August 2011
Research and Development Office

RECLAMATION
Managing Water in the West

The Knowledge Stream

Contents

Welcome to the inaugural edition of the Research and Development Office's newsletter *The Knowledge Stream*. We are introducing this newsletter to let you know about new projects and developments and to ask for your feedback. This newsletter provides a snapshot of significant happenings around and within Reclamation's research community.

Reclamation's mission to provide water and power to the 17 Western States faces challenges from climate variability and drought, growing population and changing water demands, invasive species, aging infrastructure, and the need to protect threatened ecosystems.

Reclamation's Research and Development Office addresses the technical and scientific challenges that accompany these trends. We accomplish this through a Reclamation-wide, competitive, research and development program focused on innovative solutions for the benefit of Reclamation facility managers and our stakeholders: the Science and Technology Program.

Over the past 7 years, the Research and Development Office has funded 800 research projects that have led to many important tools and solutions. We strive to distribute these results as widely as possible—to our projects, our partners, industry, and the public. This newsletter highlights just a few of our projects. You can also find short descriptions of our ongoing projects at <http://www.usbr.gov/research/docs/S&T_2011_research_abstracts.pdf>. The results of many previous projects are summarized in Western Water and Power Solution Bulletins on our Web site at <http://www.usbr.gov/research/science-and-tech>.

We would like your feedback:

- What would you like to see in this newsletter?
- What water management problems should receive additional research and development?

Please provide feedback to <research@usbr.gov>. Contact any of the researchers noted in these articles or call:

Curt Brown, Director, Research and Development, 303-445-2098
Chuck Hennig, Research Program Coordinator, 303-445-2134
Miguel Rocha, Science and Technology Program Coordinator, 303-445-2841
Kevin Price, Advanced Water Treatment Research Coordinator, 303-445-2066
Levi Brekke, Water and Climate Research Coordinator, 303-445-2494
Samantha Zhang, Technology Transfer Coordinator, 303-445-2126

Zebra and Quagga Mussels

Reclamation Mussel Task Force

The Reclamation Mussel Task Force coordinates the Mussel Detection and Monitoring Program. Contact your regional representatives:

Scott Lund, Pacific Northwest Region, 208-378-5037

Stuart Angerer, Mid-Pacific Region, 916-978-5046

Leonard Willett,Lower Colorado Region, 702-494-2216

Robert Radtke, Upper Colorado Region, 801-524-3719

Stefanie Jordan, Great Plains Region, 406- 247-7744

Denise Hosler, Technical Service Center, 303-445-2195

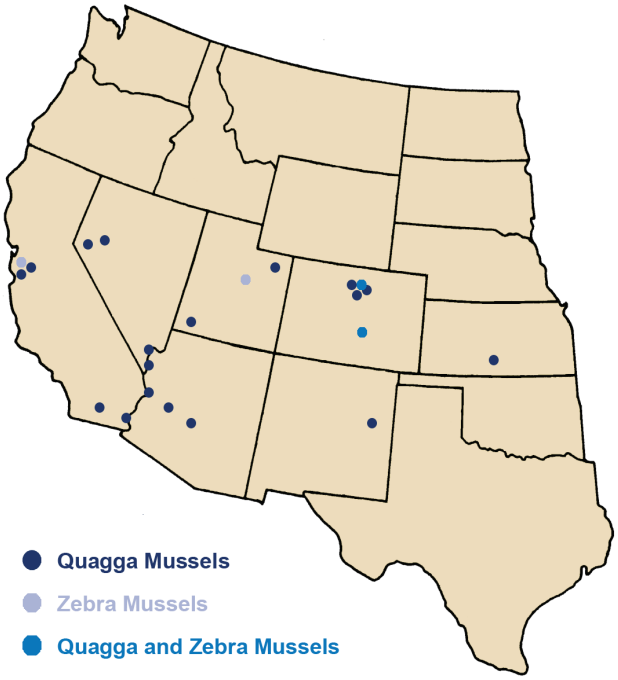
Early Detection for Easier Mitigation

As quagga and zebra mussels from Eurasia spread throughout the Western United States, they impair Reclamation's water storage, water delivery, and hydropower structures and systems; recreational use; and aquatic ecosystems. Once established, they are almost impossible to eradicate. Reclamation is concentrating on proactive measures to help reduce the post-introduction impacts of the mussels to Reclamation facilities and structures, thereby lessening the need to remove mussels or interrupt operations. For more information, visit <http://www.usbr.gov/mussels/>.

