roughly 30 lakes in the region and provide baseline information on trophic status and sensitivity to acid deposition. The primary focus of the study would be to determine nutrient conditions and algal biomass.

The objectives of the proposed research are:

1. Determine the present trophic state of high mountain lakes within the Bighorn Crags region of the Frank Church-River of No Return Wilderness based on nitrogen, phosphorus, and chlorophyll *a* concentrations.

2. Identify the sensitivity of lakes within the Bighorn Crags region to acid deposition based on measurements of alkalinity and pH.

13. **METHODS, PROCEDURES AND FACILITIES** **15%**

[Provide sufficient information to permit evaluation of the technical adequacy of approach to satisfy objectives.]

The Study Area

The Bighorn Crags region lies at the eastern edge of the Frank Church-River of No Return Wilderness in Lemhi County, Idaho. The region is characterized by steep granite pinnacles and walls, and by small cirque lakes. Mt. McGuire, at the northern end of the Crags, is the highest peak in the area at 3073 m. There are numerous subalpine lakes within the area at elevations of 2200-2800 m. Most lakes within the Bighorn Crags area were stocked with trout by Idaho Fish and Game prior to 1983, and many lakes receive considerable fishing pressure (USDA Forest Service 1986).

Methods

Approximately 30 lakes within the Bighorn Crags region will be chosen for sampling. In 1994, surveys of amphibian populations were conducted in Bighorn Crags lakes (Charles Peterson, Idaho State University, personal communication), and my sampling efforts will attempt to include all lakes for which such data was collected. Lake and watershed area will be estimated from 7.5 minute maps for each lake selected.

Field work will begin when lakes within the region are open, which is generally sometime in early July. Lakes will be reached by hiking from either the Crags Campground on the east side of Bighorn Crags or from Taylor Ranch on the west side.

Lakes will be surveyed during the period of July-August. Each lake will be visited on 2 occasions and sampled using a small inflatable boat. Field measurements at each lake will include temperature, specific conductance, Secchi disk transparency, maximum depth, alkalinity, and pH. On each visit, water samples will be collected in triplicate from the deepest part of the lake for later laboratory analysis. Water collected for analysis of total nitrogen and total phosphorus will be preserved by acidification in the field. Samples collected for ammonia, nitrate, and soluble reactive phosphorus will be filtered with a hand pump prior to acidification. Total suspended solids will be measured by pumping known amounts of lake water through pre-weighed Whatman filters. Samples collected for chlorophyll *a* will be filtered onto Gelman glass fiber filters and stored in the dark with desiccant until returned to the laboratory where they will be stored in a freezer.

Total nitrogen will be analyzed in the laboratory by cadmium reduction after persulfate oxidation and nitrate by cadmium reduction (D'Elia et al. 1977). Ammonia will be measured in the laboratory by the phenylhypochlorite method (Solorzano 1969). Soluble reactive phosphorus will be determined using the ascorbic acid method and total phosphorus using the ascorbic acid method after persulfate oxidation (Prepas and Rigler 1982). Chlorophyll *a* will be analyzed spectrophotometrically after ethanol extraction (Sartory and Grobbelaar 1984). Other chemical analyses will be conducted according to APHA (1993).

Data Analysis

Mean summer concentrations will be calculated for each water chemistry variable. Initial data analysis will focus on identifying differences among lakes. Differences in sensitivity to acid deposition shall be examined by analyzing differences in alkalinity and pH among lakes. Particular attention will focus on chlorophyll *a*. Simple and multiple linear regression models will be used to analyze variation in chlorophyll *a* among lakes and to determine if variation can be explained by differences in nutrient concentrations or by other chemical or physical variables.

Facilities

The analytical laboratory of the College of Forestry, Wildlife and Range Sciences has the equipment necessary to conduct routine water chemistry analyses, including a Beckman 640 spectrophotometer which will be used to analyze total nitrogen, nitrate, ammonia, total phosphorus, soluble reactive phosphorus, and chlorophyll *a*.

Literature Cited

APHA. 1993. Standard Methods for the Examination of Water and Wastewater, 18th edition., APHA, Washington, DC.

D'Elia, C.F., P.A. Steudler, and N. Corwin. 1977. Determination of total nitrogen samples using persulfate digestion. Limnology and Oceanography 22:760-764.

Prepas, E.E., and F.H. Rigler. 1982. Improvements in quantifying the phosphorus concentration in lake water. Canadian Journal of Fisheries and Aquatic Sciences 39:822-829.

