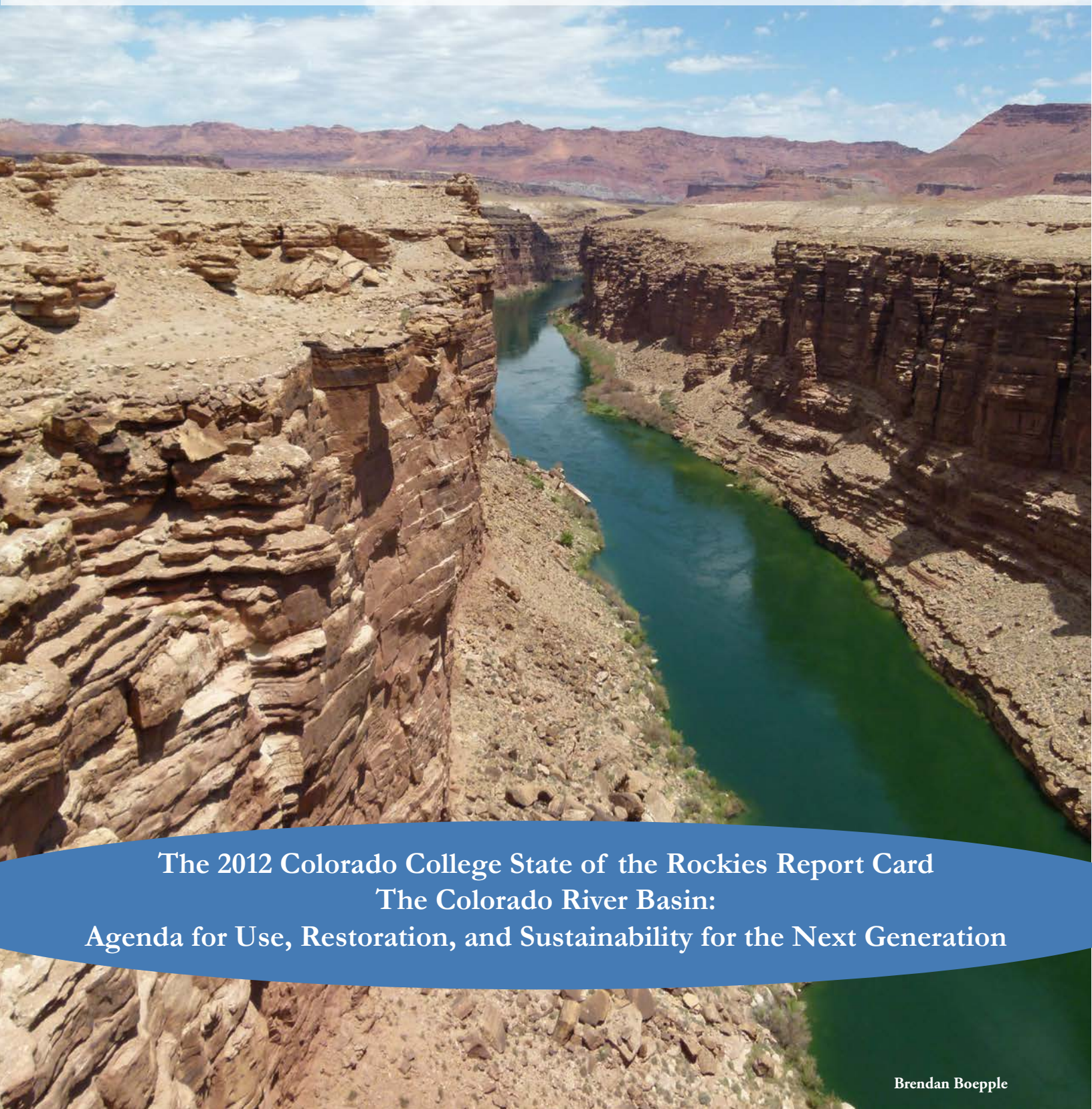
The Colorado River Basin: An Overview

By the State of the Rockies Project 2011-12 Research Team



The 2012 Colorado College State of the Rockies Report Card
The Colorado River Basin:
Agenda for Use, Restoration, and Sustainability for the Next Generation

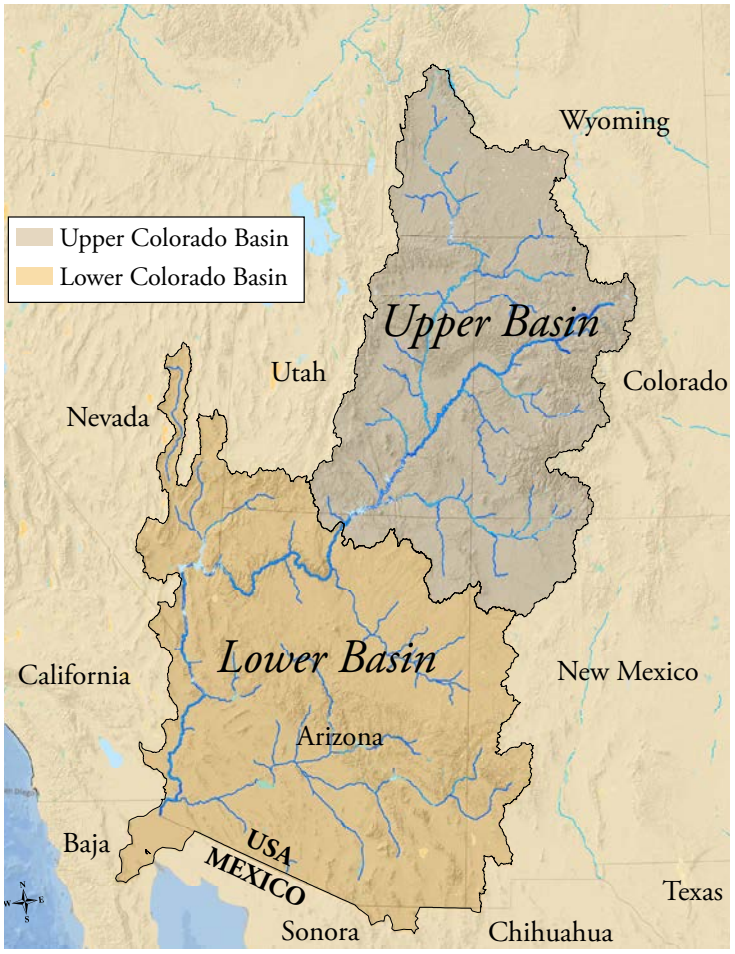
Brendan Boepple

The Colorado River Basin

The Colorado River is often referred to as the life-blood of the American Southwest. This legendary river begins both as snowmelt at its headwaters in mountainous northern Colorado, and as the origin of the Green River in the Wind River Range of Wyoming; then winds through seven states and approximately 1,400 miles of stunningly diverse ecosystems before it reaches the below-sea level desert expanses of Mexico. Thirty million Southwesterners, 20 Native American tribes, and Northern Mexico, as well as numerous species of flora and fauna, rely on its waters for their livelihoods and day-to-day survival.[1] The river supports major cities such as Denver, Los Angeles, Phoenix, and Las Vegas, through a carefully regulated dam, canal, and pipeline system. However, municipal uses pale in comparison to the nearly three million acres of farmland that utilize close to 80% of the river's annual flow.[2] Yet the flow is not what it once was, as drought, over-apportionment, and ever-expanding urban development have depleted the supplies of this cherished resource to the point where it no longer reaches the Gulf of Mexico. Its future has become increasingly contentious and uncertain.

