

~Enhancing Water Supply Reliability~

An Interdisciplinary Research Project to Enhance Predictive Capacity on the Colorado River

Quarterly Newsletter

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Issue #7

Two years of Colorado River research culminate with workshop, final report

Final report available online; Second phase of research underway with new stakeholder initiatives

On September 6, 2006, the University of Arizona's Enhancing Water Supply Reliability research group held a stakeholder workshop at the Decision Center for a Desert City in Tempe, Arizona. The event featured presentations by project researchers on all four facets of the interdisciplinary effort to improve predictive capacity and decision support on the Colorado River. Project researchers shared research findings on climate science applications and water supply reliability support tools with stakeholders from the Bureau of Reclamation (Reclamation), Salt River Project, AZ Dept. of Water Resources, Central Arizona Project, conservation organizations and others involved in the management of the Colorado River Basin.

Workshop presentations and final reports are available online at the project website:

<http://ag.arizona.edu/azwater/ewsr>

The September 2006 workshop completed the first two-year phase of research and also marks the start of a new phase of research that extends until fall 2008. Stakeholder feedback received during the workshop has influenced the research agenda for the next two years. This newsletter will outline the research priorities that have been established for the second phase of work.

Phase II of this project involves further development of our research partnership, including the Arizona Water Institute - a collaboration of the 400 faculty members at Arizona's three universities. The **work over the next two years** will include demonstrating additional strategies for enhanced use of climate information in Bureau of Reclamation river system modeling and river operations.

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The UA research team encourages stakeholders to contact project researchers with questions, suggestions, and feedback.

See contact information on pg. 8.

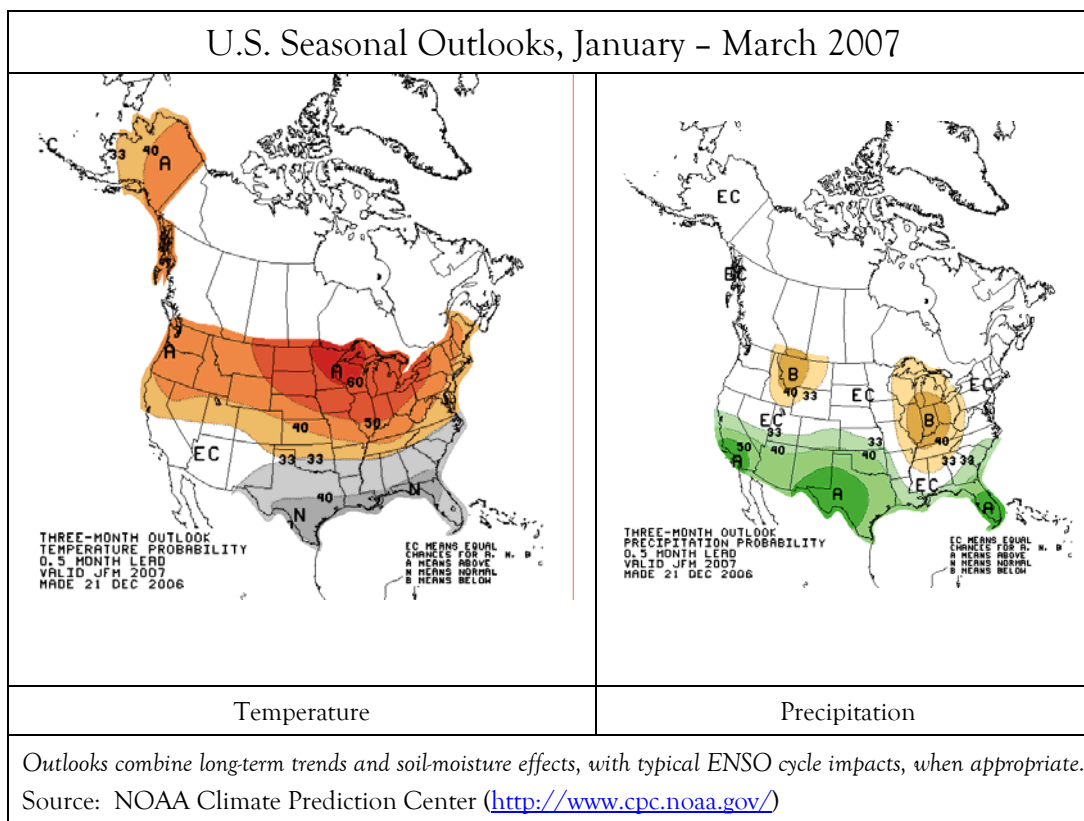
Research themes under consideration:

