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Estimates of Water Use and Trends in the Colorado River Basin, Southwestern United States, 1985–2010

Scientific Investigations Report 2018–5049

U.S. Department of the Interior
U.S. Geological Survey

Cover: Front cover photographs, clockwise from left: (1) Windmill for livestock watering, Navajo Nation Reservation, San Juan County, New Mexico (Alan Cressler, U.S. Geological Survey); (2) Hayfield irrigation near Grand Junction, Colorado (Ken Leib, U.S. Geological Survey); (3) Gas well in Garfield County, Colorado (Alan Cressler, U.S. Geological Survey); (4) Hoover Dam on the Colorado River showing the evaporation "bathtub ring," Nevada (Rick Clawges, used with permission); (5) Peaches (Ian Baldwin, Unsplash free and open use photograph [https://unsplash.com/photos/f7FwHomDgzg]); (6) Horses and flood irrigated pecan trees, Arizona (Saeid Tadayon, U.S. Geological Survey); (7; background image) Colorado River in the Grand Canyon, Arizona (Scott VanderKooi, U.S. Geological Survey).

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U.S. Department of the Interior
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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
mile, nautical (nmi)	1.852	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	0.003785	cubic meter (m^3)
million gallons (Mgal)	3,785	cubic meter (m^3)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
thousand acre-foot (taf)	1,000	million acre-foot (maf)
	Flow rate	
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year (hm^3/yr)
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second per square mile ([ft^3/s]/mi^2)	0.01093	cubic meter per second per square kilometer ([m^3/s]/km^2)
cubic foot per day (ft^3/d)	0.02832	cubic meter per day (m^3/d)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)

Datum

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Elevation, as used in this report, refers to distance above the vertical datum.

Abbreviations

Reclamation	Bureau of Reclamation
CAP	Central Arizona Project
CRB	Colorado River Basin
DOD	U.S. Department of Defense
EIA	Energy Information Administration
EPA	U.S. Environmental Protection Agency
HUC	Hydrologic Unit Code
NASS	National Agriculture Statistics Service
NWIS	National Water Information System
NWUSP	National Water Use Science Project
NWC	National Water Census
SECURE	Science and Engineering to Comprehensively Understand and Responsibly Enhance
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

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Abstract

The Colorado River Basin (CRB) drains 246,000 square miles and includes parts of California, Colorado, Nevada, New Mexico, Utah, and Wyoming, and all of Arizona (Basin States). This report contains water-use estimates by category of use for drainage basins (Hydrologic Unit Code 8; HUC-8) within the CRB from 1985 to 2010, at 5-year intervals. Estimates for public supply, domestic, commercial, industrial, irrigation, livestock, mining, aquaculture, hydroelectric and thermoelectric power, and wastewater returns are tabulated as (1) water withdrawals from groundwater or surface-water sources of fresh or saline quality, (2) water delivered for domestic use, (3) wastewater returns and instream use (hydroelectric), and (4) consumptive use, or water that is consumed (USGS definition) and not available for immediate reuse. Water transported outside of the CRB (interbasin transfers) is not included as part of withdrawals and are not accounted for in any category of use within the CRB.

Total withdrawals in the CRB (excluding interbasin transfers) averaged about 17 million acre-feet (maf) from 1985 to 2010, peaked at about 17.76 maf in 2000, and reached their lowest levels of 16.43 maf in 1990. Interbasin transfers to serve mostly public-supply and irrigation needs outside of the CRB are reported for 2000, 2005, and 2010 only, and averaged 5.40 maf. More surface water was used in the CRB than groundwater, averaging about 78 percent of total withdrawals, and its use increased less than 2 percent from 1985 to 2010, while groundwater withdrawals decreased about 12 percent. From 1985 to 2010, surface water averaged 98 percent of withdrawals in the upper CRB, and about 59 percent in the lower CRB. Nearly all withdrawals were freshwater, but some saline groundwater was used for mining and self-supplied industrial.

Interbasin transfers have a large effect on flows in the Colorado River and are listed in this report separately with no explanation of how the water is used outside of the CRB. There are 34 interbasin transfers that conveyed an estimated 5.83, 5.20, and 5.18 maf out of the CRB in 2000, 2005, and 2010, respectively. The largest interbasin transfers are in the lower CRB and convey surface water (Colorado River water) to southern California; these accounted for 80 to 84 percent of total interbasin transfers in the CRB from 2000 to 2010. Intrabasin transfers are conveyances of surface water that cross drainage basin or State boundaries in the CRB, but the water does not leave the CRB. There are many intrabasin transfers in the CRB, but this report lists 11 that are mostly in the State of Colorado. The largest is the Central Arizona Project (CAP), through which more than 1.00 maf of water was provided to irrigate nearly 1 million acres in Maricopa, Pinal, and Pima Counties, as well as provide municipal water for Phoenix and Tucson, Arizona, during 2000, 2005, and 2010. In 2010, interbasin and intrabasin transfers accounted for 24 and 11 percent of the total water withdrawals in CRB, respectively, with the larger volumes being conveyed out of the lower CRB.

Total population in the CRB increased from 4.56 to 9.44 million people from 1985 to 2010. Most of those people were in the lower CRB, with 86 percent of the total in 1985, and 90 percent of the total in 2010. Total public-supply withdrawals in the CRB provided most people with their potable water, and averaged about 1.63 maf from 1985 to 2010, ranging from about 1.07 maf in 1985 to about 2.10 maf in 2010, when it peaked. Most of public-supply withdrawals occurred in the lower CRB, ranging from 87 to 91 percent of total public-supply withdrawals in the CRB over the 25 years. Total domestic use, comprised of public-supply deliveries and self-supply domestic withdrawals, increased more than 90 percent from 1985 to 2010, from about 0.80 maf to about 1.54 maf. Domestic daily per-capita use rates in the CRB ranged from about 144 (1985) to about 121 (2000) gallons (gal) per-capita between 1985 and 2010. When comparing domestic daily per-capita rates for the upper and lower CRB, people in the lower CRB, on average, used less water for domestic purposes at 128 gal per-capita daily (1985–2010), while those in the upper CRB for the same time period averaged 133 gal per-capita daily. The trend in daily per-capita use rates for the entire CRB fluctuated between the reporting years, but decreased overall, indicating that more people used less water in 2010 than in 1985, likely due to improved infrastructure, conservation, and improvements to water using appliances in homes and businesses.

Irrigation accounted for most total withdrawals in the CRB, excluding instream use for hydroelectric power and interbasin transfers, averaging 85 percent from 1985 to 2010. Far more surface water than groundwater was used for

irrigation in both the upper and lower CRB, but in the upper CRB, it accounted for an average of more than 98 percent of the total withdrawals (1985–2010), whereas in the lower CRB, surface-water withdrawals for irrigation averaged 61 percent of total withdrawals. On average, the upper CRB accounted for 56 percent of total irrigated acres, and the irrigation systems in the upper CRB trended towards more efficient sprinkler systems from 1985 to 2010. Long-term drought in the CRB substantially decreased the amount of streamflow available for irrigation. Increases in micro-irrigation acres, which can have efficiencies that exceed 90 percent and require 20–50 percent less water than sprinkler systems, likely contributed to reduced withdrawals in the lower CRB.

For thermoelectric power, total withdrawals, including the use of reclaimed wastewater, were greater in the upper CRB from 1985 through 2005. In 2010, the lower CRB exceeded the upper by only 11,000 acre-feet. On average, thermoelectric consumptive use accounted for about 80 percent of the total withdrawals; however, consumptive-use data in the upper CRB was incomplete. Surface water was the primary source in the upper CRB and groundwater was the primary source in the lower CRB. In the CRB overall, water withdrawals for thermoelectric generation has decreased since 2000, except for groundwater withdrawals in the lower CRB. Power generation at thermoelectric plants was greater in the upper CRB from 1985 to 2000, and after 2005 the difference in power generation was small; however, the upper CRB continued to have more power generation. In both the upper and lower CRB, power generation increased from 1985 to 2005.

Introduction

The Omnibus Public Land Management Act of 2009 (Public Law 111-11) was passed into law on March 30, 2009. Sub-title F of the law, also known as the SECURE (Science and Engineering to Comprehensively Understand and Responsibly Enhance) Water Act, calls for the establishment of a “national water availability and use assessment program” in the U.S. Geological Survey (USGS). The recommendation for a national assessment of the nation’s available water resources was driven by the lack of such an assessment since 1978. In fulfillment of the Act, the USGS developed the National Water Census (NWC), under the auspices of the USGS Water Availability and Use Program, and as part of that activity, among others, collected water withdrawal and wastewater return data, including instream use at hydroelectric powerplants (water use) for purposes of expanding upon national datasets and providing these data to assist in hydrologic studies of the Colorado River Basin (CRB). The NWC foundation of science is built on an understanding of the water budget in various geographic and temporal scales and is facilitated by enhanced data collection and interpretations of the various components of the water budget (precipitation, streamflow, groundwater, and evapotranspiration), as well as improved understandings of water uses that affect the availability of the water resources. The NWC uses regional geographic studies, of which the CRB was one of three pilot study areas (Alley and others, 2013), and topical-themed studies that are designed to improve the understanding of resources such as streamflow at non-streamgaged sites, ecological flows, groundwater/surface-water interactions, and effects of snow sublimation on timing and quantity of runoff.

The USGS defines “*water use”* as the interaction of humans with the hydrologic cycle and includes the movement of water via water withdrawals and deliveries (offstream), consumptive use, reclaimed wastewater use, instream use (hydroelectric), and wastewater returns. Water-use data are reported for the following categories—public supply, domestic, commercial, industrial, irrigation, livestock, mining, aquaculture, hydroelectric and thermoelectric power, and wastewater returns. The data describe (1) water that is withdrawn from a source (groundwater or surface water, fresh or saline), (2) water that is delivered to a customer (that is, domestic homes from public suppliers), (3) water that is temporarily unavailable (consumptive use, such as evapotranspiration), and (4) water that is returned to a water resource (via wastewater returns). The USGS has collected water-use data since 1950 and reports these data in 5-year intervals as part of the National Water Use Science Project, or NWUSP, (formerly known as the National Water Use Information Program, NWUIP). This project was funded by the NWC, under the SECURE Water Act, to compile wateruse data for the CRB, some of which has not been compiled for the study area since 1995.

These water-use data are intended to assist in hydrologic studies showing the rate of withdrawals from the point of capture (withdrawal), movement (delivery, both within and outside the CRB), application or disposition (losses due to consumptive use), and returns (wastewater returns). How water resources are used has a major influence on the availability of water at any specific place and time. Understandably, the use of water within an upstream drainage basin is important to downstream water users.

