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Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho

George L. Bloomsburg
Director

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Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho 83843

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Abstract

This report addresses the research and information dissemination activities of the Idaho Water Resources Research Institute during the 1987 fiscal year. Synopses are presented for the following research projects: Groundwater Management Under the Appropriation Doctrine--Part III; Developing an Integrated Model for Evaluating the Economic and Ecologic Effects of Reducing Nonpoint Source Pollution in a Palouse Watershed; Groundwater Contamination from Agriculturally Applied Pesticides; Development and Demonstration of Pump Station and Surface Diversion Systems for Water and Energy Efficiency Improvements; Application and Testing of an Index of Biotic Integrity to Assess the Land Use Activities on Receiving Streams in Idaho; Adsorptive Separation Methods; Use of Multivariate Modeling to Estimate Impacts of Groundwater Withdrawals on Streamflow for the Camas Creek Basin and Mean Annual Precipitation Map for Idaho. Information dissemination and workshop activities are also reported.

Water Problems and Issues for the State of Idaho

The important water issues in Idaho are water allocation and management and water quality. The culmination of the water allocation problems has resulted in the Swan Falls agreement. This agreement defines the amount of water that the Idaho Power Company receives for power production at the Swan Falls dam, as well as the amount of water available for upstream agricultural development. Adjudication proceedings have begun for the entire Snake River drainage. This process may take as many as 10 years to resolve. Currently, the Department of Interior, Idaho Department of Water Resources and other state agencies are in negotiations with the Sho-Ban Indian tribe and various other Indian tribes concerning federal reserve water rights. An "offshoot" of this highly focused and important issue is the support of a study committee that FERC (Federal Energy Regulatory Commission) commissioned to address the methods and and procedures involved in maintaining mimimum flows.

In northern Idaho water allocation and management is not as important an issue as in southern Idaho where irrigated agriuclture is more widely practiced. Water quality of recreational lakes in north Idaho, however, is an important issue. This is shown by the organization of several lakeshore property owner groups, which have funded water quality studies on Twin Lakes, Spirit Lake, Cocalolla Lake, Hayden Lake and Kidd Island Bay in Lake Coeur d'Alene. In general, the water quality of these lakes is very good, but there are signs of cultural euthrophication such as reduced clarity and increased algae and weed growth. The water quality of Lake Pend Oreille has recently become of interest because the paper mill upstream near Missoula, Montana is discharging wastes into the Clark Fork which then flows in Lake Pend Oreille. The discharge of mine tailings into the Coeur d'Alene river over the last 100 years had led to degradation of the water quality in Lake Coeur d'Alene and higher than normal lead levels in fish in the lake. Many of these problems could be managed if money were available for research addressing management alternatives.

Idaho has been blessed with a plentiful supply of clean water, and it is up to us to maintain that supply and use it in a manner beneficial to the entire state.

Program's Goals and Priorities

The basic goals and priorities of the Institute's program are as follows:

1. To promote research that is relevant to state and regional needs for conservation of water and related land resources with emphasis on economic resource development, preservation and enhancement of environmental quality and social well being of people.

2. To stimulate, coordinate and provide leadership for water resources research in the established units of the universities of the state of Idaho and to cooperate with sister institutions in adjoining states. Such research should utilize an interdisciplinary approach and provide opportunities for training of students.

3. To cooperate with and help local entities, state and federal government agencies to carry out their responsibilities concerned with water and related land resources and to provide public involvement in identifying research needs.

4. To provide for dissemination of research findings in an expeditious and comprehendable manner to interested persons.

5. To develop funding for needed research and to encourage cooperation with regional research organizations in conducting an efficient and productive research effort.

Solving any of these water resource problems in the state involves five steps:

1. The problem must be identified by consultation with people affected by the problem.

2. An individual or several individuals must be identified who have expertise that may solve the problem.

3. A funding source must be identified which may even be private individuals concerned with the problem.

4. The prospective researcher must develop a proposal and present it to the funding agency or individuals.

5. The research is accomplished and the information disseminated to any persons who may be involved in this or similar problems.

The majority of research expenditures are for operating expenses and graduate student support with very little for capital outlay or faculty salary.

The money for information dissemination supports a secretarial position and operating expenses for publications. The secretary answers all publication requests and maintains the publication list and reference library and types all the technical completion reports.

Most of the money for administration is partial salary for the associate director who maintains contact with state, federal and private agencies in southern Idaho.

Synopsis

Project Number: 02 *Start:* 06/85
End: 05/88

Title: Groundwater Management Under the Appropriation Doctrine--Part III

Investigators: Ralston, Dale — Department of Geology and Geological Engineering, University of Idaho
Bruhl, Elliot — Department of Geology and Geological Engineering, University of Idaho

COWRR: 06E *Congressional District:* First

Descriptors: Groundwater, management, appropriation, legal aspects

Problems and objectives:
Groundwater is administered and managed in most western states under the appropriation doctrine. A general need exists to better understand the characteristics of groundwater management under the appropriation doctrine. The general objective is to summarize the legal and administrative controls on groundwater use in the states of Montana, Utah, Washington, Oregon, Idaho, Colorado, New Mexico and Arizona and to document and compare the impacts of these controls on groundwater systems.