Parts of the seven states of Wyoming, Colorado, Utah, New Mexico, Arizona, California, and Nevada form the U.S. portion of the 243,000 square-mile Colorado River Basin (8% of the contiguous U.S.)[3], with 2% of this area located internationally in Mexico's Sonoran Desert. The 1922 Colorado River Compact, created by these seven states, separated the basin into an upper and lower region with Lee's Ferry just below Glen Canyon Dam as the point of division. Wyoming, Colorado, Utah, New Mexico, and the northern portion of Arizona make up the 109,800 square-mile Upper Basin, while Arizona, California, and Nevada constitute the Lower Basin region as seen in **Figure 1**.[4]

Figure 1: Map of the Colorado River Basin divided into Upper and Lower Basin



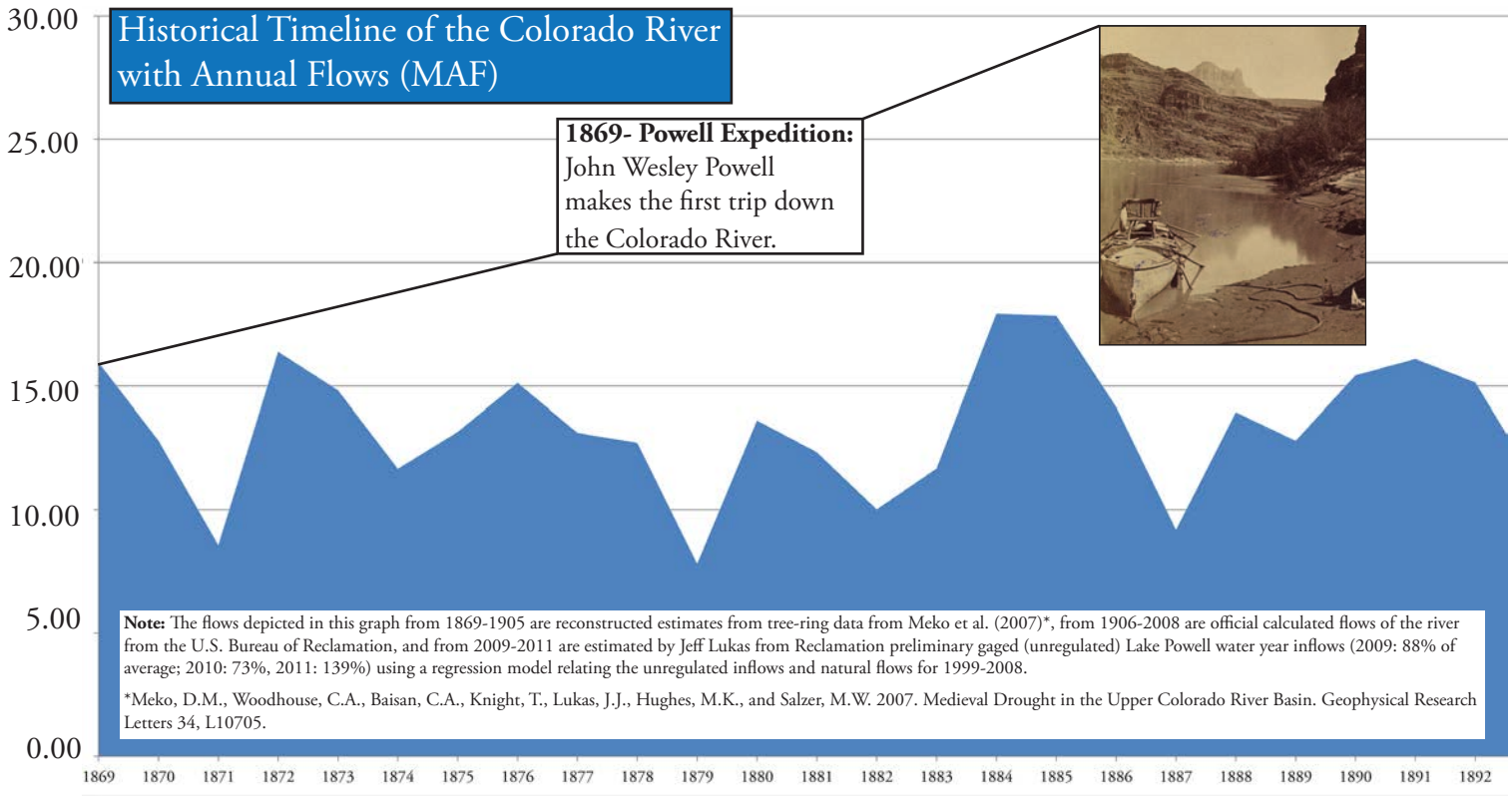


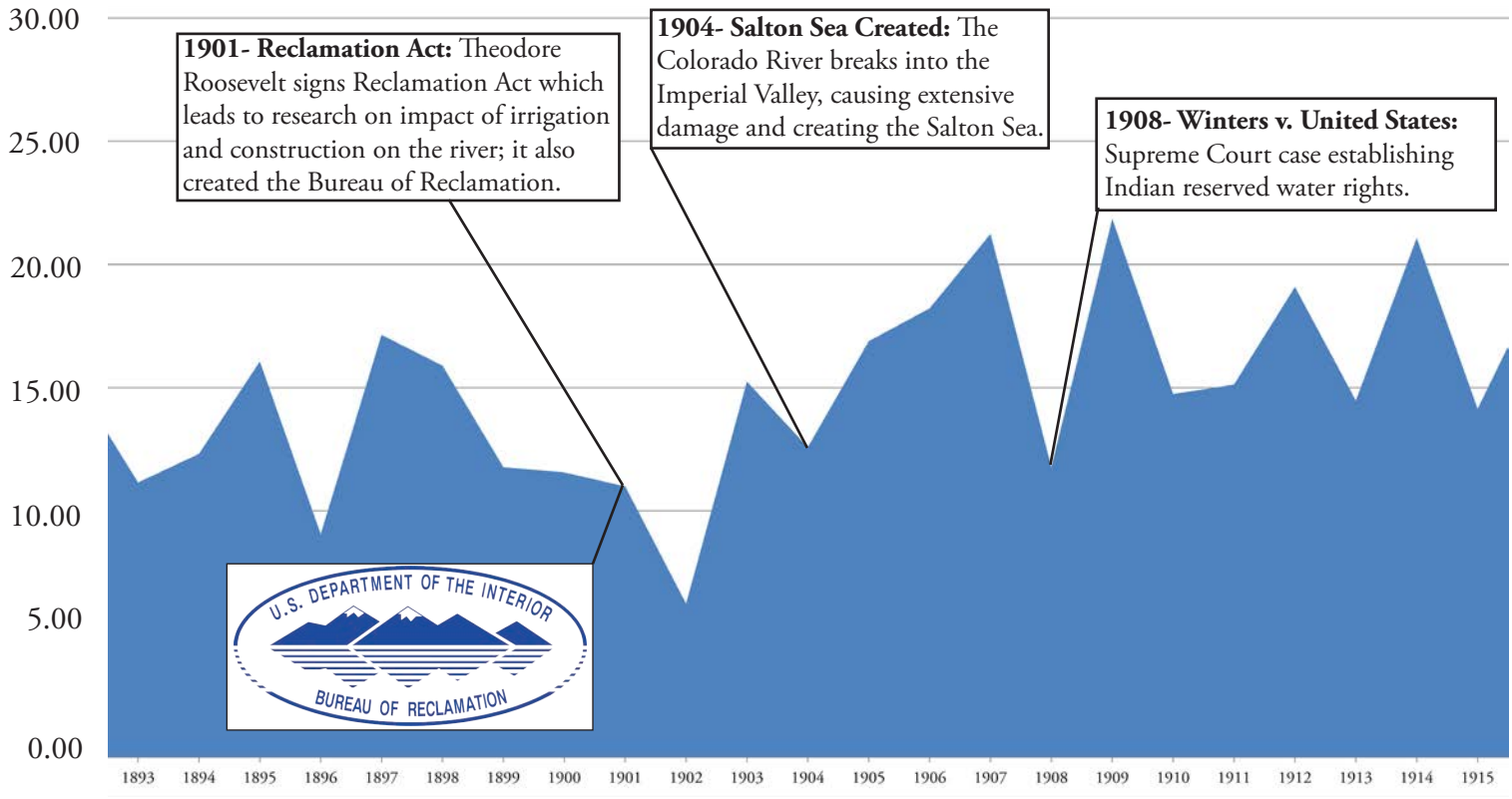
Figure 2: Colorado River Water Apportionments by State		
Upper Basin	**45.5%**	**7.5 maf**
Arizona	.3%	.05 maf
Colorado	23.4%	3.86 maf
New Mexico	5.1%	.84 maf
Utah	10.4%	1.71 maf
Wyoming	6.3%	1.04 maf
Lower Basin	**45.5%**	**7.5 maf**
Arizona	17.0%	2.80 maf
California	26.7%	4.40 maf
Nevada	1.8%	.30 maf
Total 7 States	**91.0%**	**15.0 maf**
Mexico	9.0%	1.50 maf
Total for Entire Basin	**100.0%**	**16.5 maf**

Major tributaries of the Upper Basin include the Green, San Juan, Escalante, Gunnison, and Dolores Rivers, and the Lower Basin is fed largely by the Paria, Virgin, Little Colorado, Bill Williams, and Gila rivers.[5] The basin, its water apportionment, and the protection of its environmental resources have long formed a complex combination of states' rights, federal agency involvement, and Native American tribal water rights, and as such, has often been a ground for both conflict and cooperation.

Laws and Apportionment

The Colorado River Basin is ruled by a compilation of decrees, rights, court decisions, and laws that together are referred to as the "Law of the River." The keystone of these "commandments" is the 1922 Colorado River Compact, an interstate agreement created by the seven basin states with provisions for general water allotments, including a 7.5 million acre feet (maf) annual delivery requirement from the Upper to the Lower Basin.