- (a) Demonstrating how tree ring-generated flow information can be used in modeling activities;
- (b) Demonstrating the use of downscaled global circulation model forecasts and climate change predictions to improve predictive capacity and reduce system vulnerability for the Colorado River system;
- (c) Focusing on predictive capacity in subwatersheds within the Lower Basin, where the El Nino Southern Oscillation signal is strongest;

- (d) Evaluating specific management tools designed to translate improved predictive capacity into enhanced supply reliability for water users, including tools that can be used by federal and state agencies, municipalities, irrigation districts, tribes and other stakeholders; and
- (e) Engaging with other research groups and key stakeholders to tailor research foci, approach and findings for applications of interest to Reclamation and other stakeholders.

Drought and Water Supply Report

The Climate Assessment for the Southwest reports that drought conditions have eased throughout Arizona and New Mexico. The National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center has issued an [ENSO advisory](#)¹ to announce the onset of an El Nino event, which is expected to persist through May 2007.² El Nino events are typically associated with above average winter precipitation in the Lower Colorado River Basin; however, the El Nino signal provides ambiguous predictive capacity for the Upper Colorado River Basin where over 85% of the Basin's annual water runoff is generated. The NOAA Climate Prediction Center seasonal outlook (see figures below) suggests that El Nino impacts in the Lower Basin may include above average precipitation between January and March 2007. The NOAA seasonal outlook also projects above average winter temperatures in the Upper Basin. Elevated winter and spring temperatures could impact the rate of sublimation (direct conversion of snow to water vapor), potentially diminishing the spring and summer snowmelt runoff into Colorado River reservoirs.



Winter snowpack generates a runoff pulse as snow melts from April to July, and, therefore, April to July runoff provides an important indication of annual water supply conditions. In 2006, inflow into Lake Powell during this period was 67% of average, despite forecasts in April 2006 that predicted runoff at 97% of the average inflow.

Water supply in the Colorado River Reservoir System is relatively insensitive to short term deviations from 'normal' inflow conditions due to a 4:1 ratio of reservoir storage to annual runoff in the Basin. In water year 2006, the unregulated inflow³ into Lake Powell was 73% of average, and these inflow conditions represent the sixth year in the last seven with below average inflow. Despite an unprecedented sequence of dry years from 2000

¹ http://www.cpc.noaa.gov/products/analysis_monitoring/enso_advisory/

² El Nino refers to "a disruption of the ocean-atmosphere system in the Tropical Pacific having important consequences for weather and climate around the globe." (see <http://www.elnino.noaa.gov>)

³ Unregulated inflow refers to observed inflow corrected for upstream reservoir effects.

to 2006 - constituting the driest seven-year period in the provisional instrumental record of natural flows ~ Colorado River system storage is currently at 57% of full capacity and remains roughly constant with system storage one year ago.⁴ October 2006 witnessed a rare six foot increase in Lake Powell reservoir storage due to above average precipitation events in the direct vicinity of the reservoir. As such, October (the first month of water year 2007) inflows into Lake Powell were 186% of average. The NOAA Colorado Basin River Forecast Center's January 2007 forecast reports that inflows into Lake Powell are anticipated to be 91% of average, or 7.2 million acre feet, during the critical runoff period from April to July 2007.

