Message from the Director

Managing complex water resources can be very challenging, especially when the science behind the behavior of the system is incompletely understood. Understanding such systems can require a multi-faceted approach of monitoring, modeling, and management. For instance, managing nutrient loads can require merging a variety of measurement, laboratory, and modeling techniques in order to understand how a watershed operates.

Similarly, various industrial activities can result in unpredictable effects that are difficult to understand and manage, requiring innovative research approaches.

This edition of the Water bLog focuses on some of the creative research currently underway at the UCWRR that involves monitoring, modeling, and ultimately managing the effects of nutrients in reservoir systems, as well as the potential downstream effects of static rocket motor tests on field crops. These projects represent only a fraction of the active research at the UCWRR that is designed to find practical solutions to natural resources challenges throughout the state.

UCWRR researchers are engaged in a variety of research designed to address the problem of nutrient loading in Utah’s reservoirs, streams, and wastewater treatment facilities. Two such projects are highlighted below.

Research Highlight:

Nutrient Management in Utah Reservoirs

As demands for clean water for municipal, agricultural, industrial and other uses rapidly increase, it is becoming more and more important to care for and protect the quality of water entering water collection and storage systems. Increasing human activities such as agriculture, urban development, and recreation in and around Utah’s freshwater lakes, reservoirs, and watersheds are introducing more pollutants into water supply systems.

Of particular concern are excess nutrients such as nitrogen (N) and phosphorus (P) because these nutrients stimulate algae growth, reduce dissolved oxygen,
Pineview Reservoir, Utah in early fall. A phytoplankton bloom, dominated by algae, occurs during this period each year.

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Pineview Reservoir Phosphorus and Mineral Nitrogen Processes and Algae/Cyanobacterial Bloom Ecology

Nuisance blooms of algae and cyanobacteria occur annually in Pineview Reservoir due in part to excess nitrogen and phosphorus loading, and previous studies have called for management actions to limit these nutrient loads to the reservoir. Pineview has been on Utah’s list of impaired waters since 2000, and a Total Maximum Daily Load (TMDL) study has recommended actions designed to reduce these nutrient loads; however, data needed for model calibration and validation and to support management recommendations was sparse.

Research

In response to concerns over the potential effectiveness of the proposed reduction actions, UCWRR researchers have collaborated with the Weber Basin Water Conservancy District to provide empirical information for managers so that Pineview Reservoir water quality can be preserved or improved in the most cost-effective way.

Overall objectives of the project:

- Substantially improve information available to water quality managers for Pineview Reservoir.
- Gain a better understanding of bottom draw reservoirs in the intermountain west.

Results of the study include the following.

- The reservoir is thermally stratified during summer months.
- Phosphorus accumulates in the bottom layer of the reservoir as summer progresses.
- A significant fraction of P is removed from the reservoir as water is withdrawn for irrigation and other uses.
- Annual surface water nutrient loading has been lower than estimated in earlier studies.

- Loads associated with snow-melt runoff contribute the largest fraction of the total.
- Short but intense snow-melt events in the late winter and early spring on the valley floor may contribute substantial, “first flush,” phosphorus loads.
- Ground water contributes less nitrogen and phosphorus than estimated in earlier studies.
- Certain shoreline sectors near Huntsville contribute more nitrogen and phosphorus than other sectors.

Benefits to the State

Knowing the factors that control phytoplankton productivity in the reservoir will allow effective control methods to be selected. The approach and results

Acoustic Doppler Current Profiler used to measure stream flows for calculating nutrient loads

Researchers measuring light penetration through the ice
Fencing stream banks could reduce phosphorus loads from cattle.

Echo Reservoir in Utah’s Weber Basin is currently listed as an impaired water body due to high total phosphorus concentrations and low dissolved oxygen.