To better understand the spread of mussels in the West and to provide the earliest detection possible of any new infestations, Reclamation has undertaken a cooperative detection and monitoring program with states and other partners for the past two years. The program is looking for larvae (veligers), which are 70 - 200 microns in size (about half the size of the period at the end of this sentence). Detecting larvae can provide valuable lead time (up to 3 years) to plan, budget, and implement mitigation and protection measures for water delivery and hydropower facilities before impacts become overwhelming. Technicians, scientists, and field staff monitor Reclamation facilities throughout the West for presence of invasive mussels. Water samples are sent to the Technical Service Center Mussel Lab for testing using cross-polarizng light microscopy, imaging-flow cytometry, scanning electron microscopy, as well as polymerase chain reaction testing for mussel DNA.

For the 2010 season, Reclamation collected and analyzed a total of 3,326 water samples for dreissenid mussels in 347 water bodies. Each water body was sampled in multiple locations on roughly a monthly basis during the warm season.

We had positive findings in seven states and suspects in eight states. We will continue to monitor those waters during the 2011 sampling season.



Positive findings for invasive mussels June 2011

Denise Hosler, Mussel Detection and Monitoring Coordinator, 303-445-2195

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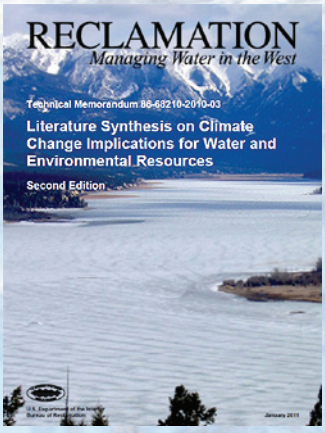
Climate Change and Variability

To download these publications, go to:
usbr.gov/research/climate

Literature Synthesis on Climate Change Implications for Water and Environmental Resources. This report describes what has been studied regarding climate change implications for Reclamation operations and activities in the 17 Western States.



Addressing Climate Change in Long-Term Water Resources Planning and Management: User Needs for Improving Tools and Information. This U.S. Army Corps of Engineers and Reclamation report identifies the needs of local, State, and Federal water management agencies for climate change information and tools to support long-term planning.

Climate Change and Water Resources Management: A Federal Perspective. This interagency report explores strategies to improve water management by tracking, anticipating, and responding to climate change.

New Publications

"Climate change impacts to water and water-dependent resources challenge water management agencies throughout the country," said Reclamation Commissioner Michael Connor. "Close collaboration by water resource managers and scientists will improve the tools and information needed to help make future decisions that support the sustainable use of water." Included within Reclamation's Science and Technology Program is water resources research targeting improved capability for managing water resources under multiple drivers affecting water availability, including climate change.

New Web Sites

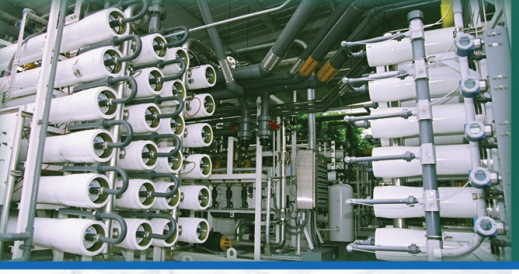
Climate change adaptation research not only improves our ability to understand and define climate change impacts on western water resources, but it also develops a portfolio of tools for adapting water management as the climate changes. To help focus research and technology efforts to provide information and tools needed for climate change adaptation, the Research and Development Office is launching a new Web site at <http://www.usbr.gov/research/climate>. This new Web site explains our research goals and approach, lists research areas and activities, publications, and contacts. Keep checking back for more information!

New Faces

Levi Brekke has moved to the Research and Development Office from the Technical Services Center. For those of you that know Levi, you will understand what a great addition Levi will be to this office. Levi will be providing direction and oversight for the climate change research funded by the Science and Technology Program. This includes working with internal investigators and outside partners to develop research strategy that would address Reclamation needs related to using climate change and variability information in both our short- and long-term planning.

