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Colorado River Basin Study

Final Report

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In conjunction with

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Tucson, Arizona

Report to the Western Water
Policy Review Advisory Commission

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Principal tributaries to the Colorado River upstream of Glen Canyon Dam include the Green, San Juan, Escalante, Gunnison, and Dolores rivers. Principal tributaries between Glen Canyon and Hoover Dams include the Paria, Virgin, and Little Colorado rivers. Downstream of Hoover Dam are the Bill Williams and Gila rivers. Major tributaries to the Colorado River are depicted in Figure 3.

Historically, the flow of the Colorado River, measured at Lee Ferry, fluctuated widely from year to year, season to season, and over long periods of time. Annual flows in excess of 24.0 million acre-feet (maf) and less than 6.0 maf have been calculated (Harding *et al.*, 1995). The long-term historical average measured is 14.95 maf but tree-ring studies covering hundreds of years suggest a long-term average annual flow of about 13.5 maf (Stockton and Jacoby, 1976). Most of the flow for the Colorado originates in the Upper Basin, which encompasses some 109,800 square miles. About 86 percent of the annual runoff originates within only 15 percent of the area, in the high mountains of Colorado (Stockton *et al.*, 1991).

The natural flow of the Colorado followed a distinct seasonal pattern, with more than 70 percent occurring in the months of May, June, and July (Harding *et al.*, 1995). Historically, floods of May and June peaked at greater than 86,000 cfs (Collier *et al.*, 1996). Since flows are now regulated by several major dams, peak flows are significantly lower. Over the last 20 years (with Glen Canyon Dam in place), peak daily discharges at Lee Ferry averaged 20,005 cfs in May and 25,735 cfs in June (USGS, 1996).

Over the past century, the bulk of the highest flows occurred in a "wet" period from 1896 to 1930, when the average annual natural flow during this period at Lee Ferry was about 17 maf/yr. By contrast, the average flow from 1930 to 1996 was about 13.9 maf/yr (Merritt, 1997). In the early 1980s, heavier than anticipated runoff led to releases from Lake Powell of over 90,000 cfs[2] and the emergency installation of flashboards on top of the spillway gates and Hoover Dam spilled for the first time since 1941. Flood control releases totaling over 50 maf led to substantial flooding and damages along the lower river. The wettest 10-year period on record (1914 to 1923) saw an average annual flow of 18.8 maf. This period is especially significant

[2] According to Dave Wegner, releases peaked at 97,300 cfs on June 23, 1983 (Wegner, 1997).

because the Colorado River Compact, which allocated the river's water, was negotiated in 1922. Since 1922, estimates of the river's average flow have been consistently revised downward.

Water Development

While most river basins in North America have less than two times the annual water supply in reservoir storage, reservoirs on the Colorado River have a total live capacity more than *four* times the average annual flow. As shown in Table 1, the total live storage capacity of major reservoirs in the basin is more than 60 maf. The capacity of the two principal reservoirs, Lake Mead and Lake Powell, is greater than 50 maf.

The unusually large storage capacity has diminished impacts of drought within the basin, at least in the short term. Growing demands on the river, however, may reduce the ability of these reservoirs to provide a buffer against drought. Most of the reservoir storage is located too far downstream for direct use in the Upper Basin, and most of the water in storage in the Upper Basin is used to satisfy Compact guarantees to the Lower Basin and for Mexico's entitlement.

Evaporative losses from the Colorado River reservoirs are especially high due to the arid climate of the region. As shown in Table 2, the average annual evaporative loss from reservoirs in the basin is more than 2.0 maf. It has been reported that the optimum level of storage in the basin, beyond which there is no net increase in usable supply due to evaporative losses, has been surpassed (Langbein, 1959; Hardison, 1972).

Diversions

Colorado River water is diverted for use both in and out of the basin at hundreds of diversion points. There are considerably more diversions in the Upper Basin, but Lower Basin diversions are much larger. Representative water development projects in the Upper Basin are shown in Figure 4. On an annual basis, more than a third of the river's supply is exported from the basin, including diversions to such cities as Denver, Colorado Springs, Salt Lake City, Albuquerque, Los Angeles, and San Diego. These service areas, in combination with the actual Colorado River basin, have been referred to as

Table 2.—Estimated evaporative losses (1,000 acre-feet) from the Colorado River Basin (1981-1985). These are the most recent estimates available from BOR

State	Year					Average
	1981	1982	1983	1984	1985	
Main stem[1]	1,598.4	1,402.9	1,896.2	1,197.1	1,782.9	1,575.5
Arizona	279.7	212.1	280.4	274.5	266.2	262.6
California	0.0	0.0	0.0	0.0	0.0	0.0
Colorado	82.7	78.4	82.3	84.2	86.3	82.8
Nevada	4.2	3.9	4.6	5.1	4.7	4.5
New Mexico	44.3	42.3	39.0	44.9	38.4	41.8
Utah	65.0	59.4	63.0	64.7	69.0	64.2
Wyoming	41.6	39.2	36.7	34.5	30.5	36.5
Total	2,115.9	1,838.2	2,402.2	1,705.0	2,278.0	2,067.9

[1] Main stem reservoir evaporation in Upper and Lower Basins and main stem channel losses for Lower Basin.
Source: BOR, 1991.

the Colorado "hydrocommons" (Weatherford, 1994) and the total population served is nearly 25 million people (Water Education Foundation, 1995). Major out-of-basin diversions are depicted in Figure 5.

Major Water Use And Allocation

The Colorado River Compact of 1922 apportioned the use of 7.5 maf/year each to the Upper Basin and Lower Basin, with an additional 1 maf allocated to the Lower Basin.[3] The 1944 Mexican Water Treaty guarantees delivery of 1.5 maf to Mexico, but provides for a *pro rata* reduction in times of shortages. Under current conditions, demands on the river are much greater in the Lower Basin. In 1996, the Lower Basin exceeded 7.5 maf of beneficial use

[3] Article III(D) of the Compact requires that deliveries to the Lower Basin at Lee Ferry for the current year plus the immediately preceding nine years (the ten-year moving average) total no less than 75 maf.