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Simple Optimization Method for Determining Best Management Practices to Reduce Phosphorus Loading in Echo Reservoir, Utah

Like many U.S. water bodies, Echo Reservoir is impaired due to excessive nutrient loads and has been placed on the list of water bodies requiring a Total Maximum Daily Load (TMDL) plan. A TMDL plan is meant to improve the water quality of impaired water bodies by providing information regarding the current pollutant loads and an approach to reduce and reallocate loads among pollutant sources to meet the instream water quality standard. TMDLs often utilize BMPs to mitigate nonpoint sources of pollution. These BMPs can include:

- Retiring land.
- Protecting grazing land.
- Cover cropping.
- Grass filter strips.
- Conservation tillage.
- Managing agricultural nutrients.
- Switching to sprinkler irrigation.
- Fencing and bank stabilization.

The current TMDL for Echo Reservoir allocates phosphorus loads to existing non-point phosphorus sources in different sub-watersheds to meet a specified total load.

Research

Current methods to determine the appropriate combination of BMPs often require complex solution techniques and long computation times and have seen limited use by decision makers and regulators. UCWRR researchers have developed a simple linear optimization program that identifies cost-effective BMPs to reduce phosphorus loads to proscribed targets.

The linear optimization program is formulated and implemented using the following information:

- Known phosphorus sources and TMDL load reduction targets.
- Individual BMP costs and effectiveness.
- Land area or stream length available to implement BMPs.

The program can be run to achieve proscribed reduction targets for each non-point source in each sub-watershed as currently specified in the TMDL plan for Echo Reservoir. Alternatively, the program can relax and combine sub-watershed reduction targets to generate global, watershed-wide reduction targets for sources across all sub-watersheds. Thus, the optimization tool:

- Offers a simple way to test the implementation feasibility of a proposed TMDL allocation, and
- Can suggest how to spatially redistribute phosphorus loads among sub-watersheds to reduce implementation costs.

For example, optimization results for Echo Reservoir show that it is feasible to implement BMPs for non-point sources in each sub-watershed to meet TMDL reduction targets at a cost of $1 million.

Looking to the Future

While ground water flow into Pineview Reservoir is small relative to surface water flows, the concentration of phosphorus in certain ground water locations far exceeds those anticipated. Future efforts will use ground water quality monitoring near the reservoir to determine the chemical characteristics and possible sources of soluble phosphorus entering the reservoir.
Grass filter strips are buffers between contamination sources and water bodies.

**Looking to the Future**

The optimization tool developed in this research is general and can support decision making in any watershed requiring non-point source reductions to meet instream water quality standards.

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**Effect of Deposition from Static Rocket Motor Test Fires on Corn and Alfalfa**

UCWRR researchers have completed a study to determine the impacts of test fire soil (TFS) from static tests of solid rocket motors on the germination, biomass production, and plant composition of corn and alfalfa exposed to TFS deposition.

Alliant Techsystems, Inc (ATK), a worldwide company that manufactures solid rocket motors (SRMs) for the National Aeronautics and Space Administration (NASA) at Promontory, UT, periodically conducts static test fires to evaluate the capability and reliability of the SRMs before sending payload into orbit. The rocket is restrained horizontally and fired into a hillside, creating a plume that entrains nearly 1.5 million kg of native soil, rocks and debris and is carried by the wind until it cools and settles.

Although the area around ATK is sparsely populated, residents are concerned with the deposition of the test fire soil (TFS) from the static rocket tests. In 2010, several crop fields nearing harvest were dusted with TFS, prompting an investigation of its effects on corn and alfalfa.

**Research**

UCWRR researchers worked with ATK to investigate the effects of TFS deposition on the germination, growth, and contaminant concentrations of corn and alfalfa. Plants were exposed to TFS under a variety of conditions in a controlled greenhouse environment:

- Plant germination studies using 0.4%, 2%, 10%, and 50% TFS by weight in soil and a control plot with no TFS
- Plants growth studies in soil containing 10% TFS, in soil with one inch of TFS added to the surface half-way to maturity, in soil with TFS or native soil applied to foliage half-way to maturity (the TFS or soil was rinsed off after one week).
- Column leaching studies with TFS either on the surface or mixed homogenously to determine the mobility of chloride and aluminum in soil.