Levi also serves as the Research and Development Office's climate and water liaison to various science organizations, including the U.S. Department of the Interior's Climate Science Centers and National Oceanic and Atmospheric Administration's (NOAA) Regional Integrated Sciences and Assessments (RISA). Prior to joining the Research and Development Office in March 2011, Levi spent 6 years at the Technical Service Center and 2 years in Reclamation's Mid-Pacific Region, focusing on technical coordination and implementation of reservoir systems analyses and hydroclimate studies. Levi's education includes a B.S.E. degree in Civil Engineering (University of Iowa), M.S. degree in Environmental Science and Engineering (Stanford University), and Ph.D. in Water Resources Engineering (University of California Berkeley). Prior to joining Reclamation, Levi spent time in the private sector, working in the areas of wastewater and water treatment engineering.

Levi Brekke, Water and Climate Research Coordinator, 303-445-2494



Advanced Water Treatment

Challenges

Our Advanced Water Treatment research focuses on meeting the National Academy of Sciences' (NAS) challenges for desalination. The NAS found that:

- Water scarcity will intensify in the coming decades
- A strategic research effort can help make desalination a more practical option for communities facing water shortages

The NAS' overarching goals for advanced water treatment research are to:

- Understand the environmental impacts of desalination and develop approaches to minimize these impacts relative to other water supply alternatives
- Develop approaches to lower the financial costs of desalination so that it is an attractive option relative to other alternatives in locations where traditional sources of water are inadequate

At the World's Best Technologies Conference

Three of the Science and Technology Program's Advanced Water Treatment research projects were selected to present at the World's Best Technologies (WBT) Conference. They were among the 100 presenters chosen to make a 6-minute presentation to venture investors and Fortune 500 licensing scouts. The WBT Innovation Marketplace has emerged as the world's largest forum that offers investors a prescreened selection of inventions and intellectual property emanating from top universities, labs, and research institutions. Reclamation was chosen to present the following new technologies.

Chlorine Resistant Polyamide Osmosis Membranes. A high performance membrane that is resistant to chlorine degradation has been long-sought by the desalination industry to simplify and lower the cost of operating desalting plants. Researchers from Reclamation, Separations Systems Technologies, and the University of Denver have collaboratively developed new polyamide membrane chemical formulations (U.S. Patent No. 7,806,275) that potentially can revolutionize the desalination membrane industry. Several of the new polyamide membranes tested indicated a superior degree of chlorine resistance and with transport properties equal to or better than traditional polyamide membranes.

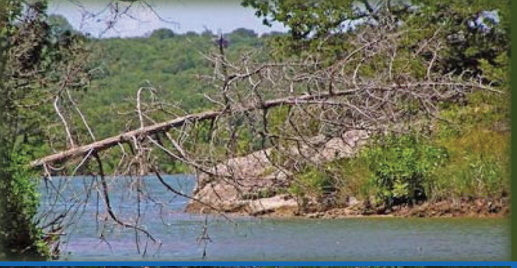
Yuliana Porras, Chemical Engineer, Technical Service Center, 303-445-2265

Forward Osmosis Water Purification. Forward osmosis employs a membrane similar to reverse osmosis, but relys on the natural force of osmosis to drive the separation process. If two solutions are placed on either side of a semi-permeable membrane, water will move toward the side with the higher concentration of solutes. Thus, if a highly concentrated solution of water and fertilizer (the "drawing solution") is placed opposite a volume of seawater (the "feed water"), the natural force of osmosis will pull pure water out of the seawater and through the membrane, resulting in a larger volume of water and fertilizer ("the forward osmosis product"). A similar process can even be used for baby formula. Improvements to forward osmosis membranes and process can significantly reduce capital and energy costs for membrane separation plants.

Chuck Moody, Research Chemical Engineer, Yuma Area Office, 303-445-2258

New Generation Cellulose Acetate Reverse Osmosis Membrane. New cellulose acetate membranes will reduce water treatment costs for water treatment plants. Existing cellulose acetate membranes do not remove as much salt and require higher pressure than other types of membranes. High operating pressures consume more energy, and adequate salt removal can require additional treatment—both of which increase operating costs. In collaboration with Separation Systems Technologies Inc., Reclamation has developed new cellulose acetate membranes that perform better than existing cellulose acetate membranes, removing more salts at lower operating pressures. Reclamation's patent pending membrane manufacturing process (U.S. Patent Application No. 11/746,288) incorporates a solvent processing step that is more effective at removing impurities than previous methods.

