Appendix 3
Summary of Past
Colorado River Basin Planning Studies

Appendix 3 — Summary of Past Colorado River Basin Planning Studies

1.0 Introduction

Throughout the 20th century, the challenges and complexities of ensuring a sustainable water supply and meeting future demand have been recognized. These challenges are documented in numerous studies conducted by the Bureau of Reclamation (Reclamation) and the Colorado River Basin States (Basin States [1]) over the past 70 years. Studies done in the early half of the 20th century were focused on development of Colorado River resources. Starting in the 1960s, Basin studies continued to focus on development, but with an eye towards water supply and demand imbalances and potential means of resolving those imbalances. There was an increasing emphasis on improving the efficiency of the operation of Colorado River reservoirs and increasing the level of predictability needed by entities that receive Colorado River water to better plan for and manage available water supplies. Studies following the comprehensive framework studies of the early 1970s have all acknowledged an imbalance between water supply and demand in the Colorado River Basin (Basin). Most of these studies have not sought to explicitly quantify the imbalance, but rather have focused on potential solutions to various problems throughout the Basin, including the problems of water supply and demand imbalances, salinity, and federally recognized tribes (tribes) water rights, to name a few. In light of the attention given to some of these issues, institutional changes, such as interim operating criteria and the Consolidated Decree, have occurred.

2.0 Studies 1946 - 1952

Studies performed in the early half of the 20th century were focused on development of Colorado River resources. The studies coming out of this period led to legislation finalizing the rights of each of the seven Basin States to Colorado River water, and provided the foundation for development of storage projects throughout the Basin. The following sections summarize the studies to come out of this period.

2.1 The Colorado River: A Comprehensive Report on the Development of the Water Resources of the Colorado River Basin for Irrigation, Power Production, and Other Beneficial Uses in Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming – 1946

The purpose of this 1946 report by Reclamation was to provide a Basin-wide perspective for planning water development throughout the Basin. It provided an inventory of 134 potential projects, and was

> intended to serve as a medium through which Congress may be appraised of the potentialities for the development of the basin's water resources and as a guide in the selection of projects that ultimately will comprise the comprehensive plan for

[1] Arizona, California, Colorado, New Mexico, Nevada, Utah, and Wyoming.

> the utilization of the waters of the Colorado River system for irrigation, electrical power, and other purposes (Reclamation, 1946).

The report advocated for a comprehensive, Basin-wide plan for development as well as complete control and utilization of water of the Colorado River. It did not advocate for any particular projects to be authorized; however, it pointed out a number of issues that needed to be resolved before the selection of any projects could occur. In particular, it noted that

> …before such a selection of projects can be made it will be necessary that the seven Basin states agree upon their respective rights to deplete the water supply of the Colorado River or that the courts apportion available water among them (Reclamation, 1946).

As a result, the report provided a basis for compact negotiations among the Upper Basin States, which resulted in the passage of the Upper Colorado River Compact (Compact) in 1948 (63 Stat. 31).

2.2 Final Report, Engineering Advisory Committee to Upper Colorado River Basin Compact Commission – 1948; and Report on Water Supply of the Lower Colorado River Basin, Project Planning Report – 1952

These are data-oriented reports intended to support potential development projects. After the 1946 report was published, it was concluded that more-detailed data regarding the average natural flow of streams and rates of water use were needed to serve as the basis for planning future developments for the maximum use of available water supplies. The purpose of the reports was to fill a need for a comprehensive analysis of the water supply of the Upper Basin and Lower Basin, respectively.

Both reports summarize data over the period 1914 to 1945. This period was chosen because it was believed to be a representative period of average stream flow as well as a period for which sufficient reliable hydrologic data were available to make a comprehensive analysis of water resources and stream depletions. Furthermore, the 1914 to 1945 period included the above-average runoff years from 1914 to 1929, as well as the drought years from 1931 through 1940, and was therefore thought to be appropriate for considering storage problems of stream flow in drought years.

Together, these reports provide a basis for a comprehensive analysis of the water supply of the entire Basin.

2.3 Colorado River Storage Project and Participating Projects, Upper Colorado River Basin - 1950

The *Colorado River Storage Project* (CRSP) *and Participating Projects* report outlined a plan of development in the Upper Colorado River Basin and recommended an initial construction program (Reclamation, 1950). The plan contained three fundamental elements: 1) reservoir storage, to conserve and regulate stream flows, and to generate power, 2) participating irrigation projects, made possible by the storage reservoirs, and 3) the Upper Colorado River Account, to be charged with scheduled payments on the construction, operations and maintenance, and replacement costs of the CRSP and participating projects.

