Water Resources Research Center
Annual Technical Report
FY 2003

Introduction

The 38th year of the Massachusetts Water Resources Research Center (WRRC) was another year of transition. Dr. David Reckhow continued in his role as Interim Director, but The Environmental Institute (TEI) Assistant Director Sharon Tracey took on a Special Projects Coordinator role at TEI. Her responsibilities at WRRC were taken on by Marie-Françoise Walk who has worked for the Center since 1987 and who stepped in the vacant Assistant Director position.

Dr. Reckhow organized a water resources conference in December 2003, involving many academic departments at UMass-Amherst. The conference was extremely well attended and deemed a success by all participants; we plan to make the conference an annual event to highlight research progress in the water resources field. Another innovation initiated by Dr. Reckhow was the formation of an External Advisory Board to the WRRC, which we expect will be instrumental in recruiting a permanent Director and securing new sources of funding.

This was the second year for two innovative research projects: Potential Movement of Pesticides Related with Dissolved Organic Matter from Organic Fertilizer Application on Turf by Dr. Baoshan Xing of UMass-Amherst Dept of Plant and Soil Sciences, and Copper Removal by Biofilms, by Dr. Xiaoqi Zhang of UMass-Lowell Dept. of Civil and Environmental Engineering. Dr. Stephen Mabee of UMass-Amhersts Dept. of Geosciences was awarded a 104G USGS grant to look at A Regional Approach to Conceptualizing Fractured-Rock Aquifer Systems for Groundwater Management.

The Center's long-term commitment to citizen involvement in scientifically-credible watershed monitoring carried on through several projects: the Massachusetts Water Watch Partnership, the Acid Rain Monitoring Project, and collaboration with UMass Extension on a stream continuity project as well as a workshop series for secondary school teachers.

Research Program

Copper Removal by Biofilms

Basic Information

Title:	Copper Removal by Biofilms
Project Number:	2003MA8B
Start Date:	3/1/2003
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	5th
Research Category:	Water Quality
Focus Category:	Treatment, Waste Water, Water Quality
Descriptors:	Treatment, toxic substances, water quality, wastewater.
Principal Investigators:	Xiaoqi (Jackie) Zhang, Xiaoqi (Jackie) Zhang

Publication

1. Brussee, K. (2004) Copper removal by biofilms. Abstracts for the University of Massachusetts Lowell 7th Annual Student Research Symposium, #10.
2. Brussee, K. and X. Zhang, Copper Removal by Biofilms, 2003, in First Annual Water Resources Research Center Conference: Water Resources in the Northeast: Science and Policy. http://www.umass.edu/tei/wrrc/presentations/Zhang.pdf

Copper Removal by Biofilms

Problems and Research Objectives

Heavy metal contamination is of growing concern nationwide because of the numerous health risks to animals and humans. Among the five pollutants of primary concern to MWRA's Toxic Reduction and Control division in Massachusetts, three are heavy metals (i.e. Hg, Cu, and Pb, http://www.mwra.state.ma.us/03sewer/html/regs2.htm). Some of the heavy metal contamination comes from agriculture and sewage disposal, although most come from industrial sources, including electroplating plants, mining, nuclear and electronics industries, metal finishing operations, tanneries, and industrial processes utilizing metals as catalysts. Since most of the heavy metal laden effluent will ultimately reach sewerage systems via direct discharge or urban runoff, it is important to remove heavy metals during wastewater treatment processes to reduce the potential harmful effects to ecosystems and public health. In Massachusetts, The Clean Water Act requires that businesses and industries that discharge into the sewerage treatment plants be regulated through an industrial pretreatment program and the discharge limit is set by the local wastewater treatment plant (WWTP). For copper, the state average local limit is 2.187 mg/l (with the maximum being 27.6 mg/l). Such program has greatly reduced the burden of local sewerage treatment plants who usually don't have the capability of handling high concentration industrial pollutants. Wastewater treated by municipal/industrial wastewater treatment plants is usually discharged into local surface water. Although many municipal/industrial wastewater treatment plants can meet the discharge limit set by DEP/EPA, some still have difficulty in meeting the copper discharge limit. Therefore there is an urgent need for an effective treatment technology to remove copper during the wastewater treatment process to meet the ever more stringent discharge limit (6.2 µg/l for copper discharge to Nashua River).