[6] The 1928 Boulder Canyon Project Act (along with the 1963 Supreme Court decision in *Arizona v. California*) divided the Lower Basin's 7.5 maf—with an extra one maf in wet years—between Arizona, California, and Nevada.[7] The 1948 Upper Colorado River Basin Compact divided the Upper Basin's average allotment of 7.5 maf among the five states.[8] States allocate their individual shares of the waters of the Colorado River and ultimately have the highest authority after the Secretary of the Interior. The Secretary of the Interior is often called the "water master" of the Colorado River, as he/she has the final ruling on nearly every conflict, be it the definition of "beneficial use" or the creation of shortage guidelines.[9]

The Colorado River Compact of 1922, which set the annual average as 15.0 maf and divided this amount up between the basin states (**as seen in Figure 2**), was created in the wettest recorded ten-year period of the last 100 years. This was from 1914-1923, in which the annual average was 18.8 maf. In 2000, the Colorado River Basin entered a period of drought, accompanied by decreased precipitation and increased average temperatures, and continues today. Flows from 2001 to 2009 averaged around 12.1 maf at Lee's Ferry: roughly a 4-5 maf reduction from the 16-17 maf assumed average flows from the Compact.[10]



Federal, State, Native American, and Mexican Involvement

Native American involvement and tribal water rights

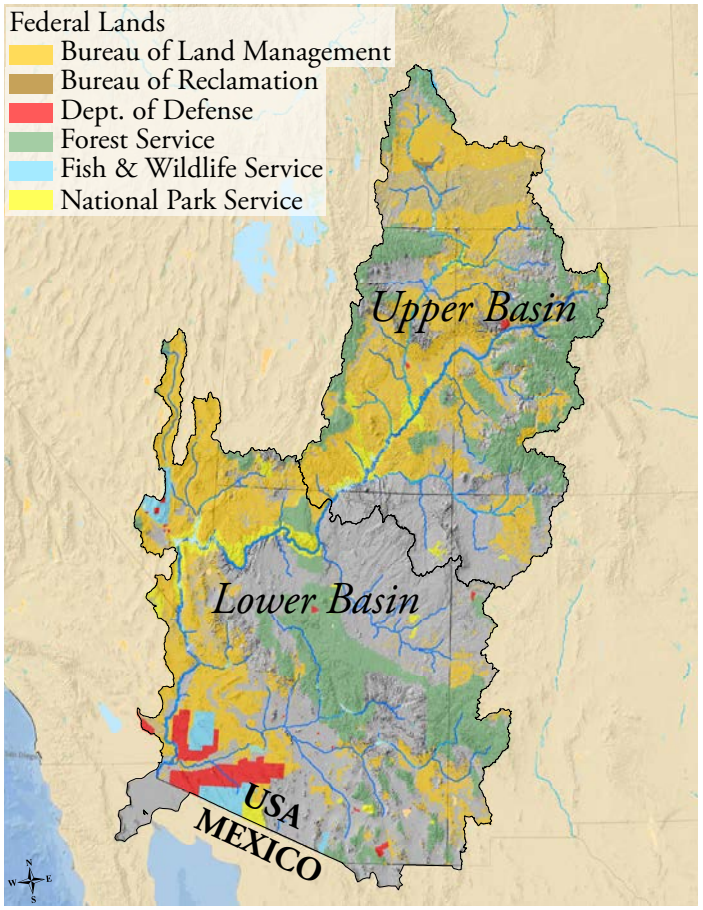
There are 34 established Native American reservations within the basin.[11] Reservations on paper have federally reserved implied water rights, but many reservations' inability to put their newly appropriated waters to beneficial use has resulted in subsequent conflicts between tribes and other stakeholders in the basin. The granting of new water rights to the tribes has led to a forced reduction of use by others.[12 13] In addition to these tribal lands, large areas of land in the basin are also owned by the federal government as seen in **Figure 3**.