Sartory, D.P., and J.U. Grobbelaar. 1984. Extraction of chlorophyll-a from freshwater phytoplankton for spectrophotometric analysis. Hydrobiologia 114:177-187.

Solorzano, L. 1969. Determination of ammonia in natural waters by the phenylhypochlorite method. Limnology and Oceanography 14:799-801.

USDA Forest Service. 1986. Frank Church-River of No Return Wilderness Management Plan. Prepared by the Wilderness Planning Team, Salmon National Forest.

14. RELATED RESEARCH **10%**

[Show by literature and communication citations the similarities and dissimilarities of this proposed project with ongoing research on the same topic.]

High mountain lakes are considered particularly sensitive to environmental changes (Nauwerck 1994). These lakes are generally characterized by dilute water chemistries, because drainage basins are small and composed of relatively insoluble and uneroded parent materials (Pennak 1963). As a result, changes in water chemistry may occur rapidly in response to changes in chemical loading from the atmosphere or from watershed activities. High mountain lake are also relatively simple ecosystems and small changes in physical or chemical conditions may potentially alter biological conditions. The prompt reaction of such lakes to environmental stress makes them good 'early warning systems' for identifying signs of perturbations (Nauwerck 1994).

Eutrophication and acidification are both potential water quality problems in high mountain lakes. Subalpine and alpine lakes are almost always nutrient-poor and watershed activities that increase nutrient loading potentially alter aquatic productivity and species composition. The susceptibility of lakes to such changes is influenced by elevation, watershed characteristics, and lake morphometry. Larson et al. (1994) surveyed 27 lakes in Mount Rainier National Park and found differences in nutrient chemistry between forested and subalpine lakes. They suggested that differences were predictable based on elevation, lake surface area, depth, and watershed size. Limited buffering capacity also makes most high mountain lakes susceptible to acid deposition. The sensitivity of high mountain lakes to acidification has received considerable attention in Europe (Marchetto et al. 1994, Nauwerck 1994, Viaroli et al. 1994). In a survey of 719 lakes in the western United States, Eilers et al. (1988) found that a high proportion were extremely dilute and had low acid neutralizing capacities, although very few exhibited pH values less than 6.0.

Studies done in the Frank Church-River of No Return Wilderness suggest that the water chemistry of lakes within the Bighorn Crags region is probably very dilute and also that the chemistry of some lakes has a high likelihood of being influenced by recreational use. Water chemistry of 9 streams within the Frank Church-River of No Return Wilderness was described by Buettner (1987). His survey reported that stream concentrations of inorganic nitrogen and inorganic phosphorus were low, with nitrate ranging from <10 to 150 µg/L, and phosphate from <3 to 9 µg/L. Alkalinities within the same streams ranged from 18 to 92 mg $CaCO_3$/L and were consistently lower in headwater streams as compared to downstream reaches. These results suggest that values for nitrogen, phosphorus, and alkalinity in lakes of the Bighorn Crags, which are within the same region but at higher altitude, are likely to have both very dilute nutrient concentrations and alkalinities. The impact of camping on vegetation at 4 lakes in the Bighorn Crags was investigated by Coombs (1976). Her study documented heavy use and significant trampling of vegetation at more accessible campsites. The continued popularity of lakes in the Bighorn Crags for hiking, camping, hunting, and fishing (USDA Forest Service1986), indicates a high potential for increased nutrient loading. These activities could increase loading directly by the addition of human or animal wastes or indirectly through soil compaction and erosion.

14. RELATED RESEARCH (cont.)

Work is currently being done on the distribution and abundance of amphibians in lakes of the Bighorn Crags by Dr. Charles Peterson and a graduate student from Idaho State University. One objective of their study is to determine the use by amphibians of lakes with and without fish in the Bighorn Crags. The proposed study would supplement their findings and help complete a description of physical, chemical, and biological conditions in these lakes.

Literature Cited

Buettner, E.W. 1987. Ecology of selected streams in the Frank Church River of No Return Wilderness Area. Masters thesis, University of Idaho, Moscow. 69 pp.

Coombs, E.A.K. 1976. The impact of camping on vegetation in the Bighorn Crags, Idaho Primitive Area. Masters thesis, University of Idaho, Moscow. 63 pp.

Eilers, J.M., D.F. Brakke, D.H. Landers, and P.E. Kellar. Characteristics of lakes in mountainous areas of the Western United Sates. Verhandlungen der Internationalen Vereinigung für Theoretische und Angewandte Limnologie 23:144-151.

