The wet winter and the basins' bathtubs

A look at winter precipitation and the future of the Colorado River reservoirs

By Zack Guido

It wasn't supposed to be like this. Not amid a La Niña event. This winter snow and rain fell, and fell often, in parts of the West and Southwest, turning dry winter precipitation forecasts for 2007–08 upside down. Fears that water supplies would continue to dwindle melted like the snow that ultimately feeds the Colorado River.

So what does this past winter mean for the Southwest, especially in light of the prolonged drought that has gripped the region and dire projections for the future of Lakes Powell and Mead?

An unanticipated wet winter

The Colorado River carves a nearly 1,500-mile course from the tips of Wyoming peaks to the Gulf of California, along the way sculpting the Grand Canyon. The river supplies water to 27 million people in seven states and Mexico, making it a critical resource in the region and a liquid lifeline for the arid Southwest.

Most of the water streaming down the Colorado River is born as snow in the mountains of Colorado, Wyoming, and Utah. When the first flakes began to fall this past winter, many southwesterners paid keen attention to the Rockies, their optimism rising for spring water supplies and water storage in the Colorado River Basin's reservoirs.

Near Silverton, Colorado, in the heart of the San Juan Mountains, snow accumulated steadily and without major storms. At the end of November, 16 inches fell, followed by 12 inches in mid-December, 21 inches in early January, 14 inches three weeks later, and another foot in mid-February. In between, it seemed like every night some precipitation graced the ground; snow fell 60 days between the first of October and the last day of March. Contrary to expectations, a steady stream of snow covered many of the basin's mountains this past winter, depositing the snow needed to create that most crucial and vital western resource—water.

"Historically, La Niña has been a slam dunk for drier-than-usual conditions" said Tom Pagano, water supply forecaster for the National Resource Conservation Service. Yet, in South Mineral Creek, slightly north and west of Silverton, the snowpack's accumulated water content surpassed its 1971 to 2000 average a few days into December.

This story was repeated throughout most of the Upper Colorado River Basin. On February 15, measurements of snow water equivalent, the depth of water that would result from melting a specific volume of snowpack, set records in the headwaters of the Rio Grande as well as many locations in the San Juan Mountains. A month later, records were again observed in those locations and also to the north in the mountains surrounding the town of Aspen. Even on April 15, a dry month-and-a-half after the weather began behaving more like climatologists had predicted, snow water equivalent records were set all over Colorado.

The early season snow accumulation in the upper basins of the Colorado River gave water planners and users hope that relief from the ongoing drought had arrived. Even though La Niña's desiccating touch returned around the first of March, the National Oceanic and Atmospheric Administration (NOAA) forecast streamflow to be 118 percent of average at Lake Powell from May through September.

Average precipitation for the entire Upper Colorado River Basin this winter was the second highest it has been in the last 10 years (Figure 1). For the Rio Grande, an important water source for New Mexico, the picture is even rosier. Winter precipitation in the headwaters of the river was the highest it has been in the last 20 years.

The snow in Colorado may not have much influence on Arizona. Reservoirs on the Colorado River were built precisely to smooth natural variability so users have a reliable supply regardless of wet or dry winters. However, the more important and long-term answer is that this winter reverses the declining water-level trend and, for the moment, takes us farther from the low reservoir level that would create a declaration of shortage to users in the lower basin.

Is a collective sigh in order? No. According to Terry Fulp, the U.S. Bureau of Reclamation's Deputy Regional Director of the Lower Colorado Region, we will have to wait and see if the drought of the last eight years is waning. Fulp cautioned that history has shown that a few wet years are common among strings of drier years.

Colorado River storage

Between October 1, 1999, and September 30, 2007, storage in Colorado River reservoirs decreased from 55.8 million acre-feet (maf) to 32.1 maf , or about 94 percent of capacity to about 54 percent. Not since the late 1960s has Lake Mead's water level been as low as it has been in the last several years, and that was when demand was much lower (Figure 2). The past eight years have been the driest eight-year stretch in the 1906–2008 recorded history and have nailed into the collective consciousness the vulnerability of western water supplies. For most of these years, people witnessed the addition of white bathtub rings on the red and black reservoir rocks. Much like counting tree rings and measuring their widths to