(Table 3). California diverts and uses well over its 4.4 maf apportionment, Nevada is approaching its 300,000 af apportionment, and Arizona is in the process of diverting its entire 2.8 maf apportionment. The Upper Basin, which has been slower to develop, is using approximately 60 percent of its entitlement (Table 4) and projections vary as to when full development will occur. In 1996, Lower Basin water use is estimated to be 8.00 maf, compared to 3.79 maf in the Upper Basin.[4]

Table 3.—Annual water use (1,000 af) in the Lower Basin, 1990-1996

State	Apportionment	Year						
		1990	1991	1992	1993	1994	1995	1996
Arizona	2,800	2,260	1,864	1,906	2,246	2,152	2,221	2,704
California	4,400	5,220	5,006	4,546	4,835	5,234	4,925	5,316
Nevada	300	178	180	178	204	228	217	249
Unmeasured returns		(233)	(214)	(202)	(221)	(254)	(283)	(266)
Total	7,500	7,425	6,836	6,428	7,064	7,360	7,081	8,003

[1] *Arizona v. California* (1963).
[2] Preliminary estimates (Source: Harkins, 1997).

Approximately 80 percent of the river's supply is used for agriculture. The largest user of agricultural water is the Imperial Irrigation District (IID) in southern California, which alone accounts for approximately 2.87 maf annually (1964-96 average), or almost 20 percent of the river's average annual flow. Other major agricultural users include the Palo Verde Irrigation District and the Coachella Valley Water District, which are also in southern California, the Central Arizona Project, the Central Utah Project and various other water districts in the Upper Basin. Municipal and Industrial (M&I) water from the Colorado River water is provided by Denver Water, the Central Utah Water Conservancy District (CUWCD), the Metropolitan Water District of Southern California (MWD), the San Diego

[4] Harkins, 1997.

Table 4.—Annual water use (1,000 af) in the Upper Basin, 1981-1985, 1990

State	Apportionment[1]	1981-1985 average[2]	1990
Arizona	50	42	42[3]
Colorado	3,079	1,994	2,206[4]
New Mexico	669	377	445[4]
Utah	1,369	657	737[4]
Wyoming	833	332	422[4]
Total	6,000	3,402	3,852

[1] For planning purposes this assumes the total Upper Basin entitlement is 6.0 maf, of which 50,000 af is the Upper Basin allocation to Arizona.
[2] Source: BOR, 1991
[3] Source: Trueman, 1996.
[4] Source: Cook, 1997.

County Water Authority (SDCWA), the Southern Nevada Water Authority (SNWA), Central Arizona Water Conservation District (CAWCD), the City of Phoenix and various other municipalities.

Depending on which flow estimates are used, the river has been over allocated by 20 to 30 percent. As shown in Table 5, a total of 17.5 maf has been allocated to the seven basin states and Mexico. While the Upper Basin is not close to fully utilizing its legal entitlement and uses 6.0 maf as the number for planning purposes, there is increased concern in the Upper Basin about future demands on Colorado River water. (Projected use to 2030 in the Upper Basin is depicted by state in Figures 6 to 10). Water use estimates were compiled in 1995 and projections were made to the year 2060 by the U.S. Bureau of Reclamation (BOR) in consultation with individual states within the Colorado River Basin and the Upper Colorado River Commission.

Tribal uses and claims will be discussed below in the "Indian Water Rights" section, but it should be noted that the general consensus is that these uses and claims to reserved rights are considered within each state's apportionment under the "Law of the River."[5]

[5] The Navajo Nation objects to the characterization that tribal water rights are considered as a part of a states entitlement (Letter from Stanley Pollack, Special Counsel For Water Rights, Navajo Nation, April 4, 1997).

Table 5.—Water allocations in the Colorado River Basin

Entity	Apportionment (maf/year)	Authority
Upper Basin	7.5	1922 Colorado River Compact. (The Upper Basin has the right to use 7.5 maf only if that quantity is available after it has satisfied its delivery requirements of 7.5 maf/year to Lower Basin plus the amount required to satisfy the Mexican Treaty obligation.)
Arizona	0.05	1948 Upper Colorado River Basin Compact
Colorado	3.86	1948 Upper Colorado River Basin Compact. (Colorado is apportioned 51.75% of the remaining flows after the Upper Basin's delivery requirements have been met.)
New Mexico	0.84	1948 Upper Colorado River Basin Compact (New Mexico is apportioned 11.25% of the remaining flows after the Upper Basin's delivery requirements have been met.)
Utah	1.71	1948 Upper Colorado River Basin Compact (Utah is apportioned 23% of the remaining flows after the Upper Basin's delivery requirements have been met.)
Wyoming	1.04	1948 Upper Colorado River Basin Compact (Wyoming is apportioned 14% of the remaining flows after the Upper Basin's delivery requirements have been met.)
Lower Basin	8.5	1922 Colorado River Compact
Arizona[1]	2.8	1963 U.S. Supreme Court decision *Arizona v. California*
California[2]	4.4	1963 U.S. Supreme Court decision *Arizona v. California*
Nevada[3]	0.3	1963 U.S. Supreme Court decision *Arizona v. California*
Additional	1.0	Article III(b) of 1922 Colorado River Compact
Mexico	1.5	Mexican Water Treaty of 1944
Total	17.5	

[1] Plus 46% of the surplus water available, as determined by the Secretary.
[2] Plus 50% of the surplus water available, as determined by the Secretary.
[3] Plus 4% of the surplus water available, as determined by the Secretary.