Methodology:
The research methodology consists of four steps. First, literature on the subject of groundwater management under the appropriation doctrine is reviewed. Second, statutory information is gained from the appropriate supplements. Third, details on administrative history are obtained from state water officials from personal interviews. Fourth, the complied data are analyzed and compared and a report of investigation is prepared.

Principal findings and significance:
State water management agencies often underutilize statutory powers which are available for groundwater management. Difficulty is encountered in applying the priority principal to controlling groundwater pumpage because of the developed management area programs used to identify areas of groundwater overuse and to reduce pumpage. However, in practice, the primary impact of area designation has been to limit further development of groundwater.

The history of groundwater management in the eight states suggests a temporal development pattern of management stages. Each state has chosen a pathway of management that considered the resource as renewable or nonrenewable. Management activities become increasingly complex and restrictive as development proceeds on either pathway.

Publications and professional presentations:
Ralston, D.R., and E.J. Bruhl, 1986. Groundwater Management Under the Appropriation Doctrine, Part I. Research Technical Completion Report, Idaho Water Resources Research Institute, University of Idaho, Moscow, Idaho.

Ralston, D.R., and E.J. Bruhl, 1987. Groundwater Management Under the Appropriation Doctrine, Part II. Research Technical Completion Report, Idaho Water Resources Research Institute, University of Idaho, Moscow, Idaho.

Ralston, D.R., and E.J. Bruhl, 1988. Groundwater Management Under the Appropriation Doctrine, Part III. Research Technical Completion Report, Idaho Water Resources Research Institute, University of Idaho, Moscow, Idaho.

M.S. Thesis:
Bruhl, E.J., (1988). Groundwater Management Under the Appropriation Doctrine. Department of Geology and Geological Engineering, University of Idaho, Moscow, Idaho.

Ph.D. Dissertation:
None

Synopsis

Project Number: 03 *Start:* 06/87
End: 05/89

Title: Developing an Integrated Model for Evaluating the Economic and Ecologic Effects of Reducing Nonpoint Source Pollution in a Palouse Watershed

Investigators: Prato, Tony — Department of Agricultural Economics/University of Idaho
Brusven, Merlyn — Plant, Soils and Entomological Sciences/University of Idaho

COWRR: 06B *Congressional District:* First

Descriptors: Nonpoint pollution sources, ecological effects, economic evaluation, statistical methods

Problems and research objectives:
The problem addressed in this project is to reduce contamination of surface waters from nonpoint source pollution in a Palouse watershed. The objectives of this project are: 1) to test and evaluate the Agricultural Nonpoint Source Pollution (AGNPS) model for the Tom Beall Creek Watershed; 2) to construct a Geographic Information System (GIS) for the Tom Beall Creek Watershed that integrates, displays and analyzes information on land use, geoclimatic conditions, hydrology, economics and water quality; and 3) to develop an integrated resource assessment model for analyzing the effects of different cropping systems and best management practices on nonpoint source pollution in the Tom Beall Creek Watershed.

Methodology:
The AGNPS model is a computer simulation model which estimates the sediment and nutrients in agricultural runoff for given land uses and geoclimatic and hydrologic conditions. AGNPS input data will be collected for the Tom Beall Creek Watershed. The AGNPS model requires the data to be collected on a cell-by-cell basis.

The GIS system employed in this study consists of a Summagraphics Digitizer, IBM-AT microcomputer, Professional Map Analysis Package (PMAP) and Golden Graphics software. This system will be used to format, integrate and output data components of the integrated watershed assessment model. The digitizer will be used to assemble large data sets consisting of land, water and economic components.

An integrated watershed assessment model will be developed. This conceptual model will be formulated using mathematical programming (MP) techniques. MP techniques are appropriate because they permit maximization of an objective function subject to appropriate physical and economic constraints. An appropriate objective function for the MP model is the present value of total net farm income for the watershed. Present value of total net farm income is the sum of the present values of net returns per acre for all agricultural activities in the watershed. Agricultural activities represent a particular combination of crops, tillage practices and cultivation.

Principal findings and significance:
The following has been accomplished:

The AGNPS model was used to estimate erosion and runoff for each of 3,145 cells in the watershed, and sediment, nitrogen, phosphorus and chemical oxygen demand in receiving waters at the watershed outlet. Two watershed management alternatives were analyzed: reducing total erosion to twice the soil tolerance level (2T); and reducing total erosion to the soil tolerance level (1T).

Input data for AGNPS was assembled using a GIS. Four categories of input data were used: rainfall, topography, soil, and land use. A cell size of approximately 3.3 acres was used to allow accurate estimation

of physical conditions in the watershed. Four storm events were simulated: 10 year; 25 year, 50 year and 100 year. All four events assume a 24-hour rainfall.

Net returns per acre for each RMS were estimated using EROPLAN, a discounted cashflow model. Cost of production estimates for calculating net returns were estimated using the Microcomputer Budget Management System (MBMS).

The most common farming method used in the watershed, and the one used as the base case, is conventional tillage with contour farming. Two alternative tillage practices (minimum tillage and no tillage) and three land treatment practices (divided slope, contour farming and cross slope farming) were evaluated. Two land use options were considered: a wheat-pea crop rotation, and permanent vegetation.