It is hypothesized that microorganisms produce negatively charged extracellular polymeric substances which can sorb positively charged copper. The objective of this research is to evaluate the effectiveness of a biofilm system in treating heavy metal containing wastewater, and determine the cellular response to copper contamination and the effects of substrate concentration on such cellular response and copper removal.

Methodology

A laboratory scale biofilm reactor (Biosurface Technologies, Corp. Jacketed Model 1120LJ) (Figure 1) is being used to generate biofilm growth on twenty removable clear polycarbonate slides by seeding the reactor with activated sludge and introducing an influent with a controlled substrate and copper concentration.

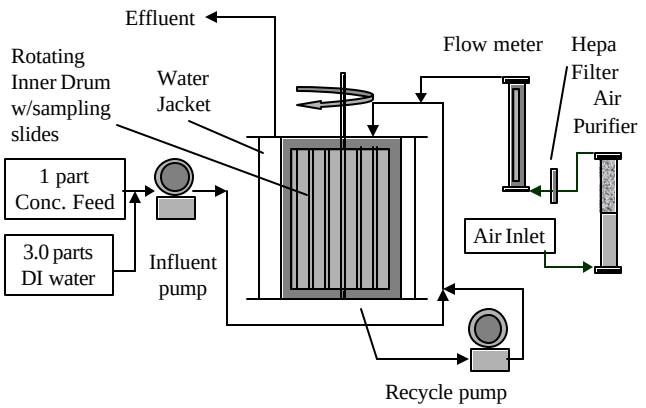

Figure 1. Experimental flow chart of biofilm reactor.

Influent Design: The substrate is introduced to the reactor using one pump (Cole Parmer No. 7553-80) with two pump heads (Cole Parmer, Masterflex No. 77200-60). One pump head utilizes Manostat 1/16th inch tygon silicone tubing to transport the concentrated feed, the other 1/8th inch tubing to transport DI water. The two lines join producing an influent with a ratio of approximately 3.0 mL of DI water to 1 mL of concentrated feed. The influent flow rate to the reactor is being maintained at 8.5 mL/min producing 106 minutes of hydraulic retention time.

Table 1. Desired influent concentrations (Zhang et al., 1999)

Organics	Influent conc. (mg/L)	Inorganics	Influent conc. (mg/L)
beef extract	41.76	NH_4Cl	1.67
yeast extract	45.93	$NaHCO_3$	156.44
peptone	41.76	K_2HPO_4	18.37
glucose	29.48	KH_2PO_4	7.11
		$MgSO_4 \cdot 7H_20$	18.37
		$FeCl_2 \cdot 4H_20$	0.25
		$CaCl_2 \cdot 2H_20$	24.56
		$NH_2 \cdot CO \cdot NH_2$	29.48
		$Na_2HPO_4 \cdot 7H_2O$	27.56

The concentrated feed is prepared according to the observed ratio described above. Table 1 shows the desired concentrations entering the reactor. A fresh twenty liters of concentrated feed is prepared weekly. The organics (except urea) and approximately eighteen liters of DI water are autoclaved to prevent the feed from fouling (fouling has shown to reduce the influent COD concentration, pH and ratio of free to total copper). The inorganics, urea, and copper are added once the autoclaved water has cooled and is then placed on a stir plate and hooked up to the influent pump.

Influent/Effluent Parameters: For each new twenty liters of feed, the COD concentration, pH, total copper and free copper concentration (Hach method 8143) of the influent are measured three times; initial, third day, and seventh day. The COD concentration, pH, total copper and free copper concentrations are also determined for the effluent on the same schedule as the influent.

