

THE COLORADO RIVER  
HISTORY AND CONTEMPORARY ISSUES OF A COMPLEX SYSTEM

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INTRODUCTION

This paper provides an overview of the Colorado River system, a historical presentation of the legal and institutional development of the river, a discussion of contemporary issues related to management of the river as well as programs to address those issues, and finally a brief section citing some broad lessons learned that may be applicable to other river basins.

OVERVIEW

The Colorado River and its tributaries extend for over 1,350 miles in the southwestern United States, connecting parts of seven American states. The river drains the western slope of the Rocky Mountains, serving a basin of 242,000 square miles that comprises approximately one twelfth of the continental United States. The river extends an additional 50 miles into the country of Mexico, where it historically drained into the Pacific Ocean via the Gulf of California. The river is the single most important economic and environmental resource of the region. In the two countries, its water serves a population of approximately 20 million people, irrigates nearly 2 million acres of farm land, generates in excess of 10 billion kilowatt hours of hydroelectric energy annually, provides over 30 million visitor days of recreation activity annually and nourishes habitat for thousands of species of plants and animals in an arid and semiarid environment. In short, the Colorado River is the life blood of the region.

The river's natural flow is highly variable, both seasonally and annually. Historical seasonal flows range from a trickle in the late summer and fall months to in excess of 200,000 cubic feet per second during spring runoff periods. Historical annual flows, measured at Lee's Ferry just before the river flows into the Grand Canyon, have ranged from as low as 5 million acre-feet, to as high as 25 million acre-feet. The average annual flow over the 93 years of measured record is approximately 15 million acre-feet.

With the high variability in flow, severe flooding and periodic drought hampered economic development in the United States and Mexico during the early part of the century. An extensive system of dams and reservoirs was developed in the United States by the Federal Government, in concert with the Basin States, from the 1920's through the 1960's, creating a reservoir system with 60 million acre-feet of storage. Today floods are, for the most part, controlled and the significant carryover storage has prevented severe drought.

## HISTORY OF LEGAL AND INSTITUTIONAL DEVELOPMENT

Management of the river is governed by a complex set of compacts, laws, court decrees, treaties, and contracts developed over a 75 year period. The development of this legal framework, known as the "Law of the River", has been fraught with controversy among the entities and institutions involved. Much of this controversy still exists today. An understanding of the historical development of the river and its legal framework is important to understanding the contemporary issues.

**1922 Colorado River Compact** - In the early 1900's, significant irrigation development with Colorado River water began in the Imperial Valley of California. Flooding and drought, however, severely hampered progress, and California began seeking Federal help to construct major dams that would allow development to proceed. States upstream of California, however, used their political power in Congress to block Federal assistance, fearing that California would develop and use all the available water supplies before the other Basin States could develop what they viewed as their fair share. The Western legal doctrine of "prior appropriation" recognized first uses of water as highest priority when supplies were limited. Hence the fear of the other Basin states was warranted.

The Basin States recognized the need for development of the Colorado River to allow economic development, and determined that an interstate compact regarding use of the river's waters was the best way to achieve this. In 1921, the States requested the Federal government's assistance in developing this compact to assure an equitable apportionment of the water. Secretary of Commerce Herbert Hoover (later President Herbert Hoover) was called on to facilitate the agreement. Hoover found consensus difficult, and was unable to achieve agreement on an allocation of water among the States. He was, however, ultimately able to fashion a compromise by dividing the river into two roughly equal basins, with an allocation of water to each basin (as opposed to each state). The Upper Basin, where most of the river's flow originates, was given the right to develop and use up to 7.5 million acre-feet annually. In return, the Upper Basin, composed of the states of Colorado, Utah, Wyoming and New Mexico, agreed to deliver, on average, at least 7.5 million acre-feet annually for use in the Lower Basin, composed of the states of Arizona, California, and Nevada.