Optimal resource management systems (RMS) for the two watershed management alternatives were determined by a linear programming model in which the present value of total net farm income was maximized subject to erosion constraints of 2T and 1T.

Results of this analysis indicate that for a 25-year storm event, total erosion decreased 9.6% for the 2T alternative and 56% for the 1T alternative. Sediment and nutrient loadings at the outlet of the watershed decreased substantially. For the 2T alternative, the reductions were 46% for sediment, 39% for nitrogen and phosphorus, and 25% for chemical oxygen demand (COD). For the 1T level, the reductions were 73% for sediment, 65% for nitrogen and phosphorus, and 30% for COD.

When erosion was reduced to 2T minimum tillage replaced conventional tillage causing net farm income to increase 1.5% and erosion to decrease 40%. When erosion was reduced to 1T, net farm income declined between 5 and 18% and erosion decreased 60%. Reducing erosion by more than 70% caused net farm income to fall by more than 30% because it was necessary to replace minimum tillage with no tillage and permanent vegetation.

Progress review:
The first year of pesticide sampling has been completed. A final report will be submitted to the Western Regional Pesticide Impact and Assessment Program in April.

Biological samples are in the final states of processing. Analysis and reporting of specific results will be completed by mid summer.

Chemical sampling of both major nutrients and pesticides is continuing. Second-level research on these parameters will include: bio-accumulation sampling for pesticide residue insect populations within the Lapwai drainage; a longitudinal analysis of chemical and biologic parameters of Lapwai Creek; and an application of in streamflow methodology to insect population analysis of selected sites within the Lapwai drainage.

Publications and professional presentations:
Brusven, Merlyn A., Gene P. Carpenter, Roger Haro, and Ron Rhew. Nonpoint Source Pesticide Contamination of Waters in Idaho Palouse Creeks and Streams and Its Possible Effects on Aquatic Organisms. WRPIAP Technical Progress Report. April 1987.

Brusven, Merlyn A. and Tony Prato. An Integrated Resource Management System for Evaluating Agricultural Nonpoint Source Sediment Pollution. Abstract, Newsletter/Bulletin, Vol. 44, No. 1. The Canadian Society of Environmental Biologists. Summer 1987.

Prato, Tony and Merlyn Brusven. An Integrated Approach to Modeling Agricultural Nonpoint Source Pollution. Soil Conservation Society of America, 42nd Annual Meeting, Billings, MT. August 2-5, 1987.

Prato, Tony and Merlyn Brusven. An Integrated Approach to Managing Agricultural Erosion and Nonpoint Source Pollution. Poster presented at National Symposium on Conservation Systems, American Society of Agricultural Engineers, Chicago, IL, December 14-15, 1987.

Prato, Tony and Merlyn Brusven. An Integrated Approach to Managing Agricultural Erosion and Nonpoint Source Pollution. In "Optimum Erosion Control at Least Cost" Proceedings of the National Symposium on Conservation Systems, ASAE Publication 08-87, American Society of Agricultural Engineers, St. Joseph, MN, December 14-15, 1987.

M.S. Thesis:
Shi, Hong-Qi. Integrated Assessment of Soil Erosion and Water Quality in Idaho's Tom Beall Watershed, Department of Agricultural Economics, University of Idaho, Moscow, ID, December 1987.

Ph.D. Dissertation:
None

Synopsis

Project Number: 04 *Start:* 06/87
End: 05/90

Title: Groundwater Contamination from Agriculturally Applied Pesticides

Investigator: Morra, Matthew J. Plant, Soils and Entomological Sciences/University of Idaho

COWRR: 05G *Congressional District:* First

Descriptors: Pesticides, soil columns, agricultural chemicals, groundwater pollution, pesticide residue

Problems and research objectives:
Groundwater represents the source of 90% of Idaho's public water supply. Preservation of groundwater quality is therefore a high priority within the state, particularly in those areas lacking an alternate source. Groundwater is susceptible to contamination from agricultural amendments including inorganic fertilizers and organic pesticides (i.e. herbicides, insecticides, nematocides, and fungicides). Regular monitoring of pesticide concentrations present in groundwater is not feasible because of the large number of different pesticides used and the lack of a sufficient quantity and distribution of monitoring wells. Groundwater reclamation is costly and difficult, thus necessitating the recognition of potential contamination problems.

Models have been developed for other regions of the country in order to overcome the site-specific problems associated with assessing pesticide movement in soils. Unfortunately such models have not yet proven accurate enough to service as a predictive tool for making management decisions. The lack exists not in the model itself, but from an incomplete understanding of the fundamental principles governing pesticide interactions with soil constituents. Studies are necessary to define the missing parameters governing pesticide mobility in soils so that a useful model can be developed. Accurate pesticide application recommendations are critical since aquifers underlie substantial expanses of agricultural lands through the state and current levels of agricultural production rely upon the continued use of pesticides.

The proposed research is aimed at providing the theoretical support and database to more accurately model pesticide movement in agricultural soils of Idaho. Prevention of future groundwater contamination is hindered because a small, but significant portion of the applied pesticide is transported through the soil column more quickly than predicted by currently available models. It has been proposed and experimentally demonstrated that measureable increases in mobility of pesticides may occur through an interaction of the pesticide with water soluable soil organic materials. The pesticide-water soluable organic complex is proposed to travel faster than the pesticide alone.