Update: NEPA Process for Shortage Guidelines & Coordinated Management of Lakes Powell and Mead

Draft alternatives unveiled; Draft EIS due February 2007

By Dustin Garrick

After five consecutive years of below average inflow into Lake Powell from 2000-2004, the Secretary of Interior (Secretary) directed Reclamation to engage in a process to develop (1) shortage guidelines for the Lower Colorado River Basin and (2) management strategies for coordinating the operations of Lakes Powell and Mead particularly during low-reservoir conditions. This process falls within the purview of the National Environmental Policy Act (NEPA). In accordance with NEPA procedural requirements, Reclamation provided notice of its intent to prepare an environmental impact statement (EIS) in September 2005 and solicited public comment on the proposed project. As a result of extensive stakeholder input and analysis of comments, the proposed action to be addressed was refined to include four operational elements, including: shortage guidelines for the Lower Basin; coordinated operations of Lakes Powell and Mead throughout a full range of reservoir conditions; storage and delivery of conserved system and non-system water in Lake Mead; and modification and /or extension of the Interim Surplus Guidelines. Reclamation anticipates that the operational guidelines will be interim in nature (put in place through 2026).

On June 30, 2006, Reclamation released five draft [alternatives](#)⁵ that meet the purpose and need of the proposed action, represent a broad range of reasonable alternatives, and will allow the evaluation of a broad range of potential impacts in the draft EIS (DEIS):

- No Action Alternative
- Basin States Preliminary Alternative
- Conservation Before Shortage Alternative
- Water Supply Alternative
- Reservoir Storage Alternative

Each alternative identifies operating strategies for the four operational elements noted above. Reclamation officials developed a matrix that compares key aspects of the five alternatives (available at the Bureau of Reclamation project [website](#).⁶

Reclamation expects to publish the draft EIS in February 2007. The DEIS will define the geographic scope and analyze the potential environmental effects associated with implementing each of the proposed alternatives

⁴ As of the "Weekly Water Supply" report published 1/4/07 by Reclamation at: <http://www.usbr.gov/lc/region/g4000/weekly.pdf>

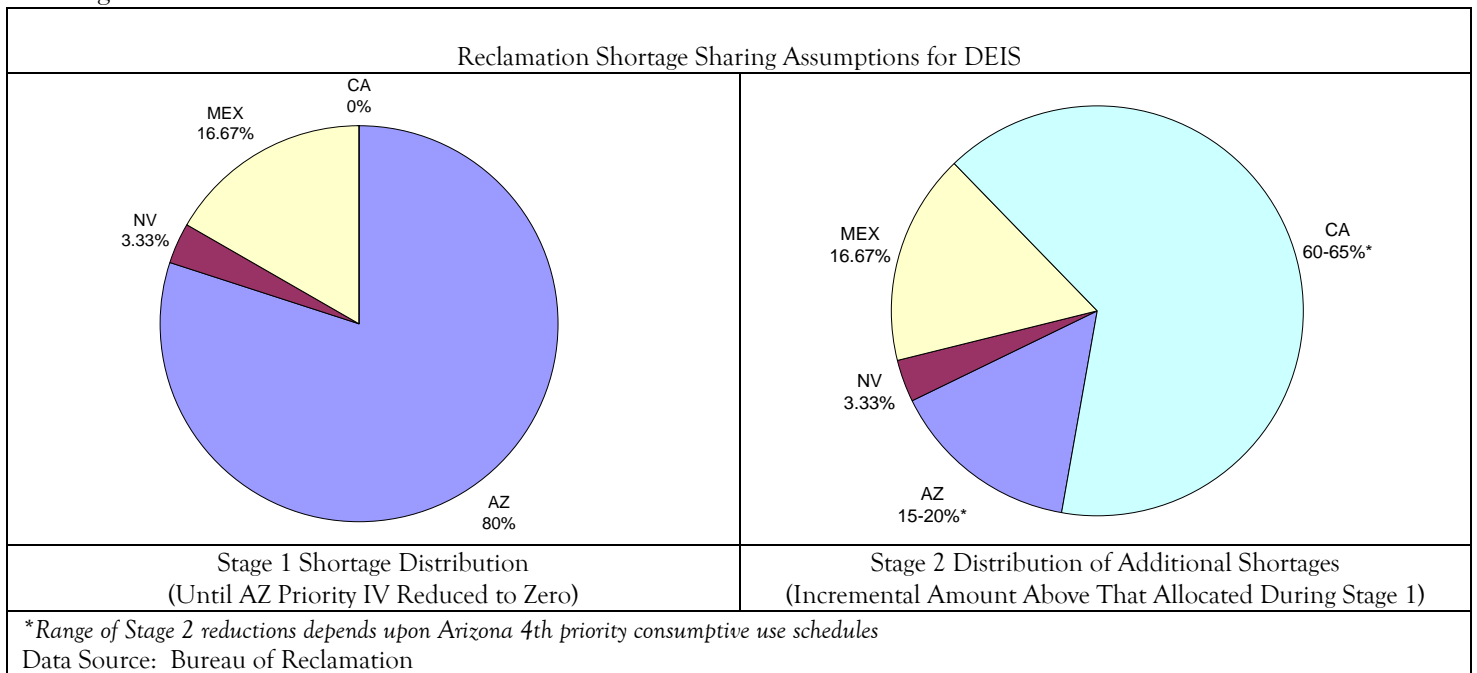
⁵ <http://www.usbr.gov/lc/region/programs/strategies/alternatives/matrix.pdf>

