RECLAMATION
Managing Water in the West
July-Sep. 2007

# S&T Highlights

## Director's Office (Denver, Colorado)

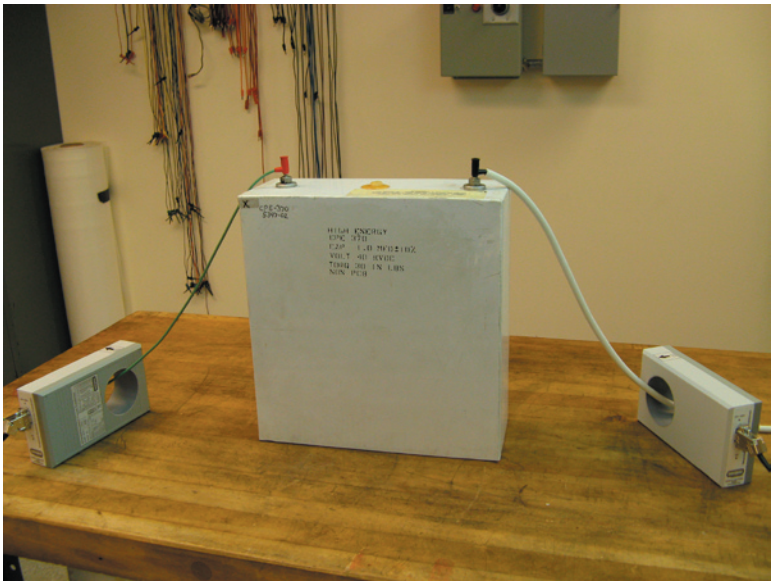
*Meeting for the annual Program Review*.—Research and Development Office members and Science and Technology Regional Coordinators met in **Boulder City, Nevada** September 18 to 20 to conduct the annual Program Review for fiscal year (FY) 2008 research proposals. The Program Review synthesizes the relevancy and technical review results, which were conducted in July and August, plus factors in Program goals, Administration and steering team priorities, progress, and affordability to arrive at funding decisions. Since there is a continuing resolution through November 16, 2007, funding levels may have to be adjusted. There were 155 submitted research proposals for FY 2008. (Siegie Potthoff, 303-445-2136)

## Improving Infrastructure Reliability

*Direct current microammeter*.—The focus of ongoing power system diagnostics research by the Hydroelectric Research and Technical Services Group of the **Technical Service Center (TSC)** is to develop new methods to diagnose abnormal equipment operation, assess the effects of aging and wear, and minimize costly downtime. The Group's review and performance analysis of existing industry technology shows promise toward the development of a "clip-on" style current transformer for powerplant generator insulation fault location and general insulation diagnostics. One of the goals is to develop a clip-on style noncontact current measurement device that can be used to identify and locate insulation problems and faults within a generator winding. This cutting edge technology is capable of indirectly measuring very small amounts of direct and alternating current, but it needs to be adapted for Reclamation's insulation diagnostic needs.

The ability to indirectly measure small amounts of direct or alternating current will allow the user to track and locate insulation problems in new windings, older windings exhibiting problems, and windings that have failed. The ability to locate these problems will result in enhanced standard test diagnostics, timely repair decisions, and expedited return to service of failed generator windings, thus reducing costly downtime and lost revenues. (Eric Eastment, 303-445-2324)

U.S. Department of the Interior
Bureau of Reclamation
Science and Technology



State-of-the-art current transformers measuring small direct-currents through a capacitor during an evaluation test period.

*Researching generator core loop flux test techniques*.—Generator stator core loop flux tests typically are performed as acceptance tests on new cores as well as on older cores to determine if the condition of the core warrants replacement or repair. This condition assessment may be necessary if a generator is being rewound, or if damage is incurred electrically due to a generator winding insulation fault or mechanically due to rubbing or abrasions. Generator stator cores are made up of thin steel sheets (laminations) coated with a thin layer of insulation to prevent circulating currents in the core. The core loop flux test assesses the integrity of the interlaminar insulation.

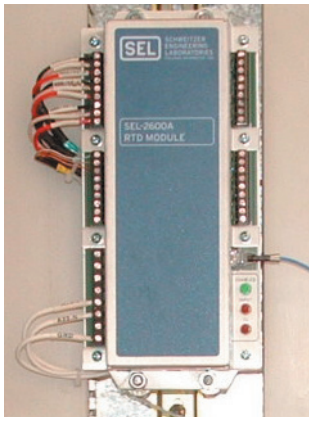
When performing these tests, calculations are made to approximate the magnetic flux test requirements. However, the calculations can vary greatly from actual test values. Therefore, we desire to research the test techniques to unveil reasons behind the wide variations in calculated values versus test values, and to attempt to quantify these variances. The Hydroelectric Research and Technical Services Group recently purchased generator stator core laminations at one-sixth scale of an actual hydroelectric generator at a Reclamation facility. These laminations were stacked and assembled to imitate a stator core for researching test methods and techniques of the stator core loop flux test (see photo below). Refining pretest calculations will save powerplant personnel both time and money as they will be able to better set up for the test using proper materials with less uncertainty involved. (Jill Smith, 303-445-2307; Phil Atwater, 303-445-2304)

Generator stator core model undergoing a core loop flux test in the Hydroelectric Research and Technical Services Group laboratory.

