Water Research, Outreach, and Teaching in the Northern Plains and Mountains Region

Impacts and Outcomes, 2000-2012

Applying knowledge to improve water quality

Northern Plains & Mountains Regional Water Program

A Partnership of USDA NIFA & Land Grant Colleges and Universities

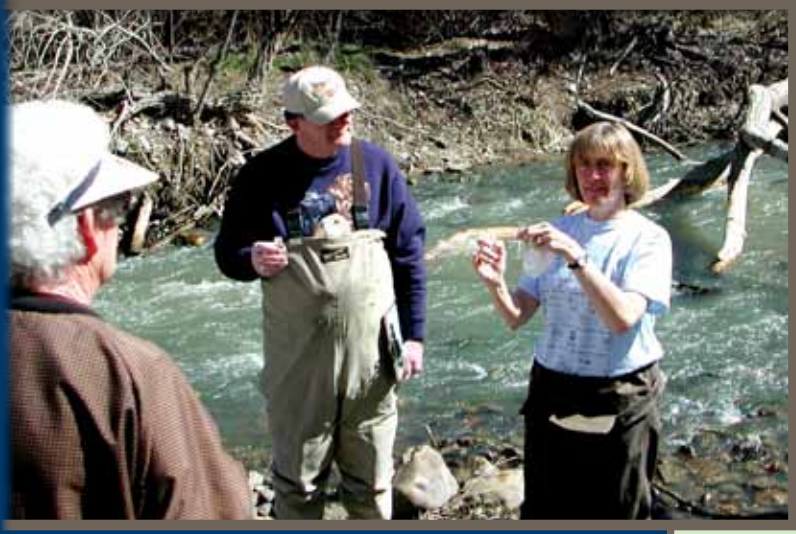

Table of Contents

Commonly Used Acronyms

AREERA: Agricultural Research, Extension, and Education Reform Act

ASA: American Society of Agronomy

AWCC: Agricultural Water Conservation Clearinghouse

AST: Aboveground storage tank

BLM: Bureau of Land Management

BMPs: Best Management Practices

CARE: Community Action for Renewed Environment

CBM: Coalbed methane

CCA: Certified Crop Adviser

CEAP: Conservation Effectiveness Assessment Project

CPIA: Central Plains Irrigation Association

CSREES: Cooperative State Research, Education, and Extension Service

CSU: Colorado State University

CWI: Colorado Water Institute

DOE: Department of Energy

EPA: Environmental Protection Agency

ET: Evapotranspiration

HSI: Hispanic Serving Institution

MSU: Montana State University

NDSU: North Dakota State University

NETL: National Energy and Technology Lab

NIFA: National Institute of Food and Agriculture

NPDAT: Nitrogen and Phosphorus Pollution Data Access Tool

NPM: Northern Plains and Mountains

NRCS: Natural Resource Conservation Service

PETE: Partnership for Environmental Education

QAPP: Quality Assurance Project Plans

SDSU: South Dakota State University

SKC: Salish Kootenai College

SLVEC: San Luis Valley Ecosystem Council

SOP: Standard Operating Procedures

SPCC: Spill Prevention, Control, and Countermeasure

STEM: Science, Technology, Engineering, and Math

TMDL: Total maximum daily load

UMN: University of Minnesota

USCID: U.S. Committee on Irrigation and Drainage

USDA: United States Department of Agriculture

USU: Utah State University

UW: University of Wyoming

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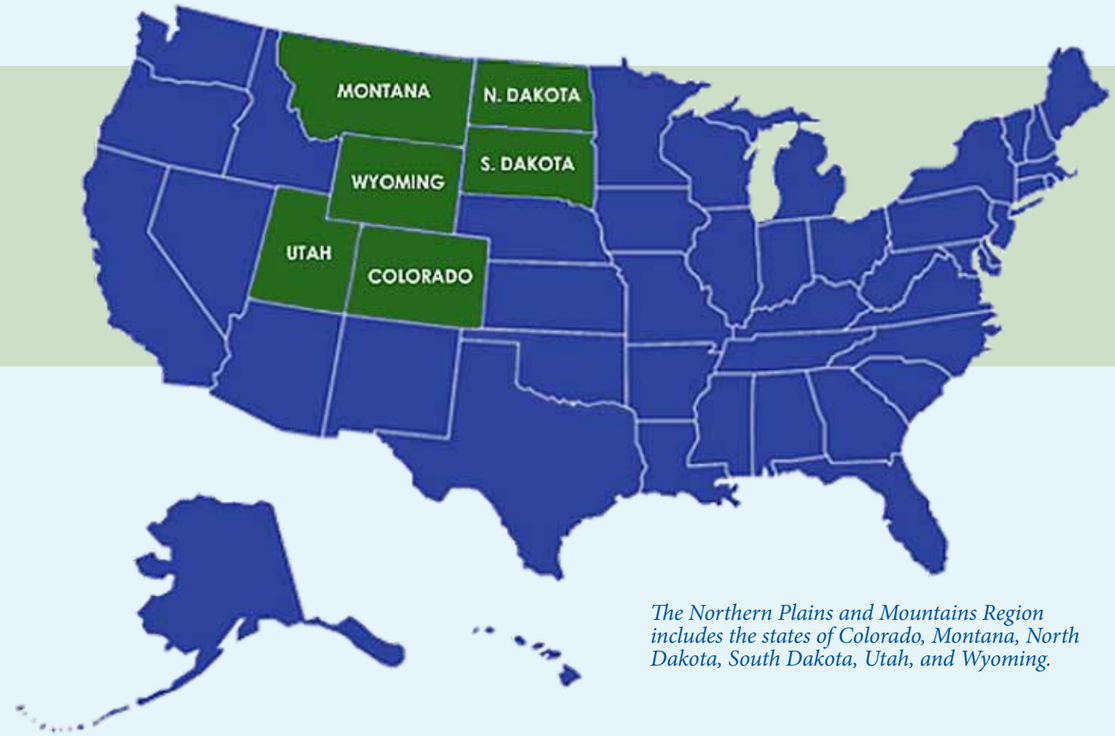

The Northern Plains and Mountains Region includes the states of Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming.

NDSU NORTH DAKOTA STATE UNIVERSITY

UNIVERSITY OF WYOMING

Colorado State University

UtahStateUniversity

MONTANA STATE UNIVERSITY

SDSU

Cover photos from top, counterclockwise: Mountain stream, photo by Mark Byzewski; Nephi Cole, NRCS Wyoming, collecting macroinvertebrate water quality sample, photo by Ginger Paige, Univ. Wyo.; Nancy Mesner, USU, training high school teachers on Stream Side Science monitoring activities, photo courtesy of USU Water Quality Extension; Irrigated field, photo by Bill Cotton, CSU Photography

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Regional Advisory Committee

The NPM Regional Program Advisory Committee consists of one representative from each state plus one representative from EPA Region 8, as key partners in identifying critical water quantity and quality issues, as well as providing constructive assessment of regional work. The committee includes:

Region 8 EPA: Jennifer Schuller, EPA Region 8 Agriculture Advisor

Colorado: Robert Sakata, Water Quality Control Commission / Farmer

Montana: Dave Phillips, Montana Area Extension Director

North Dakota: Chuck Fritz, International Water Institute

South Dakota: Pete Jahraus, South Dakota Department of Environment & Natural Resources

Utah: Carl Adams, Utah Division of Water Quality

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The goal of the Northern Plains and Mountain Regional Water Program is to integrate water research, education, and extension resources of the land-grant universities and to partner with stakeholders to develop and deliver knowledge-based programs addressing protection and improvement of water resources.

Publication date: May 2012. This material is based upon work supported in part by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under Agreement No. 2008-51130-19548. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

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Members of the Northern Plains and Mountains Regional Water Team

Introduction

The Northern Plains and Mountains (NPM) Regional Water Program is a team of Extension, research, and education faculty and staff from land-grant universities from Colorado, Montana, North and South Dakota, Utah, and Wyoming. This program, supported by the National Water Quality Program and based on the U.S. Environmental Protection Agency (EPA) regional structure, has a decade-long history of contributing to the goals of the U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA), formerly the Cooperative State Research, Education, and Extension Service (CSREES). This program is often referred to as a "406" Program because of its legislative roots in Section 406 of the Agricultural Research, Extension, and Education Reform Act of 1998 (AREERA) (7 U.S.C. 7626). Since its inception, the National Water Quality Program has been at the cutting-edge of its Extension, education, and research efforts. Today, NIFA supports regional team efforts to address national priorities as set out by the USDA. These priorities include:

- Global Food Security and Hunger
- Climate Change
- Sustainable Energy
- Childhood Obesity
- Food Safety

The NPM Regional Water Program is one of ten regional coordination programs, which have relied on a team of state water quality coordinators to promote regional and national collaboration, enhance delivery of successful programs, and encourage multistate and multi-region efforts to protect and restore water resources. Partnerships, including those with faculty of tribal, Hispanic Serving Institutions (HSIs), two-year colleges, and other land-grant universities have facilitated research, outreach, education, and collaboration with natural resource agencies, water quality regulators, and elected officials at the tribal, local, state, regional, and national levels.

The NPM Regional Water Team's priority goal is to inform science-based decision-making on water-related issues in communities across the region by integrating research, education, and Extension efforts. The objectives are to help local stakeholders improve the quality of the nation's surface and groundwater resources in agricultural, rural, and urbanizing watersheds and to address critical water resource issues, including drought preparedness, youth education, sustainability, conservation, water use and reuse in agriculture, and many other topics. Additional projects in which the NPM Regional Water Team has participated include:

- Integrated Projects, which consist of a focused research effort along with outreach education to address a specific watershed concern
- Extension Education Projects, which deliver outreach programs into target watersheds
- National Facilitation Projects, which coordinate and support implementation of successful programs that are relevant across the U.S.

Four key programmatic themes have been identified that represent critical challenges affecting the NPM Region's water resources. These themes, consistent with USDA-NIFA priorities, are:

- Watershed Monitoring and Management
- Agricultural Water Conservation and Protection
- Drinking Water - Human and Livestock Health
- Best Management Practice (BMP) Development, Training, and Assessment

Watershed Monitoring and Management

As a means of engaging citizens in watershed management, state water quality coordinators have maintained an active leadership, collaboration, and instructional role in helping natural resource agency partners and stakeholders strengthen capacity for water quality monitoring, both among volunteers and professionals. Regionally supported projects have resulted in the development of research-based tools, training resources for adult learners, and educational opportunities for youth, which are contributing to improved understanding of the principles of watershed function and effective assessment of health and management of watersheds.

Agricultural Water Conservation and Protection

The NPM Regional Water Team has recognized that in order for agriculture to maintain economic viability in the future, agricultural water users will need to aggressively adopt water conservation and management practices. The Ag Water Conservation and Protection initiative was designed to empower agricultural water users to maximize efficiency of water use, conserve irrigation water, and minimize adverse impacts of irrigation and other water management practices to the environment. This initiative also enhances the capacity of agricultural consultants, technical service providers, educators, policy-makers, and other professionals who advise, mentor, and educate water users regarding BMPs applicable to agricultural water conservation and protection.

Drinking Water - Human and Livestock Health

This initiative focuses on developing, promoting the use of, and evaluating Extension-outreach programs, educational tools, and resources addressing drinking water quality, irrigation water suitability, and functionality and maintenance of on-site septic systems. This initiative's efforts foster adoption of monitoring and management practices that improve water quality, minimize exposure of humans, livestock, and agricultural soils to waters of impaired quality, and reduce undesirable interactions between private drinking water supplies and domestic wastewater treatment systems.

BMP Development, Training, and Assessment

In contrast to limited water supplies experienced in some areas of the NPM Region, eastern parts of the region have been experiencing a growing interest in and installation of artificial drainage in many agricultural fields with elevated salinity and rising water tables. In an effort to gain a better understanding of the connectivity between tile drainage and receiving stream's water quality, water quality coordinators have developed partnerships with state and federal natural resource management agencies, private farmer groups, and water quality coordinators in the Great Lakes Region to conduct educational programs for interested farmers and initiate research related to water quality and quantity sourced from tile drains.

The following report highlights and summarizes the efforts of the projects that the NPM Regional Water Team has been leading over the past several years. These projects exemplify numerous impacts and outcomes that are a result of this decade-long regional program. Cooperation and joint support between the UDA-NIFA National Water Quality Program and water quality coordinators of the NPM Regional Team has led to measurable outcomes and impacts to protect and improve water quality across the region. For more information about the NPM Regional Water Program and Team, please visit us online at www.region8water.org

Guiding Landowners and Agencies Dealing with Domestic Energy Development

As recently as a decade ago, industry, society, and environmental management agencies' dealings with water resources and oil and natural gas development were mostly confined to issues related to off-shore drilling for oil, ruptured pipelines, and grounded oil tankers. Today, new terms, like coalbed methane (CBM), or coal seam natural gas, and drilling and extraction practices, like horizontal drilling and fracking (formally known as hydraulic fracturing), are gaining a lot of attention, particularly in the Northern Plains and Mountains (NPM) Region. Much of this attention is because of better understanding of the potential for oil and gas resource development to affect land and water resources.

In the mid-1990s, the natural gas industry developed efficient processes for locating and extracting CBM from shallow coal deposits throughout the Intermountain West. A significant increase in natural gas prices prompted the drilling and development of nearly 31,000 CBM wells in the NPM Region by 2010. Today, the Powder River Basin in Wyoming and Montana contains the largest concentration of CBM wells in the U.S. Concurrently, the increase in crude oil prices prompted expanded exploration and drilling for oil and natural gas reserves. This expanded drilling was complemented by new drilling techniques and improved methods for withdrawing natural gas and crude oil from underground oil reserves. The two most noteworthy advances have been horizontal drilling and improved hydraulic fracturing, a process whereby industry-proprietary chemicals, mixed with large volumes of water and sand, are injected into underground geologic formations to open and expand pores and channels so that oil and gas can more readily flow to the well cavity. Additionally, driving the oil and gas development industry has been the discovery of large, prolific oil and gas reserves contained in the Niobrara and Bakken shale deposits, underlying southeast Wyoming and northeast Colorado, and northeast Montana and northwest North Dakota, respectively.

Extraction of CBM requires pumping and disposing of often large volumes of water from coalbeds. This water ranges in quality from nearly fresh to brackish and saline. Pumping and discharge of water from CBM operations onto the landscape and into storage impoundments in Colorado, Montana, Utah, and Wyoming and into the Cucharas and Purgatoire (Colorado), Powder, Tongue, and Little Powder (Wyoming-Montana) rivers has increased dramatically in the past decade. The primary potential water resource risks associated with hydraulic fracturing are associated with the extraction process itself or from the wastewater. Though the risks change over the course of the extraction process, they exist through the drilling, operation and completion of the well. Most of the known/documented water quality issues have been associated with surface spills and releases or well casing failures that have impacted surface and drinking water resources.

