RECLAMATION

Managing Water in the West

Science & Technology Highlights

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Contents

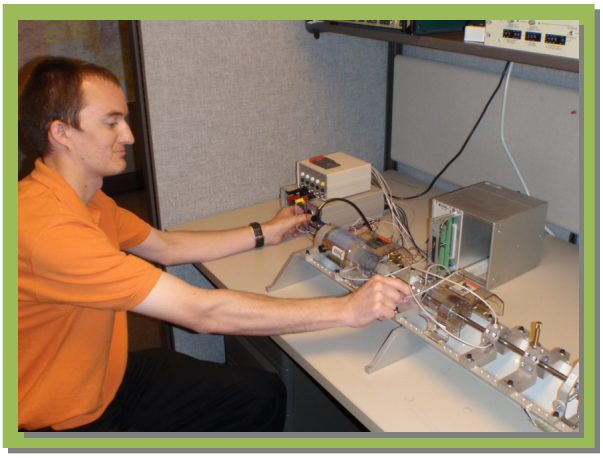
U.S. Department of the Interior
Bureau of Reclamation

Improving Infrastructure Reliability

Developing custom software for hydro powerplant machine condition monitoring

In 2009, Russia's largest hydroplant, the Sayano–Shushenskaya, broke apart violently, killing 75 people and leading to widespread power failure in the local area. Repairs are estimated at over one billion dollars. From what is known of this incident, high turbine vibration lead to a catastrophic failure that flooded the plant. A condition monitoring system could have detected the onset of this vibration and alerted the operators that there was a problem before the failure occurred.

The Hydroelectric Research and Technical Services Group has been researching and evaluating various machine condition monitoring systems for use in Reclamation hydroplants over the past several years. The overall objectives of a hydroplant condition monitoring system are to reduce operation and maintenance costs, increase plant availability, and preserve Reclamation's infrastructure by providing current and relevant information on the present condition of plant equipment.



Vibration monitoring hardware

Based on the results of this past research effort, it was decided to pursue a more generic data acquisition product, for which Reclamation would own the rights to the source code. The main advantage of this approach is it allows for in-house expansion and customization of the software. The core software for the Hydroplant Condition Monitoring system is currently being developed and tested and should be ready for initial release by spring 2011. The first release will focus on vibration monitoring. Once implemented, this system will be expanded in phases to include additional hydroplant monitoring features such as temperature trends, generator monitoring/analysis, and control system monitoring. Specialized monitoring system also can be implemented via this platform including air-gap monitoring, rough zone detection, or cavitation detection.

This software package will have several advantages over commercially available software, as it will be free to Reclamation powerplants, expandable and adaptable to meet the end users changing needs, and will work with a variety of data acquisition hardware. Users will only need to purchase the hardware and probes, which for a vibration monitoring system should cost less than $15,000. **Jim DeHaan, 303-445-2305**

Leading the way to improve the electric power industry's safety standards

The Science and Technology Program research results are improving equipment diagnostic methods and techniques and developing new methods to reduce maintenance costs and equipment downtime in areas of high-voltage insulation; rotating machine control protection, maintenance testing and diagnostics; and employee high-voltage electrical safety. Part of this effort is investigating enhancements to personal protective grounding. One of the major advancements in this area has been in identifying that the traditional method of calculating worker exposure voltage using the resistance of the grounding cable was underestimating the actual exposure voltage by about 300 percent. This research project developed a method that more accurately estimates the worker exposure voltage by including both the resistive and reactive components of the grounding cable.

These advancements were incorporated into Reclamation's Facilities Instructions, Standards, and Techniques Volume 5-1 – "Personal Protective Grounding for Electric Power Facilities and Power Lines" in 2005. Since this time, Reclamation has been working to transfer these advancements to the power industry as a whole, which will help protect all electrical power workers from electrical shock and other potential electrical safety hazards. Over the last five years, Phil Atwater and Jim DeHaan have been working with the Institute of Electrical and Electronics Engineers (IEEE) on two standard committees to transfer the results of Reclamation's research into power industry standards.

Two standards are now nearing completion and will be published soon: IEEE Standard 1246™ – "IEEE Guide for Temporary Protective Grounding Systems Used in Substations" and IEEE Standard 1048™ – "IEEE Guide for Protective Grounding of Power Lines." Both of these standards have under gone major revisions, including adding the information derived from the results of Reclamation's Science and Technology program. These revisions will enhance workers safety throughout the power industry. **Jim DeHaan, 303-445-2305**

Improving hydroturbine flexibility to optimize powerplant operations

The hydropower industry has long known both that operating hydro units over a wide range of generation levels and that increasing the number of start/stop cycles increases maintenance costs and harms powerplant efficiency. This Science and Technology research project is to improve hydroturbine operational flexibility and maintenance costs.

Yellowtail Dam and Powerplant, Montana

The research is developing, constructing, and testing software to monitor vibration levels of the hydroelectric unit and determine where the vibration is worse (defined as a Rough Zone). The software can monitor and determine the characteristic of rough zone vibration limits as a function of gross water pressure and energy

generated. This characteristic will be organized into three-dimensional tables where the rough zone monitor (vibration) amplitude will be recorded with respect to head and generation.