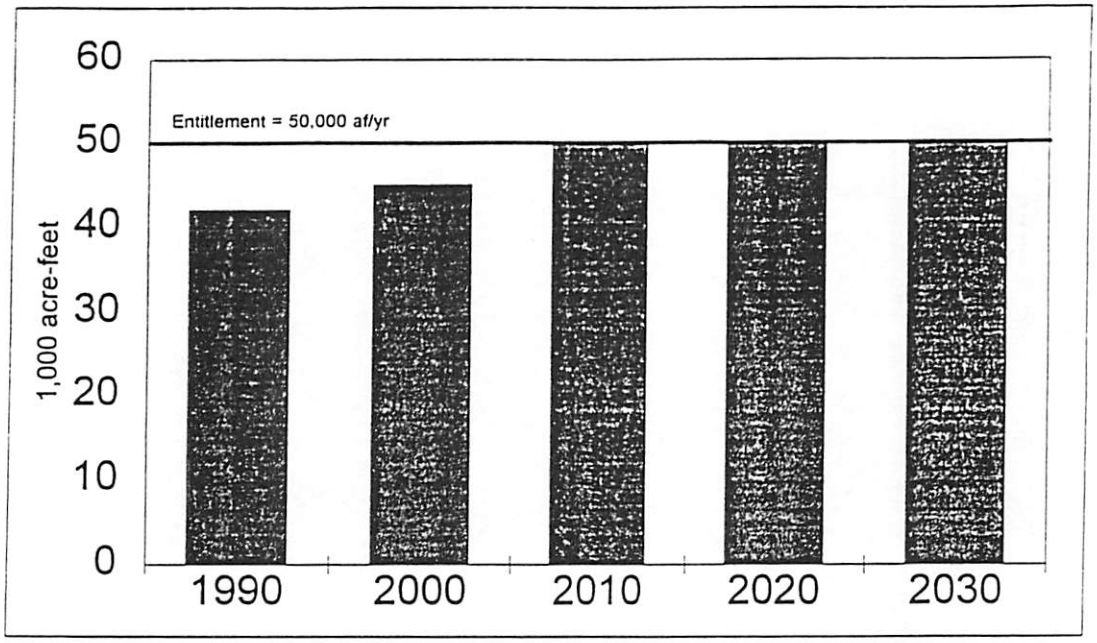

Figure 6.—Projected Colorado River water use in Arizona (Upper Basin).
Source: BOR, 1996.

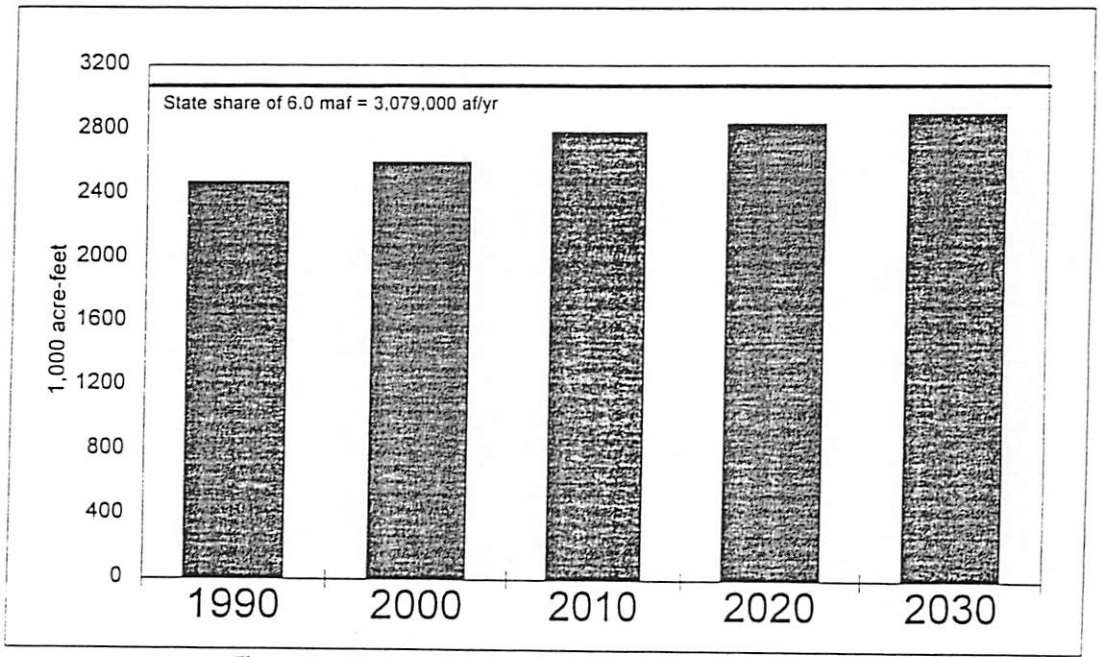

Figure 7.—Projected Colorado River water use in Colorado
Source: Cook, 1997.

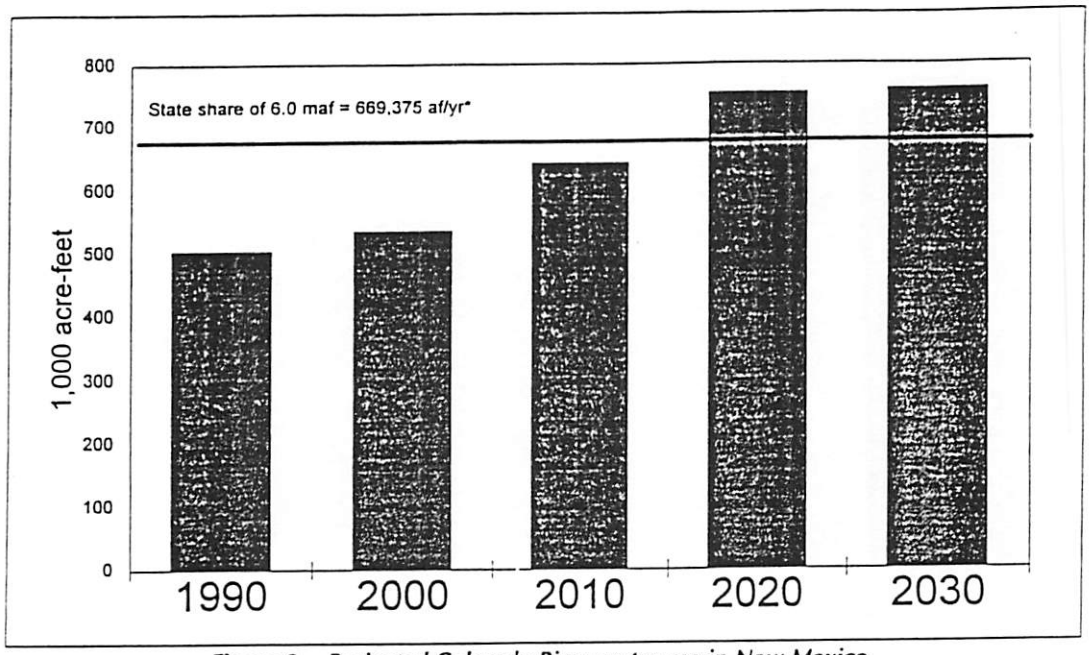

Figure 8.—Projected Colorado River water use in New Mexico.
Source: Cook, 1997.