In this report, an ultimate storage plan was envisioned that would permit full utilization by the Upper Basin of the 7.5 million acre-feet (maf) of water apportioned to the Upper Basin under the Compact. The storage capacity contemplated was designed to assure that the flow of the river at Lees Ferry would not be depleted below 75 maf in any 10 consecutive years. The goal was to provide the infrastructure with which the Upper Basin could proceed safely with use of its waters, and the Lower Basin would be assured that its rights under the Compact were protected (Reclamation, 1950).

Given the analysis of Colorado River supplies (primarily taken from the 1948 report by the Engineering Advisory Committee, but expanded to include data through 1947) and assumptions of Upper Basin depletions, the greatest 10-year flow deficiency at Lees Ferry was projected to be 20.8 maf for the period ending in 1940 (see table 1). More-detailed studies based on monthly data rather than on the annual data used in the table indicated an imbalance of 23 maf for the 1931 to 1940 decade, indicating a need for that amount of storage capacity for river regulation. Therefore, according to the plan outlined in the CRSP report, 23 maf would be reserved in project reservoirs for long-time regulatory storage. The water stored would be released as needed in drought periods to meet the Compact obligation at Lees Ferry.

3.0 Studies 1964 – 1972

Starting in the 1960s, Basin studies continued to focus on development, but with an eye towards water supply and demand imbalances and potential means of resolving those imbalances. Increasing emphasis was placed on improving the efficiency of the operation of Colorado River reservoirs and increasing the level of predictability needed by entities that receive Colorado River water to better plan for and manage available water supplies. The following sections summarize the studies to come out of this period.

3.1 Pacific Southwest Water Plan - 1964

The *Pacific Southwest Water Plan* was the first study to project a water supply and demand imbalance in the Basin (Reclamation, 1964). The report outlined a two-phase plan of action designed to meet the immediate and long-range water needs of the Pacific Southwest, defined in this report as the water service area of the Lower Colorado River Basin including southern California. In both phases, substantial emphasis was placed on the salvage of water and more-efficient water use, although the plan also called for the importation of water to make up the remaining imbalance.

> Based on estimates of the rate at which the Upper Basin will develop uses for its apportioned share of Colorado River water, it is estimated that by the year 2030, in the absence of measures to increase Lower Basin water supplies, the amount of water available from the Colorado River at and below Hoover Dam for consumptive use by the Lower Basin States will decrease to 5,620,000 acre-feet annually. This would be 1,880,000 acre-feet below the 7,500,000 acre-feet divided among the Lower Basin States by the recent decision of the Supreme Court in the case of Arizona v. California. To make up this deficiency, through the 7,500,000 acre-foot guarantee, the Initial Plan provides for water salvage and related works to yield 680,000 acre-feet annually and for import of the remaining deficiency of 1,200,000 acre-feet (Reclamation, 1964).

