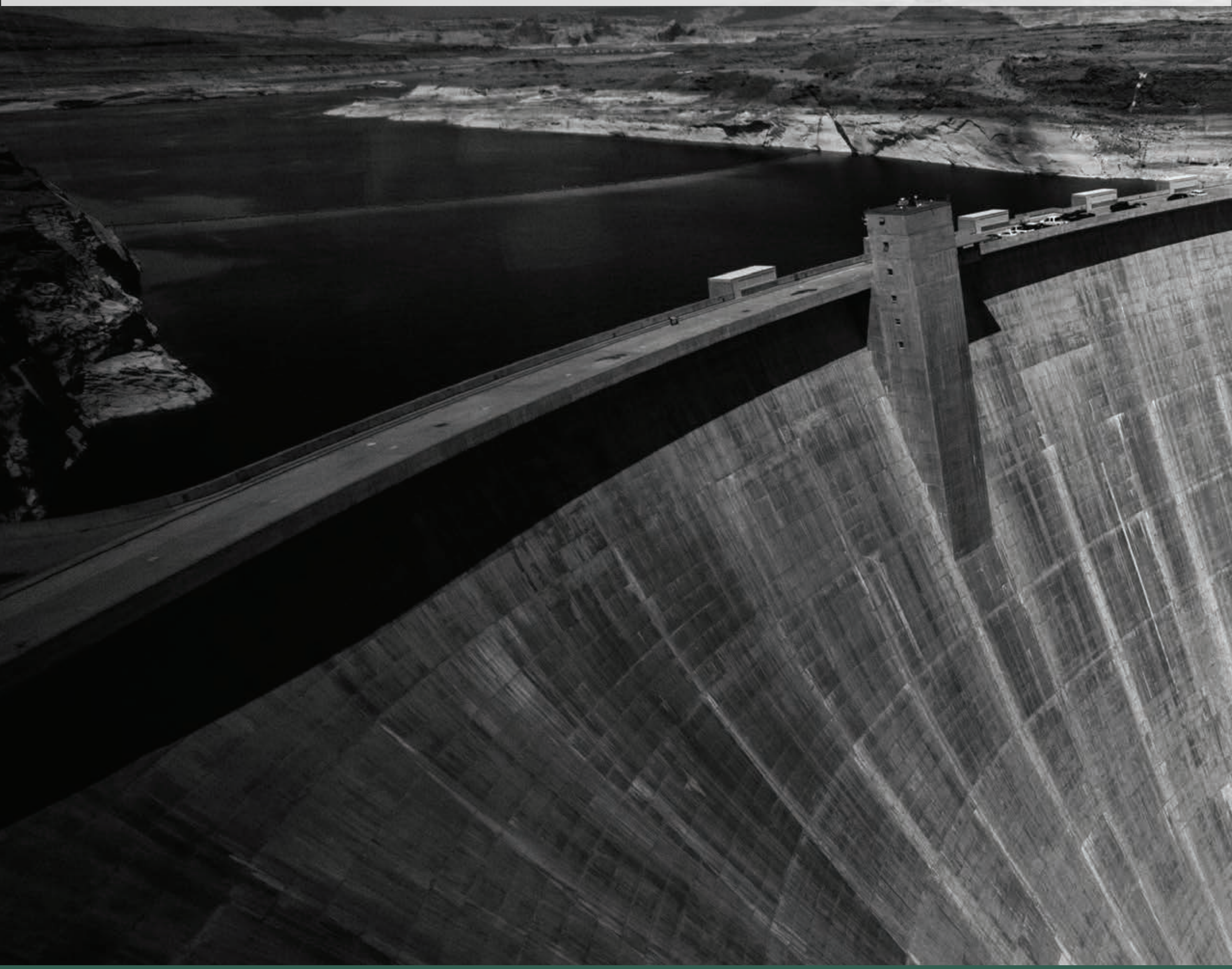
Overview: Colorado River Basin Water Demand and Supply Imbalance

By Shannon Thomas and Walter E. Hecox



The 2013 Colorado College State of the Rockies Report Card
Water Friendly Futures for the Colorado River Basin

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Will Stauffer-Norris

Introduction

Today the Colorado River and its tributaries provide water to more than 30 million people, irrigate approximately four million acres of land, and operate hydroelectric facilities that generate more than 4,200 megawatts (MW) in the seven basin states of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. The Colorado River also supports 15 Native American tribes, seven national wildlife refuges, four national recreation areas, and five national parks.[1] Initiated in 2010, the U.S. Bureau of Reclamation (BOR) conducted the Colorado River Basin Water and Supply Demand Study for the basin states in order to predict possible imbalances in future supply and demand of the Colorado River Basin and the adjacent areas (**see Figure 1**) over the next 50 years. They deal with three geographic areas:

- the Colorado River hydrologic boundary (called the basin), which historically is divided into the Upper Basin and Lower Basin;
- Adjacent areas exporting water from the basin;
- Study Area that includes the two areas above.

The State of the Rockies Project has analyzed this study's results and built upon its findings regarding current and projected future water uses by agriculture, municipal and industrial (M&I), and energy. **Figure 2** provides a list of terms used in reference to the Colorado River Basin and its adjacent areas.

Figure 1: Map of the Colorado River Basin Study Area

Source: Bureau of Reclamation

Historic Colorado River Basin Water Use

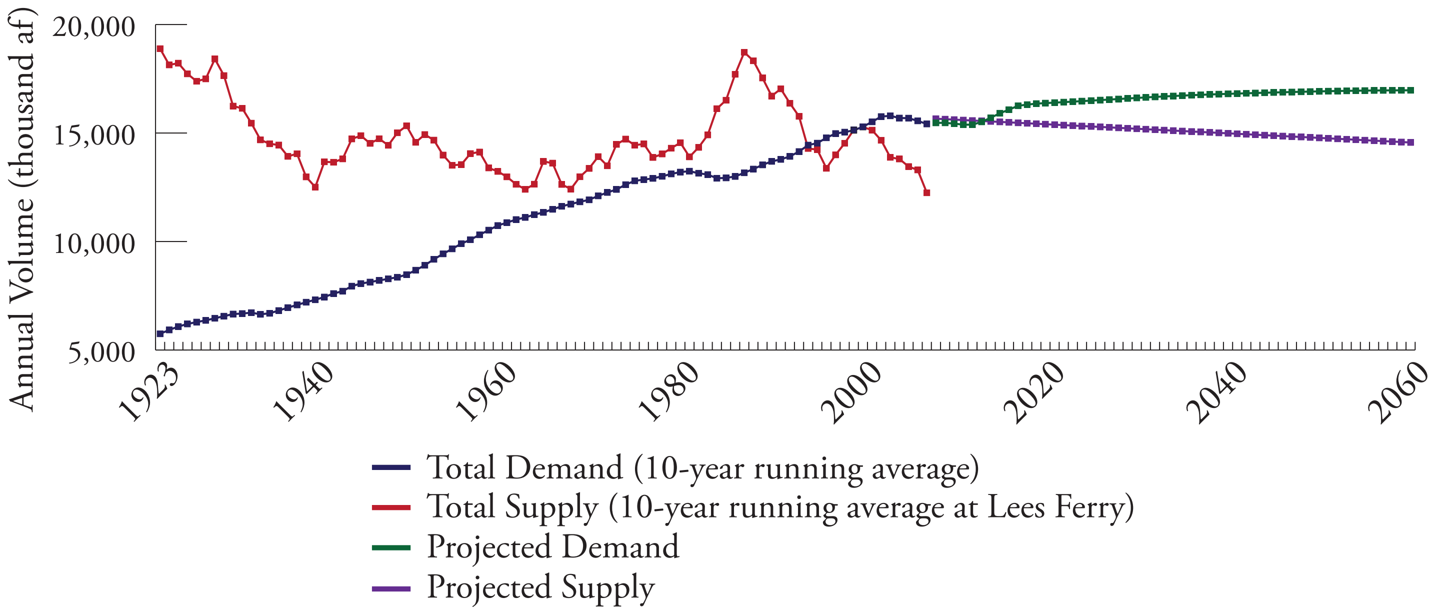
There already exists imbalances between water supply and demand in the basin and this imbalance is projected to increase in both magnitude and spatial extent over the next 50 years (**see Figure 3**). While for several decades storage capacity has been able to mask this imbalance in the current system, future drought and climate variation coupled with population growth in urban and industrial areas are projected to create more strain on the hydrologic basin and its resources. Colorado River water use has increased overall in the past century, primarily from increases in M&I water use despite a decrease in agricultural use. This increase in M&I use has primarily been caused by population growth in the basin states. These states have some of the fastest growing populations in the entire country. Improvements

Figure 2: Key Terms Used in the Colorado River Basin Supply and Demand Study

Hydrologic Basin	The geographic region naturally draining to the Colorado River.
Adjacent Area	Geographic regions outside the Colorado River hydrologic basin that receive Colorado River water.
Study Area	The hydrologic boundaries of the Colorado River Basin, plus the adjacent areas of the basin states that receive Colorado River water.
Demand	Water needed to meet identified uses.
Diversion	Water withdrawn from the river system.
Return Flow	Water diverted from and returned to the river system.
Consumptive Use	Water used, diminishing the available supply.
Non-consumptive Use	Water used without diminishing the available supply.
Loss	Water unavailable for identified uses due to reservoir/channel evaporation, phreatophyte use, and operational inefficiencies.
Other Supplies	Water supplies other than Colorado River Simulation System (CRSS) simulated Colorado River water supplies that may meet demand.
Parameter	A variable which impacts a demand category (for example, population).
Colorado River Demand	Potential Colorado River demand as computed by Study Area demand minus other supplies.