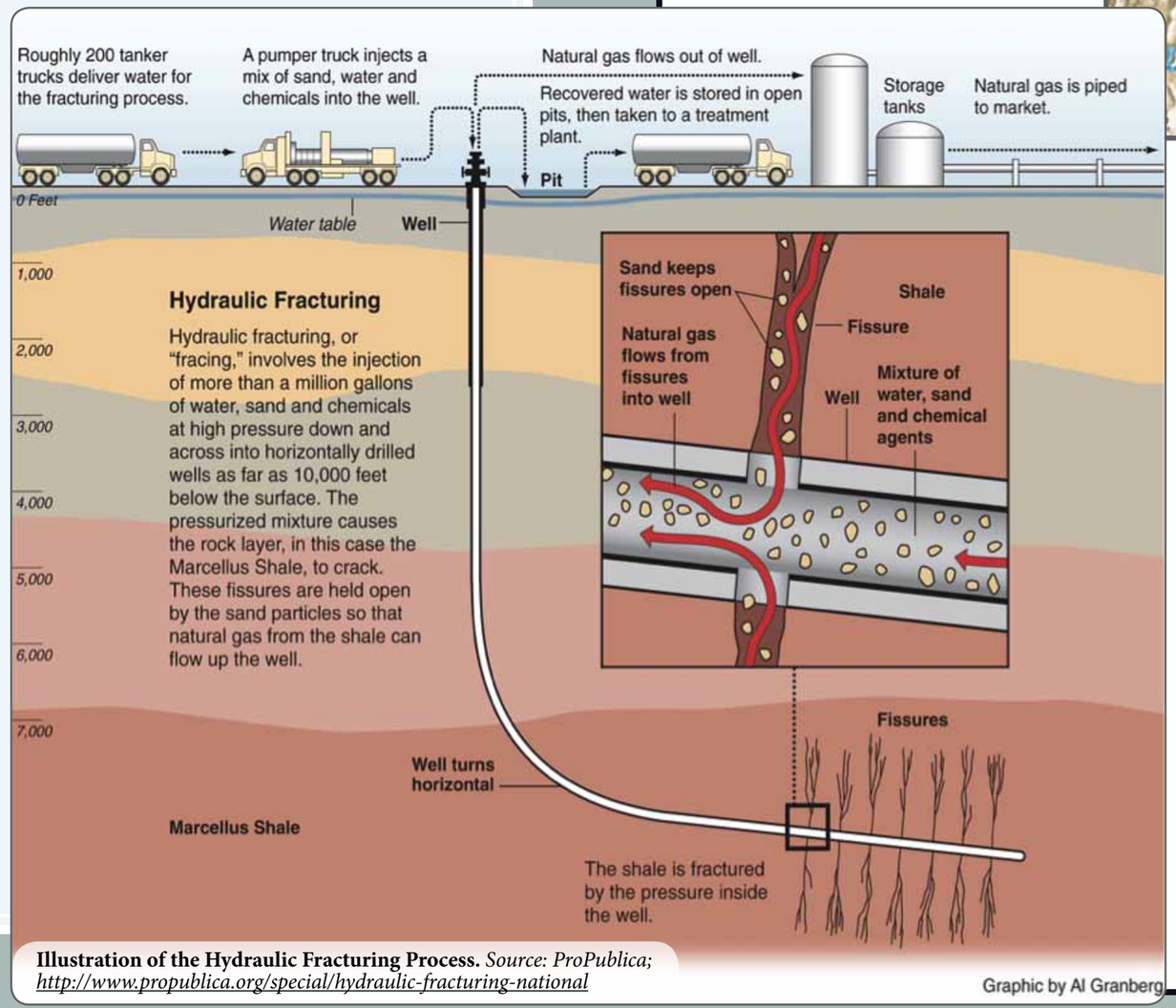
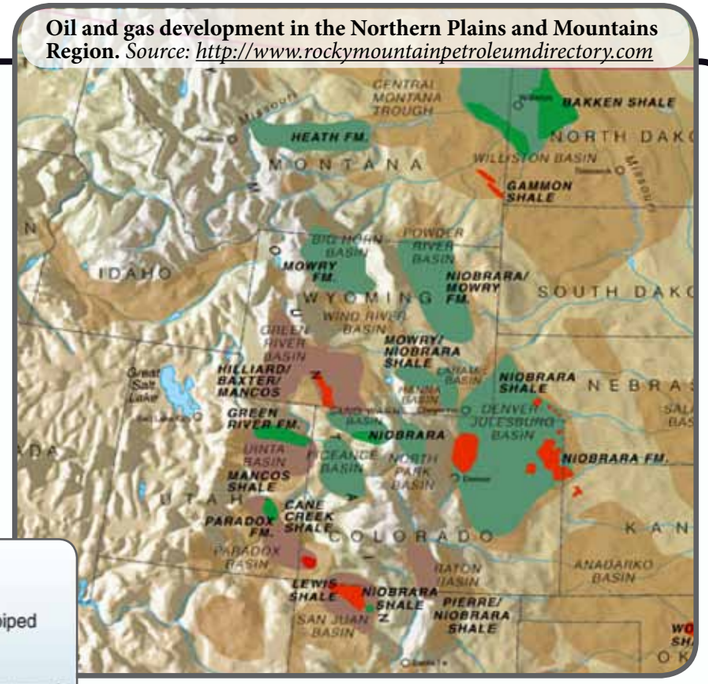


Illustration of the Hydraulic Fracturing Process. *Source: ProPublica; http://www.propublica.org/special/hydraulic-fracturing-national*



Oil and gas development in the Northern Plains and Mountains Region. *Source: http://www.rockymountainpetroleumdirectory.com*

The discharge and disposal of CBM produced water was found to alter the quality of some streams, rivers, and groundwater into which CBM produced water infiltrates from storage ponds. Research by water quality coordinators and land-grant university scientists in Wyoming, Montana, and Colorado has documented that CBM production water can often negatively alter soil properties as well. Each of these circumstances can pose a threat to the quality of water used for irrigation, livestock watering, range land, and aquatic habitat sustainability. Additionally, severance of mineral rights from surface rights often means that landowners, whether dealing with CBM or unconventional oil/gas drilling, have little control over drilling operations and must rely on surface use agreements and negotiations with gas and oil production companies to guide operations on the landscape.

Regarding the current thrust of unconventional oil and gas development in the NPM Region, landowners frequently voice concerns about whether hydraulic fracturing can or will contaminate their domestic water supplies. Irrigators wonder whether discharge of CBM-produced water will cause changes in irrigation

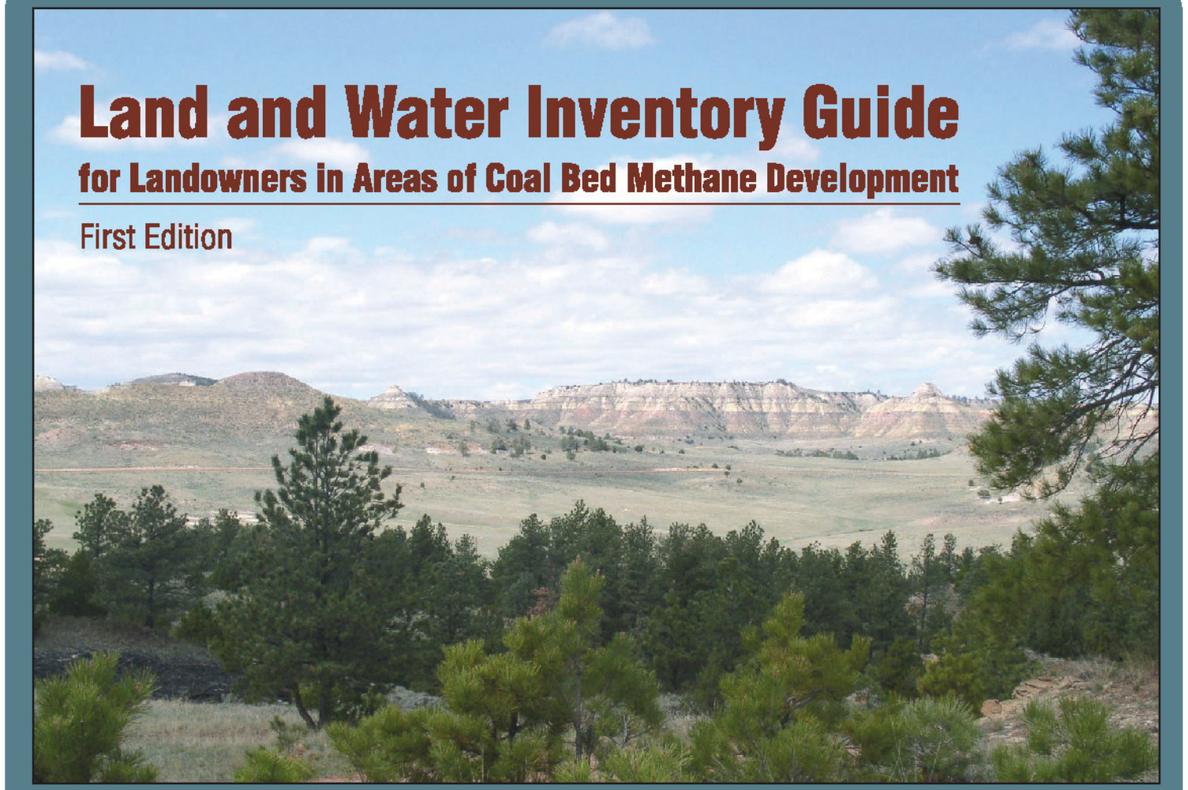
water quality, and regulatory agencies need to know what values should be assigned to water quality parameters to assure protection of water resources. An identified need is to disseminate information to landowners in these targeted areas regarding:

1. The hydraulic fracturing process, including what chemicals are used
2. Landowner rights and how to develop a surface owner agreement
3. How to collect baseline water quality and land resource data before, during, and after the hydraulic fracturing process

The NPM Regional Water Project "Guiding Landowners and Agencies Dealing with Domestic Energy Development" has had several goals, including the following:

- Help landowners understand the processes involved in CBM development and unconventional oil/gas development and landowner rights
- Help landowners understand what steps to take to insure the integrity of their domestic, livestock, and irrigation water supplies and farm and ranch lands
- Educate the general public and policy-makers about the science of water quality protection
- Work with regulatory and natural resource management agencies and tribal lands administrations to define guidelines and, where appropriate, standards for protecting water resources

Coalbed methane (CBM) produced water pumped from several wells is brought together to one outfall for disposal and management. This photo illustrates a CBM outfall releasing water into constructed pond in northeast Wyoming. *Courtesy of Suzanna Carrithers Soileau, formerly Montana State University Extension; currently USGS-Bozeman, Montana*



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MONTANA STATE UNIVERSITY
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EPA United States Environmental Protection Agency

Actions and Outcomes

Based on outcomes of needs assessments, the NPM Regional Water Team responded to stakeholder needs by:

1. Researching impacts of CBM produced water discharges on irrigation water quality and management alternatives on semi-arid landscapes and irrigation water
2. Developing educational resources for landowners, regulatory and natural resource management agency personnel, litigants, attorneys, consultants, scientists, students, the media, and educators
3. Transferring science-based information to the general public, media, landowners potentially impacted by CBM extraction, and policy makers

The NPM Regional Water Team and their partners developed an award-winning, nationally recognized Land & Water Inventory Guide for Landowners in Areas of CBM Development, which has been used to educate landowners concerning CBM issues (http://waterquality.montana.edu/docs/methane.shtml). Support for the project came from an EPA Regional Geographic Initiative, the USDA-NIFA NPM Regional Water Program, Prairie County Conservation District (Montana), and the National Energy Technology Lab (NETL). The guide assists with monitoring and assessment of CBM impacts to land and water resources. Strong collaboration was established between regional partners by distributing the manual to over 1000 partners, landowners, and land managers.

Team members produced *Prairies and Pipelines*, a public television documentary, with support from the Department of Energy (DOE), MSU Extension Water Quality Program, and the NPM Regional Water Program (http://waterquality.montana.edu/docs/Publications/CBM_Video.shtml). The documentary includes contributions from BLM, private land owners, industry representatives, scientists, and policy-makers. The film addresses the science and social issues behind CBM recovery and associated water management. It aired on PBS, reaching an audience of up to 300,000 viewers.

Constructed surface storage ponds and impoundments for coalbed methane product water along the Tongue River corridor, south central Montana. *Courtesy of Jim Bauder, formerly Montana State University Extension Water Quality Specialist*

Holly Sessoms, former Montana State University Extension Water Quality Associate, and Jim Bauder, former Montana State University Extension Water Quality Specialist, measure infiltration at a coalbed methane water spill site in southeast Montana. *Courtesy of Suzanna Carrithers Soileau, formerly Montana State University Extension; currently USGS-Bozeman, MT*

Numerous inquiries from private well owners, field Extension staff, and regional EPA office staff prompted the development of a comprehensive website addressing many aspects of the hydraulic fracturing process and implications for water resources (http://region8water.colostate.edu/fracking_resources.shtml). The website provides information about the following:

- Drilling and hydraulic fracturing techniques
- Water quality testing, split estates, and surface use agreements
- Perspectives on water quality, quantity, and health issues related to hydraulic fracturing
- Numerous links to information specific to the Marcellus shale development along the eastern seaboard and northeastern U.S.

NPM water coordinators were involved with three forums and conferences specifically addressing hydraulic fracturing held in Wyoming and Colorado in the fall 2011. Over 600 participants (landowners, scientists, federal and state regulatory agencies, etc.) attended the events. At the local scale, landowner workshops were held in areas targeted for development in southeast Wyoming. These workshops were modeled after successful NPM workshops and involved more than 250 landowners.

Impacts

In survey of landowners receiving the land and water inventory guide, 73 percent of respondents claimed the guide increased their knowledge of soil and water resource issues related to CBM development and better prepared them for negotiating agreements with development companies, and 64 percent of respondents were motivated to collect baseline soil, water, or vegetation data after reading the guide. In the same survey, 58 percent of respondents said the guide motivated them to implement a monitoring program on their property.

Impacts of the *Prairies and Pipelines* documentary were assessed by distributing the video and a survey to 360 individuals in the four major CBM basins in the West. After viewing the video, all respondents indicated that it was a highly to moderately effective educational resource. Eighty-seven percent of respondents indicated that their knowledge of social issues associated with CBM development had "increased" or "somewhat increased," while 86 percent of respondents indicated their knowledge of soil and water issues associated with CBM development had "increased" or "somewhat increased." In addition to surveying the general public's response to the video, partners at Little Bighorn Tribal College agreed that their knowledge of social issues and of soil and water issues related to CBM "increased" or "increased somewhat."

Additional impacts of the Guiding Landowners and Agencies Dealing with Domestic Energy Development Project include:

- Landowners have been made more aware of the impacts of oil and gas development, split estate issues, and landowner-surface owner rights.
- Landowners have taken proactive steps to inventory and monitor natural resources and irrigation water qualities.
- The state of Montana, the Northern Cheyenne Tribe, and the EPA have adopted numeric surface water quality standards and water management regulations specifically dealing with CBM produced water. Wyoming regulators have established narrative water quality standards, and Colorado regulatory agencies have undertaken rule promulgation and permitting protocols specific to CBM produced water.
- Wyoming and Montana Environmental Quality departments have modified their CBM water discharge permit processes, to protect existing beneficial water uses.
- Wyoming, Colorado, Montana, and North Dakota landowners and state and federal regulatory agencies have been made aware of the need for baseline (and continued) water and land resources monitoring in areas targeted for hydraulic fracturing process. As a result of this heightened awareness, the Wyoming state legislator and an oil and gas company requested that the University of Wyoming water quality coordinator develop a baseline water quality assessment program for areas within Wyoming that are targeted for development.

Leveraging and Partnerships

Collaborative efforts brought together water quality coordinators and team members from Montana, Wyoming, Colorado, and Utah and leveraged funds in excess of $2 million. Our partnerships in these efforts have included numerous state departments of environmental quality, U.S. EPA Region 8, the DOE NETL, the Montana Department of Commerce, USDA Natural Resource Conservation Service (NRCS), oil and gas development companies, many local soil and water conservation districts, and private landowners. The project also allowed the development of an extensive network of partners across the Powder River Basin (Wyoming) to access CBM wells and disposal ponds for water quality analysis and then develop optimum uses for CBM produced water.

For additional information about the NPM Regional Water Team program addressing hydraulic fracturing, visit http://region8water.colostate.edu/fracking_resources.shtml

For additional information about NPM Regional Water Team program addressing coalbed methane issues, visit http://waterquality.montana.edu/docs/methane.shtml

Regional Watershed Monitoring and Management Programs

If agriculture and natural resources are to be sustained in the West, managing watersheds while protecting water quality is critical. Urbanization, expansion of small acreage housing, and energy development are challenges facing western watersheds and natural resource management in the Northern Plains and Mountains (NPM) Region. These land uses can transform large tracts of land from agriculture, rangelands, and wild lands, resulting in changes in watershed function and water quality and quantity in these watersheds. In addition, continued application of BMPs whose benefits have not been quantified further challenges our ability to effectively manage these resources.

BMPs, also known as conservation practices, are used to address water quality impairments by federal, state, and local resource and water management agencies, including the USDA-NRCS, Bureau of Land Management (BLM), U.S. Forest Service, local conservation districts, and watershed groups. The Clean Water Act specifically identifies BMP implementation as the appropriate response to nonpoint source pollutants. The BMPs can be structural, such as sediment retention basins, or a procedure or practice such as upland grassing management. For over 50 years, BMPs have been implemented to address water resource and quality issues at a range of scales, from streams to watersheds. However, ongoing and completed monitoring programs for BMP effectiveness often failed to capture changes in water quality as a response to implemented BMPs. From years of experience with Conservation Effectiveness Assessment Projects (CEAP) and numerous projects assisting in watershed assessment and total maximum daily load (TMDL) development in Utah and Wyoming, members of the NPM Regional Water Team recognized the need for structured and formalized guidance on BMP effectiveness monitoring programs throughout the NPM Region.