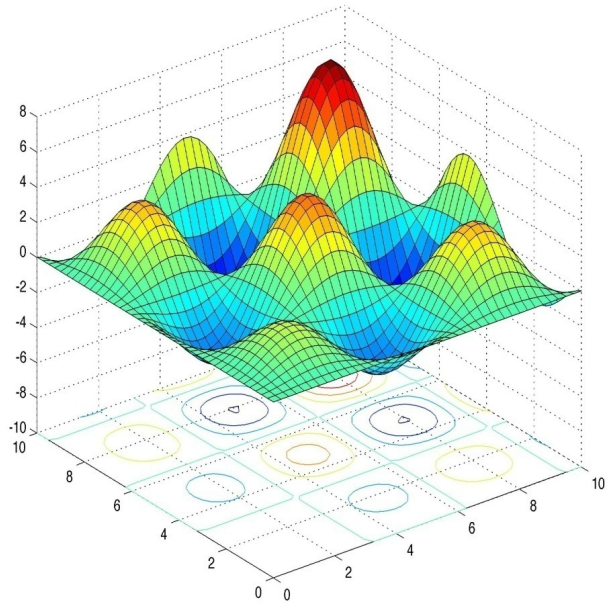
Direct input from the rough zone (vibration amplitude) monitor is used to provide an on-line, dynamic rough zone avoidance scheme. Rough zone limits determined by the monitor are updated as needed. Data are recorded to assist in developing maintenance cost data for future operations.

Once a clearly defined Rough Zone is established, the unit may have a wider range of operation that might reduce start/stop cycles. During the generation operation, unit rough zone limits are calculated by lookup from updated tables to obtain the following values: normal capacity, rough zone high, rough zone low, and low limit. A detailed software design has been provided to Western for implementation of this hydroturbine operation flexibility scheme in their Energy Management System (EMS).

This software will be installed and tested in the Yellowtail Powerplant hydroturbine to improve operational flexibility. **Ted Bechtel, 303-445-2319**

Determining the most economic way to operate generator units

On at least an hourly basis, Reclamation's powerplant operators must determine the best combination of generator units to bring online, and at what levels, given the existing load demands and other operating costs and constrains. This is known as the economic dispatch problem. Substantial gains can be realized from even small improvements in dispatch efficiency. For example, increasing the generation efficiency at Glen Canyon Dam by 2 percent would yield over four million dollars (in 2004 dollars) annually.



The Alpine function—a complex optimization problem used for development

Recently, a number of new optimization heuristics have been described. These technologies do not rely on traditional calculus-based approaches but instead are based on innovative search techniques drawn from biological and physical processes. Although computationally intensive, these methods can solve difficult constrained optimization problems, like the economic dispatch problem, quickly and reliably.

Advantages of these approaches include:

- Use primitive mathematical structures (only)
- Concise, straightforward coding
- Easily accommodates *D*-dimensional problems
- Problems may be nonlinear, continuous, discrete or complex
- Most types of constraints can be represented
- Higher probability of identifying global extrema

We plan to develop computer code for several of the most promising of these new optimization approaches, apply these algorithms to example economic dispatch problems and systematically assess their performance. The goal of this effort is to identify algorithms which can help guide the hydropower dispatch decision and improve efficiency. Improved dispatching efficiency will result in the generation of more electric power using less water--benefitting all water and power users.

So far, we have completed the test programs and have working prototypes for particle swarm optimization (PSO) and differential evolution (DE) algorithms. We have applied the DE to the economic dispatch problem and are coding the PSO for that problem. We have given presentations and demonstrated portions of the code. **David Harpman, 303-445-2733**

Using photogrammetry to map hard-to-access places

Photogrammetry also reduced processing time to obtain geologic measurements over large and/or difficult to reach formations. Following the success of this program for geologic mapping it was realized that these same tools could be used for a very wide range of applications where accurate 3D measurements are required of large and difficult-to-access structures. This Science and Technology research project has purchased camera equipment and software and has funded pilot projects to apply these tools to a variety of disciplines. These include geologic mapping, topographic mapping, hydraulic modeling, concrete crack mapping, rock erosion, and concrete deterioration.

Researchers have and continue to demonstrate and teach these methods to other engineers and geologists so they can apply these techniques to the problems they face in their current jobs. As a direct result of the photogrammetric research efforts, several organizations have adopted photogrammetric tools to help them solve a variety of measurement problems. They include Reclamation geologists in the regions, hydraulic engineers in the TSC hydraulics lab, and the U.S. Army Corps of Engineers geologists and engineers at Portuguese Dam in Puerto Rico.

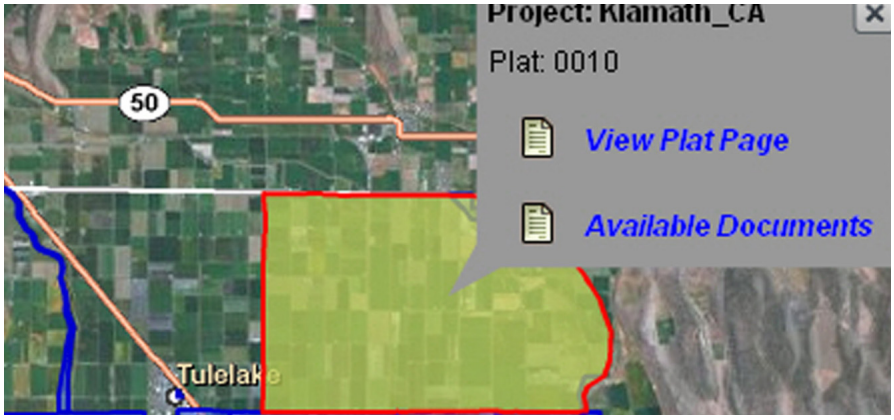
Guernsey Tunnel wall showing damage and seepage areas

Reclamation's Structural Analysis and Waterways and Concrete Dams Groups are using photogrammetry to map concrete cracks and the depth of freeze thaw damage at several sites in Reclamation's inventory. The Guernsey South Spillway Tunnel is just one example of how photogrammetry can provide the information we need in ways not possible without this Science and Technology Program research.