Larson, G.L., A. Wones, C.D. McIntire, and B. Samora. 1994. Integrating limnological characteristics of high mountain lakes into the landscape of a natural area. Environmental Management 18:871-888.

Marchetto, A., A. Barbieri, R. Mosello, and G.A. Tartari. 1994. Acidification and weathering processes in high mountain lakes in Southern Alps. Hydrobiologia 274:75-81.

Nauwerck, A. 1994. A survey on water chemistry and plankton in high mountain lakes in northern Swedish Lapland. Hydrobiologia 274:91-100.

Pennak, R.W. 1963. Rocky Mountain states. Pages 349-369 *in* Frey, D.G., editor, Limnology in North America. The University of Wisconsin Press, Madison. 734 pp.

Viaroli, P., I. Ferrari, G. Paris, G. Rossetti, and P. Menozzi. 1994. Limnological research on northern Apennine lakes (Italy) in relation to eutrophication and acidification risk. Hydrobiologia 274:155-162.

16. INVESTIGATOR'S QUALIFICATIONS **10%**

[Include narrative explaining relationship of your background to proposed project, as well as a current vitae for each investigator (not to exceed 3 pages or list more than 15 pertinent publications).]

I have a Ph.D. in fisheries with an emphasis in limnology. My graduate work focused on the limnology of small streams and rivers, with particular emphasis on nutrient conditions and primary productivity. In addition, I have worked on projects concerning lake water chemistry and eutrophication in Nepal and Costa Rica. Much of the work in Costa Rica dealt specifically with limnological conditions in high mountain lakes. I have also investigated nutrient enrichment and its effects on primary and secondary productivity in the Clark Fork River in Montana. I am familiar with both the field and laboratory aspects of water sampling and chemical analysis, as well as with the logistical difficulties of sampling remote mountain lakes.

(curriculum vitae attached)

KIRK LOHMAN

Departments of Fish and Wildlife Resources and Range Resources
University of Idaho, Moscow, ID 83844
Telephone: 208-885-7203
Fax: 208-885-6226
E-mail: stream@osprey.csrv.uidaho.edu

EDUCATION

Ph.D., 1988, Fisheries and Wildlife, University of Missouri
J.D., 1980, University of Missouri
B.A., 1975, Biology (Zoology), University of Missouri

EMPLOYMENT

1993-Present: Assistant Professor of Riparian Ecology, College of Forestry, Wildlife, and Range Sciences, University of Idaho, Moscow, ID.
1992-1993: Senior Ecologist, RD Ecological Research Associates, Anchorage, AK.
1991-1992: Visiting Assistant Professor, Department of Natural Resources Management and Engineering, University of Connecticut, Storrs, CT.
1989-1991: Postdoctoral Research Fellow, Department of Biology, Montana State University, Bozeman, MT.
Spring 1989: Instructor, School of Forestry, Fisheries, and Wildlife, University of Missouri, Columbia, MO.
1984-1988: Graduate Research Assistant, School of Forestry, Fisheries, and Wildlife, University of Missouri, Columbia, MO.
1983-1984: Graduate Teaching Assistant, Division of Biological Sciences, University of Missouri, Columbia, MO.
1981-1983: Assistant Attorney General, Environmental Resources Division, Missouri Attorney General's Office, Jefferson City, MO.

RESEARCH PROJECTS

1994-1995: Distribution and abundance of tailed frogs, *Ascaphus truei*, in relation to environmental conditions in headwater streams.
1989-1991: The effects of nutrient enrichment on the production of benthic algae, macroinvertebrates, and young-of-the-year salmonids in the Clark Fork River (with John C. Priscu and Robert White).
1984-1988: The effects of point and nonpoint source nutrient enrichment on algal growth and water quality in Ozark streams (with John R. Jones)
1987: A limnological survey of Costa Rican lakes (with John R. Jones).
1985: Limnological characteristics of lakes in the Pokhara and Kathmandu valleys, Nepal (with John R. Jones).

