Montana Water Resources Research Center

Annual Technical Report

FY 1999

Introduction

STATE OF THE MONTANA University System WATER CENTER 1999-2000
-- by Gretchen Rupp, P.E., Acting Director (June 2000)

At the end of the 20th century, the Montana University System Water Center is thriving. As in the past, our energies are divided among our missions of water research, outreach to water professionals and other adults, and education of future water professionals.

In the **research** arena, the Center administers three principal programs. Through the Water Resources Research Act, both state (104-B) and regional (104-G) programs are managed. Dollars are awarded through the state program to Montana researchers by a competitive grant review process that calls on the expertise of water professionals from varied positions. These small allotments, described in detail elsewhere in this report, serve as seed grants as well as support for several graduate students throughout the state university system. Although proposals were not submitted this year, the Montana Water Center's success at the regional 104G competition generally averages 2 proposals per cycle. As the research lists indicate, several successful grants from previous years are still active.

The Whirling Disease research program has completed four years of intensive investigations into the disease that is devastating populations of salmonids throughout the West. Federally funded, and directed by a Steering Committee of fisheries experts from around the nation, the program has to date expended more than $2 million in basic laboratory and field science to come to an understanding of the biology of this complex pathogen. Investigators from more than 10 universities and agencies have been involved in this work. Besides administering all the research funds, the Water Center operates a Wild Trout Research Laboratory specialized for the investigation of whirling disease.

The third research effort of the Center is the demonstration of promising treatment technologies for small public water systems. Funded by EPA for the last five years, this year's program involved pilot- and full-scale testing at water systems in several states.

Outreach programs took several forms this year. As always, the Center co-sponsored Montana's week-long Water School - intensive professional training for water and wastewater system operators. We also continued our commitment to co-sponsor an annual Montana water research conference, along with our state section of the American Water Resources Association. This year the Center coordinated a project to compile GIS-based data sources to assist engineers and land-use planners in assessing the water quality impacts of alternative land development scenarios. We consulted with the chief water organizations and agencies in the state to create and maintain a central website -- MONTANA WATER (http://water.montana.edu). our Media Team continued development of interactive computer-based training materials for water system operators.

Both undergraduate and graduate education benefitted from the Center's programs this year. An intern was placed with the Montana District of the USGS for summer fieldwork. Several graduate students were supported by our grant-funded research, and the Center itself made use of student interns in our day-to-day operations. One of our interns won the prestigious Goldwater Prize this year!

We're especially proud to have been commended at the March 2000 NIWR meeting as one of five "most-improved" water centers. We are particularly focused on continuing to enhance the utility of the MONTANA WATER website, which earned special recognition at that meeting.

Our collaborators during this year were nearly too numerous to mention. We benefitted from both contractual and informal ties with entities ranging from university science departments in several states, to local county government, to conservation districts, to a number of state and federal departments, as well as watershed groups. Establishing and maintaining fruitful collaborations can be exhaustive work, and the Center does not undertake it lightly. But the complex nature and high public profile of many modern water problems render it essential to include diverse viewpoints, funding sources and areas of expertise in crafting solutions.

MONTANA WATER PROBLEMS 1999-2000

Montana contains the headwaters for two of the largest river systems in the United States. The Missouri and Yellowstone rivers and their tributaries drain the eastern three-quarters of the state while the Clark Fork flows west to the Columbia River. Montana exports an average of over forty million acre feet of water per year to downstream states. While the headwaters of these rivers appear to have a super-abundance of water, the spatial and temporal distribution of water is such that many places in Montana experience water shortages. Water quality problems of both natural and human origin, affecting both surface and groundwater, also present scientific and water management challenges. Increasing demands, conflicting interests, and intense competition for water resources are a large part of Montana's history and will undoubtedly frame much of its future.

Because water is critical to every part of Montana's economic and natural well-being, a multitude of water-related problems and issues concern Montanans. These include:

- Providing sufficient opportunities for water education.
- Identification of pollutants in ground and surface waters; their source, movement and fate; and their remediation and abatement.
- Technological innovations to protect and improve water quality.
- Timely predictions of moisture and surface runoff, and development of drought mitigation options.
- Long-term monitoring of water levels and water quality.
- Baseline characterization of ground-water resource.
- Provision of adequate supplies of water for municipal, commercial, agricultural, and recreational uses; and means for resolution of competing demands.
- Protection of aquatic habitat.
- Public access to streams flowing across private lands.
- Adjudication and quantification of water rights, including Indian water rights.
- Apportionment and protection of water flowing across interstate and international boundaries.

These are complex problems and issues. Many are currently under review by executive, legislative and judicial branches of government. The mission of the Montana Center is to contribute and disseminate useful information to those who need it in ways that help resolve problems and advance policy. Because of limited financial resources, the Center's focuses are the result of public/government/peer ranking, and they concentrate on the most critical issues in which there is available expertise. The following sections of this report address the priorities and projects

of the Fiscal Year 1999 program.

Research Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Determination of Fuel Oxygenate (MTBE) Biodegradation Potential in Groundwater at Release Sites
Project Number	C-02
Start Date	09/01/1998
End Date	02/28/2001
Research Category	Water Quality
Focus Category #1	Groundwater
Focus Category #2	Toxic Substances
Focus Category #3	Treatment
Lead Institution	Montana State University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Al Cunningham	Professor	Montana State University	01
Richard Veeh	Research Associate	Montana State University	02
Paul Sturman	Research Associate	Montana State University	03
Jeff Kuhn	Research Associate	Montana Dept. of Environmental Quality	04
Stephen L. Jester	Consultant	Conoco Inc.	05