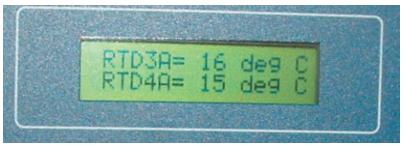
*Transformer age monitor*.—As a result of research efforts into cost-reducing benefits of new and/or improved technologies, a transformer age monitor has been installed at **Blue Mesa Powerplant** that will provide information about the health of powerplant transformers. The transformer monitoring system works with existing transformer relays and resistance temperature detectors (RTDs) (see photo below) to help predict the end-of-life of the transformers.

The unit works by measuring internal transformer temperatures, load currents, and thru-fault currents. It then performs calculations based on predetermined algorithms to estimate the end-of-life of a transformer. The data are collected and trended over time, allowing maintenance personnel and engineers to make changes to the way the equipment is used and assess when it may become necessary to perform needed maintenance.

In the event of a transformer failure, unscheduled outages of up to 1 year can result in lost revenue (up to $50 million), and the typical replacement cost for large transformers can be over $2 million. This device will forewarn Reclamation operation and maintenance personnel of impending failures and give them time to repair or replace equipment. (Nathan Myers, 303-445-2643)




Transformer age monitor.



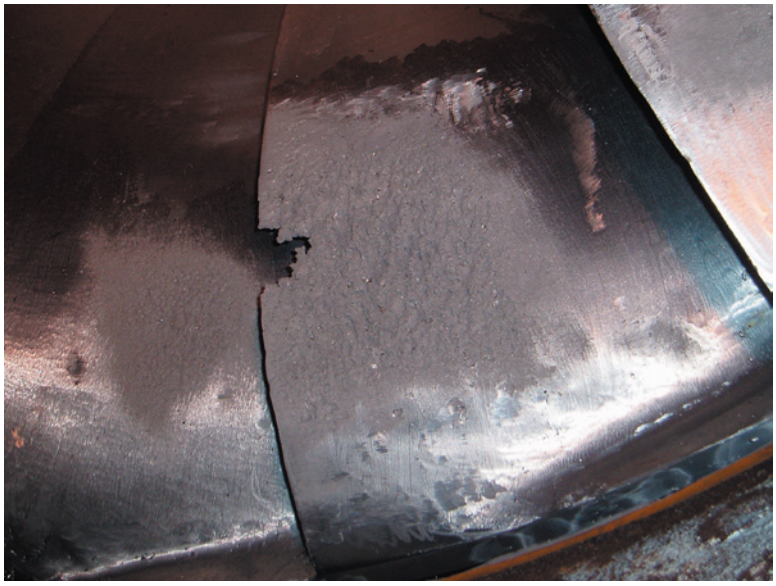

Temperature readings from RTDs.

*Turbine cavitation detection*.—Turbine cavitation is an ongoing issue in the hydroelectric industry. Turbines are designed for specific operating conditions to give the best possible performance in converting water flow to mechanical power used for power generation. However, the turbine is often required to operate at less than ideal conditions as the result of low reservoir levels, downstream water requirements, or electric power system requirements. Certain flows at these off-designed conditions promote cavitation.

Cavitation is defined as the formation of bubbles (on turbine blades, in this case) filled with vapor and/or gas in a liquid. Cavitation is to be avoided, as it reduces the turbine performance and erodes metal. The resulting metal damage on a turbine blade can be seen in the photo below.

The Hydroelectric Research and Technical Services Group is investigating newly developing techniques to monitor cavitation activity on turbine runners. Within the last year, several tests have been performed at three Reclamation plants to evaluate these monitoring techniques. Sensors (see photo below) detecting noise produced by cavitation have been installed on various turbine equipment. This includes equipment such as the draft tube (see photo below), the wicket gate stem, and the turbine bearing. An amplifier/filter also has been designed, built, and installed that permits the sensor to connect to existing condition monitoring equipment (see photo below). This allows for continuous monitoring of the cavitation signal.