TABLE 1
Determination of Active Storage Requirement

DETERMINATION OF ACTIVE STORAGE REQUIREMENT
TO PERMIT FULL UTILIZATION OF APPORTIONED CONSUMPTIVE USE

Unit: 1,000 acre-feet

Water year	1 Virgin flow of Colorado River at Lee Ferry	2 Ultimate use of upper basin apportionment [1]	3 Ultimate depleted unregulated flow at Lee Ferry (Col. 1 minus Col. 2)	4 Ten-year moving total flow at Lee Ferry	5 Ten-year variation from 75 million acre-feet
1914	21,220	9,030	12,190		
1915	14,030	6,910	7,120		
1916	19,200	8,860	10,340		
1917	24,040	9,530	14,510		
1918	15,360	7,920	7,440		
1919	12,460	6,560	5,900		
1920	21,950	9,370	12,580		
1921	23,020	9,470	13,550		
1922	18,310	8,180	10,130		
1923	18,270	8,450	9,820	103,580	+28,580
1924	14,200	7,340	6,860	98,250	+23,250
1925	13,030	6,860	6,170	97,300	+22,300
1926	15,850	7,770	8,080	95,040	+20,040
1927	18,620	8,630	9,990	90,520	+15,520
1928	17,280	8,390	8,890	91,970	+16,970
1929	21,430	8,670	12,760	98,830	+23,830
1930	14,890	7,590	7,300	93,550	+18,550
1931	7,770	5,330	2,440	82,440	+ 7,440
1932	17,240	7,950	9,290	81,600	+ 6,600
1933	11,360	6,500	4,860	76,640	+ 1,640
1934	5,640	4,480	1,160	70,940	- 4,060
1935	11,550	6,450	5,100	69,870	- 5,130
1936	13,800	7,480	6,320	68,110	- 6,890
1937	13,740	6,710	7,030	65,150	- 9,850
1938	17,550	7,840	9,710	65,970	- 9,030
1939	11,080	6,260	4,820	58,030	-16,970
1940	8,600	5,130	3,470	54,200	-20,800
1941	18,150	7,700	10,450	62,210	-12,790
1942	19,120	7,830	11,290	64,210	-10,790
1943	13,100	7,070	6,030	65,380	- 9,620
1944	15,150	6,980	8,170	72,390	- 2,610
1945	13,410	6,740	6,670	73,960	- 1,040
1946	10,420	5,950	4,470	72,110	- 2,890
1947	15,470	7,510	7,960	73,040	- 1.960
Means:					
1931-40	11,830	6,410	5,420		
1914-45	15,640	7,500	8,140		

[1] Use apportioned by Colorado River Compact, measured in terms of man-made depletions at Lee Ferry.

Source: CRSP report, 1950

In this study, importation of water from northern California was suggested to meet the imbalance. The initial plan contemplated the conveyance of 1.2 maf of surplus water from northern to southern California to guarantee against deficiencies in water supplies available from the lower Colorado River (Reclamation, 1964).

This study led to the enactment of the Colorado River Basin Project Act of September 30, 1968 (Public Law 90-537), making the Central Arizona Project (CAP) a reality.

3.2 Water Supplies of the Colorado River – 1965

The recommendations and requests for authorization contained within the 1964 *Pacific Southwest Water Plan* caused concern in the Upper Basin, particularly regarding the CAP. Consequently, the Upper Colorado River Commission sponsored a study in 1965 by consulting engineers Tipton and Kalmbach. The results of this study were presented in *Water Supplies of the Colorado River* (Tipton, 1965).

This study concluded that Upper Basin consumptive use, including evaporation, would be limited to 6.3 million acre-feet per year (mafy). Net depletion excluding evaporation would be 5.6 mafy. A water supply and demand imbalance was calculated to be 1.195 mafy (See figure 1).

FIGURE 1
Analysis of Lower Basin Supply and Demand and Resulting Deficiency

Lower River Requirements:			
1.	Beneficial consumptive use by Arizona, California and Nevada	7.500 maf	
2.	Mexican Treaty Deliveries	1.500	
3.	Reservoir Evaporation	0.730	
4.	Losses below Hoover Dam	0.810	
	Total Requirements		10.540 maf
Water Supply for the Lower River:			
1.	Delivery at Lee Ferry	8.250 maf	
2.	Net Inflow Lee Ferry to Lake Mead	0.675	
3.	Net Inflow from Bill Williams River	0.055	
4.	Release from Lake Mead (drawdown to rated power head)	0.365	
	Total Water Supply		9.345
	Deficiency		1.195 maf

Source: Tipton, 1965.

The study states that, although a delivery of 8.25 maf had been assumed, the amount delivered by the Upper Basin eventually would approximate 7.5 mafy. When the delivery from the Upper Basin lowered to 7.5 maf instead of 8.25 maf, then the deficiency would increase to 1.945 mafy. Likewise, if the provisions of Section (b) of Article IV of the Compact were invoked, Lake Mead could be drawn down to absolute dead storage, which would provide about 0.60 mafy of additional water, including a decrease in evaporation from Lake Mead. In this case, the above deficiencies would be reduced by about 0.60 maf (Tipton, 1965).

Finally, the study suggested the importation of water to meet the imbalance. It comes short of recommending a particular source of importation, stating:

> The obvious conclusion is that a firm water supply is not available in the Colorado River to satisfy a basic beneficial consumptive use requirement of 7.5

maf from the main stem by Arizona, California and Nevada, plus delivery of 1.5 maf of water to Mexico. If these requirements as well as Upper Basin requirements are to be satisfied, projects must be authorized and constructed to import major amounts of water into the Colorado River Basin from sources of surplus. Such importation is important to both the Upper and Lower Basins (Tipton, 1965).