The Guernsey South Spillway Tunnel has been out of service for many years. Recent decisions in the dam safety program resulted in a need to bring this tunnel back into service. Cost-effective repairs depend on understanding the extent of the damage. To measure damage using conventional methods is difficult. Instead, we use photogrammetric methods from a boat to develop a very accurate 3D scale model of the tunnel lining that was used to measure the extent and depth of damage as well as the roughness of the surface in the damaged areas. These measurements were used to evaluate the potential to induce cavitation at the rough damaged areas and to estimate the depth of damaged areas into the lining. These methods were very effective in developing a deeper understanding of the condition of the tunnel lining. These methods contributed significantly in the decision process and the savings several millions of dollars in tunnel repairs. This project is ongoing. The preliminary foray did not get the upstream half of the tunnel due to gate leakage. Thus, a second session is planned for this fall when the gate leakage will be temporarily halted due to the lower reservoir surface. **Rebecca Heisler, 303-445-3172**

Accessing documents through a web map

Reclamation offices are rapidly discovering the collaborative features of Windows SharePoint Services, in particular, document libraries. SharePoint document libraries provide an efficient way to store and share digital information such as documents, spreadsheets, and reports associated with Reclamation lands, facilities, or operations. But how can we make these disparate collections of documents easy to find? One solution is to organize by physical location. That is, documents tend to be associated directly or indirectly with a feature like a dam, canal, reservoir, recreation site, or land parcel. Location provides an inherent organizational framework that can greatly enhance discoverability of related information.



Information available by location

Reclamation research has developed a set of recommendations, best practices, and guidelines that can help offices structure and organize documents in SharePoint document libraries so that they can be easily linked the features to which they are related. By following these guidelines, Reclamation personnel can leverage the combined power of map-based and traditional search methods to find and access the documents they need.

These guidelines are on a shared intranet drive for Reclamation staff. Contact **Greg Gault, 208-378-5325** for a copy of the guidelines.

Getting and modeling data for complex wetlands

The combined State, Federal, and private wetlands of the western San Joaquin Basin, known as the Grasslands Ecological Area (GEA), cover approximately 170,000 acres. The State and Federal wetlands are subdivided into unique wetland management areas as well as 160 private duck clubs—each individually managed for water supply and drainage. The hydrology of this area has been largely ignored in surface and groundwater simulation models.

The 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 with field-level flow and water quality monitoring and modeling.

Flow and electrical conductivity data were collected from twelve experimental wetland pond sites in the GEA between 2006 and 2009. YSI-EcoNet, a commercial environmental monitoring system, integrates sensor hardware (acoustic flow probes, pressure and water quality sondes) and dataloggers with software that performs data storage, telemetry and visualization. The YSI-EcoNet network collects data every 15 minutes which is transmitted to a remote DataCenter via CDMA cellular phone modem from where the data are made accessible through the Internet. The wireless mesh network topology allows "point-to-point" connectivity and is self-organizing and self-healing—the loss of one or more nodes does not necessarily affect its operation. This saves time, allowing wetland managers more time to perform bi-weekly sensor quality assurance checks. Wetland managers can now review monitoring site data before travelling to the data collection points, which helps prepare field staff for contingencies.

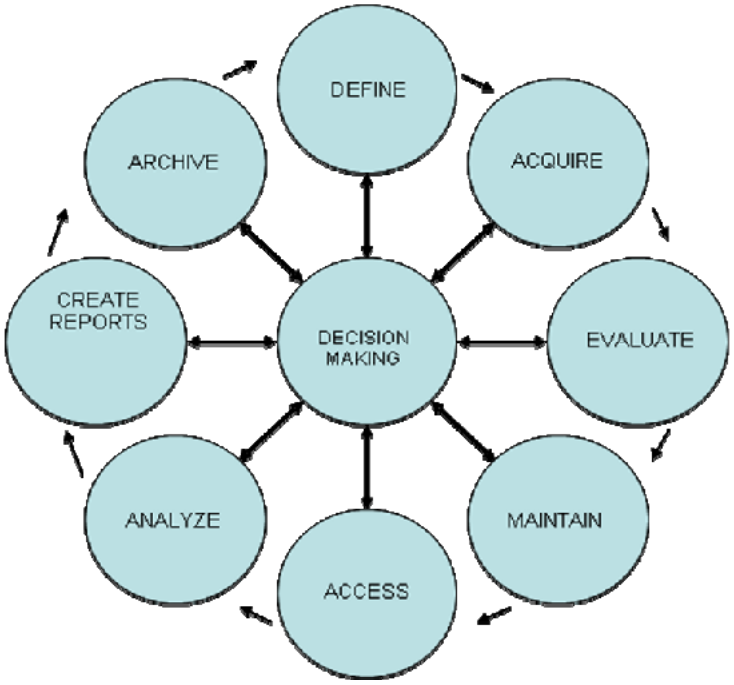
Flow and salinity monitoring station at the Ducky Strike Duck Club

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 help develop preliminary annual water and salt budgets for the project wetlands. This is the first phase in developing a fully functional seasonal wetland simulation model which will be completed in the second year of the current project. The 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.