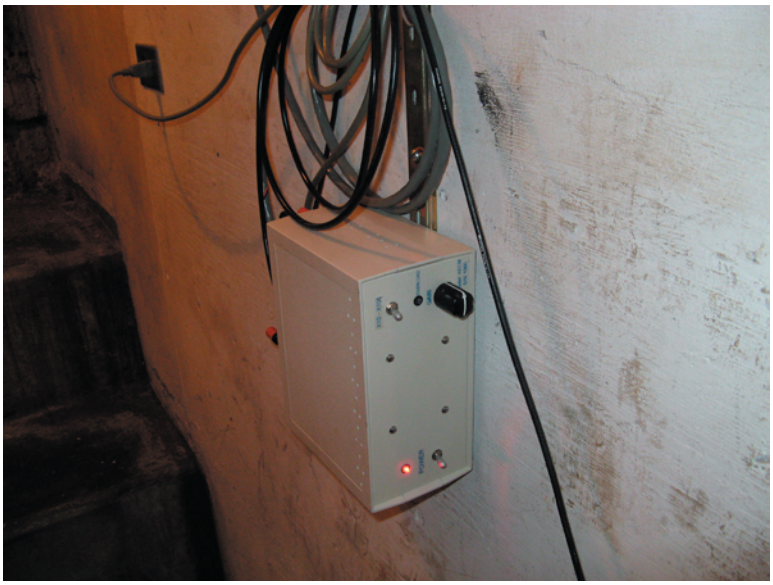
The goal of this investigation is to develop a reliable method to detect the onset of cavitation. This information would allow plant operations personnel to avoid running the unit at flows producing cavitation, thus reducing turbine damage. (Jim DeHaan, 303-445-2305)



Cavitation on a Reclamation turbine blade.

Sensor used for cavitation detection.

Cavitation system detection installation.



Prototype amplifier/filter for sensor.

## Improving Decision Support

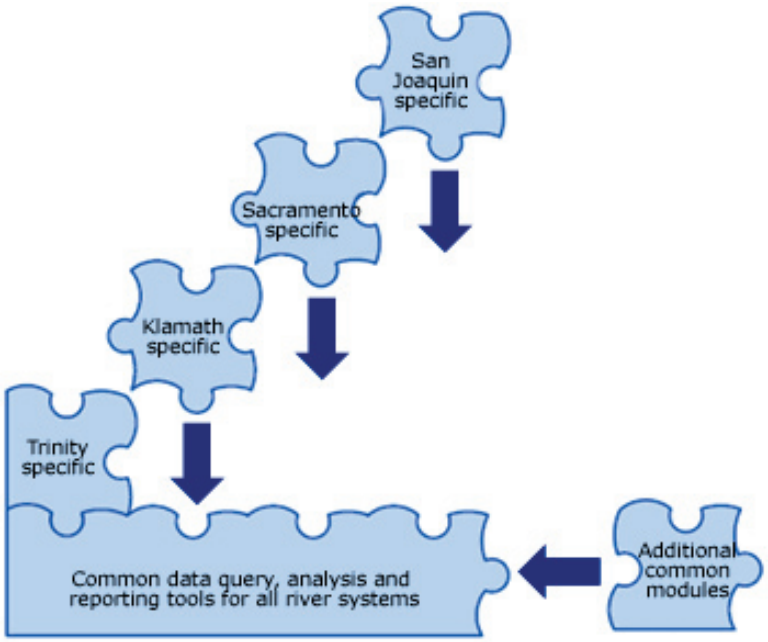
*Trinity River restoration program*.—A new, multidisciplinary scientific database has been deployed and is under evaluation in the **Mid-Pacific region**. The integrated information management system (IIMS) is a centralized warehouse for collecting in one place the disparate scientific data used to support the management of river systems. The IIMS vision is to build a modular information management system by combining the common needs of several river systems into a central tool (see figure below) that can simplify the repetitive tasks of obtaining frequently used data and performing routine analysis.

The IIMS is being developed jointly with funding from the Reclamation Science and Technology Program, as well as funding from the **Northern California Area Office's** Trinity River restoration program (TRRP, www.trrp.net), the **Klamath Basin Area Office** (for the **Klamath River**), and the **South Central California Area Office** (for the **San Joaquin River**). The system uses a centralized Oracle database located in the Mid Pacific region office in **Sacramento** that is accessible by anyone in Reclamation.