COLLEGE TEACHING EXPERIENCE

Riparian Ecology
Wildland Field Ecology
Stream Ecology
Fish Ecology
Limnology
Animal Population Dynamics (laboratory)
Fisheries Management (laboratory)
General Biology (laboratory)

PROFESSIONAL SOCIETIES

American Fisheries Society
North American Benthological Society
American Society of Limnology and Oceanography
International Association for Theoretical and Applied Limnology
Missouri Bar Association

HONORS AND AWARDS

National Academy of Sciences Young Investigator Program on Agricultural Impacts on Water Quality in Latvia and Lithuania, 1994
Graduate Student Teaching Award (Fisheries and Wildlife), 1988
Superior Graduate Student Achievement Award (Fisheries), 1988
University of Missouri School of Law Award for Environmental Law, 1980
University of Missouri School of Law Award for Land Use Law, 1980
University of Missouri School of Law Award for Local Government Law, 1980

PUBLICATIONS

Lohman, K., Jones, J.R., and B.D. Perkins. 1992. Effects of nutrient enrichment and flood frequency on periphyton biomass in northern Ozark streams. Canadian Journal of Fisheries and Aquatic Sciences 49:1198-1205.

Lohman, K., and J.C. Priscu. 1992. Physiological indicators of nutrient deficiency in *Cladophora* in the Clark Fork of the Columbia River, Montana. Journal of Phycology 28:443-448.

Lohman, K., Priscu, J.C., Kangatharalingam, N., Wang, L., and R.G. White. 1992. Nutrient enrichment effects on the growth of benthic algae, macroinvertebrates, and young-of-the-year salmonids in experimental troughs. Annual report to the Soap and Detergent Association and Stone Container Corporation.

Lohman, K., Jones, J.R., and C. Baysinger-Daniel. 1991. Experimental evidence for nitrogen limitation in a northern Ozark stream. Journal of the North American Benthological Society 10:14-23.

Lohman, K., and J.C. Priscu. 1991. Nutrient enrichment and the development of nuisance algal growth in the upper Clark Fork. Annual report to the Soap and Detergent Association and Stone Container Corporation.

Lohman, K. 1988. Nutrient sources and the influence of nutrients on periphyton in northern Ozark Border streams. Ph.D. dissertation, University of Missouri, Columbia. 209 pp.

Lohman, K., Jones, J.R., Knowlton, M.F., Swar, D.B., Pamperl, M.A., and B.J. Brazos. 1988. Pre- and postmonsoon limnological characteristics of lakes in the Pokhara and Kathmandu valleys, Nepal. Verhandlungen der Internationalen Vereinigung für Theoretische und Angewandte Limnologie 23:558-565.

Lohman, K., and J.R. Jones. 1988. Factors affecting water chemistry and algal biomass in Missouri Ozark streams: a review. Prepared for the Missouri Department of Natural Resources.

Jones, J.R., Lohman, K., and G. Umaña V. 1993. Water chemistry and trophic state of eight lakes in Costa Rica. Verhandlungen der Internationalen Vereinigung für Theoretische und Angewandte Limnologie 25:899-905.

PROFESSIONAL PRESENTATIONS

Lohman, K. 1994. Importance and value of riparian areas. Streamside Management: Alternatives for Private Landowners Workshop. Idaho Riparian Cooperative, Moscow, ID, November 1994.

Lohman, K. 1994. Stream water quality. Continuing Education in Ecosystem Management Shortcourse. Moscow, ID, November 1994.

Lohman, K. 1993. Sources and effects of nutrient enrichment in streams. College of Forestry, Wildlife, and Range Sciences, University of Idaho, Moscow, ID, May 1993.

Lohman, K. 1992. Impact of causeways and oil development activities on anadromous fishes in the Beaufort Sea, Alaska. Fish and Wildlife Management Committee, North Slope Borough, Barrow, AK, October 1992.

Lohman, K. 1990. Effects of nutrient enrichment on stream water quality. Department of Biology, Montana State University, Bozeman, MT, February 1990.

Lohman, K. 1989. Water pollution enforcement from a government attorney's perspective. Wildlife Forum, Montana State University, Bozeman, MT, October 1989.

Lohman, K., and J.R. Jones. 1989. Comparative magnitude of point and nonpoint source effects on water quality in some Ozark streams. Watershed Committee of the Ozarks Conference, Springfield, MO, June 1989.

Lohman, K., and J.R. Jones. 1989. Temporal changes in periphyton biomass in relation to ambient nutrient concentrations and flood frequency. North American Benthological Society, Guelph, Ontario, May 1989.

Lohman, K. 1988. Sources and effects of nutrient enrichment in Ozark Border streams. School of Forestry, Fisheries and Wildlife Seminar Series, University of Missouri, Columbia, MO, March 1988.