The development of tools and approaches to assess the impacts of changing land use practices on watershed function, identify water quality issues, and evaluate the effectiveness of BMPs implemented at the local or watershed scale are essential. To achieve these objectives requires water resource and credible water quality data and an understanding of the interactions between watershed characteristics, climatic factors, and land uses. The NPM team developed a suite of training systems, tools, and approaches to assist watershed managers and stakeholders with water quality monitoring. In brief, the NPM Watershed Monitoring and Management Program consisted of:

- Investigating water quality monitoring training needs in the region
- Assessing BMP monitoring programs
- Directly assessing the effectiveness of specific BMPs at mitigating water quality issues
- Developing educational resources, approaches, and materials to improve water quality monitoring programs in general
- Monitoring of BMP effectiveness

Brady Irvine and Becky Shoemaker from Platte County Resource District in southeast Wyoming looking at macro-invertebrates for water quality.
Photo by Ginger Paige

Steve Jones and Emily Ewert from Meeteetse Conservation District collecting a surface water sample.
Photo by Mickey Patterson

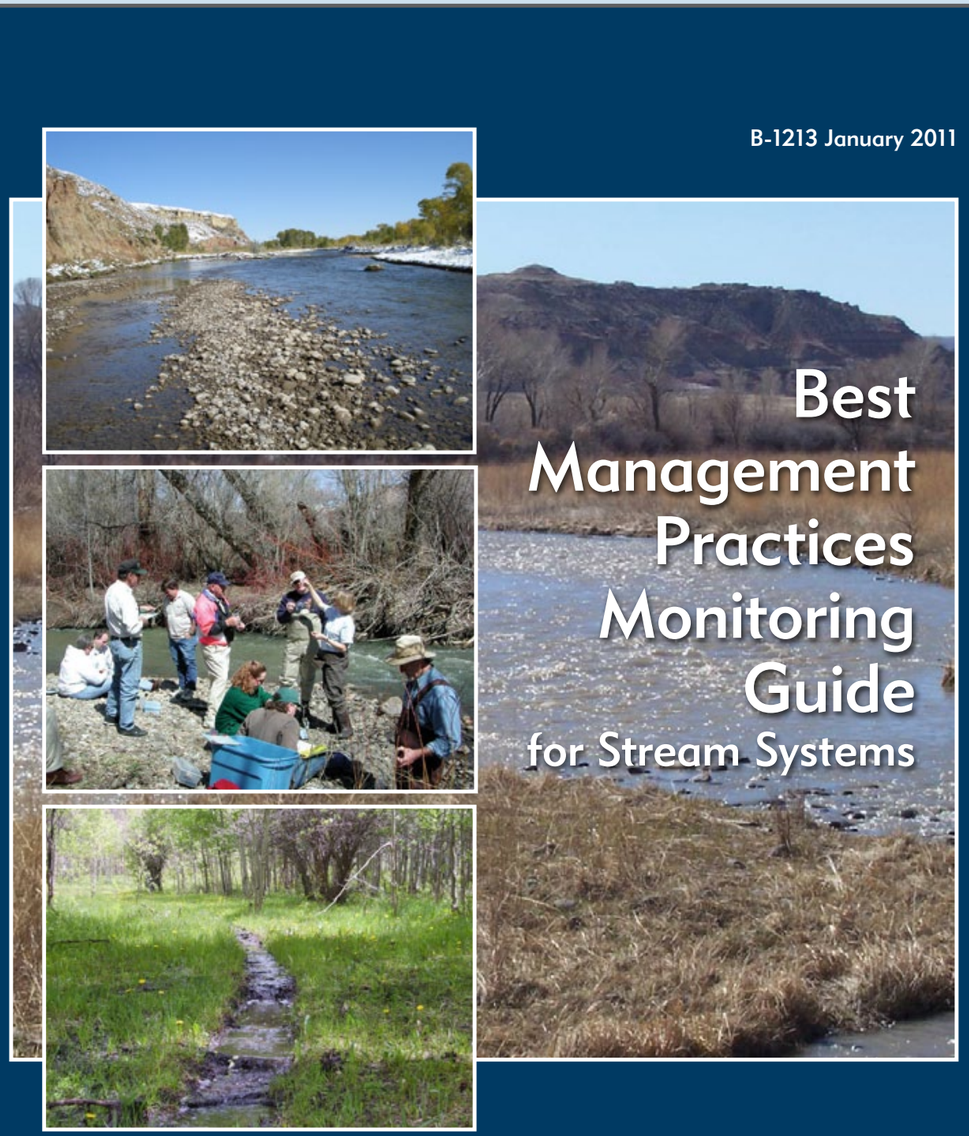
- Leading trainings and symposia for local, state, regional, tribal and national audiences

Actions and Outputs

Water Quality Monitoring Training and Certification Program

Based on outcomes of numerous needs assessments, the NPM Regional Water Team developed the Water Quality Monitoring Training and Certification Program. The goal of this program was to improve the understanding of the principles of watershed function and the understanding of effective and meaningful assessment of watershed health and management for multiple benefits. This goal was achieved by implementing several strategies, including the following.

- Improving the development and implementation of monitoring programs so that credible data are collected that target specific project objectives
- Developing and implementing training and programmatic structure for certifying water quality monitors
- Developing and distributing tools and resources to increase accessibility of data and assist in interpretation of data
- Identifying and helping to fill data gaps necessary to address important water resources related concerns in this region and surrounding Intermountain West
- Assisting in TMDL development and other watershed planning efforts



Developed by:
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Various aspects of the program have been developed and implemented by state water quality coordinators in Wyoming, Utah, and Montana, resulting in research-based tools, training resources for adult learners, and educational opportunities for youth. NPM state water quality coordinators have maintained active leadership, collaboration, or instructional roles in helping natural resource agency partners and stakeholders strengthen their capacities for water quality monitoring, both among volunteers and professionals.

The water quality monitoring training programs can be divided into three primary target areas: educational monitoring, descriptive monitoring, and certified and compliance monitoring. The monitoring programs, though diverse to meet the needs of the individual states, all share the same foundation of promoting a good understanding of watershed functions and the importance of defining clear, well-defined monitoring objectives to guide sampling design, data collection, and analysis. Wyoming developed a rigorous approach to train and certify water quality monitors and is now serving as a model for other states in the region. A complete set of water quality monitoring training materials was developed to serve as the foundation for a conservation-district-sanctioned training and certification program, and includes classroom instruction, written proficiency tests, and field audits. These materials have been shared with Montana and North Dakota water quality coordinators. Most materials are also available on the Web (http://www.uwwater.org). Through the Wyoming Water Quality Monitoring Certification Program, more than 100 state resource managers have been trained, of which 48 have been certified, and thirteen Wyoming watersheds have undergone successful field audits.

Both Montana and Utah developed state partnerships and utilized funding and support from the departments of environmental quality to develop tiered water quality monitoring training programs. MSU Extension formalized a partnership with the Montana Watercourse to follow the Wyoming example, while at the same time incorporating important principles being taught in Utah. The training program includes participation in sampling events and data management workshops. Two Montana watershed groups (six members each) have been certified for water quality monitoring. Utah, in collaboration with Utah Water Watch, is developing a water quality monitoring training program that will start spring 2012. The Utah training program includes three tiers: educational monitoring, descriptive-screening monitoring, and compliance monitoring. The Utah Department of Water Quality and all the watershed coordinators are fully engaged in the process.

BMP Water Quality Monitoring Program

Within the BMP Water Quality Monitoring Program, the NPM Regional Water Program has developed a suite of tools and approaches to assist water quality monitors with program designs that determine the effectiveness of BMPs implemented on a stream or in a watershed. The tools include:

- BMP Monitoring Guide for Stream Systems
- An interactive website
- A checklist that leads water quality monitors through the questions necessary to design and develop an effective monitoring program to assess BMPs that address water quality issues

The *BMP Monitoring Guide for Stream Systems* is a guide for planning monitoring approaches before project implementation begins. The guidance manual emphasizes the need for careful consideration of the specifics of a particular implementation project, such as understanding the potential source, transport, and fate of specific pollutants of concern, specific watershed characteristics, and a thorough knowledge of other sources of data and information. This leads to appropriate choices of monitoring or modeling techniques, and appropriate choices of frequency and scale of monitoring and data collection. Too often, water quality data collection projects and monitoring programs are implemented with little thought to specific project objectives, resulting in datasets that are of little value. The guidance document's suite of accompanying training tools leads water quality monitors through the questions that should be asked before monitoring is implemented and during the process.

The *BMP Monitoring Guide for Stream Systems* is a stand-alone resource, backed by a suite of supporting materials. The accompanying website (www.uwyo.edu/bmp-water) is an online version of the guidance document. The website also provides access to online resources with additional information on monitoring programs and protocols, including bioassessment protocols and water quality models and tools. The guidance document was reviewed by the NPM Regional Water Program Team, EPA Region 8 staff, and agency partners in Utah and Wyoming. In addition, the step-by-step process outlined in the guidance document was 'field tested' in the Bear River watershed in Utah and the Crow Creek watershed in Wyoming.

The guidance document, website, checklist, and approach have been presented at several national meetings, including the National Water Quality Monitoring Council (2010), the USDA National Water Conference (2010, 2011), and the 2011 National Tribal Water Conference. All responses and feedback indicate that this guidance is necessary to help establish effective monitoring programs that collect usable data. The tools and approaches have been integrated into water quality monitoring training programs and workshops in Montana, Utah, and Wyoming and used in the 2010 Tribal Waters Workshop held in Crow Agency, Montana that was attended by water quality coordinators from nine tribal nations.

NPM Regional Water Program Team members consistently interact and engage with stakeholders, collaborators, and tribes to deliver tools and resources to assist with strengthening watershed assessments and water quality monitoring programs. These include:

- Numerous presentations at state water quality coordinator workshops and meetings
- Presentations at national and regional meetings of the National Water Monitoring Program
- The USDA-NIFA National Volunteer Monitoring Network "Getting Started in Volunteer Monitoring" workshop at the 2010 USDA National Water Conference
- The "Effective Monitoring of BMPs for Stream Water Quality" workshop at the 2010 USDA National Water Conference
- Active participation in the Rocky Mountain water quality monitoring network, a collaborative information sharing network of natural resource agencies partnering with EPA Region 8

Adam Sigler, Water Quality Associate with Montana State University Extension, provides advanced training of water sampling and testing to the Madison Watershed Group (Summer 2011). *Courtesy of Katie Kleehammer, Montana State University Extension*

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Impacts

Impacts of the regional team effort are evident at the local, state, and regional levels:

- Water quality monitoring training programs for volunteers and professionals have expanded in scope and depth in the NPM Region
- Wyoming and Montana have certification programs, and Utah and North Dakota are expanding their monitoring trainings and developing certification programs
- Over 200 individuals, volunteers, and professionals have been trained and/or certified in the region to collect credible water quality data
- One hundred percent of volunteers certified in one of the Montana programs reported that after completing certification training, they better understood the basic functions of Quality Assurance Project Plans (QAPP) and SOP (Standard Operating Procedures), the basics of physical, chemical and biological water quality properties, water monitoring methods, and precision that varies by method, and the purpose and reason behind monitoring local streams
- New monitoring strategies that detect and quantify real change in water quality are being implemented and credible water quality data are being collected. These data are being used to assess the effectiveness of implemented BMPs, develop TMDLs that are appropriate for the region, and assess the overall health of our watersheds

Leveraging and Partnerships

This multi-state, multi-partner, multi-year project was accomplished with substantial technical and financial input from various partners. The financial foundation of this project included USDA-NIFA and support from numerous partners amounting to more than $1.7 million. Partners and/or sources of funding include:

- Little Bear River CEAP Project
- Wyoming Water Quality Monitoring Training Program
- Wyoming Department of Agriculture and Association of Conservation Districts
- Greybull River Streambed Processes & E. coli Distribution Project
- EPA 319 grants to watersheds in Utah
- EPA 319 outreach grants in Utah
- National Science Foundation Test Bed Grant in Little Bear
- Utah State University Watershed Initiative internal grants
- USDA-NIFA Rangeland Watershed Assessment Tool grant
- Wyoming, Montana and Utah Departments of Environmental Quality
- Tribal Colleges
- Montana Water Course
- Utah Water Watch
- U.S. Geological Survey
- Numerous state and local soil and water conservation districts
- USDA-Natural Resources Conservation Service
- State land-grant university Extension offices
- National Monitoring Council
- U.S. EPA Region 8

For additional information about the NPM Regional Water Quality Monitoring Training and Certification program and to access the *Guidance Document for Monitoring Effectiveness of BMPs on Stream Systems*, please visit http://www.uwyo.edu/bmp-water/

Adam Sigler, Water Quality Associate with Montana State University Extension, provides advanced training of water sampling and testing to the Madison Watershed Group (Summer 2011). *Courtesy of Katie Kleehammer, Montana State University Extension*

Stream Side Science: Hands-on Water Education that Makes a Difference

The goal of the Stream Side Science program is to promote and provide effective education about watershed functions and water quality issues for K-12 students, undergraduate and graduate students, and educators throughout the Northern Plains and Mountains (NPM) Region. Stream Side Science activities use hands-on stream exploration techniques to explain and teach about water science and watershed functions. This project has succeeded because of strong leadership; clearly defined objectives, goals, and approaches; a flexible and adaptable approach; and durable collaborations and partnerships. State water quality coordinators from Utah, Montana, Wyoming, and Colorado have actively participated in this NPM Regional Project.

Stream Side Science originated at Utah State University (USU) as a set of lesson plans for ninth graders, developed by USU in collaboration with the Utah State Office of Education and Utah Governor Walker's Watershed Initiative. It has since evolved to include:

- Lessons for all ages that are appropriate for multiple disciplines
- Online and face to face short courses for high school science teachers and master's degree students at Montana State University (MSU) and USU
- Workshops and summer institutes for teachers in Utah, Wyoming, Colorado, and Montana
- Hands-on programs for Native American tribal water quality interns
- Stream-side classroom learning modules for high school students in southern Colorado and students enrolled in introductory environmental science classes at Hispanic Serving Institutions (HSI) in Colorado

Stream Side Science began as a set of simple monitoring activities for stream, wetlands, and lake exploration. The twelve lesson plans in today's Stream Side Science manual cover science, management, and policy aspects of water science and water quality. A second set of lesson plans and activities for grades K-5

Fourth graders learn about aquatic insects and their habitat at a field day activity. *Courtesy of Utah State University Water Quality Extension*

(Bugs Don't Bug Me) focuses on exploration of aquatic macroinvertebrates, with additional lessons on the water cycle and water pollution.

In all cases, students are engaged directly through monitoring and other activities, and encouraged to become stewards of their local watersheds through service and community outreach projects. Teachers and leaders are encouraged to get kids outside, and when that is not possible, the lessons are easily adapted to bring samples from streams and lakes to the classroom.

Stream Side Science lesson plans are designed with the needs of educators in mind:

- Each lesson plan is formatted for easy use, providing clear instructions and explanations for teachers.
- All lessons are aligned to national and state science standards.
- All curricula and additional materials are available online or by request, and all materials needed for the lessons are inexpensive and easy to obtain or build.
- FAQs for each lesson plan provide "talking points" that teachers use to guide classroom discussions.
- STEM connections are explicitly provided, with tips on graphing, simple statistics and other math exercises provided throughout the Stream Side Science manual.
- Watershed specific materials have been developed in Utah for the Jordan River and the Bear River watersheds. Similar watershed specific materials are being developed as Stream Side Science is adapted for Fountain Creek watershed in Colorado.

All our lessons are reviewed by scientists, policy makers, and other content specialists to assure that they are scientifically accurate and unbiased. Educators and curriculum specialists then review the materials for appropriate pedagogy. All lessons are "field tested" with teachers who provide additional feedback. Finally, we have formally evaluated most of these activities by conducting before and after testing of approximately 500 ninth grade students using Stream Side Science activities and over 1,300 fourth grade students using our Bugs Don't Bug Us activities.

Fourth graders inspect macroinvertebrates and learn about adaptations and life cycles of these organisms. *Courtesy of Utah State University Water Quality Extension*

Actions and Outcomes

Stream Side Science provides high quality support and training for educators. Our focus groups and teacher surveys indicate that many K-12 science teachers and informal educators are hesitant to use experiential water oriented or field oriented activities because they have limited knowledge of water and watershed science. Stream Side Science teacher-training opportunities are designed to provide educators the knowledge and skills to effectively teach water science to their classrooms.