It is useful to note that, at the time the compact was negotiated (1922), the 16 years of available measured river flow indicated the average annual flow at the compact point was approximately 18 million acre-feet. The compact negotiators, therefore, thought the 15 million acre-feet allocated to the two basins could be easily met and still leave adequate water supplies to meet anticipated deliveries to the country of Mexico through a yet-to-be-negotiated treaty. Subsequent measurement of flow on the river has shown that the 16 years of flow available in 1922 was unusually high, and that actual average annual flow at the compact point over the 93 years of measured record available today is closer to 15 million acre-feet. Some hydrologists argue that, based on measurement of tree growth in the basin over a couple of centuries, the correlated longer term average annual flow is closer to 13.5 million acre-feet. Many conclude that the Colorado River system has been over-allocated and that significant shortages of water will ultimately prevail on the system.

**1928 Boulder Canyon Project Act** - It wasn't until 1928 that Congress was able to move forward with the passage of legislation authorizing the construction of infrastructure to control and develop the Colorado River. The delay was caused by strong disagreement among the Lower Basin States of Arizona and California over the allocation of the Lower Basin's share of the river. The Arizona legislature refused to ratify the Compact and, through its representatives in Congress, Arizona was able to successfully slow progress. In 1928, after much delay and bickering between the two states, the Congress passed the Boulder Canyon Project Act. In addition to authorizing the Federal construction of Colorado River infrastructure (including Hoover Dam), the Boulder Canyon Project Act ratified the Compact (in spite of the Arizona Legislature's refusal to concur), authorized the development of a Lower Basin compact if the states could reach agreement, suggested an allocation of water among the Lower Basin States if agreement on a compact could not be achieved, and authorized the Secretary of the Interior to implement the suggested allocation by contracting for permanent water service to individual entities in the Lower Basin.

Ultimately, the Lower Basin states did not agree on a compact and the Secretary implemented the suggested allocation by exercising his newly acquired contracting authority. This action, in essence, Federalized the Lower Basin of the Colorado River system. Normally, state law and administrators control the allocation of water in Western states. In this case, the interstate nature of the river, the bitter dispute among the states involved, and the need to move forward with development resulted in the Congress granting power to Federal administration.

The suggested allocation by Congress divided the Lower Basin's entitlement of 7.5 million acre-feet by apportioning 4.4 million acre-feet to California, 2.8 million acre-feet to Arizona, and 300,000 acre-feet to Nevada. At the time, the population of southern Nevada was quite small and Nevada had no arable land to support irrigation development. Nevada did not pursue a larger allocation and was given less than three percent of the Lower Basin entitlement. This contrasts with conditions today, with southern Nevada having a population of approximately 1.2 million and leading the nation in economic and population growth. The small allocation to Nevada is today inadequate to meet the needs of the area's growing urban population, and other water supplies are not readily available.

**1929 California Limitation Act and Subsequent Seven Party Agreement** - In 1929 the California Legislature passed the California Limitation Act, which made it unlawful for California entities to utilize more than their allocated share of Colorado River water. The Limitation Act was required by Congress as a concession to the other six basin states, who wanted to ensure California would abide by the Compact and the allocation provided under the Boulder Canyon Project Act. The Limitation Act was a prerequisite to the initiation of construction of facilities authorized under the Boulder Canyon Project Act.

In 1931 the California entities entered into the Seven Party Agreement, which allocates California's share of the river among the California entities. The agreement and subsequent contracts allocated 3.85 million acre-feet, the bulk of California's 4.4 million acre-foot basic apportionment, to irrigation use, leaving the remaining 550,000 acre-feet for urban use on California's coastal southern plain (i.e., the Los Angeles metropolitan area).

Like the basin states, the entities within California found it difficult to agree on specific water allocations. Ultimately, the Seven Party Agreement allowed four agricultural entities to share the first 3.85 million acre-feet of California's apportionment, but did not assign a specific allocation to each entity. The agreement only established a priority system in which the entities were given first, second, and third priority rights to beneficially use water within a specified service area. A subsequent agreement (known as the Compromise Agreement) between two entities sharing the third priority made the fourth entity (the Coachella Valley Water District) last in priority among the irrigation users. If the first three entities utilized all or most of the water, the fourth entity was responsible for adjusting its use to accommodate the increased uses of the other three entities.