Biofilm Sampling: Once the reactor has reached a pseudo-steady state condition indicated by the constant effluent COD concentration (within approximately two weeks of forward flow), and the biofilm growth is substantial enough for sampling, biofilm is scraped from one or two of the sampling slides for biofilm analysis and EPS extraction. For each sampling, the surface charge (Morgan et al., 1990), and total and free copper concentrations of the biofilm are determined (Hach method 8143). Total Solids (TS), Total Suspended Solids (TSS), and Volatile Suspended Solids (VSS) (APHA, 1998) are determined for the biofilm as well. TS is used to represent the total mass of the biofilm; TSS as the total biomass; and VSS as the viable biomass.

EPS Extraction: Biofilm EPS is extracted according to the steaming procedure described in Zhang et al. (1999). EPS is quantified by measuring polysaccharides content (Dubois et al, 1956) and protein content (Bradford, 1976). Figure 2 shows the variety of analyses that are performed on the biofilm samples, and EPS extraction procedure and its measurement.

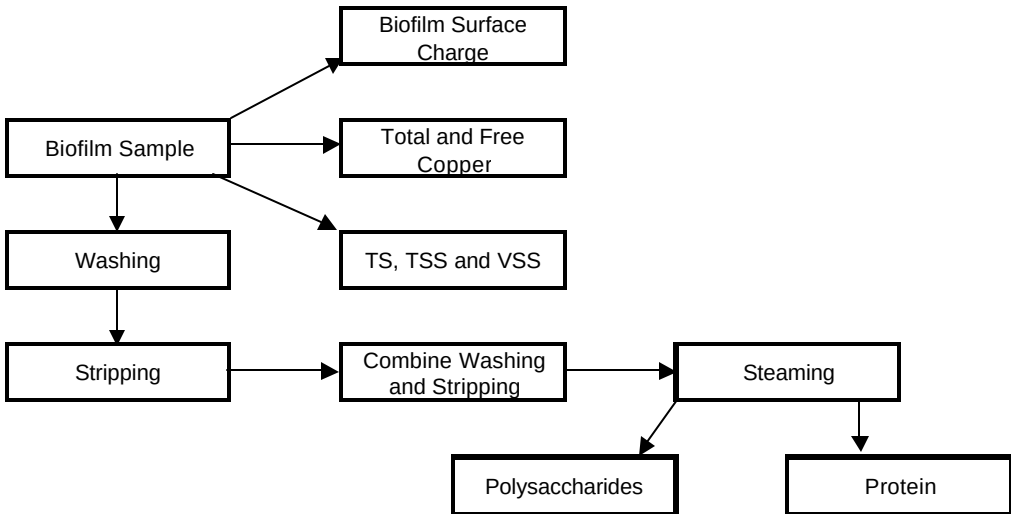

Figure 2. Flowchart of biofilm and EPS analyses.

Principal Findings and Significance

The initial reactor running conditions we studied were: a mimic wastewater influent containing 100ppb Cu^{2+} and 150 mg/L of COD. This report describes the principal findings for these running conditions.

Copper Removal: The total influent copper concentration was maintained at 104 (± 5) ppb, and the resulting total effluent copper concentration was 98 (± 5) ppb. The free copper concentration of the influent was 66 (± 7) ppb and the effluent 42 (± 9) ppb. Although only 5.8% of the total copper was removed, 36% of the free copper was removed from the influent, either by sorption or forming complexes. The toxicity of copper mainly comes from free copper, therefore, this biofilm reactor is effective in removing the free copper and reducing copper toxicity.

Biofilm: On each sampling slide, 54.0 (± 4.1) mg TS and 43.1 (± 0.4) mg TSS of biofilm were obtained from the reactor. The biofilm was found to have net surface charge of -0.51 (±0.06) μequivalents/mg TS and total copper of 1.10 (±0.06) mg Cu/g TS (see Table 2). The negative surface charge on the biofilm suggests that more copper sorption can be expected with longer reactor running time. The mass of copper contained within the biofilm is an important factor for determining the threshold of copper sorbed by biofilm and consequently the effectiveness of a biofilm system in removing copper from wastewater; and this will be further determined after more running conditions (controlled substrate and copper concentration) are studied.