> *"My kids really loved our daily trips to the river. They learned much more than they would have from just lecture and testing."*
>
> *-Feedback from a participating teacher*

The Stream Side Science program provides this training for educators in a variety of formats:

- The Stream Side Science Manual is an integral part of "Stream Side Science– an Online Approach to Field-based Education," a three credit, semester-length graduate course taught through the MSU, Office of Extended Studies (http://btc.montana.edu/courses/aspx/descrip3.aspx?TheID=171).
- Stream Side Science educator workshops are organized to meet the needs of particular groups and interests, but always provide educators with the knowledge and skills to effectively teach water science to their students. Participants receive continuing education credits or college credit and credit toward teaching endorsements.
- Utah's Community Mapping Project workshops for social studies teachers routinely integrate Stream Side Science techniques during their weeklong workshops on GPS data collection and GIS mapping.
- In response to teacher requests, advanced workshops are now offered on aquatic macroinvertebrate collection and identification.
- The manual is also being used as a field and classroom guide for mentoring environmental science students at Colorado State University-Pueblo, Hopa Mountain College, Blackfeet Community College, Little Big Horn College, and Native Science Field Centers in the NPM Region.
- Leaders in Utah's Envirothon and Science Olympiad competitions use the Stream Side Science manual as a primary resource for preparing their students.

High school students analyze water quality samples as part of a statewide Envirothon competition. *Courtesy of Utah State University Water Quality Extension*

Stream Side Science is flexible, fun for students, and promotes stewardship through service and community projects:

- The lesson plans are currently being used nation-wide to teach many disciplines, including agriculture and natural resource education, biology, chemistry, math, geography, and other social studies.
- Informal educators across the country are using Stream Side Science for 4-H, scout, after-school and summer activities.
- Student projects using Stream Side Science concepts (4-H, science fair, classroom activities) include watershed-wide monitoring, riparian restoration, community education on urban stormwater, and more.

Impacts

- Formal evaluation of Stream Side Science lessons demonstrated that student knowledge about watershed science, aquatic biology and pollution impacts increases significantly with the use of these lessons and materials. Our study of fourth graders using Bugs Don't Bug Me lessons found significant and long-term (six month) increase and retention of knowledge about aquatic biology and water pollution.
- The results of a survey of students completing the Stream Side Science course of the MSU Master of Science in Science Education program revealed that 81 percent of respondents incorporated knowledge, skills or activities from Stream Side Science into their classrooms, including one or a combination of the following: chemical and physical parameters (69 percent), stream monitoring (38 percent), and macroinvertebrate counts (31 percent).
- More than 50 percent of the students completing the Stream Side Science course of the MSU Master of Science in Science Education program indicated their teaching methods had changed as a result of Stream Side Science; the primary change in pedagogy included incorporation of more hands-on lab activities inside and outside of the classroom.
- Since 2004, over 1300 Utah educators have attended our high quality educator workshops. Follow up surveys indicate that about 40 percent of these teachers use Stream Side Science in their teaching.
- Since 2006, an estimated 150 educators from around the U.S. and beyond have taken MSU's online course: Stream Side Science– an Online Approach to Field-based Education.
- Stream Side Science activities have been adapted and incorporated into many other programs, including Adopt a Waterbody Programs, Master Naturalist Programs, and a new Utah Water Watch citizen monitoring program.
- Stream Side Science materials are being used in developing training and course work at Tribal colleges and HSIs around the country.
- In Utah alone, an estimated 80,000 students have been taught at least one Stream Side lesson by a trained educator, resulting in an increased knowledge and awareness of water quality and water science.

"The curriculum reinforced concepts, builds on previous understanding of watersheds, and modeled how I can present to students."

-Feedback from a participating teacher

Fourth graders use a simple kick net to collect aquatic insects. *Courtesy of Utah State University Water Quality Extension*

Leveraging and Partnerships

USU Extension, MSU Extension, and the USDA-NIFA National Water Quality Program provided funding for the initial and on-going efforts of the Stream Side Science project. Approximately 30 percent of the $202,820 that Utah's Extension program received in EPA 319 outreach grants from 2004-2010 was directed to Stream Side Science teacher education and youth activities. In 2011 and 2012, approximately 50 percent of the $205,000 in 319 grants were directed to teacher education, assessment, direct delivery of programs to youth, and to support a citizen monitoring program that draws on Stream Side Science activities. In addition, Utah has received $49,500 in internal USU grants for development and testing of these materials. In 2005, MSU received a $100,000 USDA Higher Education Challenge Grant to develop the online graduate water quality course.

For more information on the Stream Side Science Curriculum and the Stream Side Science online course, please visit the following websites:

http://extension.usu.edu/waterquality/htm/educator-resources/lessonplans

http://btc.montana.edu/courses/aspx/descrip3.aspx?TheID=171

"Excellent background information and discussion is provided with the lesson plans. The lesson plans also make the information understandable which in turn makes it easier to teach and pass on to the students."

-Feedback from a participating teacher

"I am going to apply all of this to my class next year!"

-Feedback from a participating teacher

Addressing Nonpoint Source Nutrients in the Northern Plains and Mountains Region

Nutrients are a nationwide and regional concern due to degradation of water resources and associated health and environmental risks. The science and policy context surrounding nutrients is complex, affecting the management of wastewater, stormwater, drinking water, agricultural runoff, and numerous other nonpoint sources of nutrient loading. Adding to the complexity of addressing the problem is that regulators are seen as requiring controls and standards that do not seem practical or effective to stakeholders who must abide by them. In response to these concerns, the Northern Plains and Mountains (NPM) Regional Water Team convened a multi-partner, multi-participant Nutrients and Water Quality Collaborative Workshop (http://www.cwi.colostate.edu/Workshops/Region8Nutrient/) for stakeholders and agencies to come together to develop a shared understanding of the science and to better understand the challenges associated with developing and implementing nutrient controls and management, while attempting to preserve other important stakeholder values.

Following up on an invitation from the U.S. EPA Region 8, the NPM Regional Water Team, the Colorado Water Institute (CWI), the Utah Water Research Laboratory, and several agency partners worked cooperatively with EPA Region 8 staff to plan the three-day nutrient workshop in Salt Lake City, Utah. The importance of diversity in the organizing committee was that workshop organizers sought to engage a diverse group of attendees, including stakeholders, academics, regulators, and administrators to work together to tackle myriad issues

Near Koosharem Reservoir, Utah. *Photo by Ken Lund*

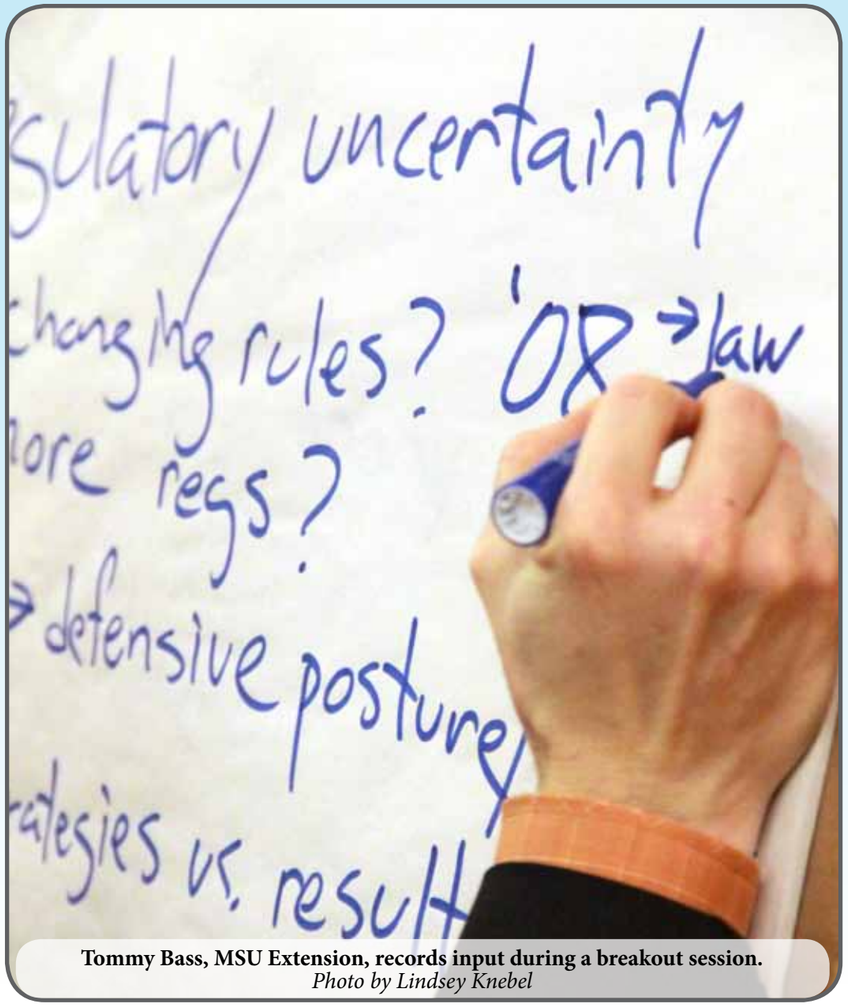
Alan Johnstone Chairman of Shields River Watershed Group, participates in workshop dialogue.
Photo by Lindsey Knebel

surrounding the topic. Subsequently, more than 220 attendees participated in open dialogue addressing problem/situation definition, institutional roles and implications with respect to addressing nutrient water pollution, and human health and social implications of nutrient water pollution and proposed or implemented solutions.

The focus of the presentations and dialogue of the first day of the conference was on defining the problems of nutrient water pollution through the presentation of existing scientific data and assessments. During the second day, speakers and participants focused their attention on understanding the institutional and social context for problem definition and solutions and gaining an understanding of what is being done to address the problems. During the third day of the conference, the participants were challenged to work together to develop a shared understanding of the problems tied to nutrients and to collectively formulate recommendations and future steps to address the issue of nutrients in water in the NPM Region. Specific and solid recommendations were discussed for the EPA, the state water quality departments, and other agencies on the topic of setting numeric standards, regulating in other ways, or providing incentives to manage nutrients affecting water quality.

Actions and Outcomes

One of the results of the workshop is a 57-page summary of speaker presentations, outcomes of dialogue sessions among attendees, and lists of recommendations to the EPA and state water quality regulatory agencies about how to go about addressing nutrient issues and working toward nutrient controls associated with storm water, wastewater, concentrated/animal feeding operations, nonpoint sources, and drinking water. In addition, the key talks from the workshop were published in a special



Tommy Bass, MSU Extension, records input during a breakout session.
Photo by Lindsey Knebel

edition of the *Journal of Contemporary Water Research and Education*.

A message that came out loud and clear is that an array of societal values, including economics, must be considered when setting nutrient standards for drinking water and rivers and streams. Regulations must be tied to credible research and those who are already successfully controlling nutrients should be consulted so their solutions can be applied elsewhere. Flexibility is favored over a "one size fits all" approach and incentives are favored over mandates, when possible. Regulators are encouraged to build relationships and credibility by coming out into the field to observe the situations they are trying to address. That should lead to common sense changes needed to improve water quality, stakeholders said. It also became clear from the participants that agricultural producers and others under fire for contributing to water pollution from nutrients – primarily phosphorus and nitrogen – want to be a part of the solution, but they also want to help craft those solutions.

Probably one of the most valuable outcomes of the conference was open dialogue among the attendees resulting in sharing of data and a better informed network of parties involved in or responsible for defining, establishing, and achieving nutrient controls. Complimenting this was the development of a detailed statement of what should be done to help states address nutrient management, which included:

- Establish a small work group of the regulated stakeholder representatives and the regulators in the NPM Region to draft and champion implementation of concrete, actionable next steps based on the recommendations from the workshop
- Encourage states to initiate internal dialogues among stakeholders, regulators and the regulated communities that build on the learning of the workshop and deal with state specific issues;
- Stage educational and relationship building opportunities such as tours in which the regulated and the regulators travel together to farms, water treatment plants, and impacted water bodies, to see what's working and what isn't working. Learn from the tours, build relationships, get inspired to act
- Pilot projects such as nutrient trading between nonpoint and point source contributors in specific watersheds within the NPM Region to demonstrate the possibilities for working partnerships that can effectively address nutrient issues
- Establish a user-friendly, online regional nutrient information clearinghouse that provides tools, literature, educational opportunities and links on nutrient success stories
- Choose five exemplary stakeholder/agency cooperation examples and honor them-use this for a press release to get the word out about these stories
- Encourage stakeholder groups to foster communication with other regions to find out what they are doing that could be useful in the NPM Region
- Establish a Speaker's Bureau with a Power Point presentation available for workshop participants to use for approved presentations to targeted groups

The EPA has outwardly expressed a desire to see individual states establish actual nutrient criteria for their waters. The EPA recognizes that it is difficult, from a credible data perspective and speculation of BMP effectiveness, to impose nutrient limits based on

Center pivot irrigation.
Photo by Louis B. Moore

TMDLs. However, the EPA has expressed that if their offices were to see that the TMDL approach was being effective in achieving nutrient management, the EPA would likely give the states a lot of latitude in TMDL development and nutrient management. However, one of the biggest challenges is quantifying or prioritizing the effectiveness of BMPs. The EPA has been doing a lot of internal discussion and collaboration about the outcomes of the conference, with a focus on approaches to assessing BMP effectiveness.

With regard to the BMP effectiveness issue, CSU water quality leaders are initiating a newly funded 319 project focused on answering many of the questions about agricultural BMPs effectiveness. The end goal of the 319 project is the development of a Web-based tool that can be used to facilitate the selection of BMPs to address nutrient pollution from agriculture.

Water quality specialists in Utah have also undertaken a state-wide evaluation of the state's NPS program and effectiveness of approximately 30 BMPs for achieving nutrient control. The intended outcome will be a publicly accessible document with recommendations of developing lessons learned.

Natural resource management agencies in North Dakota have organized a state water quality monitoring program council, which brings together all the partners in the state doing surface water quality work, to engage in more coordination and open dialogue regarding nutrient management. Additionally, the Department of Agriculture has become active in engaging EPA to see and learn firsthand what is being done to improve water quality in North Dakota.

The Montana DEQ has directed a lot of resources into standards development and placement of those standards on critical water bodies in the state. Additionally, the Montana DEQ is working on developing some degree of variances in addressing nutrients standards being put in place.

Impacts

Nearly 100 percent of those completing a post-workshop evaluation agreed or strongly agreed with the statement, "I believe the workshop brought emphasis to the need for improved interagency communication, collaboration and data sharing on the issues of nutrient management." Ninety percent are more knowledgeable about the challenges associated with nutrient controls and the network of people working on nutrient related issues. The same high percentage said they better understood other stakeholder perspectives and the importance of stakeholder involvement in the nutrient control development process. Eighty percent said they gained tools and information to improve how they approach nutrient issues.

Leveraging and Partnerships

This workshop was sponsored by the USDA-NIFA NPM Regional Water Program, CWI, Utah Water Research Laboratory and EPA Region 8. Funding for the project was provided by EPA Region 8 and the NPM Regional Water Program. CWI provided leadership in organizing and coordinating the conference and the NPM Regional Water Team supported the program planning, communication with speakers and attendees, and conference execution.

The full report and other post-workshop materials are available online at http://www.cwi.colostate.edu/Workshops/Region8Nutrient/

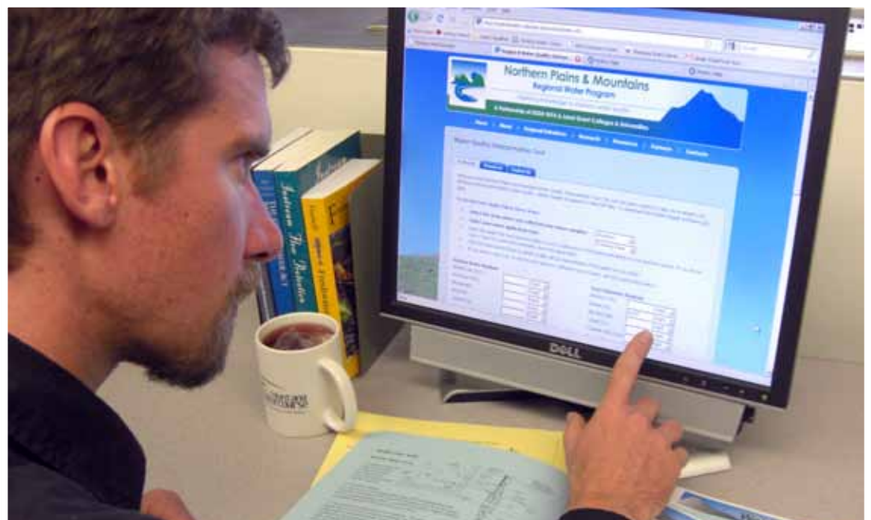
Montana sunset. *Photo by Scott Robinson*

Protecting Water Quality in the Northern Plains and Mountains Region

Since private wells and septic systems are typically not regulated after installation, it is the homeowner's responsibility to ensure their maintenance and safety. Failure to maintain either a private well or septic system can result in groundwater degradation and human health risks. The Northern Plains and Mountains (NPM) Regional Water Team has developed outreach programs like Well Educated to help teach the public about these responsibilities (http://region8water.colostate.edu/drinking_water.shtml). Well Educated seeks to enlighten private well water users about their drinking water supplies and how their household water use connects to their on-site septic system. The program also helps well owners gain confidence to take action to assure that their water supplies are safe for the whole family.