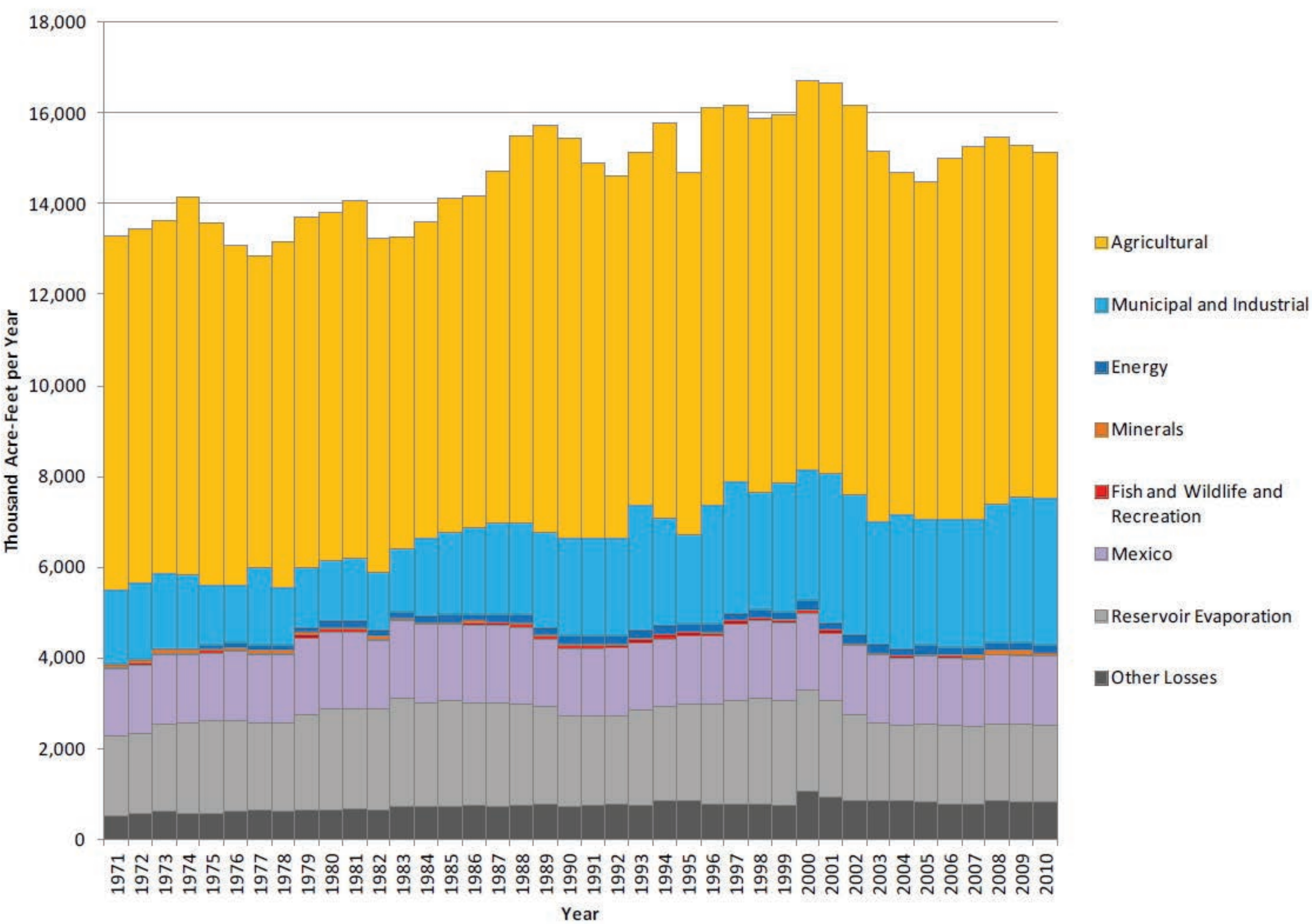
Source: Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." Reclamation Managing Water in the West (2012): 1.

Figure 3: Total Colorado River System Water Use and Required Deliveries to Mexico vs. Flow at Lees Ferry



Source: Bureau of Reclamation.

Figure 4: Historic Colorado River Water Use by Category (1971-2010)



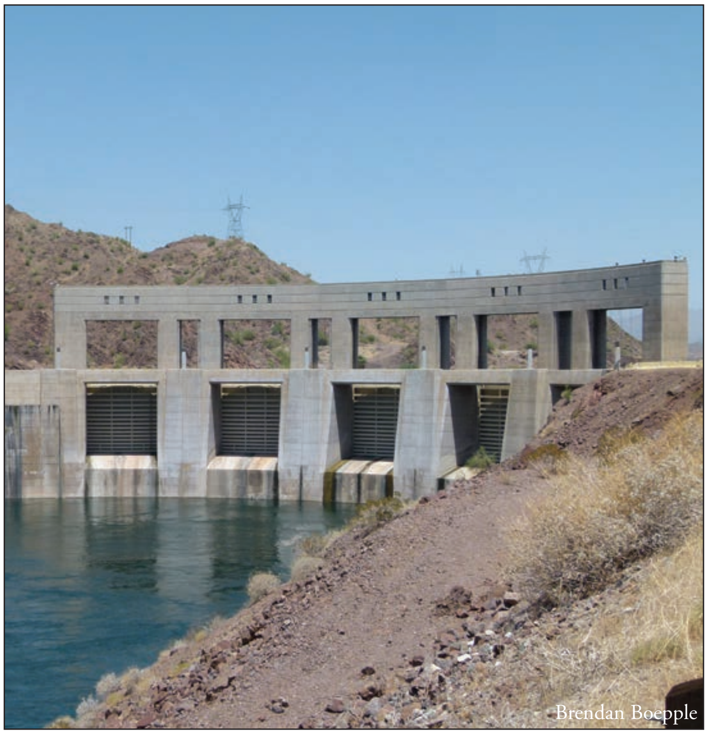
Source: Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." Reclamation Managing Water in the West (2012): 5.

Figure 5: Synopsis of Scenarios to Predict Future Supply and Demand of the Colorado River	
Current Projected (A)	Continuation of growth, development patterns, and institutions follow long-term trends.
Slow Growth (B)	Slow growth with emphasis on economic efficiency.
Rapid Growth (C1 and C2)	Economic resurgence (population and energy) and current preferences toward human and environmental values.
Enhanced Environment (D1 and D2)	Expanded environmental awareness and stewardship with growing economy.
Source: Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." Reclamation Managing Water in the West (2012): 6.	

from indoor fixtures and appliances, such as toilets and washers to outdoor xeriscaping, have led to a decrease in per capita water use and partially offset water demands from population growth; however, these water savings per capita are not significant enough to decrease overall water demand of growing total populations. In recent years, agricultural water use has been somewhat stable with drought causing variance in this pattern. Irrigated acres of land have also decreased in the basin, most likely due to economic conditions, supply limitations, and pressure from municipalities for land change and water transfers.[2] This trend is expected to continue due to population growth in the basin. Water demand for energy use has also increased over time, congruent with population growth in the West. **Figure 4** shows the historic water use of the Colorado River Basin by category. The categories include agricultural, M&I, energy, minerals, tribal, minerals, and fish, wildlife, and recreation.

The BOR's Water Demand-Supply Study analyzed six scenarios to examine possible future water supply and demand conditions related to the Colorado River Basin. **Figure 5** provides a brief synopsis of the BOR scenarios generated by reviewing key driving forces that may affect each scenario in the basin.

For each scenario, the categories of agriculture, M&I, energy, fish, wildlife, recreation, minerals and tribal were analyzed. **Figure 6** provides an overview of the definitions and parameters for each category.



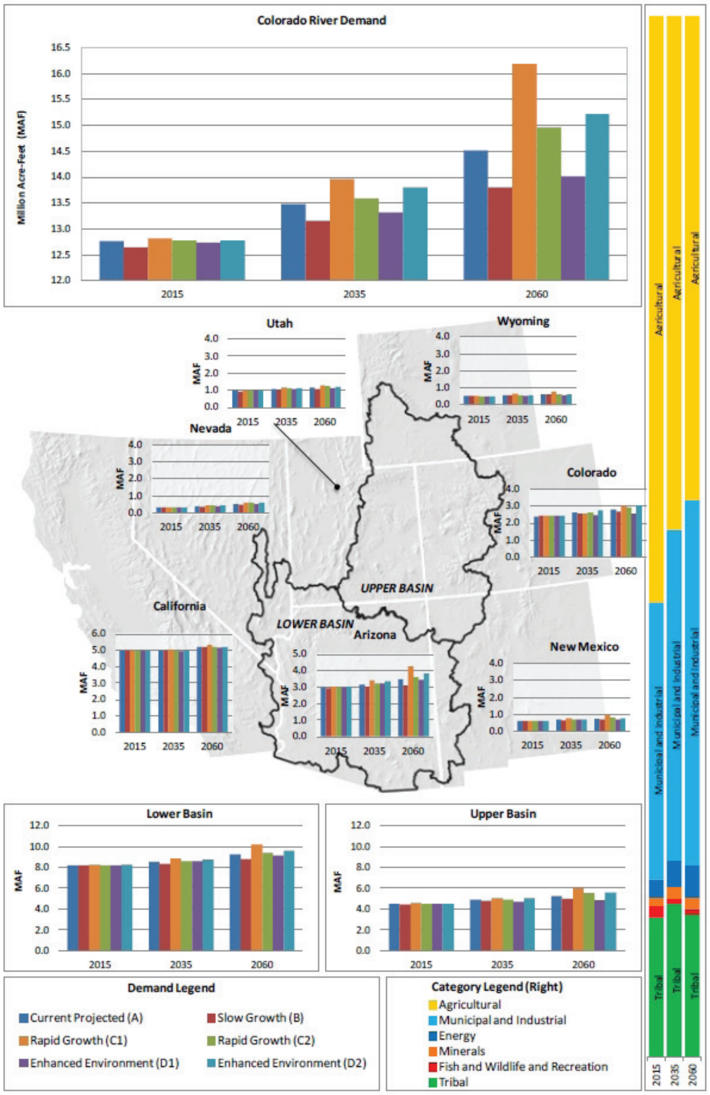
Parker Dam on the California-Arizona border.

Figure 6: Overview of Demand Categories

Demand Category	Definition	Parameters
Agriculture	Water used to meet irrigation requirements of agricultural crops, maintain stock ponds, and sustain livestock	Irrigated acreage, irrigation efficiency
Municipal and Industrial	Water used to meet urban and rural population needs, and industrial needs within urban areas	Population, population distribution, M&I water use efficiency, consumptive use factor
Energy	Water used for energy services and development	Water needs for energy generation
Minerals	Water used for mineral extraction not related to energy services	Water needs for mineral extraction
Fish, Wildlife, Recreation	Water used to meet National Wildlife Refuge, National Recreation Area, state park, and off-stream wetland habitat needs	Institutional and regulatory conditions, social values affecting water use, Endangered Species Act-listed species needs, and ecosystem needs
Tribal	Water used to meet tribal needs and settlement of tribal water rights claims	Tribal use and settlements

Source: Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." Reclamation Managing Water in the West (2012): 6.

Figure 7: Colorado River Water Demand by State



Source: Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." Reclamation Managing Water in the West (2012): 21.

Note: Demands do not include Mexico's allotment and losses such as reservoir evaporation. These factors will be included in the modeling supporting the system reliability analysis. Tribal demand within Colorado is not reflected in the tribal category but is included in other categories.