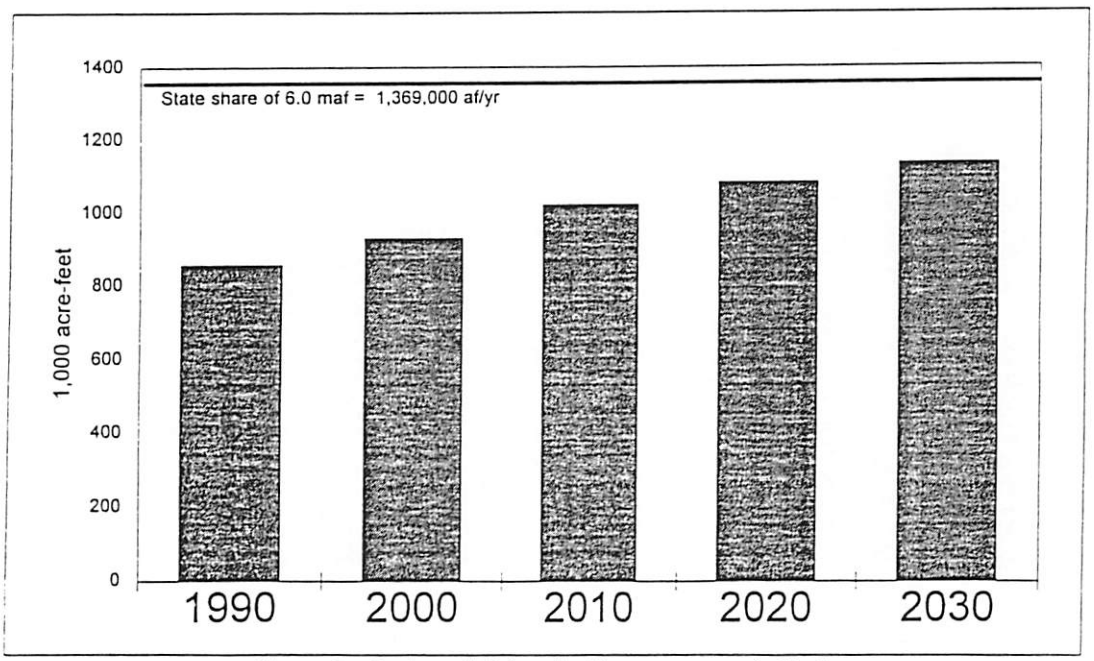

Figure 9.—Projected Colorado River water use in Utah
Source: Cook, 1997.

allocation and use of water within the states under state water law regimes– and the federal government must acknowledge water rights established under state law – a number of federal laws and court decisions (such as those establishing and interpreting reserved water rights on federal and Indian reservations) impact water allocation and use in the basin, whether directly or indirectly, including the Clean Water Act (CWA), the National Environmental Policy Act (NEPA), and the Endangered Species Act (ESA). Furthermore, the Secretary of the Interior has multiple sometimes conflicting responsibilities that impact water use in the basin such as his fiduciary responsibility to Indian tribes, to enforce the ESA, to manage federal lands and to administer reclamation law and the Law of the River.

Over the course of the last century, there has been massive federal investment in the basin to construct, operate, and maintain the dams, delivery systems and other infrastructure associated with federal projects. The federal government has an interest in protecting this investment, assuring repayment where applicable, and to operate these facilities consistent with federal law. In the Upper Basin, it is estimated that federal investment in water development totals around $3.6 billion (Calhoun, 1997). In the Lower Basin, this number is even greater. For example, the recently completed Central Arizona Project cost over $3.5 billion (of which some $1.8 to $2.2 million will be repaid over time). And although the BOR's new role in the West is primarily as a water management agency rather than as a project builder, its budget for this fiscal year for the Colorado River basin is approximately $285 million, which does not include hundreds of millions of dollars of revenues from power sales that are used to finance project OM&R and other costs.

In addition, the CWA has made the ACOE and EPA major players in important water policy arenas such as water quality issues involving municipal and industrial discharges, mine waste, and approving permits for new projects under Section 404 of the CWA. For example, the Two Forks Dam in Colorado was ultimately vetoed by the EPA Administrator pursuant to Section 404.

And, the ESA has generated a whole new level of federal-state-tribal tension in the basin because most water projects have a federal nexus and must undergo consultation with the FWS to determine if current or proposed water development will have an adverse effect on listed species. Federal, state, tribal and stakeholder efforts to develop, fund and implement plans for species protection and recovery within the framework of federal and state law and the ESA have been a major source of contention in recent years. Even if the ESA is amended to address the provisions in the law most objectionable to states, tribes, and water users, it seems clear that broad public support for preserving biodiversity and protecting ecosystems will require a continuing federal presence for the foreseeable future.

The Law of the River

The Law of the River (LOR) is the legal and institutional framework for managing the river and defining the states' and individual entitlement holders' rights and obligations.[6] Over the years, the LOR has evolved to some extent to accommodate changing policies and values about water management in the basin. The Grand Canyon Protection Act of 1992, for example, led to changes in the operating criteria for power production at Glen Canyon Dam to reflect concerns about downstream impacts on environmental and cultural resources and recreation. And, the enactment of the federal environmental statutes mentioned above add an overlay to many of the other components of the LOR which is still being sorted out.