Problem and Research Objectives

ABSTRACT

Alkyl ethers such as methyl-tert-butyl ether (MTBE), ethyl-tert-butyl ether (ETBE), and tert-amyl methyl ether (TAME) have been used as oxygenate additives in gasoline to reduce vehicle emissions such as carbon monoxide and other volatile, toxic organic compounds. MTBE, the most common oxygenate, is currently added at concentrations up to 15% (v/v) to more than 30% of all gasoline sold in the United States. In 1992, more than 1.8 billion gallons of MTBE were used in gasoline, and its use has

increased every year since. More than 29 companies now produce MTBE, and it is the second largest organic chemical produced domestically. Due to the widespread use of MTBE in reformulated gasoline, most of which is stored in underground tanks, documented release sites are continually being reported. A recent survey conducted by the USGS identified MTBE as the second most common contaminant of urban aquifers in the nation. Although human health effects are still being evaluated (Leclair, 1997), the EPA has designated MTBE as a probable human carcinogen and issued a draft nonregulatory health advisory of 70 ug/l for nonprimary water sources (Cooney, 1997). Many states have much more stringent maximum contaminant levels for MTBE. The risks to human health posed by MTBE are exacerbated by its high water solubility and mobility in groundwater systems. The relative recalcitrance of MTBE, combined with its high water solubility make it the single largest threat to ground water quality resulting from gasoline releases. Given the widespread use of MTBE and its potential health **a problem of national scope.**

Traditional methods to remove gasoline constituents from groundwater do not work well for MTBE. Air stripping is very difficult because MTBE's low volatility requires large air/water ratios to make the treatment effective. In addition, MTBE's low affinity for organic carbon prevents efficient removal by granular activated carbon. However MTBE is capable of being biodegraded by native soil bacteria, albeit at slower rates than other gasoline constituents. Available research indicates that many naturally occurring microbial populations can biodegrade MTBE as well as tert-butyl alcohol (TBA), an MTBE metabolite of concern, over time. Strategies for enhancing in situ biodegradation (i.e. accelerated natural attenuation) of MTBE are urgently needed.

The proposed research project, which involves a 3-way collaboration between MSU's Center for Biofilm Engineering (CBE), the Montana Department of Environmental Quality (MDEQ) and Conoco Inc., will assess the environmental factors which limit MTBE and other oxygenate metabolite degradation for the purpose of developing improved strategies for enhancing MTBE biodegradation in the field. MSU graduate and undergraduate students from multiple disciplines (i.e. engineering, microbiology, geology, and soil science) will be organized into teams and mentored by state regulatory and industrial officials, together with MSU faculty.

RESEARCH OBJECTIVES

The project work plan includes review of all pertinent hydrogeological and geochemical data as well as a full characterization of the microbial population present at an existing MTBE release site located in Ronan MT, and will focus on isolation, identification, and enrichment of bacterial strains that can biodegrade MTBE metabolites. Strategies for enhancing MTBE biodegradation in situ will be identified and piloted at the Ronan MT study site.

Methodology

Progress on Research Objectives The primary goal of this research is the assessment of the environmental factors which limit MTBE, other oxygenate, and metabolite degradation at fuel release sites. In order to meet this goal, work to date has focused on the following categories: I. Site Data Review

- Existing site data from an MTBE-contaminated site in Ronan, MT has been reviewed to establish release history, groundwater hydrogeology, geochemistry, availability of potential electron acceptors, free product occurrence, and evidence of natural attenuation. This information has greatly enhanced the understanding on contaminant behavior in the subsurface and has provided a

framework to assess the performance of the remediation system currently operating at the site. <

II. Field Experimentation

- Groundwater and soil samples were collected from 3 locations within the contaminant plume through existing monitoring wells (water samples) and drilling new monitoring wells (soil samples) at selected locations. This sampling assisted in the establishment of plume dimensions, contaminant transport rates, electron acceptor concentrations and biodegradation potential. Samples were indexed and cross-referenced with geochemical conditions present at each sampling location. MTBE degrading microorganisms were detected at all three locations.
- Site groundwater data were analyzed for evidence of natural attenuation of MTBE, degradation products, and other petroleum compounds. Newly collected data and historic data (1994-1999) contributed to our understanding of MTBE (and other fuel constituent) behavior in the subsurface.

III. Laboratory Experimentation

- Methods for the analysis of MTBE and its known metabolites in water and soil samples have been substantiated in CBE laboratories.
- Enrichment cultures from site soil and groundwater samples have led to the isolation of an MTBE-degrading culture using microcosms with selective growth media.
- The potential benefits of possible hydrocarbon cosubstrates (e.g. propane) that may enhance MTBE biodegradation have been investigated in microcosms. Results are being prepared for submission for journal publication.

IV. Education and Technology Transfer

- The second annual workshop on MTBE fate and transport in groundwater has been delivered to regulators at the Montana Department of Environmental Quality (MSU, December 6-7, 1999). The workshop was organized by the Principal Investigators and delivered by both the PIs and graduate students participating in CE 534 (Environmental Engineering Investigations)

Principal Findings and Significance

Progress Report - Principal Findings(6/2000)

Results to date indicate that MTBE is biodegraded very slowly in the subsurface relative to other gasoline constituents. However we also determined that if certain enrichment strategies are followed, MTBE biodegradation rates can be greatly enhanced. These results suggest that above ground treatment using an engineered bioreactor (i.e. a pump and treat system) may be a cost effective alternative for remediating MTBE contamination at this and other similar field sites. Specific strategies for enhancing MTBE biodegradation in situ will be explored at the Ronan, MT study site during Autumn 2000.

Descriptors

Bacteria, Biodegradation, Bioindicators, Contaminant Transport, Groundwater Quality, Natural Attenuation, Petroleum Additives, Solute Transport, Soil Microbiology, Underground Storage Tanks

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Influence of Organic Mine Reclamation Amendments on Metal Mobility and Water Pollution Potential
Project Number	C-01
Start Date	09/01/1998
End Date	09/30/2000
Research Category	Water Quality
Focus Category #1	Solute Transport
Focus Category #2	Acid Deposition
Focus Category #3	Geomorpological and Geochemical Processes
Lead Institution	University of Montana

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Tom H. DeLuca	Assistant Professor	University of Montana	01
Donald J. Bedunah	Professor	University of Montana	02
Aimee Vitateau	Student	University of Montana	03

Problem and Research Objectives

The formation and disposal of fine textured mine tailings during the processing of ores creates deposits of aerated, high-surface, mining wastes that result in the enhanced oxidation of sulfide minerals and the production of acid mine drainage. Mining wastes also contain high levels of heavy metals. Geologic

factors determine the types and concentrations of the metals; copper (Cu), and lead (Pb) are examples of metals that are generally expected in high concentrations in tailings from gold mining in western Montana. These metals tend to dissolve readily in the acid water associated with the tailings, and once in solution, they are readily available to plants in potentially toxic concentrations. Metals in this form can also be transported from the site to contaminate surface and groundwater. The end result is generally an acidic substrate, with little or no vegetation establishment, in which soluble metals are readily lost to water resources.