For example, a river has a series of towns along its length, and each town has a public-supply surface-water intake upstream of the town and a municipal wastewater treatment plant discharge downstream of the town. All public-supply withdrawals along the river would be accounted for, as would the treated wastewater returns. After water is used, treated, and returned to the river, it is available for subsequent withdrawals and use downstream. Each subsequent cycle of water-use along the river would be counted as a unique withdrawal and return, and the accumulative total for a geographic area, such as a county, would be totaled. Water is used repeatedly, but each point at which a withdrawal is taken has an impact on the availability of water at that point as well as in the near downstream reach. Some would correctly say that this is counting the same water multiple times, however, the NWUSP's mission is to characterize all water uses for a defined geographic area. It is important to understand where withdrawals occur and how much water is needed to satisfy each requirement.

Additionally, water uses outside of the CRB make accounting more complicated and confusing because, in the current NWUSP data model, these water uses have been accounted for at the point of use (outside of the CRB), and not the point of diversion (inside the CRB). For purposes of this report, water transported outside of the CRB (interbasin transfers) is considered exported and is not accounted for in any specific category of use within the CRB. Exported water is tabulated in this report with regards to where the water is diverted and where it is delivered (in terms of hydrologic basins). This approach to water-use accounting is valuable to decision makers who need to understand where water needs are being satisfied and how much water must be available to meet the needs. Caution should be used to avoid confusion about the relative use of water from the Colorado River among the seven Basin States, because all of Arizona's land mass is within the CRB, and Arizona's use of water from the Colorado River may appear disproportionately higher than other Basin States that also make use of Colorado River water outside of the CRB.

This report is a basin-specific summary of water uses for different purposes (categories), from the available water sources (groundwater or surface water), for each 5-year increment from 1985 to 2010, including analysis of trends over the same time period. It makes a significant contribution to the NWUSP 5-year national compilation dataset, as well as the water budget, by providing a summary of water uses aggregated by drainage basins, however, under current plans this data and report will not be repeated.

Purpose and Scope

The purpose of this report is to present estimates of water use for 1985–2010 at 5-year intervals for 147 drainage basins (146 in 2010), which are then aggregated to the subregion level (Hydrologic Unit Code [HUC] 4) and presented for the upper and lower CRB areas, and for each State. These data represent withdrawals from groundwater and surface water, both fresh and saline (>1,000 mg/L dissolved salts), for 11 categories of use. Deliveries of water from public-supply systems to domestic users are included and represent the only water delivery data. Consumptive use is reported for all areas and applicable categories for 1985, 1990, and 1995. Consumptive use for irrigation and thermoelectric power are available for all areas in 2010. Consumptive use is incomplete for all areas and other applicable categories for 2000 and 2005.

All drainage basins (Hydrologic Unit Code or HUC 8-digit) (Seaber and others, 1987) that are in the CRB, which includes parts of seven southwestern States (California, Colorado, Nevada, New Mexico, Utah, and Wyoming) and all of Arizona, are presented as the geographic areas for which average daily withdrawals from groundwater and surface water (fresh and saline) are tabulated for each category of use, in units of thousand acre-feet, for 6 calendar years (1985, 1990, 1995, 2000, 2005, and 2010). Data are summarized and presented here for the upper and lower CRB, and by States. Other data include irrigated acres (in thousand acres), total population, as well as population served by public-supply systems and self-supplied domestic users (in thousands). Population data represent the population within the HUC-8 boundaries within the CRB, and are summarized by upper and lower CRB and by State.

Interbasin transfers represent water that crosses the regional drainage basin (HUC2) boundaries and leaves the CRB, and are exported to users in areas such as Denver and the Front Range in Colorado, Salt Lake City in Utah, Albuquerque in New Mexico, and Los Angeles and other southern California metropolitan and agricultural areas. Interbasin transfers are reported separately from withdrawals, and are not stored in the NWUSP aggregate database as a water use within the CRB. The NWUSP aggregate database stores CRB water-use for the HUC-8 area where the water is withdrawn and subsequently used inside the CRB, and not where the water is withdrawn and exported for use outside the CRB. Intrabasin transfers represent the movement of large quantities of water between subregions (HUC-4) or States within the CRB, but the water is used within the CRB.

Background

One of the unifying goals of the NWC is to develop and improve national estimates of water-budget components at consistent spatial (drainage basin, HUC-8) and temporal (monthly) scales. NWC is working to achieve this goal through a series of studies designed to quantify the amount of water that resides in, or moves through, regional basin study areas (Focus Area Studies [FAS]). The NWC is producing a current, comprehensive scientific assessment of the factors that influence water availability by developing nationally consistent datasets that reflect the status and trends of major water-budget components (precipitation, streamflow, groundwater, and evapotranspiration), as well as water use within the FAS areas. Evaluations of water-resource conditions and the driving factors for competition over use of those resources in selected river basins, such as the CRB, are the basis for studying selected areas as part of the NWC. The Colorado River Basin Focus Area Study is one of three pilot FAS in the nation, along with the Delaware River and the Apalachicola Chattahoochee Flint River Basins (Alley and others, 2013). This report primarily serves the purpose to illustrate and summarize the water-use component of the water budget for the CRB, but also illustrates trends in water use in the CRB.

Description of Study Area

The CRB drains 246,000 mi^2, and includes parts of California, Colorado, Nevada, New Mexico, Utah, and Wyoming and all of Arizona (Basin States). The Colorado River flows into Mexico (fig. 1) at the terminus of its 1,450-mi course. Elevations in the CRB range from 14,309 ft above sea level at the summit of Uncompahgre Peak in the Gunnison River Basin, to sea level at the Gulf of California (outside the study boundary). Average elevation in the CRB is 5,550 ft above sea level. Elevation of Yuma, Arizona (within the study boundary), 7 mi from the border of Mexico, is 141 ft above sea level. Major tributaries to the Colorado River include the Green, Gunnison, San Juan, Dolores, Little Colorado, Gila, and Virgin Rivers. The USGS divides the CRB into the upper and lower CRB at the USGS streamgage (09380000), located at Lees Ferry near Page, Arizona, where the HUC-8 nomenclature changes from using the first two-digits of “14” (upper CRB) to “15” (lower CRB). This is not the same location as Reclamation’s boundary for the upper and lower CRB (see *Colorado River Basin Tributaries* in section, “Glossary”).

Climate varies across the primarily semi-arid CRB, where mean monthly high temperatures are 25.3 °C (77.5 °F) in the upper CRB, and 33.4 °C (92.1 °F) in the lower CRB, and mean monthly low temperatures are -3.6 and 8.9 °C (25.5 and 48.0 °F) in the upper and lower CRB, respectively (Benke and Cushing, 2005). Mean annual precipitation across the entire CRB averages 6.5 in., ranging from more than 40 in. in mountainous areas in the headwaters to 0.6 in. along reaches of the Colorado River in Mexico (Benke and Cushing, 2005). Average annual precipitation for the upper and lower CRB for 1985–2010 shows that during 1990 and 2000 considerably less precipitation fell in the upper CRB, and in the lower CRB average annual precipitation during 1995 and 2000 was much less than other years (table 1). Precipitation in the upper CRB, particularly the headwaters, falls primarily as snow, with some rain in the winter and early spring, whereas the lower CRB receives precipitation primarily as rain during intense but infrequent summer thunderstorms.

The mainstem of the Colorado River has numerous diversions, several dams, and three major reservoirs. The most upstream, or first of the large dams, is the Glen Canyon Dam near Page, Arizona—this forms Lake Powell (fig. 1), a reservoir primarily used for water supply and hydroelectric power generation. Hoover Dam, the second large dam on the Colorado River, creates Lake Mead, the largest capacity reservoir in the continental United States, which is used for municipal and irrigation water supply as well as flood control and hydroelectric power generation. Lake Havasu is the last, and most downstream, large reservoir on the mainstem of the Colorado River, and is created by Parker Dam. The primary purpose for Lake Havasu is to store water for pumping into the Central Arizona Project (CAP) Aqueduct, in Arizona, and the Colorado River Aqueduct in California. The most downstream dam, prior to the location where the Colorado River enters Mexico, is the Imperial Dam, where water is diverted into the All-American Canal and is used to irrigate California’s agricultural Imperial Valley area to the west of the CRB.

Prior to the creation of dams and diversions, the Colorado River released about 16.3 million acre-ft (maf) into the Gulf of California each year, with an average annual streamflow of 22,500 ft^3/s (Nowak, 2011). As of 2014, the regulated streamflow downstream of Hoover Dam did not exceed 35,000 ft^3/s or is not less than 4,000 ft^3/s. Mean annual streamflow (including baseflow and releases from reservoirs) based on data from USGS streamgages, for the upper and lower parts of the CRB in 1985 were 23,330 and 16,160 ft^3/s, respectively (table 2). In the upper CRB, mean annual streamflow in the Colorado River for 1990 and 2000–2010 were less than one-half of those for 1985. Streamflow in the lower CRB for 1990–2010 was less than a one-quarter of the streamflow in 1985 (table 2). The Colorado River, and its tributaries, provides water to an estimated 40 million people for municipal use, irrigates nearly 5.5 million acres of land (including lands outside the CRB), and provides water for at least 22 federally recognized Tribes, 7 National Wildlife Refuges, 4 National Recreation Areas, and 11 National Parks. The Colorado River is also vital to the Republic of Mexico to meet both agricultural and municipal water needs (Bureau of Reclamation, 2012). The largest metropolitan areas in the CRB include Las Vegas in Nevada, and Phoenix and Tucson in Arizona (fig. 1).

Table 1. Average annual precipitation for the upper and lower Colorado River Basin, Southwestern United States, 1985–2010.

[Upper and lower Colorado River Basin are shown in figure 1. Data averaged from PRISM Climate Group (2015)]

Colorado River Basin	Average annual precipitation, in inches					
	1985	1990	1995	2000	2005	2010
Upper basin	17.86	14.91	17.83	14.56	17.25	17.77
Lower basin	13.87	13.97	11.51	11.76	13.42	15.00

Figure 1. Colorado River Basin, Southwestern United States.

Table 2. Mean annual streamflow in the upper and lower Colorado River Basin, Southwestern United States, 1985–2010.

[Upper and lower Colorado River Basin and streamgages are shown in figure 1. Data from U.S. Geological Survey (2015)]

Compilation years	Mean annual discharge, in cubic feet per second	
	Upper basin	Lower basin
	Colorado River at Lees Ferry, Arizona (09380000)	Colorado River at International Boundary, Arizona (09522000)
1985	23,330	16,160
1990	10,910	1,943
1995	14,100	2,201
2000	11,920	2,616
2005	11,640	2,054
2010	11,540	2,125

These three metropolitan areas have a combined population of 7.1 million people (U.S. Census Bureau, 2011). There are a number of smaller cities along the mainstem of the Colorado River, including Grand Junction in Colorado, Moab in Utah, and Page, Bullhead City, Lake Havasu City, and Yuma, in Arizona (fig. 1). These smaller cities have a combined population of 343,605 (U.S. Census Bureau, 2011). Most municipal and industrial uses served by Colorado River water are served by interbasin transfers outside of the CRB to locations such as Salt Lake City, Denver, and southern California municipal areas. Irrigated acres in the CRB are estimated to be 3.2 million acres (Cohen and others, 2013), with most of the irrigated acres located in the upper CRB.