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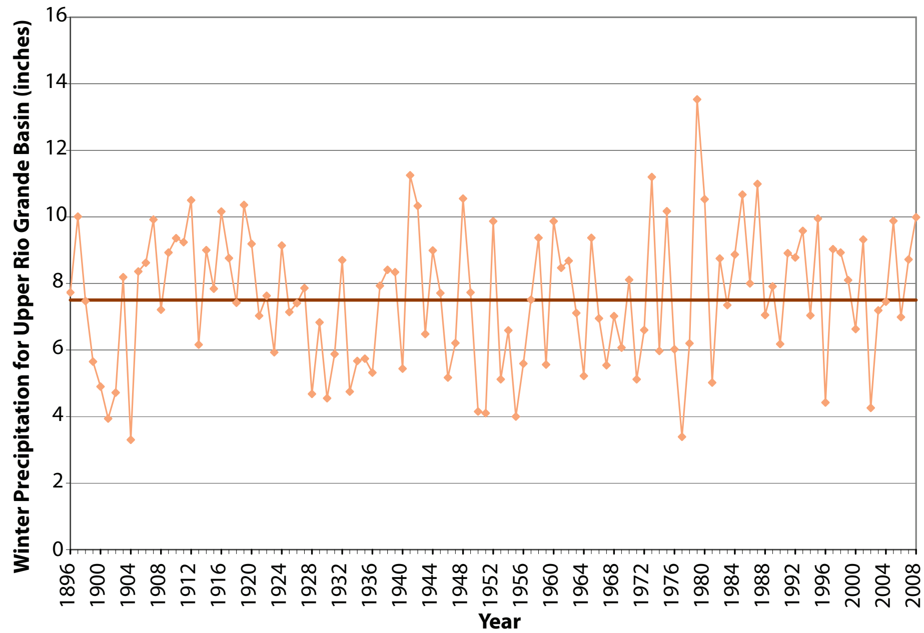
understand precipitation, the rings are a visual reminder that the water balance is tipped in the draining direction. Although this winter may have submerged some of the rings around Lake Powell, the questions still remain: is the Colorado River storage system resilient to lower future water flows? How will future climate change impact the system?

Dire predictions

Is the Colorado River over allocated? Yes, say many water mangers, including Fulp. When will Lake Mead go dry? It's difficult to imagine that water managers will let this happen, said Mike Dettinger, a researcher for the U.S. Geologic Survey and Scripps Institution of Oceanography at the University of California in San Diego. In fact, a recent environmental impact statement completed by the Bureau of Reclamation as part of a public process to develop new river operating guidelines presents a strategy to prevent exhausting the storage capacity. In spite of this, a recent article that was written by Tim Barnett and David Pierce and appeared in the journal *Water Resource Research* proclaimed that, under current conditions, a water budget analysis showed a "10 percent chance that live storage in Lakes Mead and Powell will be gone by about 2013 and a 50 percent chance that it will be gone by 2021 if no changes in water allocation from the Colorado River system are made."

Barnett and Pierce, researchers at the Scripps Institution of Oceanography, set out to answer a fundamental question that is also the paper's title: "When Will Lake Mead Go Dry?" Given the important subject, the alarming conclusions, and the media frenzy that accompanied the paper's release, it is not surprising that the headlines from Fox News and *The New York Times* respectively read, "Adios, Las Vegas: Lakes Mead, Powell May Run Dry by 2021" and "Lake Mead Could Be Within a Few Years of Going Dry, Study Finds."



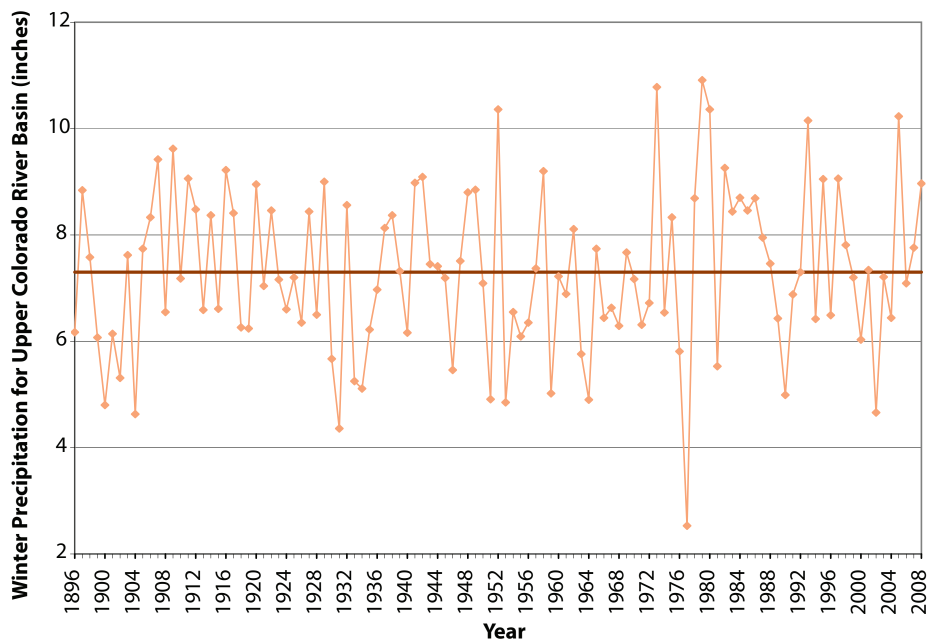


Figure 1. Total winter precipitation (October 1– March 31) for the Upper Rio Grande Basin and Upper Colorado River Basin. The two time-series are based on PRISM data which uses point measurements at many locations and an algorithm that interpolates between the measurement sites. The brown line is the 1896–2007 average. The 2008 value is preliminary.