Saied Delagah, Chemical Engineer, Technical Service Center, 303-445-2248



Environmental Issues in Water Delivery & Management

Mark Nelson installs a hyporheic sampler on the San Joaquin River. The bottomless bucket keeps gravel out while placing the sampler. Excavated gravel and bed material is placed in the sampler. Mark then places the sampler in the river, where it will stay for two months to create a sample similar to existing conditions. The sample is then extracted and analyzed for sediment sizes, macroinvertebrates, and water quality.

Reclamation and the U.S. Army Corps of Engineers held a Joint Stream Restoration workshop May 17 – 19, 2011, in Sacramento, California, to:

- Foster interagency coordination
- Improve integration of the science and practice of stream restoration
- Provide direction for future research, training, and technology transfer

Examining Salmon Spawning Gravels for Restoration Potential

Reclamation's river restoration projects help us maintain water deliveries by avoiding impacts to endangered or threatened species. Degradation of spawning grounds in streams and rivers has been implicated as one of the causes of salmon endangerment and, thus, determining the quality of spawning grounds for Chinook salmon (*Oncorhynchus tshawystcha*) is a critical part of this river restoration effort.

Mark Nelson is funded by the Science and Technology Program in partnership with the San Joaquin River Restoration Program (SJRRP) to help determine the potential quality of these spawning grounds. SJRRP is a comprehensive effort to restore flows to the San Joaquin River from Friant Dam to the confluence of the Merced River and restore a self-sustaining Chinook salmon fishery in the river.

Salmon bury their eggs in the substrate (called the hyporheic zone), often at depths of about 30 to 45 centimeters (cm). The embryos hatch into alevins, which remain in hyporheic zone for about a month. This hyporheic zone is where surface water and ground water interact. Conditions within this zone may differ markedly from those found at the surface in water quality, sediments, and invertebrate communities. These factors may impact the success of salmon egg survival. For example, 8 milligrams per liter (mg/L) of dissolved oxygen in this hyporheic zone is ideal. Lower levels could delay emergence, and very low levels (below 5 mg/L) could affect survival. To determine the dissolved oxygen concentrations at various possible spawning locations, we used hyporheic samplers in surface water and at gravel depths of 30 cm. Data indicated that seven out of nine potential spawning sites experienced at least one dissolved oxygen reading in the hyporheic zone below 8 mg/L. Most of these low readings (six of nine) were below 6 mg/L.

However, the samples did not detect any significant difficulties with sediment size and invertebrates that might impact salmon eggs or alevins. Thus, while dissolved oxygen deep within the gravel may be a limiting factor, there may be spawning sites suitable for egg and alevin survival in this section of the San Joaquin River.

Future studies in this section of the San Joaquin River will use state-of-the-art dissolved oxygen equipment currently used in wastewater treatments. These same methods could be used on rivers throughout the Western United States where Reclamation is working to restore rivers, including Truckee, Trinity, and Colorado Rivers.

Gregory K. Reed, Natural Resources Services, 303-445-2208

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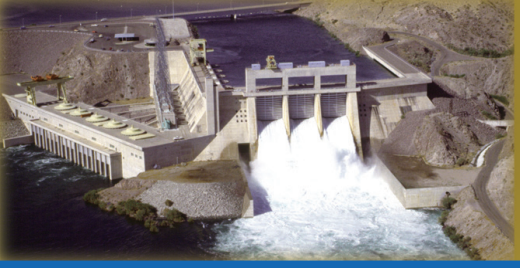

Water and Power Infrastructure Reliability

Tony Wahl measuring the erodibility of a canal embankment with a submerged jet test.

Condensed videos of the tests conducted thus far are available at <http://www.usbr.gov/pmts/hydraulics_lab/twahl/canalbreach/index.html>.

Physical Modeling of Canal Breaches

Reclamation has constructed more than 8,000 miles of irrigation water delivery canals in the seventeen western states. Threats to canals include: animal burrows, tree roots, penetrations by turnout pipes and utilities, embankment and foundation issues, seismic events, internal erosion under static loading, hydrologic events, and operational incidents. Canal failures can have significant consequences, and the potential consequences increase over time as urban development surrounds formerly rural canals.