The objectives of the research in progress are to 1) develop the methodologies for qualitatively and quantitatively studying pesticide complexation with water soluble soil materials, 2) define the key variables controlling complexation, 3) compare predicted complexation and pesticide mobility alteration with actual results obtained in simulated field situations, and 4) propose a model input variable to produce more accurate estimates of pesticide transport in soil.

Methodology:
Extraction of water soluable soil constituents which possess a potential to complex with pesticides has been conducted. Humic and fulvic acids from six Idaho soils have been extracted and purified for studies involving potential pesticide complexation. Water soluble organic materials were extracted and have been characterized with respect to organic matter content, particle size distrubtion, and pH. These analyses will be used to develop empirical relationships between complexation and the specific soils and pesticides being tested.

The extracted complexing agents have been chemically characterized using state-of-the-art instrumentation. Infrared spectroscopy provides fundamental information concerning the functional group chemistry of the extracted materials. Qualitative pesticide complexation studies are now in progress. Water soluble organic materials and extracted humic and fulvic acids will be complexed with atrazine, glyphosate, metribuzin, dicamba, picloram, or chlorsulfuron at various concentrations. The solution infrared spectra will be recorded and compared to previously recorded spectra for the same materials in the absence of pesticide. The type of intermolecular interactions in solute-soil component binding and the identity of the key functional groups of the various species involved in that binding will be determined.

Quantification of the amount of complexed pesticide is necessary for correlation with solution phase parameters, soil characteristics, and pesticide chemistry. Using relevant absorbance bands a quantitative infrared technique will be developed to determine the amount of pesticide complexed to water soluble organic material. Alternatively, a flow-through equilibrium technique will be used.

The extent of pesticide complexation with water soluble soil materials will be correlated to solution phase parameters of pH and ionic strength and to readily measurable soil parameters. Key variable controlling complexation will be identified. The success of this method depends upon the ability to determine an empirical relationship between the soils used and the amount of pesticide complexation with water soluble soil materials in those soils. Soil core studies will be conducted to compare actual pesticide transport modification by water soluble soil materials to predicted pesticide transport modification as determined above.

The information will be integrated into a model for predicting pesticide mobility in Idaho soils. The goal will be to modify an existing computer model to consider pesticide complexation with water soluble organic materials as a variable affecting pesticide mobility

Principal findings and significance:
Soil humic and fulvic acids represent two distinct pools of possible water soluble complexing agents which may interact with pesticides. Infrared spectroscopy provides fundamental information concerning the type of intermolecular interactions involved in pesticide binding to these materials. However, no infrared studies of aqueous solutions of this materials have been reported in the literature, because of the formidable problems associated with measuring infrared solution spectra in a highly infrared-absorbing solvent such as water. Recently developed instrumentation has made the infrared analysis of aqueous solutions possible. Fourier Transform Infrared spectroscopy (FT-IR) has been combined with a Cylindrical Internal Reflectance (CIR) sample cell to determine the spectra of commerically available humic acid in water at concentrations as low as 0.5 g L^{-1}. Spectral scans from 670 to 4000 cm^{-1} indicate that the region of greatest resolution for observing characteristic humic acid absorbance bands occurs form 1000 to 2000 cm^{-1}. Absorbance bands reflecting esterbonded polysaccharides, aliphatic C-H groups, and carboxyl groups were detected. Comparison of CIR spectra with a Nujol mull spectrum demonstrated increased C-H peak intensities and near total elimination of ester absorbance peaks in the mull preparations. Solution phase parameters were altered to illustrate that the spectra varied with humic acid conformational changes and functional group protonation. The ability to control these parameters is important in that pesticide interactions with humic materials have also been shown to depend on the same three variables.

Infrared studies with natural materials have been performed. Humic and fulvic acids from Idaho soils have been extracted, purified, and analyzed using FT-IR analysis. Water extracts from the same soils have also been obtained and the FT-IR spectra recorded. We have for the first time recorded the FT-IR spectra of these materials without the need for drying, a process which in preliminary studies has been shown to drastically alter their chemical characteristics. It is thus possible using developed techniques to avoid artifacts in sample preparation and to determine the spectra of extracted soil materials in their native wet state. The ability to determine the infrared spectra of humic materials using such methods will prove advantageous in determing humic materials interaction with pesticides. Preliminary infrared studies with pesticide-water soluble soil organic material complexes are in progress.

Publications and professional presentations:
Morra, Matthew J., (in review).FT-IR Analysis of Humic Acid in Water Using Cylindrical Internal Reflectance. Soil Science Society of America Journal. Submitted in April of 1988.

Morra, Matthew J., presentation will be given at the national Soil Science Society of America meetings (November 27-December 2, 1988) in Anaheim, CA.

Lee, C.L., presentation given by undergraduate research assistant at the annual Idaho Academy of Science meetings in April, 1988.