Developing accurate water and salt balances is an important first step in the development of the first comprehensive wetland simulation model for the GEA. These water and salt balances are also important for wetland managers to help assess strategies for improved wetland salinity management while meeting State-imposed salinity objectives in the San Joaquin River. **Chuck Johnson, 916-978-5266**

Drafting policy for data stewardship to facilitate data sharing and help ensure quality data

Reclamation expends substantial budget and time to collect resources data upon which important decisions are based. These data generally cover management of water, power, environmental resources, real property, and facilities. They are valuable assets for local projects, Reclamation as a whole, other agencies, and the American public. While data collection may be well planned, data standards and procedures do not exist to efficiently share, compare, or even document the bulk of data collected. This has hampered decision making.



Data life cycle

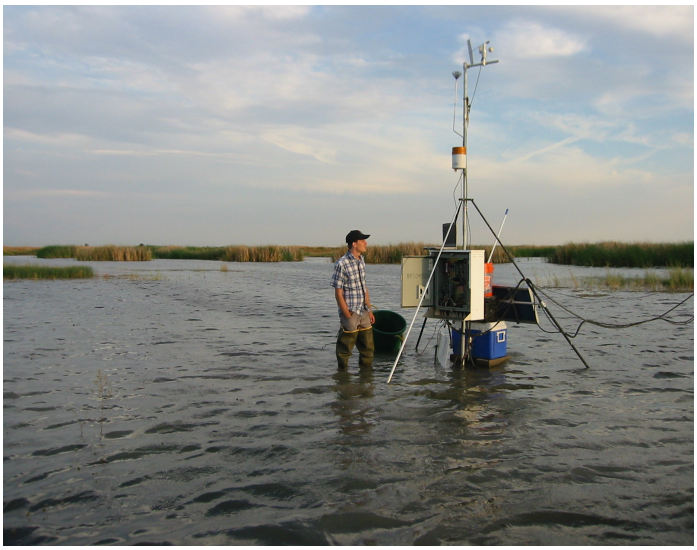
On August 27, 2010, Dr. Curt Brown, Director of Research and Development, and Mr. Jim Nagode, Information Management Coordinator, in Reclamation briefed Reclamation's Chief Information Officer's Council about ongoing efforts to develop an umbrella policy for the implementation of data stewardship within Reclamation. The policy has been drafted by a Reclamation-wide Data Stewardship Technical Team, drawing on program, information technology, policy, and scientific staff. Policy development has been funded for two years by Reclamation's Research and Development Office. Substantial matching funds have been provided by the Office of Policy and Program Services. The technical team has also sought input from an advisory body of data stewardship experts in the Bureau of Land Management, U.S. Fish and Wildlife Service, National Park Service, U.S. Geological Survey, and NatureServe (The Nature Conservancy). The team will prepare a final draft policy, submit it to the Reclamation Leadership Team, and request a formal Reclamation-wide review.

Under provisions of the draft policy, Reclamation will treat mission-critical resources data as valuable assets to ensure that their usefulness, integrity, and quality are protected. The CIO and the RLT will identify classes of data that deserve increased investment in their planning, acquisition, management, and sharing. A Business Data Steward will be named to facilitate

improvements to data management. A Data Acquisition and Management Plan (DAMP) will be required addressing how all stages of the Data Lifecycle (Figure 1) will be accomplished. A Reclamation-wide Data Stewardship Coordination Team will be created under the auspices of the CIO to support implementation of this policy, including development or adoption of data standards. Metadata will be collected and maintained as an integral part of mission-critical resources data. Each Directorate will be responsible for the stewardship of mission-critical resources data within its jurisdiction.

The benefits to Reclamation of providing stewardship for mission-critical resources data include obtaining greater return on its data investments, reducing the loss of valuable data, improving data documentation, facilitating data sharing, reducing redundant expenditures, and ensuring that data are of sufficient quality to support needed decisions. **Doug Clark, 303-445-2271**

Developing better ways to measure evapotranspiration



Bowen Ratio weather station in the Gadwall Unit of the Los Banos Wildlife Management Area, California

Evapotranspiration (ET) is water lost to evaporation and plant use. Measuring these rates is crucial to understanding water demands and supplies. A number of remote sensing techniques using indirect ET measurement have been developed in the past decade. The most popular of these techniques are SEBAL and METRIC. These modeling approaches are well accepted in the western United States because of the field testing that has occurred in states such as California. These techniques show good consistency and agreement for irrigated fields, rangelands and arid other non-agricultural settings. SEBAL can be applied without using any ground measurements and is the method of choice in regions that have no ground weather data or where high quality weather data are not available. METRIC is more applicable where high quality ground meteorological measurements are available on an hourly basis.

Science and Technology Program research worked with Colorado State University to develop ReSET, a public domain remote sensing and analysis tool based on algorithms used in SEBAL and METRIC. New features in ReSET allow multiple weather stations to be used to obtain ground data needed for interpolating between scenes. The previously developed model used just one weather station for ground data (i.e., wind speed, ET, and rain). Data from all weather stations that fall within a target area could be adjusted for each cell, based on the spatial variability of the weather stations. We also enhanced the model to calculate the cumulative ET between dates with available data.