3.3 The Comprehensive Framework Studies – 1971-1972

Three Comprehensive Framework Studies were conducted that pertain to the Basin – the Lower Colorado Region Comprehensive Framework Study, the Upper Colorado Region Comprehensive Framework Study, and the California Region Comprehensive Framework Study (Pacific Southwest Inter-agency Committee, 1971a, 1971b, and 1972). As defined in these framework studies, the Lower Colorado Region consisted of those parts of the Lower Colorado River Basin which lies downstream of Lees Ferry except for parts of the Lower Basin lying in California (e.g., west of the Colorado River). Parts of California lying within the Lower Colorado Basin were covered in the California Region Comprehensive Framework Study. The objective of the framework studies was to provide a broad guide to the best use, or combination of uses, of water and related land resources in each region to meet foreseeable short- and long-term needs.

Each of the framework studies had multiple demand scenarios, predominantly based on 1968 national population and demographic projections by the Office of Business Economics of Commerce, and the Economic Research Service, U.S. Department of Agriculture (OBERS). These projections were then modified to reflect local conditions.

Each of the studies detailed the status of development as of the base year, 1965. The studies then presented a framework program for the development and management of the water and related land resources (Framework Plan) of the respective region through 2020.

3.3.1 Lower Colorado Region Comprehensive Framework Study – 1971

Two demand scenarios were considered in the formulation of the Lower Colorado Region Comprehensive Framework Study: 1) the Base Plan, based on the regionally interpreted OBERS projections, and 2) the non-modified OBERS projections.

The basic long-range objective of this study was augmentation of the region's water supplies in sufficient increments to meet future water requirements and reduce ground water overdraft. The Framework Plan consisted of an Early Action Program to cover short-term requirements (1965 to 1980), and a Continuing Program to cover longer-term requirements (1981 to 2020). The most critical immediate need was identified as meeting the diversion requirements projected to occur before 1980 without increasing the groundwater overdraft.

After implementation of the Early Action program, a water supply deficiency of about 1.5 maf was projected to remain. Therefore, the framework program provided for the importation of 2.25 maf of desalted sea water to the Lower Colorado Region before 2000, including 1.8 maf to satisfy the 1944 Treaty with Mexico Mexican Treaty requirement and 0.45 maf as a regional program. Imported water would be conveyed to and stored in Lake Mead. It was projected that, if the initial water importation were in operation at year 2000, a regional annual water deficiency of about 0.44 maf would remain, which would increase to about 2.1 maf annually by 2020. The

framework recommended additional importation facilities between 2000 and 2020 to provide about 1.9 maf annually, reducing the annual imbalance to 0.17 maf by 2020. In the absence of an imported water supply, groundwater overdraft was expected to continue and the regional water deficiency was projected to reach 4.5 mafy by 2020.

3.3.2 Upper Colorado Region Comprehensive Framework Study – 1971

In the Upper Colorado Region Comprehensive Framework Study, four demand scenarios were analyzed: 1) the Base Plan, based on the regionally interpreted OBERS, 2) the States' alternative to the Framework Plan (6.55 maf level of development), 3) States' alternative at the 8.16 maf level of development, and 4) States' alternative for water supply physically available in the region (9.44 maf).

Land and water supply were not considered to be limiting factors in the Framework Plan in meeting the regionally interpreted OBERS level of development; however, the study concluded that the future outflow at Lees Ferry would depend on which level of development actually occurred, as well as augmentation. Augmentation practices considered as possibilities included water-yield improvement and weather modification, which were thought to increase the water supply by about 1 to 2 maf. The study concluded that 1) augmentation would definitely be required by 2020 for the two highest levels of depletion to meet the Compact obligation to the Lower Basin, and 2) local shortages in the region could occur at any level of development.

3.3.3 California Region Comprehensive Framework Study – 1972

Two subregions in the California Region Comprehensive Framework Study are pertinent to the Basin—the Colorado Desert and the South Coast subregions. Three demand scenarios were analyzed in this study: 1) the Base Plan, based on the locally interpreted OBERS projections, 2) the non-modified OBERS projections, and 3) Series D-1970 projections used in a California state study, which projected a population of 45 million (10 million less than the OBERS projections).

A number of alternatives were presented for meeting projected needs. The report states that:

> Three general approaches were taken in developing alternatives for meeting water supply requirements or to produce the goods and services dependent on water supply. These are: first an approach that relies on surface water development; second, an approach that utilizes other means for providing water supply; and third, an approach that reduces water requirements…When programs are finally implemented they will likely contain elements from each of the three approaches (Pacific Southwest Inter-Agency Committee, 1972).