The Seven Party Agreement also assigned Colorado River water rights beyond the 4.4 million acre-foot basic apportionment. A fifth priority of 662,000 acre-feet was assigned to the Los Angeles metropolitan area, and any additional water that might be available was assigned to irrigation users under priorities 6 and 7. In essence, the Seven Party Agreement allocated 5,062,000 acre-feet to priorities 1 thru 5, with urban use having the lowest priority among the California users. California entities quickly developed and utilized water under the first five priorities of the Agreement, and today are still diverting in excess of 5 million acre-feet from the river annually. The excess diversion by California entities has been allowed to occur because the allocated share of water to the other six basin states has not been fully developed and used. In essence, this has created extra water to accommodate California's water needs on a temporary basis.

**1944 Mexican Water Treaty** - In 1944, the United States and Mexico entered into the Mexican Water Treaty. The treaty defined international rights of use for three rivers flowing across the border between the two countries, including the Colorado River. The treaty calls for the annual delivery of 1.5 million acre-feet of Colorado River water to the country of Mexico, to be scheduled on a monthly basis in accordance with orders submitted by Mexico. In addition, the Treaty calls for the scheduled delivery of an additional 200,000 acre-feet to Mexico in years when surplus water is available in amounts that are in excess to the amounts required to meet the needs of water users within the United States. The treaty also calls for Mexico to share on a pro-rata basis any shortages that may occur on the Colorado River system.

The allocation to Mexico was fully utilized shortly after the treaty was negotiated. While shortages have never occurred, 200,000 acre-feet of surplus has been made available to Mexico in many years when wet cycles created abundant water supplies. Shortages may occur at some point in the future when the United States, primarily the Upper Basin States, finally achieves full utilization of water reserved under the Compact. With the treaty commitment to Mexico, the 16.5 million acre-feet of total allocation exceeds the 15 million acre-feet of annual flow by 1.5 million acre-feet.

**1948 Upper Colorado River Basin Compact** - Unlike the Lower Basin, the Upper Basin States were able to achieve consensus regarding the allocation of their Compact reserved entitlement, and created an Upper Basin Commission to oversee and coordinate matters among the Upper Basin states. The states maintain the traditional role of controlling the allocation and administration of water rights on the Colorado River and its tributaries in the Upper Basin.

Agreement among the Upper Basin States resulted in passage of the 1956 Colorado River Storage Act by Congress, ratifying the Upper Basin Compact and authorizing Federal construction of Glen Canyon Dam and many smaller projects. The dam was completed in 1964 and nearly doubled the storage capacity on the Colorado River system. In addition to providing over 1000 MW of hydroelectric generating capacity, the dam's 25 million acre-foot reservoir provides storage for the Upper Basin States to meet their compact obligation to the Lower Basin.

It is worth noting that the construction of Glen Canyon Dam was among the first environmental controversies in the history of water development in the western United States. Construction of the dam, which is located just above the Grand Canyon in the State of Arizona, was of concern to environmental interests because of its inundation of Glen Canyon, a significant historical site with important natural habitat. In addition, construction of the dam significantly altered the flow of the river through the Grand Canyon, eliminating the seasonal high and low flows of turbid water.

**1964 Arizona v. California Supreme Court Decree** - In the 1940's and early 1950's the State of Arizona began efforts to develop the Central Arizona Project (CAP), a project to divert Arizona's remaining unused mainstream Colorado River water into the central portions of the state. Like most large western water projects, Arizona needed the assistance of the Federal government to finance construction, and sought Congressional authorization. The state of California, however, objected and successfully blocked Arizona's attempt to obtain authorization for many years. California was utilizing more than its share of the river and feared development of the CAP would limit its ability to continue its high use. Further, California argued that Arizona's already full development of its Colorado River tributaries (i.e., the Gila River system) counted against its main stem entitlement allocated by the Boulder Canyon Project Act and, therefore, Arizona's Colorado River allocation was already fully utilized and there was no water available for the CAP.