The impetus for the Well Educated program came from state water quality management and regulatory agencies, county environmental health offices, well and septic system industry advocacy groups, and the EPA stating a need for private well and septic owner education to protect public health and water resources. The initial effort of Well Educated, spearheaded by MSU, was to work with private water quality testing laboratories, county Extension offices, and county public health offices in Montana to offer rural well owners a low-cost, readily available opportunity to have domestic water supplies tested, have results of tests interpreted by a university water quality specialist, and receive objective, unbiased treatment and alternative water source recommendations when test results indicated a need for changes. Once MSU introduced the Well Educated program to its regional partners, a regional vision of the program was realized. The NPM Regional Water Team first inventoried existing well and septic owner education resources and identified information and materials gaps that needed attention to make the program complete. From there, the team assembled an educational package and program for rural well owners, supported by a comprehensive website of well and septic education information.

More than 6,000 well owners in Montana, Colorado, North Dakota, Utah, and Wyoming have actively participated in the Well Educated program to date.



The online Water Quality Interpretive Tool provides homeowners with quick, easy and accurate interpretations of their drinking, livestock, and irrigation water quality.
Courtesy of Adam Sigler, Montana State University Extension

Well Educated

Understanding Your Test Results

Example Test Result

LABORATORY ANALYTICAL REPORT

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
INORGANICS							
Alkalinity, Total as CaCO3	254	mg/L		1		A2320 B	03/21/06 17:40 / qed
Chloride	27	mg/L		1		E300.0	03/22/06 19:13 / qed
Sulfate	318	mg/L		1		E300.0	03/22/06 19:13 / qed
Fluoride	1.0	mg/L		0.1		E300.0	03/22/06 19:13 / qed
Nitrogen, Nitrate+Nitrite as N	0.24	mg/L		0.05		E300.0	03/22/06 19:13 / qed

The following interpretation is based on public drinking water system standards. These standards only apply to public water systems but the health implications are the same for private well water users.

Definitions:
ND stands for no detection meaning the parameter was not detected in the sample
ppm (parts per million) is often used interchangeably with **mg/L** (milligrams per liter)
RL (reporting limit) is basically the smallest concentration a test can detect
MCL (maximum contaminant level) is a US EPA drinking water standard

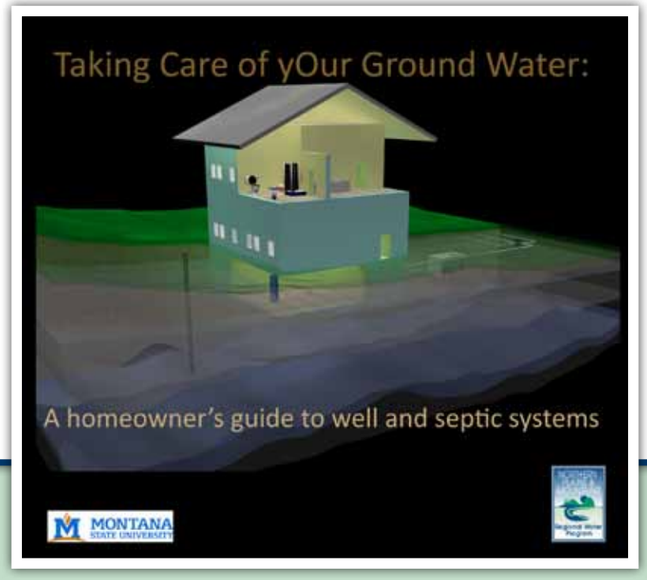
Parameter Name	Possible Results	Quick Interp.	Warnings and Suggestions
Alkalinity (Total as $CaCO_3$) The ability of water to compensate for changes in pH. Higher alkalinity means water is less likely to experience big changes in acidity.	ND or less than 100 (mg/L)	Corrosion Potential	As alkalinity decreases below 100, if pH is lower than 6.5 there is increased potential for corrosion of pipes releasing metals into the water.
	100 to 200 (mg/L)	Satisfactory	Sufficient buffer potential to resist changes in pH and generally not significant scaling in pipes.
	200 or more (mg/L)	Scaling Potential	Possible scaling in pipes and water heaters.
Aluminum A naturally occuring metal generally found in concentrations from 0.014 to 0.290 mg/L in ground water. The EPA secondary standard for aluminum is 0.050 to 0.2 mg/L because high concentrations can cause coloring of water.	ND or less than 0.05 (mg/L)	Satisfactory	No action necessary.
	0.05 or more (mg/L)	Objectionable	Standard based on aesthetics not health; if water discoloration is troublesome, consider treatment.
Antimony Antimony is not commonly found in nature; sources of contamination include petroleum refinery discharge, fire retardants, ceramics, electronics and solder.	ND or less than 0.006 (mg/L)	Satisfactory	Result generally shouldn't change dramatically through time, consider retesting next year if result is 0.005 or more.
	0.006 or more (mg/L)	Unsatisfactory	Health risk exists; consider water treatment and/or alternative sources; see fact sheet for more information
Arsenic Groundwater contamination can happen from mining, pesticides and wood preservatives; contamination can also occur naturally.	ND	Satisfactory	Retesting not necessary unless a change is suspected.
	0 to 0.010 (mg/L)	Satisfactory	Ideally, drinking water should contain no detectable arsenic; consider retesting next year if result is 0.008 or more.
	0.010 or more (mg/L)	Unsatisfactory	Health risk exists; consider water treatment and/or alternative sources; see fact sheet for more information.

Actions and Outcomes

Anyone accessing the website will find a series of videos to educate homeowners about their well and septic systems, well and septic record keeping folders, and an online Water Quality Interpretation Tool (http://region8water.colostate.edu/drinking_water.shtml) which provides homeowners with interpretations of test results, immediate feedback about the suitability of water for drinking, livestock, or irrigation use, acceptable water quality standards, recommendations for action, and links to additional resources about water quality standards. The tool has had over 2,700 users, with the majority of searches for information relating to either drinking or irrigation water quality.

The DVD, Taking Care of yOur Ground Water, educates homeowners about caring for their well and septic systems to assure protection of drinking water resources. The video, produced by MSU and CSU partners with assistance from the MSU School of Art and Architecture and the Colorado School of Mines and Geology, is available on the Web, and over 5000 hard copies have been distributed. Taking Care of yOur Ground Water addresses well head protection, septic system function, testing and interpreting water quality results, chlorinating a water system, and buying or building a new house with a private water system. The video series focuses on how well and septic systems are connected to the water cycle and what homeowners can do to help protect water resources. The videos contained on the DVD have been presented at water system professional meetings in Colorado, Montana, North Dakota, and Utah.

Generally, the first point of contact and introduction to the Well Educated program is through county Extension offices, local volunteer facilitators, state Extension networks, county environmental health offices, and water quality districts. North Dakota water quality specialists have used the Well Educated materials, especially the interpretation tool and well and septic system folders, to support water quality screening programs at local field days, where more than 250 well water samples have been tested. Following the 2011 floods in parts of North Dakota, about 200 each of the well and septic folders were distributed to private well/septic owners impacted by flooding. In addition, the materials have been distributed at livestock producer and Extension agent training programs. In Montana, the Crow environmental health office and students and faculty of Little Bighorn Tribal College have helped advance the opportunities of the Well Educated program on tribal lands, while faculty and water quality specialists at CSU-Pueblo (a Hispanic Serving Institution) have introduced the Well Educated program to rural families in southern Colorado. To further advance the introduction of the Well Educated program in the region's Spanish-speaking communities, the materials are currently being translated into Spanish. Through these points of contact, the Well Educated materials have reached thousands of homeowners across the NPM Region. Once discovered by privately run water quality testing laboratories within the region, even the labs began using the Web-accessible resources and directing clients to the regional website.



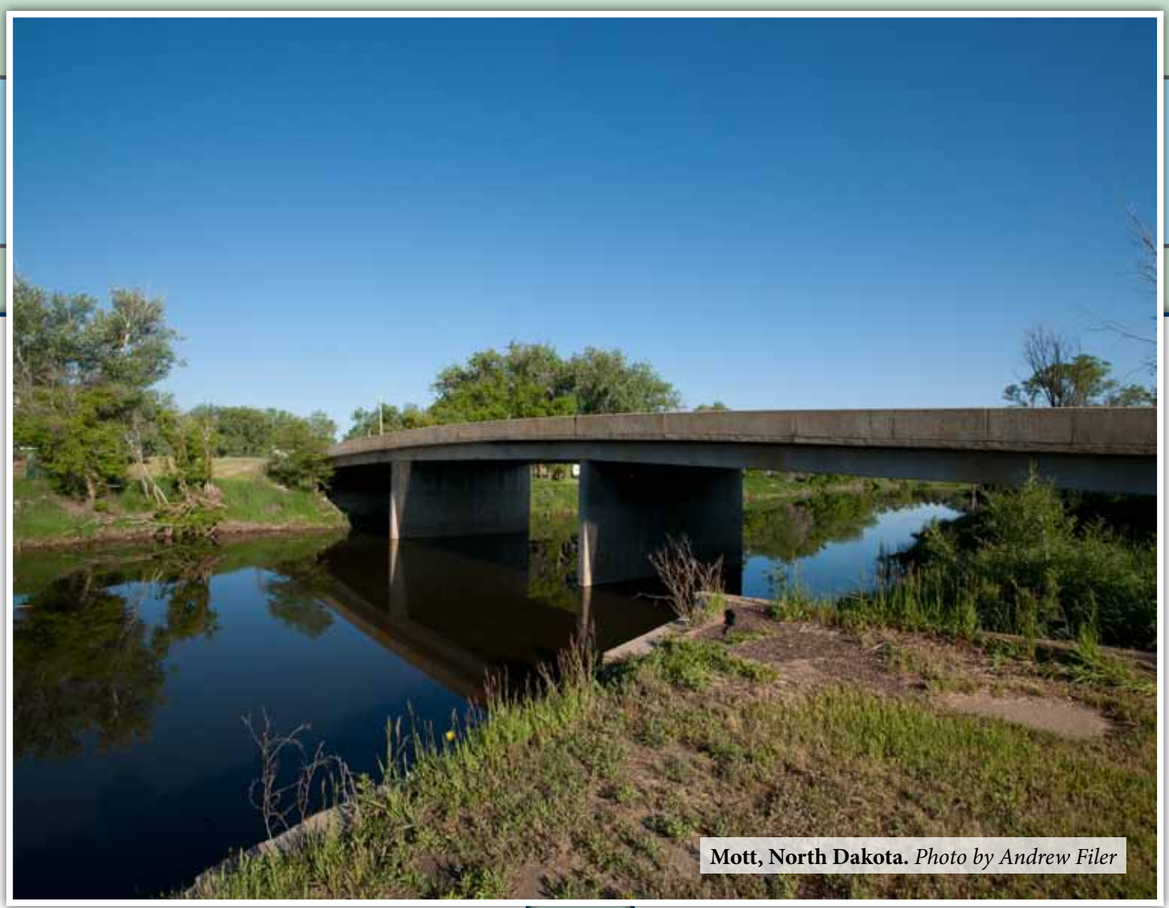
Taking Care of yOur Ground Water DVD.

Adam Sigler (Montana State University) demonstrates the process of shock chlorinating a well for the "Taking Care of yOur Ground Water" DVD. *Courtesy of Suzanna Carrithers Soileau, formerly Montana State University; currently USGS-Bozeman, Montana*

Impacts

- Participants in the program and individuals accessing the Well Educated materials through the website report with confidence that they are identifying and addressing problems with their water systems, maintaining their septic systems more regularly, and testing their water quality more frequently
- Ninety-three percent of individuals participating in the program and responding to a post-program survey indicated that they felt confident in sharing what they learned about private well testing and maintenance with their neighbors

- Sixteen and a half percent of participants had well water that tested with the level of some parameter greater than a drinking water standard; 30 percent of this group initiated treatment, 30 percent either retested or plan to retest within year, and the remaining 40 percent took no action
- Individuals participating in Well Educated workshops nearly unanimously reported that they would use the folders to keep septic system records in the future, that the information in the folders increased their knowledge of their own septic systems, and that the folders would provide a means for individual septic system users to keep better records in the future
- In the San Luis Valley of Colorado, the NPM Team partnered with the San Luis Valley Ecosystem Council (SLVEC) to provide educational materials for a campaign that tested 300 wells and held a series of public meetings. The videos and online Water Quality Interpretive Tool provided critical support for an Environmental Justice Grant that SLVEC received to address well water quality issues in the San Luis Valley, particularly among the minority population in the area. After participation in the program, 24 percent of participants identified a problem with their water system and, 78 percent of those people said they planned to address the issue. More than 95 percent of participants started a well file and said they were better able to monitor and maintain their wells and would retest in the future.



Mott, North Dakota. *Photo by Andrew Filer*

- Ninety-seven percent of water system professionals surveyed after viewing Taking Care of yOur Ground Water said they would use it as an educational tool
- County environmental health offices across the region are linking to Taking Care of yOur Ground Water from their websites, and the County of Jefferson, Colorado purchased copies of the DVD for distribution with every new septic permit
- North Dakota water quality specialists have used the DVDs as part of a realtor training/education program plan, and also provided copies of the DVD to all county Extension and conservation district offices, along with post-viewing surveys
- Eighty-two percent of homeowners returning surveys after watching the DVD agreed that the film increased their knowledge of their water system, and 27 percent said they identified a problem with their well or septic system that they intended to address after watching the film

Leveraging and Partnerships

These projects have brought together water quality coordinators and team support members from the NPM Regional Water Program, Montana Department of Environmental Quality, Colorado School of Mines, and MSU School of Film & Photography. The Taking Care of yOur Ground Water DVD was sponsored in part by NPM Regional Water Program, EPA, Montana's Department of Environmental Quality 319 Program, and the Colorado Department of Agriculture. Additionally, state water quality coordinators from outside the NPM Region have played a valuable role in materials evaluation, critical review, support with identification of key issues and development of working partnerships. This project has been able to reach out to a wide audience beyond private well and septic system users, including Extension faculty, agricultural producers, irrigation managers, NRCS technical field staff, technical service providers, tribal college faculty, tribal communities, Certified Crop Advisers, federal and state agency partners, Bureau of Reclamation National Irrigation Water Quality Program coordinators, watershed groups, local and state conservation and irrigation districts, recreation organizations, college students, K-12 students and teachers, policy makers, and realtors.

Visit http://region8water.colostate.edu/drinking_water.shtml to view Well Educated materials and other drinking water resources. The interactive Water Quality Interpretation Tool can be found online at http://region8water.colostate.edu/wqtool/index.cfm

North Dakota Petroleum Product SPCC Program

Not until November of 2011 was much attention or focus given to EPA requirements for Spill Prevention, Control, and Countermeasure (SPCC)—that was when farmers with operations meeting a specific set of circumstances with respect to petroleum fuels and their relation to impacting surface water quality needed to have completed SPCC Plans on file. The regulation calls for a written plan of how farmers would protect nearby navigable waters from a petroleum product spill on their farm. Other sections call for secondary containment of fuel tanks and inspections of the tanks. SPCC applies to farms that store, transfer, use, or consume oil or oil products, such as diesel fuel, gasoline, lube oil, hydraulic oil, adjuvant oil, crop oil, vegetable oil, or animal fat, and store more than 1,320 U.S. gallons in aboveground storage tanks (ASTs) or more than 42,000 U.S. gallons in completely buried containers, and could reasonably be expected to discharge oil to waters of the U.S. or adjoining shorelines, such as interstate waters and intrastate lakes, rivers, and streams. On Oct. 18, 2011, the U.S. EPA amended the date by which farms must prepare or amend and implement their SPCC Plans to May 10, 2013 (http://www.epa.gov/oem/docs/oil/spcc/spccfarms.pdf).