Biofilm EPS Production: The EPS polysaccharides to protein ratio was 0.785 (see Table 2). This is quite different compared to the data collected by Ramasamy and Zhang (2004) under the reactor influent conditions of 0 ppb Cu^{2+} and 150 ppm COD, which showed EPS polysaccharide concentrations more than twice that of protein. This clearly indicates that this could be the result of cellular response to copper contamination. The response is expressed by producing less polysaccharides.

Table 2. Analyses for biofilm and biofilm EPS

	Parameter	Value
Biofilm	TS, mg/sampling slide	54.0 ± 4.1
	TSS, mg/sampling slide	43.1 ± 0.4
	Total copper sorbed by the biofilm, mg Cu/g TS	1.10 ± 0.06
	Biofilm surface charge, μequivalents/mg TS	-0.51 ± 0.06
Biofilm EPS	EPS-carbohydrate, mg/g TS	15.7 ± 2.2
	EPS-protein, mg/g TS	20.0 ± 1.6

Note: VSS of the biofilm didn't work out.

References

American Public Health Association; American Water Works Association; Water Environment Federation (1998) *Standard Methods for the Examination of Water and Wastewater*. 20th ed., Washington, D.C.

Bradford, M. M. (1976) A rapid and sensitive method for the quantification of microgram quantities of protein utilizing the principle of protein-dye binding. *Analyt. Biochem.* **72**, 248-54.

Dubois M., Gilles K. A., Hamilton J. K., Rebers P. A. (1956) Colorimetric method for determination of sugars and related substances. *Analyt. Chemistry* **28**, 350-356.

Morgan, J.W., Forster, C.F., Evison, L. (1990) Comparative study of the nature of exopolymers extracted from anaerobic and activated sludges. *Wat. Res*. **24** (6), 743-750.

Ramasamy, P. and Zhang, X. (2004) Effects of shear stress on the secretion of extracellular polymeric substances in biofilms. Env. Eng. Sci. (In preparation)

Zhang, X., Bishop, P. L., Kinkle, B. K. (1999) Comparison of extraction methods for quantifying extracellular polymers in biofilms. *Wat. Sci. Tech*. **39,** 211-218.

Publications

Water Resources Research Institute Annual Report (this report)
Brussee, K. (2004) Copper removal by biofilms. Abstracts for the University of Massachusetts Lowell 7th Annual Student Research Symposium, #10.

Students Supported (number and level)

One Master's student is being supported.
A Master's thesis is being written as a result of this project.

Future Funding

The PI is actively seeking funding from NSF to continue research on this topic.

Potential Movement of Pesticides Related to Dissolved Organic Matter from Organic Fertilizer Application on Turf

Basic Information

Title:	Potential Movement of Pesticides Related to Dissolved Organic Matter from Organic Fertilizer Application on Turf
Project Number:	2003MA9B
Start Date:	3/1/2003
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	1st
Research Category:	Water Quality
Focus Category:	Water Quality, Groundwater, Solute Transport
Descriptors:	Dissolved organic matter (DOM); Sorption; Organic contaminants
Principal Investigators:	Baoshan Xing, William Torello

Publication

1. Li, K., W.A. Torello, and B. Xing. 2003. Effect of dissolved organic matter on pesticide leaching in a USGA sand column experiment. Agronomy Abstracts, Denver, CO. Nov. 2-6. 2003.
2. Xing, B. and L. Kun. 2003. Pesticide movement and organic fertilizer application on turf. Water Resources in the Northeast Science and Policy Conference; Dec. 5, 2003; University of Massachusetts; p. 18 of the Final Program book. PowerPoint Presentation of this paper is available at http://www.umass.edu/tei/wrrc/presentations/Li.pdf