In 1951, Arizona filed suit against California in the United States Supreme Court, asking that the relative rights among the two states be clarified. The Court appointed a Special Master who gathered data and information over a 12 year period. The Court decided in Arizona's favor, ruling in a 1963 decision that tributary use in the Lower Basin did not count against the mainstem entitlement apportioned under the Boulder Canyon Project Act. The Court left administration of tributary flows prior to commingling with the mainstem to control by the states, but strengthened the role of the Secretary of the Interior as Water Master of the mainstem in the Lower Basin. The Court also ruled that California could continue to utilize more than its mainstem entitlement of 4.4 million acre-feet as long as there was unused apportionment available from the other Lower Basin states. The Court made clear, however, that California maintains no long-term right to the unused entitlement and must defer its use to the other states as their uses increase to the apportioned amounts.

The 1964 Decree enjoined the Secretary from delivering water outside the apportioned entitlements and directed the Secretary to prepare an annual accounting of water use in the Lower Basin. The Decree recognized, however, that periods of hydrologic surplus and shortage were likely to occur, and charged the Secretary with making such determinations on an annual basis.

The court apportioned surplus supplies by giving 50 percent to California, 46 percent to Arizona, and 4 percent to Nevada. In the case of shortage, the Court left the assignment of reductions to the discretion of the Secretary subject to the prior satisfaction of those water entitlements established under state law prior to passage of the Boulder Canyon Project Act in 1928.

The Decree also established the reserved rights of five Indian tribes located along the river in the Lower Basin. The reserved rights of the five tribes totaled approximately 900,000 acre-feet and was included as part of the 7.5 million acre-feet allocated to the Lower Basin States. Most of the Indian reserved rights have been utilized through irrigation development on reservation lands.

**1968 Colorado River Basin Project Act** - With Arizona and California's relative rights to mainstem water finally settled, Arizona pressed ahead for Congressional authorization of the CAP. That occurred with passage of the Colorado River Basin Project Act in 1968. True to form, however, passage of the act did not occur without additional skirmishes between California and Arizona. Arizona needed California's political support to obtain Congressional authorization, and California extracted a price for that support. The Act authorized the CAP, but also provided that the CAP water supply of approximately 1.5 million acre-feet annually would have a lower priority to California's 4.4 million acre-feet in times of shortage on the Colorado River system.

Recognizing the Secretary of the Interior's more completely defined role under the Decree, the Act also directed the Secretary to prepare Long Range Operating Criteria for Colorado River reservoirs. The criteria, to be prepared in consultation with representatives of the Governors of the seven basin states, would address such issues as release of water from the Upper to the Lower Basin and conditions under which normal, shortage and surplus conditions on the Colorado River occur. The Secretary adopted long range criteria shortly thereafter (in 1970) and has reviewed the criteria at five year intervals since. The criteria are quite broad, leaving considerable discretion to the Secretary in making annual operating decisions for the river.

**1973 Mexican Treaty Amendments and 1974 Salinity Control Act** - In the 1960's and early 1970's, the salinity level of Colorado River water delivered to Mexico increased substantially. The increases were caused primarily by irrigation return flows from new irrigation development in the Wellton Mohawk Irrigation District northeast of Yuma, Arizona. Diplomatic protests filed by Mexico with the American State Department resulted in an amendment to the Mexican water treaty in 1973 to address standards of water quality. The treaty amendment, known as Minute 242, required the United States to deliver water at Mexico's northern international border with a quality approximately equal (within 115 parts per million total dissolved solids) to that delivered to water users in the United States.

Congress supported the treaty amendment by passing the 1974 Colorado River Salinity Control Act, which authorized construction of facilities to collect and prevent highly saline drainage flows from returning to the river and commingling with Mexican deliveries. A drainage canal was constructed to bypass approximately 132,000 acre-feet of highly saline drainage water to the Santa Clara Slough in Mexico. The flows have been bypassed since the late 1970's, creating marsh habitat in the Colorado River delta in Mexico that is now viewed as a valuable environmental resource.