The methodology and conclusions in Barnett and Pierce's paper have drawn strong criticism from water managers and researchers and have stimulated much discussion.

"There's nothing wrong with sparking debate, and Tim Barnet certainly did that," Fulp said.

The study's model

The study used a water balance model that added the inflows of the water system to the current total reservoir storage and then subtracted the outflows. The model used the total current storage in both Lakes Mead and Powell of 25.7

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maf, which was reported by Reclamation in June 2007. To the total storage, the model added stream discharge predictions that were based on the 1906–2005 observed streamflow record and a 1,250-year record reconstructed from tree-rings. In order to analyze the many different and possible scenarios of future annual streamflows, both in magnitude and order, the model produced 10,000 annual river flows using several different statistical techniques. This is why the conclusions were expressed in probability. Scientists don't know which scenario is going to happen, and because all possibilities are based on past observations, each is possible.

Summing the storage and streamflow for each year produced the projected inflows to the system. From this, the estimated future water supply for each

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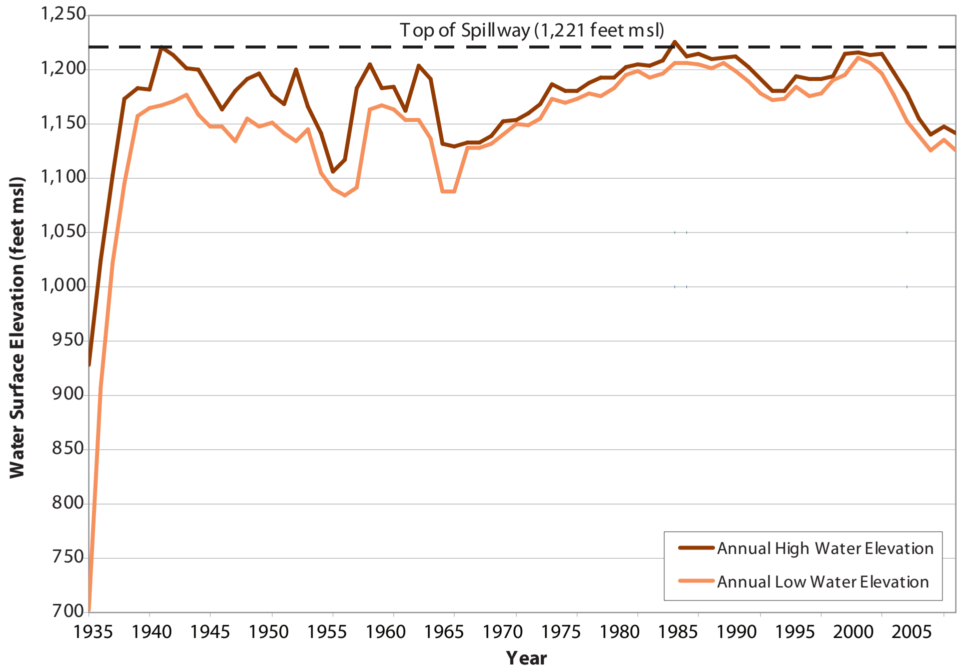

Figure 2. . Historic annual water level elevations in Lake Mead. The solid blue line is the maximum annual water elevation; the solid red line is minimum annual water elevation. *Source: Bureau of Reclamation's Final Environmental Impact Statement, 2007*

Model Type	Inflow	Outflows			Results	
	Streamflows	Evaporation/ infiltration (maf)[a]	Climate Change Option: reduction in stramflow by 2058	Management Option: supply decrease when storage capacity <15 maf[a]	10% chance to deplete storage by year	50% chance to deplete storage by year
Probalitic Model	Variable	1.7	Yes, 20%	No	2014	2028
	Variable	1.7	Yes, 20%	Yes, 25%	2025	2048
Net Inflow Model	'-1.0 maf/yr[b]	1.7	Yes, 20%	No	2013	2021
	'-1.0 maf/yr[b]	1.7	No	No	2014	2028

[a]maf = million acre-feet
[b]the model begins with a 2008 net water deficit of 1.0 maf/yr and extends that value into the future.