Project Description: Incorporation of organic fertilizers/amendments has been, and will continue to be, a popular strategy for golf course turfgrass management. Dissolved organic matter (DOM) derived from these organic materials may, however, facilitate organic chemical movement through soils. A batch equilibration technique was used to evaluate the effects of organic fertilizer-derived DOM on sorption of two organic chemicals (naphthalene and chlorpyrifos) in USGA (United States Golf Association) sand and a silt loam soil (Typic Fragiochrept). DOM was extracted from two commercial organic fertilizers. Different concentrations of DOM were used in the sorption experiments. In addition, surface tension was determined for solutions with various DOM concentrations. Surface tension decreased with increasing DOM concentration in water, indicating that the extracted DOM had similar properties to surfactants. Data from the sorption experiments showed that sorption coefficient was significantly reduced with increasing DOM concentration as compared with that without any DOM addition. These results suggest that organic fertilizer-derived DOM might lead to enhanced transport of applied chemicals in turf soils if not used properly. Further research with different chemicals and soils is underway. Also, we have started column experiments. Characterization of sequentially extracted humic substances from compost was initiated.

Publications:

Abstracts:

1) Li, K., W.A. Torello, and B. Xing. 2003. Effect of dissolved organic matter on pesticide leaching in a USGA sand column experiment. Agronomy Abstracts, Denver, CO. Nov. 2-6. 2003.

2) Xing, B. and L. Kun. 2003. Pesticide movement and organic fertilizer application on turf. Water Resources in the Northeast Science and Policy Conference; Dec. 5, 2003; University of Massachusetts; p. 18 of the Final Program book.

Students Supported:

One undergraduate student
One Ph.D. student

A Regional Approach to Conceptualizing Fractured-Rock Aquifer Systems for Groundwater Management

Basic Information

Title:	A Regional Approach to Conceptualizing Fractured-Rock Aquifer Systems for Groundwater Management
Project Number:	2003MA19G
Start Date:	9/30/2003
End Date:	9/30/2005
Funding Source:	104G
Congressional District:	1st District of MA
Research Category:	Ground-water Flow and Transport
Focus Category:	Water Supply, Groundwater, Water Quantity
Descriptors:	fracture characterization, domain analysis, well yield, fractured rock aquifers, groundwater availability, groundwater mapping, borehole geophysics
Principal Investigators:	Stephen B. Mabee, Michele Cooke

Publication

Project Description

Problem Statement

The use of fractured-bedrock aquifers to meet private, public and commercial water supply needs is increasing in the New England region. Municipalities and water suppliers are finding it increasingly difficult to locate and develop water supplies in overburden aquifers because of contamination and a lack of suitable sites. In addition, recent droughts in the northeast have forced many communities and homeowners to drill new wells. As a result, water suppliers are going deeper into bedrock aquifers. Yet information on the factors that influence the availability and recharge characteristics of fractured bedrock aquifers in highly deformed crystalline metamorphic rocks is limited.

The availability of water in fractured rock aquifers is particularly critical in New England because growth and development along the coast, major transportation corridors and in rural communities adjacent to large metropolitan areas is rampant. For example, the I-495 corridor in Massachusetts, a circumferential highway 30 miles west of Boston, has become the focus of recent growth. Professional office buildings, research and development parks associated with the computer industry, warehouses and light industry are springing up along this corridor, as are housing and condominium developments. Municipalities and water suppliers are simply unprepared for the onslaught of development and need help in understanding the complex dynamics of the ground water system.

Sustaining and managing ground water resources in fractured bedrock requires an evaluation of 1) the availability of water, 2) the source and vulnerability of recharge to water supply wells and 3) the impact of water withdrawals from the bedrock on streams, wetlands and unconsolidated aquifer systems that overlie the bedrock. These evaluations all require basic information on the physical characteristics of the ground water system.

Objectives

The objectives of this project are to gather regional bedrock characteristics that relate to the occurrence and movement of ground water in bedrock and use this information to begin constructing regional conceptual models of the fractured-rock aquifers in the Nashoba terrane in Massachusetts. The approach utilizes existing information augmented by the collection of low-cost field data to develop regional conceptual models of the ground water flow system. Water managers can then use these conceptual models as an initial framework for formulating an understanding of bedrock flow behavior and recharge characteristics.