⁶ <http://www.usbr.gov/lc/region/programs/strategies.html>

enumerated above. In accordance with key provisions of the Law of the River⁷, the Secretary of Interior has the authority to declare and allocate shortages to the Lower Division states. Although some guidance exists with regard to how shortages would be allocated (e.g., Present Perfected Rights must be met without regard to state lines, California does not incur shortages until Arizona post-1968 contracts are reduced completely), there are no specific guidelines in place to further inform the Secretary’s decision with respect to how shortages might be shared by the water users in Arizona, California and Nevada. In addition, the determination of shortages to Mexico does not fall under the authority of the Secretary, and therefore is not a part of the proposed federal action. Nevertheless, in order to analyze the range of potential impacts to hydrologic and other environmental resources associated with the five alternatives, Reclamation assumed certain shortage sharing distribution percentages in a two-stage strategy (see figures below). The shortage modeling distribution assumptions are identical for all of the alternatives being analyzed.

Under Reclamation’s assumptions, two stages of shortages are identified, each with a distinct distribution of shortages among the three Lower Colorado River Division states and Mexico. These stages are defined in relation to the shortage impact on Arizona’s Priority IV Colorado River water users, a group that includes Central Arizona Project contract holders as well as on-river users with priority dates after the passage of the Colorado River Basin Project Act of 1968 (post-1968).

Under the *first* stage, shortages are shared by the most junior user within Arizona and Nevada, and with Mexico. Shortages would continue until the deliveries to the post-1968 water rights holders in Arizona are reduced to zero. Shortages during this *first* stage would be apportioned to Arizona (80% of shortage reductions), Nevada (3.33%), and the Mexico (16.67%). Under stage *two* shortages, *additional* shortages (after the first stage cuts had taken effect) would be distributed to California (60-65% of additional shortage reductions), Arizona (15-20%), Nevada (3.33%), and the Republic of Mexico (16.67%). The pie charts (below) depict the two progressive stages of shortage distributions.



⁷ For Law of the River documents, see: <http://www.usbr.gov/lc/region/pao/lawofrvr.html>

Reclamation also had to assume how shortages might be allocated and shared by Colorado River water entitlement holders within each state. Absent shortage-sharing agreements among those water users, Reclamation has developed a Shortage Allocation Model to simulate shortage allocation distributions within each state by integrating information about water contracts with the Secretary and other water rights settlement agreements. The model assumes that lower priority users within a state would share shortages on a prorated basis, based on scheduled annual uses.

More details on the NEPA process, DEIS, and shortage guidelines will be unveiled in February 2007. To track the process, visit Reclamation's Lower Colorado Region project [website](#) (see footnote 6).