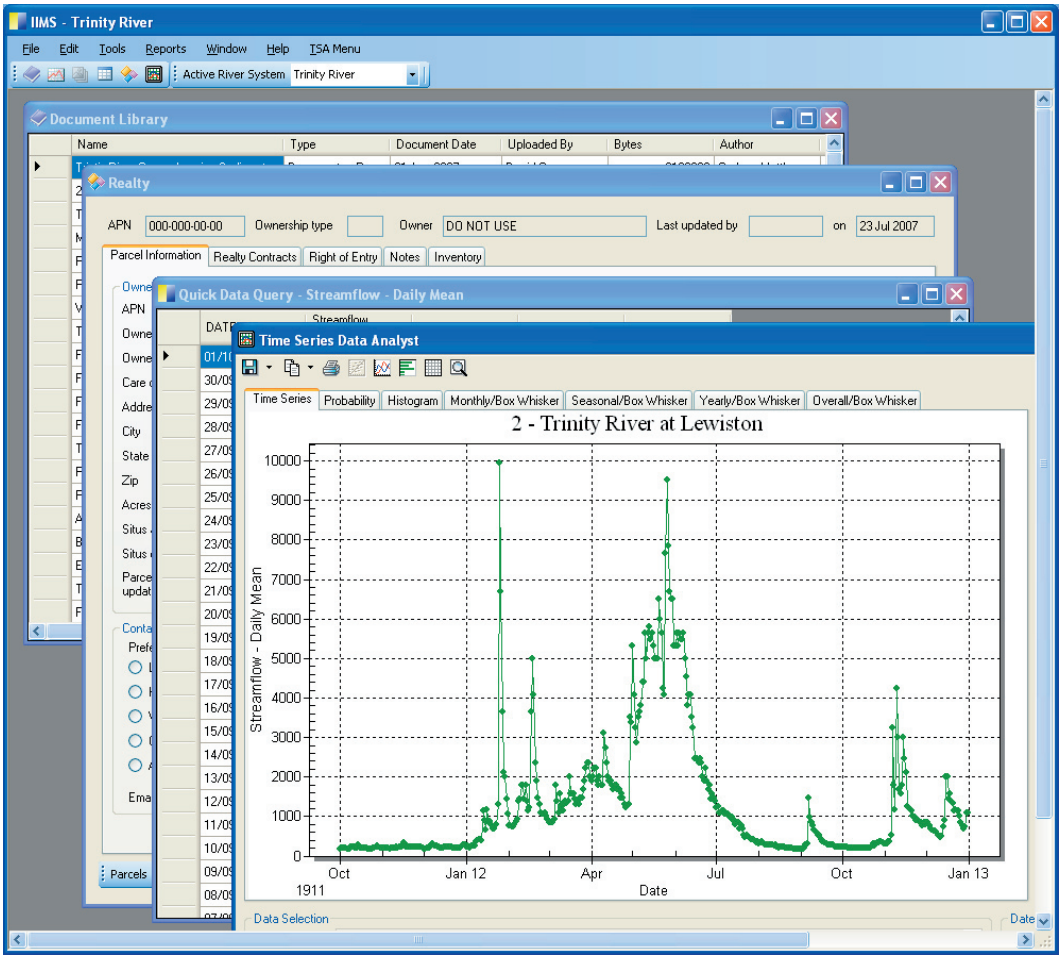
Data must meet various criteria before they are incorporated into the IIMS. They must be quality controlled and of high priority and widespread need. Once data are imported into the IIMS database they are available for visualization through the Time Series Analyst (see figure below) and can be downloaded through a "quick data query" interface. Several custom analysis tools are also being developed in Microsoft Excel for quick repetitive tasks, such as custom data analysis. Data visualization and analysis tasks benefit from having disparate datasets in one integrated data store. For example, calculating bedload sediment transport rates uses both streamflow and bedload data. Examples of the types of data already in the IIMS are streamflow, sediment transport, water temperature, lake temperature profiles, fish populations, realty land ownership and return on equity, reservoir inflows and releases, dam elevations and storages, water quality, and a document library.

The IIMS data are spatially referenced and can also be accessed through a suite of custom ArcGIS tools. These GeoIIMS tools (see figure below) are intended to make it easy for relatively inexperienced geographic information system (GIS) users to produce useful preformatted maps for their project areas.