In the Colorado Desert subregion, the study noted that water, not land, is the limiting factor in future development. The study predicted that 675,000 acres would be under irrigation by the year 2020; however, if water were readily available within the service area of the Colorado River, an additional 330,000 acres of new land could be utilized. Although the possibility of developing this additional acreage was not considered, it was believed that at least an additional 1.5 maf of water could be used in this area if it were available (Pacific Southwest Inter-Agency Committee, 1972).

The South Coast subregion was projected to have a water supply and demand imbalance of 1.64 maf by 2020. The study suggested this imbalance would need to be resolved through sources

such as reuse of surface and ground waters, waste water reclamation, distillation, and development of new supplies outside of the area. Waste water reclamation of 560 thousand acre-feet per year was included as a plan element for the South Coast subregion. Importation of North Coastal water supplies was necessary to meet Base Plan projections, but not OBERS or Series D-1970 projections.

4.0 Studies 1975 - 2007

Studies following the Comprehensive Framework Studies have all acknowledged an imbalance between water supply and demand in the Basin. Most of these studies have not sought to explicitly quantify the imbalance, but rather have focused on potential solutions to various problems throughout the Basin, including the problems of water supply and demand imbalances, salinity, and tribal water rights. In light of the attention given to some of these issues, institutional changes, such as interim operating criteria and the Consolidated Decree, have occurred. The following sections summarize what these more-recent Basin studies have concluded about water supply and demand imbalances.

4.1 Westwide Study Report on Critical Water Problems Facing the Eleven Western States - 1975

The *Westwide Study Report on Critical Water Problems Facing the Eleven Western States* (Reclamation, 1975) was an interagency state-federal effort meant to provide the information necessary to assist the federal government in making decisions on policy, funding, and action programs for development of the West's water resources.

The principal conclusions regarding water supply and demand imbalances were that the Colorado River should be able to meet all quantitative physical water demands for some years to come; however, assuming a long-term average annual supply of 14.9 maf, sometime after the CAP became fully operational the Colorado River would not yield enough water under normal circumstances to meet Upper and Lower Basin demands, Mexican Treaty obligations, and system losses. Therefore, the study concluded, the Basin faces future water shortages unless its natural flows are augmented or Basin development is curtailed. Assuming a fairly intensive level of future Upper Basin development and a conservative long-term hydrologic cycle, the study predicted the Colorado River water supply would not meet all water demands, beginning in about 1990, and shortages would become progressively greater thereafter. The extent and timing of these shortages would depend on the rate of future consumptive use development and the volumes of annual runoff (Reclamation, 1975).

The study continued to discuss potential options for a total water management program. It envisioned a program that would include activities such as:

- Coordinated operations of all major structures and conjunctive use of surface and groundwater supplies
- Increasing irrigation efficiency through such means as better on-farm system and management practices and improved distribution systems
- Waste water reclamation and reuse

- Increasing water yield through selective phreatophyte removal and control, reducing snowpack evaporation, and watershed management practices
- Reallocation of water supplies through institutional procedures
- Water pricing mechanisms

The study ultimately concluded:

> It is evident that a total water management program can only delay and not prevent water shortages from occurring eventually. When such shortages do occur there appears to be two alternative courses open. The first would be to accept the limitation in water supply and pattern the economic and social future of the basin to that limitation. The second option would be to augment the flows of the Colorado River thus increasing its water supply and permitting continued growth of water dependent developments (Reclamation, 1975).

4.2 Colorado River Basin Water Problems: How to Reduce the Impact - 1979

This report, by the Government Accounting Office, described numerous water problems existing within the Basin and discussed the need for the states and the federal government to work together to solve these problems. One of the key problems addressed is that "water supply is insufficient to meet future demands" (Government Accounting Office, 1979).

The study's discussion of water supply included Reclamation's estimate of average annual natural flow and three challenging estimates. Reclamation's estimate, based on records dating 1906 through 1977, was 14.8 mafy. Alternative estimates of average annual natural flow came from 1) the Upper Colorado River Commission, which stated that it considered the gauged records for 1922 1977 to be more reliable and accepted the estimate of 13.7 maf as the future annual virgin flow, 2) engineers from the Lower Basin States, who testified before Congress during hearings for the 1968 Colorado River Basin Project Act that the virgin river flow was between 13.7 and 14.0 mafy, and 3) researchers at the Laboratory of Tree Ring Research, University of Arizona, who used tree ring reconstructions to estimate the river's annual flow to be about 13.5 mafy.