The Colorado River demand was analyzed by BOR at three geographic levels that are shown in **Figures 7, 8, and 9.** These figures show the Study Area, both the Upper and Lower Basin, and individual state demands for each scenario. The bars on the right side in these figures show the "relative contribution of each demand category to the total Colorado River demand at a point in time (2015, 2035, or 2060) in the Current Projected (A) scenario. In general, the category proportions remain relatively consistent across the scenarios."[3]

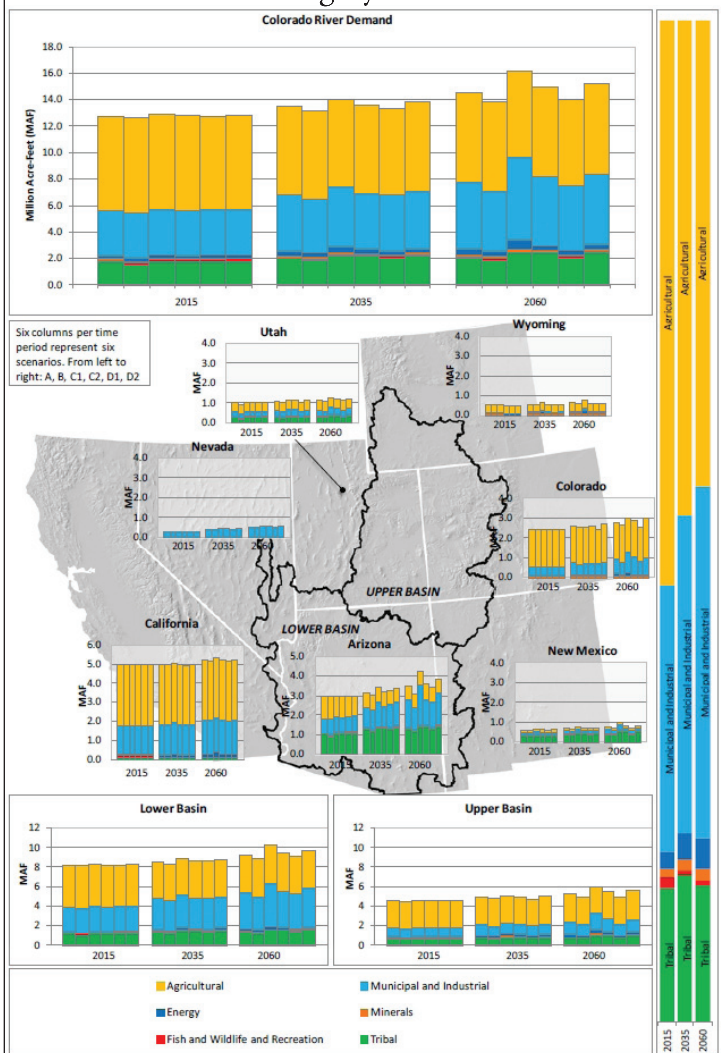
Figure 7 shows that change in Colorado River demand varies substantially across the basin states in both magnitude and percentage with Colorado and Arizona showing the greatest growth in demand in the next 50 years. The varied levels are due to different population growth and M&I demand. Tribal demand is also significant in growth for Arizona.

Figure 8 displays varied levels of demand across the Upper and Lower Basin. There is, however, almost equal demand in agriculture and M&I use in the Lower Basin. The Upper Basin's demand is comprised of two-thirds agriculture.

Figure 9 demonstrates the change in demand by category from 2015 for each scenario with increases in M&I leading to the majority of future growth in demand. Only in the Enhanced Environment (D1) scenario does M&I demand show an insignificant increase to demand, namely because per capita use decreases so substantially. Tribal, energy, and mineral demand are also expected to increase in all scenarios while agricultural demand is projected to decrease.

Figure 10 shows the percent change for each category in relation to the varying scenarios. In all scenarios, agriculture and M&I show the greatest change in demand, with agricultural decreasing and M&I use increasing. Energy also increases in all scenarios while the other categories show variance in the different scenarios.

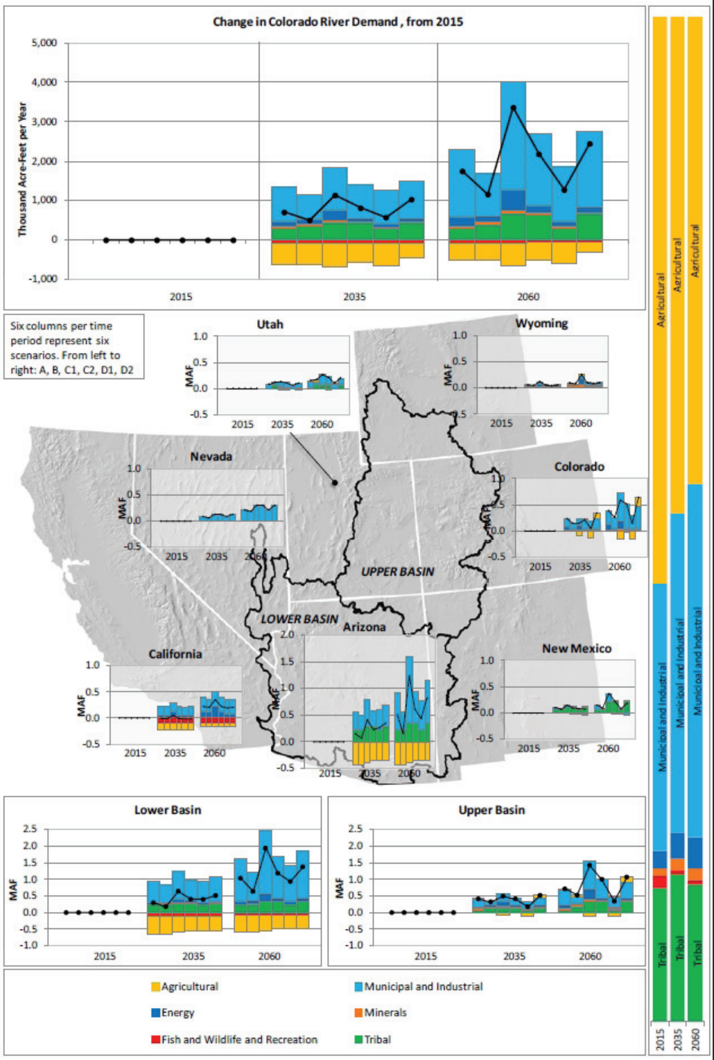
Figure 8: Colorado River Water Demand by Category of Use



Source: Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." Reclamation Managing Water in the West (2012): 22.

Note: Demands do not include Mexico's allotment and losses such as reservoir evaporation. These factors will be included in the modeling supporting the system reliability analysis. Tribal demand within Colorado is not reflected in the tribal category but is included in other categories.

Figure 9: Colorado River Water Changes in Demand 2015-2060 by Category



Source: Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." Reclamation Managing Water in the West (2012): 22.
Note: Demands do not include Mexico's allotment and losses such as reservoir evaporation. These factors will be included in the modeling supporting the system reliability analysis. Tribal demand within Colorado is not reflected in the tribal category but is included in other categories.


Brendan Boepple

Rockies researchers at the Imperial Dam in southern California.

Figure 10: Total Colorado River Changes in Sector Demand- Total and Shares

Total Colorado River Demand	2015	2035	2060
Current Trends (A)	100.00%	100.00%	100.00%
Economic Slowdown (B)	99.16%	97.58%	95.11%
Expansive Growth (C1)	100.62%	103.60%	111.53%
Expansive Growth (C2)	100.20%	100.83%	103.05%
Enh Envir Healthy Econ (D1)	100.48%	99.01%	96.88%
Enh Envir Healthy Econ (D2)	100.53%	102.54%	104.88%
Current Trends (A)	100.00%	100.00%	100.00%
Agricultural	56.42%	49.36%	46.47%
Municipal and Industrial	26.14%	31.36%	34.66%
Energy	1.75%	2.58%	3.04%
Minerals	0.79%	1.15%	1.19%
Fish, Wildlife, and Recreation	1.16%	0.42%	0.45%
Tribal	13.36%	14.71%	13.67%
Other	0.38%	0.43%	0.51%
Economic Slowdown (B)	100.00%	100.00%	100.00%
Agricultural	57.08%	50.80%	49.12%
Municipal and Industrial	26.95%	30.62%	32.28%
Energy	1.77%	2.44%	2.76%
Minerals	0.79%	1.21%	1.28%
Fish, Wildlife, and Recreation	1.18%	0.44%	0.47%
Tribal	11.85%	14.06%	13.54%
Other	0.38%	0.44%	0.54%
Rapid Growth (C1)	100.00%	100.00%	100.00%
Agricultural	55.93%	47.01%	40.69%
Municipal and Industrial	26.40%	32.09%	37.89%
Energy	1.81%	3.39%	4.58%
Minerals	0.82%	1.25%	1.31%
Fish, Wildlife, and Recreation	1.16%	0.41%	0.40%
Tribal	13.51%	15.44%	14.67%
Other	0.37%	0.41%	0.46%
Rapid Growth (C2)	100.00%	100.00%	100.00%
Agricultural	56.37%	49.25%	45.08%
Municipal and Industrial	26.12%	30.81%	34.59%
Energy	1.67%	2.23%	2.46%
Minerals	0.71%	0.95%	0.94%
Fish, Wildlife, and Recreation	1.19%	0.48%	0.57%

Continued on following page.
Source: Bureau of Reclamation

Figure 10: Total Colorado River Changes in Sector Demand- Total and Shares (cont.)

Total Colorado River Demand	2015	2035	2060
Rapid Growth (C2)	100.00%	100.00%	100.00%
Tribal	13.57%	15.85%	15.87%
Other	0.37%	0.43%	0.53%
Enhanced Environment (D1)	100.00%	100.00%	100.00%
Agricultural	56.13%	48.85%	46.80%
Municipal and Industrial	26.20%	31.77%	34.10%
Energy	1.65%	2.15%	2.41%
Minerals	0.71%	1.00%	1.01%
Fish, Wildlife, and Recreation	1.65%	0.95%	0.96%
Tribal	13.30%	14.86%	14.12%
Other	0.37%	0.43%	0.53%
Enhanced Environment (D2)	100.00%	100.00%	100.00%
Agricultural	55.66%	48.47%	44.90%
Municipal and Industrial	26.43%	31.51%	34.81%
Energy	1.65%	2.12%	2.29%
Minerals	0.71%	0.97%	0.94%
Fish, Wildlife, and Recreation	1.66%	0.92%	0.96%
Tribal	13.52%	15.59%	15.61%
Other	6.57%	0.42%	0.49%

Source: Bureau of Reclamation.

In order to understand the projected changes in demand more clearly, the Current Projected Scenario (A) was used in the BOR Study as a baseline against which other scenarios can be compared. In other words, “general relationships were used to relate the expected changes in parameters for each scenario in comparison to the Current Projected (A) scenario consistent with each storyline.”[4] **Figure 11** shows these relationships amongst the scenarios.

Comparison of Demand Scenarios

The section below shows a broad comparison of how the scenarios vary over time by focusing on the key “determinant” forces in the basin. The driving forces for each scenario were categorized and include: Demographics and Land Use, Technological and Economics, and Social and Governance.