Lohman, K., Jones, J.R., Knowlton, M.F., Swar, D.B., Pamperl, M.A., and B.J. Brazos. 1987. Pre- and postmonsoon limnological characteristics of lakes in the Pokhara and Kathmandu valleys, Nepal. SIL Congress, Hamilton, New Zealand, February 1987.

17. TRAINING POTENTIAL **15%**

[Estimate the number of graduate students, fields of speciality and degrees expected to result from participation in the project--also estimate the number of undergraduate students expected to participate in the project.]

One masters student in the Department of Fish and Wildlife Resources would participate in this project. One undergraduate student would be hired as a field assistant for 6 weeks during the summer of 1995. In addition, field assistance would be provided by two undergraduates working as summer interns at the Taylor Ranch, a field station which is located near the Bighorn Crags lakes and which is operated and administered by the Wilderness Research Institute and the College of Forestry, Wildlife and Range Sciences. I also anticipate that one additional undergraduate will be available through work-study to participate and assist with laboratory analyses.

SECTION V. DETAILED PROJECT/ACTIVITY BUDGET

Proposed Date June 1, 1995 Proposed Completion Date May 31, 1996

Project Number _____ Project Title Limnology of High Mountain Lakes in the Bighorn Crags Region of the Frank Church - River of No Return Wilderness

Principal Investigator(s) Kirk Lohman

All categories of funding must be supported by a written budget justification (e.g. travel - one out-of-state trip to annual meeting at a cost of $500.00, one airfare $199.00/per diem $100/lodging $200.00, etc.)

		Federal	Non-Federal			
SALARIES	FTE%	FUNDING	UNIVERSITY	AGENCIES	OTHER	TOTAL
Faculty Name(s) Rate						
_____ $/Hr _____	____	_____	_____	_____	_____	_____
_____ $/Hr _____	____	_____	_____	_____	_____	_____
_____ $/Hr _____	____	_____	_____	_____	_____	_____
Professional Staff Name(s) Rate						
Masters Student $/Hr 833/mo	0.75	$7,497	_____	_____	_____	_____
_____ $/Hr _____	____	_____	_____	_____	_____	_____
_____ $/Hr _____	____	_____	_____	_____	_____	_____

Classified Staff Name(s) Rate _____ $/Hr _____ _____ $/Hr _____ _____ $/Hr _____							
Irregular Help Name(s) Rate Field Assistant $/Hr 6/hour (6 weeks) _____ $/Hr _____ _____ $/Hr _____		$1,440					
SALARY SUB-TOTAL							
EMPLOYEE BENEFITS **Faculty/Professional Staff** **Over $30,000 27.5%** **Under $30,000 33.5%** **Classified Staff 27.5%** **Graduate Students 1.0%** **Permanent Irregular Help 25.0%** **Irregular Help 13.0%**		 75 187					
OPERATING EXPENSES Publication Supplies Laboratory Other		 500 1,050					
CAPITAL OUTLAY Non-Expendable Equipment Special Purpose Equipment							

SUBCONTRACT OR CONSULTANTS						
TRAVEL In State Out of State		700				
OTHER DIRECT COSTS						
SUB-TOTAL OF ALL CATEGORIES		11,449				
INDIRECT COSTS* Current Rate 30.7 (Indicate rate used)		3,515				
TOTAL ESTIMATED COSTS		$14,964				

EMPLOYEE BENEFITS: If your proposal orginates from a non-University of Idaho department (e.g., Idaho State University, Boise State University), please provide employee benefit percentage rates and indirect cost rates. Should the proposal be funded support documentation will need to be provided.

INDIRECT COST RATES:

Type	Effective Period From	To	Rate	Location	Applicable to
Predetermined	7/1/94	6/30/95	43.0	On Campus	Organized Research
Predetermined	7/1/94	6/30/95	25.0	Off Campus	Organized Research
Predetermined	7/1/94	6/30/95	38.9	On Campus	Instruction
Predetermined	7/1/94	6/30/95	18.3	Off Campus	Instruction
Predetermined	7/1/94	6/30/95	30.7	All Campus	Agriculture and Forestry Experiment Station

IMPORTANT: If you choose to provide graduate tuition support, this cost must be identified separately in your budget.

* Indirect costs may be used as matching.

Budget Justification

Please provide a written budget justification for each category. Be as specific and as detailed as possible.