Methods

Since 1950, the USGS has published water-use data in Estimated Use of Water in the United States reports (referred to as "national compilations"); the latest data is for 2010 (Maupin and others, 2014). The national compilations contain spatially varying aggregated data using information collected by numerous private, local, State, and Federal entities. Standard methods and techniques to compile, aggregate, and estimate these data have been in use since about 1995, and are outlined in the technical guidelines manual (Bradley, 2017). Both reported and estimated withdrawal data are used to aggregate water use by category for various spatial areas in the United States, including county, State, HUC-4 (1950–80), and HUC-8 (1985–95). National compilations of water use by HUC-8 have not been produced after 1995. This project used the same methods and data sources as the national compilations to compile data by HUC-8 for all categories that were last reported in the 1995 national compilations. An online matrix illustrates the changes to categories of water use, and spatial scales that water-use data are reported for, as part of the 5-year national compilations (https://water.usgs.gov/watuse/WU-Category-Changes.html).

Data for this study include 2010 estimates for irrigation and thermoelectric power consumptive use. After 1995, national compilations of consumptive use estimates for domestic, commercial, industrial, irrigation, and thermoelectric power were not produced. However, this report includes estimates of consumptive use for the irrigation and thermoelectric power categories using data developed through the NWC and FAS efforts. The final dataset used and analyzed in this report is available in Ivahnenko and Maupin (2018).

Sources of Data

The primary sources of data for each of the 11 categories are Federal and State agencies. The primary State agencies included Water Resources Departments, Engineer Offices, Water Permitting Offices, and Health Departments. Additional sources include agricultural statistics offices, conservation boards, corporate or development commissions, water authorities, cities and local entities, and facility records. However, for some categories (aquaculture, livestock, mining, and thermoelectric power), data were collected and developed into aggregate datasets and documented nationally by the NWUSP (Lovelace, 2009a, 2009b, 2009c; Diehl and others, 2013; Diehl and Harris, 2014). The approach for compiling and analyzing data can vary by State based on the water-use programs in each State, or the availability of other reliable water-use data.

Public-supply data were compiled from the previously mentioned State agencies, cities, local entities, and facility records, which showed reported annual withdrawals by source, and total population served. These data were aggregated to the various reporting areas (county, HUC-8). Deliveries to domestic users were determined using customer-base information or other ancillary or reported information. Domestic deliveries are used to compute per-capita use coefficients for each year of compilation, and these coefficients are then applied to the self-supplied population for estimating self-supplied domestic withdrawals. Per-capita use coefficients are computed by dividing the volume of water that is withdrawn or delivered by the number of people who use the water, and are expressed as gallons per-capita daily (gpcd). All public-supply withdrawals were considered to be from freshwater sources. Self-supply domestic populations (mostly rural populations) were computed as the difference between the county or HUC-8 total population and the public-supply population that was served within the same geographic area. Self-supply domestic withdrawals were computed using the self-supply domestic population and per-capita use coefficients derived from the public-supply deliveries to domestic users. Nearly all self-supply domestic withdrawals were from fresh groundwater sources; only a few drainage basins had fresh surface-water withdrawals reported from 1985 to 1995.

Self-supply industrial estimates were derived using data from State agencies, Federal Agencies, Water Commissions, Water Districts, and proprietary databases purchased by the USGS NWUSP, which included industrial facility listings with ancillary information on employee numbers, produced commodities, and locations. Some facilities were contacted directly for verification, but where a facility was known to exist but no data were directly reported, estimation methods were used to fill in data gaps and included using employee population data and water-use coefficients based on the commodity production at missing facilities. Withdrawals were reported as groundwater, fresh or saline, and fresh surface water; no saline surface-water withdrawals were reported.

Mining estimates were derived using data from State agencies as well as entities that specifically deal with oil and gas or hard rock mining, such as Colorado Oil and Gas Conservation Commissions, the Bureau of Mines and Geology, Nevada Departments of Business and Industry. Also, data provided through the NWUSP included estimates for hard rock, and oil and gas mining operations (Lovelace, 2009c) using methods that entailed mining water-use coefficients (gallons of water used per weight of commodity mined) based on the commodity and quantity mined. Withdrawals were reported as fresh or saline groundwater, or fresh surface water. No saline surface-water withdrawals were reported. Self-supply commercial estimates were derived using data from State agencies and urban water management plans using coefficients based on ancillary data such as size of community or entity. Withdrawals were reported as fresh groundwater and surface water; no saline withdrawals were reported.

Livestock estimates were computed using data from State and Federal agencies (U.S. Department of Agriculture [USDA] Census of Agriculture, 2015), and NWUSP datasets (Lovelace, 2009b), as well as metered withdrawal data. Estimates were based on livestock coefficients and livestock population if withdrawals were not metered. All withdrawals were reported as fresh water. Aquaculture estimates were derived using data from State and Federal hatcheries, State agencies, or NWUSP datasets (Lovelace, 2009a). NWUSP estimation methods used the type of rearing operation (flow-through raceways, rearing tanks, etc.) and water-use coefficients that were applied to the quantity of fish production. Hatchery data generally were reported from measured data. All withdrawals were reported as fresh water from groundwater or surface-water sources.

Irrigation estimates included data from State and Federal agencies, specifically Reclamation and USDA Census of Agriculture, Farm Services Agency, as well as universities, irrigation districts, conservancy districts, and extension agencies. The Golf Course Superintendent's Association of America provided the irrigated acres for golf courses. Irrigation withdrawals were reported for golf courses and crops, separately, for all States except Wyoming and California, which reported irrigation withdrawals as a total amount combining both.

Withdrawal data were a mix of reported measurements and estimates for irrigation. Estimates were derived from the modified Blaney-Criddle method and produced irrigation water requirements derived from irrigated acres, climate data, and irrigation system efficiencies. Food and Agricultural Organization of the United Nations (1986) describes the modified Blaney-Criddle method as a theoretical approach for reference ET (ETo) estimation that is used when field-measured observations are not available. The method relies on mean air temperature values (along with sunshine hours) and is used to quantify irrigation water requirement, and assumes that crops are grown under optimal conditions, free of diseases, with favorable soil, fertilizer and water conditions. These conditions allow crops to reach their full production potential, but are not representative of actual growing conditions where disease, drought, and poor soil conditions affect crop productivity. Total withdrawals are derived from the irrigation water requirements, as derived from modified Blaney-Criddle, that are supplemented with system conveyance losses.

Irrigation consumptive use, which is a fraction of the total withdrawals, was derived either using the modified Blaney-Criddle method, or from the actual evapotranspiration (ETa), which represents the actual growing conditions and was computed from satellite thermal-band data and the Operational Simplified Surface Energy Balance (SSEBop) model (Senay and others, 2013, 2016; Singh and others, 2014). ETa is considered a surrogate value for irrigation consumptive use (Maupin and others, 2012; Savoca and others, 2013), and more realistically reflects that actual growing conditions in the field. Not all States computed modified Blaney-Criddle data, but ETa data were produced for the entire CRB at monthly scales, and annual totals were summarized from this source using several digital data sources to filter out and select only irrigated lands. Digital data used to filter out irrigated lands included national landcover data (for example, National Land Cover Database [NLCD], 2011], Homer and others, 2015; Cropland Data Layer [CDL], Boryan and others, 2011), field-verified digital aerial photography maps (Arizona), data from the Colorado Decision Support System (Colorado), or published geospatial datasets (for example, Buto and others, 2014). The ETa values, originally expressed as a depth of water (in millimeters) within the filtered spatial area of irrigated lands (thousand acres), were converted to a volume (thousand acre-feet).

Thermoelectric power estimates were derived using reported data from powerplant operators or data provided by the NWUSP (Diehl and others, 2013; Diehl and Harris, 2014), which used Energy Information Administration (EIA) power production data and linked heat and energy budget models. Thermoelectric power water use in this report are derived from a mix of metered (reported from State or powerplant operators) and model estimates from Diehl and others (2013) and Diehl and Harris (2014). Reclaimed wastewater and other deliveries were reported by powerplant operators or public utilities (city or local). Power production data were provided either from powerplant operators or through EIA reports for exclusively stream generating plants. No co-generation plants were included.

Estimates of consumptive use at thermoelectric powerplants were developed by Diehl and others (2013) using linked heat and water-budget models. They reported thermoelectric withdrawals and consumption, as well as thermodynamically plausible ranges of minimum and maximum withdrawal and consumption for 1,290 thermoelectric-power generating plants in the United States in 2010 (Diehl and Harris, 2014). Powerplants were categorized into two tiers; first, generating units were assigned to categories based on the technology used to generate electricity. These generation-type categories were combustion steam, combined-cycle, nuclear, geothermal, and solar thermal. Second, cooling systems were separately categorized as either wet cooling towers or surface-water cooling systems, and the surface-water cooling systems were subcategorized as cooling ponds, lakes, and rivers (Diehl and others, 2013). Calibrated model data for thermoelectric plants in Nevada were used in this project (CRB); otherwise, data were collected and reported (both withdrawals and consumptive use) from data reported directly from plant operators.

Hydroelectric power was derived using direct reports from powerplant operators or State and Federal agencies and reflect the total amount of water that was passed through the hydropower plant turbines to produce electricity. These water-use data do not include evaporation losses from the reservoirs; however, a summary of reservoir evaporation from Reclamation’s Hydrologic Database System (Rich Eastland, Reclamation, written commun., 2016) is included for the three largest lower CRB reservoirs (Mead, Mohave, and Havasu). Wastewater returns were compiled from Environmental Protection Agency (EPA) databases that store wastewater treatment plant discharge records, and includes publicly owned treatment works (POTWs) or sewage treatment plants.

Data Limitations

Withdrawals for all categories, except self-supply domestic, hydroelectric power, and wastewater returns, include a combination of reported and estimated data. All self-supply domestic water use is estimated, and all of hydroelectric and wastewater returns is from reported data. The USGS 5-year national compilations, and this project, used significant amounts of reported and measured data for population, public-supply withdrawals, irrigated acres, power generation, livestock populations, wastewater returns, and the quantities of materials mined. In many cases, the Federal and State agencies that collected these data have experienced decreases in resources, both funding and personnel, thereby either decreasing or limiting the frequency and spatial extent of collected data. The extent and detail of reported data varies by State, requiring additional work (estimates) in those States to meet the requirements of the national compilations, and other study efforts such as this study. USGS internal documentation was compiled for each State as part of the national compilation effort in 2010, and served as the sources of data and methods used for each of the categories.