Phase II approach: Cost-effective supply reliability strategies

By Lana Jones

The economics section of Phase II will focus on evaluating alternative supply reliability management options in the context of the ongoing shortage sharing negotiations among basin state and other stakeholders. We will also evaluate different forbearance program designs and implementation strategies, including management of third-party impacts and price negotiations.

Policymakers from multiple levels of government are currently considering tools to address supply reliability. In Phase II we will develop and demonstrate a method for evaluating the economic tradeoffs between different water uses and options to firm supply reliability. Interested parties will be able to use this framework to systematically compare varying proposals including revised reservoir operations or changes in on-farm water management. The initial analysis will focus on developing several potential drought scenarios characterized by the geographic extent (size) of the area impacted by drought, warning time prior to the onset of drought, length of drought, and drought severity.

Forbearance is one of the key tools being examined to adapt to supply variability linked to climate variability and change. The successful design and implementation of forbearance programs depends on the careful consideration of program elements. As third-party impacts are a major concern for all interested parties, this issue will receive some attention in Phase II, in the context of suggesting mitigation options. Price negotiations are also a vitally important aspect of successful programs, and there are a number of methods for structuring negotiations. We will develop guidelines for price negotiations that highlight the pros and cons of alternative tools for determining price and suggest criteria for determining which negotiation method is most suitable for a specific forbearance context. The work will refine and apply two years of economic research by [Colby et al \(2006\)](#) on farm profitability and net returns to water for irrigating major crops in Yuma and La Paz Counties.⁸

It is useful to identify the specific characteristics that facilitated a program's success and the ways that prior programs have addressed difficulties. We propose the creation of a guide (either booklet or web-based) summarizing tested strategies from forbearance programs worldwide. Each brief case overview will include information on the agricultural districts and irrigators involved in the program, the nature of the program (i.e. temporary, long-term, or permanent), criteria for inclusion in the program, how the price was negotiated, the volume of water transferred and at what price, and unique strategies used in structuring or carrying out the program. Such a guidebook would not only be useful for structuring programs but will also be useful to irrigators and irrigation districts. Information about forbearance programs that addressed urban and environmental

⁸ See Colby B., K. Pittenger and L. Jones. "[Voluntary Irrigation Forbearance to Mitigate Drought Impacts: Economic Considerations](http://ag.arizona.edu/AZWATER/EWSR/COLBY_BOR_forbearance_rpt_20061013.pdf)." October 6, 2006 http://ag.arizona.edu/AZWATER/EWSR/COLBY_BOR_forbearance_rpt_20061013.pdf

reliability needs while also addressing the concerns of irrigators, agricultural districts, and rural communities can help build momentum for programs in the Lower Colorado River Basin.