The report quoted Reclamation studies indicating that a water supply and demand imbalance could occur as early as 1992 and probably would occur before 2023. It concluded that after the CAP came online, the river would probably not yield enough water to meet all Basin demands, the Mexican Treaty obligations, and river system losses. It further concluded that, unless the water supply available to CAP were increased, farmland would have to be reduced significantly to balance water supply and use by 2020, assuming median growth rate in nonagricultural activities.

Suggested solutions to the predicted imbalance included water salvage programs, conservation, and various augmentation methods. Water salvage measures included dredging the river channel, removing vegetation along the river bank, construction of Senator Wash Dam to improve control of the flow of water to the United Mexican States (Mexico) by reducing excess deliveries, and installing wells near the border to reduce the flow of groundwater to Mexico. Conservation measures primarily focused on farming efficiency. Augmentation methods considered included

weather modification, vegetation management, desalting geothermal brines and sea water, and importation of water from other river basins.

Finally, the report included three recommendations to the Secretary of Interior for addressing water supply and demand imbalances, referred to as shortages in the report:

1. Direct Reclamation to develop a series of water management plans that reflect various supply estimates and present a number of alternative actions. Coordinate these plans with all the Basin's water managers.

2. Amend reservoir operating criteria by stating 1) the conditions under which a water supply shortage will be declared, 2) the amounts to be released during a shortage, 3) the reservoir storage levels to be maintained in low-flow years, and 4) the amount of water each subbasin must provide for the 1944 Treaty with Mexico commitment.

3. Direct Reclamation to develop a comprehensive plan specifying the conservation, water salvage, and augmentation techniques that will be used to prevent or minimize the adverse effects of shortages. This plan should identify factors that would interfere with implementing the plan and address how they would be resolved.

4.3 Colorado River Basin Study – 1997

This study was requested by the Western Water Policy Review Advisory Commission (Commission), and completed by Dale Pontius. It included analysis of the most critical issues projected to be facing the basin in the near future, efforts being made to address these problems, and specific recommendations to the Commission for Basin water management and governance over the next 20 years. The study conceptualized a vision for the Basin for the year 2025, the basic premise of which was that

> …we should be working toward three general goals in developing water policy for the basin in the next century: they are equity, efficiency, and sustainability in water use and management (Pontius, 1997).

Regarding water supply and demand imbalances, the analysis depended on previous studies for information, and concluded that the river was over-allocated by 20 to 30 percent, depending on which flow estimates were used. The report stated that for planning purposes in the Upper Basin, the Upper Colorado River Commission had used 6.0 mafy as full development. Based on this number, current depletions in the Upper Basin (including 520,000 acre-feet per year of reservoir evaporation) were already more than 75 percent of the available amount, and projections showed that the Upper Basin states would be using 90 percent of 6.0 mafy by the year 2030. The study further concluded that in the Lower Basin, implementation of the Arizona Water Bank would mean that Arizona would divert its full apportionment as early as 1998 and that Nevada would be using its full 300,000 af apportionment by 2010.

Included in the recommendations to address water supply and demand imbalances were the following:

- An interstate water bank should be established in the Lower Basin with maximum flexibility for marketing and banking water.

- The Basin States and local water managers need to develop stronger conservation programs to maximize conservation and reuse potential and more clearly define and regulate reasonable beneficial use.

- The Secretary, Basin States, and tribes, with input from other interests, should agree on a plan for reservoir operation and surplus and shortage criteria that is equitable to all interests and meets federal statutory obligations and treaty obligations to Mexico.

4.4 Colorado River Basin Water Management: Evaluating and Adjusting to Hydroclimatic Variability - 2007

This report was prepared by the Committee on the Scientific Bases of Colorado River Basin Water Management. The activities of this committee were overseen and supported by the National Research Council's Water Science and Technology Board. The committee was asked to review the hydrologic and climatic bases of Colorado River water management and to consider broad topics of system operations and water management practices. Terms such as "population growth" and "water demand" did not appear in the statement of task.

Nonetheless, as the committee proceeded,

> …it became clear that broad understanding of Colorado River management issues is not possible unless both water supply and demand issues are adequately considered. Thus [they] felt it incumbent to comment on topics of water demand, technologies and practices for augmenting water supplies, and programs for coping with drought" (Committee on the Scientific Bases of Colorado River Basin Water Management, 2007).

Within the scope of its statement of task and its available resources, the committee chose to focus on reviewing existing scientific knowledge of hydroclimatic variability and on discussing the implications of hydroclimatic variability in the context of key water management challenges in the Basin. The committee also aimed to broadly assess key Colorado River scientific issues as they relate to water supply, demand, management, and drought preparedness.

The committee concluded that:

> Technological and conservation options for augmenting or extending water supplies – although useful and necessary – in the long run will not constitute a panacea for coping with the reality that water supplies in the Colorado River basin are limited and that demand is inexorably rising (Committee on the Scientific Bases of Colorado River Basin Water Management, 2007).

The report contained three major conclusions, based on the committee's evaluation of drought planning strategies:

- Interstate cooperation and initiative will prove increasingly valuable and essential in coping with future droughts and growing water demands.

- A commitment to two-way conversation among scientists and water managers is important and necessary in improving overall preparedness and planning for drought and other water supply shortages.

- A comprehensive, action-oriented study of Colorado River region urban water practices and changing patterns of demand should be conducted because such a study could provide a more systematic basis for water resources planning across the region. The study could be conducted by the Basin States, a federal agency or agencies, a group of universities from across the region, or some combination thereof. These groups should be prepared to take action based on this study's findings in order to improve the region's preparedness for future inevitable droughts and water shortages.

5.0 Summary and Conclusions

Previous studies of the Colorado River Basin reveal that water supply and demand imbalances have been on the radar since the 1960s. A number of useful developments have come out of these studies. For example, the *Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead Final Environmental Impact Statement* (Reclamation, 2007) partially addressed recommendations from the more-recent group of studies, by amending reservoir operations under low reservoir conditions for an interim period.

The current Colorado River Basin Water Supply and Demand Study is the next logical step in the series of studies. Such a comprehensive state-federal cooperative study has been envisioned and recommended in several of the more recent 'survey' studies, and picks up where the previous studies have left off.

6.0 References

Bureau of Reclamation (Reclamation). 1946. *The Colorado River: A Comprehensive Report on the Development of the Water Resources of the Colorado River Basin for Irrigation, Power Production, and Other Beneficial Uses in Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming*.

Bureau of Reclamation (Reclamation). 1950. *Colorado River Storage Project and Participating Projects; Upper Colorado River Basin.*

Bureau of Reclamation (Reclamation). 1952. *Report on Water Supply of the Lower Colorado River Basin: Project Planning Report*.

Bureau of Reclamation (Reclamation). 1964. *Pacific Southwest Water Plan*.

Bureau of Reclamation (Reclamation). 1975. *Westwide Study Report on Critical Water Problems Facing the Eleven Western United States*.

Bureau of Reclamation (Reclamation). 2007. *Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead Final Environmental Impact Statement.*

Committee on the Scientific Bases of Colorado River Basin Water Management. 2007. *Colorado River Basin Water Management: Evaluating and Adjusting to Hydroclimatic Variability.*

Engineering Advisory Committee. 1948. *Final Report, Engineering Advisory Committee to Upper Colorado River Basin Compact Commission*.

Government Accounting Office. 1979. *Colorado River Basin Water Problems: How to Reduce Their Impact*.

Pacific Southwest Inter-agency Committee. 1971a. *Comprehensive Framework Study, Lower Colorado Region*. Prepared by the Lower Colorado Region State – Federal Interagency Group for the Pacific Southwest Inter-agency Committee, Water Resources Council. Washington D.C.

Pacific Southwest Inter-agency Committee. 1971b. *Comprehensive Framework Study, Upper Colorado Region*. Prepared by the Upper Colorado Region State – Federal Interagency Group for the Pacific Southwest Inter-agency Committee, Water Resources Council. Washington D.C.

Pacific Southwest Inter-agency Committee. 1972. *Comprehensive Framework Study, California Region*. Prepared by the California Region State – Federal Interagency Group for the Pacific Southwest Inter-agency Committee, Water Resources Council. Washington D.C.

Pontius, Dale. 1997. *The Colorado River Basin Study*. Prepared for the Western Water Policy Review Advisory Commission.

Tipton, Royce J. 1965. *Water Supplies of the Colorado River*.