Organic amendments are frequently applied to mine tailings in an effort to reduce the bioavailability of metals so that a healthy self-maintaining vegetative cover can be established. However, organic amendments can influence the bioavailability and mobility of metals through several different mechanisms. Lieta and DeNobili (1991) concluded that the soluble, low-molecular weight, organic acids associated with some organic materials may actually increase metal mobility, while the insoluble nature of high molecular weight organic acids combined with their capacity for the sorption of metals could potentially help reduce both the mobility and bioavailability of metals (Temminghof et al., 1994). Stabilization of organic matter through composting prior to its application on a reclamation site can increase the ratio of high molecular weight, organic acids (humic acids) to low-molecular weight organic acids (fulvic acids) through the humification process (Pare et al., 1999). DeLuca and Lynch (1997) found that laboratory applications of composted material to tailings significantly reduced the concentrations of exchangeable Cu and Pb, while the application of uncomposted material only slightly decreased the concentration of exchangeable Cu and increased concentrations of exchangeable Pb.

Methodology

We have developed a study in order to investigate the effect of five different organic materials on the mobility and bioavailability of toxic mine waste contaminants when used in the reclamation of abandoned mine sites. The five amendments include the following: composted municipal sewage sludge (CSS), cow manure composted with straw (CCM), log-yard waste (LYW), straw (RS), and pulp mill sludge (PMS).

Laboratory Experiment - Summer 1999 through Spring 2000 -- Tailings from along the Clark Fork River, and from the Combination Mill site were used in laboratory experiments. In both experiments the tailings and the organic amendments were combined in a 10:1 ratio, brought to 60% water holding capacity and allowed to incubate for 12 weeks. The experiment using the Clark Fork River tailings is a 6x2 factorial experiment, in which the first factor is the five organic amendments and a control (NT) and the second factor is the presence or absence of lime to raise the pH of the tailings to approximately 6.5. After 12 weeks, the samples were subjected to a sequential fractionation using the procedure outlined in McGrath and Cegarra (1992) and analyzed on an AAS. Briefly, this fractionation involves the following: (1) 0.01 M $CaCl_2$ to extract the water soluble and exchangeable fractions of metals, (2) 1 M NaOH to extract primarily the organic bound metals, (3) 0.05 M Na_2-EDTA to extract primarily the carbonate bound metals, (4) an aqua regia digest to extract the residual metals. The experiment using the Clark Fork River tailings was conducted in the spring and summer of 1999 and analyzed on the AAS in the early fall.

Because the Combination Mill tailings were limed during a failed reclamation attempt at the site they were not treated with lime during the laboratory experiment. The experiment using the tailings from the Combination Mill is in progress. The incubation process is complete and we are currently performing the extraction. Later this summer, the organic bound fraction from the Combination Mill site will be further fractionated using ultrafiltration to assess the percentage of metals that exist in organic

complexes with either humic or fulvic acids (Temminghof et al., 1994).

Field Study - Summer 1999 through Summer 2000 Summer 1999 -- A single, riparian, tailings site in Phillipsburg, MT was selected where reclamation using straw, log yard waste and lime has failed in the past. A large portion of the Combination Mill site is devoid of vegetation and has been shown to contain elevated levels of heavy metals. Water and sediment samples collected upstream and downstream from the site indicate that the site is a source of metals to nearby Willow Creek (Schafer & Associates, 1992). During the early summer of 1999, we applied six treatments, consisting of the five amendments and a control to the site. The treatments were replicated six times with 3x3-m plots using a randomized split plot design.The organic amendments were incorporated to a depth of 7.5-cm and the plots were seeded and fertilized. Plot samples were collected prior to treatment. These samples were analyzed for pH, carbon to nitrogen ratio, and metal content using the extraction described above for the laboratory experiment. **Summer 2000** Mixed bed ionic resins were placed at a depth of 15-20-cm in each plot to capture metals, which leach below the rooting zone. The resin capsules will be retrieved after 3 weeks and analyzed for total metal content using an AAS. Plot samples were also collected 12 months after the treatments were applied and these will be analyzed for pH, carbon to nitrogen ratio, and metal content using the extraction method described for the laboratory experiment. Vegetation establishment will be determined by the end of June and aboveground biomass will be determined at the end of the growing season. **Greenhouse Experiment - Winter 2000** Tailings from the Combination Mill site and from along the Clark Fork River were set up in two greenhouse experiments. As in the laboratory experiments, the Clark Fork River tailings were used in a 6x2 factorial experiment with the first factor being the five organic amendments and a control and the second factor being the presence or absence of lime. Again, lime was not a factor in the experiment using the Combination Mill site tailings. Each treatment in both experiments was replicated 5 times. The tailings and amendments were mixed in a 10:1 ratio in small conetainers and seeded with exactly seven seeds each. Currently the plants have been growing for 14 weeks. We have recorded germination and survival data once a week since the experiments began. At five weeks, we also recorded plant height and leaf number as a gross estimate of biomass. After 18 weeks, any grass shoots will be dried and weighed. The plant material will be digested and analyzed using an AAS to determine the metal and oxyanion concentrations. This will provide both a measure of revegetation success and metal bioavailability in tailings treated with different amendments.

Principal Findings and Significance

http://water.montana.edu/programs/research/MWC/deluca-progress.PDF

The concentration data for the sequential extraction technique performed on the samples from the laboratory experiment using the Clark Fork River tailings indicate that different organic amendments appear to have a variable influence on Cu speciation, which could influence metal mobility and water pollution potential. Figure 1, and Figure 2 depict this data for the unlimed and limed tailings respectively. (See link for figures as .pdf file.)

The pulp mill sludge and the composted amendments appeared to most reduce the total soluble copper in the unlimed tailings (Figure 1). The addition of log yard waste to the tailings appeared to have little influence on the total extractable metals. In all of the limed treatments (Figure 2), the metals are predominately found in non-extractable, inorganic, precipitate forms. None of the amendments appeared to seriously reverse the beneficial effects of the lime. The majority of metals in the tailings treated with pulp mill sludge were not sorbed to organic material, but rather appeared to be in inorganic precipitates. Similar results were found for Pb.