Phase II approach: Hydrology and Modeling

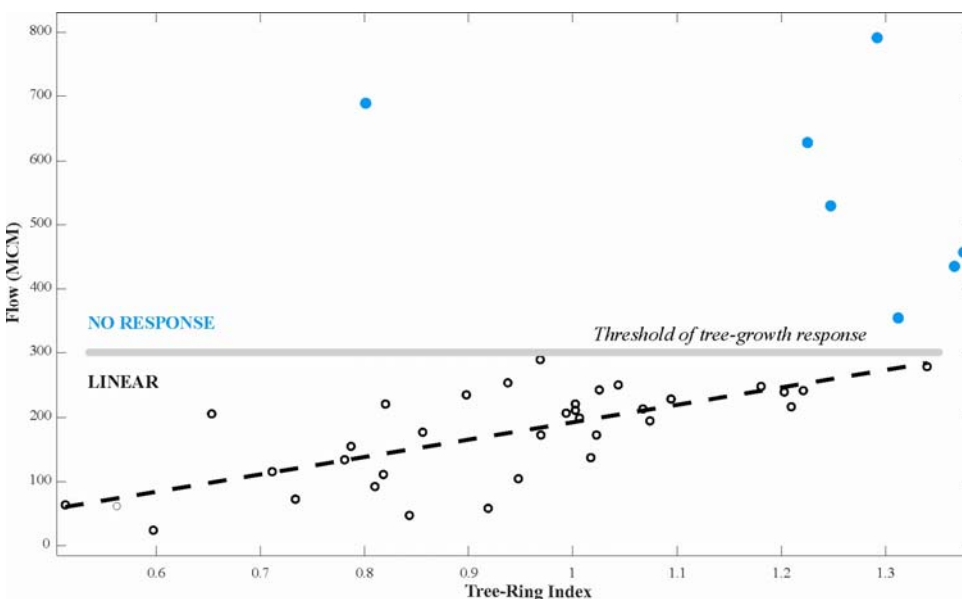
By Matt Switanek

The stakeholder meeting that was held in Phoenix on September 6 helped the team focus on high priority projects to be addressed in Phase II.

A better understanding must be developed of the sustainability of Colorado River flows, and its ability to support both a growing population and specific high value ecosystems. The daunting task of projecting what the future might hold initially involves looking to the past to see what the range of climate variability has been through tree ring studies. Improving the ability to predict Lower Basin flows also means gaining a greater understanding of the potential impacts of global climate change. This requires applying forcing data that is consistent with accepted ranges of future climate variability derived from global circulation models, for example, a rise in temperature, a decrease in precipitation, or both.

While it is necessary to pursue and understand climatic variability and change in the Colorado River Basin, the impacts of managerial decisions must also be considered to truly represent this dynamic system. We intend to develop inputs to Reclamation's 1-2 year operations model (the 24 month study) that incorporate management decisions as well as new climate inputs, so that a more useful comparison can be made between current modeling approaches and this project's contributions.

The project team will also support a nationwide meeting of investigators that is focused on research needs relative to improving climate projections in the 1-year to 3-year time frame. Stakeholders have repeatedly indicated that projections in this time frame would be useful, and there are preliminary indications that some progress could be made in this arena.



Scatterplot showing the relationship between mean annual flow in the Little Colorado and tree-ring width (unitless). Years with mean flows above 300 million cubic meters are represented by blue circles.

Phase II approach: Tree Ring and Paleoclimate Science Applications

By Scott St. George

During the first phase of this project, scientists working on the tree-ring component achieved two primary goals. The first was to develop a new reconstruction of annual streamflow of the Colorado River at Lees Ferry using a denser network of tree-ring sites and a more modern suite of analytical techniques. These results confirmed the main findings of previous studies, and

showed that, over the last 500 years, mean annual flows in the main stem of the Colorado were roughly 14.7 million-acre-feet. Secondly, researchers examined the spatial variability of past droughts across the Colorado watershed by developing new reconstructions of flow at four important sub-basins – the Green River at Green River, Utah, the Colorado River near Cisco, Utah, the San Juan River near Bluff, Utah, and the Salt-Verde River near Phoenix, Arizona. Understanding the interplay between these smaller watersheds allowed scientists to identify the spatial fingerprint of past droughts and to evaluate the efficacy of management strategies that depend on inter-basin transfers in the event of local shortages.

Work in the second phase will continue to expand the network of tree-ring reconstructions of streamflow across the Colorado basin. These reconstructions will target gauges close to input points used in the U.S. Bureau of Reclamation’s Colorado River Simulation System (CRSS) model, which is used for long-term planning in the Lower Basin (i.e., this model is being used in the EIS analysis). The Little Colorado River in Arizona will be the first CRSS input analyzed, and will serve as a pilot study to test the ability of tree-ring records to estimate flows in small basins with ‘flashy’ flow regimes.

Brief periods of high runoff caused by short, intense rainstorms can have a considerable impact on annual flows in small watersheds. However, because these storms occur too quickly to affect soil moisture – and presumably tree growth – across the basin, trees can act as poor recorders of extremely high-flow years. In the Little Colorado, preliminary results demonstrate that tree growth is linearly related to streamflow when annual flows are below 300 million cubic meters per year (*see diagram above*). In contrast, when flows are above this threshold, trees in the Little Colorado do not show any relationship with mean discharge. Future work will explore methods to deal with this apparent ‘capped’ response to streamflow, including treating high-flow years separately from other years.

PROJECT CONTACTS FOLLOW, PAGE 8

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