Mexico's Role

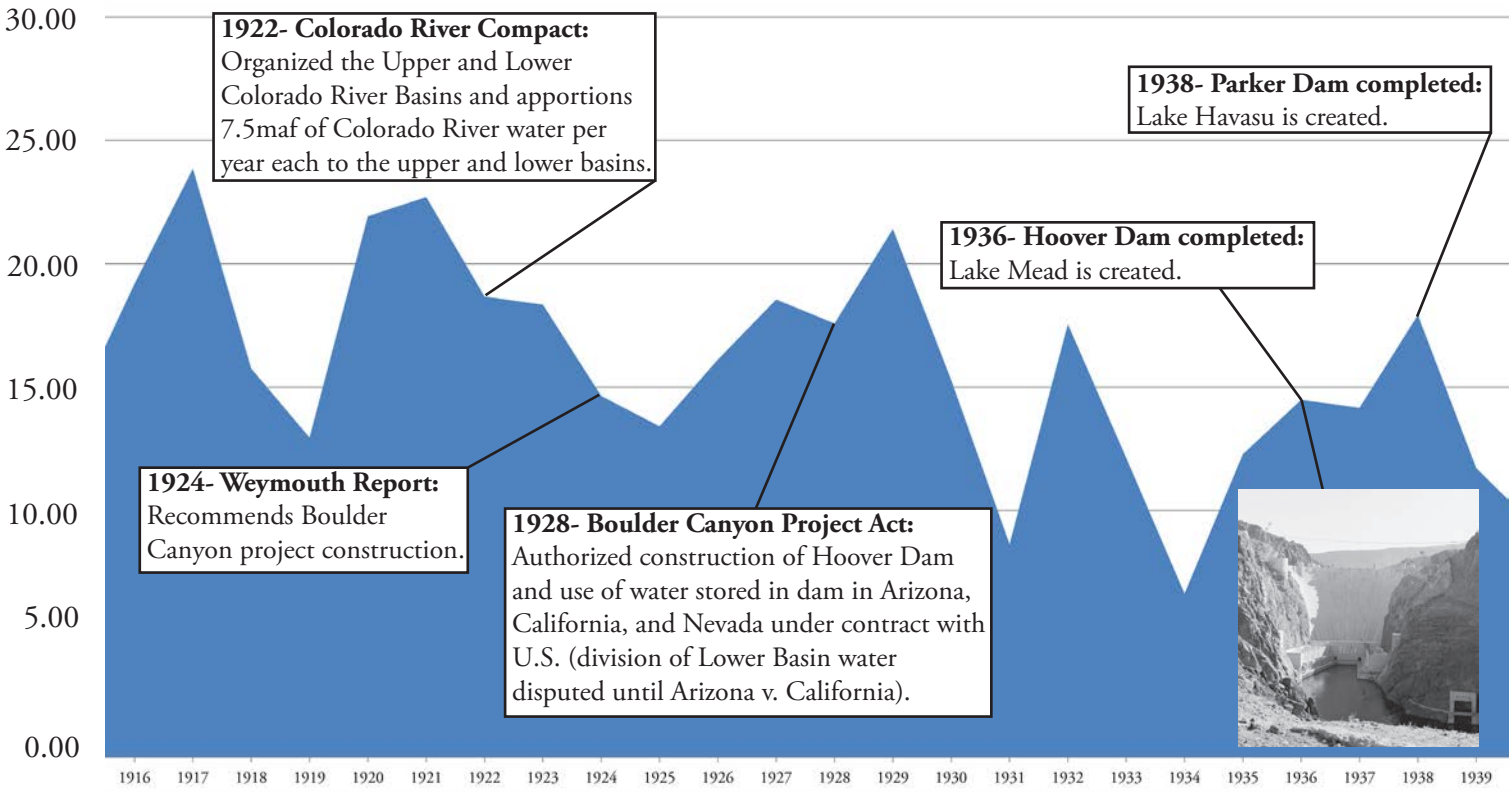
In 1944, a treaty facilitated by the International Boundary Water Commission (IBWC) was signed granting Mexico 1.5 maf annually. However, no water quality standards were established and as the river became increasingly developed, deliveries to Mexico were often diverted and/or had a near-toxic salinity level. In 1973, IBWC Minute Number 242 was signed mandating the U.S. to adopt measures to reduce the salinity of those waters delivered to Mexico. Issues such as the lack of water reaching the Colorado River Delta, the lining of the All-American Canal, and maintaining the Ciénega de Santa Clara continue to affect U.S.-Mexico relations.

Brendan Boepple, The dry Colorado River bed near San Luis Rio Colorado, Mexico

Figure 3: Federal Land Ownership in the Colorado River Basin



Source: U.S. National Land Atlas Federal and Indian Lands Areas



Uses of the Colorado River

Nearly all water in the Colorado River has been put to "beneficial use" both inside and outside of the basin. Human beneficial use does not generally include instream flows (leaving water in the river for environmental purposes), and has largely meant use for agriculture, municipal and industrial purposes, and recreation. Forty-five percent of Colorado River water is diverted out of the basin for both agricultural, municipal, and industrial use; many cities such as Denver, Los Angeles, and Salt Lake City already rely heavily on trans-basin diversions which disrupt surrounding ecosystems.[14] **Figure 4** illustrates the low and high flow of the river with many of these diversions.