While there is broad acceptance of the LOR within the basin's water interest community, some aspects of the LOR are still unsettled and may create management problems for the future as competition for Colorado River water increases. For example, nothing in the statutes or the *Arizona v. California* decree specifically authorizes interstate marketing of apportionments, and some provisions arguably prohibit it. When BOR tried to clarify the legal authority for interstate marketing in its rule-making process in 1994, a number of states and water users raised legal objections. As will be discussed in this report, water marketing, including off-reservation and interstate leasing of Indian water rights, and other issues remain unresolved under the LOR.

Furthermore, the *Arizona v. California* decree did not settle the extent of "*Winters* rights" for many of the Indian tribes in the Lower Basin. Paragraph VIII(C) of the decree states that the decree shall not affect the "rights or priorities, except as specific provision is made herein, of any Indian Reservation." The main stem rights of the Navajo Nation the Hualapai Tribe, and the Havasupai Indian Reservations, all located between Lee Ferry and Hoover Dam were not adjudicated in that case and remain as significant unresolved claims in the Lower Basin.

Other federal reserved rights for a number of national parks and monuments and other federal reservations have not been quantified. Grand Canyon National Park (GCNP) is a prime example. This is now a major problem for the GCNP, which is in need of additional water supplies to serve its growing number of visitors and for park facilities. On a more positive note, negotiations concluded recently between federal, local, and state officials in Utah that resulted in an agreement that will protect Zion National Park from

[6] The major components of the LOR are listed in Appendix B. This report will not attempt to summarize the various laws, contracts, opinions, compacts and treaties that make up the LOR.

upstream dam proposals, recognizing a federal reserved water right to the Virgin River, which flows through the park. There are a number of other outstanding federal claims in the basin which must be addressed and quantified through similar negotiations.

Arizona and Nevada, who claim the right to tributary water under the Compact, can divert water from the tributaries but cannot divert it once it has flowed into the Colorado River. Thus, Nevada would have to build a pipeline approximately 60 miles long at great expense to divert Virgin River water. Arizona would have to do something similar to make use of water from the Bill Williams River, even though it flows into Lake Havasu very near the CAP diversion point. The issue of rights to tributary water and a number of other issues remain unsettled despite the LOR.

The Secretary of the Interior: Water Master in the Lower Basin

While the states have authority over water management within their borders,[7] Congress delegated considerable authority to the Secretary of the Interior over the use and management of Colorado River water in the Lower Basin. The Boulder Canyon Project Act of 1928, as interpreted by the Supreme Court in *Arizona v. California*, vested extraordinary authority with the Secretary to serve as "water master" for the Lower Basin. Any user of main stem Colorado River water in the Lower Basin (with few exceptions for prior perfected rights) is required to have executed a contract with the Secretary to use Colorado River water. The Secretary has the authority to define what is "reasonable beneficial use," to contract for the disposition of hydropower, to develop an annual operating plan for the reservoirs, and to establish surplus and shortage criteria, among other things.

The Secretary is required, under Section 602(b) of the Colorado River Basin Project Act, to consult with the seven basin states regarding the annual operating plan and the BOR regularly consults with the states, tribes, and other interests on a range of management issues on an *ad hoc* basis. If consensus cannot be reached on an operational issue, such as reservoir operations, however, it is clear that the Secretary has the authority to act.

Although the Upper Basin states have a significant interest in the annual operating plan, reservoir operations, and other decisions regarding water use in the Lower Basin, they are not subject to the same level of "federalized" management. In 1948, the Upper Basin states approved the Upper Colorado

[7] States generally do not have authority over water management on Indian Reservations within their borders. State regulation of water use in Indian country may be barred if preempted by federal law or if it would infringe on tribal sovereignty.

River Basin Compact, subsequently approved by Congress, which established each state's apportionment and the Upper Colorado River Commission to address issues related to water development in the Upper Basin. While the Secretary has responsibilities to administer the various reclamation laws and statutes that authorized projects in the Upper Basin, he does not have the level of authority to regulate water use as was delegated to him by Congress in the Lower Basin. The Upper Basin states control the rights to use Compact water under state water law.

Proposed Regulations for the Lower Basin

In 1994, the BOR proposed regulations to address a number of issues in the Lower Basin. Initially, the purpose of these regulations was to deal with the increasing problem of illegal pumping of the river's "sub-flow" (groundwater hydrologically connected to the river). However, growing interest in water marketing and a number of other unresolved issues led the BOR to also draft regulations to deal with beneficial use, new conservation requirements, prohibited uses, establishing fees for services to water users, and to govern leasing, banking and exchanging water entitlements, including tribal water rights, on an intrastate and interstate basis.

Under the draft regulations, water conserved as a result of "extraordinary" conservation measures or land fallowing could be marketed. One of the more controversial provisions provided that conserved water would be considered a "beneficial consumptive use" within the state in which it occurred and, therefore, would no longer be considered "Colorado River water" which was subject to LOR restrictions. This water could therefore be conveyed for use in another Lower Basin state or banked as "top water" in Lake Mead (meaning it had the lowest priority of stored water and would be released first when flood control releases were necessary).

Another major point of controversy in the proposed regulations was the Department's position that tribal water rights could be leased off reservation under existing law. The BOR set forth an extensive legal analysis defending this proposal, relying on a number of statutes, Solicitor opinions, and court cases, including *Arizona v. California* (and the 1979 Supplemental Decree), and concluded:

> *In summary, it is the Department's preliminary conclusion that it is appropriate to include Indian reserved water rights in the direct leasing and banking-marketing provisions of the proposed regulations ... that most of the legal commentators who have considered the subject of Indian water marketing have agreed that Indian reserved rights are*

> *transferable property rights which have the potential to generate not only financial benefits, but also to create jobs, increase services, and stimulate reservation economic growth* (BOR, 1994).