To protect the quantity of water supplies for United States users, the salinity control act also authorized construction of facilities to replace the bypassed flows, including the construction of a plant to desalt and return to the river up to 108,000 acre-feet of otherwise bypassed flow. Construction of the desalting plant was completed in 1992, but its operation has been held in abeyance because replacement water supplies from other sources have been available.

## CONTEMPORARY ISSUES

The primary force driving contemporary issues on the river is the increasing use of water. Completion of the Central Arizona Project has allowed Arizona to begin using its full apportionment. Significant population growth in Las Vegas has pushed Nevada's use close to its full entitlement, and with California's overuse, the Lower Basin has been exceeding its basic apportionment since 1996. For the first time, the Secretary of the Interior has been faced with the possibility of having to enforce limits on water use in the Lower Basin as required under the Supreme Court Decree in *Arizona v. California*. Fortunately, a wet cycle over the last four years has kept Colorado River reservoirs full and the Secretary has been able to declare that surplus conditions exist, allowing all lower basin needs to be met. In addition, Upper Basin development has still not fully materialized, with annual use approaching only 4 million acre-feet of its apportionment. With the lack of Upper Basin development, total current use on the Colorado River system hovers around 14 million acre-feet, still less than the long-term historical average flow.

California interests argue that, with less than full development of the Upper Basin, system water supplies are adequate to continue to meet the State's need, and the Secretary should continue to declare surplus so the water needs of the California urban users can continue to be met (under the Seven Party Agreement, the fifth priority urban use would be required to reduce use if surplus supplies were not available). California has petitioned the Secretary for the development of more specific criteria regarding surplus decisions so it can have more certainty regarding the availability of surplus water. Alternatively, the other basin states are concerned that California's appetite for Colorado River water will never be satisfied and its continued reliance on surplus for urban use is not conducive to good long-term water planning. The Upper Basin states are concerned that California's reliance on, in essence, their unused Compact apportionment may make it more difficult for them to ultimately develop their full share of the river. Arizona is concerned about potential dry cycles and the possibility that California's continued overuse could exacerbate the impacts of shortages on the Central Arizona Project, especially in light of the CAP's junior entitlement, which was imposed by California in exchange for political support for the project's authorization.

Other forces that are likely to place increasing demands for water from the river include: (1) the state of Nevada, which, like California, will soon have demand for more than its basic entitlement; (2) Mexico, which would also like more access to surplus water as allowed under the treaty; and (3) environmental needs, which are not recognized under the traditional "Law of the River," but are recognized through the National Environmental Protection Act of 1969 and the Endangered Species Act of 1973.

Finding solutions to these issues is a difficult task. The "Law of the River" creates a relatively inflexible framework that is not necessarily conducive to meeting the changing needs of the river basin. The river's contentious development history only makes the legal and institutional framework more inflexible. Nevertheless, population growth and new public values related to environmental protection dictate the need for flexibility.

Developing an approach to dealing with these issues is a work in progress. Some of the issues are better defined than others, and the approach to resolution more fully developed. Other issues are less defined, and there is still debate about how to resolve them. In general, however, significant progress is occurring. Following is a brief overview of the major programs and initiatives underway.

**Development of a California 4.4 Plan** - California's continued use of more than its 4.4 million acre-foot basic apportionment is probably the single most talked about problem on the Colorado River today. The basin states and the Secretary of the Interior fear that if California was forced to make a major reduction in use, that could have devastating impacts on the 16 million people in the southern California urban area who depend on this water. The political ramifications of such a reduction are of concern to the other six basin states as well as the Secretary. As a result, there is consensus, even among California interests, that a plan for gradual reduction in California's use is needed. The development of such a plan is currently under way.

The primary focus of the plan is to provide for willing seller-to-buyer market transfers of water from the California agricultural users, which have the highest priority to Colorado River water, to the urban area, which has the lowest priority. Such transfers will allow the agricultural users to bear the burden of reducing California's use in exchange for appropriate monetary compensation from the urban area.