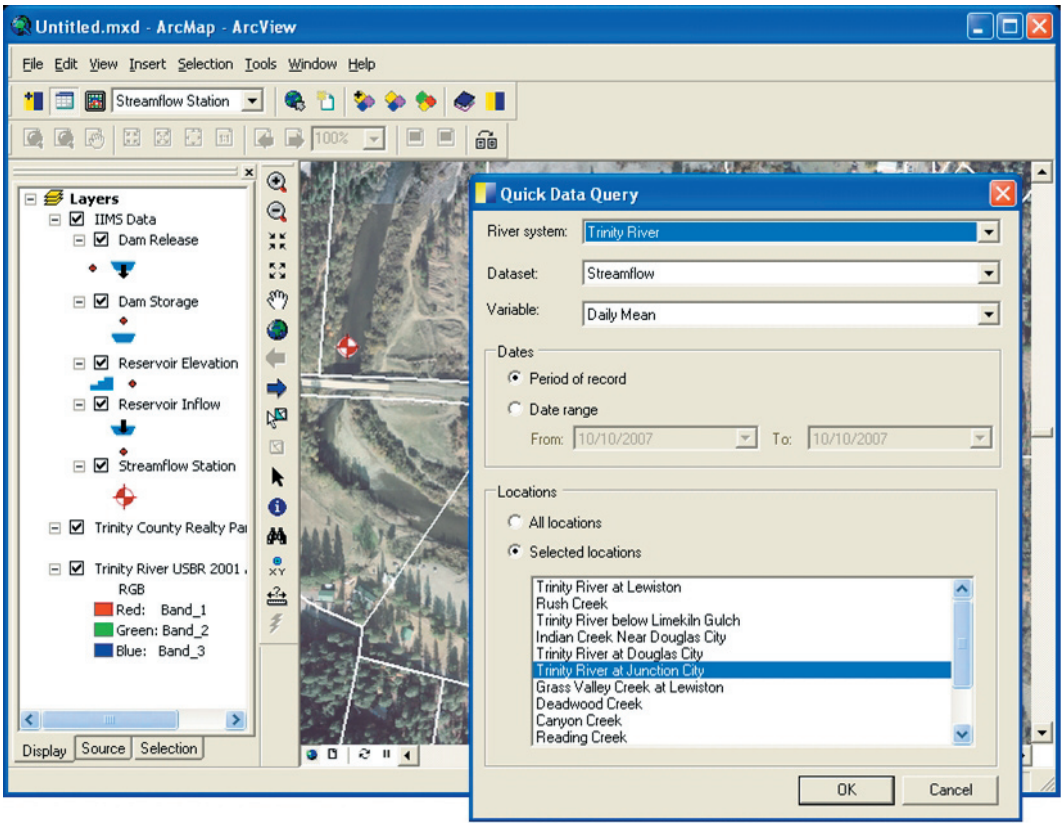
With the IIMS, Reclamation staff are able to more quickly retrieve and share the scientific data that they need on a daily basis without having to repeatedly search for and control for the quality of the same data repeatedly. (Andreas Krause, 530-623-1807)




Modular approach used to design the IIMS database.




Automated data visualization in the Time Series Analyst tool.




Linking tabular and spatial data in the GeoIIMS tool.

*Managing water resource conflicts*.—Reclamation's Research and Development Office and the **Upper Colorado (UC) Regional Office**, held a workshop at the University of Utah entitled *Institutional Solutions for Water Resource Conflicts: A Forum for Reclamation Managers*. The purpose of the workshop was to allow Reclamation managers to (1) discuss successful strategies for managing water conflict, (2) expose them to current conflict management research, and (3) provide information about new and emerging conflict management computer technologies.

UC Regional Director, Rick Gold led off the workshop. He spoke about the causes of conflict (competition, historic conflict, differing values), what managers can do about it (seek areas of flexibility, collect accurate data, find leverage points), and strategies for success (know your own position and others, understand end points, be inclusive, know how to close). Other Reclamation personnel followed Mr. Gold to speak about Reclamation-wide issues as well as region-specific conflict and collaboration case studies. Experts from Oregon State University, the University of Utah, the Public Policy Research Institute at the University of Montana, the Policy Analysis and Science Assistance Branch of the U.S. Geological Survey, and the Massachusetts Institute of Technology also spoke.

For a CD of the workshop, please contact Douglas Clark at drclark@do.usbr.gov. (Doug Clark, 303-445-2271)

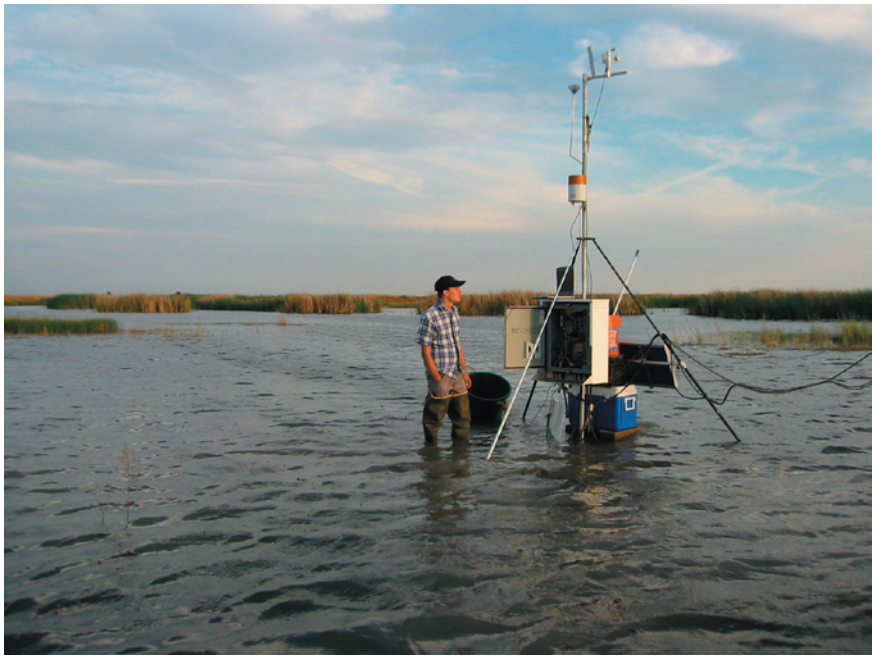
Curt Brown, Director, Research and Development (left), with Matthew McKinney, Director, Public Policy Research Institutute, University of Montana.