Challenges with compiling withdrawal data included unknown errors in the reported data and use of older data than the compilation timeframe. For example, crop acreage data from the USDA Census of Agriculture (USDA-NASS, 2015) is collected every 5 years, for years ending in “2” and “7.” These are years offset from the USGS national compilation years (years ending in “0” and “5”) and may present some factor of error due to extrapolation. The lack of site-specific data about water sources in most of the categories increased the difficulty in converting county-level data to the drainage basin areas, especially in Western States where counties are typically very large and water users (people, crops, livestock, industries) may be distributed unevenly.

Water Use and Trends

Water use includes withdrawals for public supply, domestic (including self-supply withdrawals and public-supply deliveries), self-supply commercial, industrial, mining, livestock, aquaculture, irrigation, and thermoelectric power, as well as flows through hydroelectric powerplants and wastewater returns from publicly owned treatment plants and industrial facilities. Estimates of consumptive use for thermoelectric power and irrigation for each drainage basin are reported for 1985–1995, and 2010; consumptive-use data are reported sporadically for drainage basins for 2000 and 2005.

Withdrawals from groundwater and surface-water sources, by water quality (fresh or saline), are reported as an average daily volume for each drainage basin, year, and category of use. Ancillary data includes total population that are either served by public-supply systems or are self-supplied, irrigated acres by system type, and power generation (thermoelectric and hydroelectric). All ancillary data are reported for all years and drainage basins except for thermoelectric-power generation in 2000. Withdrawals are totaled for each category by water source and type, as well as a cumulative total for upper and lower CRB and by State (for areas of the State within the CRB).

Total Water Use

Water use, in a broad sense of the term, is depicted as withdrawals from groundwater or surface-water resources to be used away from the point of withdrawal (offstream). Interbasin transfers are a type of withdrawal and are considered separately in this report as an export of water outside of the CRB. Withdrawals may be delivered for a specific use, such as domestic deliveries from public suppliers, or consumptively used in the process, such as evapotranspiration from irrigated crops. Also, water may be used for an instream purpose, such as water that passes through turbines at hydroelectric powerplants, and finally, water is accounted for as a return flow, such as wastewater returns. Water that is withdrawn and leaves the CRB (interbasin transfers) is considered an export and may be used for a number of different particular type of use; it is summarized and depicted separately from water that is used within the CRB.

Withdrawals

Withdrawals in the CRB (excluding interbasin transfers) averaged about 17 maf from 1985 to 2010, peaking at about 17.76 maf in 2000, and was at the lowest level of 16.43 maf in 1990 (fig. 2*A*; table 3). Withdrawals (excluding interbasin transfers) were about evenly split between upper and lower CRB from 1985 to 2010 (fig. 2*B*). Interbasin transfers to serve mostly public-supply and irrigation needs outside of the CRB are reported for 2000, 2005, and 2010 only (table 3), and averaged 5.40 maf. Interbasin transfers out of the CRB in California (2000–2010) increased the lower CRB percentage of total withdrawals and exports to range from 55 to almost 58 percent of the total CRB water use (withdrawals plus exports) (fig. 3). Illustrating interbasin transfers along with withdrawals that are used within the CRB gives a depiction of the overall ranking of water use by State.

Total withdrawals in the CRB (excluding interbasin transfers) varied about 2 percent from 1985 and 1995, then increased almost 6 percent from 1995 to 2000, and remained steady (<1 percent different) from 2000 to 2005, and finally decreased a little more than 6 percent from 2005 to 2010 (fig. 2*A*). Surface water was the dominant source of water used in the CRB, averaging about 78 percent of total withdrawals over these years (table 3). It increased less than 2 percent from about 12.92 maf in 1985 to about 13.14 maf in 2010, and peaked in 2000 with about 13.62 maf. Groundwater withdrawals decreased by almost 12 percent from 3.87 maf in 1985 to almost 3.39 maf in 2010 (fig. 2*B*; table 3).

In the upper CRB, withdrawals from 1985 to 2010 averaged 98 percent from surface-water sources, and in the lower CRB, surface water averaged 59 percent of the withdrawals during the same time period. In the lower CRB, groundwater withdrawals were about one-half of the total water withdrawn in 1985, 2000, and 2005 (fig. 2*B*). When interbasin transfers in California are included with the total lower CRB withdrawals, the lower CRB accounted for 55–58 percent of the total CRB withdrawals. All interbasin transfers were from surface-water sources (table 3).

Nearly all withdrawals were from freshwater sources; there was a small amount of saline groundwater that was used for mining and self-supplied industrial. The lower CRB accounted for most of the total groundwater withdrawals, averaging 93 percent over the 6 years. Water use in the upper CRB was predominantly from surface water (excluding interbasin transfers), averaging about 63 percent of total CRB surface-water withdrawals. When interbasin transfers from the Colorado River in the lower CRB (California) are considered, the lower CRB accounted for more surface-water withdrawals than the upper CRB.

From 1985 to 2010, withdrawals (excluding interbasin transfers) were dominated by irrigation (80–90 percent). Public-supply withdrawals ranged from 6 to 13 percent, and the remaining portion, usually less than 5 percent, were for industrial, thermoelectric, livestock, and aquaculture uses. Pie diagrams showing total use by category for the upper and lower CRB for 2010 illustrate that when all withdrawals, returns, and interbasin transfers are considered, more than 90 percent of water use is for hydroelectric power generation, irrigation, and interbasin transfers (table 4; fig. 4).

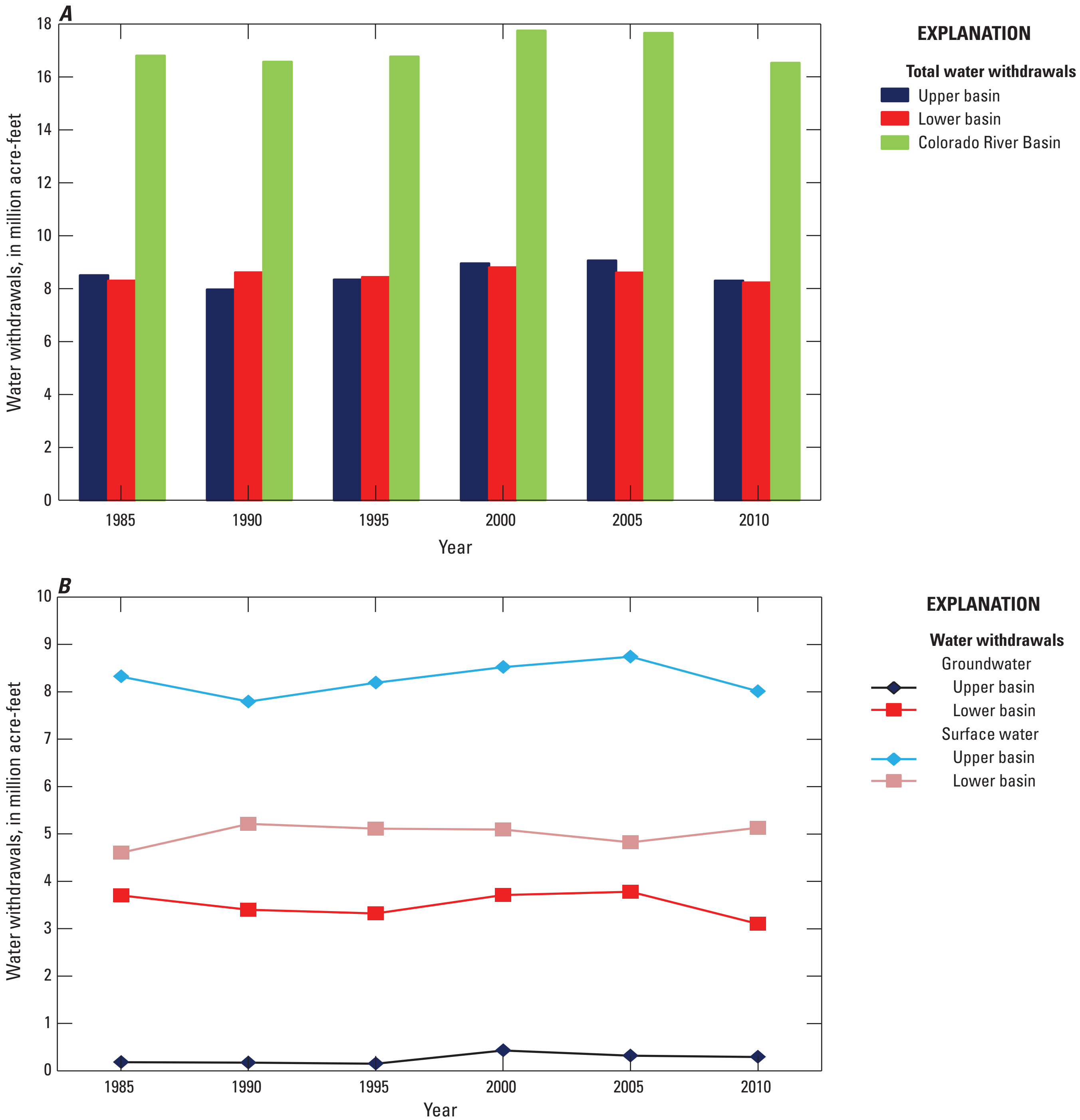


Figure 2. Total withdrawals (excluding interbasin transfers) for the upper, lower and combined Colorado River Basin (*A*) and groundwater and surface-water withdrawals (excluding interbasin transfers) for the upper, lower and combined Colorado River Basin (*B*), Southwestern United States, 1985–2010.

Table 3. Total water use, including withdrawals for the upper and lower Colorado River Basin and States included in the Colorado River Basin, by source, Southwestern United States from 1985 to 2010, and interbasin transfers by States from 2000 to 2010.