Specific tasks of this project involve: 1) Fracture Characterization and Domain Analysis - collection and synthesis of fracture characterization data over the region and mapping of the spatial distribution (domain analysis) of fracture sets and their characteristics, 2) Compilation and Analysis of Existing Well Data - compilation and statistical analysis, including variography, of available well data to link spatial continuity of well yields to

characteristics of the fractured rock system, 3) Borehole Geophysics - collection of optical and acoustic televiewer data from selected boreholes to verify sheeting joints, 4) Compilation of Regional Litho-Group Map - development of a mapping classification system that uses the notion of "litho groups" to characterize bedrock units in terms of their fracture characteristics, physical properties and geologic setting (eg., overburden type and thickness) and 5) Conceptual Model - preparation of a qualitative conceptual model of ground water flow behavior in each litho group category.

Relationship of Project to USGS and Other Activities

This project is part of a much larger, more comprehensive five-year study being conducted by the USGS WRD Northborough office on the Geohydrology of the Nashoba Terrain, Massachusetts. This larger scale project involves the collection of data at three scales: regional, quadrangle and the local well-field scale. Recent work by the USGS in Connecticut and New Hampshire indicates that an understanding of ground water occurrence and movement in fractured rock aquifers can be made by combining the results of 1) fracture, geologic, well, and geophysical analyses performed at the regional level, 2) detailed mapping of bedrock lithology and physical characteristics that affect water occurrence and flow at the quadrangle scale, and 3) hydrogeologic and geophysical investigations at the well-field scale. This larger scale project is a joint effort that involves the participation of USGS scientists from the Water Resources Discipline, USGS mappers from the BRASS (Bedrock Regional Aquifer Systematics Study) program, the Office of the Massachusetts State Geologist, and University of Massachusetts scientists (this project). Table 1 describes the tasks that each agency will perform and shows how the work will be coordinated.

Table 1. Coordination Plan and Approximate Timetable

Task	Activity	Timetable	Responsible Party
Existing Data (Regional Scale)	Base map	Year 1	USGS[1]
	Geologic map	Year 1	USGS
	Imagery	Year 1	USGS
	Fracture data/analysis	Year 2	This Project[2]
	Existing well data/analysis	Year 2	This Project
	Add'l well data in field	Year 2	USGS
	Borehole fracture data	Year 1&2	This Project/USGS
	Litho-group map	Year 2	This Project
Geologic & Fracture Data (Quadrangle Scale)	Map Quad #1-Grafton	Year 2	USGS BRASS[3]
	Map Quad #2-Marlboro	Year 1	State Geologist[4]
	Map Quad #3-Concord	Year 3	USGS BRASS[3]
	Map Quad #4-Hudson	Year 2	State Geologist[4]
Conceptual Model Devel.		Year 2-4	This Project/USGS
Test and Verify Model (Well Field Scale)		Year 4	USGS
Prepare and Publish Reports		Years 3-5	This Project/USGS

[1] Start date (Year 1) of USGS cooperative project is March 2003, Bruce Hansen, USGS

[2] Start date (Year 1) of this project is September 30, 2003
[3] USGS BRASS = Bedrock Regional Aquifer Systematics Study project, start date (Year 1) Oct. 2003, mapping begins summer 2004, Greg Walsh, USGS
[4] State Geologist – Mapping funded by the STATEMAP component of the National Cooperative Geologic Mapping Program, start date (Year 1) for mapping commences in summer 2003.

Work Accomplished on this Project to Date

Since project inception, we have spent most of the time recruiting a Ph.D. candidate. We received 34 inquiries but were unable to find someone who could start in January 2004 or in June 2004. We finally selected Alex Manda for the project. Alex received his undergraduate degree in geology from Cardiff University in 2001 and will finish his M.S. degree at Florida International University this summer. He will begin his graduate studies at the University of Massachusetts in September 2004. Alex is currently working with Dr. Michael Gross and is working on characterizing macropore geometries in the Floridan Aquifer.

When Alex arrives he will begin assembling and analyzing the well data. Field work to collect fracture data will commence in the summer of 2005.

Work Accomplished on this Project by Collaborators (Table 1)

USGS – The USGS WRD Northborough office has commenced with several tasks in support of this project. A summary of their activities follows.

1. Well completion reports from the Massachusetts Department of Conservation and Recreation have been assembled for the towns of Berlin and Bolton. The well completions reports are logs submitted by well drillers.
2. Aeromagnetic data at a 0.5 mile grid spacing has been assembled from existing data and will be used to support the identification of regional faults.
3. Quadrangle-scale geologic map information has been collected and will be used to assemble a base map of the geology for the project area.
4. Borehole logging of several high yield wells have been performed at Intel in Hudson, MA and at a public water supply well in Maynard, MA. Several high-yielding golf course wells located in Stowe, MA, will be logged this summer.
5. Preliminary pumping test data has also been collected for the above wells and will be used in testing and verifying conceptual models at the well-field scale.

Office of the Massachusetts State Geologist – The office of the Massachusetts State Geologist has contributed in the following way using funds supplied by the National Cooperative Geologic Mapping STATEMAP program.

1. New bedrock, fracture characterization, and surficial geologic maps have been prepared for the Marlborough quadrangle. These maps provide detailed lithologic and fracture characterization data as well as information on the distribution of

permeable overburden deposits at the quadrangle scale. These data will be used as a test for the regional scale litho-group maps to be prepared under this project.
2. A well database consisting of over 1800 wells has been assembled for the Marlborough quadrangle. This includes eight towns all located within the project area. These data will be used as part of the well inventory for the project.
3. During the summer of 2004, bedrock and fracture characterization data will be collected for the Hudson quadrangle. A well database is also being prepared for the towns located in this quadrangle.

USGS BRASS Program – Greg Walsh from the USGS BRASS program will be conducting bedrock and fracture mapping in the Grafton quadrangle during the summer of 2004. This will provide detailed lithologic and fracture characterization data for a third quadrangle within the project area.

Summary

Collection of the well-field scale pumping test data, borehole geophysical data, well inventory information and quadrangle-scale geologic and fracture mapping being performed by project collaborators is well underway and will continue through 2004. Alex Manda, a Ph.D. student who will be perform the majority of the regional-scale work for this project, has been hired and will begin work in earnest beginning in the fall of 2004. His initial efforts will be in constructing the regional well database. Regional-scale fracture characterization work will begin in summer 2005.

Information Transfer Program

The Massachusetts Water Watch Partnership

Basic Information

Title:	The Massachusetts Water Watch Partnership
Project Number:	2003MA16B
Start Date:	3/1/2002
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	1
Research Category:	Not Applicable
Focus Category:	Water Quality, Surface Water, Non Point Pollution
Descriptors:	Citizen Monitoring, Non-point Pollution, Monitoring, Volunteer, Quality Control
Principal Investigators:	Marie-Francoise Walk

Publication

1. Walk, MF, 2003, Lake Volunteer Water Quality Monitoring Manual, Water Resources Research Center, Blaisdell House, University of Massachusetts Amherst, MA 01301, 92pp., http://www.umass.edu/tei/mwwp/acrobat/lake%20manual.pdf

Problem and Research Objectives

The Massachusetts Water Watch Partnership (MassWWP) was formed in 1990 to empower citizens to collect, evaluate, and act on scientifically credible water quality information for the Commonwealth's surface waters. The program relies on building a partnership with government, industry, educators, conservation organizations and the general public, who lend their respective talents to this effort to achieve practical solutions to water quality problems. The program has grown from working with 15 groups in 1990 to over 80 today.

Methodology

MassWWP services fall into a number of broad categories:

- *Workshops and Conferences* - to train volunteers and promote information sharing on the major aspects of planning and running a monitoring program, from program planning to field and laboratory methods to data management and presentation. MassWWP also regularly presents papers and workshops and helps plan water monitoring related conferences around New England and the nation.
- *Partnership and Network Building* - to foster productive relationships among volunteer groups and between volunteer programs and governments, business, and other interests.
- *Special projects* - on specific issues, such as satellite imagery and a nationwide Secchi disk survey.
- *Research* - on topics that have the potential to enhance the utility of volunteer monitoring programs.
- *Consultation and Advice* - including the loaning of sampling equipment, and other direct services.
- *Publications* - development and/or distribution of documents of use to volunteer monitors.
- *Statewide Coordinator and Western Massachusetts Service Provider* - as one of the four designated regional service providers and responsible for western Massachusetts.

Principal Findings and Significance

MassWWP saw a reduced level in funding this year but continued providing assistance to volunteer monitoring groups throughout the state. We offered eight training sessions or courses, including one on introduction to lake monitoring, two on lake field sampling methods, one on lake macrophyte mapping and identification, one on lake data interpretation, six classes as part of the Quality Assurance Project Plans (QAPP) workshop series, and two river benthic macroinvertebrate workshops.

We managed a listserv of about 135 members to facilitate communications in the Massachusetts watershed monitoring community, and updated our website www.masswwp.org with the latest news and technical information.
As part of our Memorandum of Understanding with the University of Massachusetts Extension we worked on three projects:

- Initiated and advised a new monitoring program for Lake Warner in Hadley
- Conducted training of volunteers and surveys for a stream continuity project (looking at the effect of roads and railroad crossings of streams on fish and wildlife passage)

- Taught 4 classes on monitoring (study design, streamside macroinvertebrate surveys, shoreline surveys and lab analyses, and data interpretation) in a workshop series for secondary school science teachers.
- Served on various technical advisory committees.

We produced the following materials:

- A Lake Volunteer Water Quality Monitoring Manual.
- An updated version of our Aquatic Plant Mapping manual.
- An Excel spreadsheet utility for analysis and graphing of macroinvertebrate data and a similar Excel utility for chemical data.
- Quality Assurance Project Plans for two volunteer monitoring groups (one lake and one river) and for the Springfield Surface Water Action Program.
- A Microsoft Access database of Massachusetts Monitoring groups.

Finally we chaired and organized one session of the WRRC conference, on "Directions in Watershed Management Policy and Practices in the Northeast."

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	1	0	0	0	1
Masters	1	0	0	0	1
Ph.D.	1	0	0	0	1
Post-Doc.	0	0	0	0	0
Total	3	0	0	0	3

Notable Awards and Achievements

Water Resources in the Northeast: Science and Policy Conference On December 5, 2003, the Center hosted its first annual WRRC conference at the University of Massachusetts-Amherst. The efforts of a multi-departmental team under the leadership of Interim Director David Reckhow culminated in a first-class program with nine sessions and 27 presentations on current water resources research and policy topics. Congressman John W. Olver gave the keynote address and was presented the first MA WRRC Environmental Leadership Award by Chancellor John Lombardi. The conference was attended by 155 people from academia, governmental agencies and non-governmental organizations as well as students.

Creation of an External Advisory Board The first External Advisory Board was assembled in the winter of 2003-2004. During this period, Interim Director David Reckhow invited upper-level government and agency representatives to serve on an advisory board to the WRRC. The role of this EAB is to provide general direction to the Center and its Director, along with some high-level oversight to its associated activities across the Commonwealth. A WRRC prospectus was developed to describe the WRRC to prospective members. The first meeting of the EAB is planned for June 2004.

Publications from Prior Projects

1. 2000MA5B ("Monitoring disinfection byproducts in drinking water: Strategies for small utilities") - Water Resources Research Institute Reports - Carlson, B. and D.A. Reckhow, 2003 Monitoring Disinfection Byproducts in Drinking Water: Strategies for Small Utilities, MA Water Resources Research Center, University of Massachusets, Amherst, MA, 68 pp.http://www.umass.edu/tei/wrrc/WRRC2004/pdf/reckhow.pdf