*Tools to assess seasonal wetland management practices for water conservation and salinity management*.—Managed seasonal wetlands in **California's San Joaquin Valley** are an important national resource providing overwintering habitat to waterfowl in the Pacific Flyway. These wetlands are irrigated during the summer to closely mimic natural conditions prior to the construction of dams on the San Joaquin River and its major tributaries. Saline drainage from these wetlands negatively impacts San Joaquin River water quality providing pollutant loads that contribute to violations of water quality objectives for salt and boron. The Grassland Water District and California Department of Fish and Game (CDFG) have joined with Reclamation and Berkeley National Laboratory in an experiment to improve the understanding of salt balance on seasonally managed wetlands. Reclamation's role in this multi-agency experiment has been to collect original wetland evapotranspiration (ET) data at a Bowen weather station located on a seasonal wetland in the Gadwall unit (see photos below) and within the Los Banos Wildlife Management Area complex, which is managed by the CDFG. These data will be compared with evapotranspiration estimates obtained by (1) mass balalnce and (2) the use of Landsat data and an Energy Balance ET methodology from Colorado State University. Evapotranspiration estimates for the 2006/2007 season were compared with potential ET rates obtained from nearby sites that are part of the California Irrigation management Information System (CIMIS). Three stations that report ET data to the CIMIS network were selected primarily for their geographic proximity to the Gadwall unit.

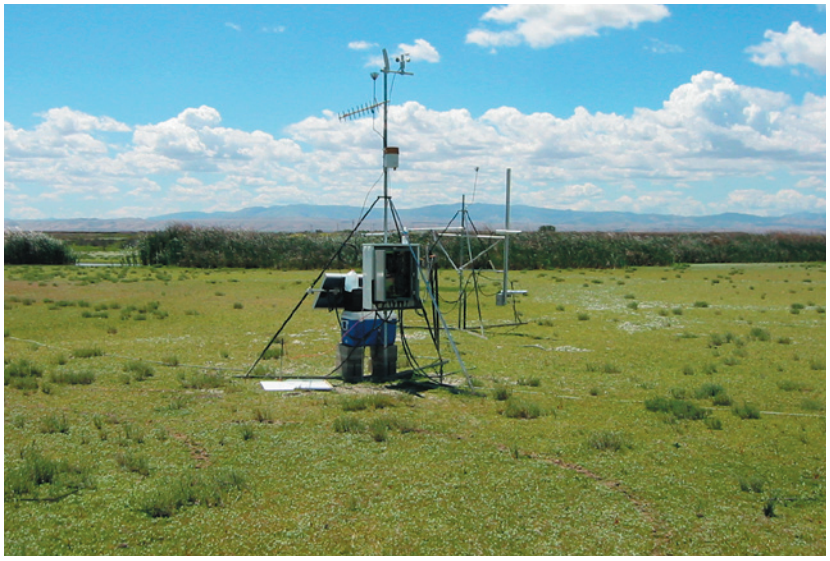
The data collected at this station during 2006/2007 (see figure below) show that estimates of potential ET made by the CIMIS network stations are comparable

with estimates of ET from the Bowen Ratio Energy Balance system. Ongoing work with remote sensing data may allow for accurate estimation of percentage cover of each plant species at each stage of the growing season. Using the ET estimates from the Bowen weather station in conjunction with accurate remote sensing data on species density and distribution throughout the growing season, it may be possible to develop a species coefficient ($K_S$) specific to each species, for open water, and bare soil. Using these species coefficients along with species density and distribution data, this model might be applied to arrive at landscape coefficients ($K_L$) in other similar wetlands based on ETo reported by the CIMIS network.