Demographics and Land Use: Variations in demographics and land use were driven by different rates of economic growth, agricultural water supply projects, conversion of agricultural land to urban land, and phasing out lower economic-value crops. The Current Projected (A) and Enhanced Environment (D1) scenarios reflect a “best estimate” for population projects while Rapid Growth (C1 and C2) and Enhanced Environment (D2) reflect high-end population projections and the Slow Growth (B) model reflects low-end population projections. Agricultural land decreases in all scenarios with the greatest decrease in Rapid Growth (C1 and C2) models; however, irrigated acreage increases in Upper Basin areas in the Current Projected (A) and Slow Growth (B) models by 2060.[5]

Technology and Economics: Different rates of advancement of technology and conservation in the basin will result in reduced levels of water demands for agriculture, M&I and energy with regards to shifts in social values, economic forces, and resource restrictions. Although M&I water use is expected to become more efficient under all scenarios, this greater per capita efficiency varies for each scenario depending upon the changes in social values that will lead to increases in investment for water conserving programs at the local, state, and federal level. For example, Slow Growth (B) contains the lowest efficiency increase because it is expected that there is a slower rate for societal support for conservation programs and a shortage of resources to advance these initiatives. The largest increase in efficiency is in the Enhanced Environment (D1 and D2) scenarios where changes in social values, federal investment, and future conservation efforts are largest.[6]

Agricultural per acre water delivery ranges from a modest increase under the Rapid Growth (C2) scenario to a modest decrease under the Enhanced Environment (D1) scenario. The primary reason for the small decrease under this scenario is favorable economic conditions coupled with changing social values that create a willingness and incentives to invest in agricultural water conservation. This leads to rapid adoption of new technologies, resulting in decreased agricultural demands due to increased agricultural water use efficiency.[7]

Water needs for energy development increase across all scenarios and range from the most modest increase under the Enhanced Environment (D1 and D2) scenarios to the greatest increase under the Rapid Growth (C1 and C2) scenarios. Water needs for energy expand relative to population growth and results in the highest demand under the Rapid Growth (C1) scenario. Under the Enhanced Environment (D1 and D2) scenarios, an emphasis on renewable energy requirements and investments in technologies that reduce water consumption associated with energy production and new development decreases projected water demands for energy production despite a rapidly growing population featured under the Enhanced Environment (D2) scenario.[8]

Social and Governance: Changes in agricultural and M&I water use efficiency and the advancement of ecological and recreational programs have influenced institutional and regulatory changes. Water use efficiency changes vary from no meaningful changes in current practices (shown in Current Trends and Slow Growth scenarios) to increased efficiency from social values (Enhanced Environment). As a result of changing social values, the Enhanced Environment (D1 and D2) scenarios show increases in the following: investments for programs that support the recovery of endangered species, ecological and river recovery, and recreational use;

Figure 11: Scenario Matrix of Typical Changes in Parameters Compared to the Current Projected (A) Scenario

	Population	M&I Per Capita Use	Self-Served Industrial Demand*	Agriculture Irrigated Acreage	Agriculture Efficiency	Energy Demand	Minerals Demand	Fish, Wildlife, Recreation Demand	Tribal Demand
Slow Growth (B)	Slower Growth	No Change	No Change	No Change	Decreased Efficiency	No Change	No Change	No Change	Slower Growth
Rapid Growth (C1)	Rapid Growth	No Change	No Change	Increased Ag Land Use	Decreased Efficiency	Increased Demand	Increased Demand	No Change	Faster Growth
Rapid Growth (C2)	Rapid Growth	Increased Efficiency	Increased Efficiency	Increased Ag Land Use	Increased Efficiency	Decreased Demand	Decreased Demand	Increased Demand	Faster Growth
Enhanced Environment (D1)	No Change	Increased Efficiency	Increased Efficiency	No Change	No Change	Decreased Demand	Decreased Demand	Increased Demand	No Change
Enhanced Environment (D2)	Rapid Growth	Increased Efficiency	Increased Efficiency	No Change	Increased Efficiency	Decreased Demand	Decreased Demand	Increased Demand	Faster Growth

Notes: Blue represents a decrease and red represents an increase in the parameter value when compared to the Current Projected (A) scenario. *Self-served industrial demand represents the demand of industries in a given area that have water supply systems independent of municipal systems.

Source: Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." Reclamation Managing Water in the West (2012): 10.

government regulations for increasing supply and reducing demand; additional incentive programs for renewable energy use; and the implementation of further conservation programs.[9]

Comparing Demand Scenarios

The largest factor for the increase in demand is due to population growth in the basin states. It is estimated that there will be approximately 40 million in the study area by 2015. This figure is expected to increase to between 49 million (low-end population growth) and 77 million (high-end population growth) by 2060.[10] The low-end population growth is modeled in the Slow Growth (B) scenario while the high-end population growth is modeled in the two Rapid Growth (C1 and C2) scenarios and one of the Enhanced Environment (D2) scenarios. As mentioned previously, this growth in demand due to the municipal population will be partially offset by more efficiency in per capita water use. Based on passive and existing conservation measures, per capita water use is already expected to decrease by 7% to 19% by 2060, varying in both the scenarios and basin states.[11] However, this decrease in per capita water use is not enough to offset the increase in total demand of Colorado River water caused by the large influx in population that is predicted in all scenarios.

Irrigated acreage is expected to decrease in all scenarios through 2060. More specifically, irrigated acreage is projected to decrease more than 830,000 acres in the Rapid Growth (C1 and C2) scenarios and decrease about 300,000 to 550,000 in all other scenarios.[12]

Water demand for both energy and mineral use is expected to increase in all scenarios due to the growing demand for energy and mineral extraction. Arizona, California, and Colorado are projected to have the largest increase for energy demand while Arizona, Colorado, and Wyoming are expected to have the largest increase for water use for mineral extraction.

Under all scenarios, tribal demand is projected to increase over time as Native American Treaty water rights become "quantified rights."[13]

Figure 12 provides a brief summary of results for both the Study Area demand and the Colorado River demand with regard to the six scenarios. The first section discusses the changes in population growth, per capita water use, and irrigated acreage as explained above. The next two sections show the changes in the Study Area demand and Colorado River demand in relation to both the categories and the different scenarios. Demand in the Study Area ranges between 28.7 and 32.5 million acre feet (maf) by 2060 while Colorado River demand ranges between 13.8 and 16.2 maf; however, the increase in Study Area demand is expected to be partially met by other supplies. It is projected that Colorado River demand from 2015 to 2060 will increase between 1.1 and 3.4 maf with the Lower Basin contributing to about 60% of the increase.[14]

Figure 12: Summary of the Results for Water Demand Scenario Quantification by 2060

Key Study Area Demand Scenario Parameters							
	2015	2060 Scenario Parameters					
		A	B	C1	C2	D1	D2
Population (millions)	40.0	62.4	49.3	76.5	76.5	62.4	76.5
Change in per capita water usage (%) from 2015	--	-9%	-7%	-9%	-16%	-19%	-17%
Irrigated acreage (millions of acres)	5.5	5.1	5.2	4.6	4.6	4.9	5.0
Change in per-acre water delivery (%), from 2015	--	+1%	+2%	+1%	+3%	0%	+3%
Study Area Demand (maf)							
Agricultural Demand	16.5	15.2	15.7	13.7	13.8	14.9	14.9
Municipal and Industrial Demand	8.6	12.5	10.2	15.1	13.9	11.0	13.7
Energy Demand	0.35	0.66	0.57	1.01	0.58	0.53	0.56
Minerals Demand	0.1-0.11	0.18	0.18	0.22	0.15	0.15	0.15
Fish, Wildlife, and Recreation Demand	0.16-0.23	0.08	0.08	0.08	0.10	0.16	0.16
Tribal Demand[1]	1.6-1.8	2.0	2.0	2.5	2.4	2.1	2.4
Total Study Area Demand[2]	**27.6**	**30.7**	**28.7**	**32.5**	**30.9**	**28.7**	**31.9**
Colorado River Demand (maf)							
Agricultural Demand	7.2	6.7	6.8	6.6	6.7	6.5	6.8
Municipal and Industrial Demand	3.4	5.1	4.5	6.2	5.2	4.9	5.4
Energy Demand	0.22	0.44	0.38	0.74	0.37	0.34	0.35
Minerals Demand	0.09-0.11	0.17	0.18	0.21	0.14	0.14	0.14
Fish, Wildlife, and Recreation Demand	0.15-0.21	0.06	0.07	0.06	0.08	0.15	0.15
Tribal Demand[1]	1.5-1.7	2.0	1.9	2.4	2.4	2.0	2.4
Total Colorado River Demand[2]	**12.8**	**14.5**	**13.8**	**16.2**	**15.0**	**14.0**	**15.2**

Notes: [1] Tribal demand within the state of Colorado is included in other demand categories.
[2] Excludes Mexico's allotment and losses (reservoir evaporation, phreatophytes, and operational inefficiencies).
Source: Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." Reclamation Managing Water in the West (2012): 15.

Figure 13 displays historical Colorado River use coupled with the projected demand scenarios. The figure takes into account past and future losses due to reservoir evaporation and other factors and shows the historical Colorado River use and projected future Colorado River demand by scenario. This figure includes historical and future projected losses (comprised of reservoir evaporation and other losses) and deliveries to Mexico in order to provide a more accurate view of total demand.

Figure 14 shows the percent increase in demand by category with 2008 as the baseline. Expansive Growth (C1) shows the largest increase in overall demand with a total percent increase of 25.06% while Economic Slowdown (B) shows only an increase of 10.74%.

Major Demands for Colorado River Water

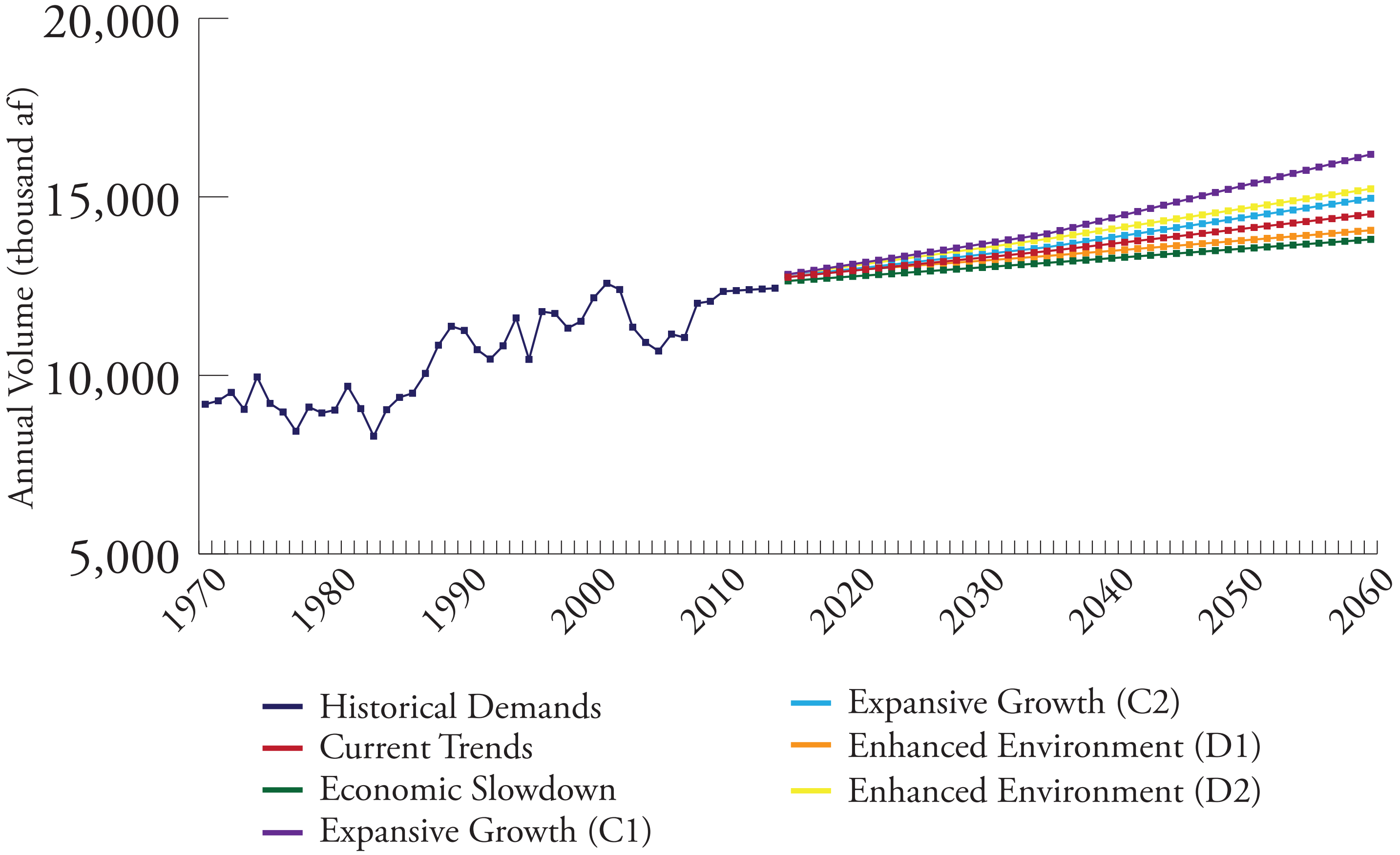
Agriculture Water Demand

Agriculture water demand is the largest component of total demand for the Colorado River and is determined by irrigated acreage and per-acre water delivery – the amount of water diverted per acre taking into account losses from evaporation, delivery, farm losses, etc. Under all scenarios, agricultural demand is expected to decrease as a result of reduction in irrigated acreage. Per-acre delivery, however, is expected to increase slightly in all scenarios.