Salaries	9 months of support for a masters student 6 weeks of support for a summer field assistant
Operating	Publication costs of $500 (5 pages at $100/page) Laboratory expenses of $1,050 (water chemistry analysis, chemicals, sampling bottles)
Capital Outlay	
Subcontract or Consultants	
Travel	Travel from Moscow to Bighorn Crags and back; food costs while camping at Bighorn Crags
Other	

Instructions: USGS specifies the following format exactly as it appears. Please complete each section. Should you need additional space, attach a separate piece of paper and note the letter appropriate to the section being addressed in the upper right-hand corner. Do not deviate from the format provided and address only the area which is specified in each section. Please do not consolidate section areas.

PROJECT SYNOPSIS

1. PROJECT NUMBER _____ (to be completed by IWRRI)

2. TITLE Limnology of High Mountain Lakes in the Bighorn Crags Region of the Frank Church - River of No Return Wilderness

3. COWRR CATEGORY _____ (to be completed by IWRRI)

4. KEYWORDS Mountain Lakes, Limnology, Wilderness

5. DURATION June 1, 1995 through May 31, 1996
(month/year to month/year use actual beginning and estimated ending month/year for projects continuing from earlier grants or expected to continue beyond the 1991 grant)

6. FISCAL YEAR 1995 FEDERAL FUNDS $14,964 (Total) $ 11,449 (Direct) $ 3,515 (Indirect)

7. FISCAL YEAR 1995 NON-FEDERAL FUNDS $_____ (Total) $_____ (Direct) $_____ (Indirect)

8. NAME(S) DEPARTMENT(S) AND UNIVERSITY OF PRINCIPAL INVESTIGATOR(S)

Kirk Lohman, Dept. of Range Resources/Fish and Wildlife Resources

9. CONGRESSIONAL DISTRICT OF UNIVERSITY PERFORMING RESEARCH 1

C:\wp51\forms\synopsis.pro

11. STATEMENT OF RESULTS, USES AND POTENTIAL BENEFITS OF THE RESEARCH TO IWRRI PRIORITIES (refer to attached list) **10%**

[What is expected to be gained by use of the grant during the performance period or by the end of the project, if of longer durarion, and how will the results be used. (2 paragraphs maximum)]

The results of this research will identify current water quality conditions in lakes of the Bighorn Crags region. This study will report nutrient (nitrogen and phosphorus) and chlorophyll *a* concentrations which can be used to characterize trophic status. Measurements of alkalinity and pH will be used to assess the buffering capacity of lakes within the region. These results, together with measurements of other water quality variables (temperature, Secchi disk transparency, specific conductance, total suspended solids), will help describe water chemistry and trophic conditions within the Bighorn Crags lake district.

Water quality data collected on the lakes of the Bighorn Crags region will provide baseline information which can be used to assess future changes in lake water quality. Lakes in the area may be affected by nutrient additions originating from nonpoint sources such as recreational use. These lakes may also be sensitive to changes in pH and the effects of acidic deposition. Baseline data on current conditions will provide essential information for assessing future changes in water quality.

13. **METHODS, PROCEDURES AND FACILITIES** **15%**

[Provide sufficient information to permit evaluation of the technical adequacy of approach to satisfy objectives.]

The Study Area

The Bighorn Crags region lies at the eastern edge of the Frank Church-River of No Return Wilderness in Lemhi County, Idaho. The region is characterized by steep granite pinnacles and walls, and by small cirque lakes. Mt. McGuire, at the northern end of the Crags, is the highest peak in the area at 3073 m. There are numerous subalpine lakes within the area at elevations of 2200-2800 m. Most lakes within the Bighorn Crags area were stocked with trout by Idaho Fish and Game prior to 1983, and many lakes receive considerable fishing pressure (USDA Forest Service 1986).

Methods

Approximately 30 lakes within the Bighorn Crags region will be chosen for sampling. In 1994, surveys of amphibian populations were conducted in Bighorn Crags lakes (Charles Peterson, Idaho State University, personal communication), and my sampling efforts will attempt to include all lakes for which such data was collected. Lake and watershed area will be estimated from 7.5 minute maps for each lake selected.

Field work will begin when lakes within the region are open, which is generally sometime in early July. Lakes will be reached by hiking from either the Crags Campground on the east side of Bighorn Crags or from Taylor Ranch on the west side.