[All values are in million acre-feet. Upper and lower Colorado River Basin and States included in the Colorado River Basin are shown in figure 1. Total withdrawals may include small amounts (<0.10 million acre-feet) of saline water, mostly groundwater. Total interbasin transfers out of the Colorado River Basin, 2000–2010. Values may not sum to totals because of independent rounding. **Symbol:** <, less than]

Colorado River Basin	1985			1990			1995			2000			2005			2010		
	Groundwater	Surface water	Total	Groundwater	Surface water	Total	Groundwater	Surface water	Total	Groundwater	Surface water	Total	Groundwater	Surface water	Total	Groundwater	Surface water	Total
Upper basin[1]	0.17	8.32	8.49	0.17	7.79	7.96	0.14	8.19	8.33	0.43	8.52	8.95	0.32	8.73	9.04	0.29	8.00	8.30
Lower basin[1]	3.70	4.60	8.30	3.40	5.07	8.47	3.32	5.10	8.42	3.71	5.09	8.80	3.78	4.82	8.60	3.10	5.13	8.23
Total	3.87	12.92	16.79	3.57	12.86	16.43	3.46	13.29	16.75	4.14	13.62	17.76	4.09	13.55	17.64	3.39	13.14	16.52

State	1985			1990			1995			2000			2005			2010		
	Groundwater	Surface water	Total	Groundwater	Surface water	Total	Groundwater	Surface water	Total	Groundwater	Surface water	Total	Groundwater	Surface water	Total	Groundwater	Surface water	Total
Arizona	3.47	3.73	7.21	3.07	4.13	7.20	3.13	4.00	7.14	3.53	3.80	7.33	3.55	3.61	7.16	2.88	3.97	6.85
California[1]	0.03	0.51	0.54	0.14	0.54	0.68	0.02	0.62	0.64	0.00	0.74	0.75	0.01	0.62	0.63	0.01	0.57	0.58
Colorado[1]	0.09	6.08	6.16	0.08	5.56	5.64	0.08	5.74	5.82	0.18	5.68	5.86	0.12	5.73	5.86	0.07	4.94	5.01
Nevada	0.11	0.25	0.36	0.11	0.36	0.47	0.09	0.40	0.50	0.09	0.45	0.55	0.10	0.46	0.56	0.11	0.45	0.56
New Mexico	0.07	0.53	0.59	0.05	0.53	0.59	0.06	0.45	0.50	0.10	0.40	0.45	0.08	0.43	0.51	0.06	0.45	0.50
Utah[1]	0.07	0.83	0.91	0.07	0.77	0.84	0.06	0.86	0.91	0.15	0.96	1.11	0.14	1.23	1.36	0.16	1.05	1.21
Wyoming	0.03	0.99	1.02	0.04	0.97	1.01	0.02	1.23	1.25	0.12	1.58	1.70	0.10	1.47	1.56	0.10	1.71	1.81
Total	3.87	12.92	16.79	3.57	12.86	16.43	3.46	13.29	16.76	4.14	13.62	17.76	4.09	13.55	17.65	3.39	13.14	16.52

Interbasin transfers (all surface water)	**2000**	**2005**	**2010**
California	4.90	4.13	4.23
Colorado	0.62	0.63	0.54
Utah	0.30	0.42	0.40
Wyoming	0.02	0.02	0.01
Total	**5.83**	**5.20**	**5.18**
Total use (withdrawals plus interbasin transfers)	23.60	22.84	21.70

[1]Does not include interbasin transfers.

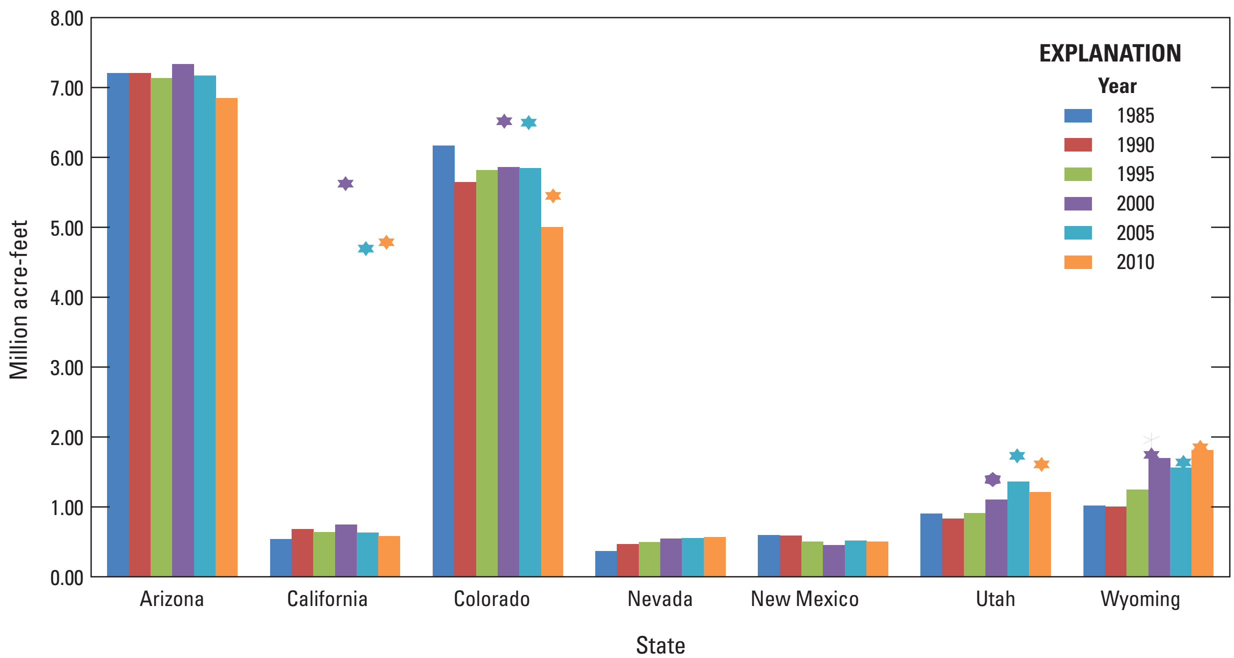


Figure 3. Total water use (including interbasin transfers for 2000–2010) for States included in the Colorado River Basin, Southwestern United States, 1985–2010.

Water in the Colorado River is used in many different ways. However, with changes in climate, population, and agriculture, there is, and will likely continue to be, an imbalance between water supply and the needs put on that available supply, both within and outside of the CRB (Bureau of Reclamation, 2012a). Excluding hydroelectric and interbasin transfers, irrigation withdrawal accounted for 83 to 90 percent (table 4) of the total withdrawals from 1985 to 2010, followed by public-supply withdrawals. Together, these two categories accounted for 94 to 96 percent of total withdrawals over the 25 years. Other categories that used at least 1 percent of the water in the CRB were thermoelectric in the upper and lower CRB, and commercial in the lower CRB. The remaining categories of aquaculture, self-supplied domestic, livestock, and mining had less than 1 percent of the total withdrawals in the CRB.

Consumptive use for hydroelectric power generation is attributed to reservoir evaporation. The USGS does not report reservoir evaporation, but Reclamation does account for it in the consumptive uses and losses reports. Irrigation represents the category of use that has the largest proportion of consumptive use in both the upper and lower CRB, with the upper CRB having the largest irrigation withdrawals.

Since 1985, total withdrawals, excluding interbasin transfers and hydroelectric power instream use, by State in descending order are Arizona, Colorado, Wyoming, Utah, California, Nevada, and New Mexico. This ranking does not fully account for total use of CRB water within some States (California, Colorado, New Mexico, Utah, Wyoming) because interbasin transfers are not included in this ranking. The CRB States rank in descending order as Arizona, Colorado, California, Wyoming, Utah (except 2005 when Utah slightly surpassed Wyoming), Nevada, and New Mexico when interbasin transfers are included.

Table 4. Total water use, including interbasin transfers, by category and States included in the Colorado River Basin, Southwestern United States, 1985–2010.

[All values are in million acre-feet. Upper and lower Colorado River Basin and States included in the Colorado River Basin are shown in figure 1. Total withdrawals may include small amounts (<0.10 million acre-feet) of saline water, mostly groundwater. Values may not sum to totals because of independent rounding. **Symbols:** –, no data; <, less than]

State	Public supply	Self-supply domestic	Irrigation	Livestock	Aquaculture	Industrial and mining	Thermo-electric	Hydro-electric	Wastewater returns	Interbasin transfers	Total, excluding hydroelectric, wastewater returns and interbasin transfers
						1985					
Arizona	0.69	0.03	6.18	0.07	–	0.15	0.06	40.67	0.14	–	7.28
California	0.01	0.00	0.53	0.00	–	0.00	0.00	14.60	0.00	–	0.54
Colorado	0.08	0.00	5.98	0.03	–	0.04	0.02	6.42	0.03	–	6.16
Nevada	0.21	0.00	0.11	0.01	–	0.01	0.02	9.26	0.09	–	0.36
New Mexico	0.02	0.01	0.48	0.01	–	0.03	0.05	0.00	0.01	–	0.59
Utah	0.05	0.00	0.81	0.00	–	0.02	0.02	1.36	0.01	–	0.91
Wyoming	0.01	0.00	0.94	0.00	–	0.04	0.03	0.24	0.00	–	1.02
Total	1.07	0.04	15.03	0.12	–	0.29	0.21	72.55	0.29	–	16.86
						1990					
Arizona	0.79	0.04	5.94	0.08	–	0.22	0.12	35.65	0.61	–	7.28
California	0.01	0.00	0.67	0.01	–	0.00	0.00	7.69	0.00	–	0.68
Colorado	0.07	0.00	5.42	0.08	–	0.04	0.02	3.55	0.70	–	5.64
Nevada	0.30	0.00	0.10	0.02	–	0.01	0.03	3.44	0.12	–	0.46
New Mexico	0.02	0.00	0.47	0.03	–	0.02	0.05	0.40	0.01	–	0.59
Utah	0.05	0.00	0.67	0.03	–	0.01	0.07	0.71	0.01	–	0.84
Wyoming	0.01	0.00	0.91	0.00	–	0.04	0.03	0.79	0.01	–	1.01
Total	1.25	0.05	14.19	0.24	–	0.48	0.32	52.24	1.46	–	16.48
						1995					
Arizona	0.91	0.04	5.83	0.04	–	0.22	0.13	23.73	0.40	–	7.25
California	0.01	0.00	0.63	0.00	–	0.00	0.00	7.12	0.00	–	0.64
Colorado	0.10	0.01	5.65	0.01	–	0.02	0.02	6.38	0.46	–	5.81
Nevada	0.38	0.00	0.07	0.00	–	0.01	0.03	5.64	0.14	–	0.49
New Mexico	0.02	0.01	0.40	0.01	–	0.01	0.05	1.19	0.01	–	0.50
Utah	0.04	0.00	0.78	0.04	–	0.01	0.03	1.44	0.01	–	0.91
Wyoming	0.01	0.00	1.19	0.00	–	0.01	0.03	0.81	0.01	–	1.25
Total	1.47	0.06	14.54	0.11	–	0.30	0.30	46.30	1.05	–	16.85

Table 4. Total water use, including interbasin transfers, by category and States included in the Colorado River Basin, Southwestern United States, 1985–2010. —Continued