Although demand overall decreases under all scenarios, Upper Basin states show increases in agricultural demand under several scenarios with demand in Colorado showing the largest increase under the Enhanced Environment (D2) scenario. Colorado, however, also shows decreases in demand in several scenarios due to predicted future irrigated acreage. Both Utah and Wyoming show small increases in most scenarios while New Mexico demand varies from no change to a notable decrease. The most significant decreases in demand in the Lower Basin are located in Arizona with small decreases also occurring in California under all scenarios. Nevada has no agricultural demand to report. The main factor behind the decrease in agricultural acreage is increased urbanization, which also causes pressure for water transfers that will greatly affect Colorado and Arizona.[15]

Figure 15 shows the percent change in agricultural demand for each scenario from 2015 to 2060. All scenarios show a significant decrease in demand, with the Expansive Growth (C1) scenario showing the largest decrease with agricultural making up nearly 56% of total demand in 2015, down to 45% in 2060. Economic Slowdown shows the smallest decrease with only about an 8% decrease over the period. **Figure 16** shows the changes in agricultural demand for the scenarios. For each of the scenarios, agricultural decreases significantly until 2035 in which there is then a slight increase for the remaining years.

Figure 13: Historic and Projected Colorado River Demand



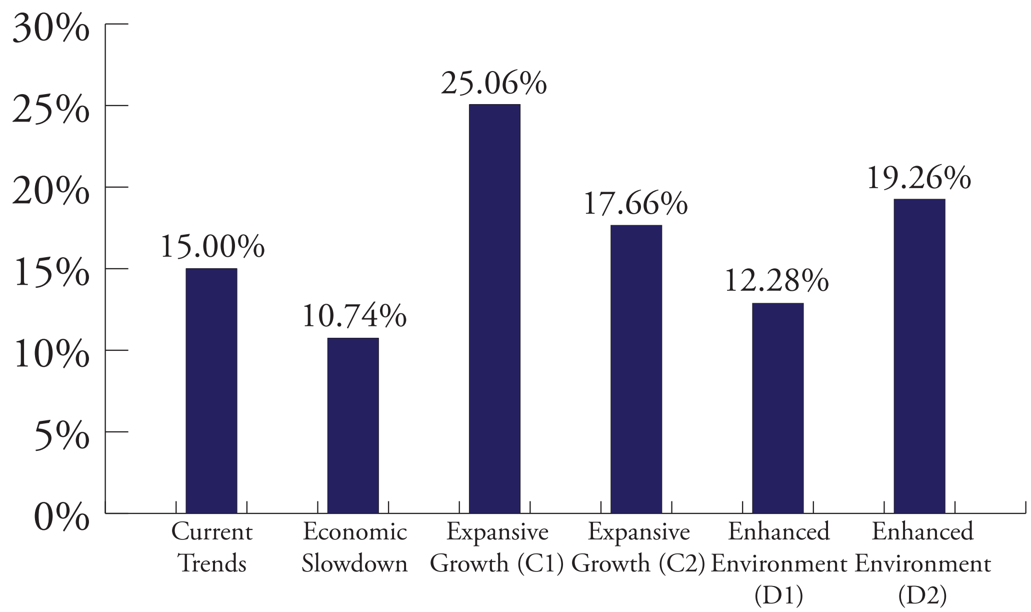
Source: Bureau of Reclamation.

Municipal and Industrial (M&I) Water Demand

M&I demand is the second largest component of total Colorado River demand and is calculated through population, per capita water use, and self-served industrial (SSI) demand. Per capita water use is measured by the amount of water used per person in a given service area that includes industrial, commercial, institutional, and residential demand. SSI demand is a measure of demand by industries that have an independent supply system for water. Since SSI demand is independent, it is not directly correlated to "population and per capita water use rates that are assumed for M&I demand projections" and only makes up less than 10% of M&I demand. Comparing M&I demand is quite difficult because of the many factors that influence it such as climate, number of industries, demographics, economy, number of visitors, etc.[16]

M&I demand is projected to increase in all scenarios. This demand is expected to increase from 27% of total demand in 2015 to between 33-38% by 2060, depending on the scenario. The main catalyst behind this increase is population growth within the basin states. For the Upper Basin, the increase in M&I demand is expected to increase between 19% and 32 %, with Colorado having the most significant impact and Utah and New Mexico contributing as well, while the Lower Basin shows a staggering

Figure 14: Demand Increase by Category from 2008 to 2060



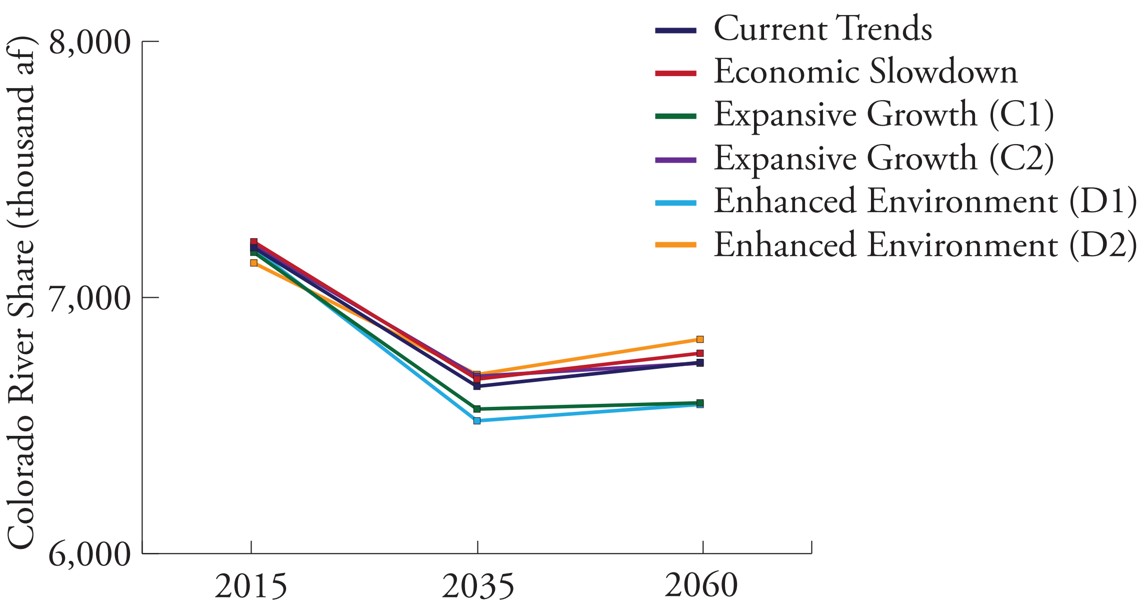
Source: Bureau of Reclamation.

Figure 15: Change in Percent Share of Agricultural Demand from 2015-2060

Agricultural Total Demand	2015	2035	2060
Current Trends	56.42%	49.36%	46.47%
Economic Slowdown	57.08%	50.80%	49.12%
Expansive Growth (C1)	55.93%	47.01%	40.69%
Expansive Growth (C2)	56.37%	49.25%	45.08%
Enhanced Environment (D1)	56.13%	48.85%	46.80%
Enhanced Environment (D2)	55.66%	48.47%	44.90%

Source: Bureau of Reclamation

Figure 16: Change in Share of Agricultural Demand for All Scenarios from 2015-2060



Source: Bureau of Reclamation.

increase between 68 and 81% with Arizona alone making up half of the increase. The other half is due to increases in California and Nevada.[17]

Per capita water use is expected to decrease in six out of the seven basin states in the scenarios. Wyoming is the only state where per capita rates slightly increase due to increased urbanization.[18]

Figure 17 shows the percent change in M&I demand for each scenario from 2015 to 2060. All scenarios show a significant increase in demand, with the Expansive Growth (C1) scenario showing the largest increase with M&I demand making up around 26% of total demand in 2015 to 37% in 2060. Economic Slowdown shows the smallest increase with a percent change of only approximately 5%. The remaining scenarios increase from around 26% to 34-35%. **Figure 18** shows the changes in M&I demand for all scenarios. Each scenario shows a steady increase from 2015 to 2060.

Energy Water Demand

Water demand for energy is only a small percent of total demand and is comprised of expected growth in the different types of power generation including solar, geothermal, thermoelectric, and oil shale. The water demand for energy is determined by known plans for future power plants and by incorporating a per capita energy water use factor. Because energy can be imported and exported in the Study Area, the relationship between population and energy demand alone cannot determine the actual water demand for energy.[19]

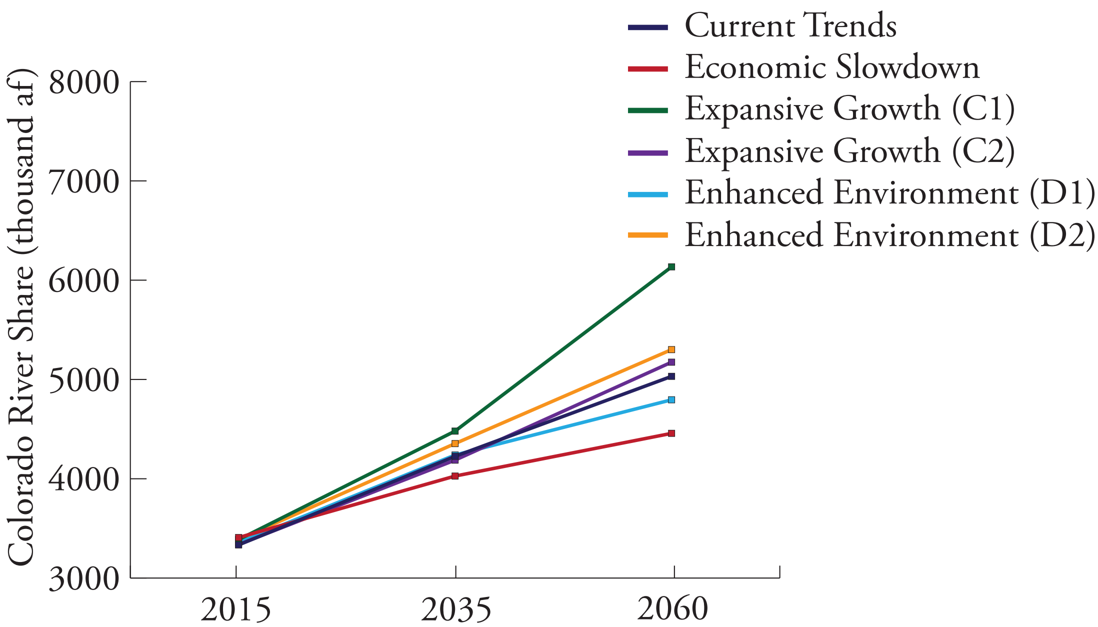
Energy demand is expected to increase from only 1.7% of total demand in 2015, to 2.3% to 4.6% in 2060. All scenarios show an increase in energy demand with the most significant increase shown in the Expansive Growth (C1) scenario. Both the Upper Basin and Lower Basin states all show increases in energy demand with the Upper Basin showing an increase between 31% and 56% primarily due to Colorado, and the Lower Basin showing an increase between 44% and 69% almost entirely from energy growth in California. The Upper Basin shows increases in energy demand from the expansion of thermoelectric power plants and oil shale production while the Lower Basin shows increases in geothermal and solar projects, mainly in California.[20]

Figure 17: Change in Percent Share of M&I Demand from 2015-2060

M&I Total Demand	2015	2035	2060
Current Trends	26.14%	31.36%	34.66%
Economic Slowdown	26.95%	30.62%	32.28%
Expansive Growth (C1)	26.40%	32.09%	37.89%
Expansive Growth (C2)	26.12%	30.81%	34.59%
Enhanced Environment (D1)	26.20%	31.77%	34.10%
Enhanced Environment (D2)	26.43%	31.51%	34.81%

Source: Bureau of Reclamation

Figure 18: Change in Share of M&I Demand for All Scenarios from 2015-2060



Source: Bureau of Reclamation.