Preliminary results from the greenhouse experiment indicate that the composted cow manure, and the pulp mill sludge have the greatest revegetation success. Table 1 presents the average total leaf heights in millimeters after five weeks for the Combination Mill tailings. The average, total, leaf-height was calculated by adding the height of each leaf per plant and averaging it over the number of established plants in that treatment. N represents the total number of plants that were established for each treatment. Comparing the average, total, leaf-height with the number of plants established gave us an initial rough estimate of biomass produced by each treatment.

Table 1. Average total leaf heights in millimeters of plants grown in the greenhouse experiment after 5 weeks using the Combination Mill tailings (CMT). CMT-NT CMT-RS CMT-PMS CMT-LYW CMT-CSS CMT-CCM Mean 4 mm 0 mm 140 mm 17 mm 24 mm 140 mm Std Dev 3.4 N/A 53.8 12.6 16.3 53.8 N = 6 0 15 11 14 18 It is interesting to note that no seeds germinated in the straw treatment (RS) and that it had even less success than the control (NT). This could indicate that the metals in the tailings become more available for plant uptake due to the unhumified nature of the straw.

Statement of Benefits

The purpose of this study is to provide much needed information on how commonly used organic, mine reclamation, amendments influence the mobility of metals and consequently the potential for the pollution of water resources.

The final results of this research will have many benefits including these:

- the funding of one M.S. student degree in resource conservation,
- assist in the understanding of the effect of various organic amendments on metal and oxyanion mobility in mine reclamation efforts,
- provide operational guidelines for the use of organic amendments in acid mine reclamation,
- enhance the potential for successful mine reclamation and minimize the potential for metal loss to groundwater.

Literature Cited DeLuca, T.H., & E.L. Lynch, 1997. Assessment of amendments in the reclamation of an abandoned

Lieta, L., & M. DeNobili, 1991. Water soluble fractions of heavy metals during and after long-term applications of sewage sludge to soil. Journal of Soil Science 43: 313-321.

McGrath, S.P., & J. Cegarra, 1992. Chemical extractability of heavy metals during and after long-term applications of sewage sludge to soil. Journal of Soil Science 43: 313-321.

Pare, T., H. Dinel, & M. Schnitzer, 1999. Extractability of trace metals during co-composting of biosolids and municipal solid wastes. Biology and Fertility of Soils 29: 31-31.

Schafer & Associates, 1992. Final Report for The Combination Mill Site Stabilization Project, Black Pine Mining District, Montana.

Temminghof, E.J.M., S.E.A.T.M Van Der Zee, & M.G. Keizer, 1994. The influence of pH on the desorption and speciation of copper in a sandy soil. Soil Science 158(6): 398-408.

Descriptors

Metals, Oxyanions, Colloid Assisted Transport, Sorption, Humic Acids, Chelation, Organic Matter

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

June 14, 1999 No publications have been prepared based on the research performed under this support. An abstract for the research was submitted to the American Society of Agronomy and Soil Science Society of America to present our findings at the 1999 Annual Meetings in Salt Lake City.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Computational Methods in River Engineering - Modeling Water Surface Profiles over a Bendway Weir using HEC-RAS 2.2
Project Number	B-01
Start Date	03/01/1999
End Date	04/30/2000
Research Category	Engineering
Focus Category #1	Surface Water
Focus Category #2	Methods
Focus Category #3	Floods
Lead Institution	Montana State University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Joel E. Cahoon	Assistant Professor	Montana State University	01
David G. Breck	Student	Montana State University	02

Problem and Research Objectives

Design and analysis tools for the structures used in river restoration projects are not fully developed. Contemporary software, if used correctly, may be able to fill the gap. The objective of this project was to assess the capability of HEC-RAS to adequately model an existing bendway weir in a small mountain stream.

Methodology

The following steps were taken to compare model-generated water surface profiles to those observed at the field site:

1. Survey – surveying equipment was used to determine the ground elevations at all pertinent stations including the weir, streambed and stream banks.
2. Flow measurement – the USGS method was used to determine the flow rate for two trials.
3. Hydraulic parameters- roughness and boundary conditions were determined from field observations.
4. Modeling – all possible combinations of a) survey data interpretations (in-line with weir or perpendicular to flow) and b) modeling options (blocked obstructions, ineffective flow areas, no flow adjustments, and the “weir” option) were evaluated by ranking the mean absolute difference between model generated and observed water surface profiles.

Principal Findings and Significance

The modeling approach that most nearly predicted the observed water surface profile was to record stream cross sections perpendicular to flow at one-foot intervals over the structure. Include these cross sections as river stations in HEC-RAS with adequate upstream and downstream stations to capture boundary conditions there. Then identify the portions of the weir cross sections that are between the weir and the outer radius bank as either ineffective flow areas or blocked obstructions. This approach worked well during low flows where subcritical flow dominated.

Descriptors

rivers, engineering, methods,

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Cahoon, Joel C., and David Breck, 2000, Computational Methods in River Engineering - Modeling Water Surface Profiles over a Bendway Weir using HEC-RAS 2.2, Montana University System Water Center Techical Report # 203, Montana State University, Bozeman, MT, 30 pgs.

Conference Proceedings

Breck, David and Joel Cahoon. 1999. Stream restoration on a small scale, Presentation, field trip and in Abstracts -- Water for the New Millennium – AWRA/Water Center Conference. Great Falls, MT.

Other Publications

Breck, David. 1999, Modeling Water Surface Profiles over a Bendway Weir using HEC-RAS 2.2, M.S. Professional Paper, Civil Engineering Department, Montana State University, Bozeman, MT. 30 pages.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Watershed Restoration Assessment for Lost Creek -- a Tributary of the Upper Clark For River (formerly - Nutrient Load Reductions from Land Conservation : Restoration in the Lost Creek Watershed...)
Project Number	B-05
Start Date	03/01/1999
End Date	02/29/2000
Research Category	Water Quality
Focus Category #1	Non Point Pollution
Focus Category #2	Nutrients
Focus Category #3	Management and Planning
Lead Institution	University of Montana

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Vicki J. Watson	Professor	University of Montana	01
James Harris	Student	University of Montana	02

Problem and Research Objectives

Lost Creek, a tributary to the Upper Clark Fork of the Columbia, is listed on Montana's 303(d) list as impaired for a number of beneficial uses, including aquatic life support, drinking water supply, and cold water fishery. Lost Creek is undergoing major riparian restoration and grazing management changes which will be the basis of a Total Maximum Daily Load (TMDL) for nutrients and sediment for the lower 17 stream miles. Therefore the objectives of this project include the following:

1. assess current conditions in Lost Creek including kinds and degrees of impairment;
2. provide baseline data to evaluate benefits of restoration work;
3. evaluate Lost Creek as a nutrient source to the nutrient-impaired Clark Fork River;
4. make recommendations for TMDL development for Lost Creek, and how it should relate to the Clark Fork VNRP (which calls for a 20% reduction in nonpoint sources of nutrients).