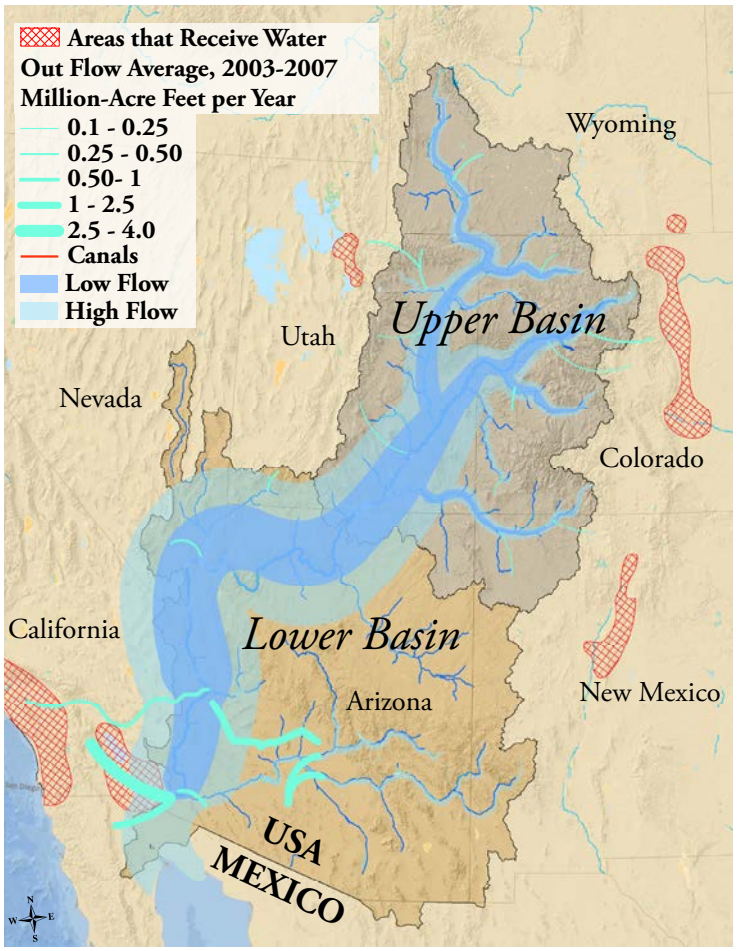
Agricultural Use

Areas in the West that use Colorado River water have proven to be agriculturally productive despite the arid climate, with a diverse crop yield that includes alfalfa, hay, wheat, cotton, and lettuce. Today, 78% of the water from the Colorado River is used for agricultural purposes. The concentrations of some of these minerals are now sufficiently high in some areas of the basin as to threaten the viability of agriculture there, as well as causing local water quality issues.[15]

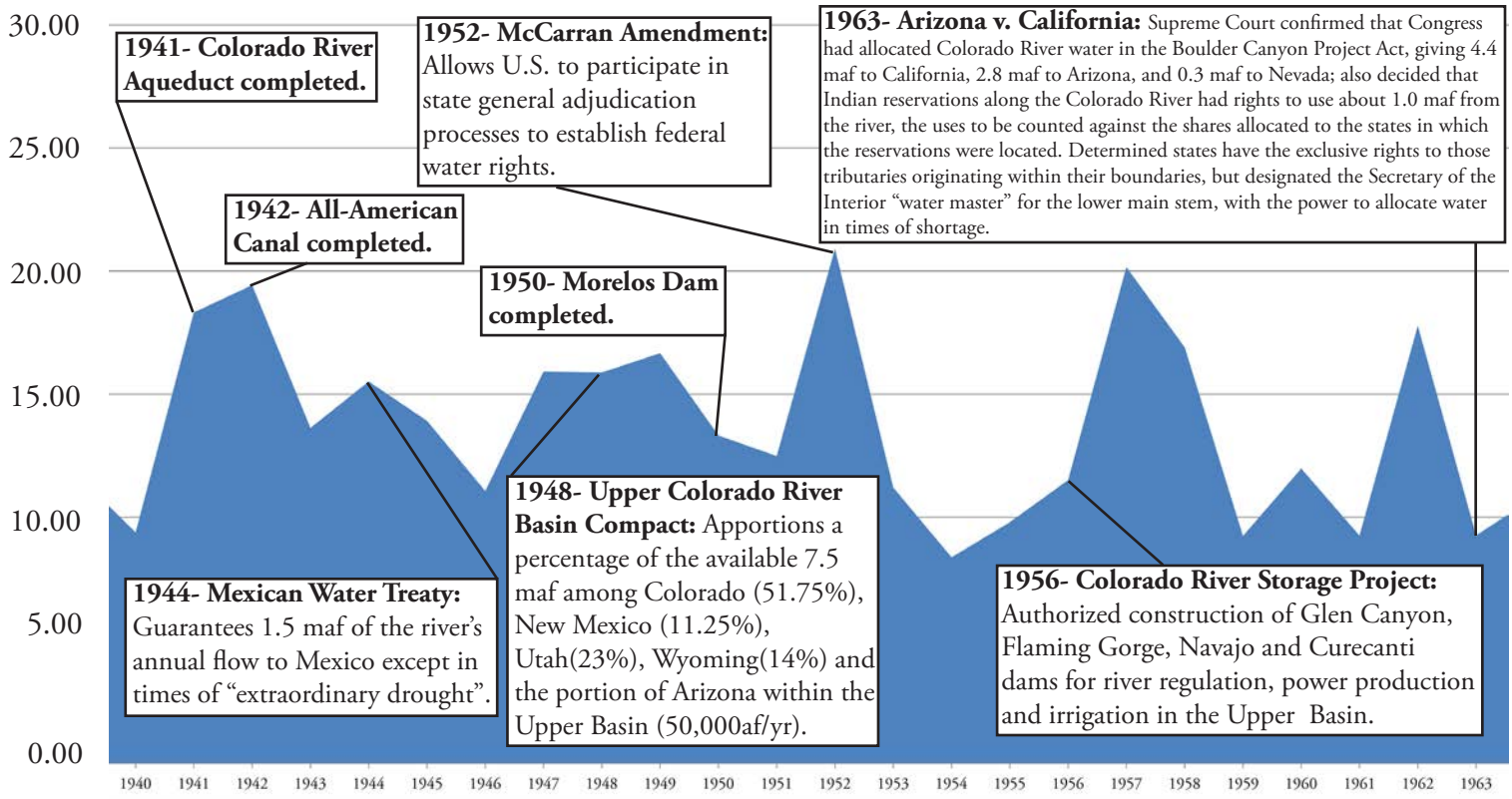
Recreational Use

The natural diversity and picturesque backdrop throughout the Colorado River Basin make it a popular destination for many outdoor recreation activities such as fishing, skiing, boating, camping, hiking, wildlife-viewing, hunting, and swimming. The multi-billion dollar industry relies on continued precipitation and flows in order to attract the tens of millions of people each year who support local economies and businesses.

Figure 4: Inflows and Outflows of the Colorado River



Source: Jonathan Waterman, Samuel Velasco, and Robert E. Pratt, *Colorado River Basin: Lifeline for an Arid Land*, National Geographic Society, September 2010.