M.S. Thesis:
None

Ph.D. Dissertation:
None

Synopsis

Project Number: 05 *Start:* 06/87
End: 05/88

Title: Development and Demonstration of Pump Station and Surface Diversion Monitor Systems for Water and Energy Efficiency Improvements

Investigator: Brockway, Charles E. Department of Agricultural Engineering/University of Idaho

COWRR: 03F *Congressional District:* First

Descriptors: Flow, irrigation, energy, pumps, open channels, monitoring

Problems and objectives:
Management of water and energy in irrigated agriculture requires measurement on a timely basis of discharge, energy use, and pumping characteristics to determine operation efficiencies and indicate specific system or operation improvements. Low cost electronic monitoring systems are not available. The objectives of this research are to develop low-cost electronic devices for monitoring open channel irrigation diversion rates and pump station discharge, energy use and system efficiency, and to install and demonstrate such units in southern Idaho.

Methodology:
Automatic, electronic data acquisition systems were developed to monitor and record water stage levels on open channel irrigation diversion measurement devices and to monitor pump lift, pressure head, and energy input and discharge on pumping plants. The devices utilized HP41CX calculators as the microprocessor, pressure transducers, and pulse-type wattmeters for energy input signals. The processor stored the measuring device rating curves and calculated and stored daily values of minimum, maximum, and average flow; pump lift, pressure, energy input signals. The processor stored the measuring device rating curves and calculated and stored daily values of minimum, maximum, and average flow; pump lift, pressure, energy input; and, pumping efficiency. Data were stored on EPROM units and transferred to the office for analysis on personal computers. Software for data retrieval and analysis was developed.

Principal findings and significance:
Diversion Monitors:

Two open channel discharge monitors were installed in eastern Idaho during the 1987 irrigation season. One measured water stage and calculated discharge of a broad crested weir previously installed; the other monitored two open channel diversions using modified Stevens F1 stage recorders equipped with variable resistors. The standard HP41CX power supply consisting of 4 N-Cell alkaline batteries was not adequate for long term data collection with 15 minute scans and was replaced with a D-Cell battery pack which alleviated the problem. Another problem occurred when the monitors would erratically lock up due either to adverse shelter environment or long lead wire requirements. This problem is currently being investigated.

Time of Operation Monitors:
Seven exchange wells located in the Teton river fan area were instrumented with four HP41CX monitoring systems. These systems recorded the percent of time each day the exchange well(s) were operated and calculated the daily volume pumped from the wells. Only two of the instrumented wells were operated during the 1987 irrigation season. The monitors interrogated the pumps every fifteen minutes to determine if they were on and recorded the last time they were either turned on or off. The only problems experienced with the monitors in this configuration was a small programming error in which the wrong file size was created.

Pump Station Efficiency and Diversion Monitors:
Six pump station monitors were installed in eastern Idaho and four were to be installed in southern Idaho during the 1987 irrigation season. Only one of the monitors was installed in southern Idaho due to equipment arrival and scheduling problems. Flow sensor electronic interface problems were experienced on these units; however, all units were operable by mid September of 1987. Four of the monitors in eastern Idaho experienced problems with the watt hour meter interfacing and this problem is being resolved at this time. Pumping efficiencies ranging from 28 to 74 percent were measured.

Results showed that the HP41CX based units are cost effective, and a relatively easy program to install. The same units will be installed during the 1988 irrigation season to obtain further performance data.

Publications and professional presentations:
Brockway, C.E., 1988. Development and Demonstration of Pump Station and Surface Diversion Monitor Systems for Water and Energy Efficiency Improvements. Technical Completion Report, Idaho Water Resources Research Institute, University of Idaho, Moscow, Idaho.

M.S. Thesis:
None

Ph.D. Disseration:
None

Synopsis

Project Number: 06 *Start:* 06/87
End: 05/88

Title: Application and Testing of an Index of Biotic Integrity to Assess the Impact of Land Use Activities on Receiving Streams in Idaho

Investigators: Bennett, David H. Department of Fisheries/University of Idaho
Fisher, Timothy R. Department of Fisheries/University of Idaho

COWRR: 05C *Congressional District:* First

Descriptors: Fish, streams, land use, indexing

Problems and objectives:
One principal goal of water resources management is to maintain the ecological integrity of aquatic systems. Although ecological integrity includes physical, chemical, and biological components, standards used to assess the quality of aquatic resources have been almost exclusively based on monitoring concentrations of various contaminants. However, monitoring has very limited application when dealing with nonpoint sources of pollution. Since an ability to sustain a balanced biotic community is probably the best indicator of watershed conditions, monitoring programs should assess the condition of "health" of biological communities.

Substantial evidence exists that fish communities can be used to assess human influence on the biological integrity of freshwater ecosystems. Numerous groups of organisms have been proposed as indicators of environmental health, but none has emerged as being more commonly used or accepted. Recently, in other parts of the United States fish have been used as indicators of stream "health."

To assess stream "health" the index of biotic integrity (IBI) has been developed. The IBI has been based on three fish community charactertistics (metrics): trophic composition (insect versus fish feeders), species composition, and fish health. Suitable fish community attributes or metrics that show a consistent relationship with the severity of stream degradation are used. Metrics are scored against those obtained from streams having a relative absence of human influence. Differences in the scores of the various metrics provide a measure of the extent of stream degradation due to land use activities. Results of this project will provide an index of stream health of Idaho streams.