Lakes will be surveyed during the period of July-August. Each lake will be visited on 2 occasions and sampled using a small inflatable boat. Field measurements at each lake will include temperature, specific conductance, Secchi disk transparency, maximum depth, alkalinity, and pH. On each visit, water samples will be collected in triplicate from the deepest part of the lake for later laboratory analysis. Water collected for analysis of total nitrogen and total phosphorus will be preserved by acidification in the field. Samples collected for ammonia, nitrate, and soluble reactive phosphorus will be filtered with a hand pump prior to acidification. Total suspended solids will be measured by pumping known amounts of lake water through pre-weighed Whatman filters. Samples collected for chlorophyll *a* will be filtered onto Gelman glass fiber filters and stored in the dark with desiccant until returned to the laboratory where they will be stored in a freezer.

Total nitrogen will be analyzed in the laboratory by cadmium reduction after persulfate oxidation and nitrate by cadmium reduction (D'Elia et al. 1977). Ammonia will be measured in the laboratory by the phenylhypochlorite method (Solorzano 1969). Soluble reactive phosphorus will be determined using the ascorbic acid method and total phosphorus using the ascorbic acid method after persulfate oxidation (Prepas and Rigler 1982). Chlorophyll *a* will be analyzed spectrophotometrically after ethanol extraction (Sartory and Grobbelaar 1984). Other chemical analyses will be conducted according to APHA (1993).

14. RELATED RESEARCH **10%**

[Show by literature and communication citations the similarities and dissimilarities of this proposed project with ongoing research on the same topic.]

High mountain lakes are considered particularly sensitive to environmental changes (Nauwerck 1994). These lakes are generally characterized by dilute water chemistries, because drainage basins are small and composed of relatively insoluble and uneroded parent materials (Pennak 1963). As a result, changes in water chemistry may occur rapidly in response to changes in chemical loading from the atmosphere or from watershed activities. High mountain lake are also relatively simple ecosystems and small changes in physical or chemical conditions may potentially alter biological conditions. The prompt reaction of such lakes to environmental stress makes them good 'early warning systems' for identifying signs of perturbations (Nauwerck 1994).

Eutrophication and acidification are both potential water quality problems in high mountain lakes. Subalpine and alpine lakes are almost always nutrient-poor and watershed activities that increase nutrient loading potentially alter aquatic productivity and species composition. The susceptibility of lakes to such changes is influenced by elevation, watershed characteristics, and lake morphometry. Larson et al. (1994) surveyed 27 lakes in Mount Rainier National Park and found differences in nutrient chemistry between forested and subalpine lakes. They suggested that differences were predictable based on elevation, lake surface area, depth, and watershed size. Limited buffering capacity also makes most high mountain lakes susceptible to acid deposition. The sensitivity of high mountain lakes to acidification has received considerable attention in Europe (Marchetto et al. 1994, Nauwerck 1994, Viaroli et al. 1994). In a survey of 719 lakes in the western United States, Eilers et al. (1988) found that a high proportion were extremely dilute and had low acid neutralizing capacities, although very few exhibited pH values less than 6.0.

Studies done in the Frank Church-River of No Return Wilderness suggest that the water chemistry of lakes within the Bighorn Crags region is probably very dilute and also that the chemistry of some lakes has a high likelihood of being influenced by recreational use. Water chemistry of 9 streams within the Frank Church-River of No Return Wilderness was described by Buettner (1987). His survey reported that stream concentrations of inorganic nitrogen and inorganic phosphorus were low, with nitrate ranging from <10 to 150 µg/L, and phosphate from <3 to 9 µg/L. Alkalinities within the same streams ranged from 18 to 92 mg $CaCO_3$/L and were consistently lower in headwater streams as compared to downstream reaches. These results suggest that values for nitrogen, phosphorus, and alkalinity in lakes of the Bighorn Crags, which are within the same region but at higher altitude, are likely to have both very dilute nutrient concentrations and alkalinities. The impact of camping on vegetation at 4 lakes in the Bighorn Crags was investigated by Coombs (1976) Her study documented heavy use and significant trampling of vegetation at more accessible campsites. The continued popularity of lakes in the Bighorn Crags for hiking, camping, hunting, and fishing (USDA Forest Service1986), indicates a high potential for increased nutrient loading These activities could increase loading directly by the addition of human or animal wastes or indirectly through soil compaction and erosion.

16. INVESTIGATOR'S QUALIFICATIONS **10%**

[Include narrative explaining relationship of your background to proposed project, as well as a current vitae for each investigator (not to exceed 3 pages or list more than 15 pertinent publications).]