State of Nevada , The Lights of Las Vegas

Municipal and Industrial Use (M&I)

M&I water demand is increasing due to the rapid population growth in the arid West. Today, 30 million people in the U.S. depend on the Colorado River for some or all of their water, up from 23.5 million in 1990.[16] In years to come that statistic will continue to rise, as Nevada, Colorado, and Arizona alone are expected to add seven million residents to the basin population in the next 30 years.[17]

Water Supply and Demand

Constant development and manipulation of the Colorado River threaten the quality and quantity of the water supply. The demand for water has historically been greater in the Lower Basin, home to larger cities and agricultural operations with a more arid climate. As a result, prior to 2000 the Lower Basin was using more than its allotted 7.5 maf. In the past, the Upper Basin has under-used its allocation, partly for lack of adequate storage capacity and partly because it is a less populous region.[18] Overall, water use throughout the entire basin has been slowly overtaking supplies of the river, causing concern about over-allocation of future flows.

Shortages

In 2007, the Secretary of the Interior signed the Interim Shortage Guidelines created by the basin states as a continued drought began to put stress on delivery requirements. These guidelines designate three different decreased delivery requirement scenarios linked to the reservoir level of Lake Mead—and continue through 2026—allowing water managers to gather a better understanding of how to operate in times of shortage. This means that the Lower Basin's flows could be reduced from 7.5 maf to between 7.0 and 7.167 maf, depending on the intensity of the drought and resulting shortage.[19]

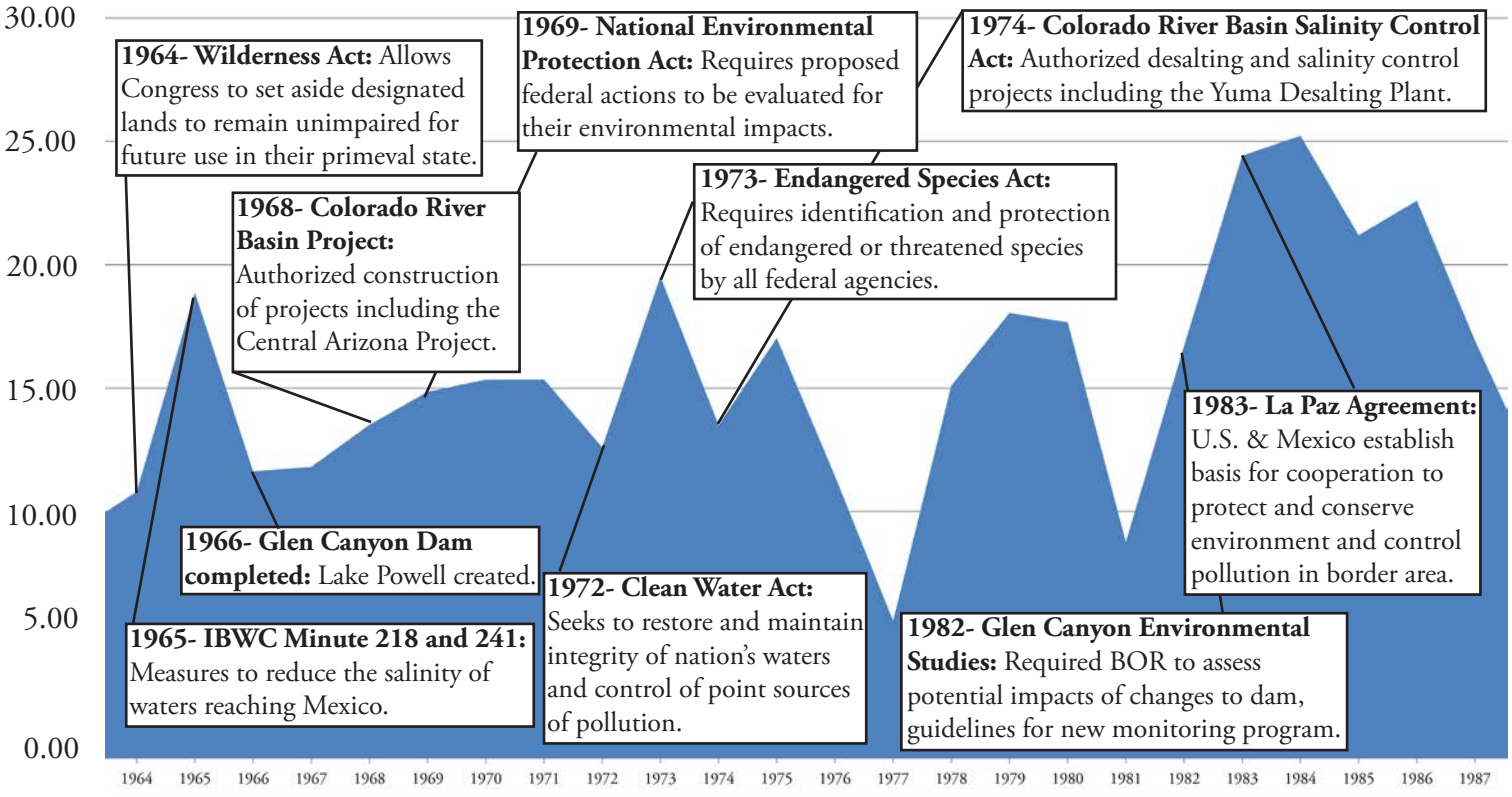
Dams and Reservoirs

Over 20 dams have been constructed on the Colorado River and its major tributaries in order to store and divert water. Reservoirs created by the Colorado River are used to generate electricity, increase storage capacity, and alter natural flows for human use. However, the basin reservoirs are considered by some to be inefficient; because of the susceptibility of still pools of water to evaporation, roughly two maf of the Colorado River's flow is lost annually to evaporation and seepage from its reservoirs.[20] Lake Powell alone averaged 378,500 acre feet of annual evaporative losses from 2006-2010.[21] Many environmental concerns have resulted from the manipulation of the Colorado River. However, without these dams and diversions the West would be unable to sustain the populations and development that it houses today.

Environmental Concerns

Instream Flows

With a rising demand and a shrinking supply of water in the West, flows in the river system of the Colorado River are becoming increasingly depleted. When people think of our



dwindling water supply, the immediate concern is usually restricted to the threat that it could have on human consumptive needs. Because the 1922 Colorado River Compact designated water rights strictly in terms of human use, no water was ever legally reserved for the health of the stream. Through later legislation and management guidelines, however, stakeholders have begun to acknowledge the environmental and economic threats that will arise if environmental flows are not protected.