Specific objectives were to:
1. To develop an index of biotic integrity applicable to Idaho headwater streams.
2. To evaluate, refine, and test the index of biotic integrity to assess the health of Idaho streams.
3. To compare evaluations of stream health using the IBI with those of other specific measures, such as substrate embeddedness, water chemistry and stream channel morphology.

Methodology:
Initial efforts to develop suitable metrics for aquatic animal communities in northern Idaho were initiated in June 1987. Forty-nine headwater streams of order two to five in the North Fork Clearwater, St. Joe, St. Maries, Coeur d'Alene, and Priest Lake systems in northern Idaho were selected from drainages that presented a wide gradient of habitat quality. Stream quality ranged from poor to pristine.

Fish, amphibians, and aquatic invertebrates were sampled from a 50 to 100 m section representative of that stream. Vertebrate (fish and amphibians) sampling included electrofishing a 50-100 m reach of the stream that encompassed a typical sequence of riffle, pool, and run habitats. Salt was added at the head of the stream reach to increase the typically low water conductivity found in Idaho headwater streams. Fish and amphibians collected were identified, weighed and measured, and returned to the stream. Invertebrates were

collected by taking four samples with a Surber sampler in a riffle area with the stream reach, and preserved in FAA for later laboratory identification.

Also at each location, data on stream width, depth, and flow, instream and riparian vegetation, substrate embeddedness, water conductivity and alkalinity, and water and air temperature were collected. Additional data gathered after the field collecting, included the elevation of the sample site, the drainage area of the stream channel gradient, and the amount of timber harvest and road density in the drainage. Stream elevation, order, and drainage area were obtained from USGS (scale 1:20,000) topographic maps. The extent of harvest and roading of each watershed was determined through consultation with personnel from the U.S. Forest Service at Orofino, St. Maries, Avery, Wallace, and Priest Lake, and the Idaho Department of Lands.

Principal findings and significance:
Fish, amphibian, and invertebrate data are being analyzed as "candidate" metrics for inclusion into the IBI. Multivariate data analysis has shown that the candidate metrics did significantly vary with stream physical characteristics but not with quality. Physical variables which most contributed to the principal components were shreve link number (measure of stream size), discharge and drainage area. We have used these measures for cluster analysis.

We have found that road density (Km/Km^2) and harvest area vary with stream quality. Cobble embeddedness (%) was highest for streams considered to represent a medium level of quality and lowest for the lowest level of quality. Number of fish and amphibian species, number of salmonid species, density ($No./m^2$) of tailed frog larvae, Shannon diversity of fish and amphibians (numbers and biomass), index of well being, and Brillouin's diversity of fish and amphibians all showed decreases with decreasing quality.

After completion of the multivariate analysis, candidate metrics will be incorporated into an IBI. We will then evaluate the sensitivity and accuracy of the IBI by using several streams that were not included in the overall data analysis.

Publications and professional presentations:
None

M.S. Thesis:
Fisher, Timothy, in progress (1988). Establishing an Index of Biotic Integrity for Idaho Headwater Streams. Department of Fisheries, University of Idaho, Moscow, Idaho.

Ph.D. Dissertation:
None

Synopsis

Project Number: 07 *Start:* 06/87 *End:* 12/88

Title: Adsorptive Separation Methods

Investigator: Carleson, Thomas E. Department of Chemical Engineering/University of Idaho

COWRR: 05F *Congressional District:* First

Descriptors: Groundwater, adsorption, heavy metals, separation, pollutants

Problems and research objectives:
Removal of trace amounts of heavy metals such as zinc and cadmium by chelation with organic compounds and separation from groundwater by adsorption at gas-liquid interfaces (foaming) or solid-liquid interfaces (activated carbon adsorption) will be evaluated experimentally and correlated by thoeretical models of the process.

Methodology:
Laboratory scale foam generation columns will be used to experimentally strip chelated heavy metals from their solutions. The effects of chelating agent and metal concentration as well as operating parameters upon the separation efficiency will be elevated and correlated with a simple mathematical model of the process. The concentrated chelated metal will be adsorbed on activated carbon for eventual desorption and reclamation.

Principal findings and significance:
Work is continuing on the evaluation of the foam separation. Chelation of zinc and cadmium with sodium dodecyl sulfate and separation in a sparged gas column resulted in removal of more than 90% of the metal. Optimum gas/liquid flow rate ratios and column lengths were identified.

Publications and professional presentations:
Carleson, Thomas E., November 1987. Presentation: Removal of Low Concentrations of Cadmium from Water by Chelation and Foam Separation, American Institute of Chemical Engineers.

Carleson, Thomas E., Fall 1988, Presentation made at: AIChE Meetings, Los Angeles, CA.

Carleson, Thomas E. and M. Moussavi, 1988. Chelation and Foam Separation of Metal Ions from Solutions. Submitted to Separation Science and Technology.

M.S. Thesis:
Brazil, Brian, January 1989. Foam Separation of Heavy Metals from Groundwaters, Department of Chemical Engineering, University of Idaho, Moscow, Idaho.

Ph.D. Dissertation:
None

Synopsis

Project Number: *08* Start: *06/87* End: *05/88*

Title: Use of Multivariate Modeling to Estimate Impacts of Groundwater Withdrawals on Streamflow for the Camas Creek Basin

Investigators: Horn, Dennis — Department of Civil Engineering/University of Idaho
Jeong, Sangman — Department of Civil Engineering/University of Idaho

COWRR: 06B *Congressional District:* First

Descriptors: Groundwater, multivariate analysis, streamflow

Problems and research objectives:
The conjunctive use of surface and groundwater has been recognized as posing significant water rights issues in many of the Idaho river basins. Increases in groundwater pumping rates, primarily for irrigation, have led to changes in surface streamflow, affecting the previously allocated surface water rights. However, the magnitude of this effect and its variability over time remain difficult to estimate.

The primary objectives of this research were to develop a multivariate monthly flow model for Camas Creek, based on streamflows in neighboring basins, and to test whether such a model is sensitive enough to detect, at some statistical level of significance, any streamflow changes that may have resulted from groundwater withdrawals.

Methodology:
Monthly streamflow records from Camas Creek and three similar neighboring basins were used to develop a multivariate monthly streamflow model of Camas Creek. Model parameters were based on the record statistics for the common record period prior to groundwater development within the Camas basin. Once the model was developed and tested for its ability to adequately reproduce the historic pre-irrigation time series for Camas Creek, it was applied to the time period of significant groundwater pumping effects on the monthly, seasonal, and annual streamflows. The differences between the two time series were related to the history of groundwater development within the basin.

Principal findings and significance:
Although the model appeared to simulate the overall historic time series reasonably well, its performance varied by month and season. The poorest agreement between modeled and observed flow occurs in the peak spring runoff months, and is probably attributable to variations in snowpack among the four basins used in the model development.

The application of the model to the time period in which the Camas basin groundwater withdrawals are significant produced a simulated record with higher streamflows than the observed streamflow. Preliminary findings indicate that this may be attributable to the fact that most of the large wells have pumped from deep aquifers, with little or no connection to the surface stream system.

Publications and professional presentations:
None

M.S. Thesis:
None

Ph.D. Dissertation:
Sangman, J., July 1988. Estimate of Impacts of Groundwater Pumping on Streamflow by Multivariate Modeling, Department of Civil Engineering, University of Idaho, Moscow, Idaho.

Synopsis

Project Number: 32 *Start:* 06/87
End: 05/89

Title: Mean Annual Precipitation Map for Idaho

Investigators: Molnau, Myron — Department of Agricultural Engineering/University of Idaho
Winters, Francis — Department of Geography/University of Idaho

COWRR: 10A *Congressional District:* First

Descriptors: Precipitation, maps

Problems and objectives:
Current research in the state of Idaho regarding runoff, evapotranspiration, revegetation potential, hydropower, irrigation and a host of related disciplines, has made apparent a need for sound estimates of the distribution of precipitation throughout the state. The current map of mean annual precipitation (MAP) was compiled by the NWS in 1965. This map has been shown to be inaccurate, especially at higher elevations. The specific objective of this research is to develop a map of Idaho showing the mean annual precipitation as well as its temporal variability. The map will be presented in both printed form and digital form.

Methodology:
YEAR 1 The following are the steps which were completed in the first year of this study:

1. Assemble all available monthly precipitation data for the study area (Idaho and portions of the surrounding states).

2. Quality control - look up missing data records and perform mass curve and multiple correlation to estimate missing values.

3. Compute mean, standard deviation, and Cv for all data points for monthly, annual, October through March and April through September periods.

4. Plot preliminary MAP map. This was done in a computer mapping package. Cv will be shown either on the same map as the precipitation values or on a separate sheet, depending upon its pattern.

YEAR 2 The following steps involved with the final MAP map production will be completed in the second year of the project:

1. The map will be plotted using computer interpolation techniques at scale of 1:250,000.

2. The lines on the initial map will be manually adjusted using 1:250,000 scale topography sheets, the original data, soils and vegetation data, the old MAP map, Landsat imagery, and area elevation curves. Records as to the confidence level for each area of the map will be kept and displayed on the final map. After three or four quads have been completed they will be sent to SCS and BLM for review and comments. The following will be produced:

    1. Two sets of mylar overlays one at 1:250,000 and one at 1:1,000,000 of annual and October thru May precipitation.

    2. The above in digital form.

3. A printed map at 1:1,000,000 with isohyets over an Idaho base map.

4. A graduate thesis and an Agricultural Experiment Station bulletin.

Principal findings and significance:
The data for 1961-1985 has been entered into a microcomputer database. Any data fields which were thought to be missing were flagged and are being looked up to verify their values. A large majority of the missing fields have an actual value of 0.0 or trace precipitation. In the event of trace precipitation a value of 0.0 was entered and the flag was changed to "T". Old programs have been modified and new ones written in Fortran to compute the mean from the monthly data, record the appropriate station number, latitude and longitude. These values are read by another program which converts the latitude and longitude to UTM coordinates. The output can easily be read by Surfer (Golden Software Topographic Mapping Package). The first map of MAP has been plotted at a small scale to test the entire process. This map can be used for comparison as missing data verification and estimation continues. Intitial graphs of Cv for the various climatic regions of the state have been started and will be compared with plots of Cv taken from individual data points.