The rules also proposed new requirements for conservation plans required for all contractors of Colorado River water, if economically feasible, and a time schedule for meeting these objectives. If the water user failed to implement a plan, the BOR could make a determination that the user was engaging in unreasonable beneficial use and presumably reduce the diversion right under the contract.

As the state with the largest unused apportionment in the Lower Basin, Arizona was concerned with a number of these marketing provisions, which were viewed as promoting interstate marketing of Arizona's water without adequate state involvement or control, and threatened to sue. A number of other states and interests expressed similar concerns about the draft regulations. As a result, the Secretary put the regulations on hold to allow the states time to seek a regional solution and reach consensus on water marketing in the Lower Basin.

In a speech to the Colorado River Water Users Association (CRWUA) in December of 1995, Secretary Babbitt acknowledged that the process had broken down, but reiterated his optimism that consensus could be reached on a number of water marketing and transfer issues and that "whenever possible, the administration of the river should be by consensus among the three affected states..." (Babbitt, 1995).

In December of 1996, the Secretary was back before the CRWUA in Las Vegas. There was still no consensus on marketing apportionments and California's failure to resolve internal disagreements between major water users had become a basin-wide issue. In the interim, Arizona had established its water bank, which could provide a solution for meeting future needs in Nevada and California, if necessary federal regulations could be put in place. Secretary Babbitt seemed less optimistic about consensus than the previous year, but vowed to continue facilitating that process.

The Secretary also took a less ambitious position on future regulations for the Lower Basin, citing the need for incremental progress on a number of issues, such as the water bank, finding a way to implement the San Luis Rey Indian settlement, and resolving the internal dispute in California. He deferred action, for example, on adoption of surplus criteria until California had developed a plan to reduce their use, over time, to their 4.4 maf/yr apportionment. In the final analysis, however, the Secretary does have the authority -- and hinted he may ultimately have to exercise it -- if agreement cannot be found on these management issues that is acceptable to the basin states and the federal government, given its statutory and trust

responsibilities. Ultimately, the federal stick held by the Secretary may need to be invoked in the Lower Basin to resolve some of these issues.

The BOR is currently drafting new rules for the Lower Basin, which are expected to be less ambitious in scope given the controversy that accompanied the 1994 draft. It is not anticipated that these regulations will allow for interstate marketing of tribal water rights except as it may occur through state authorized water banks.

The Mexican Treaty Obligation and Augmenting the Basin Supply

There is no consensus within the basin as to how to meet the requirements to deliver 1.5 maf/yr to Mexico as required by the 1944 treaty.[8] There is some ambiguity as to whether this is an obligation of the basin states, as contemplated by the 1922 Compact, or whether this is now a federal obligation.

In 1968, Congress enacted the Colorado River Basin Project Act (CRBPA), which authorized the Central Arizona Project and a number of water projects for the Upper Basin.[9] In section 202 of the CRBPA, Congress declared:

> *the satisfaction of the requirements of the Mexican Water Treaty from the Colorado River constitutes a national obligation which shall be the first obligation of any water augmentation project planned pursuant to section 1511 of this title and authorized by the Congress. Accordingly, the States of the Upper Division (Colorado, New Mexico, Utah, and Wyoming) and the States of the Lower Division (Arizona, California, and Nevada) shall be relieved from all obligations which may have been imposed upon them by article III(C) of the Colorado River Compact so long as the Secretary shall determine and proclaim that means are available and in operation which augment the water supply of the Colorado River system in such quantity as to satisfy the requirements of the Mexican Water Treaty together with any losses of water associated with the performance of that treaty:* Provided, *That the satisfaction of the requirements of the Mexican Water Treaty (Treaty Series 994, 59 Stat. 1219), shall be from the waters of the Colorado River pursuant to the treaties, laws, and compacts presently relating thereto, until such*

[8] Federal law directs the Secretary of the Interior to operate federal reservoirs so as to meet the Mexican obligation (43 USCA § 1512).

[9] Besides the Central Arizona Project, the CRBPA authorized Hooker Dam in the Gila Wilderness of New Mexico, the aqueduct from Lake Mead to Las Vegas, the Dixie Project in Utah, and the Utah Unit of the Central Utah Project. It also authorized the San Miguel, Dallas Creek, West Divide, Dolores, and Animas-La Plata projects in Colorado.

time as a feasibility plan showing the most economical means of augmenting the water supply available in the Colorado River below Lee Ferry by two and one-half million acre-feet shall be authorized by the Congress and is in operation as provided in this chapter.

This provision seems to say that delivering to Mexico is now a national obligation, but it could be interpreted to mean that it only becomes a federal obligation when (and if) the basin's water supply is augmented by 2.5 maf as a result of programs funded by Congress.

Assuming that it is now a federal obligation, as the states maintain, how is it to be met? California and other states have repeatedly pressed for augmentation studies, including cloud seeding in the Upper Basin, but very little federal money has been budgeted for such research and there are no realistic plans on the drawing board to augment the river's supply. While augmentation is not a dead issue, it does not seem to be a very feasible option in the foreseeable future. Congress has ruled out looking to the Columbia River basin for an inter-basin transfer, which was once considered. The Colorado River basin may well have to live within the natural supply.

Due to above-average flows in recent years, unused apportionments, and sufficient storage, enough water has been available to meet the 1.5 maf/yr obligation to Mexico. And it has not been necessary to operate the Yuma Desalting Plant (YDP), which would produce approximately 68,000 af of the Mexico allocation and lower salinity levels in the river by desalinating Wellton-Mohawk drainage water. This water is now bypassed through a BOR canal to the Cienega de Santa Clara in Mexico and is not counted toward the U.S. obligation because of its excessive salinity.[10]

This issue has been avoided for now, but will ultimately have to be confronted. Assuming this is a federal obligation, how is the water to be obtained in times of shortage other than from state apportionments? How will shortages be shared? Would the Upper Basin be required to deliver more than half of the Mexican obligation if the Upper Basin is not using its full entitlement, as is now the case? Although shortages are not forecast for the river for some time to come, shortages are inevitable and clarification needed as to how the Mexican obligation will be met during an extended drought.