A Bowen-Ratio weather station was installed in the Gadwall Unit in 2007 and the site was operated and maintained through 2009. A comparison of the daily ET estimate using ReSET and the Bowen Ratio-derived ET showed reasonable agreement, despite problems with soil heat sensors owing to cracking soils. The ReSET model has been extensively used by the Reclamation's Technical Services Center (TSC) for projects in Colorado and California. The Remote Sensing Group within the TSC has made considerable technical improvements to the original ReSET code in collaboration with the model developer at Colorado State University. In September 2010, the TSC Remote Sensing Group gave a one-day workshop on the new updates to the ReSET model. The workshop was attended by agency personnel and private consultants interested in applying ReSET as a tool to supplement current crop coefficient-based ET estimation efforts in California.

The Science and Technology funded project has been successful in advancing ET estimation in agricultural and wetland areas and providing technology transfer to Reclamation agency collaborators. **Tracy Slavin, 916-978-5556**

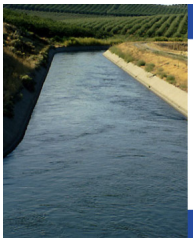
Developing sediment analysis guidelines for dam removal

Managing reservoir sediment erosion, transport, and deposition are some of the most important physical considerations of dam removal or reservoir sluicing. Depending on the local conditions and the method of decommissioning or sluicing, impacts can range from negligible to very large. Reclamation river engineers have been actively involved in evaluating reservoir sediment impacts for several large-scale dam removal projects in recent years. However, guidelines on the level of sediment data collection and analysis appropriate to the scale of the sediment and/or management questions do not currently exist.

Visiting Lake Mills delta on the Elwha River restoration project to discuss potential sediment impacts

This Science and Technology research project will advance the state of knowledge related to sediment effects of dam removal. The research objective is to provide guidance on scaling the level of assessment needed with the scale of the reservoir sediment volume. This effort is nearing completion and is being sponsored by the interagency Subcommittee on Sedimentation <http://acwi.gov/sos/index.html>. Reclamation plans to use the guidelines adopted by this committee as a reference and guideline. This will be used when working with local agencies, permitting agencies, and stakeholders to determine types of sediment analysis needed for decisions on reservoir sediment management.

This project will develop the guidelines document, and evaluate dam removal case studies Reclamation has been involved with at Savage Rapids Dam in Oregon, Gold Hill Dam in Oregon, Chiloquin Dam in Oregon, Marmot Dam in Oregon, and the planned Elwha and Glines Canyon dam removals in Washington State. Over 50 scientists and practitioners involved in dam removal work from across the country have collaborated on this effort with Reclamation. Two workshops were held where participants visited actual dam removal sites and then developed key pieces of the guideline. Comments from the last workshop in 2009 are being incorporated, and final review is expected to occur in FY11. **Tim Randle, 303-445-2557**



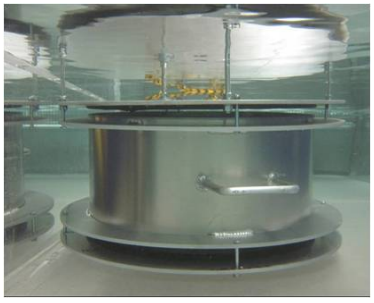
Addressing Environmental Issues

Using sediment oxygen demand chambers to find sources of nutrients in reservoirs

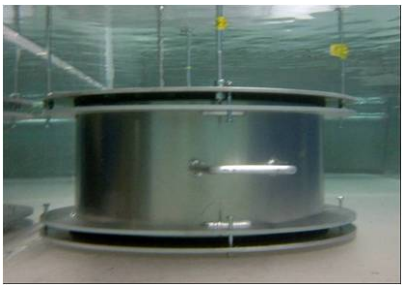
Sediment deltas in reservoirs are sources of nutrients and organic material which can affect reservoir water quality. These causes are not well understood, and Reclamation needs to understand these causes to effectively address water quality in our reservoirs. This research project is investigating water quality interactions between sediment deltas and reservoir basins using Deer Creek Reservoir, Utah as a field laboratory. The results will be tools for quantifying water quality impacts from sediment delta interactions, such as sampling methods, equipment, and reservoir models.

This research project is developing a sediment oxygen demand (SOD) chamber to evaluate the potential and magnitude of nutrient fluxes from the reservoir sediments to the water column. This will help Reclamation be aware of potential for and the timing of events and also study how operations might influence such events. Researchers have used SOD chambers for more than two decades but design features limited applications. The SOD chamber, designed by Brigham Young University as part of this research study, minimizes required operator interactions with testing equipment during use, incorporates interchangeable parts, and is self-sealing—which make the device adaptable to various types of aquatic environments.