Methodology

Water samples were collected from May through August 1999 at sites along the creek which bracketed suspected sources. Samples were analyzed for nutrients (nitrate/nitrite, total Kjeldahl nitrogen, soluble reactive phosphorus, and total phosphorus) using an EPA-approved protocol. Riparian health assessments were performed on the lower 20 miles of Lost Creek using the University of Montana's Riparian and Wetland Research Program's Lotic Inventory Form. Riparian inventories are used to identify and prioritize problem areas and provide detailed baseline information for gauging the success of restoration projects on Lost Creek.

Principal Findings and Significance

Lost Creek does not provide good habitat for attached algae growth, but in some areas aquatic plants may be a problem. Hence, the main reason for reducing nutrients in Lost Creek is to reduce the load to the Clark Fork. Phosphorus levels in Lost Creek were below those considered to be a problem for streams according to the Clark Fork VNRP. Total nitrogen (particularly nitrate/nitrite) levels are high enough to be a concern. Nitrate/nitrite levels increase in the area near Dutchman reservoir. Although wetland disturbance by cattle grazing is a likely source of nutrients in this area, it appears likely that irrigation water from the land application of Anaconda's municipal wastewater is leaching into groundwater from nearby hay fields and from storage ponds in the Dutchman Creek drainage. Riparian inventories found 30% of riparian areas were not performing their functions while the other 70% were at risk to become nonfunctional.

In terms of TMDL development for Lost Creek, the conservation practices being undertaken by landowners with state and federal funding will likely improve habitat and reduce nutrient loads. Success should be judged by periodic reevaluation of riparian condition and nutrient loads. Lost Creek does provide a significant TN load to the Clark Fork, and this is probably best addressed by riparian wetland restoration and land application of Anaconda wastewater over a larger area at an appropriate agronomic rate.

Descriptors

watershed conservation & restoration, nutrients, algae

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Harris, J. A. 2000. Watershed Restoration Assessment for Lost Creek -- a tributary of the Upper Clark Fork River. MS thesis in Environmental Studies, University of Montana, Missoula, MT, 40 pp.

Water Resources Research Institute Reports

Harris, James A. and Vicki Watson (advisor), 2000, Watershed Restoration Assessment for a Tributary of the Upper Clark Fork River. Montana Water Resource Research Institute Report #207, Univ. Montana, Missoula, MT, 30 pp.

Conference Proceedings

Harris, James A. and Vicki Watson, 2000, Watershed restoration assessment for a tributary of the Upper Clark Fork River. “in” Proc. Clark Fork River Symposium 2000, Missoula, MT. Published online at http://ibscore.dbs.umt.edu/clarkfork

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Assessment of Groundwater Contamination from Subdivisions
Project Number	B-02
Start Date	03/01/1999
End Date	02/28/2001
Research Category	Ground-water Flow and Transport
Focus Category #1	Nutrients
Focus Category #2	Groundwater
Focus Category #3	Surface Water
Lead Institution	Montana State University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Stephan G. Custer	Associate Professor	Montana State University	01
Keri Fleming	Student	Montana State University	02

Problem and Research Objectives

Abstract The Gallatin Valley, along with other areas in Montana, has experienced an increase in population which has created concern about the potential for degradation of ground water and surface water due to an increase in subdivisions on individual septic systems. To test whether degradation is occurring from subdivisions specifically, two mature subdivisions with shallow ground water and a proximity to water-quality impaired streams were chosen to study.

The shallow ground water, through installed monitoring wells upflow, midflow, and downflow of the subdivision, and deeper ground water, through domestic wells, were sampled around high water and around low water for pH, specific conductivity, temperature, dissolved oxygen, total coliform (if present, then also for E. coli), chloride, total ammonia as nitrogen, nitrate plus nitrite as nitrogen, and total phosphorus. The water-quality impaired streams in the selected subdivisions were also sampled for these parameters upflow, midflow, and downflow of the subdivision, and discharge was measured once for each stream.

Each subdivision will be characterized by well and septic system locations, hydrogeology, and land use. The characterization information for each subdivision will then by used to analyze data temporally and spatially. Expected nutrient loading based on available data and compared to observed data will be calculated using the Bauman-Schafer model and a phosphorus breakthrough analysis. Nutrient loads delivered from subdivision ground water to water-quality impaired streams will be evaluated.

Problems and Research Objectives

Septic systems have been shown to contaminate ground water at a variety of locations. Nutrients and pathogens have been identified as parameters that limit water quality for some streams in the Gallatin Valley, and residential rural subdivision development has been identified as a potential source of contamination, but the nutrient and microbial load delivered to water-quality impaired streams by shallow ground water which flows beneath subdivisions has not been directly measured. To date, the traditional approach used to assess contamination from septic systems has been to examine county-wide trends in groundwater quality, and trends have been elusive. The Department of Environmental Quality (DEQ) has suggested a reexamination of subdivisions studied by Peavy et al. in 1980 to determine if groundwater quality has been degraded below and down flow of subdivisions and to determine whether the Bauman-Schafer and phosphorus breakthrough methods currently used for subdivision review and non-degradation assessment reasonably predict impacts of development on groundwater quality. While the DEQ’s proposed reexamination is interesting, the original research wells are gone, homeowner cooperation is not assured, and the study areas would require significant travel. An alternative is to examine ground water below mature subdivisions (1970’s-vintage) in the Gallatin County Local Water Quality District (LWQD) which are thought to contribute nutrient and/or coliform to streams. Such a study could be used to answer several important questions of interest both to the state of Montana and to the LWQD.