I have a Ph.D. in fisheries with an emphasis in limnology. My graduate work focused on the limnology of small streams and rivers, with particular emphasis on nutrient conditions and primary productivity. In addition, I have worked on projects concerning lake water chemistry and eutrophication in Nepal and Costa Rica. Much of the work in Costa Rica dealt specifically with limnological conditions in high mountain lakes. I have also investigated nutrient enrichment and its effects on primary and secondary productivity in the Clark Fork River in Montana. I am familiar with both the field and laboratory aspects of water sampling and chemical analysis, as well as with the logistical difficulties of sampling remote mountain lakes.

(curriculum vitae attached)

COLLEGE TEACHING EXPERIENCE

Riparian Ecology
Wildland Field Ecology
Stream Ecology
Fish Ecology
Limnology
Animal Population Dynamics (laboratory)
Fisheries Management (laboratory)
General Biology (laboratory)

PROFESSIONAL SOCIETIES

American Fisheries Society
North American Benthological Society
American Society of Limnology and Oceanography
International Association for Theoretical and Applied Limnology
Missouri Bar Association

HONORS AND AWARDS

National Academy of Sciences Young Investigator Program on Agricultural Impacts on Water Quality in Latvia and Lithuania, 1994
Graduate Student Teaching Award (Fisheries and Wildlife), 1988
Superior Graduate Student Achievement Award (Fisheries), 1988
University of Missouri School of Law Award for Environmental Law, 1980
University of Missouri School of Law Award for Land Use Law, 1980
University of Missouri School of Law Award for Local Government Law, 1980

PUBLICATIONS

Lohman, K., Jones, J.R., and B.D. Perkins. 1992. Effects of nutrient enrichment and flood frequency on periphyton biomass in northern Ozark streams. Canadian Journal of Fisheries and Aquatic Sciences 49: 1198-1205.

Lohman, K., and J.C. Priscu. 1992. Physiological indicators of nutrient deficiency in *Cladophora* in the Clark Fork of the Columbia River, Montana. Journal of Phycology 28:443-448.

Lohman, K., Priscu, J.C., Kangatharalingam, N., Wang, L., and R.G. White. 1992. Nutrient enrichment effects on the growth of benthic algae, macroinvertebrates, and young-of-the-year salmonids in experimental troughs. Annual report to the Soap and Detergent Association and Stone Container Corporation.

Lohman, K., Jones, J.R., and C. Baysinger-Daniel. 1991. Experimental evidence for nitrogen limitation in a northern Ozark stream. Journal of the North American Benthological Society 10: 14-23.

Lohman, K., and J.C. Priscu. 1991. Nutrient enrichment and the development of nuisance algal growth in the upper Clark Fork. Annual report to the Soap and Detergent Association and Stone Container Corporation.

17. TRAINING POTENTIAL **15%**

[Estimate the number of graduate students, fields of speciality and degrees expected to result from participation in the project--also estimate the number of undergraduate students expected to participate in the project.]

One masters student in the Department of Fish and Wildlife Resources would participate in this project. One undergraduate student would be hired as a field assistant for 6 weeks during the summer of 1995. In addition, field assistance would be provided by two undergraduates working as summer interns at the Taylor Ranch, a field station which is located near the Bighorn Crags lakes and which is operated and administered by the Wilderness Research Institute and the College of Forestry, Wildlife and Range Sciences. I also anticipate that one additional undergraduate will be available through work-study to participate and assist with laboratory analyses.

Classified Staff Name(s) Rate _____ $/Hr _____ _____ $/Hr _____ _____ $/Hr _____						
Irregular Help Name(s) Rate Field Assistant $/Hr 6/hour (6 weeks) _____ $/Hr _____ _____ $/Hr _____		$1,440				
SALARY SUB-TOTAL						
EMPLOYEE BENEFITS Faculty/Professional Staff Over $30,000 27.5% Under $30,000 33.5% Classified Staff 27.5% Graduate Students 1.0% Permanent Irregular Help 25.0% Irregular Help 13.0%		75 187				
OPERATING EXPENSES Publication Supplies Laboratory Other		500 1,050				
CAPITAL OUTLAY Non-Expendable Equipment Special Purpose Equipment						

Budget Justification

Please provide a written budget justification for each category. Be as specific and as detailed as possible.

Salaries	9 months of support for a masters student 6 weeks of support for a summer field assistant
Operating	Publication costs of $500 (5 pages at $100/page) Laboratory expenses of $1,050 (water chemistry analysis, chemicals, sampling bottles)
Capital Outlay	
Subcontract or Consultants	
Travel	Travel from Moscow to Bighorn Crags and back; food costs while camping at Bighorn Crags
Other	