SOD chamber is lowered into the flume



Submerged chamber with open top and bottom plates



Submerged chamber is shown resting on the bottom of the flume with top and bottom plates closed

Deploying the sediment oxygen demand chamber

The chambers have been fabricated and have passed the initial engineering check-out tests. We are field testing the chambers at Deer Creek Reservoir. In the field, two chambers are deployed simultaneously. One chamber is closed on the top and open to the sediment on bottom while the other chamber is closed on top and bottom. Dual deployment allows for the separation of sediment oxygen demand from the water column oxygen demand. Field measurements and data will be processed and analyzed in the fall. Results from the field testing will be used to develop methods for measuring the potential for elevated nutrient fluxes under various conditions. **Nick Williams, 801-524-3888**

Evaluating devices to guide Pacific lamprey away from irrigation canals and other diversions

Pacific lamprey (*Entosphenus tridentatus*) play an important role in the Columbia River Basin ecosystem. However, Pacific lamprey have declined significantly over the last half century throughout much of their native range, including the Columbia River Basin. There are renewed calls to list the species under the Endangered Species Act (ESA). Reclamation and other Federal and State agencies and tribes can take proactive measures now to improve survival of Pacific lamprey and thereby avoid listing under the ESA.

Many small irrigation diversions within the range of the Pacific lamprey have the potential to divert juvenile lamprey out of the river into an unsuitable environment. This research will assess several behavioral and physical guidance devices for their ability to guide juvenile Pacific lamprey away from irrigation diversions so they remain in the river. Reclamation and other Federal, State, or private entities can use the results of this research to reduce or eliminate unintended diversions of juvenile Pacific lamprey into irrigation canals. Results of this research could extend to other migratory fish species as well, and may be applicable Reclamation-wide.

Beyond the initial work in 2009 of compiling a comprehensive list of both Reclamation and non-Reclamation irrigation facilities in the Yakima and Umatilla river basins and noting some of the impediments to adult and juvenile Pacific lamprey passage, we conducted preliminary tests at a field site near Pendleton, Oregon, of juvenile Pacific lamprey response to an air bubble curtain in a test flume. Based on preliminary results of these tests, in 2010 we redesigned the test flume, which was constructed at our Umatilla Field Office.

Redesigned flume looking downstream (left) and upstream (right)

The new test flume was designed to provide a more uniform flow in the channel. It featured a wide upper channel that split into two narrower channels downstream as well as a fish trap at the bottom of each narrow channel to collect fish. A new method was developed to release juvenile lamprey or other test fish into the flume—releasing the fish through one of three vertical tubes in the head box that outlet through and near the bottom of the porous diffuser. A behavioral or physical guidance device was positioned at the upstream end of either of the two downstream channels. Below this screened area, fish diverted by the device continued downstream into a fish trap for counting. If test fish did not or could not avoid the behavioral or physical guidance device, they continued downstream and moved into the downstream fish trap.

These tests were completed at the same field site near Pendleton, Oregon. We tested a bubble curtain and high intensity light behavioral guidance devices, as well as physical guidance devices such as wedge wire and woven wire screen that meet or approach National Oceanic and Atmospheric Administration Fisheries fish screening criteria. Construction of the new test flume was completed in early September 2010 and testing of juvenile Pacific lamprey in the flume during the week of September 20th, 2010. Biologists from the Confederated Tribes of the Umatilla Indian Reservation provided juvenile Pacific lamprey for the testing. **Jennifer W. Beardsley, 208-378-5035**

Giving wildlife better water when Owyhee Reservoir water has toxic algal blooms

In the summer months when Owyhee Reservoir in Oregon is drawn down and has minimal flowing water, algal blooms form along the banks. Drinking water with these blooms could be fatal for wildlife, dogs, and potentially humans. One approach to mitigate this risk is to create water catchments with good water as an alternative to wildlife drinking algal bloom-infested waters.

Reclamation, Bureau of Land Management (BLM), Oregon Department of Fish and Wildlife (ODFW), Wild Sheep Foundation (WSF) and several other individuals and non-government organizations such as the Wild Turkey Federation, and Ada County Highways are interested in water quality and the variety of wildlife in the Owyhee area and are choosing locations and installing water catchments to better serve the wildlife during the hot dry months. These partners have created various water catchments to not only conserve reservoir water, but to hold, save and use other sources of water (snow and rain runoff) to benefit wildlife. Many of these catchments need to be monitored for upkeep and for use to determine if their placement is effective.

For 2010 another water catchment (North Table) was installed in May in horrendous weather conditions by extremely dedicated persons (Figure 1). A Biological Assessment written for BLM includes placing 10 new water catchments since 2006. Currently 6 have been completed and 4 more are proposed to be installed. Studies of their effectiveness will assist in determining location placement to better benefit the wildlife. We are currently deploying data loggers or HOBO water temperature Pro v2 gages into at least 10 of the drinkers (Figure 2). These will remain in the drinkers for up to a year and several will record temperatures every hour throughout the day while others will record temperatures in smaller time increments such as 15 minute intervals. No reservoir water sampling will be conducted this year due to the cooler summer temperatures and the excellent results of last year's testing.

Figure 1. Installing North Table Guzzler in some inclement weather!

Figure 2. Deploying temperature gages at a water catchment

The Bensley water catchment will be installed in spring 2011 and possible South Table, which would conclude the installation of catchment per the BA. The Oregon Native Desert Association and Western Watersheds organizations have recently joined in our effort.

These catchments support Reclamation's commitment to mitigate for the loss of wildlife, while still being able to satisfy agricultural water needs. The area is popular for not only wildlife watching, but hunting, fishing and boating, so avid sportspersons benefit from these projects. Monitoring water quality will also provide better information for warnings for public safety, if necessary. **Gretchen Fitzgerald, 208-383-2231**

Searching for marketable uses for algae

Reservoir waters with large concentrations of nutrients often support excessive algae growth. Is it possible to turn the high productivity of reservoir algae into an asset? If there were a commercial use for the algae that grows so well in some reservoirs, a commercial venture could consider harvesting the material for some useful purpose and fill a potentially valuable market niche.

Figure 1. Sampling an *Aphanizomenon flos-aquae* mat

Reclamation Klamath Basin Area Office is working closely with it partners (U.S. Geological Survey, Oregon Institute of Technology, and Klamath Tribes) to chemically characterize *Cyanobacterial biomass* in Upper Klamath Lake Oregon, a hypereutrophic (nutrient rich) reservoir. This project will use techniques to fractionate Upper Klamath Lake blue green algae cells into their chemical constituents to determine if potentially useful products can be developed. These products could ultimately lead to commercial harvesting of algae on an economically viable scale, and potentially improve water quality, fish habitat, and the health of flowing (lotic) and standing (lentic) water ecosystems impaired by high nutrient inputs. A Science and Technology research project was started this year on Upper Klamath Lake, Oregon, to evaluate *Aphanizomenon flos-aquae* (AFA), an algae that holds a near monopoly of algae in the lake. Normally, this algae produces extensive high density mats that float on the lake water surface (Figure 1).

This summer, the weather in Klamath Falls, Oregon, was cooler than normal and development of AFA blooms were delayed. Development of AFA mats did not occur until mid summer.

Figure 2. The amount of algae collected from 8 liters of water during early summer 2010

Figure 2 shows a typical amount of algae collected in the first half of the summer by filtering 8 liters of lake water. The mass of AFA we were able to collect from Upper Klamath Lake this summer was modest and less than we had anticipated based on collection efforts in recent years.

In FY 2011, we will perform a variety of chemical analyses, including sample digestion, supercritical fluid extraction and ^{31}P nuclear magnetic resonance spectroscopy to characterize the elemental composition, extractable organic material, and both inorganic and organic phosphorus compounds in this algae. **Chuck Korson, 541-880-2575**

Tracking sedimentation levels at Reclamation facilities

As rivers enter the still waters of reservoirs, they drop their sediment load. Sediment accumulation increasingly diminishes reservoir storage capacity. Sediment accumulation can also cause marinas and boat ramps to become useless and can clog intake structures. This Science and Technology research project answers two questions:

Sediment stored behind Savage Rapids Dam, Oregon

- Based on historic rates of sedimentation, when will sediment levels reach critical levels at Reclamation facilities?

- What techniques are best used to calibrate sediment accumulation model to historic data from reservoir sedimentation surveys?

Reservoir operators need to know how water surface area and storage capacity changes with water surface elevation and how this information will change in the future. These area-capacity data are particularly important during droughts and floods. Reservoir surveys will provide data to update the area-capacity tables, and the proposed model will predict future changes. This will suggest how much time is available to implement actions to mitigate reservoir sedimentation impacts on facilities. For example, marinas could be relocated, dam outlets could be modified, or sediment could be dredged or flushed from the reservoir.

Reservoir sediment accumulation can be modeled spatially in three dimensions successfully with initial terrain surface input to better visualize sediment as it advances downstream over time and impacts the reservoir facilities and water storage. This graphic analysis makes it easier to understand reservoir impacts due to sediment accumulation. This research project modeled sediment at Bighorn Lake, in southern Montana and northern Wyoming, impounded by Yellowtail Dam. The lake's relatively small-radius curves provide a robust test of the modeling algorithm. Predictions of sedimentation at dam intakes and other facilities will greatly aid in planning either sediment removal efforts or alternate courses of action, such as dam decommissioning and removal, installation of alternate water intakes, or sediment bypasses.

Managers could prioritize reservoir sediment surveys and sediment removal so that dams with those intakes clogging the soonest could be the first candidates for dredging, etc. Having this information presented visually makes it easier for Reclamation managers, irrigation district officials, and other stakeholders to assess the potential significance of sediment accumulation rates and prioritize actions.. **John Carlson, 303-445-2270**

Understanding how altering streamflow dynamics changes ecosystem functioning

There is growing public demand that river flows should be managed to balance the needs of ecosystems and society. To do this requires an understanding of how changing natural streamflow dynamics alters biological communities and ecosystem functioning. A team of Reclamation, U.S. Geological Survey (USGS), and Utah biologists are collecting information on the degree to which natural hydrology can be altered before there are measureable declines in biological integrity.

Biological integrity is measured by comparing how a stream's plant and animal community composition and diversity differs from reference conditions found in similar unregulated streams in the region. Similarly, hydrological alteration is the degree to which various streamflow characteristics (e.g., characteristics of annual minimum flows) differ from expected natural conditions in the region.

This study is intended to be a preliminary exploration of the range of biological integrity—as represented by macroinvertebrate and fish communities. Biological samples were collected in September 2010 and identification of material (e.g., mayflies, stoneflies, and caddisflies) along with characterization of stream flows will now take place. **S. Mark Nelson, 303-445-2225**

Sampling below Currang Creek Reservoir

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Conserving or Expanding Water Supplies

Measuring flows in hard-to-guage canals

Measuring flows in Mohave Valley Irrigation and Drainage District (MVIDD) in Arizona is challenging. Corrosive minerals in the water lead to a short service life for electronic sensors or instruments with moving parts that come in contact with the water. Most MVIDD canals are designed without enough head available to operate a conventional flume to allow straightforward measurements.