Water Quality

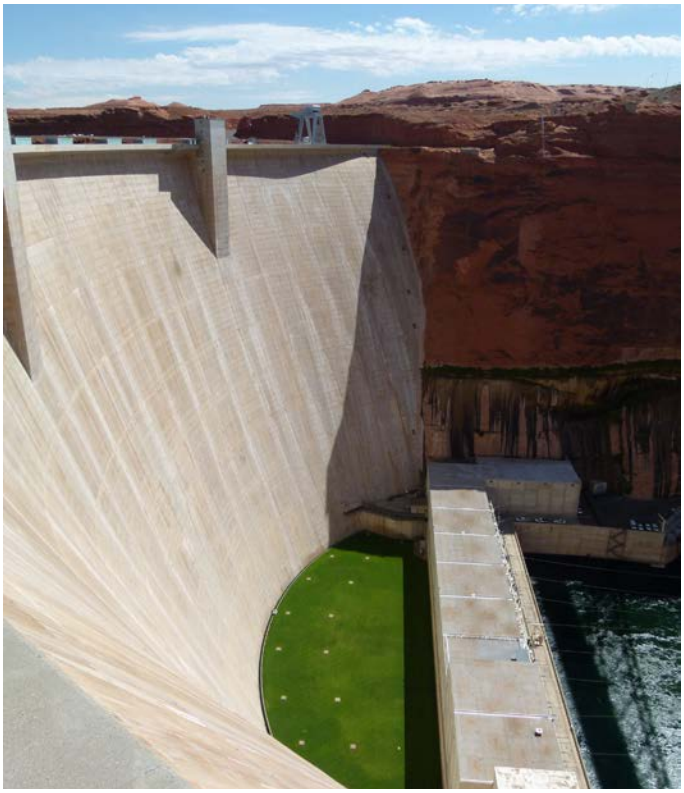
Contamination from agricultural and urban run-off, toxic leaching from mines, and the disruption of nutrient and sediment flow caused by dams are just a few examples of how current use and manipulation of the Colorado River can threaten ecosystems along the river through the deterioration of water quality.

Sediment

Historically, the flow of sediment in the free flowing Colorado River facilitated the construction of natural sandbars that served as the foundation for a diverse makeup of fish and wildlife. Many species evolved so that they could thrive in the sediment-rich environment of the free flowing river, a condition that no longer exists, as the construction of dams in the Colorado River Basin has disrupted the natural flow of sediment downstream.[22] Dams cause sediment to build up in the reservoirs, thus also decreasing the storage capacity and making the dam system less efficient for water storage and electricity generation.[23]

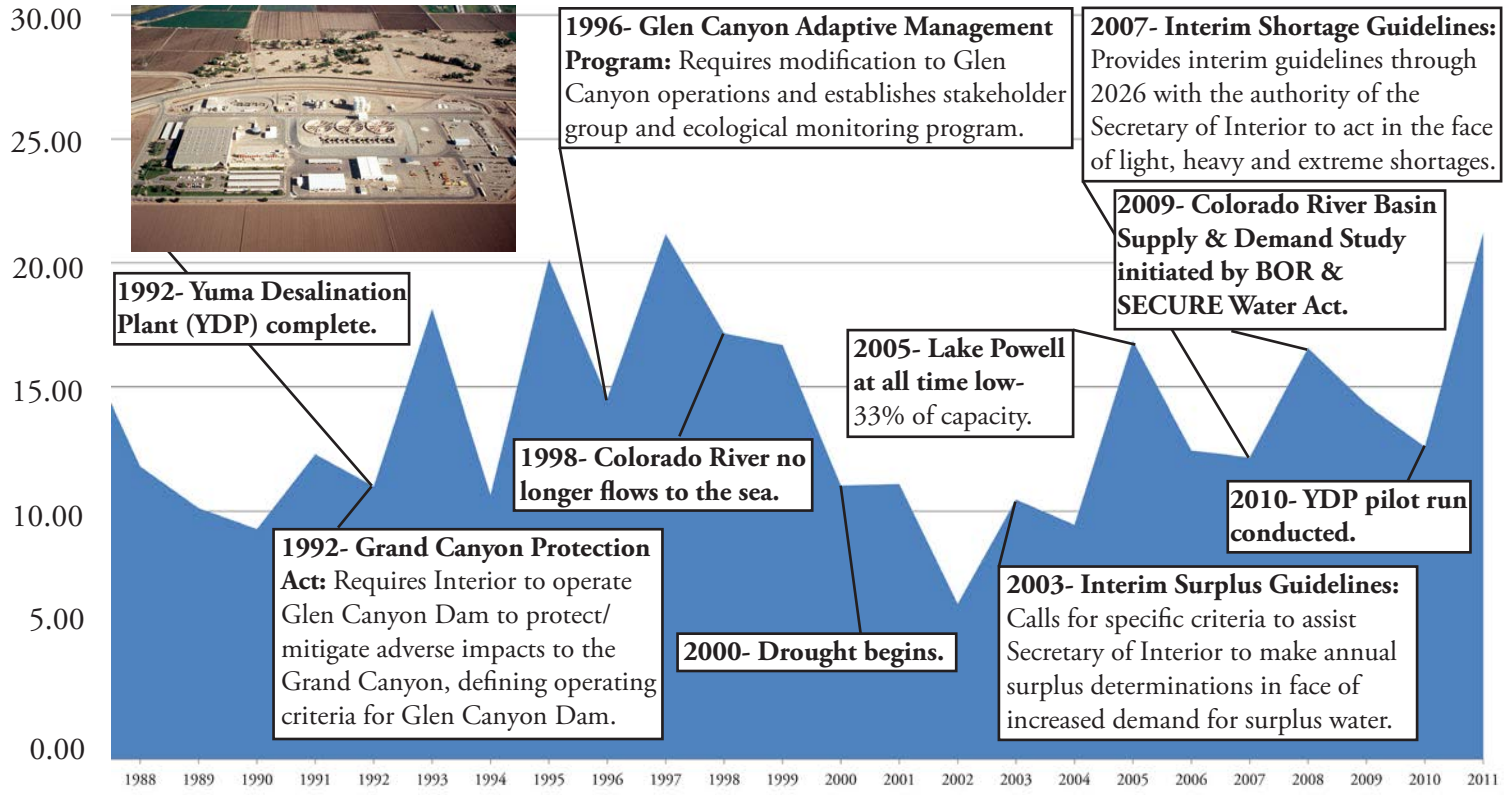
Salinity

In 1974, the Colorado River Basin Salinity Control Act was passed in an effort to control the salinity of the water being delivered to the Lower Basin and Mexico.[24] Today, increased salinity levels are a major water quality concern



Brendan Boepple, The Glen Canyon Dam

that threatens agricultural, municipal, and industrial users as well as the river's fish and wildlife populations. The Colorado River's salt content comes from a variety of sources; agriculture alone accounts for 37% of the river's salt. Natural sources such as stream flow, reservoir storage, climatic conditions, and natural runoff account for about 50% of the river's salt.[25] Currently, $306-312 million per year are spent on salinity control, and the Bureau of Reclamation estimates that by the year 2025 that number will increase to $471 million per year if no additional projects are put in place.[26]



Invasive and Endangered Species

Five percent of the Colorado River's native fauna are already extinct and 32% are currently endangered. Of the 14 native fish in the Colorado River, four species are currently endangered. They are threatened by stream flow regulation, habitat modification, poor water quality, and competition with nonnative species. If they are not addressed, these problems will continue to worsen due to a decrease in essential resources and increased interspecies competition. In addition to the ecological importance of species and habitat preservation, there are also legal requirements such as the Threatened and Endangered Species Act that mandate conservation.