The primary impediment to implementing water transfers has been the nature of the Seven Party Agreement, which does not assign specific entitlements to the four irrigation districts involved. Every time a transfer arrangement is proposed, the low priority irrigation user (i.e., the Coachella Valley Water District) brings litigation claiming rights to the transferred water via its intervening priority. The Secretary, as Lower Basin water master, recognized this problem and conditioned approval of pending transfers of approximately 400,000 acre-feet on a revision of the Seven Party Agreement to specifically quantify the rights of the irrigation users. To provide incentive for California to cooperate, the Secretary threatened to withhold the development of surplus guidelines until the California agencies could reach a quantification settlement. To further place emphasis on the need to make progress, Secretary Bruce Babbitt commissioned his top deputy, David Hayes, to facilitate settlement discussion among the California entities. The Governor of California similarly commissioned the state's top water official to assist in the discussions. After nearly 18 months of contentious and complex negotiations, a settlement framework was approved by the entities on October 15, 1999. The agreement quantifies the third priority rights of the Seven Party Agreement and opens the door for the pending transfers to be approved. When implemented, the agreements will allow California to gradually reduce its use by roughly 400,000 acre-feet.

**Development of Surplus Guidelines** - As noted earlier, the Supreme Court, in *Arizona v. California*, made the Secretary of the Interior responsible for making annual hydrologic determinations regarding the amount of water available for use in the Lower Basin (i.e., normal, shortage or surplus). Until 1996, the demand for water in the Lower Basin had been less than the Basin's normal year apportionment. With large amounts of reservoir storage, there was little need to consider anything but normal determinations. Now, with Lower Basin use exceeding the basic apportionment, there is significant focus on the Secretary's annual decision. California desires more certainty regarding the annual determination and has requested that criteria or guidelines be developed to guide the decision making process. With California's significant recent progress in developing a 4.4 plan, the Secretary has indicated his desire to move forward with development of the guidelines. The current schedule calls for the guidelines to be completed by December 2000.

The Secretary's desire is to develop guidelines that represent the consensus view of the seven basin states. In accordance with the Colorado River Basin Project Act of 1968, the Secretary must consult with the seven states before adopting the guidelines. While progress on the California plan will placate some of the concerns of the other six basin states, it is currently unclear whether consensus can, in fact, be achieved. California will undoubtedly prefer a liberal set of guidelines that allow surplus declarations to occur even during dry cycles. California interests will argue that large carryover storage on the Colorado River system will minimize the probability of shortages and not cause undue risk to the other basin states. The other states, however, will have an aversion to the risk of shortage and will undoubtedly prefer more conservative criteria that make surpluses available only when spills occur or are highly likely to occur. The other states will argue that any additional risk of shortage, however small, is unacceptable. The Secretary and his staff will likely find it a significant challenge to develop a set of surplus guidelines acceptable to all. At this point it is not clear what perspective the guidelines will take. It is thought, however, that they will be of limited duration, possibly 15 years, and will be contingent upon California's successful implementation of its 4.4 plan.

**Interstate Transfers of Colorado River Water** - Historically, market transfers of Colorado River water have been limited to transfers between entities within a single state. Traditional interpretation of the state entitlement system defined under the Boulder Canyon Project Act and the Supreme Court Decree in *Arizona v. California* has been that interstate transfer is prohibited. Similarly, the 1922 Colorado River Compact has been interpreted to preclude interbasin transfers. In recent years, that interpretation has been questioned, primarily by the states of Nevada and California. These two states have near-term demands that exceed their apportionments and see the potential need for interstate cooperation through market-based transfers. In the Upper Basin, the State of Utah has expressed interest in being a seller of water to other states, primarily Nevada in the Lower Basin. The other four states - Wyoming, Colorado, New Mexico, and Arizona - are resistant to wholesale interstate marketing. Secretary of the Interior Babbitt has expressed strong support of interstate water marketing, seeing it as a win/win solution to meeting the changing demands for water throughout the basin. In 1994, the Secretary informally proposed regulations to allow interstate transfers in the lower basin. Because of strong objections from the state of Arizona, the proposal was withdrawn.