State	Public supply	Self-supply domestic	Irrigation	Livestock	Aquaculture	Industrial and mining	Thermo-electric	Hydro-electric	Wastewater returns	Interbasin transfers	Total, excluding hydroelectric, wastewater returns and interbasin transfers
						2000					
Arizona	1.24	0.03	5.74	0.03	0.05	0.14	0.15	25.16	0.40	0.00	7.39
California	0.00	0.00	0.74	0.00	0.00	0.00	0.00	7.76	0.00	4.90	0.75
Colorado	0.11	0.02	5.59	0.01	0.02	0.03	0.07	5.81	1.00	0.62	5.86
Nevada	0.43	0.01	0.05	0.00	0.01	0.02	0.03	10.48	0.22	0.00	0.54
New Mexico	0.03	0.01	0.36	0.00	0.00	0.00	0.05	1.25	0.12	0.00	0.45
Utah	0.07	0.00	0.90	0.01	0.07	0.00	0.04	1.22	0.01	0.30	1.10
Wyoming	0.02	0.00	1.58	0.00	0.00	0.05	0.04	0.81	0.04	0.02	1.70
Total	1.91	0.07	14.98	0.05	0.15	0.26	0.39	52.49	1.79	5.83	17.79
						2005					
Arizona	1.31	0.03	5.50	0.03	0.05	0.11	0.18	22.16	0.41	0.00	7.21
California	0.01	0.00	0.63	0.00	0.00	0.00	0.00	6.16	0.00	4.13	0.63
Colorado	0.10	0.01	5.60	0.00	0.04	0.00	0.07	4.62	0.87	0.63	5.83
Nevada	0.45	0.02	0.04	0.00	0.00	0.02	0.03	8.13	0.26	0.00	0.56
New Mexico	0.03	0.01	0.41	0.00	0.00	0.00	0.06	0.58	0.12	0.00	0.51
Utah	0.08	0.00	1.18	0.00	0.05	0.00	0.04	1.17	0.02	0.42	1.36
Wyoming	0.02	0.00	1.45	0.00	0.00	0.04	0.04	0.80	0.02	0.02	1.56
Total	1.99	0.08	14.82	0.04	0.14	0.18	0.40	43.62	1.70	5.20	17.65
						2010					
Arizona	1.36	0.03	5.12	0.03	0.05	0.11	0.19	23.22	0.47	0.00	6.90
California	0.00	0.00	0.57	0.00	0.00	0.00	0.00	6.38	0.00	4.23	0.58
Colorado	0.11	0.01	4.79	0.00	0.04	0.02	0.02	4.93	0.73	0.54	4.99
Nevada	0.49	0.02	0.03	0.00	0.00	0.01	0.01	9.22	0.31	0.00	0.56
New Mexico	0.03	0.00	0.41	0.00	0.00	0.01	0.05	0.65	0.18	0.00	0.50
Utah	0.09	0.00	1.01	0.00	0.05	0.01	0.04	1.09	0.02	0.40	1.20
Wyoming	0.02	0.00	1.72	0.00	0.00	0.03	0.04	0.59	0.05	0.01	1.81
Total	2.10	0.07	13.65	0.04	0.15	0.19	0.35	46.08	1.75	5.18	16.55

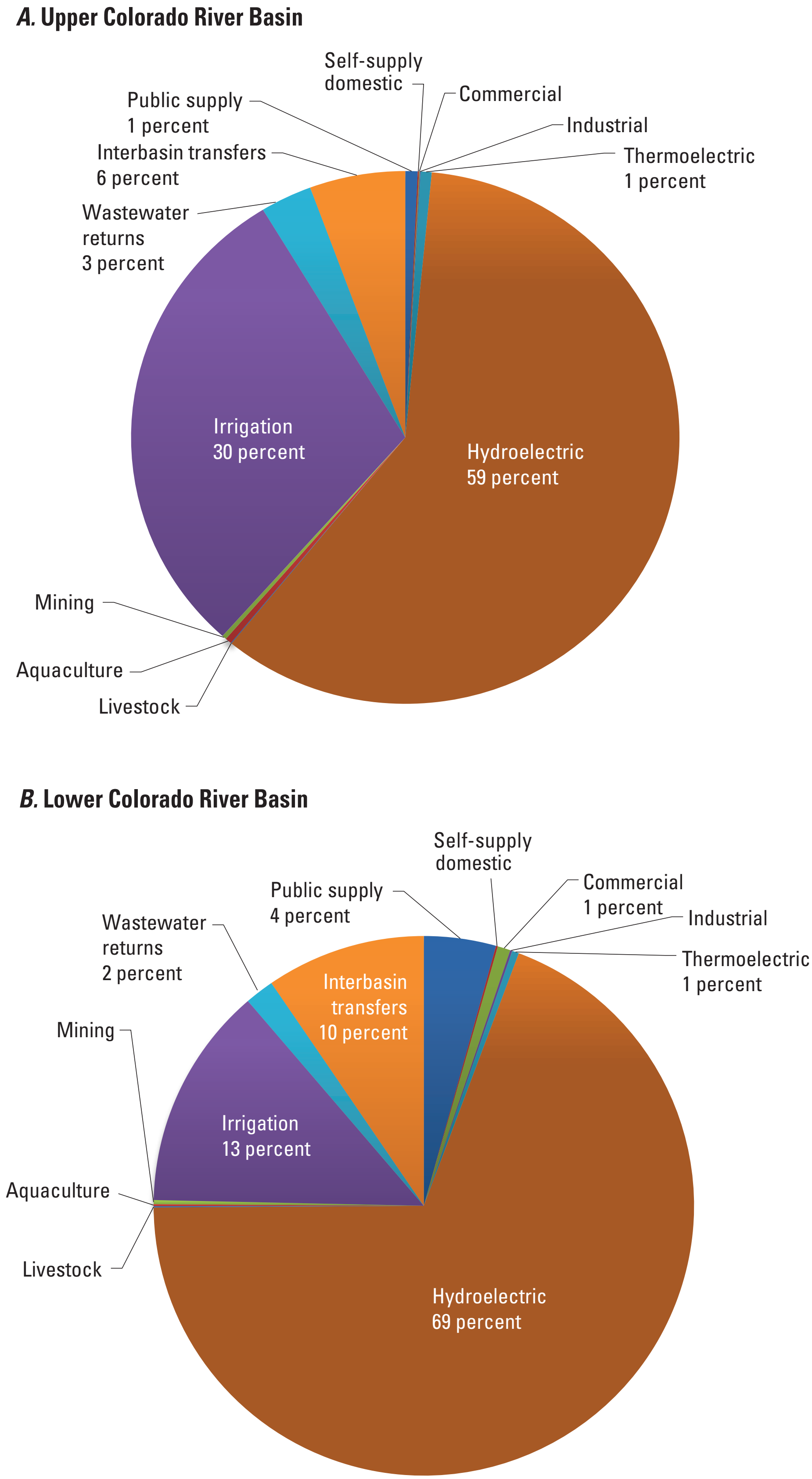


Figure 4. Percentage of total estimated water withdrawals by category, interbasin transfers, hydroelectric power use, and wastewater returns for the upper (*A*) and lower (*B*) Colorado River Basin, Southwestern United States, 2010.

Interbasin and Intrabasin Transfers

Interbasin and intrabasin transfers are facilitated via structures such as pipelines, canals, ditches, and tunnels, and are designed to move water from one drainage basin to another. Interbasin transfers provide water to users outside of the CRB (water crosses the HUC-2 boundary), and intrabasin transfers are conveyances of water that cross HUC-4 drainage basins or State boundaries, and the water is used within the CRB. There are 34 interbasin transfers (table 5; fig. 5) and 11 intrabasin transfers (table 6) in the CRB. In 2010, interbasin and intrabasin transfers were 24 and 7 percent of the total water withdrawals (21.7 maf) in the CRB, respectively.

Table 5 lists the largest interbasin transfers and the quantities of water diverted through the structures with the associated source (from) and destination (to) drainage basins. This report does not explain how water that leaves the CRB was used, and all transfers were reported as fresh surface water. The 34 interbasin transfers conveyed approximately 5,831, 5,195, and 5,183 thousand acre-feet out of the CRB in 2000, 2005, and 2010, respectively. Combined, the Colorado River Aqueduct and All-American Canal conveyed from 4,130 to 4,896 taf from 2000 to 2010, the largest of all interbasin transfers, and accounted for 80–84 percent of the total interbasin transfers. Water conveyed through the Colorado River Aqueduct is primarily used by the Metropolitan Water District of Southern California for municipal use, serving about 19 million people in 15 cities including Los Angeles, Beverly Hills, and Burbank (Metropolitan Water District of Southern California, 2015). Water in the All-American Canal is primarily owned by the Imperial Irrigation District to irrigate nearly 500,000 acres in the Imperial Valley in California (Imperial Irrigation District, 2015). In Colorado, a number of tunnels from the western side of the Continental Divide, including the Alva B. Adams, Harold D. Roberts, and Homestake convey water to major metropolitan cities on the eastern side of the Continental Divide (which includes Denver), while others, such as the Boustead, provide irrigation water to the eastern side of the Divide. Interbasin transfers across the Continental Divide from Colorado ranged from 10 to 12 percent of the total interbasin transfers. Interbasin transfers in Utah to serve areas to the west of the CRB, including Salt Lake City, ranged from 5 to 8 percent of the total interbasin transfers. The smallest interbasin transfers were in Wyoming and in each of the 3 years was less than 20 taf, the smallest (< 1 percent) interbasin transfer from the CRB.

There are 11 intrabasin transfers, mostly in Colorado, but the largest are in Arizona (table 6). The Central Arizona Project (CAP) (fig. 5), the largest intrabasin transfer, conveyed between approximately 1,365 taf and 1,697 taf each year from 2000 to 2010, and provided irrigation water to nearly 1 million acres in Maricopa, Pinal, and Pima Counties, as well as municipal supplies for Phoenix and Tucson (Pitzer and others, 2007). Some of the water that was used from an intrabasin transfer, such as CAP, is potentially returned to the hydrologic system somewhere within the CRB as recharge to aquifers or as surface-water return flows after it is used.

Population

Population data are presented in this report as the number of people who lived within the CRB during the reporting years, and does not include the population of people who use Colorado River water outside of the CRB, via interbasin transfers. Population data are either derived from the Census Bureau or obtained from other sources such as City, County, or State statistical data summaries. Total population in the CRB increased from 4.56 to 9.44 million people from 1985 to 2010. Most people were located in the lower CRB, with 86 percent of the total in 1985, and 90 percent of the total in 2010. Arizona accounted for 67 percent or more of the total population within the CRB during 1985–2010. Las Vegas, Phoenix, and Tucson are the largest cities in the CRB. The total population increased by 106 percent from 1985 to 2010, with the largest percentage increase from 1995 to 2000, when the population increased by 23 percent (fig. 6; table 7).