1. Is microbiological contamination dominantly from poor well seals, septic contamination, or other sources?
2. Are coliform-contaminated or nutrient-contaminated wells on a flow line that contains one or more septic systems?
3. Are wells that are contaminated with nutrients also contaminated microbiologically?
4. Is the contamination level and type (nutrient/coliform) dependent on the texture of the sediments below the subdivision?
5. What nutrient and coliform loads enter and leave a subdivision area via the ground water, and what are the likely loads being delivered to water-quality impaired streams in the LWQD?
6. Do the Bauman-Schafer and phosphorus breakthrough model correctly predict observed concentrations of nutrients below mature subdivisions?

Methodology

Subdivision Selection

Subdivisions were selected as candidates for the project based on the proximity to a water-quality impaired stream, maturity, shallow groundwater depth, proximity to public groundwater supply, previous contamination history, and the absence of other subdivisions on septic systems directly upflow. Not all conditions could be met for each subdivision, but the order above is the order of importance with the first listed as the most important criteria.

Once the list of candidate subdivisions was completed, the subdivisions were compared by substrate material, either coarser or finer, and then split into two lists, so one subdivision could be selected from each. A presentation was then prepared for final selection.

A meeting was held in Helena with staff from MSU, LWQD, DEQ, and EPA to discuss which subdivisions should be selected for the research project. Based on the above criteria, one subdivision was selected to represent a coarse substrate, and one subdivision was selected to represent a finer substrate. The other subdivisions were rank ordered behind the ones selected in case problems occurred, such as getting permission to conduct the study in the selected subdivisions.

Getting permission from the majority of the homeowners was the final step in the selection process. Door-to-door inquiries were done with a answer sheet to fill out and a informative letter for the homeowner to keep that had relevant information about the study and who to contact for questions.

Subdivision Characterization

Well and septic system locations, hydrogeology, and land-use history, which was determined by visiting with the homeowners and by observation, are the main factors in subdivision characterization. Well and septic system locations were the found by going to the county health department and pulling the septic system permits for each house in the subdivision. Due to the maturity of the subdivisions, some permits were not detailed enough, or site locations were difficult to determine. From the properly filled out permits, well and septic system location could be determined.

Once the locations of the well and septic systems were determined, either from the septic system permits or by asking the homeowner, GPS locations for each septic system and well, with permission, were mapped. These maps were then used for the hydrogeology characterization.

The hydrogeology characterization was done through well logs, water-level information, and the geomorphology of each subdivision. Attempts at water-table elevations were made using the water-levels and the GPS-produced ARC View maps. (Due to a large error in GPS elevation information, a survey will be conducted of the well heads so the water-table elevations can more accurately be determined.)

Subdivision Sampling

Two sampling rounds were done, one at low ground water and one at high ground water (spring and fall). Each well, with permission, in the two subdivisions was sampled for pH, specific conductivity, dissolved oxygen, temperature, and pressure using a probe that was calibrated daily. Also, two sample bottles were filled from each well to be sent to the lab for analysis of total coliform (if present, then also for E. coli), chloride, total ammonia as nitrogen, nitrate plus nitrite as nitrogen, and total phosphorus.

Prior to sampling, a water-level measurement was made if possible. Next, a hose was connected to the spigot to run into a bucket where the probe was set up in the flow of the water. The probe readings were noted until stabilization was reached, then sampling took place.

The spigot was sprayed with alcohol to kill any coliform that may have grown, and then rinsed. The two sample bottle were then filled by the student, who was wearing vinyl gloves and following aseptic technique. The bottles were then kept on ice and shipped overnight to the lab in Helena for analysis within twenty-four hours. For quality control, duplicate samples were taken at least one every ten samples.

For the installed well points (upflow, midflow, and downflow), the sampling procedure differed, except for the water-level measurement and the bottles. Two different types of wells were installed. Three of the wells were two inch steel well points, and a bailer was used to sample these, removing three well volumes prior to sampling. Nine of the wells were one inch PVC, and these were sampled using a foot-valve to remove three well volumes prior to sampling.

The surface water was sampled at the same time the ground water was sampled. For each stream in the subdivisions, an upflow, a midflow, and a downflow sample were taken along with one discharge measurement per stream. The surface-water sampler used was decontaminated and rinsed at each site to prevent cross-contamination. Probe measurements were taken and two bottles filled using aseptic technique at each sampling site.

Analysis

Data will be interpreted in terms of spatial and temporal relationships between well and septic location, hydrogeologic setting, and contamination type and source. The potential effect of travel time on patterns of contamination will be assessed, and expected nutrient loading will be calculated based on available data using the Bauman-Schafer model and a phosphorus breakthrough analysis. Nutrient and microbial loads delivered from subdivisions to water-quality impaired streams via the groundwater flow system will be evaluated.

Principal Findings and Significance

Descriptors

Nutrients, Microbiology, Septic Systems, Groundwater, Surface Water

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Ground-Water Recharge Characterization Using Isotope and Geochemical Analyses, West Billings Area, Yellowstone County, Montana
Project Number	B-04
Start Date	05/01/1999
End Date	04/30/2000
Research Category	Ground-water Flow and Transport
Focus Category #1	Groundwater
Focus Category #2	Water Quality
Focus Category #3	Water Quantity
Lead Institution	Montana Tech of the University of Montana

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
John Olson	Professional Staff	Montana Bureau of Mines and Geology	01
Jon Reiten	Professional Staff	Montana Bureau of Mines and Geology	02

Problem and Research Objectives

Much of the area west of Billings, Montana is not served by municipal water, and the shallow alluvial aquifer is the sole water source for many water-supply systems. Most of recharge to the alluvial aquifer is derived from the infiltration of relatively high quality flood-irrigation water from the Yellowstone River. However, rapid population growth and land-use changes from agricultural croplands to residential subdivisions threaten to change the sources and diminish quantity of ground-water recharge received by the aquifer.

The purpose of this investigation is to use ground-water sample analyses for common ions, stable isotopes, and radiometric ground-water dating to better understand the current sources and rates of recharge and to evaluate their controls on the areas ground-water quality. This data will provide tools to assess the affects of urbanization on the alluvial aquifer in the west Billings area.