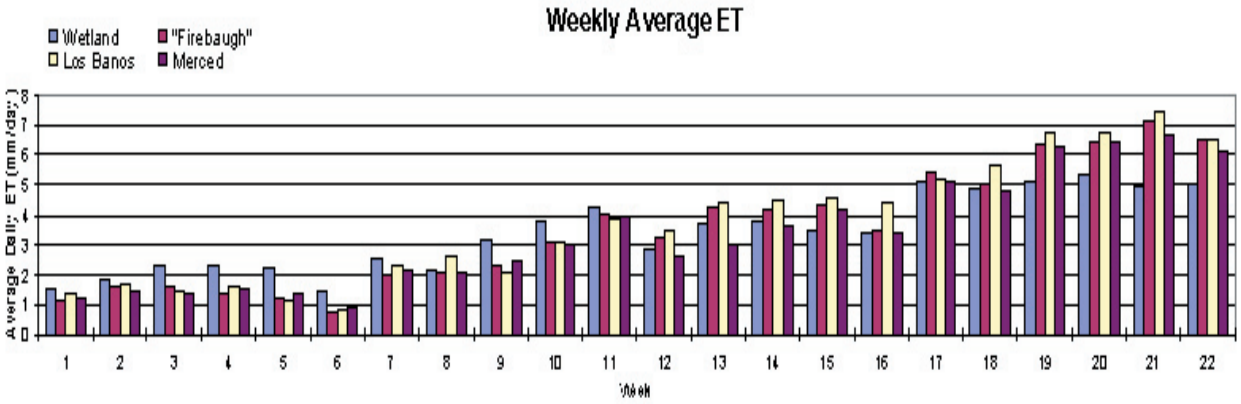
The information collected as part of this cooperative, inter-agency study will be used to improve the understanding of wetland water and salt balances and help to develop seasonal wetland best management practices. Improved knowledge and predictive capability using simulation modeling will allow the manipulation of annual drawdown management practices in a manner that preserves optimal marsh habitat for migratory wildfowl and sustains hunting success while improving compliance with State water quality objectives. (Nigel W.T. Quinn, 916-978-5079; Tracy Slavin, 916-978-5202; Jeff Milliken, 916-978-5267)



Bowen weather station after wetland flood-up in September 2007.



Bowen weather station in spring 2006 after wetland drawdown showing emergent swamp timothy.




Comparison of Bowen weather station ET estimates with surrounding CIMIS stations.

## Improving Water Delivery Reliability

*Spiny softshell movements and habitat usage,* ***Upper Missouri River, Montana***.— Twenty-two spiny softshell turtles were affixed with radiotransmitters and tracked during the summer and fall of 2007. The spiny softshell is considered a Species of Concern in Montana due to its fragmented population and lack of recent sightings in portions of its range. The species typically inhabits slower sections of larger rivers and streams where it basks on banks and forages for food. While this study is still in the early stages, preliminary data suggest that the radio-tagged turtles in the Missouri River are using backwater and slough-type habitats for a majority of their activities and occasionally venture into faster moving currents. One individual moved almost 30 miles downstream in two months. Data from

this study will help the Bureau of Reclamation to better manage the Upper Missouri River and its aquatic inhabitants. (S. David Moore, 303-445-2242)

A spiny softshell turtle affixed with a radiotransmitter.

## Improving Water Supply Technologies

*Long-term testing of irrigating salt-tolerant plants with concentrate produced by reverse osmosis (RO).*—As **Arizona's** population grows and the demand for water across the State increases, responsible use of water resources involves full utilization of **Central Arizona Project (CAP)** water. Such use depends on salinity management, inasmuch as the salt concentration in CAP waters is three times higher than the average water being delivered to residential customers. RO can be used to maintain the salt levels, but treating the saline water with RO results in the generation of a concentrate stream. There are many management options for concentrate including discharge into surface waters, evaporation ponds, deep well injection, zero liquid discharge, and land application via irrigation. However, each of these options presents significant obstacles to implementation including negative environmental impacts, technical challenges, and cost.

The Bureau of Reclamation along with the towns of **Marana** and **Oro Valley**, the Metropolitan and Flowing Wells water districts, the **City of Tucson**, and the University of Arizona are using the concentrate residual from reverse osmosis treatment for irrigation of lawns, parks, golf courses and agricultural crops, which if managed properly, is a viable option for concentrate management. Slowsand filters for potable water treatment and RO to reduce the salt content of water from the CAP are being used as cost effective ways to produce the concentrate.