Table1. Summary of the results presented in the study by Barnett and Pierce (2008) and the corresponding water inflows and outflows from their models.

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year was subtracted. The Bureau of Reclamation estimated that the demand by the upper basin states (Colorado, Utah, Wyoming, and New Mexico) will continually increase, while demand by the lower basin states (Arizona, Nevada, and California) and Mexico will remain constant. In addition, the model subtracted from the sum of storage and streamflow 1.7 maf each year due to the estimated water loss from evaporation and infiltration. The authors also built into the model a management strategy that reduces the water supply when the reservoirs drain to less than 15 maf. Finally, the authors allowed the model to simulate the impacts of climate-driven reductions in streamflow that reflect estimated reductions in basin-wide precipitation (Table 1). The model predicts a 50 percent chance that Lake Mead will run dry as soon as 2021 or as late as 2048. The date of storage depletion changes depending on the streamflow quantification method, management strategy, and climate change. The earliest prediction is startlingly soon. However, the model is oversimplified and, according to Dettinger, does not capture in a meaningful way the management of the Colorado River system. At best, the results emphasize the importance of proper water management and use. At worst, some researchers say, the study could prompt managers to ignore future academic input.

Stakeholders' response

In addition to the news headlines, the paper's abstract and a press release issued by the American Geophysical Union about the study emphasized the dire projections: the press release states, "50 percent probability that storage in Lakes Mead and Powell will be gone by 2021 if climate changes as expected and future water usage is not curtailed." As the public relations office at the Bureau of Reclamation's Lower Colorado Regional Office points out, it is important to keep this issue in the forefront of people's minds. However, Fulp does not agree that current climate projection models present the kind of information with which to make such definitive projections of future water supplies.

Fulp and the Bureau of Reclamation say the study does not take into account the management of the Colorado River under shortage conditions. In fact, Reclamation recently concluded a two-and-a-half year study that led to the environmental impact statement for determining and allocating lower basin water shortages and coordinating operation of Lakes Powell and Mead under a wide range of conditions. The guidelines specify that water deliveries in the lower basin will be reduced by 0.33, 0.417, and 0.5 maf per year when the water level of Lake Mead drops below 1,075, 1,050, and 1,025 feet above mean sea level, respectively. The guidelines include a provision that reconvenes state and federal water mangers and other interested parties if the water level in Lake Mead dips below 1,025 feet. This action would be taken to develop further management strategies to reduce the likelihood of draining these two large reservoirs. This management strategy would further reduce the probability of Barnett and Pierce's study becoming a reality. The primary assumption in the study is that water will continually be taken out of the system without regard for management and the evolving water supply, Dettinger said. A better analysis, he continued, "would have been to follow the management strategy of the Bureau of Reclamation to the T."

The study also does not account for additions to the system below Lakes Mead and Powell, according to Reclamation. Although the amount is small, it is an important contribution to the water balance, Fulp said. The authors of the paper tally water consumption in 2008 to be 15.2 maf, representing withdrawals of 13.5 maf for the upper basin, lower basin, and Mexico, and 1.7 maf in evaporative and infiltration losses. They also calculate supply to be 15.05 maf, creating a net deficit of 0.15 maf. However, if the contribution of tributaries in the lower basin is included, then the river is not in a net deficit. This accounting would change the authors' results for the models that analyze the system in terms of net inflows.

The study uses a 20 percent reduction in streamflow that results from climate change. This assumption is the most difficult for management because the state-of-the-art models predict reductions in precipitation between 5 and 50 percent. Furthermore, the models make these estimates over large spatial scales that exclude important, finer-resolution details. For Fulp, it is difficult to make management decisions based on one scenario that adopts a 20 percent reduction in streamflow from climate change. Climate change may have a significant impact on future flows. But before explicit reductions in streamflows from climate change can be included in decision making, resource managers need proper downscaling of the global models to regional scales and better quantification of the uncertainty in the precipitation estimates. Fortunately, collaboration between organizations like Reclamation and the academic science communities continues with these ends in mind.

The bottom line

The deep snowpack this winter in the upper basin does not mean that the water supply concerns will disappear. Similarly, the alarming headlines portending the emptying of the reservoir system do not mean that we are doomed. The reality is somewhere in between. According to Fulp, the challenge is to conduct prudent water management, a concept that encompasses water conservation, multi-sector collaboration, and adaptive management. However, that does not mean that the responsibility for water resides solely with people in high places. According to researchers and water managers, everyone living in the seven states should treat water as a precious resource and use it wisely.