Methodology

Ground-water samples were collected from the existing supply-well pumps or from MBMG monitor wells using a portable peristaltic pump. Prior to collecting the samples, the wells were purged to assure a representative ground-water sample. Water samples for metals and cations were field filtered through a 0.45-micron filter to remove suspended materials. Water samples for common ion and trace metals analyses were submitted to the MBMG analytical laboratory in Butte Montana. Stable isotope samples (oxygen-18, hydrogen-2, sulfur-34, nitrogen-15, and carbon-13) were submitted to the University of Waterloo laboratory in Waterloo, Ontario.

Water samples for helium analyses (per laboratory instructions) were collected in a ¼-inch copper tube mounted to a 1-inch copper bailer below and 1/8- inch polyethylene air vent tubing to the surface. Water was allowed to collect in the copper bailer, sample tubing and vent tube then was pulled to the surface. The upper and lower ends of the copper sample tube were crimped sealed and capped to prevent air exchanges with the sample. Samples for tritium and helium-3 were submitted to the University of Utah laboratory in Salt Lake Utah.

Principal Findings and Significance

PROGRESS REPORT

In September 1999, thirty-six ground-water samples from across the west Billings area were collected and analyzed for common ions and trace metals. At 14 selected locations, samples were additionally analyzed for stable isotopes of oxygen, hydrogen, sulfur, and nitrogen. At 9 locations samples were collected for tritium-helium-3 age dating. A follow-up ground-water sampling event for common ion analyses was performed in March 2000. Analyses of the common ions and stable isotopes have been completed. Results of the tritium-helium-3 analyses are still pending and are expected in June or July 2000.

Interpretation of the chemical and isotope data will be completed after receipt of the tritium-helium-3 analyses. Results of the investigation will be reported at a professional conference in the fall of 2000 and will be published as part of a larger MBMG project for the west Billings area.

Descriptors

Geochemistry, Ground-Water Hydrology, Ground-Water Management, Ground-Water Quality, Ground-Water Recharge, Irrigation, Land Use, Resource Planning, Urban Planning, Water- Quality Management

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Ground-Water Age Dating as a Tool to Assess Land-Use Effects on Recharge and Water Quality in Intermontane Basins
Project Number	B-03
Start Date	07/01/1999
End Date	06/30/2000
Research Category	Ground-water Flow and Transport
Focus Category #1	Groundwater
Focus Category #2	Hydrogeochemistry
Focus Category #3	Water Quality
Lead Institution	Montana Bureau of Mines and Geology

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
John LaFave	Assistant Professor	Montana Tech of the University of Montana	01

Problem and Research Objectives

The objective of the proposed research is to evaluate the tritium/helium-3 (3H/3He) and chlorofluorocarbon (CFC) methods for dating young ground water (0.1–45 years old) with the aim of improving the technical basis for ground-water protection in intermontane alluvial aquifers affected by population increases and land-use changes. The Missoula Valley was chosen because considerable data are available concerning the ground-water flow and ground-water quality for the Missoula Valley aquifer; there are a variety of land uses near Missoula; and land-use patterns have changed over the past 10 years and are likely to continue to change.

Methodology

Tritium-Helium and CFC's

Measurement and interpretation of tritium-helium isotopes and CFC's are relatively new techniques that allow direct dating of single ground-water samples. Tritium (3H), the radioactive isotope of hydrogen with a half-life of 12.43 yr, is produced naturally in the upper atmosphere and decays to the noble gas helium-3 (3He). As water enters the ground-water system and becomes isolated from the atmosphere, 3He concentrations will increase as ground water becomes older. By determining the amounts of tritium and tritiogenic 3He in a ground-water sample, an age can be calculated according to the relationship:
$t = t1/2/\ln 2 * \ln(1+ 3Hetrit/3H)$
where t is the tritium-helium age, 3Hetrit is the tritiogenic helium-3 in the sample, 3H is the tritium concentration, and t1/2 is the tritium half life. Ratios of tritium to helium-3 have been used to accurately date shallow ground water with ages ranging from a few months to 50 years.

Chlorofluorocarbons (CFC-11, CFC-12, and CFC-113) are human-made organic compounds first produced in the 1930's. Atmospheric concentrations of CFC's are uniform over large areas and have steadily increased since the 1940's. The atmospheric input of CFC's to ground water can be determined for most localities. Once in ground water, these compounds are soluble and stable. CFC ages are determined by converting CFC concentrations in ground water to equivalent air concentrations using known solubility relationships and recharge temperature. Limitations to the method include reducing conditions in aquifers that can degrade CFC's in ground water and non-atmospheric sources of CFC's. Under optimal conditions CFC's can be used to estimate ground-water age with about a 1- to 2-year accuracy.

The Missoula Valley aquifer underlies, and is the sole source water supply for the city of Missoula. It is unconfined and composed of 100 to 150 feet of Quaternary sand, gravel, and cobbles. Ground-water generally flows away from the valley margin on the north toward the flood plain in the center of the valley. South of the Clark Fork River ground water flows southwest toward the Bitterroot River and its confluence with the Clark Fork River. The aquifer is recharged primarily by leakage from the Clark Fork River and underflow through Hellgate Canyon as well as precipitation and inflow from deeper units; water leaves the aquifer as base flow to streams, as evapotranspiration, and as pumpage from wells.

During the summer and fall of 1999 and the spring of 2000, sixteen wells were sampled for noble gases and tritium, twelve of the wells were also sampled for CFC's. Most of the wells were monitoring wells, but two of the wells were commercial wells (serving a business) and one well was part of a heating and cooling system on the University of Montana campus. The tritium, noble gas and CFC analyses are

being performed by the University of Utah Isotope Geochemistry Laboratory. At this time tritium and noble gas results from about half of the wells have been received; the CFC analyses are complete.

Principal Findings and Significance

Progress Report

The geologic setting and land-use activities in the Missoula Valley are complicating the interpretation of the 3H/3He and CFC results. Twelve wells located along transects of ground-water flow were sampled for CFC's. All but two of the samples came back with "excess" CFC's (the CFC concentration was greater than what could be accounted for by equilibrium dissolution from the atmosphere) indicating that the ground water had been contaminated with CFC's. The excess CFC's rendered the samples unsuitable for age dating. The areal distribution of the CFC's in the aquifer suggests that septic effluent may be a potential source. The highest CFC concentrations (CFC-12: 19 to 77.7 pmole/kg) were detected immediately down gradient from areas with high septic tank densities, ground water beneath the sewered areas had much lower concentrations (CFC-12: 2.9 to 7.9 pmole/kg).