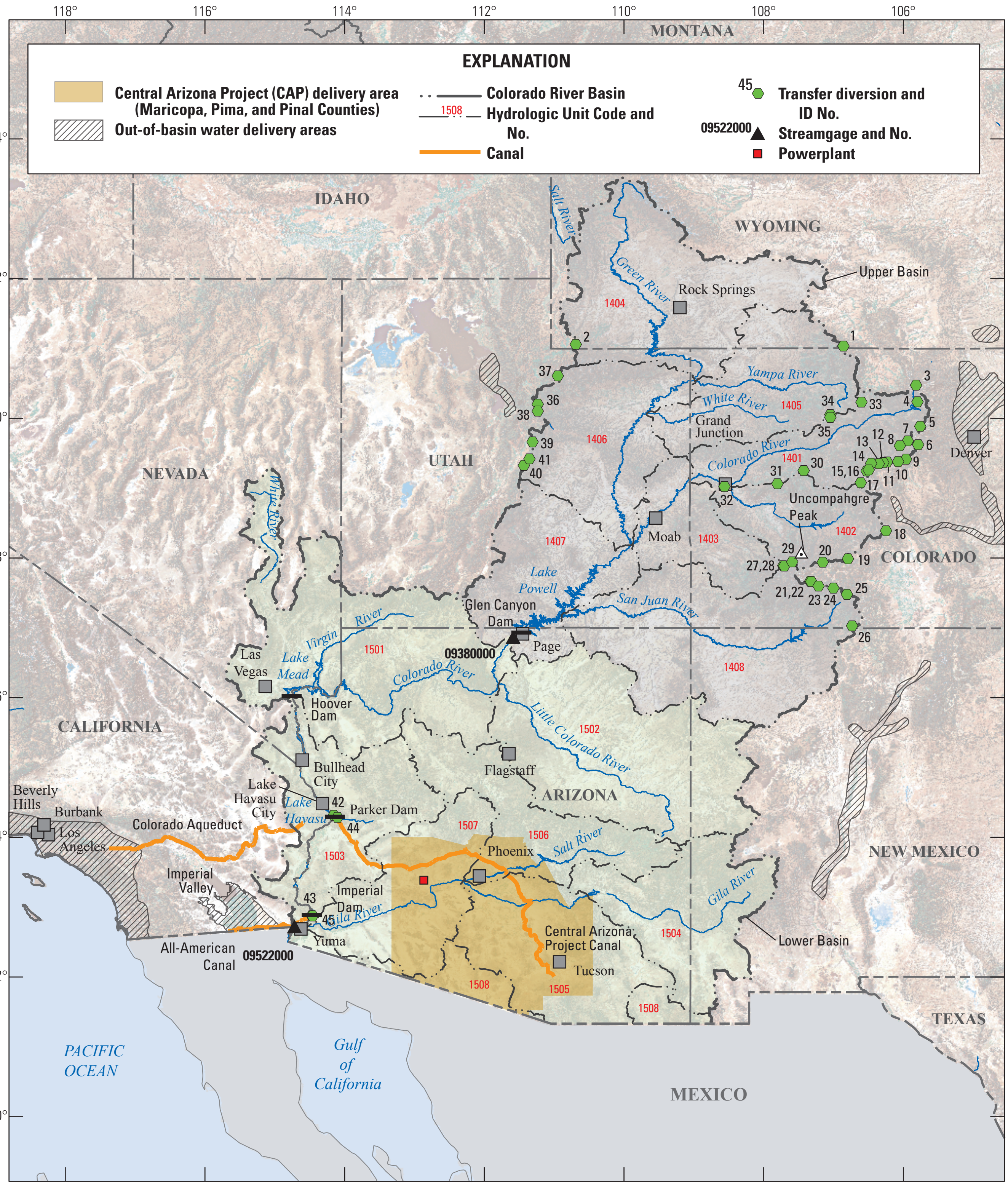
The rate of population growth in the CRB slowed from 2005 to 2010, when it increased by 9 percent. Nevada's population growth within the CRB represented the highest population growth of any State in the CRB, with the population of Las Vegas increasing by 245 percent from 1985 to 2010. Arizona and Utah populations within the CRB showed similar increases from 1985 to 2010, as compared to Nevada, with 95 and 85 percent, respectively. Populations for areas of California within the CRB have fluctuated from 1985 to 2010, resulting in an overall decrease of 17 percent. However, the California portion of the CRB population has never accounted for more than 1 percent of the total CRB population.

Populations outside of the CRB that receive water via interbasin transfers also experienced substantial growth. From 2000 to 2010, the population of the city of Denver, Colorado, increased more than 8 percent, and the population of Salt Lake City, Utah, increased 2.6 percent. The largest population outside of the CRB that receives water is Los Angeles, California, which is the second largest city in the United States with nearly 3.8 million people in 2010, and experienced over a 2.5 percent growth from 2000 to 2010 (U.S. Census Bureau, 2011).

Table 5. Interbasin transfers out of the upper and lower Colorado River Basin and States included in the Colorado River Basin, and the source and destination of transfers between hydrologic subregions (Hydrologic Unit Code 4), Southwestern United States, 2000–2010.

[Upper and lower Colorado River Basin and States included in the Colorado River Basin are shown in figure 1. NA, not applicable]

Map ID No. (fig. 4)	Diversion name	Quantity diverted, in acre-feet			Hydrologic Unit Code	
		2000	2005	2010	From	To
	Colorado					
3	Grand River Ditch	18,673	21,171	13,414	1401	1019
4	Alva B. Adams Tunnel	270,743	153,148	202,323	1401	1019
5	Moffat Water Tunnel	57,881	57,682	29,453	1401	1019
6	Straight Creek Tunnel	220	211	138	1401	1019
7	Vidler Tunnel	332	517	940	1401	1019
8	Harold D. Roberts Tunnel	93,645	59,233	75,016	1401	1019
9	Columbine Ditch	1,742	1,530	353	1401	1019
10	Boreas Pass Ditch	124	133	102	1401	1019
11	Hoosier Pass Tunnel	9,295	10,502	10,070	1401	1019
12	Ewing Ditch	1,024	784	930	1401	1102
13	Warren E. Wurts Ditch	2,603	2,298	1,693	1401	1102
14	Homestake Tunnel	24,137	46,402	9,024	1401	1102
15	Boustead Tunnel (FryArk)	50,688	55,347	56,840	1401	1102
16	Ivanhoe Tunnel	5,208	5,002	3,317	1401	1102
17	Twin Lakes Tunnel	41,881	52,294	47,089	1401	1102
18	Larkspur Ditch	0	174	226	1401	1102
19	Tarbell Ditch	0	1,127	603	1402	1301
20	Tabor Ditch No 2	0	1,073	568	1402	1301
21	Weminuche Pass Ditch	0	2,706	653	1408	1301
22	Pine River-Weminuche Pass Ditch	203	474	274	1408	1301
23	Williams Squaw Pass Ditch	230	632	303	1408	1301
24	Don La Font Ditches 1 and 2	10	41	22	1408	1301
25	Treasure Pass Diversion Ditch	70	337	183	1408	1301
26	Azotea Tunnel (San Juan/Chama)	42,741	155,195	89,403	1408	1302
	State total	621,449	628,011	542,935		
	Wyoming					
1	Cheyenne Diversion	15,438	17,454	11,575	1405	1018
2	Broadbent Supply Ditch	NA	1,101	367	1404	1601
	State total	15,438	18,555	11,942		
	Utah					
36	Central Utah Project	NA	75,670	33,233	1406	1602
37	Provo River Project	29,528	28,377	29,696	1406	1602
38	Strawberry Tunnel	NA	49,824	65,470	1406	1602
39	Ephraim Tunnel	268,833	264,353	273,314	1406	1603
40	Fairview Tunnel	NA	NA	NA	1406	1603
41	Spring City Tunnel	NA	NA	NA	1406	1603
	State total	298,361	418,223	401,713		
	California					
42	Colorado River Aqueduct	1,303,148	869,704	1,101,590	1503	Multiple
43	All-American Canal	3,593,063	3,260,345	3,124,436	1503	Multiple
	State total	4,896,211	4,130,049	4,226,026		
	Total	5,831,459	5,194,838	5,182,616		



Base from The National Map, hydrography from the National Hydrography Dataset.
Geographic coordinate system, North American Datum of 1983.

Figure 5. Selected interbasin and intrabasin transfers and areas served in and out of the Colorado River Basin, Southwestern United States.

Table 6. Intrabasin transfers between hydrologic subregions (Hydrologic Unit Code 4) and States included in the upper and lower Colorado River Basin, and the source and destination of subregions, Southwestern United States, 2000–2010.

[Upper and lower Colorado River Basin and States included in the Colorado River Basin are shown in figure 1]

Map ID No. (fig. 4)	Diversion name	Quantity diverted, in acre-feet			Hydrologic Unit Code	
		2000	2005	2010	From	To
		Colorado				
27	Red Mountain Ditch	0	38	0	1408	1402
28	Carbon Lake Ditch	112	0	0	1408	1402
29	Mineral Point Ditch	95	0	0	1408	1402
30	Divide Creek Highline Feeder Ditch	0	441	0	1402	1401
31	Leon Tunnel	1,560	100	776	1401	1402
32	Redlands Power Canal	557,536	327,654	623,393	1402	1401
33	Sarvis Creek Ditch	26	561	878	1405	1401
34	Stillwater Ditch	1,536	2,113	1,943	1405	1401
35	Dome Creek Ditch	213	100	118	1405	1401
	State total	561,078	331,007	627,108		
		Arizona				
44	Central Arizona Project	1,424,158	1,319,871	1,652,767	1503	1507
45	Gila Project	48,965	44,827	43,868	1503	1507
	State total	1,473,123	1,364,698	1,696,635		

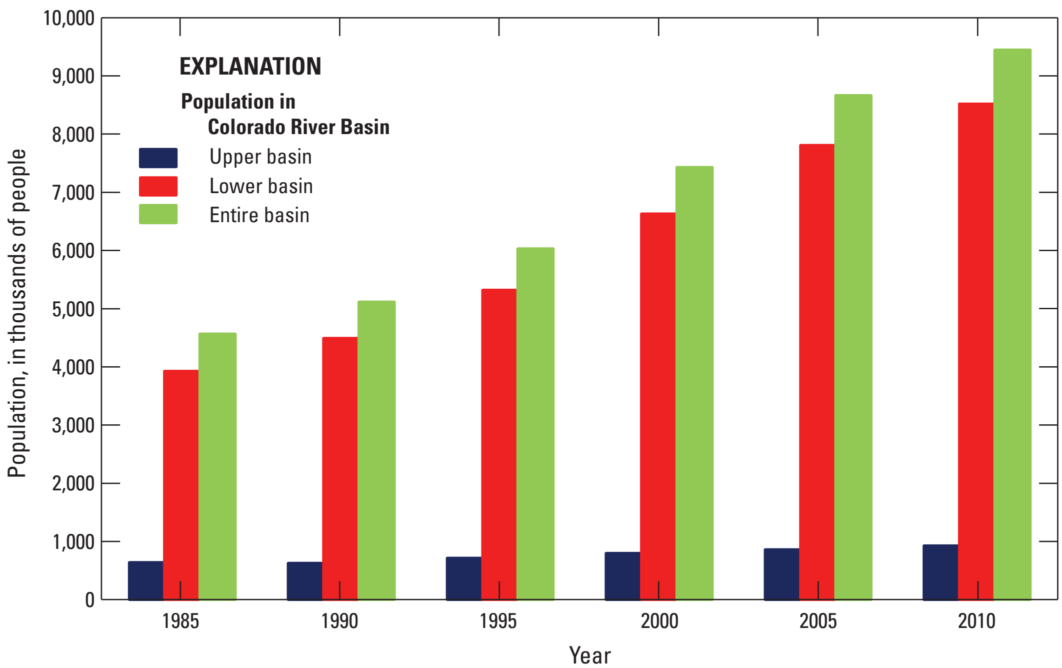


Figure 6. Total population for the upper, lower, and entire Colorado River Basin, Southwestern United States, 1985–2010.