Publications and professional presentations:
None

M.S. Thesis:
None

Ph.D. Dissertation:
None

Information Transfer Activities

The principal information transfer activities were:

1. During the 1987 grant period an irrigation workshop was held at Kennewick, Washington on November 5 and 6. The irrigation workshop addressed water use and management. The audience was primarily irrigation managers and engineers. The purpose of this workshop was to inform the participants of the most recent research results available.

   A Water Resources Seminar was held during the Fall semester 1987-88. The topic was Problems Associated with the Northwest Power Planning Council's New Program of the Water Budget. Six students enrolled in this class.

   A Groundwater Workshop was held in April 1988 at Idaho Falls and Boise, Idaho. The audience was primarily engineers and hydrologists.

2. The Director attended 20 meetings of various water user and property owners groups. Following is a list:

Computational Hydrology Symposium	07/15/87	Los Angeles, CA
Water Quality Hearing	07/22/87	Lewiston, ID
Coeur d'Alene Lakeshore Owners Meeting	09/13/87	Post Falls, ID
Northwest Water Pollution Control Conference	10/26/87	Spokane, WA
Coeur d'Alene Forum Organizational Meeting	10/28/87	Cheney, WA
Regional Director's Meeting	11/12/87	Honolulu, HI
EPA Water Quality Workshop	12/14/87	Seattle, WA
Coeur d'Alene Forum Organizational Meeting	01/04/88	Moscow, ID
Coeur d'Alene Forum Organizational Meeting	01/21/88	Cheney, WA
EG&G, Inc. Meeting for Proposal Collaboration	03/12/88	Idaho Falls, ID
Clark Fork Coalition/Water Quality Meeting	03/26/88	Sandpoint, ID
Coeur d'Alene Forum Organizational Meeting	03/30/88	Cheney, WA
Idaho Wildlife Federation-Speaker	04/09/88	Sun Valley, ID
Coeur d'Alene Forum Organizational Meeting	04/27/88	Moscow, ID
NAWID	05/03/88	Washington, DC
Coeur d'Alene Forum Organizational Meeting	05/18/88	Cheney, WA

Division of Environment/Seminar Participant	05/20/88	Boise, ID
Policy Advisory Committee Meeting	05/24/88	Idaho Falls, ID
Coeur d'Alene Forum	06/04/88	Coeur d'Alene, ID

3. A total of two newsletters were printed during the year which contained such information as activities of the Institute, other activities associated with water in the state, calendar of events and director's comments.

4. The professional publications submitted during the year are as follows:

Brusven, Merlyn A. and Tony Prato. An Integrated Resource Management System for Evaluating Agricultural Nonpoint Source Sediment Pollution. Abstract, Newsletter/Bulletin, Vol. 44, No. 1. The Canadian Society of Environmental Biologists. Summer 1987.

Prato, Tony and Merlyn Brusven. An Integrated Approach to Modeling Agricultural Nonpoint Source Pollution. Soil Conservation Society of America, 42nd Annual Meeting, Billings, MT. August 2-5, 1987.

Prato, Tony and Merlyn Brusven. An Integrated Approach to Managing Agricultural Erosion and Nonpoint Source Pollution. Poster presented at National Symposium on Conservation Systems, American Society of Agricultural Engineers, Chicago, IL, December 14-15, 1987.

Prato, Tony and Merlyn Brusven. An Integrated Approach to Managing Agricultural Erosion and Nonpoint Source Pollution. In "Optimum Erosion Control at Least Cost" Proceedings of the National Symposium on Conservation Systems, ASAE Publication 08-87, American Society of Agricultural Engineers, St. Joseph, MN, December 14-15, 1987.

Morra, Matthew J., (in review).FT-IR Analysis of Humic Acid in Water Using Cylindrical Internal Reflectance. Soil Science Society of America Journal. Submitted in April of 1988.

Carleson, Thomas E. and M. Moussavi, 1988. Chelation and Foam Separation of Metal Ions from Solutions. Submitted to Separation Science and Technology.

Cooperative Arrangments

Cooperative arrangements and projects are conducted with the following organizations:

Idaho Department of Water Resources
Bureau of Reclamation
Water District I
Texas A & M
Bell Rapids Irrigation District
E.G. & G., Inc.
A & B Irrigation District
City of Moscow
City of Pullman
Washington State University
Latah County/Idaho
Whitman County/Washington
Bureau of Reclamation
Army Corps of Engineers

Policy Advisory Committee

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Idaho Water Users Association
410 South Orchard, Suite 144
Boise, Idaho 83705

Mr. Wayne Haas
Administrator, Resources Analysis
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Idaho Department of Water Resources
Statehouse
Boise, Idaho 83720

Mr. Roy Heberger
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U.S. Department of Interior
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Dr. Edward House
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Christine Moffitt
Assistant Professor
Fish and Wildlife
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Training Accomplishments

Field of Study	Undergraduate	M.S.	Ph.D.	Post Ph.D.	Total
Chemistry	*1*				*1*
Chemical Engineering		*1*			*1*
Hydrology		*1*			*1*
Fisheries		*1*			*1*
Agricultural Economics		*1*			*1*
Civil Engineering			*1*		*1*
TOTAL	1	4	1		6