View of exhaust cloud containing TFS from static rocket motor test.
The study shows that high amounts of deposition from static test fires at ATK could impact field crops, especially during more sensitive growth stages. Results include the following:

- High amounts of TFS in the root zone inhibited germination and growth; however, the detrimental impacts of TFS on germination can be mitigated by precipitation or irrigation.
- Corn grown in 10% TFS/soil mixtures or in soil with an inch of TFS applied to the surface produced less kernels.
- Plants grown in TFS contained significantly higher concentrations of chloride and other elements relative to controls, but the concentrations were well below the maximum tolerable limits (MTL) for consumption by cattle recommended by the National Research Council (NRC).

Application of TFS to leaves did not impact biomass production but resulted in higher concentrations of aluminum and a few other elements relative to controls.

The effects of test fire soil are attributed to high levels of chloride that induce salt stress. Crop damage may be avoided by conducting static test fires after crops are harvested or providing extra irrigation to soil impacted with the TFS.

Benefits to the State

This research contributes information regarding the potential impact of test fire soil from static test fires on crop production. Results can be used to develop Best Management Practices and test fire protocols that will reduce impacts of static test fires on crop growth.

Looking to the Future

Further research could examine the potential impact of TFS on various other crop growth stages.

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In the News

Vaughn Hansen Honored for Service to UWRL/UCWRR

Dr. Vaughn E. Hansen’s family and colleagues gathered with current faculty and administrators at Utah State University’s Utah Water Research Laboratory (UWRL) on September 11, 2012 to honor his contribution to the establishment of the UWRL, home of the Utah Center for Water Resources Research (UCWRR).

Dr. Hansen was one of the many dedicated individuals in the 1950s who foresaw the need for a multi-disciplinary water research complex that could make substantial contributions to water sciences and water resources planning and management. When the building was dedicated in 1965, Vaughn Hansen served as the first director of the UWRL and UCWRR.

Future Issues:
Research Highlights:

“Utah Water Education Project” (This project uses digital photos with short, water-related captions to encourage a reduction in per capita water use through incremental education)

“The Bear River Watershed Information System” (This internet-based platform is a central location where users can get data and information related to water quality and other watershed related issues in the Bear River Basin)

Far Afield
In the past year our UCWRR faculty members and researchers have traveled around the globe conducting and presenting their research and enhancing and sharing their extensive water resources expertise.

Countries visited
San Jose, Costa Rica
Helsinki, Finland
Berlin, Germany
Munich, Germany
New Delhi, India
Tel Aviv, Israel
Bari, Italy
Amman, Jordan
Rabat, Morocco
Kathmandu, Nepal
Muscat, Oman
Tubas, Palestine
Porto, Portugal
Cordoba, Spain
Lausanne, Switzerland
Tunis, Tunisia
Abu Dhabi, UAE

Switzerland has the highest density of dams in the world with 1500 hydro-power plants providing approximately 57% of the country’s electricity. With a goal to replace nuclear power generation with additional hydroelectric power, the importance of hydraulic structure and river engineering disciplines is continually increasing.

UCWRR faculty member, Blake P. Tullis, spent 6 weeks during summer 2012 as a visiting professor at the Hydraulic Construction Laboratory of École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland. He participated in collaborative research related to piano key weir debris handling and the characteristics of sediment exchange between coupled reservoirs utilized for pumped-storage hydroelectric schemes.

Grande Dixence Dam in Hérémence, Switzerland, the tallest concrete gravity dam in the world at 285m (main photo). Dr. Tullis’s experimental piano key weir model set up for a debris handling study at EPFL (inset).