Modeling of potential failures is needed to understand threats to Reclamation canals and to reduce flooding risks. There are potentially significant differences between canal and embankment dam failure scenarios. Most notably, the flow of water past a developing canal breach and limitations on the ability of the canal to convey water to a breach site may significantly affect the mechanics of the erosion process and the resulting breach outflow rates, compared to earthen dam breaches.

The present research study uses laboratory physical models to study the breaching processes of typical canal embankments. The effects of varying material properties and different failure initiation mechanisms are being considered. Material erodibility is measured with a small-scale submerged jet erosion test device that is suitable for both laboratory and field use. The long-term objectives of the research are the development of canal-specific breach simulation computer models and relationships for predicting canal breach outflow rates as a function of canal and embankment geometry and geotechnical/erodibility characteristics. These tools will support both rapid appraisal-level evaluation of large numbers of canals and more detailed analyses of specific cases.

Three test breaches have been carried out so far. Each embankment was constructed with an intentional “defect” in the form of a half-inch diameter rebar embedded in the embankment that could be withdrawn to initiate an internal erosion failure. The location of the defect and the erosion resistance of the embankment have been varied in these tests. The weakest embankment breached in about 7 minutes. The strongest embankment withstood 21 hours of flow and was only breached with mechanical assistance.

Tony Wahl, Hydraulic Investigations and Laboratory Services, Technical Service Center, 303-445-2155

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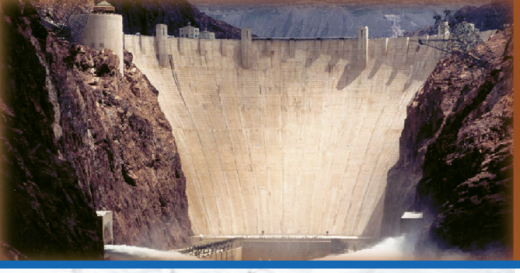
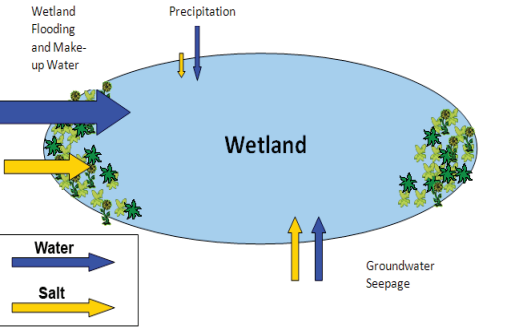


Water Operations Decision Support

Water and Salt Balances

Hydrologic Inputs for Seasonal Wetland Model



The annual water balance is the sum of pond inflow, outflow, precipitation, seepage and evapotranspiration. Net storage is zero since the pond is drained each spring. More residue indicates more inflow; less residue indicates less inflow than outflow.

The salt balance compares salt imported with the water supply to salt exported in outflow together with salt lost to groundwater. A positive residual salt balance can indicate water storage in the soil or shallow groundwater that is not exported. A negative residual salt balance indicates that more salt is being discharged than was imported into the wetland during flood-up.

Managing Water and Salt in Wetlands

Healthy wetlands are vital for effective water quality management. To manage constructed wetlands, it is vital to measure the quantity of salts in the water that are imported and exported. This salt balance compares salt imported with water supply to salt exported in outflow together with salt lost to groundwater. These preliminary water and salt balances provide feedback to field personnel to improve flow and water quality monitoring and estimation techniques for seepage and evapotranspiration losses.

A decision support model that tracks water balances and salt balances will help Reclamation's wetland managers simulate salinity buildup, schedule wetland drainage scheduling, and assess strategies for wetland management. To develop this modeling framework, Chuck Johnson and Nigel Quinn in Reclamation's Mid-Pacific Region are modeling water and salt balances in the 170,000 acre-Grasslands Ecological Area (GEA) in the San Joaquin Basin. This is the largest contiguous wetland tract in the western United States, and it is subdivided into unique wetland management areas. These areas can be further subdivided into individual ponds, each with a water supply inlet and drainage outlet. There are 160 private duck clubs in the GEA—each one has an area that is individually managed for water supply and drainage.