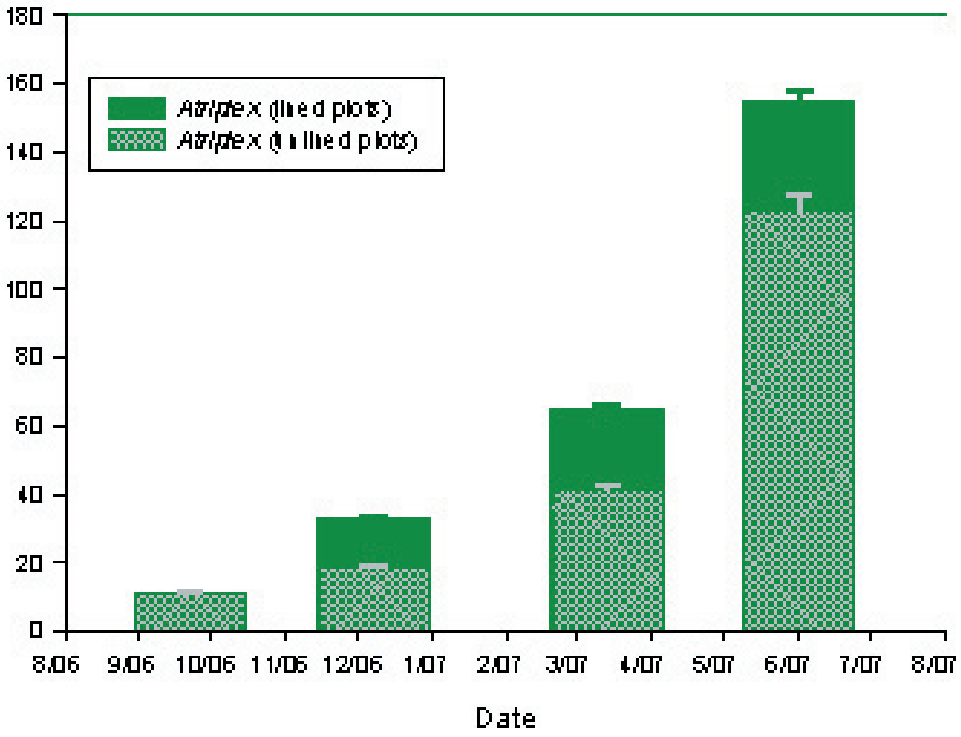
The focus of the study is on developing best management practices for irrigating salt tolerant turf or crops with concentrate. Water use by the plants is being monitored in order to determine the best irrigation strategy, and water and salt movement through the soil are being monitored to check how salt moves through the soil and to be able to evaluate the possible risk of groundwater contamination. Lined and unlined planting plots are planted with *Atriplex lenitiformis,* a riparian salt-tolerant shrub; the remaining plots contain a salt-tolerant turfgrass. Each plot receives one of four irrigation regimes:

- Regime 1. Plots are irrigated according to the needs of a reference plant evapotranspiration (Eto).
- Regime 2. Plots are irrigated at1.5 times the Eto.
- Regime 3. Plots are irrigated at a uniform or constant rate.
- Regime 4. Turfgrass plots are irrigated at a rate of 0.85 times the Eto.

The performance is being evaluated by obtaining direct measurements of the daily concentrate use, concentrate salinity, drainage, soil moisture, plant growth and plant water use. Plant growth is measured every 3 months by determining the plant height and the average width.

Measurements indicate that irrigation regime 2 is receiving more water (and salt) than the other two irrigation regimes and that this is reflected in the plant growth measurements (see photos below). Plant height increased dramatically in response to an increase in the irrigation volume, irrigation salinity, and average daily temperature. The mean plant height was significantly greater for plants irrigated under regime 2 compared to regimes 1 and 3. (Eric Holler, 520-670-4825)

Photographs of lined *Atriplex* plot development over time (left top). The plots were fitted with an irrigation system and *Atriplex* were transplanted. Plant growth over the course of the next year was documented by photography, December 2006 (right top), April 2007 (left bottom) and September 2007 (right bottom).




Average plant height (cm) measured quarterly for Atriplex in the lined and unlined plots.

*Urban conservation opportunity—efficient turf irrigation*.—As the population in the arid West increases, landscaping puts more pressure on existing water supplies. The increased demand on this finite resource will require greater efficiency to optimize the use of water in landscapes.

Previous studies of water needed for turf grass have measured the maximum amount of water needed to keep the lawn looking nice while maintaining health and vigor. This study is looking at the minimum amount of water needed to have the desired look without having a significant negative impact on health and vigor. This study will determine a "turf grass water demand factor." The study looks at predominate grass species used in the urban environment and grass mixes that have claims of lower water use.

The study will determine the optimum irrigation schedules to respond to the growth cycle of each turf grass species and turf grass mix. A better understanding of the growth cycle will provide important information on when the plants require the most water and when the water demands are less, even during hot and dry periods in the summer.

Soil moisture sensors, using electronic pulses through wires, are used to determine true volumetric moisture. This approach is cost effective, can be repeated at other locations throughout the West, and only requires a small plot.

All the equipment has been installed (sprinkler system, turf grass plots, moisture sensors, tipping buckets, water meters, rain gauge, wiring, data loggers, and computer software). The data are being collected, which will continue for a total of three years. Each year, the data will be evaluated and observations made to determine a "turf grass water demand factor" for each of the turf grass species evaluated.

The study will document the methodology and equipment being used to determine the turf grass water demand. This is a new and innovative approach that, if shown to be accurate, could be used as a more cost effective approach to lysimeters for future research with other plant species.

The study area is open to the public and professionals to visit. Tours can be arranged by calling the Northern Colorado Water Conservancy District in **Berthoud, Colorado** at 970-532-7700. (Fred Liljegren, 801-524-3765)


Study location at Colorado Water Conservation District Conservation Gardens.

Study plots showing turf grass, tipping buckets, and irrigation controllers.

Tipping bucket container showing data logging connection.

Cabinet containing data logging equipment from sensors.