Since 1973, the U.S. EPA has used the SPCC plans as a cornerstone of its strategy to prevent oil spills, including those associated with farming operations, from reaching our nation's waters. Owners and operators of ASTs, which store more than 1,320 gallons of oil, must have and implement an SPCC plan. Unlike oil spill contingency plans that address cleanup measures after a spill has occurred, SPCC plans are preventive measures to assure that a spill from an AST is contained and countermeasures

Fort Clark, North Dakota. *Photo by J. Stephen Conn*

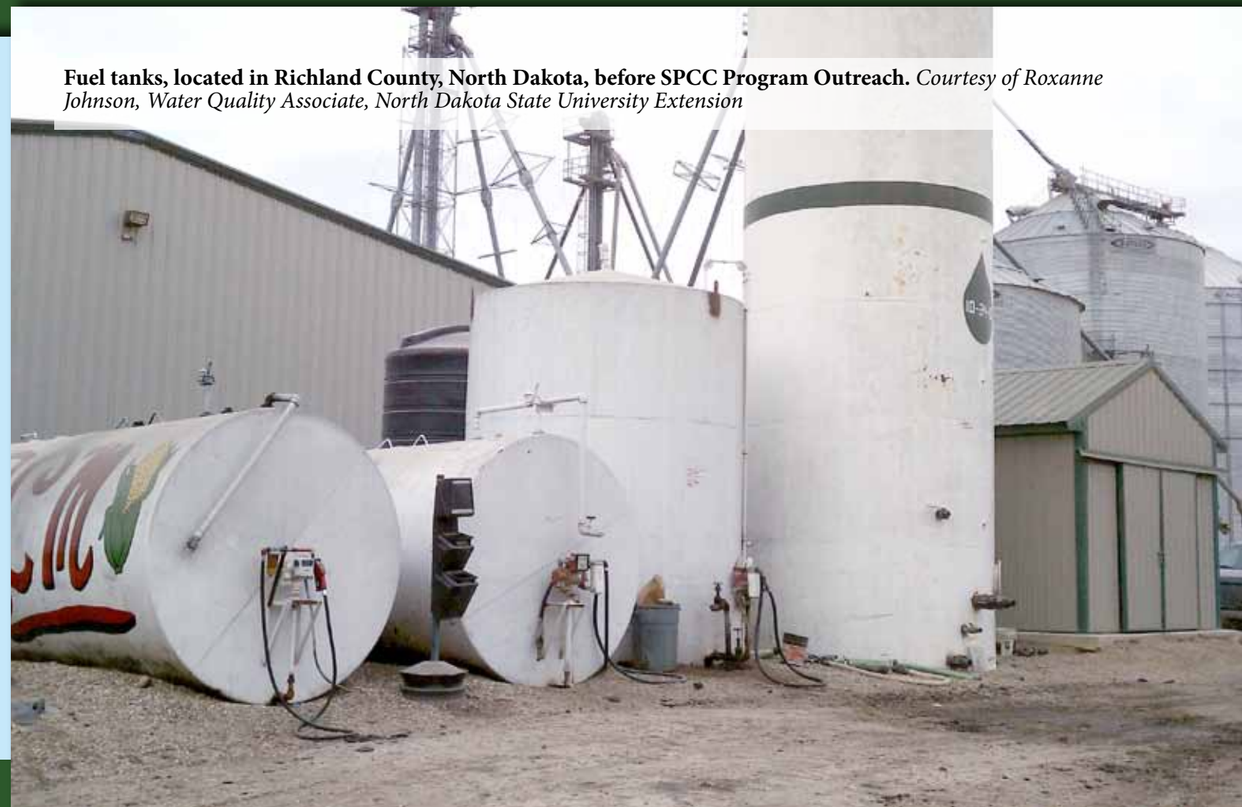
are established to prevent oil spills that could reach navigable waters. A spill contingency plan is required as part of the SPCC plan if a facility is unable to provide secondary containment (e.g. berms surrounding oil storage tanks). Affected farm operations must keep a copy of their SPCC Plan at their facility. The EPA requires that an SPCC plan be available for on-site review and inspection during normal working hours.

Not only was the topic of SPCC unfamiliar to most Extension water quality coordinators in the NPM Region, but conservation districts, individual farmers, farm organizations, and some state and federal natural resource management agencies also found the topic unfamiliar. The SPCC Program is maintained within the EPA regional offices and can't be delegated to state regulatory agencies (http://www.spccplan.com/).

Farmers' concern quickly created a need for the North Dakota SPCC Project, a NIFA-funded project, which subsequently provided valuable resources for the other partners of the NPM Regional Water Team. The overall objective of the project was to enable farmers and agricultural producers to develop written SPCC plans and implement measures on the ground to reduce the possibility of oil and fuel spills into surface waters.

The North Dakota State University (NDSU) water quality coordinators set out to develop a user-friendly, objective outreach education program about SPCC, with the goal of providing the information and guidance necessary to increase the number of farmers and agricultural producers in compliance with the SPCC regulations, thereby resulting in fewer oil spills which might reach navigable waters in the region. Farmers and agricultural producers engaging in the outreach program and the resources available on the topic of SPCC would gain a better understanding of the EPA regulation and how it affects them. In addition, farmers and agricultural producers would:

- Be more aware of the regulation
- Know where to find information on completing the forms necessary to complete a SPCC Plan



Fuel tanks, located in Richland County, North Dakota, before SPCC Program Outreach. *Courtesy of Roxanne Johnson, Water Quality Associate, North Dakota State University Extension*

- Have a source of information to find professional engineers and tank inspectors
- Have access to examples of plans to refer to when developing their own plans
- Know how to apply for financial assistance through NRCS to help agricultural producers comply with revised regulations by EPA

Actions and Outcomes

Materials developed include a fact sheet describing the regulation and whom it pertains to, a PowerPoint presentation for use by Extension agents and state specialists to explain the regulation and how it affects farmers and ranchers, a document to help producers size their secondary containment area, and an example of a Tier I plan. The program continues today with updates to NDSU Extension agents and the public as the regulation is modified.

Impacts

As a result of the presentations and personal visits, farmers and agricultural producers said that they would be making some changes on their farms:

- Producers with oil storage on their farms expressed more confidence in their ability to comply with the regulation
- They noted that they understood that a common sense approach to stop oil from reaching navigable waters was manageable, and how they could accomplish this in a cost-efficient manner
- They verbally responded that having a list of professional engineers and tank inspectors was very helpful, and that the completed Tier I template made the process much easier for them to move forward

Extension's role was to make the public aware of the regulation—not to be a regulator. Based on the number of requests for the program and the attendance at the meetings, it was apparent that the need was there, and Extension gave the audience an unbiased educational program. Further evidence of outreach impacts included the response for financial assistance provided through the NRCS (over 1600 applicants). When farmers and agricultural producers participating in outreach efforts were asked about preparing SPCC Plans, 85 percent believed that it was difficult in determining what tier their operation qualified under, and at the conclusion of the training only five percent still were unclear.

Today, producers are not afraid to approach NDSU Extension personnel to talk about their farm fuel storage situation. Program information developed by NDSU Extension personnel has been requested by many universities, recognized by regional and national EPA offices, and cited by many farm organizations. In addition, the North Dakota SPCC Program was recognized as a Program of Excellence at the NDSU Extension Conference in the fall of 2011.

Leveraging and Partnerships

Partnerships and collaboration were essential to the success of the program, including EPA Region 8 personnel out of Denver and agencies including North Dakota Stockman's Association, North Dakota Grain Growers, North Dakota Department of Ag, North Dakota Association of Conservation Districts, NDSU Extension, and the North Dakota State Conservation Committee. Regional EPA inspectors were also made available to the public at two NDSU Research Center field days. The NRCS, private engineering firms, and tank inspectors helped develop lists of qualified specialists to assist farmers in writing their plan, building secondary containment, and inspecting their tanks. All of this information was made publicly available through the NDSU Extension water quality Web page (http://www.ag.ndsu.edu/waterquality/spcc-1).

NDSU Extension agents have used the PowerPoint presentation and fact sheets to deliver the information to over 1,500 individuals throughout North Dakota. Extension specialists have delivered over 40 presentations to audiences numbering over 1,200. Close to one thousand attendees visited the NDSU Extension booths at the 2010 Big Iron event at the Red River Fairgrounds to visit with specialists on the SPCC regulation. Radio, television, and newspapers extended the information through interviews with Extension personnel.

Visit http://www.ag.ndsu.edu/waterquality/spcc-1 to access NDSU's SPCC resources and materials.

"The presentation took the 'fear factor' out. Now maybe I can do this knowing that I can develop a plan that makes sense on my farm."

- SPCC Program participant

Fuel tanks, located in Richland County, North Dakota, after SPCC Program Outreach. *Courtesy of Roxanne Johnson, Water Quality Associate, North Dakota State University Extension*

Agricultural Water Conservation and Protection in the Northern Plains and Mountains Region

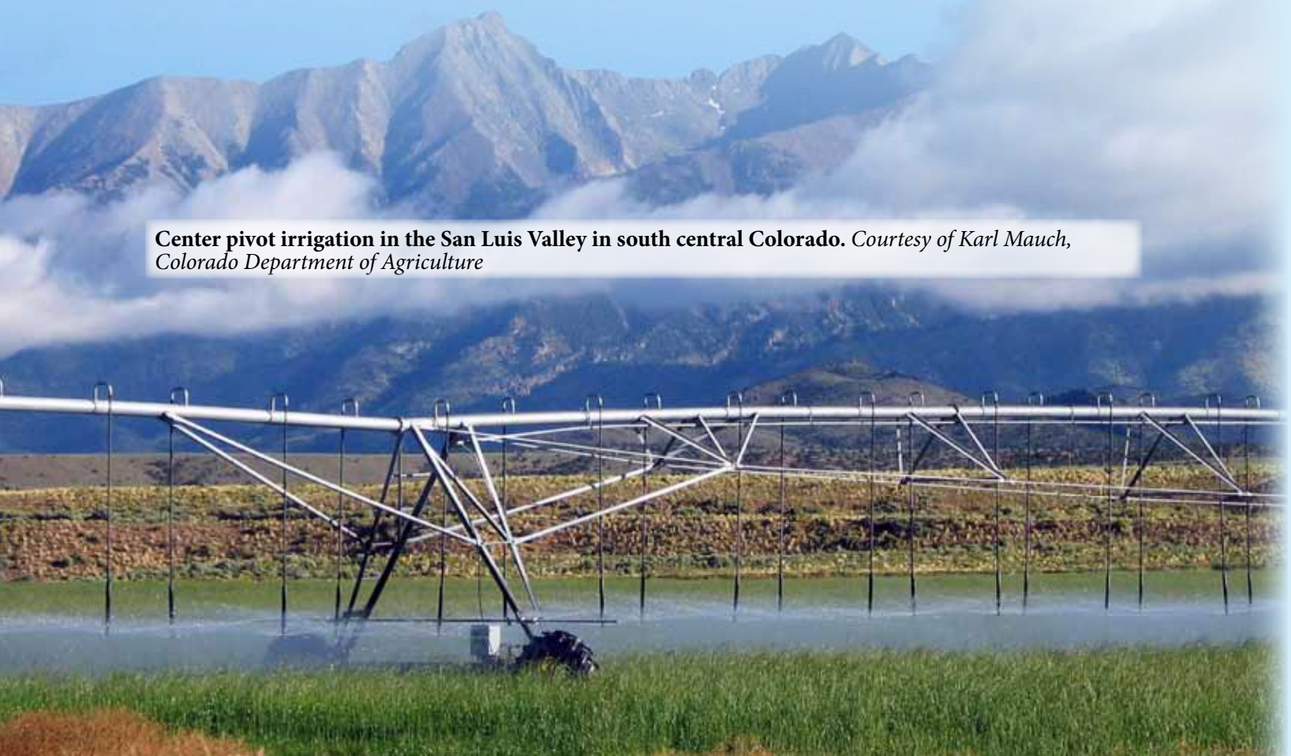
Population shifts, growth, and climate variability are putting increasing pressures on limited water resources; consequently, extensive collaboration is needed to develop long-term working solutions to the complex issue of water resource supply management. A key player in this complex issue is agriculture, which consumes an estimated 80 percent of available water in the western U.S. Given that available water supplies are not likely to increase, and existing supplies may shift in their distribution with continuing changes in climate, future water needs for an expanding urban population will likely come from agriculture. In turn, reduced water resources in agriculture will add to the challenge of meeting a growing global demand for agricultural outputs. Therefore, it is increasingly urgent for farmers, water managers, Extension agents, educators, and policy-makers to understand agricultural water conservation methodology, technology, and policy necessary to make informed management decisions.

In response to the need for resources and tools that provide increased knowledge, understanding, and adoption of agricultural water conservation and protection, the USDA-NIFA Northern Plains and Mountains (NPM) Regional Water Team has developed the Agricultural Water Conservation Clearinghouse (AWCC) (http://www.agwaterconservation.colostate.edu/) and a series of online, self-study modules for the American Society of Agronomy (ASA) Certified Crop Adviser (CCA) recertification and proficiency program.

Actions and Outcomes

The Agricultural Water Conservation Clearinghouse Project

The AWCC is an innovative Web-based project that seeks to bring together science-based, objective information, educational resources, and tools, while at the same time joining together communities of practice to collaboratively address the complex issues



Center pivot irrigation in the San Luis Valley in south central Colorado. *Courtesy of Karl Mauch, Colorado Department of Agriculture*

The Agricultural Water Conservation Clearinghouse - http://agwaterconservation.colostate.edu/

of agricultural water use and conservation. The focal point of the AWCC is a comprehensive library that identifies materials on all aspects of agricultural water conservation from sources including refereed journal articles, books, reports, theses, dissertations, and conference proceedings. Often this information is not readily available to water users, especially outside of the academic and government communities, which makes the AWCC a valuable resource. Assembling the library has required an ongoing effort to research and compile over 5,600 bibliographic records addressing agricultural water policy and economics, irrigation management and systems, water supply and storage, recovery and recycling, and drought tolerance.

The AWCC website provides links and contact information to federal and state Agricultural Experiment Stations and land-grant universities, as well as up-to-date information on agricultural water related research centers, irrigation management curricula, workshops, conferences, irrigation tools, software, manuals, guides, calculators, and irrigation schedulers. It features upcoming events and news related to agricultural water conservation at regional and national scales. The AWCC currently performs the following functions:

- Creates a venue for sharing information regarding agricultural water conservation and increases access to new technologies and best management practices

Irrigating with Limited Water Supplies

A PRACTICAL GUIDE TO CHOOSING CROPS WELL-SUITED TO LIMITED IRRIGATION

Colorado State University
CSU Water Center
Fort Collins, CO

Utah State University
Extension Irrigation
Program–Logan, UT

Northern Plains &
Mountains Regional
Water Program

MONTANA STATE UNIVERSITY | EXTENSION

Extension Water Quality Program • Bozeman

- Provides targeted audiences current information about pressing and complex agricultural water conservation and security challenges, helping them to make more informed decisions and to accurately communicate information about agricultural water use and conservation
- Identifies gaps in current research, education, and outreach related to agricultural water conservation, thereby helping U.S. federal, state, and local natural resource management and policy-making agencies to better target programs to improve water and food security
- Links industry with related research, educators to scientists, and technical experts to resource materials
- Provides students of all levels with access to reliable information on water conservation
- Provides support and assistance to policy makers by linking them to experts and current research, as well as to the USDA-NIFA National and Regional Water Programs
- Provides an online, social media meeting place, where individuals can express ideas, facts, and opinions and where discourse about solutions to agricultural water conservation challenges opens a dialogue between experts, decision makers, and stakeholders

Scan this code with your smartphone or other mobile device for quick and easy access to the AWCC.