Reclamation's Science and Technology Program previously supported developing remote sensing analysis techniques for the first realistic estimates of seasonal wetland evapotranspiration. This follow-on research project is developing credible water and salt balances for seasonal wetland ponds throughout the GEA, using a combination of field-level flow and water quality monitoring and numerical simulation modeling.

Flow and electrical conductivity data were collected from twelve experimental wetland pond sites in the GEA between 2006 and 2009. This reseach also helped eliminate tedious data acquisition and processing procedures by adopting YSI-EcoNet. This data collection system also allowed wetland managers more time to perform biweekly sensor quality assurance checks, including cleaning sensors and checking the accuracy of staff gauge data (used in the computation of flow). Wetland managers have appreciated the time-saving benefit of reviewing monitoring site data ahead of routine quality assurance checks. This review helps prepare field staff for contingencies such as sensor failure prior to travelling to the sites (which can be up to 18 miles apart).

Error-corrected pond inflow and outflow data and the salinity concentrations associated with these flows were entered into a daily time-step wetland water and salinity balance spreadsheet model to allow the development of preliminary annual water and salt budgets for the project wetlands. This is the first phase in the development of a fully functional seasonal wetland simulation model, which will be completed in the second year of the current project.

Nigel Quinn, HydroEcological Engineering Advanced Decision Support, Group Leader, 510-486-7056

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Conserving or Expanding Water Supplies

Earth-lined canal from Yellowstone Project, Montana

Reclamation conducted a workshop in February 2008 to define current uses and issues associated with using PAM. This workshop drafted a research and development plan designed to meet the needs for a biological or chemical canal sealant. To develop effective and safe alternative products, we are collaborating with other federal agencies, the agricultural community, industry, and state and local interests. The workshop results are available at: <http://www.usbr.gov/research/science-and-tech/research/results/PAM/2008 PAM Workshop.pdf>.

Using Chemical or Biodegradable Products to Seal Canals

Reclamation is seeking industry partners to develop chemical or biodegradable products to add to canal waters to reduce seepage losses and conserve water in unlined canals. Ensuring such products are safe for human and natural environments is key. Several candidate materials demonstrate potential effectiveness and safety—and show promise as low-cost, easy-to-apply methods for thousands of miles of unlined canals and laterals. We are also seeking assistance from the U.S. Environmental Protection Agency (EPA) to guide evaluation and permitting.

Some owners and operators of unlined water delivery canals now use polyacrylamide (PAM) to reduce seepage. PAM causes sediment-laden clumps to settle to the bottom of the canal (flocculation) and fill small voids in the canal. PAM has many commercial applications as a flocculent, but it is not labeled for reducing seepage from canals. Reclamation sponsored studies, in coordination with the EPA, indicate that the flocculating action of PAM can reduce seepage by as much as 90 percent in some areas. However, PAM also contains small amounts of acrylamide which is a neurotoxin, genotoxin, and possible carcinogen. If PAM applications were properly applied, controlled, and managed, the associated risks to human health and the environment would likely be low. However, developing application protocols and ensuring that applications are properly controlled and managed are difficult due to the absence of any regulatory and product-labeling requirements to govern the use of PAM, or other additives, in canal waters to reduce seepage.

Thus, Reclamation decided in 2007 not to allow the use of PAM in Reclamation-owned facilities. As part of that decision, Reclamation committed to pursue the development of safe, alternative products and seek assistance from the EPA and states in defining environmental compliance or product labeling requirements for such products. The Reclamation Decision Memorandum and Technical Report of Findings are available at: <http://www.usbr.gov/research/science-and-tech/research/results/PAM/index.html>.

In 2011, the Research and Development Office is partnering with Reclamation's Great Plains, Mid-Pacific, and Upper Colorado regions to identify several canals with a range of representative field conditions to test materials and, if shown to have merit, develop these into effective, safe products. We will measure baseline seepage conditions in selected reaches of these "test-bed" canals during the 2011 irrigation season. During the 2012 irrigation season, we will test the effectiveness of candidate materials against the baseline measurements and their ability to be safe to human health and the environment.

Rod Wittler, Mid-Pacific Regional Science Liaison, 530-623-1801

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