The Water Conservation Program of Reclamation's Yuma Area Office has teamed up with engineers from Reclamation's Hydraulic Laboratory to apply a technology developed under Reclamation's Science and Technology Program for measuring flow at selected sites at MVIDD. The flow measurement system uses a solution based on measured levels at both the approach and throat section of a long-throated flume. The flow measurement equation used is essentially the same solution used for pipe venturi meters.

In conventional flume operation, only the approach section water level is needed. When this measured level is plugged into the flume rating equation, the flow rate may be readily determined. This methodology works well up to the point where submergence (the ratio of the water level below the flume compared against the upstream level) exceeds what is known as the modular submergence limit. At submergence levels in excess of the modular limit, conventional flume measurement yields erroneously high discharge values.

Using the two-level "venturi solution" method developed during a previous Science and Technology Program research project (495), flow may be accurately measured at a long-throated flume under conditions suitable for conventional flume operation as well as under submergence conditions well in excess of the modular submergence limits. To accurately measure water levels at multiple locations, a bubbler level sensing system linked to solenoid valves was devised.

Measuring the cumulative flow from two pump discharge pipes in an MVIDD canal

Using this system, a single sensor could be used for all levels being measured, thus eliminating some of the variability inherent with the use of multiple sensors. The bubbler sensor technology also allows a pressure measurement to be translated into a water level without bringing the pressure sensing instrument into contact with the water. Hence, for a combination of reasons, measuring water with a long-throated flume instrumented to apply the venturi solution has been a viable alternative for measuring flow at selected sites at MVIDD.

Long-throated flumes equipped for venturi solution flow measurement can be a cost-effective flow measurement option for sites where operation of conventional open channel flow devices is not feasible under all operating conditions due to limited head availability. As seen at the MVIDD sites, the bubbler sensing configuration that was devised for measuring multiple water levels (which are needed for the venturi solution measurement system) can provided an added advantage of keeping sensitive instrumentation out of contact with the water carrying corrosive agents. **Tom Gill, 303-445 2201**

Designing an economical overshot canal gate for irrigation districts

Overshot gates offer many advantages over stop log bays and other types of gates, including:

- Passing discharge variations down canals with limited water level fluctuations, which helps conserve water and limit delivery fluctuations
- Allowing surge flow and debris to pass over and carry on downstream
- Operating without creating the dangerous undertow currents that sluice gates create.

Overshot gate at Bostwick

However, converting stop log bays to overshot gate control is difficult for many irrigation districts because commercially produced overshot gate systems tend to be prohibitively expensive. Thus, this Science and Technology Program research project is developing detailed designs for an overshot gate that districts can readily construct themselves which can be readily adapted to automated and/or remote operation.

During 2010, prototype overshot gates were constructed and installed at Bostwick Irrigation District at a site near Red Cloud, Nebraska and at the South Platte Ditch Company at a site near Merino, Colorado. At the Bostwick site, the overshot gate was installed in a two-bay check. During the 2009 season, district staff built and installed a vertical sluice gate in the left bay. The district also installed an overshot gate in the right bay prior to watering up the canal for the 2010 season. Automated operation will be based on maintaining a target upstream water elevation. The algorithm for this gate combination will call for overshot gate adjustments as needed to keep the vertical sluice gate opening within a target range to the extent possible. The district also constructed two additional overshot gates for installation at other checks prior to the 2011 season.

The South Platte Ditch overshot gate system was constructed with side panels and a bottom plate. Square tubing attached vertically to the outside of the side panels are held equidistant by a horizontal round pipe section welded at top of the square tubes. This gate structure was designed as a “drop-in” to fit the existing stop log bay. This gate is approximately 48 inches

wide and has a maximum raised height of approximately 48 inches. During the 2010 season, the gate actor was manually operated. After the 2010 irrigation season, a radio control unit will be installed and programmed to operate the gate to maintain a constant upstream water level.

Projected cost of the South Platte Ditch gate system complete with solar charging system and radio/control automation equipment is approximately $6,000. Cost of the Bostwick installation is approximately $4,000 (as radio/control and solar charging equipment were already in place). For districts with in-house steel fabrication capabilities commonly needed for routine maintenance work, the self-constructed overshot gate system may be a highly cost effective alternative to commercially produced overshot gates. **Tom Gill, 303-445-2201**

Mining water billing data to identify areas with the greatest potential to conserve

Expanding urban populations and increasing urban water crises underscore the need for Reclamation to promote urban water use efficiency. This Science and Technology Program research project is identifying analytic approaches to use billing data provided by Water Districts to help guide water conservation efforts. This research first quantifies landscape water use to determine individual users' capacity to conserve and then statistically quantifies water savings effectiveness of conservation programs.

This research is done with Reclamation's Water Conservation Field Services Program (WCFSP) in partnership with universities, the Extension Service program, and many other state and local partners to promote more efficient water use by the urban water users.

Irrigated urban landscapes account for 50-70 percent of total yearly water use for these agencies, thus are a principal focus for water conservation program employing rebates for water efficient appliances, water use ordinances, and education programs to encourage low water landscaping.

Extracting data is often difficult because the data are collected by Water District in formats not amenable to analysis. The software developed for this project will facilitate data transformation and analysis. The goal is to have the data tie into a Geographic Information System (GIS) so that indoor and outdoor water use can be determined and priorities established for conservation efforts. **Fred Liljegren, S801-524-3765**