In 1994 and 1995, a technical committee of representatives of the Secretary, the Lower Basin States, and Lower Basin Indian Tribes explored various options for cooperation in facilitating Lower Basin interstate transfers. The results of that effort are reflected in a new set of federal regulations, published in October 1999, to facilitate the interstate banking and transfer of Colorado River water in the Lower Basin. Under these regulations, state authorized entities can utilize offstream storage facilities to divert and store surplus and unused Colorado River water. The water preserved in the storing state can then be sold to a consuming state. The storing state would transfer the water to the consuming state by withdrawing the water for local use at some future date and forbearing its diversion of Colorado River water, allowing the consuming state to directly divert water from the river. While this approach is somewhat more complicated than direct market based transfers, it provides a water management tool that can help meet some of the new demands on the river. Under this regulation, it is expected that the state of Arizona, with a very large groundwater basin, will serve as the primary storing state, while the states of Nevada and California will be the primary consuming states. Nevada views this program as the primary tool for meeting its increasing water needs over the next 30 to 50 years. All of the basin states support this form of interstate water transfer.

**Glen Canyon Dam Adaptive Management Program** - Since its completion in 1964 and until recently, releases from Glen Canyon Dam were made to maximize the value of power produced at its power plant. Highly fluctuating flows were made to meet the peaking demand of the power market in the southwestern United States. Operation of the dam in this fashion totally altered the sediment and flow regime historically experienced in the section of the river flowing through the Grand Canyon. Beginning in 1992, the impacts of this form of operation on the Grand Canyon's ecosystem were cooperatively studied by all interested parties. The result was the development of the Glen Canyon Dam Adaptive Management Program, a science-based effort to manage the dam's operations in a manner that considers impacts on downstream environmental resources. Today, the highly fluctuating releases that meet demands of the power market have been curtailed in favor of gradual and limited daily fluctuations that minimize sand bar and habitat erosion along the river. Periodic experimental floods to mimic the natural hydrograph are also part of the dam's periodic operation.

The change in operational patterns of Glen Canyon Dam comes at significant expense and with considerable conflict. Power contractors reluctantly went along with the changes, in spite of power market losses literally in the millions of dollars. Changes made at Glen Canyon Dam represent the public's focus and desire to protect environmental values, especially in areas of national significance such as the Grand Canyon.

**Lower Basin Multi-Species Conservation Program** - Under Section 7 of the Endangered Species Act (ESA), Federal agencies are required to consult with the U.S. Fish and Wildlife Service if their actions potentially affect species listed as endangered under the act. The Service must review the agency action to ensure that adverse affects to the species are avoided, and may prescribe appropriate reasonable and prudent actions to avoid jeopardizing the species. The Lower Basin of the Colorado River has four endangered fish species and two endangered birds occupying habitat in or near the river. Operational decisions of the Secretary require consultation, as do the diversion decisions of the water users. To comply with the Endangered Species Act,

the Lower Basin States, the Bureau of Reclamation, and other affected parties have embarked on the development of a multi-species conservation plan (MSCP) with the Fish and Wildlife Service. The plan is aimed at developing aquatic and terrestrial habitat along the lower river that will move the listed species toward recovery and prevent other species from being listed. These actions will result in achieving ESA compliance and allow operational decisions that continue the water and power deliveries in the Lower Basin.

The MSCP is a work in progress. The current schedule calls for the plan to be selected in December 2000. Many controversial issues will have to be addressed before the plan is completed. Some of the issues include: establishing a formula for cost sharing; obtaining water supplies to support the development of new habitat; and providing assurances that additional compliance will not be required at a later date.

**International Cooperation With Mexico** - There are a number of ongoing international issues with the country of Mexico that are being addressed in collaboration with the U.S. Department of State's International Boundary and Water Commission (IBWC). IBWC serves as the focal point for all communication with Mexico, hosting joint meetings between the technical staff of river management agencies of both countries. In general, the working relationship between the two countries on river management matters is good. Water deliveries and occasional flood operations between the two countries are coordinated in a routine manner. Ongoing areas of special consultation and cooperation include: (1) managing sediment loads in deliveries to Mexico; (2) maintaining salinity levels consistent with treaty requirements for deliveries at both the northern and southern international boundaries between the two countries; (3) addressing issues related to making surplus water supplies available to Mexico under the treaty; and (4) coordinating environmental study efforts of the Colorado River delta in Mexico.