Irrigation technology field workshop in Colorado. *Courtesy of Bob Pearson, former water quality associate, Colorado State University Extension*

Irrigation of alfalfa with siphon tubes on Roger Maddox Farm near Swink, CO. *Courtesy of Timothy Gates, Colorado State University*

Online Certified Crop Adviser Study Modules:

The NPM Regional Water Team has also focused on increasing the knowledge level of private consultants, certified professional agronomists and soil scientists, and agency personnel that influence decision making by growers in the NPM Region and around the U.S. To accomplish this, CSU and MSU water quality specialists authored and published a series of online, self-study modules for the ASA-CCA Recertification and Proficiency Program (https://www.certifiedcropadviser.org/certifications/self-study). Using a pilot survey of CCA Boards in the NPM Region and Canada, the NPM Regional Water Team focused the modules on water conservation under limited irrigation and irrigation water quality. The self-study modules and accompanying proficiency tests were developed through collaboration with research scientists, university faculty from throughout the region, from neighboring regions, and from Canada. Selected module titles include:

- Guide to Choosing Crops Well-Suited to Limited Irrigation
- Principles and Practices for Irrigation Management with Limited Water
- Assessing the Suitability of Water (Quality) for Irrigation - Salinity and Sodium
- Limited Irrigation of Alfalfa in the Great Plains and Intermountain West

Irrigation diversion structure along the Uncompahgre River, Colorado. *Courtesy of Reagan Waskom, Director, Colorado Water Institute*

Impacts

With regard to AWCC, over 5,600 bibliographic records have been added to the AWCC, including several grey literature documents through a partnership with the Colorado Water Institute (CWI), the Central Plains Irrigation Association (CPIA), and the U.S. Committee on Irrigation and Drainage (USCID). The library has been searched by over 24,000 users since it was unveiled in 2008, and participation continues to grow. The AWCC also launched a Facebook page to engage related communities of practices and is receiving favorable responses from users. http://www.facebook.com/pages/Agricultural-Water-Conservation-Clearinghouse/112871155470347?ref=ts

As for the ASA-CCA program, since the fall of 2009, nearly 600 self-study CEU modules have been completed, in which 551 received a passing score. Over 89 percent of CCAs completing post module surveys indicated that they would utilize knowledge gained from the series while advising their farmer clients.

Leveraging and Partnerships

The NPM Regional Water Team, with leadership from CSU water quality coordinators, and in cooperation with CWI, CSU Libraries, and the Agriculture Network Information Center worked to design the AWCC as a user-friendly, comprehensive resource for the latest news, research, literature, and tools related to agricultural water conservation. Building partnerships has proven to be both critical and very helpful to the success of the AWCC Library. The NPM Regional Water Team has built valuable relationships with the CPIA and the USCID which has greatly increased access to grey literature published through these organizations. Until recently, much of this literature has only been available in hard copy and often was not available from traditional library or Web searches.

The AWCC is available online at
http://www.agwaterconservation.colostate.edu/
and the ASA-CCA Program is available at
https://www.certifiedcropadviser.org/certifications/self-study

South Dakota Urban Lawn Water Use Assessment Project

Urban irrigation water conservation has become an issue in eastern South Dakota, where shallow aquifers, which supply domestic-use water to cities and many small towns, have been slowly depleting, due in large part to growing demands for water and also contamination of existing sources beyond acceptable levels. The goal of the South Dakota Urban Lawn Water Use Project was to engage urban water users in understanding lawn water use and to change their behavior by putting intelligent lawn watering practices into use in order to stem the depletion of those aquifers.

The use of intelligent lawn watering practices means having knowledge and understanding of evapotranspiration (ET), lawn growth and physiology, and nutrient and pesticide management for lawns among homeowners. It also means being able to demonstrate to lawn owners that aesthetically pleasing turf can be achieved while conserving water and saving money on their water bill. In both the short term and long term, accomplishing this would help conserve water for Sioux Falls, reducing the need for both exploring alternative water sources and expanding the city's existing water delivery infrastructure.

Sixty Sioux Falls homeowners with automated in-ground lawn irrigation (watering) systems volunteered to participate in the project, which required the homeowners to follow a specific set of instructions about their lawn watering. The instructions established lawn watering schedules and amounts of water to be applied during each lawn watering, based on various levels of estimated ET demand. After being taught some rudimentary principles of plant water use and ET, some homeowners were instructed to water their lawns as usual—on a traditional time-based irrigation schedule. The "control-treatment" homeowners, using their traditional time-based irrigation control, continued their previous practices. The local standard is to apply an inch of irrigation water per week, and the control-treatment homeowners were asked to continue that practice

Irrigation water collection cup used to monitor the irrigation uniformity. *Courtesy of Todd Trooien, Professor, South Dakota State University*

Turf quality of the lawns included in the study: low (left), medium (center) and high (right). The turf quality did not necessarily track well with irrigation treatment. *Courtesy of Todd Trooien, Professor, South Dakota State University*

although they were allowed to adjust the controller and schedule to keep their turf as green as they chose. The ET-based irrigation treatments were programmed into the controllers. At the start of the project, other homeowners were instructed to water their lawns using a replacement schedule (i.e., to replace either 70 percent of the irrigation requirements or 100 percent of the irrigation requirement), based on calculations of ET using locally available climate data. There is an option in the ETWater controllers to adjust the percent of ET (actually, ET minus rainfall) to replace with irrigation. The original treatments were replacement of 70 percent and 100 percent. After the first year, because there appeared to be potential for water savings, the controllers were changed to replace 50 percent and 70 percent of estimated ET demand.

Impacts

The highest water user in the study was in the control (time-based irrigation control) group, indicating a potential for water savings by that group of homeowners. After the first summer of the project (2009), homeowners were surveyed for their satisfaction regarding the conditions of their lawns/turf. Despite measurable differences in the amount of water used by the homeowners, survey results revealed that all participating homeowners were satisfied with their turf.

Since each homeowner had control of their own irrigation system, nearly half of the homeowners adjusted their controller to override the original treatment target. As would be expected, irrigation amounts were quite variable, even within treatments. Audits of lawn watering uniformity showed that watering uniformity was often below industry-recommended standards. Audit results were provided to the homeowners following the first summer of the program, along with an explanation of the value of improving uniformity to reduce water use. In total, 60 lawn owners were educated about lawn status and lawn water usage, and an additional 10 city officials and eight urban irrigation installer contractors were educated about lawn water savings. The objectives and outcomes from the project were additionally discussed with urban homeowners at the Sioux Falls Lawn and Garden Show in 2009, 2010 and 2011.

Automated weather station used to assess the meteorological conditions on an hour-to-hour basis. *Courtesy of Todd Trooien, Professor, South Dakota State University*

Irrigation uniformity measurement for residential irrigation sprinklers. *Courtesy of Todd Trooien, Professor, South Dakota State University*

Multi-regional BMP Development for Tile Drainage and Saline Waters

Farmers in eastern North and South Dakota and western Minnesota have plenty of evidence of a localized change in weather during the past decade—too much rainfall. The consequence of too much rainfall has become an inability to plant crops in a timely manner. Another problem has been increased soil salinity levels as a result of water tables existing close to the soil surface. Farmers have even reported some fields having water tables come right to the land surface, and early-planted crops being drowned out because of spring rainfall combined with moisture from the previous winter's snowfall. These conditions have caused growing interest and activity in the installation of subsurface (tile) drainage in many agricultural fields that have experienced reduced profitability due to elevated salinity, water logging, and rising water tables.

Northern Plains and Mountains (NPM) Region water quality coordinators in North and South Dakota combined efforts with Great Lakes Region water quality coordinators in Minnesota to organize the Tile Drainage Project to address this issue with concerned farmers, state and local natural resource management agencies, and regulatory agency personnel. The goals of the Tile Drainage Project include:

- Achieve a clearly recognizable increased knowledge of the installation practices and consequences of tile drainage through educating of farmers, drainage contractors, the general public, legislators, and water resource management policy boards
- Help farmers and other interested individuals gain better understanding of the connectivity between subsurface drainage and receiving stream water quality
- Increased understanding of the mechanics and consequences of tile drainage installation and communication of that information to farmers considering or having already installed tile drains

Actions and Outcomes

Water quality coordinators involved in this project initially recognized a need for three critical elements for the Tile Drainage Project to result in measurable and reportable outcomes and impacts:

1. Facts and understanding about tile drainage in the region
2. User-friendly, non-threatening, factual information to provide to farmers, agency personnel, and policy-makers
3. Working partnerships

One outcome of the Tile Drainage Project has been that the North Dakota permitting process for tile drainage has changed over the course of the last five years. Although the North Dakota Century Code, which is the codification of all general and permanent law enacted since statehood, does not specifically identify tile drainage or laws pertaining to tile drainage activity, the State Engineer's Office requires a drainage permit for tile drainage because of potential problems with increased water flow to watercourses. In the past, the same permit application was used for both surface and subsurface drainage. Thus anyone installing tile into a field had to follow surface drainage rules and regulations.

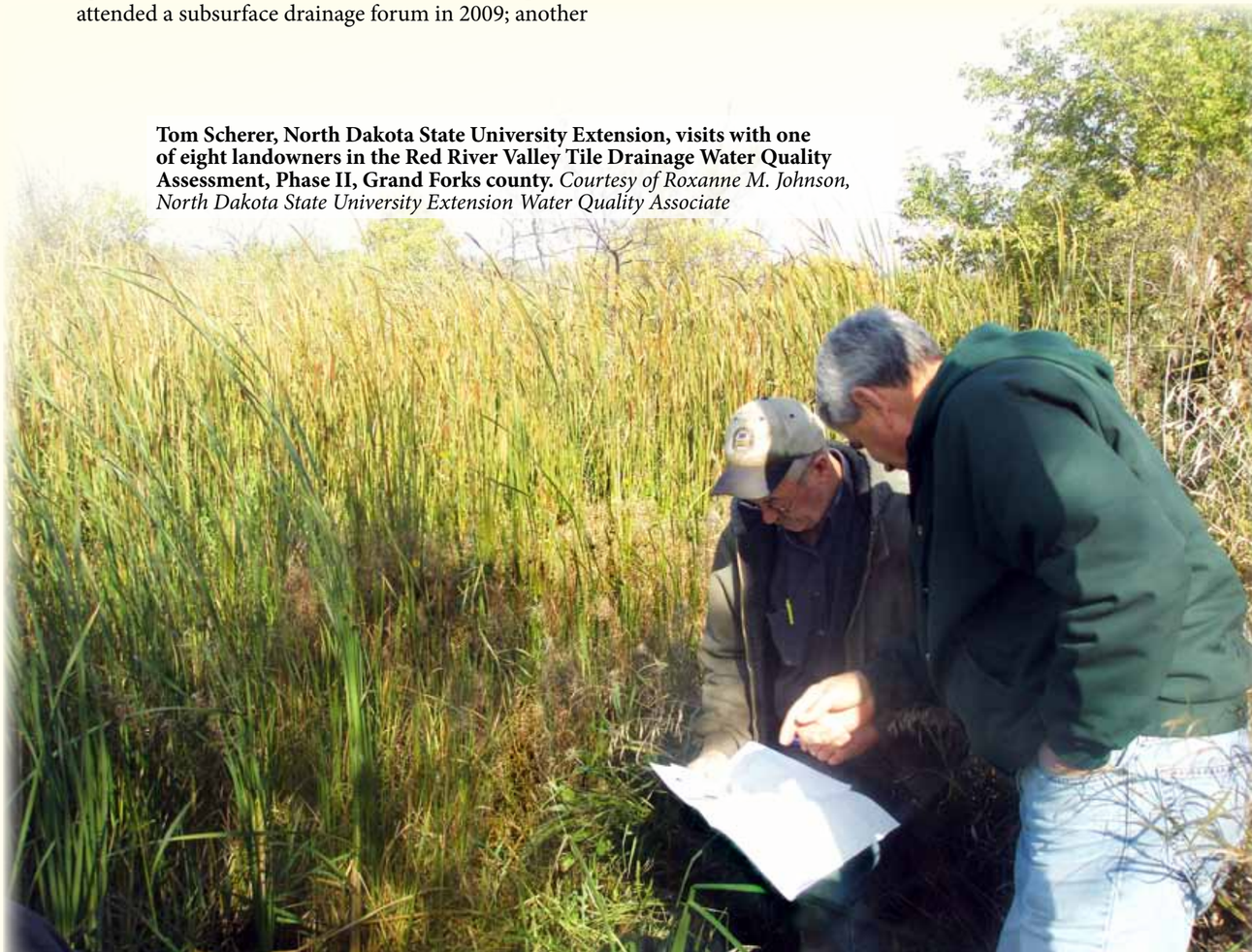
One regulation that created the most problems was the requirement for a permit if a watershed had 80 acres or more contributing to the field or if drainage from a field had statewide significance. Once the State Engineer's Office approved the application, it was sent to the local county water board for their endorsement. This process was very time consuming, with the permit application sitting at the state level, without the benefit of local knowledge or input of the circumstances surrounding the application, for months to over a year. Due to panel discussions at tile drainage forums, the difficulties associated with the permitting process were highlighted and noted by many in attendance. Many water resource board members and legislators attended the tile drainage forums. Thus, in 2011, North Dakota legislators enacted changes to the permitting process. A permit application specifically for tile drainage was developed and is now in use by all water boards in North Dakota. Permit applications now go directly to the county water board and the water board forwards applications with statewide significance to the State Water Commission. The county water board cannot deny a permit unless it is of statewide significance or the proposed drainage will flood or adversely affect downstream landowners within one mile of the proposed subsurface drainage outlet. Landowners within a mile of the proposed outlet are given thirty days to respond to a certified letter asking for their objections or approval of the project. The board can also require flowage easements before approving the application.

The multi-regional team for the Tile Drainage Project recognized from past experience that first-hand experience and farmer-to-farmer interactions are often one of the most effective ways to convey the information that was being developed on tile drainage—methods, permitting, implications, consequences, costs and benefits, and outcomes. These information delivery methods translated into field tours, media releases (http://minnesota.publicradio.org/display/web/2009/07/28/discovery-farms/), public workshops and forums, newspaper articles, and tile drainage design schools for interested farmers (http://www.ag.ndsu.edu/extension-aben). Two hundred people attended a subsurface drainage forum in 2009; another 135 attended in 2010, and 175 more in 2011. NDSU Extension, South Dakota State University (SDSU), and the University of Minnesota (UMN) Extension services organized all events jointly, with faculty from each state giving presentations and participating on panels.

Impacts

More than 40 percent of the individuals attending the forums indicated that to a "great extent" the forums were worth their time. About 85 percent of the attendees rated the presentations as good to excellent. Over 50 percent of the attendees responding to a post program survey indicated that the information presented was usable to them.

In June 2009, a tile drainage field tour was held, and 55 people participated. Several people attending were subsequently interviewed at a tile drainage forum in February of 2010. Overwhelmingly, those interviewed indicated that the tour was extremely useful to them,



Tom Scherer, North Dakota State University Extension, visits with one of eight landowners in the Red River Valley Tile Drainage Water Quality Assessment, Phase II, Grand Forks county. *Courtesy of Roxanne M. Johnson, North Dakota State University Extension Water Quality Associate*

and many of the questions they had about tile drainage were answered during the tour. In addition, a farm with substantial subsurface drainage became one of the three Discovery Farms in North Dakota. As part of a 319 Project, farmer cooperators in eight counties were identified and began participating in water quality monitoring and BMP evaluations in 2010.

Participants of a 2011 design workshop reported that the information was "priceless," "worth $5,000," and "will save me at least $10,000."

In addition to responding to questions about the value of the information about tile drainage they received by attending workshops and forums, some farmers shared opinions. Taken together, the attendees estimated the value of the information gained at the forum, on average, to be $65 per acre (potential impact 100 people attending, each farming an average of 3,115 acres). Also, attendees indicated that there is a need for more information about the impact of tiling on downstream neighbors, tile water quality, and nutrient management and more uniform regulation and policies across county lines. Also, farmers reported that the information would be very useful in helping to decide where to install tile drains, how to install tile drains, and how to assess the consequences of tile drainage installation. When farmers attending design workshops were asked to identify one action they planned to take as a result of the workshop, participants listed the following. "talk to landlords and NRCS," "look at financing for tiling," and "start installing tile."

Leveraging and Partnerships

A multi-state, multi-regional project like the Tile Drainage Project requires leadership, partners, and financial support. Approximately $60,000 in USDA-NIFA program funds served as the foundation for the project development. As of June 2011, EPA 319 non-point source funding to support the project has amounted to nearly $90,000, while the North Dakota State Water Commission, soil conservation districts, and state Extension programs have provided an additional $39,000 to support the project.

The list of partners participating in this project is both long and impressive, representing private landowners, Extension faculty from NDSU, SDSU, and UMN, the North Dakota Department of Health and the State Water Commissioner's Office, and Departments of Agriculture.