[10] Under Section 102 of the Colorado River Basin Salinity Control Act, the U.S. obtained temporary right to approximately 130,000 af of water saved by lining the Coachella Canal. However, under the statute, this water is only available for treaty obligation purposes for an "interim period" which will expire when there is not enough water to meet California's needs, at which time the Secretary has to find a substitute supply.

Major Issues

Water Management

How the over-appropriated Colorado River will be managed in the 21st century to meet the ever-increasing demands for its water is one of the most critical issues in the West. The Colorado is relied upon by seven states and northern Mexico to supply water for food, cities, and recreation; and to sustain a vast ecosystem that stretches from the Rocky Mountains to the Gulf of California.

Water management issues in the 21st century will be more complex and even more closely tied to the resolution of the other critical issues discussed in this report: ecosystem protection, salinity control, and Indian water rights. Issues such as protecting habitat for endangered fishes and other species at risk, maintaining water quality standards, adequate flows for sport fisheries and rafting, as well as resolving Native American rights to Colorado River water and meeting our treaty obligations to Mexico must all be dealt with within the context of water management in the basin. Thus, while these issues will be discussed separately, it is important to keep in mind that they are integral components of successful water management within the basin in the future.

Water Management in the Lower Basin

Current Uses and Projected Demand Colorado River water currently serves over 20 million people in the Lower Basin. The majority of these people live outside the Colorado River basin, primarily in the southern California metropolitan areas. (Table 6 shows the major water users in the Lower Basin.) Lower Basin demand for water is projected to continue to increase substantially (Figures 11 to 13). By 2025, California may gain more than 16 million people and the areas of Arizona and Nevada using Colorado River water may double in the next 25 years (Pacific Institute, 1996). Arizona, which has historically relied heavily upon the use of groundwater, now has the capacity to transport 1.5 maf/yr of Colorado River water through the Central Arizona Project (CAP), which was completed in 1993, to central Arizona cities and farms. In addition, implementation of the Arizona Water Bank (discussed below) means that Arizona will divert its full apportionment as early as 1998. Nevada is projected to be using its full 300,000 af apportionment by 2010.

California's Water Issues California is the largest user of Colorado River water with a basic apportionment of 4.4 maf, but has consumptively used much more than that for many years. Between 1983 and 1996, California used from 4.2 to 5.2 maf/yr, taking advantage of unused apportionments.

Table 6.—Colorado River main stem water use in the Lower Basin, 1996

Entity	Water use[1] (1,000 af)
Nevada	**249**
Southern Nevada Water System	209
Others	40
California	**5,222**
Metropolitan Water District	1,227
Irrigation Districts	3,962
Others	33
Arizona	**2,532**
Central Arizona Project	1,196
Others	1,336
Total Lower Basin	**8,003**
Delivery to Mexico	**1,505**

[1] Preliminary estimates.
Source: Carson, 1997.

The 1931 Seven Party Agreement set priorities for apportionment and use of Colorado River water in California. Under the agreement, priorities for beneficial use of Colorado River water within California were established, as shown in Table 7.

The total water right for the first three priorities for agriculture is not to exceed 3.85 maf, but it is not quantified per entity. This has led the BOR to conclude that these apportionments were "at best difficult to administer and, at worst, impossible to administer" (Rieke, 1994). It is difficult to assign responsibility for over-use if the 3.85 maf is exceeded (as it has been) and there are disagreements among the agricultural entities over accounting and whether some irrigation uses are wasteful and exceed beneficial use standards. The Colorado River Board of California, which is an umbrella agency for the seven entities, has been unable to obtain an agreement among these entities to quantify their rights despite repeated efforts over the past few years.

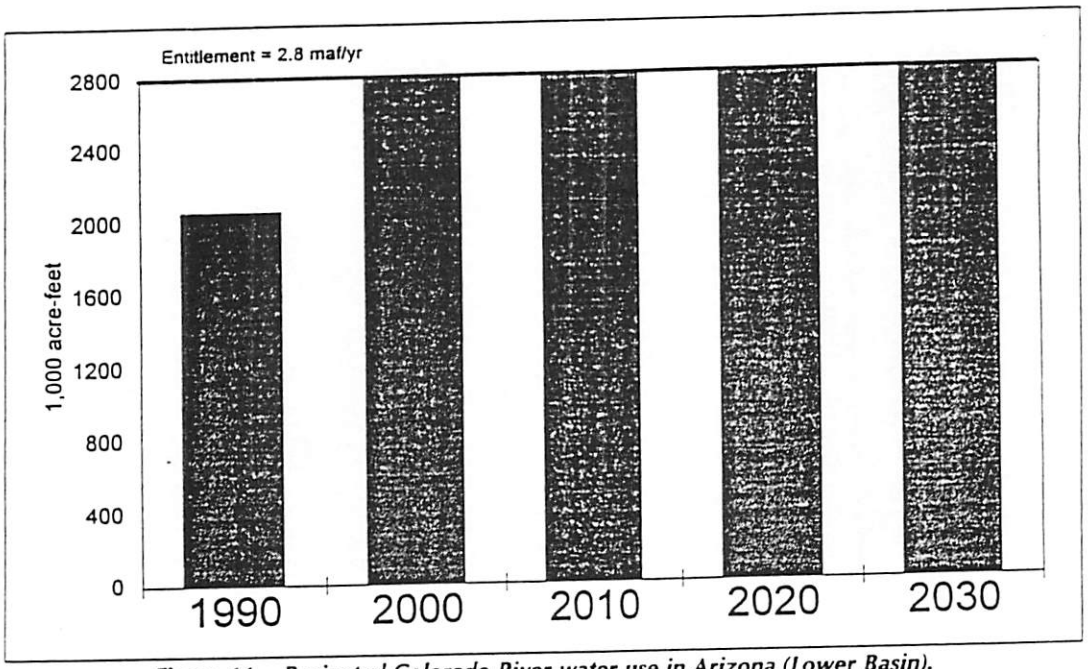

Figure 11.—Projected Colorado River water use in Arizona (Lower Basin).
Source: ADWR, 1997.