Past, Present, and Future Climate

The climate of the Colorado River Basin has long been defined by high variability in both precipitation and temperature, but the constant nature of the system is a cold and humid climate in the relatively small headwaters regions where snowpack contributes to streamflow, but a semi-arid and arid climate throughout the rest of the basin. The average temperature in the basin is expected to increase; The SECURE Water Report noted a 2.16°F (1.2°C) increase in basin-wide temperatures in the 20th century. The Lower Basin alone saw a 3.06°F (1.7°C) increase, due to the dryer and hotter climate of the lower states. Findings also predict a 6-7°F (3.3-3.9°C) increase in Upper Basin average temperatures over the course of the 21st century, coupled with a 5-6°F (2.8-3.3°C) increase in Lower Basin temperatures over the same period.[27]

Impacts on Water Supply

Nearly all studies agree that the temperature increases predicted for a changing climate have a large probability of further reducing the water supply of the Colorado River. The Bureau of Reclamation has projected future changes in average annual runoff using an ensemble of 112 climate model runs; the ensemble mean is an 8.5% decrease by 2050. The climatic explanation for this flow reduction lies in a diminished accumulation of high elevation snow during the cool season due to higher average temperatures, which translates into a smaller snowpack and less snowmelt to sustain runoff during the warm season.[28] Expected changes in precipitation in the range of a 2.1% increase and a 1.6% decrease in the upper and lower basins, respectively, may also impact the supply of the river.

Impacts on Ecosystems

Increases in temperature will create additional stress on already sensitive fisheries, creating both ecological and economic strain in the region. A warmer climate also provides an optimal habitat for some invasive species, which will continue to threaten native flora and fauna. The hotter temperatures will likely be accompanied by increased wildfire potential and subsequent habitat destruction.[29]

Conclusion

These issues are individually complex, and their relationships with one another are not fully understood. If efforts are not made to reach a careful balance between supply, demand, and competing uses, however, the negative impacts of each issue will become amplified, leading to drastic changes in the state of the Colorado River. While most matters of the river are currently in the hands of powerful stakeholders and politicians, what happens in the next decade largely dictates the future of the river for the next generation and beyond. It is time for the younger generation to become informed, involved, and engaged in making clear its desires, expectations, and solutions for the future of the Colorado River, before it is too late.

[1]Jonathan Waterman, Samuel Velasco, and Robert E. Pratt, *Colorado River Basin: Lifeline for an Arid Land*, National Geographic Society, September 2010, http://maps.nationalgeographic.com/maps/print-collection/colorado-basin1-map.html.
[2]Dale Pontius and SWCA, Inc. Environmental Consultants, "Colorado River Basin Study: Final Report," Report to the Western Water Policy Review Advisory Commission, 1997, 13.
[3]Jonathan Waterman, Samuel Velasco, and Robert E. Pratt, *Colorado River Basin: Lifeline for an Arid Land*, http://maps.nationalgeographic.com/maps/print-collection/colorado-basin1-map.html.
[4]Dale Pontius and SWCA, Inc. Environmental Consultants, "Colorado River Basin Study: Final Report," 2.
[5]Ibid., 5.
[6]Ibid.
[7]Colorado River Compact, 1922. Art. III Sec. (b).
[8]Dale Pontius and SWCA, Inc. Environmental Consultants, "Colorado River Basin Study: Final Report," 15.
[9]Ibid., 21.
[10]Douglas Kenney, "An Introduction to Key Facts and Issues Regarding the Allocation and Use of the Colorado River" (conference primer for Hard Times on the Colorado River: Growth, Drought, and the Future of the Compact, Natural Resources Law Center, University of Colorado at Boulder, June 8-10, 2005), p. 9.
[11]Dale Pontius and SWCA, Inc. Environmental Consultants, "Colorado River Basin Study: Final Report," 30.
[12]Congressional Budget Office, *Water Use Conflicts in the West: Implications of Reforming the Bureau of Reclamation's Water Supply Policies*, accessed January 24, 2012, http://www.cbo.gov/doc.cfm?index=46&type=0&sequence=3#N_7_ .
[13]Jonathan Waterman, Samuel Velasco, and Robert E. Pratt, *Colorado River Basin: Lifeline for an Arid Land*, http://maps.nationalgeographic.com/maps/print-collection/colorado-basin1-map.html.
[14]Western Resource Advocates, "Smart Water: A Comparative Study of Urban Water Use Efficiency Across the Southwest," December 2003, p. 9.
[15]Jonathan Waterman, Samuel Velasco, and Robert E. Pratt, *Colorado River Basin: Lifeline for an Arid Land*, http://maps.nationalgeographic.com/maps/print-collection/colorado-basin1-map.html.
[16]Michael J. Cohen, "Municipal Deliveries of Colorado River Basin Water," Pacific Institute, June 2011, p. 36.
[17]Western Resource Advocates, "Smart Water: A Comparative Study of Urban Water Use Efficiency Across the Southwest," p. 9.
[18]US Bureau of Reclamation, "2. Basin Report: Colorado." In SECURE Water Act Section 9503(c): Reclamation Climate Change and Water, Report to Congress, 2011, 17-40.
[19]Dale Pontius and SWCA, Inc. Environmental Consultants, "Colorado River Basin Study: Final Report," 22.
[20]US Bureau of Reclamation, "Colorado River System Consumptive Uses and Losses Report 1996-2000," accessed August 10, 2011, http://www.usbr.gov/uc/library/envdocs/reports/crs/pdfs/crs962000.pdf
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[22]Glen Canyon Dam Adaptive Management Program, "Sediment and River Sand Bars in the Grand Canyon," accessed June 26, 2011, http://www.gcdamp.gov/keyresc/sediment.html.
[23]International Rivers, "Sedimentation Problems with Dams," accessed June 26, 2011, http://www.internationalrivers.org/node/1476.
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[25]US Bureau of Reclamation, "Quality of Water: Colorado River Basin Progress Report No. 22," 2005, p. 13.
[26]Ibid., p. 23.
[27]US Bureau of Reclamation, "2. Basin Report: Colorado," p. 17-40.
[28]Ibid.
[29]Ibid.