Additional information about the NDSU-led tile drainage educational programming effort can be found at http://www.ndsu.edu/waterquality

Tile drainage water sampling training for watershed coordinators in conjunction with the North Dakota Department of Health. *Courtesy of Roxanne M. Johnson, NDSU Extension Water Quality Associate*

Building Capacity of Hispanic Serving Institution Partners

The Northern Plains and Mountains (NPM) Regional Water Team partnered with Colorado State University-Pueblo to enhance and strengthen the capacity of faculty of this Hispanic Serving Institution (HSI) to educate students, the general public, public service providers, educators, and local policy-makers about water quality. Two projects which were modified to fit the needs of students and faculty of CSU-Pueblo and citizens of southeastern Colorado, and which have played valuable roles in capacity building, are the Stream Side Science and the Well Educated projects of the NPM Regional Water Team.

As an HSI, CSU-Pueblo is in a unique position to impact a large number of under-represented groups in southern and southeastern Colorado. Due to lack of funding and faculty with expertise, water quality and resource management have not been as readily available as in other parts in Colorado. However, despite CSU-Pueblo's water research, education, and outreach consortium including only seven faculty and staff members from the chemistry and biology departments, the faculty are actively involved in various studies and outreach education programs focused on water quality in southeastern Colorado. This includes the Fountain Creek drainage system as well as the Lower Arkansas River from Pueblo Reservoir downstream through the agricultural communities in eastern Colorado.

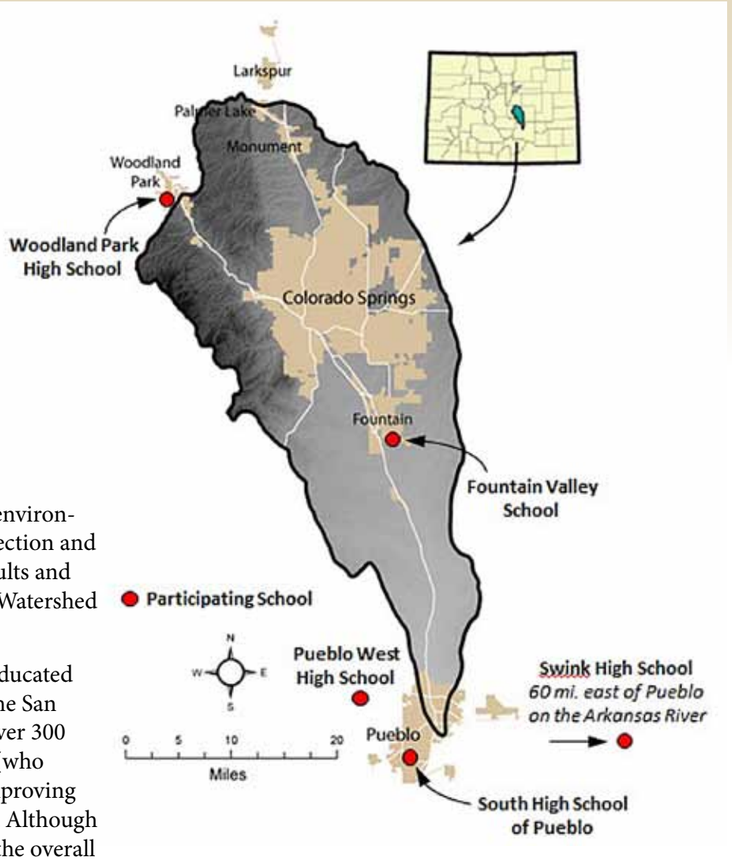
Actions and Outcomes

Faculty of CSU-Pueblo partnered with the water quality coordinator from USU to incorporate the Stream Side Science Teacher's Guide into high-school level science curriculums in southern Colorado. The team enlisted partners in five high schools across four counties along the Fountain Creek and Arkansas River drainage systems to integrate Stream Side Science lessons into the Spring Semester of 2012 high-school curriculum. Preparatory work involved soliciting input from the teachers at partnering schools, as well as the CSU Extension Science, Technology, Engineering, and Math (STEM) regional specialist. Each of the drainage systems being used as part of the curriculum has its confluence near the CSU-Pueblo campus, providing opportunity for students, teachers, and CSU-Pueblo faculty to experience first-hand stream-side learning opportunities of local relevance, while working together. The local high schools range in demographics from entirely rural to predominantly urban. The NPM Regional Program has provided support funds to develop the course as well purchase necessary field and lab equipment. Local reception of a Colorado Stream Side Science Program has been positive. The primary deliverable from this effort will be a Colorado-based curriculum to match the original materials developed by USU.

Impacts

Students and teachers alike stand to gain a great deal from this HSI capacity-building effort. Capacity of teachers to instruct their students about water quality will be strengthened by their participation in the Stream Side Science curriculum. Through this effort, students will gain a better understanding of the hydrologic cycle and its influence on flow patterns, water storage and use, and water quality impairment by using Fountain Creek as a baseline example. In addition, they will gain a better understanding of quantitative assessment of water quality through measurement by recording abiotic water quality factors (pH, dissolved oxygen, turbidity, and temperature).

Ingram Falls near Telluride, Colorado. *Photo by Richard Hurd*



Map of the Fountain Creek Watershed (Colorado) showing the locations of schools participating in the Streamside Science Program. The Fountain Creek drainage system is a 927-square mile watershed that drains south into the Arkansas River at Pueblo. Portions of El Paso, Teller, and Pueblo counties make up the watershed, which encompasses the municipalities of Pueblo, Colorado Springs, Fountain, Manitou Springs, Green Mountain Falls, Woodland Park Palmer Lake, and Monument. *Courtesy of Perry Cabot, Water Resources Specialist, Colorado State University-Pueblo*

Students will also explore diversity in aquatic environments through aquatic macroinvertebrate collection and engage in small "summits" to present their results and findings for the benefit of the Fountain Creek Watershed Flood Control and Greenway District.

In another capacity-building effort, the Well Educated program developed at MSU was deployed in the San Luis Valley of Colorado, beginning in 2009. Over 300 wells were tested, and 97 percent of attendees (who participated in follow-up surveys) reported improving their well monitoring and maintenance ability. Although the sample of wells tested is only a fraction of the overall number in the San Luis Valley region, this work assisted a local partner, the San Luis Valley Ecosystem Council (SLVEC), to receive competitive funding ($93,452) from the EPA under the Community Action for Renewed Environment (CARE) Program. The SLVEC has continued to use Well Educated materials in their programming. Efforts are also underway to promote Well Educated in the rural regions of Pueblo County, including participation by the Movimiento Estudiantil Chicano de Aztlan (MEChA) Organization of Chicano and Latino students.

Post-program surveys of individuals participating in the Well Educated program in the San Luis Valley indicated that:

- Participants came away from the program with an improved understanding of the importance of testing their well water quality at regular intervals
- Participants learned where to send water samples for subsequent analysis at certified laboratories, how to access resources for understanding the meaning of their water quality analyses, and any important actions to take in regards to unacceptable contamination levels
- As an added beneficial outcome, County Health Nursing Staff were able to acquire water-related educational resources to fulfill environmental health mandates

The general impact of these efforts and programs has been the establishment of greater footing, program resources, and visibility pertaining to water-related programming in the under-served area of southeastern Colorado and the Arkansas River Valley. In particular, the Stream Side Science Program has helped assert the value of using water-related programming to accomplish STEM outreach goals and has helped create a valuable partnership between several school districts and the Fountain Creek Watershed Flood Control and Greenway District. The Well Educated Program has assisted a relatively poor area of Colorado with resources to maintain their drinking water quality, in regions outside the purview of municipalities in the Arkansas River Valley.

Building Tribal College Water Quality Education Capacity

Adam Sigler (Montana State University) leading discussion at Tribal Waters Workshop: Effective Monitoring Strategies to Address Impaired Waters, held in Crow Agency, MT. *Courtesy of Katie Kleehammer, Montana State University*

Many underserved communities on Native American reservations face critical water quality impairment issues, specifically including access to safe drinking water. While there is often significant desire, both from within these underserved communities and from outside entities, to address water quality needs, in many cases there is a lack of knowledge among community members about how to characterize and address these issues. Additionally, among 1994 land-grant institutions, a critical mass of faculty and instructors with water quality expertise and experience is often limited.

A needs survey under a 2008 USDA-NIFA national facilitation project, Increasing Tribal Involvement in the Water Quality Network, identified the need for capacity building, including water quality and quantity, invasive plant species, climate change, protection of cultural values, and water science education. In light of the significant Native American population in the region and the outcome of the needs assessment, the Northern Plains and Mountains (NPM) Regional Water Team recognized a need and commitment to work with Native American populations and 1994 land-grant institution faculty.

Actions and Outcomes

Responding to the national needs assessment, MSU partnered with the Salish Kootenai College (SKC) and state water quality program coordinators from throughout the NPM Region to produce a "classroom ready" teaching package to support tribal college faculty in teaching sophomore/junior level water quality courses at tribal colleges. The tribal faculty was then introduced to the teaching package and how to best use the materials in the classroom.

The development of the teaching package was paired with a concurrent undertaking to develop a new water quality course at MSU with resources and reviews contributed by the NPM Regional Water Team and SKC faculty. The package includes collegiate-level, classroom-ready instructional materials for a 25 to 30 minute lecture-format water quality course, introductions to basic hydrology and water law, and the primary parameters used in the characterization of physical, chemical, and biological water quality criteria.

The materials developed include lesson summaries, suggested reading resources, PowerPoint lectures with instructor notes, assignment possibilities, test questions, and two films in a Tribal Waters series.

Subsequently, the materials were utilized and reviewed by 1994 tribal college instructors who modified the materials accordingly to include attention to cultural relevancy and instructor and student background knowledge. Workshops were then arranged to provide the opportunity to review course materials and receive additional insights and mentoring from other water quality educators.

The curriculum materials have been introduced to 1994 tribal college instructors from nine states and plans are being developed to work collaboratively with these instructors to make modifications to the curriculum based on initial teaching and to jointly develop additional curriculum that will support further capacity building among the 1994 tribal institutions. The teaching package was presented to tribal college faculty from

Adam Sigler, Water Quality Associate with Montana State University Extension presents the water quality teaching package at the 2010 Tribal Fellows Institute at Salish Kootenai College in Pablo, Montana. *Courtesy of Katie Kleehammer, Montana State University Extension*

across the U.S. at both the 2009 and 2010 Tribal Fellows Institutes, organized by the National Partnership for Environmental Education (PETE). In August of 2009 at Sitting Bull College in North Dakota, the teaching package was presented to 20 educators from tribal institutions from nine states with representation from 15 institutions. Based on feedback from the 2009 Fellows Institute, incorporation of hands-on teaching exercises into the teaching package was initiated, and a pilot was presented to participants at the 2010 institute.

A uniqueness of teaching water quality at tribal colleges is the importance of educating students about the delicate and often controversial, yet complex, interplay between western U.S. water law and policy and the role of tribal history in evolving water law in the West. The tribal capacity building teaching package does this with the help of a two part Tribal Waters video series, produced by the NPM Regional Water Team, MSU, and SKC. The film explores the historic pursuit of clean water by tribal environmental water programs on three Montana Indian Reservations, the Confederated Salish and Kootenai Tribes, the Northern Cheyenne Tribe, and the Crow Tribe. EPA's Montana Office also actively participated in the development of the film. The Tribal Waters films include a 13-minute film on Indian Water Rights and a 30-minute film on the administration of the Clean Water Act in Indian Country.

> ***"Your water quality teaching packet is excellent! There are not any resources like it! The level of the material is appropriate for the Technical College and beyond. This package could also be used at the AP high school level."***
>
> ***- Scott Heinritz, natural resources instructor at Fox Valley Technical College in Appleton, WI***

Tribal Waters films: An Introduction to Indian Water Rights and The Clean Water Act in Indian Country.

Impacts

Participants of the 2009 Tribal Fellows Institute were surveyed after being lead through the teaching materials:

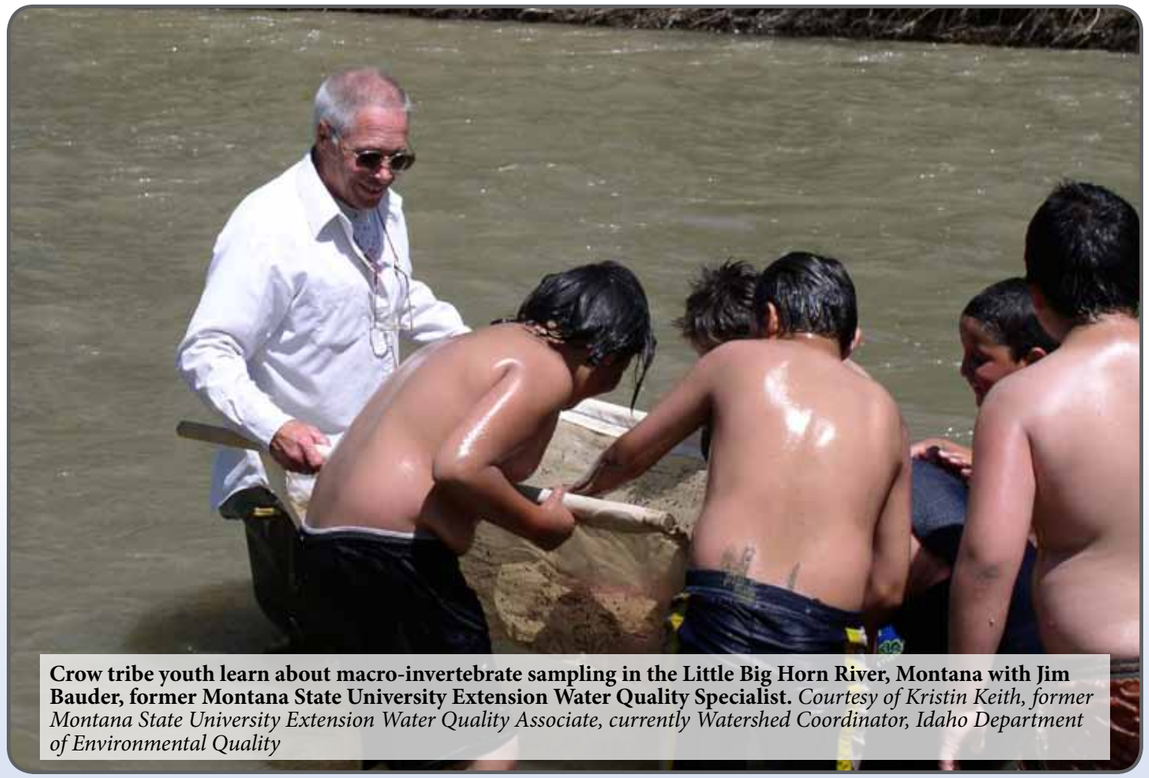
- Ninety-four percent of the institute participants said the teaching package would increase their capacity to teach water quality
- Eight-two percent said they would use the package to teach water quality at their institutions
- Before the Institute, over 70 percent of attendees agreed that lack of teaching materials was an obstacle to teaching a water quality course
- Over 70 percent of attendees agreed that they would use the teaching package to offer a new water quality course or to add water quality aspects to existing environmental science courses
- Sixty-one percent of those surveyed said the teaching package would increase their capacity to teach a water quality course

In addition to the teaching package being used by tribal college faculty from the Fellows Institutes, the materials are also used by instructors at SKC in the first four-year hydrology degree accredited at a tribal college.

As for the Tribal Waters films, 88 percent of tribal college faculty surveyed said that before watching the film, they did not have a good understanding of how the Clean Water Act is administered in Indian Country, while 100 percent of tribal college faculty surveyed said that the video would help to prepare students to explore water quality monitoring and management on their reservations.

> ***"As a relatively new instructor, it was extremely useful to see how an entire class in this area (including background material) was put together, including the PowerPoint presentations. This is absolutely amazing!"***
>
> ***- Instructor at Fellows Institute***

Additional information about the Tribal Capacity Building program can be found at http://waterquality.montana.edu/docs/TribalHome.shtml and http://waterquality.montana.edu/docs/TribalCommunity/TribalVideos.htm



Crow tribe youth learn about macro-invertebrate sampling in the Little Big Horn River, Montana with Jim Bauder, former Montana State University Extension Water Quality Specialist. *Courtesy of Kristin Keith, former Montana State University Extension Water Quality Associate, currently Watershed Coordinator, Idaho Department of Environmental Quality*

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This material is based upon work supported in part by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under Agreement No. 2008-51130-19548. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.