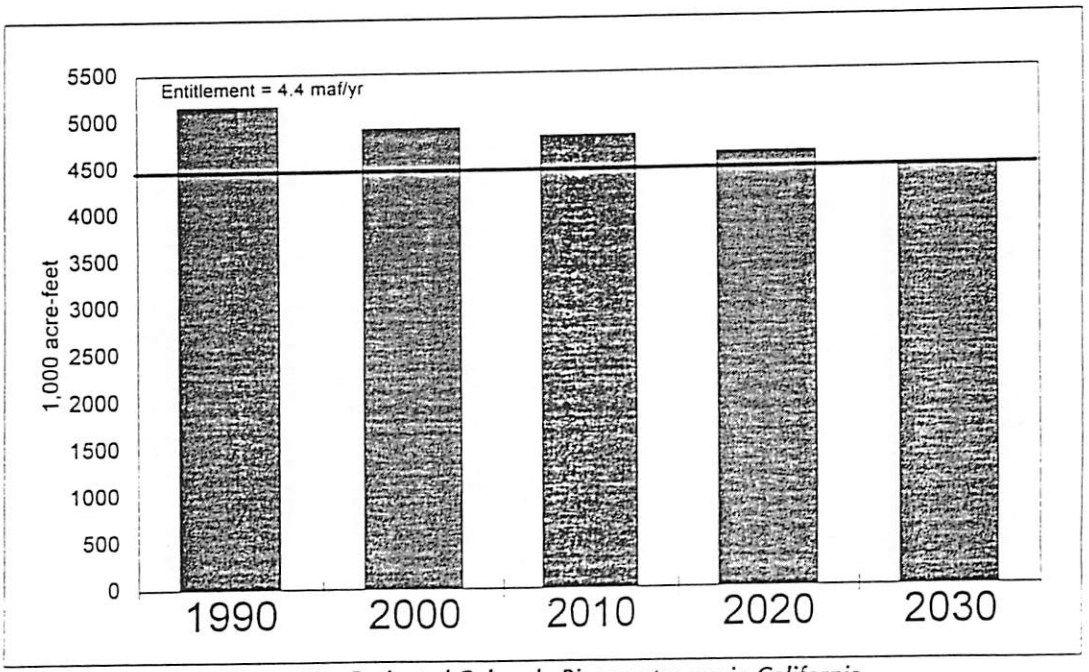

Figure 12.—Projected Colorado River water use in California.
Source: BOR, 1996.

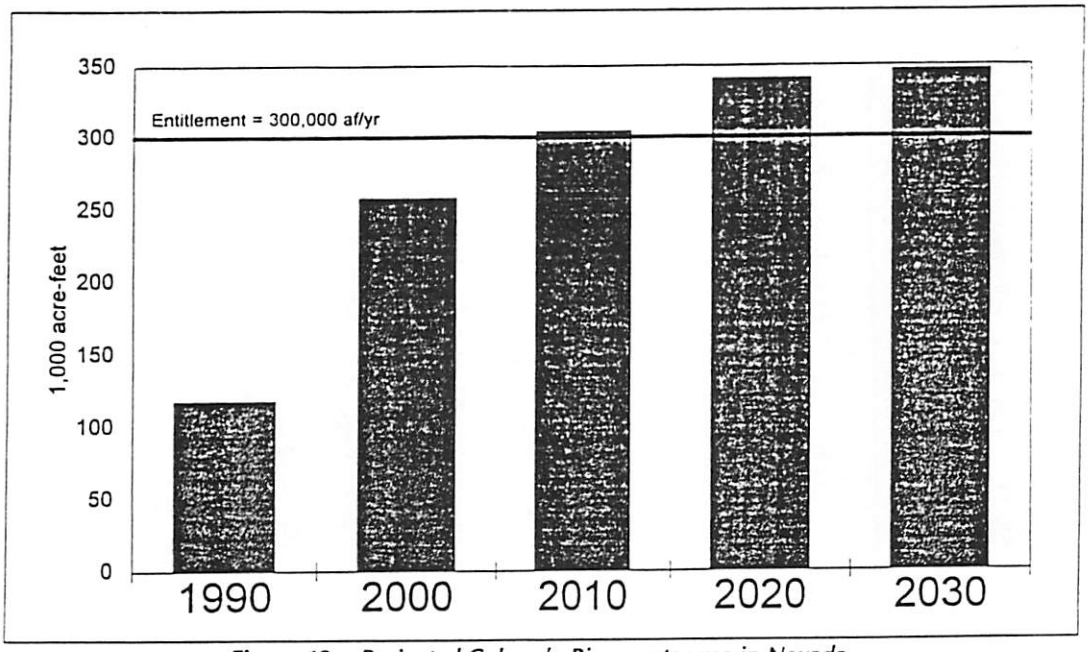

Figure 13.—Projected Colorado River water use in Nevada.
Source: BOR, 1996.

MWD, which is the wholesale provider for southern California municipal users, diverts about 1.2 maf/yr in its aqueduct.[11] MWD faces a shortfall in supply as they project the population of their service area to grow from the current 15.7 million to 19.5 million by 2010. Comparing the existing supplies to the projected hot/dry weather retail demands, MWD forecasts a water supply shortage of 1.1 maf in the year 2000 and 2.1 maf in the year 2020 (MWD, 1996).

Beneficial Use Issues IID's rights stem from a water service contract with the U.S. executed in 1932 for delivery of water stored behind Hoover Dam. This contract is for "permanent water service" and at no cost to the district, except for their repayment obligations, which have been met. IID submits that the Secretary must deliver water "as reasonably required for potable and irrigation purposes." This rather vague and unquantified right has led to attempts by the State of California Water Resources Control Board in 1984 and, more recently, the BOR to determine what is reasonable

[11] Under the Seven Party Agreement, San Diego has an equal fifth priority right to MWD for 112,000 af, although the San Diego apportionment was consolidated with the MWD apportionment in agreements made in 1946-1947, when San Diego became a member of MWD.