A Study of Colorado River Basin Water Demand by the Colorado College State of the Rockies Project

For the purpose of this report, we focused on agriculture, M&I, and energy uses as they constitute more than 80% of water usage in the Colorado River Basin. We also excluded Expansive Growth (C2) and Enhanced Environment and Healthy Economy (D2) from our analysis for simplicity's sake as our research has determined that these scenarios will be the least likely to reflect conditions in the future.

The scenarios were determined by differentiated factors in population, efficiency, institutional and regulatory ordinances, and social values. **Appendix A-C** lists the descriptions for each scenario for agricultural, M&I, and energy demand.

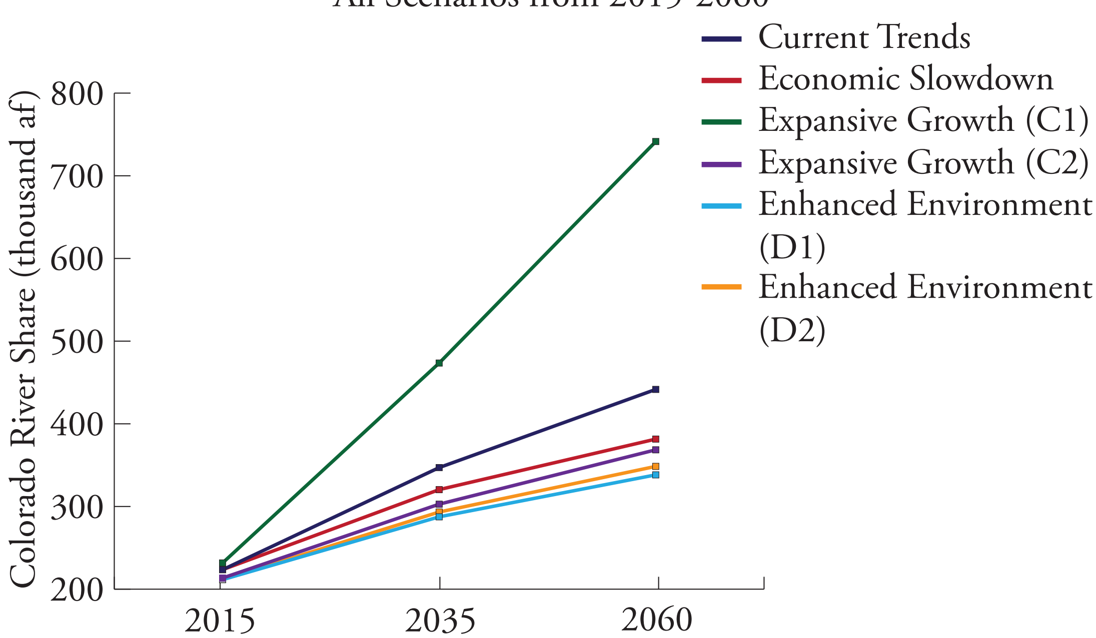
Figure 19: Change in Percent Share of Energy Demand from 2015-2060

Energy Total Demand	2015	2035	2060
Current Trends	1.75%	2.58%	3.04%
Economic Slowdown	1.77%	2.44%	2.76%
Expansive Growth (C1)	1.81%	3.39%	4.58%
Expansive Growth (C2)	1.67%	2.23%	2.46%
Enhanced Environment (D1)	1.65%	2.15%	2.41%
Enhanced Environment (D2)	1.65%	2.12%	2.29%

Source: Bureau of Reclamation

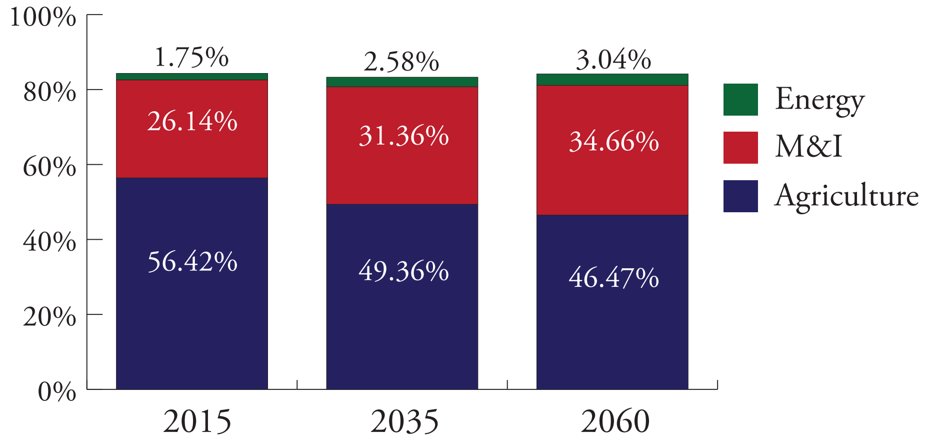
Figure 19 shows the percent change in energy demand for all scenarios from 2015 to 2060. All scenarios show an increase, but Expansive Growth (C1) shows the largest percent change, increasing from 1.8% to 4.6%. The other scenarios range from an increase of 1.7-1.8% to 2.4-3.0%. **Figure 20** shows the change in energy demand for all scenarios. Each scenario displays a steady increase in demand over the time span. The Expansive Growth (C1) scenario shows a significant increase in demand compared to the remaining scenarios.

Figure 20: Change in Share of Energy Demand for All Scenarios from 2015-2060



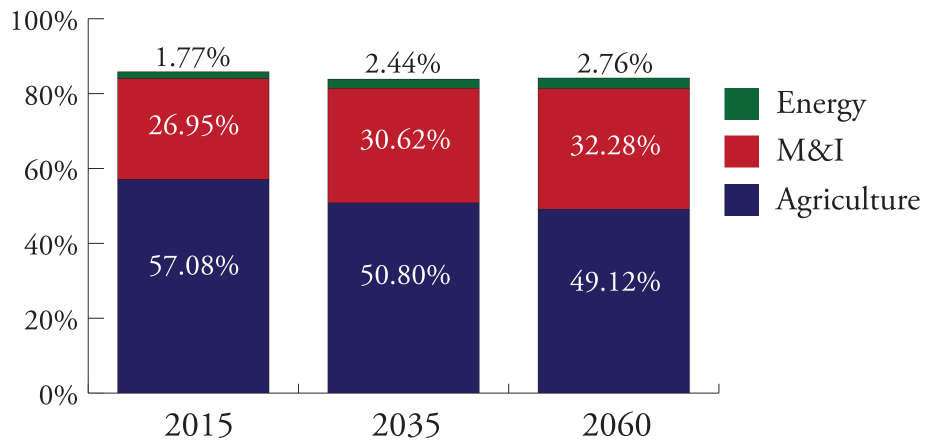
Source: Bureau of Reclamation.

Figure 21: Percent Change in Agricultural, M&I, and Energy Demand for Current Trends Scenario



Source: Bureau of Reclamation.

Figure 22: Percent Change in Agricultural, M&I, and Energy Demand for Economic Slowdown Scenario



Source: Bureau of Reclamation.

Figures 21-26 show a comparison in the percent change in demand for agricultural, M&I, and energy demand for each scenario. Each scenario shows a decrease in agriculture and an increase in M&I and energy demand.

Other Demand Sectors

Mexico

Mexico was awarded access to Colorado River water under a 1944 treaty that specifies: "Of the waters of the Colorado River, from any and all sources, there are allotted to Mexico: A guaranteed annual quantity of 1,500,000 acre-feet." Plus when it is determined that there exists a surplus of waters of the Colorado River in excess of the amount necessary to supply uses in the United States and the guaranteed quantity of 1,500,000 acre-feet annually to Mexico, the United States will undertake to deliver to Mexico additional waters of the Colorado River system to provide a total quantity not to exceed 1,700,000 acre-feet a year. In such cases Mexico does not acquire additional permanent water rights beyond the guaranteed 1.5 million acre feet annually. Finally, in the event of extraordinary drought or serious accident to the irrigation system in the United States, thereby making it difficult for the United States to deliver the guaranteed quantity of 1,500,000 acre-feet a year, the water allotted to Mexico will be reduced in the same proportion as consumptive uses in the United States are reduced.[21]

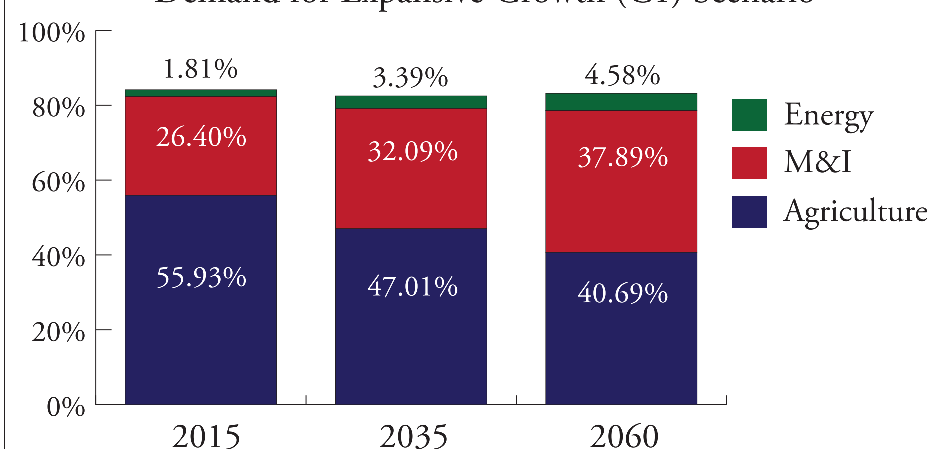
Native Americans

Water demand for Native Americans is based on quantified entitlements and rights; however, numerous tribes in the basin have unquantified rights. Projections for tribal demand are based on quantified rights and future use and development.[22]

Climate Change Effects on Demands

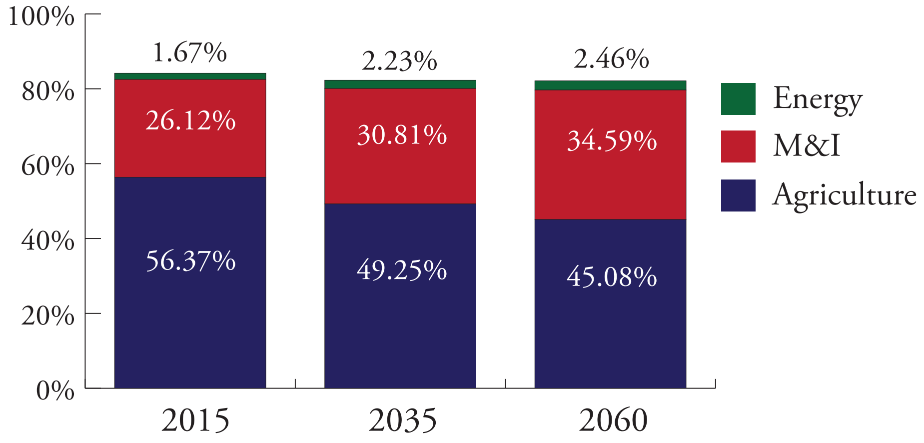
The BOR study expected that future water demand may be affected by climate change in the coming years, specifically with regards to stream flow and climate (temperature and precipitation). The BOR addresses the effects of expected future climate change, namely temperature and precipitation, on evapotranspiration (which affects agriculture), outdoor M&I use, phreatophyte, and reservoir evaporation losses. Changes not addressed by the BOR study that could be caused by climate change include changes in demand for energy, environmental flow regulations, and changes in crop type.[23]

Figure 23: Percent Change in Agricultural, M&I, and Energy Demand for Expansive Growth (C1) Scenario



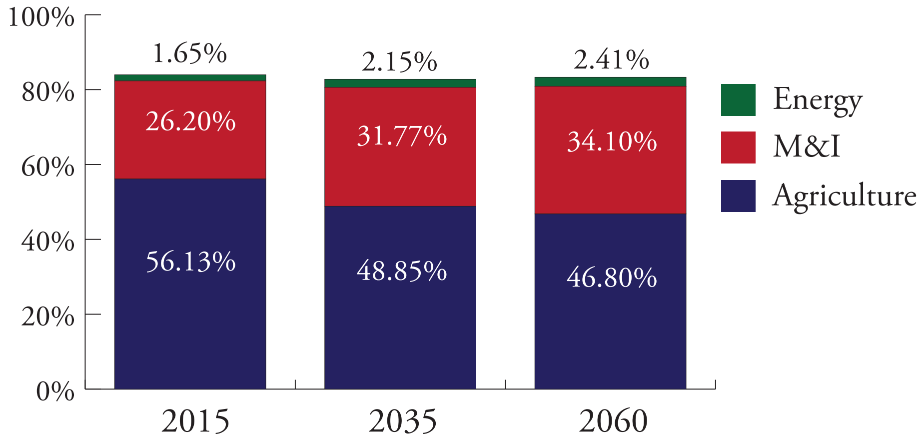
Source: Bureau of Reclamation.

Figure 24: Percent Change in Agricultural, M&I, and Energy Demand for Expansive Growth (C2) Scenario



Source: Bureau of Reclamation.

Figure 25: Percent Change in Agricultural, M&I, and Energy Demand for Enhanced Environment (D1) Scenario



Source: Bureau of Reclamation.

Reservoir Evaporation

Reservoir evaporation varies depending on the surface area of a reservoir and the climate of the region. The evaporation from large basin reservoirs, including Lake Mead, Lake Mohave, and Lake Havasu in the Lower Basin and Morrow Point, Blue Mesa, Crystal, Fontenelle, Flaming Gorge, Navajo, and Lake Powell in the Upper Basin, was calculated on a monthly basis through a modeling simulation in the BOR study. Calculations for smaller reservoirs are estimated from historical losses that are calculated monthly through model simulation. Evaporation from other reservoirs in the basin states is estimated from historical losses.[24]

Limitations

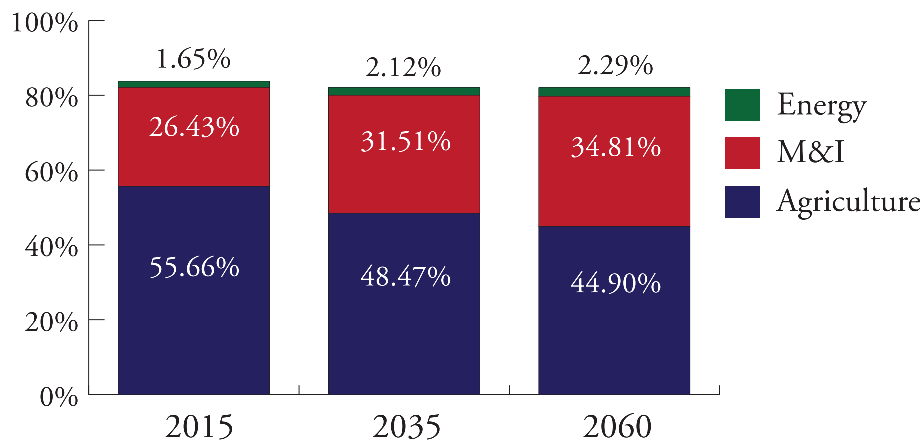
The BOR study demand scenarios for the Colorado River are by no means concrete and many factors can influence demand for each of the categories including population growth, efficiency, agricultural markets, government regulations, social values, availability of supplies and resources, and a variety of other forces that will continue to change in the future. The scenarios do not include programs by water management companies that may alter demand. Actual demand in the future will be compromised of both external factors (that the BOR uses to predict their scenarios) and direct, active management. The quantification of the scenarios was based on information provided by the basin states. Because the information was state-provided, there are differences in the treatment of data, reference points, assumptions, methods, etc.[25] Regardless, the BOR study still represents a comprehensive evaluation of Colorado River demand.

Citations:

1 "Colorado River Basin Water Supply and Demand Study: Basin Study Program." Bureau of Reclamation press release, September 2011, on the Bureau of Reclamation's website, http://www.usbr.gov/lc/region/programs/crbstudy/FactSheet_May2011.pdf, accessed September 19, 2012.
2 Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." *Reclamation Managing Water in the West* (2012): 4-5.
3 Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." *Reclamation Managing Water in the West* (2012): 8.
4 Ibid.
5 Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." *Reclamation Managing Water in the West* (2012): 13.
6 Ibid.
7 Ibid.
8 Ibid.
9 Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." *Reclamation Managing Water in the West* (2012): 14.

Citations continue on page 45.

Figure 26: Percent Change in Agricultural, M&I, and Energy Demand for Enhanced Environment (D2) Scenario



Source: Bureau of Reclamation.

Appendix A: Agriculture Demand Scenario Descriptions

Agriculture Scenarios	Land Use	Water Use Efficiency	Institutional and Regulatory	Social Values
Current Trends	There are nominal increases in irrigated agricultural lands primarily due to the build out of currently planned agricultural water supply projects. Agricultural land use growth varies by location with some agriculture to urban land conversion occurring and lower economic-value crops being phased out in some areas.	Current trends in agricultural water use efficiency continue making modest improvements to on-farm and system efficiency through projects such as those supported under the Salinity Control Program. These improvements result in little change to Colorado River Basin consumptive use. No radical changes in technology are anticipated. Agricultural uses are generally consistent with today's practices (e.g., no major changes in techniques, crops, or practices).	Federal and state laws and regulations affecting the basin continue in a similar manner as today. Despite the potential for sunsetting of future regulations and agreements, the operations of the Colorado River are relatively unchanged.	Social values that affect water use in all categories remain consistent with the recent past. These values include continued support for ongoing planned M&I and agricultural conservation efforts as well as support for the ESA and its implementation.
Economic Slowdown	There are nominal increases in irrigated agricultural lands primarily due to the build out of currently planned agricultural water supply projects. Agricultural land use growth varies by location with some agriculture to urban land transfer occurring and lower economic-value crops being phased out in some areas.	Lack of economic growth results in decreased revenues and reduced capital investment for routine and long-term maintenance. Reduced maintenance results in an overall decline in on-farm and delivery efficiency. These efficiency reductions require greater diversions to meet consumptive use requirements. However, Colorado River Basin consumption changes little as additional losses are returned to the Colorado River system.	Economic slowdown and focus on economic efficiency lead to no significant change in institutional and regulatory requirements. Existing federal and state laws and regulations affecting the basin continue.	Economic efficiency is the overwhelming driver affecting social values. Social values that affect water use in all categories trend toward preferences for human water use and systems over other concerns. This focus is driven largely by a lack of funds for capital outlay and a lack of societal willingness to take on new programs.
Expansive Growth (C1)	Agricultural land use increases at a slightly faster rate than current trends due primarily to economic growth resulting in faster development of currently planned projects. Agricultural land use growth varies by location with some agriculture to urban land transfer occurring and lower economic-value crops being phased out in some areas.	Lack of economic growth results in decreased revenues and reduced capital investment for routine and long-term maintenance. Reduced maintenance results in an overall decline in on-farm and delivery efficiency. These efficiency reductions require greater diversions to meet consumptive use requirements. However, Colorado River Basin consumption changes little as additional losses are returned to the Colorado River system.	Federal and state laws and regulations affecting the basin continue in a similar manner as today. Despite the potential for sunsetting of future regulations and agreements, the operations of the Colorado River are relatively unchanged.	Social values that affect water use in all categories remain consistent with the recent past. These values include continued support for ongoing planned M&I and agricultural conservation efforts as well as support for the ESA and its implementation.
Expansive Growth (C2)	Agricultural land use increases at a slightly faster rate than current trends due primarily to economic growth resulting in faster development of currently planned projects. Agricultural land use growth varies by location with some agriculture to urban land transfer occurring and lower economic-value crops being phased out in some areas.	Economic conditions result in investment and rapid adoption of new technologies resulting in significant increases in agricultural water use efficiency. These technologies result in denser cropping patterns and higher yields with subsequent greater overall consumptive use demand. Irrigation techniques and delivery system water control are significantly improved over current trends. Gains in distribution efficiency partially offset the increased consumptive use.	Changing social values leads to increased governmental regulation including the enactment of climate change and greenhouse gas mitigation measures. These measures primarily manifest themselves in more integrated management of water and energy (water use efficiency).	Slight increase in social values and subsequent pressure focused on conservation efforts results in management of the basin with increased flexibility for multiple water uses (e.g., recreational). Trends continue toward M&I conservation adoption.
Enh Envir Healthy Econ (D1)	There are nominal increases in irrigated agricultural lands primarily due to the build-out of currently planned agricultural water supply projects. Agricultural land use growth varies by location, with some agriculture to urban land conversion occurring and lower economic-value crops being phased out in some areas.	Current trends in agricultural water use efficiency continue making modest improvements to on-farm and system efficiency through projects such as those supported under the Salinity Control Program. These improvements result in little change to Colorado River Basin consumptive use. No radical changes in technology are anticipated. Agricultural uses are generally consistent with today's practices (e.g., no major changes in techniques, crops, or practices).	Changing social values leads to increased governmental regulation including the enactment of climate change and greenhouse gas mitigation measures. These measures primarily manifest themselves in more integrated management of water and energy (water use efficiency).	Increase in social values and subsequent pressure focused on conservation efforts results in management of the basin with increased flexibility for multiple water uses (e.g., recreational). Trends continue toward M&I conservation adoption and public demand for in-stream flows (tourism, Wild and Scenic Rivers).
Enh Envir Healthy Econ (D2)	There are nominal increases in irrigated agricultural lands primarily due to the build-out of currently planned agricultural water supply projects. Agricultural land use growth varies by location, with some agriculture to urban land conversion occurring and lower economic-value crops being phased out in some areas.	Economic conditions result in investment and rapid adoption of new technologies, resulting in significant increases in agricultural water use efficiency. These technologies result in denser cropping patterns and higher yields with subsequent greater overall consumptive use demand. Irrigation techniques and delivery system water control are significantly improved over current trends. Gains in distribution efficiency partially offset the increased consumptive use.	Changing social values leads to increased governmental regulation including the enactment of climate change and greenhouse gas mitigation measures. These measures primarily manifest themselves in more integrated management of water and energy (water use efficiency).	Increase in social values and subsequent pressure focused on conservation efforts results in management of the basin with increased flexibility for multiple water uses (e.g., recreational). Trends continue toward M&I conservation adoption and public demand for in-stream flows (tourism, Wild and Scenic Rivers).

Source: Bureau of Reclamation

Appendix B: M&I Scenario Descriptions				
M&I Scenarios	**Population**	**M&I Water Use Efficiency**	**Institutional and Regulatory**	**Social Values**
Current Trends	Populations in the basin, the adjacent water-dependent basins, and the southwestern U.S. grow at rates commensurate with the "best estimate" demographic projections. Population growth generally occurs centered in existing urban areas.	Increases according to current basin water provided policies and technology. External factors, beyond the control of basin water providers, that limit the water use of fixtures and appliances (e.g., federal statutes) continue resulting in "natural" increases in in-home efficiency. Water use efficiency changes vary by location according to local goals and mix of water use categories. No radical changes in technology are anticipated.	Federal and state laws and regulations affecting the basin continue in a similar manner as today. Despite the potential for sunsetting of future regulations and agreements, the operations of the Colorado River are relatively unchanged.	Social values that affect water use in all categories remain consistent with the recent past. These values include continued support for ongoing planned M&I and agricultural conservation efforts as well as support for the ESA and its implementation.
Economic Slowdown	Economic efficiency is the overwhelming driver affecting social values. Social values that affect water use in all categories trend toward preferences for human water use and systems over other concerns. This focus is driven largely by a lack of funds for capital outlay and a lack of societal willingness to take on new programs.	Water use efficiency increases according to current policies (e.g., SNWA's current gpcd planning goals) and technology. External factors that limit the water use of fixtures and appliances (e.g., federal statutes) continue resulting in "natural" increases in in-home efficiency. Water use efficiency changes vary by location according to local goals and mix of water use categories. No radical changes in technology are anticipated. Aging infrastructure and lack of capital investment due to economic slowdown result in some acute water loss events. However, these events are generally absorbed by the long-term natural trends toward greater efficiency.	Economic slowdown and focus on economic efficiency lead to no significant change in institutional and regulatory requirements. Existing federal and state laws and regulations affecting the basin continue.	Economic efficiency is the overwhelming driver affecting social values. Social values that affect water use in all categories trend toward preferences for human water use and systems over other concerns. This focus is driven largely by a lack of funds for capital outlay and a lack of societal willingness to take on new programs.
Expansive Growth (C1)	Rapid population growth focused around urban centers with sprawl to outlying areas is driven by rapid economic recovery followed by a period of prolonged growth. This population growth is similar to typical "High" demographic projections for the southwest basin states.	Water use efficiency increases according to current policies (e.g., SNWA's current gpcd planning goals) and technology. External factors that limit the water use of fixtures and appliances (e.g., federal statutes) continue, resulting in "natural" increases in in-home efficiency. Water use efficiency changes vary by location according to local goals and mix of water use categories. No radical changes in technology are anticipated.	Federal and state laws and regulations affecting the basin continue in a similar manner as today. Despite the potential for sunsetting of future regulations and agreements, the operations of the Colorado River are relatively unchanged.	Social values that affect water use in all categories remain consistent with the recent past. These values include continued support for ongoing planned M&I and agricultural conservation efforts as well as support for the ESA and its implementation.
Expansive Growth (C2)	Rapid population growth focused around urban centers with sprawl to outlying areas is driven by rapid economic recovery followed by a period of prolonged growth. This population growth is similar to typical "High" demographic projections for the southwest basin states.	Increased federal investment in water-saving technology and conservation programs results in a substantive increase in water-saving technology (e.g., WaterSmart, EnergyStar, landscape technology). These technologies are applied basin-wide, resulting in reduced demand and consumptive use.	Changing social values lead to increased governmental regulation including the enactment of climate change and greenhouse gas mitigation measures. These measures primarily manifest themselves in more integrated management of water and energy (water use efficiency).	Slight increase in social values and subsequent pressure focused on conservation efforts results in management of the basin with increased flexibility for multiple water uses (e.g., recreational). Trends continue toward M&I conservation adoption.
Enh Envir Healthy Econ (D1)	Populations in the Basin, the adjacent water-dependent basins, and the Southwestern United States grow at rates commensurate with the "best estimate" demographic projections. Population growth generally occurs centered in existing urban areas.	Increased federal investment in water-saving technology and conservation programs results in a substantive increase in water-saving technology (e.g., WaterSmart, EnergyStar, landscape technology). These technologies are applied basin-wide, resulting in reduced demand and consumptive use.	Changing social values lead to increased governmental regulation including the enactment of climate change and greenhouse gas mitigation measures. These measures primarily manifest themselves in more integrated management of water and energy (water use efficiency).	Increase in social values and subsequent pressure focused on conservation efforts results in management of the basin with increased flexibility for multiple water uses (e.g., recreational). Trends continue toward M&I conservation adoption and public demand for in-stream flows (tourism, Wild and Scenic Rivers).
Enh Envir Healthy Econ (D2)	Rapid population growth focused around urban centers driven by rapid economic recovery, followed by a period of prolonged growth. This population growth is similar to typical "High" demographic projections for the southwest basin states.	Increased federal investment in water-saving technology and conservation programs results in a substantive increase in water-saving technology (e.g., WaterSmart, EnergyStar, landscape technology). These technologies are applied basin-wide, resulting in reduced demand and consumptive use.	Changing social values lead to increased governmental regulation including the enactment of climate change and greenhouse gas mitigation measures. These measures primarily manifest themselves in more integrated management of water and energy (water use efficiency).	Increase in social values and subsequent pressure focused on conservation efforts results in management of the basin with increased flexibility for multiple water uses (e.g., recreational). Trends continue toward M&I conservation adoption and public demand for in-stream flows (tourism, Wild and Scenic Rivers).

Source: Bureau of Reclamation

Appendix C: Energy Demand Scenario Descriptions

Energy Scenarios	Water Needs	Institutional and Regulatory	Social Values
Current Trends	Water needs for energy expand relative to population growth and current regulations, policies, and planning for the energy industry. Current requirements for renewables are met according to current schedules. Fossil fuel development and, in particular, oil-shale development occur according to current plans. No dramatic changes to global economies or energy demand that would spur additional consideration occur (e.g., increased fossil fuel prices.)	Federal and state laws and regulations affecting the basin continue in a similar manner as today. Despite the potential for sunsetting of future regulations and agreements, the operations of the Colorado River are relatively unchanged.	Social values that affect water use in all categories remain consistent with the recent past. These values include continued support for ongoing planned M&I and agricultural conservation efforts as well as support for the ESA and its implementation.
Economic Slowdown	Water needs for energy expand relative to population growth and current regulations, policies, and planning for the energy industry. Current requirements for renewables are met according to current schedules. Despite the regional economic slowdown, global energy demand and in particular fossil fuel development (including oil-shale development) occur according to current plans. No dramatic changes to global economies or energy demand that would spur additional consideration occur (e.g., increased fossil fuel prices.)	Economic slowdown and focus on economic efficiency lead to no significant change in institutional and regulatory requirements. Existing federal and state laws and regulations affecting the basin continue.	Economic efficiency is the overwhelming driver affecting social values. Social values that affect water use in all categories trend toward preferences for human water use and systems over other concerns. This focus is driven largely by a lack of funds for capital outlay and a lack of societal willingness to take on new programs.
Expansive Growth (C1)	Water needs for energy expand relative to population growth and current regulations, policies, and planning for the energy industry. Current requirements for renewables are met according to schedules. Fossil fuel development and, in particular, oil-shale development, occur at a faster rate due to economic drivers spurring growth in energy production.	Federal and state laws and regulations affecting the basin continue in a similar manner as today. Despite the potential for sunsetting of future regulations and agreements, the operations of the Colorado River are relatively unchanged.	Social values that affect water use in all categories remain consistent with the recent past. These values include continued support for ongoing planned M&I and agricultural conservation efforts as well as support for the ESA and its implementation.
Expansive Growth (C2)	Water needs for energy expand relative to population growth and current regulations, policies, and planning for the energy industry. However, investment in technology results in adoption of water-saving techniques (e.g., dry cooling). Renewable energy requirements continue, with an emphasis on dry cooling due to an increase in social considerations related to carbon production. World economic conditions do not favor new fossil fuel development in the southwest.	Changing social values lead to increased governmental regulation including the enactment of climate change and greenhouse gas mitigation measures. These measures primarily manifest themselves in more integrated management of water and energy (water use efficiency).	Slight increase in social values and subsequent pressure focused on conservation efforts result in management of the basin with increased flexibility for multiple water uses (e.g., recreational). Trends continue toward M&I conservation adoption.
Enh Envir Healthy Econ (D1 & D2)	There are nominal increases in irrigated agricultural lands primarily due to the build-out of currently planned agricultural water supply projects. Agricultural land use growth varies by location, with some agriculture to urban land conversion occurring and lower economic-value crops being phased out in some areas.	Changing social values leads to increased governmental regulation including the enactment of climate change and greenhouse gas mitigation measures. These measures primarily manifest themselves in more integrated management of water and energy (water use efficiency).	Increase in social values and subsequent pressure focused on conservation efforts result in management of the basin with increased flexibility for multiple water uses (e.g., recreational). Trends continue toward M&I conservation adoption and public demand for in-stream flows (tourism, Wild and Scenic Rivers).

Source: Bureau of Reclamation

Citations (cont.):

[10] Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." *Reclamation Managing Water in the West* (2012): 15.

[11] Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." *Reclamation Managing Water in the West* (2012): 16.

[12] Ibid.

[13] Ibid.

[14] Ibid.

[15] Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." *Reclamation Managing Water in the West* (2012): 24.

[16] Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." *Reclamation Managing Water in the West* (2012): 26.

[17] Ibid.

[18] Ibid.

[19] Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." *Reclamation Managing Water in the West* (2012): 28.

[20] Ibid.

[21] Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." *Reclamation Managing Water in the West* (2012): 41.

[22] Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." *Reclamation Managing Water in the West* (2012): 34.

[23] Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios." *Reclamation Managing Water in the West* (2012): 41-42.

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