Periodic flooding on the Colorado and its main Lower Basin tributary, the Gila River, has from time to time substantially increased the sediment load of water delivered to Mexico. Gila River floods in 1992 deposited more than 10 million cubic yards of sediment in the section of the river just north of the major delivery point to Mexico. This has created recurring operation problems in Mexico, with sediment filling canals and restricting delivery capacity. After significant consultation, the Bureau of Reclamation agreed to dredge the sediment-laden section of the river between the Mexican diversion point and the confluence of the Gila and Colorado Rivers. The dredging program was initiated last year and will be completed in 2001 at an estimated cost of \$15 million. (U.S. dollars).

As discussed earlier, salinity has been a long-standing issue between the two countries. Deliveries at the northern border, which constitute 90 percent of the Mexican delivery, are governed by the standard established in Minute 242. That standard is routinely met without controversy. The remaining 10 percent of the Mexican entitlement is met through deliveries at the southern international boundary, where the standard for salinity is to be maintained at levels that were customarily experienced just prior to the establishment of Minute 242. The United States believes this standard is being met. Mexico, however, has experienced changes in the crop mix served by south boundary deliveries and has found that new cropping patterns include crops that are less salt tolerant. Mexico, therefore, raised concerns with the quality of south boundary deliveries. As a

matter of comity, the United States did studies to see if the quality of south boundary deliveries could be improved. The studies showed that the salinity of south boundary deliveries are particularly critical during certain months when crop germination occurs, and that salinity improvement during those periods would have the most impact. After consultation with Mexican and American interests, the United States agreed to substitute better quality groundwater for flows that would otherwise occur at the south boundary during those periods when salinity was high and crop germination was occurring. Variable speed pumps and a small bypass channel will have to be installed at American expense to implement the program over the next couple of years.

The Colorado River delta in Mexico also has become a focal point of interest between the United States and Mexico. Environmental interests in both countries have recognized the importance of habitat in the delta, and the two countries have agreed to work jointly to better understand the broad ecosystem implications for the river and the delta. In many years the delta is dry, with the exception of American drainage flows to the Santa Clara Slough. If the desalting plant is operated, most of the drainage flows would be eliminated. Environmental interests would like to see a commitment of water supply to protect environmental values in the delta, but the river, in both countries, is already fully allocated. American and Mexican water interests are resistant to any consideration of restoration of the delta. The United States is interested in looking at offstream banking programs in Mexico or the United States to see if dry year water supplies for the delta might be provided without infringing on the rights of existing entitlement holders. Such an approach would be similar to the approach of Nevada and Arizona under the interstate offstream banking program. Final solutions however, are still undefined and will require significantly more study.

## LESSONS LEARNED

In summary, the Colorado River has a contentious history with plenty of challenges still available to the contemporary managers of the river basin. An understanding and appreciation of the history is critical to successful resolution of today's issues. Significant progress is occurring on many fronts, but undoubtedly new issues will arise as old ones are resolved. While many of the problems and issues are unique to the Colorado, there are some general observations that might apply to all river basins:

- 1. Change is Difficult, Full of Conflict, but Necessary** - River basin managers must not only have the technical skills to manage a complex river system, but also the human interaction skills to facilitate resolution of conflict-ridden issues. Good skills in mediation and facilitation are critical to finding solutions to river basin problems.
- 2. Leadership is Important** - Good leadership from a neutral river basin manager is helpful in achieving success. In the case of the Colorado River, Secretary Babbitt's willingness to use his role as water master has been critical in getting progress on the California Plan, interstate transfers and surplus guidelines. A willingness to make proposals, persuade, coax, cajole, and make difficult decisions are critical in making entrenched parties move toward consensus.

**3. Progress is Slow and Comes One Step at a Time** - Resolution of water issues take years to occur and many times happens incrementally. River basin managers should appreciate even limited progress, always maintaining an optimistic outlook.

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