Interpretation of the 3H/3He ages is being complicated by the presence of relatively large amounts of excess helium (helium in excess of air-water solubility) in the ground water. The results to date show that all of the wells sampled in the Missoula Valley aquifer have tritium (8.7 to 13.2 tritium units), however the presence of excess terrigenic helium has hindered successful dating by the 3H/3He method. The source of excess helium is not clear, potential sources include the mantle or aquifer matrix material.

The next round of work will focus on clarifying the source and amount of excess helium in the hope that a correction factor may be determined and 3H/3He dates obtained.

Descriptors

Groundwater Movement, Groundwater Quality, Groundwater Recharge, Tritium/Helium Isotopes, Chlorofluorocarbons (CFC's), Surface-Groundwater Relationships

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

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Information Transfer Program

Throughout its 35 year history, research, education, and information transfer (IT) have been the key components of the Montana University System Water Center's mission - ' to promote problem-solving partnerships among

university, government, and private sector participants.' Prior to the advent of the World Wide Web (WWW), small budgets assigned to the IT effort were mainly used up by copying and postage costs, leaving little remaining to support this effort.

In 1996, the entire concept of IT at the Water Center was redefined when hosting a WWW site became an affordable reality on the Montana State University campus. As with most fledgling WWW sites, the Center's first attempts at online information were small – reports, notices, directories, links, etc. generally highlighting only Center activities.

The idea soon evolved however, that the Center's WWW efforts could better be utilized by developing and maintaining an impartial clearinghouse of Montana water information. There was no unified and affordable structure through which scientists, agency personnel, and watershed group participants could access information and resources, and exchange experiences.

Through a timely EPA appropriation for watershed development in 1997, the Water Center seized the opportunity to construct a significant Web presentation entitled MONTANA WATER. Concurrently, the Montana Watershed Coordination Council (MWCC) provided guidance (and a few small grants) on watershed group materials, since many isolated watershed projects were moving vigorously forward throughout the Northern Rocky Mountain region. PURPOSE –Create a website to centralize communication and data-sharing efforts among agencies, organizations, and individuals engaged in Montana water issues i.e., watershed modeling and planning, water quality efforts, etc. PARTNERS of MONTANA WATER - (funding) EPA Montana Office, Bureau of Reclamation through the Montana Watershed Coordination Council, U.S. G.S. - Water Institute Program base grant. (others) Natural Resources Information System (NRIS) of the Montana State Library, Montana Bureau of Mines & Geology, MT DEQ, MT DNRC, MT Association of Conservation Districts, USDA Natural Resources & Conservation Service, MT Dept. of Fish, Wildlife & Parks.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Montana Watersheds
Description	A WEBsite to Bring People and Watershed Information Together
Start Date	01/01/1997
End Date	01/01/2003
Type	Publications
Lead Institution	Montana Watershed Coordination Council

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Michael McLane	Professional Staff	Montana Watershed Coordination Council	01
Kathy Tohe Stephens	Professional Staff	Montana Water Resources Research Center	02
Ann Marie Gooden	Student	Montana Water Resources Research	03

		Center	

Problem and Research Objectives

These pages have been developed with the guidance of the Montana Watershed Coordination Council (MWCC) for the purpose of encouraging citizen participation in watershed discussions and to make resources available to local groups and committees. Included are 'Events', 'Watershed Groups', 'Funding and Technical Resources', 'Links', and 'All about the MWCC.' All pages are part of an interactive WEB database. Users can access -- add, delete, or edit their information online. Please visit the site at http://water.montana.edu/WATERNET/watershed/

This is an ongoing multiyear project.

Methodology

Principal Findings and Significance

Articles in Refereed Scientific Journals

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	MONTANA WATER
Description	A WEB switchboard for Montana Water Information
Start Date	03/01/1997
End Date	02/28/2001
Type	Library And Database Services
Lead Institution	Montana Water Resources Research Center

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Kathy Tohe Stephens	Research Associate	Montana Water Resources Research Center	01
Ann Marie Gooden	Student	Montana Water Resources Research Center	02

Problem and Research Objectives

MONTANA WATER is an ongoing WEB site designed and maintained as an information switchboard for all of Montana and the region. Highlights from this year's work include:

- Total redesign of the site --- http://water.montana.edu
- Site categories includw: Information, Featured Programs, Training & Education, Montana Watersheds, and Policcy and Legislation.
- development of several database driven sites - were web users can access, add, and change information online. These include: Events, Water Expertise Directory, Grants and Funding, Technical Resources, Watershed Groups and online library
- the Montana Source Water Protection Site
- Montana Operator Training

Methodology

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	Water for the New Millenium
Description	AWRA-MT and Water Center Annual Meeting
Start Date	10/04/1999
End Date	05/05/1999
Type	Conferences
Lead Institution	Montana Water Resources Research Center

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Ginette Abdo	Professional Staff	Montana Bureau of Mines and Geology	01
Kathy Tohe Stephens	Professional Staff	Montana Water Resources Research Center	02
Carole Mackin	Professional Staff	Montana Dept. of Environmental Quality	02
Joanna Thamke	Professional Staff	US Geological Survey	02

Problem and Research Objectives

The 1999 meeting was co-hosted at the new Lewis and Clark Interpretive Center, on the Missouri River in Great Falls Montana. Approximately 120 registered conference goers attended 4 sessions with over 25 speakers plus approximately 6 poster sessions. In addition to year-round planning for this statewide event, the Water Center Information Services Manager helped design and launch a new website for the AWRA-Montana Section at http://awra.org/montana/

Jane Holzer, Director of the Montana Salinity Control Association was recognized as the Montana Water Legend

Information on the Year 2000 meeting in West Yellowstone MT is available at the web address listed above.

Methodology

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USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	4	N/A	1	N/A	5
Masters	4	1	N/A	N/A	5
Ph.D.	N/A	1	N/A	N/A	1
Post-Doc.	N/A	N/A	N/A	N/A	N/A
Total	8	2	1	N/A	11

Awards & Achievements

Watershed Restoration Assessment for Lost Creek

James A. Harris and Vicki Watson, Environmental Studies, University of Montana, Missoula, MT 59812

The recommendations for TMDL development made by this work are being used by Montana DEQ, Montana DFWP, NRCS and the TriState Water Quality Council. ----------

Publications from Prior Projects

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications