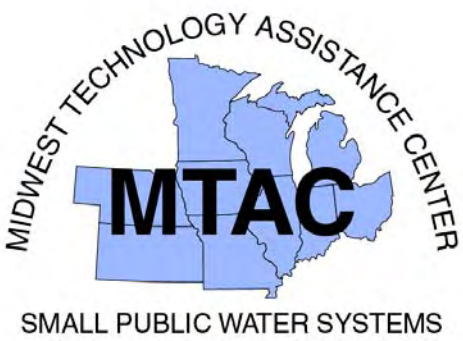

Midwest Technology Assistance Center for Small Public Water Systems Final Report

USEPA Grant# X829218-01

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MTAC Publication FR08-X829218-01
ISWS Contract Report 2008-07

Disclaimer

This material is based upon work supported by the Midwest Technology Assistance Center for Small Public Water Systems (MTAC). MTAC was established October 1, 1998 to provide assistance to small public water systems throughout the Midwest via funding from the United States Environmental Protection Agency (USEPA) under section 1420(f) of the 1996 amendments to the Safe Drinking Water Act. MTAC is funded by the USEPA under Grant No. X829218-01. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the USEPA or MTAC.

Midwest Technology Assistance Center for Small Public Water Systems Final Report

USEPA Grant# X829218-01

The Midwest Technology Assistance Center (MTAC) was established October 1, 1998 to provide assistance to small public water systems throughout the Midwest via funding from the United States Environmental Protection Agency (USEPA) under section 1420(f) of the 1996 amendments to the Safe Drinking Water Act. This report summarizes all projects funded under USEPA Grant# X829218-01, corresponding to funding received from federal fiscal years 2001, 2002, 2003, and 2004.

MTAC was formed as a cooperative effort of ten Midwest states (congruent with USEPA regions 5 and 7), led by the Illinois State Water Survey and the University of Illinois. Dr. John Braden and Kent Smothers were the original Principal Investigators for this project. Kent Smothers has served as the Managing Director of the Center since its inception, and is responsible for overseeing the activities of individual project Principal Investigators and preparing and submitting quarterly and final reports. Dr. Richard E. Warner has been actively involved as an advisor to MTAC in his role as Director of the Illinois Water Resources Center at the University of Illinois, and has replaced Dr. Braden as the lead Principal Investigator for the project. The final report is organized by the fiscal years the projects were funded.

Fiscal Year 2001 Projects

Competitive Grants

MTAC issued a Request for Proposals (RFP), which was posted on its web site and forwarded to the other Technical Assistance Centers (TACs), and to universities in Illinois and around the Midwest. All of these proposals underwent an external review, and were approved by the USEPA as suitable topics before final selection and funding. MTAC funded four competitive grants during this funding cycle. The project description, results and outputs, and (to the extent possible) outcomes are described in the following text.

Arsenic in Illinois Groundwater:
Applications for Non-Community Water Supplies

Steve Wilson
Illinois State Water Survey

Project Description

The new arsenic rule, which lowered the Maximum Contaminant Level (MCL) for arsenic from 50 micrograms per liter (µg/L) to 10 µg/L, included for the first time non-community, non-transient public water supplies. This change in regulations affected 450 of the approximately 3950 non-community supplies in Illinois that are regulated by the Illinois Department of Public Health (IDPH). These facilities, primarily schools and small businesses, could have a difficult time meeting the new standard if their groundwater supply exceeds the acceptable limit for arsenic because the costs of treatment, monitoring and reporting may be prohibitive.

The goals of this proposed project were:

1. To help characterize the occurrence of arsenic in non-community groundwater supplies statewide.

2. To evaluate the chemical conditions and well construction details of each data point to determine what characteristics affect the dissolution of arsenic in groundwater.

3. To evaluate the potential costs for those non-community supplies whose results indicate that additional treatment will be required to meet the new USEPA standard for arsenic of 10 µg/L.

4. To evaluate the effectiveness of two cost effective arsenic testing kits that could be used by University of Illinois Extension, schools, and environmental groups to provide a low-cost screening for arsenic in water samples as well as provide an educational tool to promote public awareness of arsenic in groundwater.

5. To contribute to a central database of arsenic data that includes the historical sampling results from the laboratories of the IDPH, Illinois Environmental Protection Agency (IEPA), and Illinois State Water Survey (ISWS) as well as the results of the 250 wells that would be sampled as part of this study.

Project Results/Outputs

The tasks listed above were all completed, and the results are summarized in the final report http://mtac.sws.uiuc.edu/mtacdocs/finalreports/IDPH_Final_Report.pdf, which is posted on the MTAC web site (http://mtac.sws.uiuc.edu/). There were 127 samples submitted for analysis in this study. There were 89 non-transient systems (9% of which exceeded the 10µg/L standard) and 53 transient, non-community systems (17% exceeded) included in the study. Results confirmed the conclusion of previous studies that arsenic in Illinois groundwater is a greater problem in shallow sand and gravel aquifers that are confined and under reducing

conditions. The performance of both test kits was disappointing, and neither was recommended by the authors. The author has given several presentations at regional meetings detailing the results of this study.

Project Outcomes

1. This project increased the knowledge of the relationship between geological, geochemical, and well construction parameters and arsenic concentration for non-transient and non-community groundwater supplies in Illinois. This may result in fewer new wells being installed that will exceed arsenic standards, thereby reducing human risk exposure.

2. Two commercially available arsenic test kits were determined to be unreliable for the samples in this study.

3. Many non-transient, non-community supplies were tested for arsenic, and this could increase their awareness in regard to drinking water related health issues in the future. Those found to have concentrations exceeding the arsenic MCL were made aware of the health hazard and the need to treat the water to remove arsenic or secure another drinking water source.

Guide to Developing a Source Water Protection Plan: Interactive Training Tool for Illinois Water Systems

Kevin Kundert and Gretchen Rupp
Montana State University

Project Description

The Principal Investigators of this project worked with Anthony Dulka of the Illinois Environmental Protection Agency (IEPA) to produce an interactive CD-ROM that small communities and operators could use to assist them in meeting amendments to the 1996 Safe Drinking Water Act (SDWA) that required states to implement a Source Water Assessment and Protection Program. The CD-ROM, titled "Guide to Developing a Source Water Protection Plan" also educates operators on issues related to source water protection and groundwater in addition to assisting them in developing their plan.

Project Results/Outputs

There were 3800 copies of the CD-ROM produced and distributed to water operators, the IEPA, the Illinois Section American Water Works Association (ISAWWA), and MTAC. There is an interactive version on the IEPA web page that is still in use (http://www.epa.state.il.us/water/groundwater/source-water-assessment/index.html), and the IEPA credits completion of this coursework towards training requirements. The IEPA has taken over updating and maintaining the on-line program.

Project Outcomes

1. Assisted operators and small systems in Illinois in producing acceptable Source Water Protection Plans.

2. Provided small system operators and the IEPA with a valuable training tool that is still in use.

3. Small systems addressed source water protection issues identified while developing the plan, resulting in safer water supplies.

Development of Financial Benchmarks for Small Water Systems Using Annual Financial Reports

Janice A. Beecher, PhD
Beecher Policy Research, Inc.

This project was terminated due to the project PI being unable to reach an agreement on hourly rates and documentation that meet the University of Illinois and USEPA guidelines that govern the administration of this grant. MTAC forwarded a letter to the USEPA to request permission to use the funds originally allocated for this project to sponsor a workshop on financial issues important to small systems. Permission was granted and the project below was initiated as a replacement.

Workshop on Economic and Financial Management for Small Water Systems

Dr. John Braden
University of Illinois

Project Description

The target audience for this workshop was technical assistance providers and state and federal regulators in the Midwest. Nationally recognized experts from a variety of backgrounds and expertise were invited as speakers. The primary focus was to identify the current and future needs of small systems in this area and to develop a strategy for meeting those needs.

Project Results/Outputs

The workshop was deemed to be a success by all in attendance, and selected manuscripts were published in a special edition of the University Council on Water Resources' Publication *Water Resources Update*. The name of that publication has been changed to the *Journal of Contemporary Water Research and Education*. This also included a white paper that details attendees' discussion and recommendations on the results of the workshop by John Braden. This issue is available on-line at http://www.ucowr.siu.edu/updates/128/index.html.

Project Outcomes

1. Exposure to experts from a variety of backgrounds and expertise increased the knowledge of all participants and made technical assistance providers and regulatory staff better prepared to address economic, management, and social issues in the future.

2. Publishing of key papers and the white paper enhanced the literature resource base for this subject area, which is available for researchers, regulators, assistance providers, and the public at large.

Arsenic Removal in Water Treatment Facilities: Survey of Geochemical Factors and Pilot Plant Experiments

Dr. Thomas R. Holm, Dr. Walt Kelly, and Steve Wilson
Illinois State Water Survey

Project Description

There were three objectives proposed to be addressed by this study. The first was to identify factors, including raw water quality and treatment processes that were most effective at increasing arsenic removal efficiency. The second phase of the study involved bench- scale tests to determine the impact of potassium permanganate ($KMnO_4$) oxidation and manganese greensand filtration on arsenic (As) removal at a water treatment plant. The last objective was to characterize arsenic speciation and determine how different treatment processes impact that speciation. This is critical since there are two chemical forms of arsenic in groundwater, and the chemical and toxicological properties are very different.

Project Results/Outputs

The project tasks were completed, and the final report is posted on the MTAC web site at http://mtac.sws.uiuc.edu/mtacdocs/finalreports/ArsenicTreatmentMTACFinalReport.pdf. The research team produced some interesting findings and recommendations, which are included in the report. Some of these items are discussed briefly below:

1. Contrary to general belief and previous reports published in the literature, it does not appear that bedrock is the primary source of arsenic for the Mahomet Aquifer (a large aquifer covering much of central Illinois and Indiana), but that the sand and gravel geology is the primary source. Additionally, there are indications that local, near-well conditions control the release rate of arsenic, and this may be driven by microbial activity.

2. Most of the wells with very high arsenic concentrations (> 50 μg/L) were in shallow sand and gravel aquifers (generally thought to be low in arsenic) and have not been studied extensively by researchers.

3. The greatest correlation with arsenic removal efficiency is the iron to arsenic (Fe:As) ratio. The higher the iron to arsenic ratio is, the greater the observed removal efficiency.

4. Arsenic concentrations show great temporal variability, in one case fluctuating between 30 and 40 μg/L in only one hour.

Project Outcomes

1. Increased knowledge of arsenic occurrence, speciation, and removal in Illinois. This enhances the ability of small systems, researchers, and regulators to seek solutions to improve arsenic removal and protect public health.

2. Provided information critical to guiding future research to develop more effective arsenic removal strategies.

Outreach Activities

Long Distance Learning

Robert Whitworth
Director, Environmental Resources Training Center, Southern Illinois University, Edwardsville

Project Description

The Environmental Resources Training Center (ERTC) at Southern Illinois University, Edwardsville (SIUE) conducted three distance learning training sessions sponsored by MTAC. These workshops addressed topics related to disinfection using chloramines, including: determining the correct chlorine to ammonia ratio, preventing loss of residual, proper sampling technique, total coliforms, and the cause and effects of nitrification in the distribution system.

Project Results/Outputs

The first session was simultaneously telecast to three community colleges (SIUE, Rend Lake Community College, and John A. Logan Community College) in southern Illinois on April 8, 2002, the second was simultaneously telecast to three community colleges (Parkland Community College, John Wood Community College, and Lincolnland College) in central Illinois and SIUE on May 13, 2002, and the last was simultaneously telecast to three community colleges (Elgin Community College, Highland Community College, and Kishwaukee College) in northern Illinois and SIUE on June 24, 2002. The total attendance at these sessions was 32 operators. Course evaluation was very positive, of the 23 individuals that responded to the questionnaire all but three evaluated the instructors as very good or good and all but one gauged the level of presentation to be at the right level for the audience and indicated they would recommend it to another operator.

Project Outcomes

1. Operators that attended the training increased their knowledge in the subject areas and received training credit. The knowledge gained better enabled them to meet regulatory requirements and protect the public health.

Development of a Workshop to Introduce Small Drinking Water Systems Managers to Financial Benchmarking

Tom Bik, Dr. Ben Dziegelewski, and Dr. Roger Beck
Southern Illinois University, Carbondale

Project Description

The workshop project had several tasks. The first was to collect and evaluate workshop materials that are currently being used for financial training in small communities and prepare a bibliography of available training materials and resources. The bibliography is included in the workbook discussed below. The next major task was to prepare the initial workshop curriculum, PowerPoint presentations, participant workbooks, and evaluation procedures. This was then presented and post-workshop evaluations were used to improve the training materials based upon feedback from attendees. The ultimate goal of this project was to introduce small systems to the concept of financial benchmarking and educate them on the data that needs to be collected and how it can be used to enhance their own financial planning and management.

Project Results/Outputs

The Self-Instruction Training Module is available on the Southern Illinois University web site in both Microsoft PowerPoint and Adobe Portable Document Format and can be downloaded or viewed online. This product is available as an html file on the MTAC website (http://mtac.sws.uiuc.edu/pres/mtacpres.htm). There is also an accompanying workbook available on-line at http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR06-06.pdf. This can be used with the presentation, but it is an excellent stand-alone resource as well.

Project Outcomes

1. Small systems and technical assistance providers were introduced to the concepts and tools of financial benchmarking and are more effective at financial planning and management.

Emergency Response Planning Guide Workbook

Laurie Papanos
Illinois Section AWWA

Project Description

The purpose of this product was to introduce small systems and Native American communities to the concept of Emergency Response Planning, and to make them aware of the information that is required for this process. The workbook accompanied a CD-ROM addressing the same topic produced earlier, and provided the information necessary to produce a draft Emergency Response Plan.

Project Results/Outputs

This product was completed and delivered. MTAC mailed copies of the product to various organizations and technical assistance providers in Illinois and around the Midwest. We also provided USEPA Region 5 with some copies of this product. Sahba Rouhani, the Capacity Development Coordinator for Region 5, requested an additional 50 copies of the CD-ROM and workbook to supply to all of the Native American communities in the Midwest. The product was compliant with the provisions of Title IV of the Bioterrorism Act for systems serving less than 3300, but not for those up to 10,000. Small systems requesting copies of the product were made aware of this information.

Project Outcomes

1. Small systems and Native American communities were made aware of the topics that needed to be considered and addressed, and were assisted in the process of preparing Emergency Response Plans.

Bacteria Speciation CD-ROM and Workbook

Laurie Papanos
Illinois Section AWWA

Project Description

This project was to produce a CD-ROM and workbook that would educate small system operators on common bacteria found in drinking water systems, and assist them in identifying those bacteria in their systems.

Project Results/Outputs

This product was completed. Unfortunately, MTAC and the USEPA both felt that this product failed to accomplish its intended task. The end product is better suited to technical assistance providers than small system operators. MTAC has asked that distribution be targeted to those individuals and that the product not be identified as an MTAC or USEPA sponsored project. MTAC received 30 copies of the CD-ROM and workbook; ISAWWA was instructed to distribute the rest to technical assistance providers upon request. No additional copies of this product were produced.

Project Outcomes

1. Technical assistance providers can use the CD-ROM/workbook as a tool to identify problem bacteria.

Self-Evaluation CD-ROM and Workbook

Laurie Papanos
Illinois Section AWWA

Project Description

The project used a sample evaluation form supplied by the IEPA to prepare an interactive CD-ROM and workbook with 1500 questions. The purpose was to prepare small systems for an on-site evaluation from IEPA. The goal was for them to be able to identify potential issues and take action before an actual on-site evaluation occurs, improving their compliance to applicable rules and regulations.

Project Results/Outputs

The CD-ROM and workbook were produced and a limited supply was distributed by both MTAC and the ISAWWA.

Project Outcomes

1. Small systems that utilized the product were able to identify and correct problems before an on-site IEPA evaluation occurred.

Capacity Development/Emergency Planning Workshops

MTAC/Illinois Rural Water Association

Project Description

MTAC sponsored two small system workshops presented by the Illinois Rural Water Association (IRWA) on Emergency Preparedness. These were two-day workshops, with MTAC presenting an evening session on the Benchmark Investigation of Small Water System Economics, the Emergency Response Planning CD, and an overview of current and future MTAC activities.

Project Results/Outputs

The first workshop was presented at the Rend Lake State Resort in southern Illinois on November 7-8, 2001, and the second was held at the Starved Rock State Lodge in northern Illinois on December 5-6, 2001. This training was approved by the Illinois Environmental Protection Agency. There were a total of approximately 50 attendees, who each received 14 ½ contact hours for training purposes.

Project Outcomes

1. Attendees were exposed to a variety of issues that were current for small systems at the time, with intensive education in Emergency Preparedness, enabling them to address all of these topics more effectively and helping maintain a safe and secure water supply.

Fiscal Year 2002 Projects

Competitive Grants & Applied Research Projects

MTAC issued a Request for Proposals (RFP), which was posted on its web site and forwarded to the other Technical Assistance Centers (TACs), and to universities in Illinois and around the Midwest. All of these proposals underwent an external review, and were approved by the USEPA as suitable topics before final selection and funding. MTAC funded four competitive grants during this funding cycle. The project description, results and outputs, and (to the extent possible) outcomes are described in the following text. MTAC also funded three Applied Research Projects during this funding cycle to address topical issues.

Development of Sulfur-Limestone Autotrophic Denitrification Processes for Treatment of Nitrate-Contaminated Groundwater in Small Communities

Dr. Tian C. Zhang
University of Nebraska-Lincoln at Omaha

Project Description

There is a need for a simple and reliable method to treat nitrate contaminated groundwater for small communities in some areas of the Midwest. These small communities are largely rural, and have limited financial, managerial, and technical resources to fund expensive upgrades to existing systems. The long term goal of this project was to promote and expedite acceptance and utilization of the Sulfur-Limestone Autotrophic Denitrification Process (SLAD) for this purpose. The specific short term objectives to be accomplished by this project were to develop a simple and reliable SLAD process for the treatment of nitrate contaminated groundwater in small systems, and to evaluate the economic feasibility of the SLAD process based upon experimental results and the anticipated available resources of the small communities.

Project Results/Outputs

The project successfully completed the objectives, and results are presented in detail in the final report, which is posted on the MTAC web site at: (http://mtac.sws.uiuc.edu/mtacdocs/finalreports/DenitrificationMTACFinalReport.pdf).

The author investigated the performance of SLAD columns using a variety of nitrate-nitrogen loading rates and hydraulic retention times (HRT). A polynomial linear regression model was developed that can be used to estimate SLAD performance with nitrate-nitrogen concentrations of 20 to 110 milligrams per liter (mg/L) and a HRT of 2 to 9 hours. The process was found to be able to achieve removal efficiencies of over 95% under certain conditions. The study also identified the key kinetic parameters that need to be considered in the system design.

Preliminary economic analysis done during the study indicated that the cost to add the SLAD process to a small drinking water system serving a town of 200 people was only $50,800-$58,500. This cost was calculated assuming that the existing wells, pumping equipment, and

piping could be used, which should be the case for most systems. The cost of installation being less that $235/person is deemed reasonable and economically viable.

Project Outcomes

1. Small drinking water systems with nitrate contaminated groundwater were provided with an economically viable method for denitrification of their water supply, helping to protect the public health by allowing the supplies to meet the existing MCL for nitrate in drinking water.

Interactive Guides to Creating Source Water Protection Plans for Region V Public Water Supplies

Kevin Kundert
Montana State University

Project Description

The Interactive Source Water Protection Guide for Illinois (a completed FY01 project), was used as a template for working with the other USEPA Region V states. This work began with the presentation of the Illinois product to USEPA Region V Source Water Protection Planners in September 2003. Specific projects were tailored to meet the requirements of the individual states. Due to fiscal limitations, only two states were included in this project: Indiana and Ohio.

Project Results/Outputs

This project was completed, and utilized by the respective state agencies to assist small communities in preparing source water protection (SWP) plans. Indiana utilized the product under a "Best Management Practices" approach, and Ohio chose to design a product similar to the one employed in the original version still in use in Illinois. The Ohio interactive program, *Developing a Drinking Water Source Protection Plan*, is still available at: http://www.epa.state.oh.us/ddagw/pdu/swap_online.html.

Project Outcomes

1. Assisted operators and small systems in Indiana and Ohio in producing acceptable Source Water Protection Plans.

2. Provided small system operators and the respective state regulatory agencies with a valuable training tool that is still in use.

3. Small systems addressed source water protection issues identified while developing the plan, resulting in safer water supplies.

The Effects of Different Modes of Coagulation as Pretreatment to Membrane Filtration for Drinking Water Production in Small Systems

Dr. Isabel C. Escobar
University of Toledo

Project Description

Membrane filtration is used by many small communities as a solution for a variety of water quality problems since it is both economically viable and readily commercially available. However fouling can be a major operational problem in these systems due to the accumulation of insoluble inorganic species, organic material, and biological growths. This study sought to determine the effectiveness of coagulation as a pretreatment to help prevent fouling of these membrane systems. To accomplish this, the study proposed three tasks. First, to characterize the effect of Lake Erie water containing organics, inorganics, and bacteria on ultrafiltration, nanofiltration, reverse osmosis, and low-pressure reverse osmosis membrane systems. The next step was to determine whether ferric or ferrous chloride would be most effective for testing with a membrane system using jar tests. Lastly, ferric chloride was tested using four different coagulant dosage methods and an ultrafiltration unit.

Project Results/Outputs

The project successfully completed its objectives, and results are presented in detail in the final report, which is posted on the MTAC web site at: (http://mtac.sws.uiuc.edu/mtacdocs/finalreports/CoagulationMTACFinalReport.pdf).

The four membrane systems were tested with Lake Erie water, and the ultrafiltration unit was determined to have the poorest performance, so it was selected for further study. The performance results collected during this phase were used as a baseline comparison for the coagulation tests that followed to gauge any improvements in efficiency. The most effective coagulant using Lake Erie water was determined to be ferric chloride, and the optimum dosage was found to be 25 mg/L. The most effective coagulation method in this experiment proved to be slurry coagulation, with dynamic membrane coagulation also providing acceptable results. The conventional and inline methods were determined to be unsuitable in this application. For an explanation in the differentiation of these methodologies, refer to page 6 of the report noted above.

Project Outcomes

1. Small drinking water systems and technical assistance providers can use the information produced in this report to reduce fouling tendencies in membrane systems used for the treatment of surface water supplies, and thus increase the economic viability of said systems.

Development of Low-Cost Treatment Options for Arsenic Removal in Water Treatment Facilities

Gary R. Peyton and Dr. Thomas R. Holm
Illinois State Water Survey

Project Description

The goal of this project was to develop a treatment process for arsenic removal from ground water by manipulating the Fenton chemistry (Fe^{2+} + H_2O_2) that occurs upon hydrogen peroxide addition, to effect As(III) oxidation to As(V), followed by sorption of the arsenic onto the resulting $Fe(OH)_3$ precipitate, which is removed by filtration using existing equipment in most Illinois drinking water treatment plants. There were four primary tasks for this project. Preliminary laboratory experiments were conducted to determine the oxidation rates of iron by oxygen and the effect of hydrogen peroxide on the iron oxidation rate. Following this, a series of laboratory flow experiments were conducted followed by on-site pilot scale flow experiments at a small drinking water system in Illinois. Lastly, the research team conducted a financial analysis and provided treatment cost estimates.

Project Results/Outputs

The project successfully completed its objectives, and results are presented in detail in the final report, which is posted on the MTAC web site at: (http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR06-03.pdf).

The study determined that a combination of low hydrogen peroxide doses followed by ferric chloride addition was capable of oxidizing most of the arsenic (III) to arsenic (V) in Danvers, Illinois groundwater, and reducing total arsenic from about 40 µg/L to less than 5 µg/L in batch, laboratory flow, and pilot-scale flow experiments. The estimated chemical costs for treatment totaled about $0.07/thousand gallons. Equipment required to update the existing plant would be two pumps and two tanks. In pilot-scale experiments, the residual As concentration was well below the MCL (10 µg/L) with an added Fe dose of 6 mg/L and a hydrogen peroxide dose of 0.9mg/L.

Arsenic removal was more efficient when peroxide was added to the anoxic groundwater rather than aerating first. Aeration oxidizes less than 25% of the As(III) in groundwater to As(V) for a reaction time of 30 minutes. This is typical of the residence time in an aeration/sand filtration unit and is representative of present performance of the Danvers plant. The degree of As(III) oxidation is roughly proportional to the H_2O_2 dose, which is much higher than the As(III) concentration.

Adding increasing amounts of $FeCl_3$ results in progressively lower dissolved As concentrations. The likely explanation is that the As has to compete with other dissolved substances for the hydrous ferric oxides (HFO) adsorbent. Increasing the amount of HFO increases the adsorption capacity. The dependence of As adsorption/removal in the pilot-scale experiments was consistent with a chemical equilibrium model of As adsorption.

Project Outcomes

1. An economically viable method for treatment of groundwater containing arsenic levels in excess of the MCL was proposed and tested. This provides small systems and technical assistance providers with another potential tool to employ in reducing arsenic concentrations and protecting the public health in effected small systems.

Applied Research

Countywide Projections of Community Water Supply Needs in the Midwest

Tom Bik, Dr. Ben Dziegelewski
Southern Illinois University, Carbondale

Project Description

The purpose of this study was to prepare countywide municipal and industrial water system demand forecasts for Illinois, Michigan, Minnesota, Ohio, and Wisconsin for the years 2005 to 2025, in five year increments. In order to accomplish this, the authors first had to collect data that could be used to estimate the "capacity" to produce and deliver drinking water for all of the systems in each state, and to organize this data on a countywide basis to prepare an estimate of the supply. These estimates of water supply capacity were compared to the projected water demand for each of the five forecast years, and this was used to prepare the need projections.

Project Results/Outputs

The project successfully completed its objectives, and results are presented in detail in the final report, which is posted on the MTAC web site at: (http://mtac.sws.uiuc.edu/mtacdocs/finalreports/FinalReportMidwestCWSProjections.pdf). There is also a companion document, which investigates the issue in more detail for Illinois that was funded by the Illinois State Water Survey available at: (http://info.geography.siu.edu/geography_info/research/documents/ISWS_IL_Water_Use_Projections.pdf).

There were several interesting conclusions presented in this report. First of all, the demand in the entire region is expected to increase by almost one-half billion gallons by 2025. This is primarily due to expected population growth. Anticipated changes (reduction) in the per capita water usage have little effect on overall demand projections. Major increases in water use are projected for Illinois and Ohio, Indiana, Michigan, and Minnesota are expected to see a net decrease in total water use.

Ohio and Illinois have the largest number of counties projected to increase their water use, and in the region as a whole, 20 percent are expected to have a major increase in water consumption. The study also predicts that more than half of the counties in the six-state region will have relatively constant water use rates for the 20 year study period. Less than one third of Ohio counties are projected to have the delivery capacity to meet demand in 2025 without substantial upgrade to the existing infrastructure.

Project Outcomes

1. Small drinking water systems throughout the Midwest have access to information that may not otherwise be available to assist them in infrastructure decision making process.

2. Information will assist local and regional water supply planning initiatives and provides small systems with the resources they need to participate effectively in these activities.

Control of Microbial Contaminants and Biological Agents in Small Systems

Benito Marinas, Martin Page
University of Illinois, Urbana

Project Description

Small drinking water systems had to prepare to meet the requirements of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2 ESWTR) at the time this study was conducted. The purpose of this study was to determine the efficacy of using ultraviolet light (UV) in combination with existing or a somewhat modified disinfection strategy to meet the requirements of the rule. The goal was to find an economically viable solution for small and very small systems. The study was also intended to evaluate the effectiveness of this system in dealing with some potential bioterrorism issues. The authors used *B. subtilis* spores in this study to model *B. anthracis* (anthrax) since they exhibit similar characteristics.

Project Results/Outputs

This project was completed, and the final report, (http://mtac.sws.uiuc.edu/mtacdocs/finalreports/2003_ThesisMainSporesFinalReport.pdf), is posted on the MTAC web site.

The study concluded that most small drinking water systems would benefit from the incorporation of a UV system in the disinfection process for their water. The addition of a UV dose of 40 mJ/cm^2 upstream of free chlorine substantially increases the inactivation of *B. subtilis* spores versus traditional disinfection with free chlorine alone. The cumulative inactivation achieved by sequential UV/free chlorine treatment achieved high enough CT values in the lower pH and higher temperature ranges.

Project Outcomes

1. Sequential UV/free chlorine disinfection was shown to be a valuable tool for small systems in meeting LT2 ESWTR disinfection requirements and potential bioterrorism threats resulting from the introduction of a species such as *B. anthracis*.

Cylindrospermosis raciborskii

Environmental Resources Training Center, Biology Department
Southern Illinois University, Edwardsville

Project Description

Cylindrospermosis raciborskii is a toxin producing blue-green algae whose ideal breeding grounds are reservoirs, small water storage ponds, and slow moving rivers. It has been identified in the southeastern United States in the past, and in 2001 it was found blooming and producing toxin in Steuben County, Indiana. Since there is no taste or odor associated with the toxin produced by *C. raciborskii*, it has the potential to be very dangerous and even lethal. The researchers contacted surface water supplies in Illinois and offered to conduct screening to determine if *C. raciborskii* was present.

Project Results/Outputs

This project was completed, and the final report was submitted. It has been posted on the web site (http://mtac.sws.uiuc.edu/mtacdocs/finalreports/2003_MTACAlgaeFinalReport.pdf) and is available in limited quantities as a hard copy, or on CD upon request.

Thirteen samples were submitted by surface water supplies in Illinois. The only sample that contained *C. raciborskii* was submitted by Elgin, and came from the Fox River. The levels found were not high, but algae blooms are known to erupt in a very short time under the proper conditions. The system was informed of the presence of *C. raciborskii*, and they were made aware of the need for continued screening.

Project Outcomes

1. Public health was protected by making system aware of a potentially dangerous biological in their water supply.

2. Systems not found to have *C. raciborskii* were able to reassure any concerned individuals that this was not a problem in their system.

Outreach Activities

Vulnerability Assessment of Water Utilities for Small Communities

Robert Whitworth
Director, Environmental Resources Training Center
Southern Illinois University, Edwardsville

Project Description

The Illinois Environmental Protection Agency (IEPA) selected Vulnerability Self Assessment Software (VSAT) for use by Illinois communities to conduct vulnerability

assessments of their drinking water plants and systems. The Environmental Resources Training Center (ERTC) at Southern Illinois University in Edwardsville (SIUE) developed a workshop using VSAT software to assist small public water systems in evaluation of their water plant security systems. MTAC sponsored the development and presentation of this workshop for small drinking water systems.

Project Results/Outputs

ERTC conducted six, 7.5 hour workshops. Two workshops were held in Moline on May 28 and 29, with a total of 23 in attendance. Two workshops were held in Springfield on June 12 and 13, with a total attendance of 34 participants. Ten people attended a session in Mt. Vernon on November 19 and another 12 attended training held at the ERTC training facility in Edwardsville. Trainees included small drinking water system operators and supervisors, city managers, and fire chiefs. Evaluation forms submitted by attendees indicated that all but two of the 79 attendees considered the workshop to be "good" or "very good", and all indicated they would recommend others to attend.

Project Outcomes

1. Attendees gained a greater understanding of the key parameters of vulnerability assessment, and became familiarized with the software that IEPA required them to use in preparation of their system vulnerability assessment. This greater understanding will assist them in not only meeting regulatory requirements, but in better protecting the public health.

Distance Learning Special Topics Workshops

Robert Whitworth
Director, Environmental Resources Training Center
Southern Illinois University, Edwardsville

Project Description

Small systems had to prepare to deal with a number of new regulations, and small drinking water system operators and managers have limited time and resources for training on these issues. ERTC developed workshops that dealt with new requirements for small systems at the time and presented them via telecasts at several community colleges around the state. This allowed for local attendance with minimal travel time or expenses and no registration costs for the attendees.

Project Results/Outputs

ERTC presented two small drinking water system educational workshops. Each of these workshops was offered three times, at different community colleges or universities simultaneously, via distance learning technology equipment. The first series of three-hour workshops was offered October 6, 2003 and addressed "Components of the New Arsenic Rule." The workshop was transmitted from SIUE and telecast simultaneously to the southern region of

Illinois, including; Rend Lake College, Shawnee Community College, John A. Logan College and SIUE. The second series of workshops on the same topic was offered October 13, 2003. The workshop was telecast simultaneously to the central region of Illinois, including; Lincoln Land College, Parkland College and SIUE. The third series of workshops on the same topic was offered October 20, 2003. This workshop was telecast simultaneously to the northern region of Illinois to include; Kishwaukee College, College of Lake County and SIUE. The fourth through sixth series of workshops addressed "Elements of Emergency Response Planning." These workshops were conducted November 3, 10 & 17, 2003. Each was simultaneously telecast in the southern, central and northern regions at the aforementioned colleges and universities, respectively. Attendance for each workshop averaged 10-15 small system operators or managers.

Project Outcomes

1. Small drinking water systems operators and managers that attended the workshop gained a better understanding of the two issues and were better able to help their systems comply with federal regulations, protecting the public health.

Disinfection Profiling Workshops

Robert Whitworth
Director, Environmental Resources Training Center
Southern Illinois University, Edwardsville

Project Description

The Environmental Resources Training Center held three workshops titled "Disinfection Profiling." This workshop for surface water systems included instruction on constructing a graphical profile, calculating contact time and calculating Giardia lamblia inactivation time requirements. Operators were trained to complete disinfection benchmark requirements. The workshop also assisted in simultaneous compliance issues between LT1ESWTR and Stage 1 D/DBP Rule.

Project Results/Outputs

The locations of these workshops were Rockford, the ERTC training facility and Mt.Vernon, held May 8, June 4 and June 10, 2003. A total of 11 people attended. The attendance was disappointing, and the presenters determined a better method of advertising the workshops needed to be employed in the future. However, the attendees all rated the content and presentation as "good" or "very good", and felt the information gained was very valuable.

Project Outcomes

1. Small drinking water systems operators and managers that attended the workshop gained a better understanding of the two issues and were better able to help their systems comply with federal regulations, protecting the public health.

Fiscal Year 2003 Projects

Competitive Grants

MTAC issued a Request for Proposals (RFP), which was posted on its web site and forwarded to the other Technical Assistance Centers (TACs), and to universities in Illinois and around the Midwest. All of these proposals underwent an external review, and were approved by the USEPA as suitable topics before final selection and funding. MTAC funded four competitive grants during this funding cycle. The project description, results and outputs, and (to the extent possible) outcomes are described in the following text.

System Development Charge Development Project

C. Gary Carroll, William Jarocki
Northwest Environmental Finance Center
Boise State University

Project Description

The Environmental Finance Center (EFC) at Boise State University developed a computer software tool that can be used by a small water system's in-house staff to develop accurate and justifiable system development charges. Small systems are under particular strain in determining how to finance the costs of growth of the existing water system. This is a matter for public policy as well as finance. The System Development Charge (SDC) calculator provides small utilities with two options for calculating these charges. They can use either the *growth regulated method* or the *equity buy in method*, and can generate charges based upon either the equivalent dwelling unit basis or on service meter size. The EFC introduced this program to technical assistance providers in two training workshops.

Project Results/Outputs

EFC staff developed the software program, and it is available on the Boise State University EFC web site at http://sspa.boisestate.edu/efc/sdccalculator/. There is a companion workbook available for download on the site as well. One of the requirements of MTAC funding this work was that the program would be made available for any small drinking water system in the MTAC 10-state region at no cost. There is a small charge for systems outside the MTAC region. The EFC presented the software at two regional capacity development workshops.

Project Outcomes

1. Small drinking water systems and technical assistance providers have access to a flexible and convenient method for calculating SDCs in an equitable manner. This will result in more financially secure and responsible systems, and greatly increase their long-term financial capacity.

Arsenic and Bacteriophage Ms2 Removal from Groundwater by Nanoparticulate Aluminum Oxide Coated Granular Filter Media: A Pilot-Scale Evaluation on the Effect of pH and Coating Density

Boris L. T. Lau, Gregory W. Harrington, and Marc A. Anderson
University of Wisconsin-Madison

Project Description

There are many small groundwater systems that need to treat water for both arsenic concentrations that exceed the MCL, and the removal of microbial contaminants. This study sought to evaluate a method for simultaneous removal of both contaminants in a manner that would be both technically and economically viable. Adsorptive filtration is a technique that involves coating an existing filter media with an adsorbent, so that the filter bed can act as both an absorbent and a filter. This study sought to coat filter media with nanoscale aluminum materials, and evaluated the capacity for arsenic and microbial removal (using bacteriophage MS2 as a representative virus), and also monitored for aluminum release from the media.

Project Results/Outputs

Anthracite coal and granular activated carbon (GAC) were both coated with nanoscale aluminum oxide. Coating the anthracite led to an increase in surface area and surface charge, and increased removal efficiency for both arsenic and MS2. Coating the GAC also resulted in an increase in removal efficiency for arsenic and MS2. Lowering the pH resulted in greater removal rates, but increased aluminum release as well. The final report was submitted and is available on the MTAC web site at http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR06-01.pdf.

Project Outcomes

1. This study demonstrated the effectiveness of nanoparticulate aluminum oxide coating of filter media to improve arsenic and MS2 removal, but also showed the risk associated with high rates of aluminum release. Study conclusion is that the technology is promising, but requires further study before application in small drinking water systems.

Watershed Modeling to Evaluate Water Quality at Intakes of Small Drinking Water Systems

Deva K. Borah, Edward C. Krug
Illinois State Water Survey

Project Description

Water quantity and quality and surface water supply intakes are a serious concern, but there was little research on evaluating these issues and no modeling tools available to do so. This study sought to develop a model capable of assessing water quality and quantity problems such as erosion, sediment transport, nutrient and pesticide transport, and associated issues. The intent was that the information provided by the model could be used to help make the correct best management practices to help reduce or eliminate the associated problems. The decision was

made to build upon the existing Soil and Water Assessment Tool (SWAT) using the Little Wabash River watershed. SWAT was chosen because it is well-documented, familiar to many technical assistance providers, and readily available. The Little Wabash River watershed was selected because much of the necessary information for the model was already available, and it had been intensively characterized in the past and was well understood. This project hoped to incorporate a storm event model and SWAT and test the performance in a real watershed.

Project Results/Outputs

This project was completed, and the final report (http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR06-09.pdf) is posted on the MTAC web site.

Long-term hydrological simulations in the Little Wabash River watershed were evaluated by comparing simulated flows from the model against actual observed monthly flows for four evenly distributed gauging stations. Data from five years were used to calibrate the model, and the model was used to produce an eight year simulation period. The statistical values for three of the stations were very reasonable for the entire period, and the remaining station was reasonable for five of the eight years. Calibration of the water quality component was based upon limited data, and the results were varied. Sediment loading showed gross over-predicting, but predictions for monthly total phosphorus, nitrate nitrogen, and ammonia were mixed but much better. It was determined that additional data would be needed for proper calibration of the model in order to improve the modeling of the water quality component.

Project Outcomes

1. The storm event hydrologic model used interchangeable parameters from SWAT, and had mixed success in modeling hydrologic and water quality data. Enhanced precipitation data and additional sampling data are required to make this a more useful tool. The information gathered is useful to technical assistance providers and researchers in further work.

2. This information was publicized in a National Drinking Water Clearinghouse (NDWC) publication in the fall 2006 issue. http://mtac.sws.uiuc.edu/mtacdocs/qf/MTAC-Storm.pdf

Understanding and Minimizing Impacts of Agricultural Pesticides on Small Water Systems Using Surface Water

Jane Frankenberger
Purdue University

Project Description

Small drinking water systems that use surface water are particularly vulnerable to contamination from agrichemicals in general, and in particular pesticides such as atrazine that pose a serious risk to the public health. This is especially true in the Midwest where intensive row crop agriculture is practiced and the vast majority of farmers use pesticides such as atrazine.

Protecting surface water supplies from contamination by pesticides is difficult. Larger systems suffer from the same exposure, but have greater resources available to them to treat the problem due to the economies of scale. This project proposed to accomplish three tasks. First, assess the water quality impacts of potential changes in pesticide application and management practices. Also, to compile information on atrazine levels in community drinking waters systems in Indiana that use surface water. Lastly, the project sought to educate pesticide applicators and the public about protecting watersheds used by community water supply systems.

Project Results/Outputs

This project was completed, and the final report (http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR06-04.pdf) is posted on the MTAC web site.

Several models were used to study the impacts of various management practices on the concentration of atrazine in runoff on a watershed scale. Conservation tillage is predicted to have almost no impact on atrazine concentrations, and delayed application only minimal effect. The most successful strategies are the installation of filter strips (riparian buffers), which are predicted to reduce atrazine concentration by more than 50%, and a reduced rate of application. The incorporation of atrazine in the soil rather than surface application after the emergence of weeds also significantly reduced atrazine. Available data on atrazine concentrations in surface water supplies (both raw and finished) was gathered and presented to the public, pesticide applicators, and crop advisors.

Project Outcomes

1. Data assembled and presented to the public and pesticide applicators will educate and encourage them to use pesticide application methods that will reduce pesticide concentrations in public water supplies, thereby protecting the public health.

Outreach Activities

Vulnerability Self Assessment Tool (VSAT) Software Assistance

Robert Whitworth
Director, Environmental Resources Training Center
Southern Illinois University, Edwardsville

Project Description

Community water supplies that serve populations greater than 3300 were required to prepare a vulnerability assessment for the water treatment plant by June 2004. The Illinois Environmental Protection Agency (IEPA) decided to endorse the VSAT software for training and Vulnerability Assessment Report generation. Small drinking water systems needed assistance using VSAT, and the IEPA requested that MTAC and ERTC provide that service. ERTC agreed to provide technical support via telephone and on-site assistance to small communities serving a population of 3301 to 10,000 that use VSAT software to generate vulnerability assessment reports from January through June 2004. MTAC advertised the

availability of this service through its web site and in a post card mailing that was sent to the entire IEPA mailing list for operators serving systems with a population of 3301 to 10,000. ERTC also advertised the service on their web site, and through their normal practices for posting/advertising training and educational services.

Project Results/Outputs

ERTC personnel provided assistance in use of the VSAT software and preparation and submission of vulnerability self-assessment reports to numerous communities who attended VSAT workshops. This was done at no additional charge to the communities.

Project Outcomes

1. Small drinking water systems in Illinois received assistance in utilizing VSAT software, enabling them to complete their Vulnerability Assessment Report in a timely manner.

Rate Maker Workshop

Robert Whitworth
Director, Environmental Resources Training Center
Southern Illinois University, Edwardsville

Project Description

ERTC, working in conjunction with Gary Brown of the Missouri Department of Natural Resources, presented workshops on setting water rates for operators/administrators of Illinois small water systems using Missouri's Show Me Rate Maker software. The four workshops were presented around the state of Illinois, and focused on small community water systems with populations of 3300 or less. ERTC provided technical support via telephone for the operators/administrators using the software. Workshop attendees were provided with a copy of the software and instructions on how to use it. IEPA requested that MTAC and ERTC provide this service. MTAC advertised the availability of this service through its web site and in a post card mailing that was sent to the entire IEPA mailing list for operators serving systems with a population of less than 3300. ERTC advertised the service on their web site, and their normal practices for posting/advertising training and educational services. This course work qualified attendees for seven IEPA-approved contact training hours and 0.7 CEU's.

Project Results/Outputs

Four one-day rate analysis workshops were conducted. They covered the essential principles, practices and strategies that should be used to analyze their own system's rates and to make proper rate adjustments successfully for a small to medium sized water or sewer system with rates and finances commensurate with their size. The workshop locations and attendance were as follows: June 8 at the Environmental Resources Training Center, with 22 students; June 9 at Mt. Vernon, IL, with 9 students; June 27 at Rockford, IL, with 11 students; and June 28 at East Peoria, IL, with 18 students.

Project Outcomes

1. Small system operators and mangers learned how to calculate and qualify water rates for their community, increasing their financial and managerial capacity.

Informational Technology/Security Workshops

Robert Whitworth
Director, Environmental Resources Training Center
Southern Illinois University, Edwardsville

Project Description

ERTC developed and conducted a one-day training workshop designed to train engineers, managers, and supervisors of water and wastewater plants in protecting infrastructure assets. The course addressed informational technology security awareness, management and organization, early warning systems, contingency planning, and security systems testing. The course also addressed penetration testing, which can be used to detect SCADA system vulnerability and security breaches that could be used to attack internal networking including: databases, process control, confidential documents, email, and other electronically stored information. The course was offered to representatives of small community populations of 10,000 or less for a fee of $40 per enrollee, to cover the expense of materials. The target audience for this training was engineers, managers of systems, and technical assistance providers from around the Midwest to train them in protecting infrastructure assets. Attendees of vulnerability assessment workshops and the IEPA requested this training. The level of expertise addressed in this workshop required a higher level of qualification from the instructors, and this is reflected in the high cost relative to other training activities. This course work qualified attendees for seven IEPA approved contact training hours and 0.7 CEU's. MTAC advertised the availability of this service through its web site and in a one post card mailing that was sent to the entire IEPA mailing list for operators serving systems with a population of up to 10,000. ERTC advertised the service on their web site, and their normal practices for posting/advertising training and educational services.

Project Results/Outputs

This workshop was developed and taught by Dr. Bradley Noble of the Electrical and Computer Engineering Department of Southern Illinois University Edwardsville on April 14, 2005, with nine students in attendance.

Project Outcomes

1. The technical assistance providers that attended are better prepared to assist small drinking water systems in implementing effective security precautions to protect their electronic assets.

Water Operator Short Course

Robert Whitworth
Director, Environmental Resources Training Center
Southern Illinois University, Edwardsville

Project Description

The ERTC developed manuals and presented an intensive training session to develop skills specific to water supply operators, covering Class D, C, B, and A operations. All aspects of water plant operations, testing, sampling, operations reports and related math were covered. Water operators and the IEPA requested this training. The course was held over a four-day period (Tuesday-Friday, 8:30a.m.-5:00p.m.). It was anticipated that operators would take this course to meet training requirements and to either obtain or upgrade their existing operator's license. On Friday afternoon, representatives from the Illinois Environmental Protection Agency were on hand to proctor the water operator certification exam for those students that wished to take the exam and met all IEPA defined eligibility requirements. Materials used in this course were developed by ERTC after a review of the literature and approval by IEPA. The course was equivalent to 3.3 CEU's or 33 contact hours.

Project Results/Outputs

The Water Operator Short Course was held October 11-15, 2004, at the ERTC facilities on the campus of Southern Illinois University in Edwardsville, Illinois. There were 15 students enrolled in the course, and 13 of those took a certification exam proctored by IEPA at the end of the course. Ten of the students that took the exam passed and received certification.

Project Outcomes

1. Ten operators received required certification, and coursework was developed that can be used to train additional operators in the future.

Condensed Fact Sheet for Small Systems

Kent Smothers, Steve Wilson
MTAC, Illinois State Water Survey

This project was canceled and another project was substituted due to circumstances discussed in a quarterly report submitted in 2006. The following project was its replacement.

Groundwater Handbook for Small Systems
Steve Wilson, Al Wehrmann
MTAC, Illinois State Water Survey

Project Description

This project is a groundwater handbook on wells targeted towards small systems and individuals. The booklet provides an introductory section on groundwater terms and concepts to provide the operator a basic knowledge of groundwater and well hydrology and hydraulics, a description of the areas in the Midwest suitable for groundwater exploration, step by step instructions on what tasks and considerations are necessary to properly develop a groundwater supply, responsibilities for planning and developing a groundwater supply, state by state (USEPA Region 5) contacts and links to the requirements for permitting, installing, and operating a groundwater supply, and a list of resources in each state that the operator can turn to for advice and guidance.

Project Results/Outputs

The booklet provides the small system operator with an easy to follow, and understandable guide for developing a groundwater supply. Several hundred print copies are available from MTAC; it can also be provided on CD-ROM, and the booklet is available on the MTAC web site at http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR08-02.pdf.

Project Outcomes

1. This document is expected to become the go-to resource for groundwater exploration for small system operators and provide a framework for small communities to minimize expenses for planning as they utilize the information in the booklet to work with their state resource personnel to develop a successful water supply.

2. The booklet also provides community leaders with a basic understanding of groundwater concepts so that they can effectively communicate with their constituents and the contractors they hire to undertake the task of supply development.

Fiscal Year 2004 Projects

Competitive Grants

MTAC issued a Request for Proposals (RFP), which was posted on its web site and forwarded to the other Technical Assistance Centers (TACs), and to universities in Illinois and around the Midwest. All of these proposals underwent an external review, and were approved by the USEPA as suitable topics before final selection and funding. MTAC funded three competitive grants during this funding cycle. The project description, results and outputs, and (to the extent possible) outcomes are described in the following text.

Watershed Modeling to Evaluate Water Quality at Intakes of Small Drinking Water Systems, Phase II

Deva K. Borah, Edward C. Krug
Illinois State Water Survey

The funding for this project was split between FY03 and FY04 fiscal years. Project description, results, and outcomes for the entire project are discussed under the FY03 Competitive Grants section on pages 20-21 of this report.

Using Technical, Managerial, and Financial Capacity Measures in an Assistance-Oriented Approach to Comparative Performance Assessment of Small Drinking Water Utilities.

R. Lawton, A. Desai, & M. Stanford
Ohio State University
National Regulatory Research Institute

Project Description

Performance measurement is a critical tool in evaluating the worth of the services provided by public and private utilities. This project sought to provide a mechanism that could be used for the development of comparative performance measures for public and private small drinking water systems with the MTAC region. This analysis included data from the states of Illinois, Indiana, Missouri, Ohio, and Wisconsin.

Project Results/Outputs

This project was completed, and the final report (http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR06-07.pdf) is posted on the MTAC web site.

The authors of this report employed the capacity development requirements of the Safe Drinking Water Act (SDWA) at their performance assessment framework as a starting point to accomplish the following key tasks:

1. A panel of experts was convened to identify suitable performance measures for public and private small drinking waters systems in the Midwest.

2. Data were accumulated for these measures on a representative sample group of utilities (both privately and publicly owned) regulated by state utility commissions.

3. The data were analyzed in an attempt to develop benchmarks based upon identification of observed best practices.

Project Outcomes

1. The project identified the elements needed to perform a thorough assessment of water utility performance, and developed a process that could be used to perform this analysis.

However, it was also discovered that insufficient data currently exist to complete this analysis. Significant changes in the data reported by utilities would be required for accurate performance assessments to be completed.

Demonstration of Low-Cost Arsenic Removal from a Variety of Illinois Drinking Water Sources

Gary R. Peyton and Thomas R. Holm
Illinois State Water Survey

Project Description

Previously funded work (*Development of Low-Cost Treatment Options for Arsenic Removal in Water Treatment Facilities*) from FY02 that is described on pages 13 and 14 of this report determined that a combination of low hydrogen peroxide doses followed by ferric chloride addition was capable of oxidizing most of the arsenic (III) to arsenic (V) in Danvers, Illinois groundwater, and of reducing total arsenic from about 40 µg/L to less than 5 µg/L in batch, laboratory flow, and pilot-scale flow experiments. This study proposed to test this process in a variety of Illinois groundwater supplies to confirm its viability as a treatment process.

Project Results/Outputs

This project was completed, and the final report (http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR06-11.pdf) is posted on the MTAC web site.

Four groundwater sources used as drinking water in Illinois were treated using the Fenton reaction (hydrogen peroxide + Fe(II)) to oxidize As(III) to As(V) before adsorption of the arsenic to the iron precipitate produced during iron removal by aeration/filtration. For all four waters used, the arsenic concentration could be reduced to below the 10 microgram/liter maximum contaminant level using relatively inexpensive doses of iron and peroxide, despite the need to add iron (Fe(II) and Fe(III) were both tried) in all cases to completely adsorb the arsenic. The waters differed in their treatability, but in each case, the least expensive configuration used Fe(III) rather than Fe(II). It was shown that consumption of reactive species by reaction with Fe(II) was a very significant sink for Fe(II) at higher iron concentrations, and was primarily responsible for the difference in efficiency using Fe(II) and Fe(III). Chemical addition in the range of 3-6.4 milligrams per liter Fe(III) and 20-45 micromolar (0.68-1.5 milligrams/liter) peroxide was adequate to reduce the total arsenic to the maximum contaminant level in all four waters. The estimated chemical cost was $0.04 to $0.07 per thousand gallons in the most favorable cases for each of the water supplies studied.

Project Outcomes

1. The previously developed method for arsenic removal was proven to be potentially viable in a variety of Illinois groundwater, and additional information about the reaction was obtained.

2. The treatment method was highlighted as a Tech Brief in the fall 2006, Vol. 6, Issue 3 of On Tap magazine, published by the National Drinking Water Clearinghouse.

3. Many small communities have expressed interest in using this method and some have experimented with using this method for arsenic removal in groundwater.

Internal Applied Research Projects

MTAC funded a total of eight applied research topics in FY04. The first three projects are part of a focused effort by MTAC to thoroughly address the subject of arsenic in drinking water. These projects sought to control the concentration of arsenic in drinking water not only through optimizing removal in the water treatment plant, but also by gaining a better understanding of the geochemical processes that control the release of arsenic into the groundwater supply. A better understanding of the processes involved may allow us to recommend practices that will reduce the rate of release of arsenic before it is pumped from the aquifer. There final five internal research topics were determined to address a specific need of the small drinking water community.

Topic 1: Chemical Oxidation for Arsenic Removal

Thomas R. Holm
Illinois State Water Survey

Project Description

The results of previous MTAC research indicated that the iron to arsenic molar ratio (Fe:As) is a critical parameter in arsenic removal at water treatment plants designed to remove Fe. The chemical form of As may also affect its removal in water treatment plants. The predominant form of As in most Illinois groundwater is As(III). However, the As(V) form may be removed more efficiently than the As(III) form under some conditions. This project proposed to conduct experiments using untreated water from facilities that currently do not meet the As MCL. The treatments included $KMnO_4$, $FeCl_3$, and combinations of $KMnO_4$ and $FeCl_3$. The $FeCl_3$-only treatment involved aeration, while in the $KMnO_4$-only and $KMnO_4$/$FeCl_3$ treatments there was no aeration. Samples from all treatments were analyzed for dissolved As. Selected samples were also analyzed for As(III). The first round of experiments was performed in the laboratory. The results of the first experiments were used to design further in-plant experiments at selected facilities. Untreated and treated water samples were collected from each plant for As determination. The data was compared with the results from the first MTAC project.

Project Results/Outputs

This project was completed, and the final report (http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR06-05.pdf) is posted on the MTAC web site.

Aeration with no added $FeCl_3$ removed 20-25% of the As from Kenney and Waterman groundwater. Adding $FeCl_3$ improved As removal by aeration in all cases but only satisfied the MCL for Waterman because of the relatively low As concentration (18 g L^{-1}). Aeration had little effect on As speciation; As(III) made up a large fraction of filtered As in all aeration experiments. $KMnO_4$ effectively oxidized As(III). In all $KMnO_4$ experiments As(III) was below

the practical quantitation limit (2.5 - 5.0 g L^{-1}) and was below the method detection limit (0.5 - 1.0 g L^{-1}) in most experiments. NaOCl only partially oxidized As(III), even when there was excess NaOCl relative to Fe^{2+}. A fairly large excess of NaOCl and a total Fe concentration (natural Fe^{2+} plus added $FeCl_3$) of ~4 mg L^{-1} were needed to meet the As MCL.

Arsenic was almost entirely in the As(III) form in all raw groundwaters. Two doses of both NaOCl and $KMnO_4$ were used at Kenney. For both oxidants the higher dose resulted in significantly better As removal. At Grand Ridge As removal was better with $KMnO_4$ than with NaOCl because of the better oxidant-to-reductant ratio. Arsenic removal at Grand Ridge was lower than at the other two facilities because of the low Fe concentration. The oxidant dose seemed to have little effect on the Waterman samples. However, this groundwater had the highest Fe:As ratio of the three facilities. In general, As removal asymptotically approached 100% as the oxidant-to-reductant ratio increased. The Fe:As ratio seems to be a key parameter in As removal. Both chemical oxidation and adsorption seem to be important factors in As removal.

Project Outcomes

1. This report provides small community water systems with guidance as to the rates of iron and permanganate addition required for optimal arsenic removal and provides information on a cost effective method facilities can use to meet the new MCL for arsenic.

Topic 2: Microcosm Experiments for Arsenic Solubility Determination

Walt Kelly, Illinois State Water Survey
Rob Sanford, University of Illinois

Project Description

The recent extensive arsenic sampling in various parts of Illinois has indicated that geochemical conditions, specifically redox conditions and the availability of organic matter, exert a strong control on arsenic concentrations in groundwater. The processes controlling arsenic solubility are complex and variable. Most aquifers, especially unconsolidated deposits in Illinois, contain abundant iron oxyhydroxide minerals. Arsenic is likely associated with these iron oxyhydroxides, and the reduction of these minerals is hypothesized to be the source of arsenic in most Illinois' groundwaters. Sulfate reduction, which theoretically occurs at redox potentials lower than for iron reduction but has been commonly observed to occur in conjunction with iron reduction, is hypothesized to limit arsenic solubility by precipitation of sulfide phases. Groundwater samples with relatively high sulfate concentrations have been observed to have low arsenic concentrations, presumably due to active sulfate reduction. Elevated arsenic concentrations tend to be found in samples in which sulfate is not detected. This suggests that sulfate reduction is not active and sulfide minerals are not being precipitated and removing arsenic from solution. This project proposed to investigate some of these redox sensitive processes that may be affecting arsenic solubility.

Project Results/Outputs

This project was completed, and the final report (http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR06-08.pdf) is posted on the MTAC web site.

Arsenic concentrations in the microcosms behaved for the most part as predicted. Under both oxidizing (NO_3^-) and SO_4^{2-} reducing conditions, As levels dropped. Somewhat unexpected was the decrease in As concentrations when any electron donor was added. It remains to be established if this was associated with sorption to biomass as suggested. The report also showed that the As concentration rapidly increased from oxidized sediments when ferric-iron reducing conditions were stimulated. This suggests that it may be best to maintain either oxidizing or reducing conditions in an aquifer. Any oscillation between oxidizing and reducing conditions may lead to oscillation in the As concentration. Finally, a relationship between Fe(II) and As emerged from this study. Although this suggests that it may be possible to use Fe(II) as a predictor for possible As hot spots in aquifers known to retain As, this relationship between Fe(II) and As is not always observed in groundwater samples, including those collected from the Mahomet aquifer.

Project Outcomes

1. Researchers gained information pertaining to the effect of oxidizing and reducing conditions on As concentrations in groundwater and the relationship between Fe and As in the aquifer studied. This may lead to improved methods of treatment for arsenic in the future.

Topic 3: Temporal Variability of Arsenic in Municipal Well Water

Tom Holm, Steve Wilson, Walt Kelly
Illinois State Water Survey

Project Description

Past research projects have indicated arsenic concentration in wells can vary with time and pumping. In another MTAC project, samples of treated water were collected from 34 water utilities that had a history of arsenic above the new MCL. For each facility the sampling crew collected a sample of the water as the consumer would receive it (unfiltered sample) and they also collected another sample which they filtered through a 0.45 mm filter. For three of these facilities the arsenic concentrations in the unfiltered samples exceeded the MCL but the concentrations in the 0.45 mm-filtered samples met or were well below the MCL. Two of those facilities had two wells and the results were consistent for both wells. For these facilities, therefore, it may be possible to satisfy the arsenic MCL by improving filtration.

The study proposes to collect water samples over a five-hour period from five water treatment plants. Researchers collected unfiltered and filtered samples of untreated and treated water, as well as samples from wells “rested” for short lengths of time. They also collected filtered and unfiltered samples of treated water from the facilities that seemed to have high particulate arsenic concentrations.

Project Results/Outputs

This project was completed, and the final report (http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR06-10.pdf) is posted on the MTAC web site.

Arsenic concentrations in three municipal wells were essentially constant over five hours of pumping. In Ridgway Well 3, As concentrations increased from 60 µg/L to 80 µg/L in the first 2.5 hours of pumping. A likely explanation is a heterogeneous distribution of As in groundwater in the vicinity of the well. In Kingman Well 1, the As concentration increased from 40 to 68 µg/L between the first and second samples. The relatively rapid increase in As may have been due to Fe oxide precipitation and As adsorption during overnight stagnation followed by displacement of the low-As water by high-As water when the pump test was started.

Particulate As concentrations were low in all raw groundwater samples. There was no evidence of mobilization of particulate or colloidal material in any of the tests.

The study results are consistent with those of previous studies. In three systems, there was very little change in As with time. The other two systems had significant changes over a period of 0.5-2.5 hours. There is currently no general guidance on predicting which systems likely would show temporal variability in As. It may be necessary to determine the characteristics of every system affected by As.

Project Outcomes

1. Study confirmed that some groundwater systems with arsenic concentrations exceeding the MCL, arsenic varies with time and/or pumping patterns. This information may be useful to the operators to develop a pumping strategy that reduces their overall arsenic concentration in the drinking water supply.

Topic 4: Drought Planning for Small Public Water Systems in the Midwest

Derek Winstanley
Illinois State Water Survey

Project Description

The provision of adequate and secure supplies of clean water at reasonable cost is a cornerstone of social and economic development and national security. Major droughts have occurred in the past and will occur again in the future. Such droughts have two major impacts on small public water systems: water supply is reduced (surface waters and shallow groundwater) and water demand increases. The combination of these impacts can result in major stresses on the ability of water systems to meet demand. The goal of this proposal was to review the status of drought planning, methodologies suitable for drought planning, and adequacy of databases and analytical tools needed for drought planning by small public water systems in the MTAC region.

To define the extent of potential water shortages due to climate variability and increased demand, the systems must first be identified and characterized. Evaluation of the risk of a system experiencing potential water shortages requires some basic data to develop a water budget including but not limited to: stream flow records or surrogate use of models, reservoir volume, evaporation, and operation data on reservoir levels, aquifer properties, well-field operation data, and water withdrawals. This study proposed to identify within the 10-state MTAC region (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin) those small systems (serving less than 10,000 persons) dependent on surface water or groundwater; and general availability of the basic systems data necessary to evaluate water availability under various drought scenarios. On the basis of data availability, methods for evaluating water budgets and system adequacies under drought conditions were recommended.

This project produced an inventory of contacts and data sources for characterizing small water systems in the MTAC region: e.g. location, water supply, water withdrawal, system capacity, water demand forecasts. It will also identify and assess the availability of climatic, surface water, and groundwater data and analytical tools within the MTAC region that can be used to conduct drought analyses. A review of approaches for using real-time climate and hydrological data products to identify the thresholds for potential water supply impacts due to drought were conducted, including:

1. Analysis of methods used to relate magnitude/duration thresholds of climatological drought to potential surface water and groundwater supply or demand impacts.

2. Examination of schema used in states in the MTAC region for relating climate thresholds to water supply impacts in drought watch and warning systems.

Project Results/Outputs

This project was completed, and the final report (http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR06-02.pdf) is posted on the MTAC web site.

The major recommendation of this report is that there is a need for drought preparedness at the state, regional, and local scales. The general status of drought preparedness planning for small communities in the Midwest is particularly limited at this time. This study has identified several national and state drought planning documents that provide general guidelines for small community water systems, but the technical information required to develop detailed drought plans are often not available. Although this study provides some basic resources for evaluating drought, comprehensive guidance documents and step-by-step methodologies for the assessment of source water adequacy need to be developed that can be used by individual communities, with emphasis on small communities that may otherwise lack the resources or knowledge to evaluate the drought susceptibility of their system.

Consistent technical expertise and resources for assisting small communities may likely need to come from broader state or regional efforts. Small community water supply managers and operators should take their own proactive steps to develop a drought plan that evaluates the capabilities of their systems to cope with severe and protracted droughts. The establishment of an

initial drought preparedness plan by a community need not be complex. An awareness and compilation of material regarding 1) state drought plans, 2) state water regulations, 3) an idea of the historical droughts for the area, 4) system behavior in previous drought periods, and 5) an assessment of current and near-future water supply and demand will go a long way towards the development of a functional plan. The need for drought assessment is particularly great if a water supply system has experienced even mild or moderate drought concerns since the mid-1960s. Records of increasing water use, including those associated with population or commercial growth and outdoor and recreational uses should be evaluated against limitations experienced in past drought situations and the potential for severe and extended events such as those experienced in the 1930s and 1950s.

There is also a special climate and drought page (http://mtac.sws.uiuc.edu/dpa/) on the MTAC web site that was developed and is maintained by the authors of this report. This contains links to state resources for Midwestern states as well.

Project Outcomes

1. Small system operators and managers will employ the recommendations of this project to institute effective drought planning for their supply. This will help reduce the impact of a prolonged drought on those systems and allow them to continue to deliver an adequate amount of safe drinking water to their consumers.

2. This information was publicized in a NDWC publication in summer 2006. http://mtac.sws.uiuc.edu/mtacdocs/qf/MTAC-DroughtPlanning.pdf

Topic 5: Toxic Drinking Water Disinfection By-Products (DBPs): Accelerating the Generation of Reliable Toxicology Information for Small Water Systems

Michael J. Plewa
University of Illinois

Project Description

Disinfection of drinking water primarily uses chemical disinfectants that convert naturally occurring and synthetic organic material along with bromide and iodide in the raw water into chemical DBPs. DBPs represent an important class of environmentally hazardous chemicals that carry long-term human health implications. While the awareness of adverse health risks associated with exposure to toxic drinking water disinfection by-products (DBPs) is increasing, there is not an appropriately funded program to characterize DBPs and their health hazards. Further, little information regarding DBPs has been targeted to the managers of small water systems. Thus, the general goal of this research is to accelerate the generation of reliable toxicology information about DBPs and related compounds so that managers of small water systems can make informed decisions about the options and potential health hazards related to chemical disinfection of drinking water. This project was funded in partnership with The American Water Works Association Research Foundation.

The approach will be to generate an in vitro mammalian cell chronic cytotoxicity and acute genomic DNA damage database that will focus on priority DBPs and related compounds. This quantitative, comparative database will link the analytical chemistry and analytical biology of the priority DBPs identified in the Nationwide Occurrence Study.

Project Results/Outputs

This project was completed, and a copy of the report is posted on the MTAC web site at http://mtac.sws.uiuc.edu/finalrep.asp.

Researchers concluded that the brominated haloacetaldehydes are more toxic than their chlorinated analogues and that all of the agents analyzed are potent mammalian cell cytotoxins except for trichloroacetaldehyde. Mammalian cell cytotoxicity and genotoxicity data provided a rank ordering of the relational toxicities of regulated and emerging DBPs and related agents both within an individual chemical class and among classes. The use of alternative disinfectants generates new DBP compounds and alters the distribution of DBP chemical classes. The water supply community will be able to consider these factors when employing alternatives to chlorine disinfection. In addition these data will be available to prioritize DBPs for future *in vivo* toxicological studies and risk assessment.

Project Outcomes

1. This mammalian cell cytotoxicity and genotoxicity database will serve as a practical resource for small water systems disinfection facilities as they consider switching to alternatives to chlorine in order to meet more stringent government regulations.

Topic 6: Continuing Education to Support Smaller Water Systems Assessment

Richard Warner
University of Illinois

Project Description

The Office of Continuing Education at the University of Illinois and county governments in the state have recently formed partnerships with industries and local governments to develop continuing education programs via a web portal. The emerging partnership afforded the opportunity for MTAC to take advantage of the web portal design and other resources related to the partnerships, initially for Illinois. Hence, MTAC developed continuing education programs for the needs of managers of Midwestern smaller water supply systems. The key partners in this initiative were initially the Illinois Water Resources Center, the Illinois Water Survey, MTAC, the Office of Continuing Education University of Illinois at Urbana-Champaign, and University of Illinois Extension. As the programs continue to be developed and tested, they will be made available to the TAC network and via other organizations such as the AWWA and NIWR. This project was funded over two fiscal years. The FY04 funding was used for the preliminary planning and the early development of the first continuing education course, *Thinking Critically about Security Needs for Small Water Supply Systems*. The course was designed to help

managers of small water systems think holistically about security, including the protection and monitoring of critical assets (e.g., physical infrastructure, finished drinking water, etc.).

Project Results/Outputs

The continuing education course, *Thinking Critically About Security Needs for Small Water Supply Systems* was outlined, the module writing was completed, and the Internet portal for the course was designed. The early course development planning also verified that this effort does not duplicate efforts underway by other TACS, AWWA, or other entities. The next fiscal year will include convening the workshop with small drinking water system operators and managers, and reworking materials and format based upon their input.

Project Outcomes

1. The course developed will prove valuable for small systems should an appropriate delivery vehicle be developed. This project made clear that there is a need in the small drinking water community for something more robust and interactive than a traditional web site. MTAC has begun development of a Cybercollabratory to address this need.

Topic 7: Improved Monitoring for Safe and Secure Water Supplies: An Integrated Approach to Emerging Monitoring Technologies

Richard Warner
University of Illinois

Project Description

The federal government is moving rapidly toward developing sensors to protect national security. At the same time, nearly all major federal agencies are beginning to discuss and design region-to-continent approaches to science and earth systems monitoring that will deploy sensors and cyber infrastructure that will enable information-sharing in real time among scientists, agencies, and society in general. Such technology has great potential for developing more effective and efficient approaches to testing, monitoring, and reporting of the health of water systems.

The tasks of this project were to (1) convene a workshop of 12 experts from academia (including The National Center for Supercomputing Applications (NCSA)), industry, and public agencies to describe the status of work underway in this regard; (2) invite representatives of the other TACs to attend and otherwise participate; (3) establish an ongoing work group to identify promising, priority areas of sensor development as they relate to the management of water supply systems; and (4) develop recommendations for how the emerging vast cyber infrastructure for national security and science can be used to help ensure a safe and secure water supply.

Project Results/Outputs

The workshop was convened on the University of Illinois campus on June 27-28, 2005. The group discussed recommendations for improvements that more effectively employing the cyber infrastructure for the benefit of the small drinking water community.

Project Outcomes

1. This project made clear that there is a need in the small drinking water community for something more robust and interactive than a traditional web site. MTAC has begun development of a Cybercollabratory to address this need.

Topic 8: Building Technical, Financial, and Managerial Capacity for Small Water Systems: The Role of Consolidation, Partnership, and other Organizational Innovations

John Braden, Martin Jaffe
University of Illinois

Project Description

The project involved assessing the role of institutional innovation (municipalization, privatization, merger, partnerships, and outsourcing) as a strategy for small water supply systems to gain the technical, financial, and managerial capacity needed to provide safe and reliable drinking water. The project has the following components: (1) Relevant literature in the drinking water, economics, and management literatures will be reviewed to identify organizational innovations for water supply and factors that affect their adoption. The resulting model of organizational choice will generate hypotheses about organizational response to new technologies, demographic trends, and regulation. (2) Data relevant to describe and explain trends in the organization and performance of water systems serving small communities will be collected. The data will facilitate the testing of hypotheses drawn from the model of organizational choice. Data from federal and state sources will be used to describe organizational changes in water supply and to test concepts drawn from the literature and model about the nature of organization response to demographic, technical, and policy influences affecting small water systems; (3) Select econometric models to analyze data. Choice-based models such as probit or logit will be reviewed by the research team for applicability to the conceptual model and data on CWSes. (4) The econometric methods will be applied to test hypotheses from the choice model and to draw conclusions about organizational responses to changing economic, technical, and policy forces. (5) Disseminate results through published papers, presentations, and technical briefs describing the analysis and results.

Project Results/Outputs

The study produced the following conclusions: (1) Environmental and public utility regulations limit organizational options for small water systems. (2) A review of relevant literature indicates that mandated changes in operational requirements, access to financial resources and political climate can influence whether small systems consider organizational

change as a way to enhance effectiveness. (3) Economic theories of organizational change emphasize competition between managers for assets to manage and market pressure for improvements in the performance of low-yielding assets. 4) The empirical analysis of recent merger activity among small water systems in the Midwest reveals that merger is more common for systems that are smaller, privately owned, already purchase water from another source, have a record of water quality violations, or have monitoring violations. Acquisitions are slightly more likely in counties with a higher density of water systems and outside of metropolitan areas. Although these findings do not directly test theories of organizational change, they are compatible with the hypothesis that low performing water systems, and those with the costs of organizational change that are lower, are more likely to be acquired.

Project Outcomes

1. The political, economic, and social forces that are the governing factors in small drinking water systems were identified and discussed. This information will stimulate further investigation and progress in fully defining these issues. This will be a valuable asset to small systems in future planning.

Testing of Homeland Security Implemented from Vulnerability Assessments and Emergency Response Planning

Harlan H. Bengtson
Director, Environmental Resources Training Center
Southern Illinois University, Edwardsville

Project Description

This is a cooperative project with the Environmental Resources Training Center (ERTC) at Southern Illinois University, Edwardsville. ERTC has conducted numerous training workshops and inspections related to Vulnerability Assessment, and has provided consulting services to small systems throughout Illinois to assist them in using VAP software. ERTC will investigate four different types of representative small water systems (groundwater treatment, surface water treatment, distribution system, and a system that both treats and buys water wholesale) serving less than 3300 people that have VAPs to evaluate the effectiveness of their implemented security measures. This process will help the small systems and TACs assess whether or not additional resources should be directed towards improving existing VAPs.

Project Results/Outputs

This project was completed, and a copy of the reports detailing the complete evaluations for the four systems chosen is posted on the MTAC web site at: http://mtac.sws.uiuc.edu/finalrep.asp. The most striking finding of these investigations was that very few of the vulnerabilities identified in the VAPs had been addressed following development of the VAP. This was largely due to a lack of resources available to address the problems.

Project Outcomes

1. Small systems, technical assistance providers, and state regulators will have a better idea of the effectiveness of current security measures and what areas may require additional effort or resources. Ultimately, these small systems may be better prepared to prevent terrorism or sabotage as a result of this effort.

Cross-Connection Control for Small System Administrators

Harlan H. Bengtson
Director, ERTC-SIUE

Project Description

This is a cooperative project with the Environmental Resources Training Center (ERTC) at Southern Illinois University - Edwardsville. This one day workshop was held at five different locations; three around the state and two out of state. The workshop was 7.5 hours long and included the following course material: concepts of backflow, methods of prevention, jurisdictions, water purveyors, plumbing codes, fire protection, and problems with program development/startup, ordinance, management, test procedures and reporting and survey of distribution lines.

Project Results/Outputs

The one day workshop, Cross Connection Control Administrative Workshop was developed and conducted at three locations in Illinois as follows: May 12 at Rockford, IL, with eight students in attendance; June 1 at Bloomington, IL, with 11 students in attendance; and June 14 at Mt. Vernon, IL, with five students in attendance. On September 2nd the workshop was conducted, for the first time, in Jefferson City, Missouri. Thirteen students attended the Missouri workshop and it was well received. Based upon the success of that workshop, four additional workshops were conducted in Missouri, funded by the Missouri Department of Natural Resources. The final one-day "Cross Connection Control Administrative Workshop" was complete on January 11, 2006. It was held in Terra Haute, Indiana, with an attendance of five people.

Project Outcomes

1. This project resulted in improved understanding and implementation of a cross-connection control program for the small systems represented.

Groundwater Resource Assessment for Small Communities

Ken Hlinka
Illinois State Water Survey

Project Description

For over 50 years, the Center for Groundwater Science at the Illinois State Water Survey (ISWS) has provided groundwater information to any requesting individual, commercial facility or public water facility. Groundwater resource assessments have been an integral part of this public service and have been undertaken for thousands of individuals and facilities throughout our history. Using existing staff and focusing on the smaller communities (less than 2,000 population), current groundwater system adequacy (Adequate, Marginal, or Deficient) and resource potential (within a five and ten mile radius) will be developed for those small communities determined to have "deficient" groundwater supplies based on certain criterion. This would create a base document that would be available to the communities for planning and/or emergency purposes. The 60 facilities identified as being at the most risk will be investigated further. The first 12 of these will receive a letter report entailing the potential sources within 5 and 10 miles from each "deficient supply" facility. The remaining 48 facilities will also be addressed in subsequent FY05 funding not covered in this report.

Project Results/Outputs

Phase 1 of the project consisted of developing a list of potential facilities for detailed study. A composite list of sole groundwater source facilities with populations of less than or equal to 2,000 individuals was developed from the IEPA database of 2005 Community Water Supplies. The list was analyzed and ranked for detailed study in Phase 2 and 3 based upon well depth and water table conditions.

Phase 2 used the sorted list developed from Phase 1 to begin a detailed review of available facility information. Facilities were ranked as to their "adequacy" to supply groundwater under current conditions by; 1) their ability to supply water for demand within certain time frames (i.e. operating time), 2) aquifer limitations, 3) well pumpage to pumping water level ratios (i.e. well Specific Capacity), and 4) their well and facility history. Four "Assessment Criterion" were used to determine a facility "Adequacy Ranking." Each facility was given a ranking of; 1) Adequate, 2) Marginal, or 3) Deficient. The "deficient" facilities will be targeted for detailed resource potential studies.

In Phase 3, groundwater resources within a five and ten mile radius will be studied for the first 20% of the facilities that are determined to be "Deficient Supplies." Various source documents such as the computerized ISWS aquifer and potential yield maps, the ISWS Public-Industrial-Commercial Survey Database (PICS), the ISWS private well database, the ISGS Major Bedrock Valley map, the ISGS Groundwater Geology Circular Series, etc. will be used in this assessment. Geographic Information System analysis and display will be used where possible. Letter reports detailing this information were sent to the first 12 systems studied.

This information is also available on the MTAC web site at http://mtac.sws.uiuc.edu/gwassmnts.asp.

Project Outcomes

1. Small system operators and managers that have limited groundwater resources will utilize the resources of the Public Service group to assist them in decision making and in reviewing potential options for maintaining and protecting their water supplies. These individual facility reports are a necessary first step in drought/growth planning for small systems that do not have the resources to complete them.

Non-Community Water System Compliance to the New Arsenic Rule

Steven D. Wilson
Illinois State Water Survey

Project Description

The goal of this project is to work with the USEPA Region 5 and 7 states to create statewide maps of their non-community, non-transient public water supplies that might not have met the new arsenic standard when it took effect in January 2006.

Project Results/Outputs

The mapping became more detailed than originally planned. The original effort was to simply map the non-community systems that had an arsenic compliance issue. By working more closely with each state and getting a more detailed picture of each systems status, the final maps provided much clearer information on the status of each state's program. Rather than just indicating compliance or non-compliance, the maps show the type of compliance resolution or status if not compliant. The maps are complete and will be posted on the MTAC web site at http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR08-04.pdf.

Project Outcomes

1. Maps provide an indication of the progress of non-community systems towards meeting requirements of arsenic standard. The information gathered from states more successful in meeting the standards may help other states in developing strategies for addressing the problem more effectively.

Additional Applied Research Projects

MTAC determined that several research projects previously discussed in this document were able to accomplish their tasks under budget. USEPA granted MTAC permission to reallocate that money and fund the following projects.

Field Testing and Modeling of the Fenton/Filtration Process for Arsenic Removal

Thomas R. Holm, Gary R. Peyton, and Steven D. Wilson
Illinois State Water Survey

Project Description

The project proposed three major tasks: (1) Full-scale process testing, (2) Jar testing, and (3) Modeling and laboratory experiments. Field work was to be performed at the Danvers, IL water treatment plant. The Danvers plant was testing $KMnO_4$ addition and H_2O_2 addition as they continue to try and meet compliance for the arsenic standard. Both approaches have shown promise and this testing was proposed to determine which, if either, method will provide the best arsenic removal while allowing Danvers to minimize costs. Jar testing would be conducted at the same time as the sampling for full-scale testing to take advantage of the raw water characterization. Tests would then be performed to determine the effect of oxidant and Fe doses.

Project Results/Outputs

This project was completed, and a copy of the report is posted on the MTAC web site at http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR08-03.pdf.

The Danvers plant normally receives water from wells 3 and 4 simultaneously or well 5. The water quality is similar for all three wells. The Fe concentration in the raw water generally fluctuated between 2.5 and 3.0 mg/L regardless of which wells were operating. Aeration and filtration had usually reduced Fe concentrations to below 0.2 mg/L (Wilson, 2004) but at the beginning of the tests Fe concentrations in the clearwell were between 1.0 and 2.0 mg/L. It was discovered that one of the filter cells had lost all of its sand, probably during back washing. When the cell was closed off in early December 2007 and subsequently refilled, clearwell Fe concentrations dropped to below 1.0 mg/L. The Fe concentrations in the finished water were almost always lower than in the clearwell, probably because the cation exchange resin acted as a filter and removed particulate HFO from the 33% of the water that went through the softener.

The As concentrations in the raw water generally fluctuated between 35 and 40µg/L regardless of which wells were operating. The As concentrations in the clearwell fluctuated between 20 and 40 µg/L before the empty filter cell was closed off and between 10 and 20 µg/L afterward. The finished-water As concentrations generally decreased as the $KMnO_4$ dose increased and one might speculate that the degree of As(III) oxidation increased through the entire series of tests. However, the few As speciation determinations showed that As(III) was more than 90% oxidized at a relatively low $KMnO_4$ dose of 1.25 mg/L. The lower the Fe concentration, the lower the As concentration. Arsenic removal with $KMnO_4$ oxidation was better than with aeration alone (20-25%). However, adsorption was inadequate. It is probably necessary to add some $FeCl_3$ along with $KMnO_4$ to satisfy the MCL.

Project Outcomes

1. Further characterization of arsenic chemistry in Illinois groundwater supplies provides small systems and technical assistance providers with additional information to consider in formulating a strategy for arsenic removal to meet the existing MCL.

Radium and Barium in the Ironton-Galesville Bedrock Aquifer in NE Illinois

Walt Kelly, Illinois State Water Survey

Project Description

Elevated radium and barium concentrations have long been known to be a water quality concern in the deep bedrock aquifers in parts of Northeastern Illinois, especially west of Chicago. There is rapid development occurring in this region of Illinois, and most residents will be relying on groundwater for their drinking water. Because most wells drilled into the deep bedrock aquifers are open to multiple aquifers allowing mixing of waters within the borehole, it is difficult to establish which aquifers may be contributing to the elevated radium and barium. There is some evidence suggesting that the Ironton-Galesville aquifer may be the major source of contamination, but this has not been fully established. An increasing number of bedrock wells are being drilled into the deep bedrock aquifers open only to individual aquifers instead of across the entire depth. The purpose of this research was to identify and sample wells open only to the Ironton-Galesville and St Peter formations, the predominant bedrock sources in the region west of Chicago, and analyze for radioisotopes (gross alpha, ^{226}Ra, ^{228}Ra, ^{222}Rn) and complete inorganic chemistry. Complete inorganic chemistry is necessary because radium and barium are controlled by geochemical conditions, especially sulfate concentrations and ionic strength. Samples were collected by ISWS personnel using established sampling and storage procedures. Inorganic analyses were conducted at the ISWS Public Service Laboratory in Champaign. Radiological analyses were performed at a governmental laboratory. Data were evaluated and compared to existing radioisotope data for wells in the area that have known geology.

Project Results/Outputs

This project was completed, and a copy of the report is posted on the MTAC web site at http://mtac.sws.uiuc.edu/mtacdocs/pubs/MTACTR08-01.pdf.

The geographic distributions of Ra and Ba were consistent with results reported in other studies. Looking at the data as a whole, Ra and Ba concentrations did not significantly differ among the various deep bedrock aquifers. However, within the geographic groups there is some evidence that the Ironton/Galesville aquifer had higher Ra concentrations than the Galena/Platteville and Ancell aquifers. Also, Ba concentrations in group 2 were highest, by far, in the two Ironton/Galesville wells. The MCL for Ra was exceeded in wells from all aquifers and the MCL for Ba was exceeded in wells from all the aquifers except the Galena/Platteville. Differences in 226Ra/228Ra ratios as a function of aquifer identity suggested there may be some differences in the source and mechanism of release of Ra into solution. The smaller percentage of 226Ra in the Ironton/Galesville and Mt. Simon aquifers compared to the shallower aquifers may indicate less U in the deeper aquifer materials and/or that a significant fraction of the 226Ra

that has been produced has been transported away. Barite appeared to be the primary control of both Ra and Ba concentrations.

Three of the wells with Ba concentrations above the MCL (Gilberts 3 and 4 and Volo 5) had the three greatest Ra activities. It appears that geographic location exerts a stronger control on overall groundwater chemistry, specifically Ra and Ba, than does the identity of the particular deep bedrock aquifer. An additional factor to consider is that there are a large number of wells penetrating through all the deep bedrock aquifers in this region, which may allow for enhanced leakage between the aquifers. This may have the effect of reducing geochemical differences among aquifers.

This was a fairly small study, sampling 25 wells in five counties. Additional studies that could improve understanding of Ra and Ba occurrence in deep bedrock aquifers in northern Illinois include (1) expanding the study area and sampling of wells open to single units, including private domestic wells; (2) age dating of archived samples; and (3) analysis of cores collected and stored by the ISGS, including extractions, to determine where Ra resides.

Project Outcomes

1. Important information on the distribution of Radium and Barium in the deep bedrock aquifers of Northeastern Illinois was gathered. This first step may serve to better direct research in the future that will provide critical guidance on the siting and construction of wells within the aquifers.

Information Dissemination (FY01, FY02, FY03, and FY04)

The MTAC web site has continued to see a steady flow of traffic and downloads. We have software that tracks web traffic, but it can only go back to 2004. From June 4, 2004 to March 31, 2008 the web site had more than one-half a million hits and over 162,000 user sessions. There was an average of 118 user sessions per day. The MTAC web site experienced more than 200,000 downloads during this period. The software somewhat loosely defines a download as a pdf file being opened, so we can't tell for sure how downloads were saved to the individuals computer. However, we can say for certain that there is a great deal of traffic on the site and interest in our final reports. There were nearly 40,000 unique visitors to the site during this period and of those more than 9,000 visited multiple times. This indicates a substantial number of people have identified our web site as a valuable resource and refer back to it for information.

We have given an account in various quarterly reports during the duration of this project regarding presentations at regional and national meetings and papers in refereed journals that are based upon work funded by MTAC and detailed in this report. The exact number is difficult to track, but there have been dozens of presentations and many articles, including one entire journal issue dedicated to an MTAC project. We also cooperated with the Drinking Water Clearinghouse to produce three of the Tech Briefs based upon MTAC projects. MTAC has also produced and distributed thousands of training aides, such as the Source Water Protection Plan Guide.

The dissemination and distribution plan for all completed final reports was as follows: Pending completion of the review of the report, hard copies were produced of each document. Hard copies were mailed and/or electronic copies were e-mailed to each of the following locations: USEPA Project Officer, USEPA Regions 5 and 7 Capacity Development Coordinators, IEPA Division of Public Drinking Water, and the other 7 Technology Assistance Centers. Electronic versions of the report and a one-two page summary document suitable for use by small public water systems operator/administrators were posted on the MTAC web site. Additionally, project teams were all encouraged to publish their work in appropriate scientific journals, and make presentations at professional meetings to increase dissemination of the results of their work.

Financial Accounting

Official financial accounting for the project was conducted by the University of Illinois Office of Grants and Contracts, and they will be forwarding any required information regarding budgetary expenditures.

Acknowledgements

The authors wish to thank USEPA for sponsorship of this work, and each of the individual project Principal Investigators and team members who are too numerous to mention here. We also wish to thank all of those associated with the University of Illinois and Illinois State Water Survey Fiscal and Grant and Contract offices for all of the work they provided in helping to set up and track the many individual projects. Thanks are extended to Steve Wilson for helping to coordinate many of the Illinois State Water Survey projects. Special thanks is also extended to Jennifer Tester, Rosa Townsend, Kevin Merrifield, Dan Webb, and Mark Brooks, who have all provided great assistance at various times. We also wish to recognize the helpful guidance offered by our Project Officers at USEPA (Deborah McCray, Evyonne Harris, and Holly Waldman) during the course of this project.