Table 7. Population served from public suppliers and self-supplied in the upper and lower Colorado River Basin and States included in the Colorado River Basin, Southwestern United States, 1985–2010.

[Upper and lower Colorado River Basins and States included in the Colorado River Basin are shown in figure 1]

Year	Population, in thousands of people		
	Public supply	**Self supply**	**Total**
	Upper Colorado River Basin		
1985	512.100	126.400	638.500
1990	488.440	136.870	625.310
1995	560.650	153.110	713.760
2000	581.301	208.950	790.251
2005	686.281	173.298	859.579
2010	767.773	157.952	925.725
	Lower Colorado River Basin		
1985	3,691.940	233.890	3,925.830
1990	4,188.900	301.230	4,490.135
1995	4,950.340	367.180	5,317.520
2000	6,310.961	354.133	6,624.970
2005	7,454.873	351.237	7,805.151
2010	8,194.363	323.115	8,517.478
	Total Colorado River Basin		
1985	4,204.040	360.290	4,564.330
1990	4,677.340	438.100	5,115.445
1995	5,510.990	520.290	6,031.280
2000	6,892.262	563.038	7,427.738
2005	8,141.154	524.535	8,665.669
2010	8,962.136	481.067	9,443.203

Total population, in thousands of people						
State	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
Arizona	3,279.220	3,665.230	4,217.940	5,130.632	5,939.292	6,392.333
California	27.830	26.245	34.270	18.780	28.274	23.062
Colorado	324.350	330.700	389.690	457.860	505.065	549.543
Nevada	561.200	730.430	976.320	1,366.689	1,698.253	1,941.471
New Mexico	164.060	164.430	182.040	198.599	208.460	213.528
Utah	139.400	142.530	172.120	197.602	226.567	257.247
Wyoming	68.270	55.880	58.900	57.576	59.758	66.021
TOTAL	4,564.330	5,115.445	6,031.280	7,426.869	8,664.215	9,443.205

Public Supply and Domestic

Public supply refers to water withdrawn by public and private water suppliers that provide potable water to at least 25 people, or that have a minimum of 15 connections. This water may be delivered to domestic, commercial, industrial, or thermoelectric power customers, either within the drainage basin (HUC-8) where it is withdrawn, or in a neighboring drainage basin. Total public-supply withdrawals include water that is eventually delivered to a customer, as well as water used for public purposes (public uses such as pools) and maintenance (such as flushing lines), and losses due to leaky or broken water lines. Public-supply withdrawals may be transported across drainage basins at the HUC-8 level, creating situations where withdrawals and deliveries are reported in different drainage basins, thus creating situations in the data where large public uses and losses are calculated when in actuality it's a reflection of a water conveyance to a neighboring HUC-8 (not intrabasin transfer). Water conveyance from Lake Mead (15010005) to Las Vegas Wash (15010015) is such a situation. Similarly, this has an effect on other calculated values such as per-capita use rates, since populations may be reported in different drainage basins than where water is withdrawn.

Total withdrawals for public supply in the CRB averaged about 1,632 taf from 1985 to 2010, ranging from about 1,072 taf in 1985 to about 2,100 in 2010 (table 8). Most of the CRB total public-supply withdrawals occurred in the lower CRB, from 87 to 91 percent of the total, and averaged 1,469 taf. The upper CRB total public-supply withdrawals averaged 164 taf. Withdrawals in the upper CRB increased (with fluctuations) by 32 percent; withdrawals in the lower CRB increased by 105 percent from 1985 to 2010. Surface water was the primary source (fig. 7), and in 2010, it accounted for 74 and 60 percent of total public-supply withdrawals in the upper and lower CRB, respectively.

Deliveries to domestic users from public suppliers are reported for all drainage basins and years, and account for part of the total public-supply withdrawals. In both the upper and lower CRB, domestic deliveries from public suppliers increased from 1985 to 2010 (fig. 7); in the upper CRB, the increase was 31 percent, and in the lower CRB, the increase was 102 percent. Domestic water is used for both indoor and outdoor purposes at residences, and this water may come from either a self-supply source (predominantly homeowner wells) or a delivery from a public supplier. In this report, total domestic use represents the domestic deliveries from public-supply systems combined with self-supply withdrawals. Public-supply deliveries to commercial, industrial, and thermoelectric power customers are reported as a subset of total public-supply withdrawals for all areas from 1985 to 1995, but are incomplete for years thereafter. Populations that are served by public suppliers are separate of self-supply populations, and the combined total of the two represent the total drainage basin population. Domestic per-capita use represents the average daily per-person use in the domestic setting (homes, regardless of whether the water is delivered from a public supplier or is self-supplied) and is calculated by combining public-supply deliveries with self-supply withdrawals averaged over the entire drainage basin population (table 8).

The total populations served by public suppliers in the CRB increased by 113 percent from 1985 to 2010. Population growth accounted for the increases in water withdrawals and domestic deliveries. In both the upper and lower CRB, more people were served by public suppliers than were self-supplied. In the upper CRB, the percentage of people on public-supply systems ranged from 74 to 83 percent from 1985 to 2010, and in the lower CRB, the percentage of people on public-supply systems ranged from 93 to 96 percent. Arizona's public-supply population averaged 70 percent of the CRB's total population served by public supply, and Nevada's public-supply population, notably Las Vegas, averaged 18 percent.

Most domestic water needs were met from public suppliers, accounting for more than 90 percent of total domestic use in any of the reporting years. Most of the water that public suppliers withdrew was delivered to domestic users (ranging from 64 to 74 percent), even with incomplete data for deliveries to industrial and commercial users in some States from 2000 to 2010. Total domestic withdrawals in the CRB (deliveries plus self-supply withdrawals) ranged from about 800 to almost 1,540 taf, showing an increase of 93 percent with the peak year in 2005. Domestic use decreased from 2005 to 2010 to about 1,516 taf. Domestic per-capita use across the entire CRB ranged from 144 gpcd in 1985 to 121 gpcd in 2000, and averaged 130 gpcd over the 25 years. When comparing gpcd for the upper and lower CRB, the population of the lower CRB, on average, used less water for domestic purposes. Average domestic water use in the lower CRB was 128 gpcd, while in the upper CRB it was 133 gpcd. The per-capita daily use for the entire CRB fluctuated between the reporting years, but decreased overall. Some drainage basins were missing data for public-supply deliveries to commercial and industrial facilities, mostly those in Colorado, Wyoming, and New Mexico; however, commercial deliveries were greater than industrial deliveries when they were reported.

Table 8. Public-supply withdrawals, by source, and deliveries to domestic, commercial, and industrial uses, and self-supply domestic withdrawals, total domestic use and domestic per-capita use for the upper and lower Colorado River Basin and States included in the Colorado River Basin, Southwestern United States, 1985–2010.

[Upper and lower Colorado River Basin and States included in the Colorado River Basin are shown in figure 1. Values may not sum to totals due to independent rounding]

Year	Population (thousands of people)			Public-supply withdrawals (thousands of acre-feet)			Public-supply deliveries (thousands of acre-feet)			Domestic withdrawals (thousands of acre-feet)		Domestic per-capita use, in gallons per-capita daily
	Public supply	Self supply	Total	Groundwater	Surface water	Total	Domestic	Commercial	Industrial	Total self-supply	Total	
Upper Colorado River Basin												
1985	512.100	126.400	638.500	43.72	98.55	142.28	98.19	15.71	1.87	9.99	108.18	142
1990	488.440	136.870	625.310	35.80	96.88	132.68	92.48	20.92	4.91	11.40	103.88	120
1995	560.650	153.110	713.760	38.88	119.27	158.15	96.91	27.64	4.67	13.06	109.97	142
2000	587.125	208.950	796.075	36.34	150.98	187.33	95.03	[1]5.44	[1]1.01	27.04	122.07	111
2005	686.281	173.298	859.579	44.68	130.25	174.93	104.41	[1]4.17	[1]0.98	20.40	124.81	122
2010	767.774	157.953	925.727	48.20	139.88	188.08	129.33	[1]4.15	[1]1.38	20.16	149.49	162
Lower Colorado River Basin												
1985	3,691.940	233.890	3,925.830	513.21	416.19	929.40	653.44	146.45	91.09	34.84	688.28	146
1990	4,188.900	301.230	4,490.135	520.04	601.79	1,121.83	761.74	213.67	89.80	38.07	799.81	129
1995	4,950.340	367.180	5,317.520	533.58	782.91	1,316.49	848.60	263.96	75.67	49.99	898.59	119
2000	6,310.961	319.833	6,630.794	633.21	1,089.70	1,722.91	1,155.52	[1]290.64	[1]31.34	39.74	1,195.26	132
2005	7,455.058	349.578	7,804.636	720.23	1,093.87	1,814.10	1,359.37	[1]313.47	[1]33.60	55.25	1,414.62	125
2010	8,194.363	323.115	8,517.478	756.81	1,151.09	1,907.90	1,317.54	[1]314.59	[1]34.58	49.39	1,366.93	116
Total Colorado River Basin												
1985	4,204.040	360.290	4,564.330	556.93	514.74	1,071.68	751.63	162.16	92.96	44.83	796.46	144
1990	4,677.340	438.100	5,115.445	555.84	698.67	1,254.51	854.22	234.59	94.71	49.47	903.69	125
1995	5,510.990	520.290	6,031.280	572.46	902.18	1,474.64	945.51	291.60	80.34	63.05	1,008.56	130
2000	6,898.086	528.783	7,426.869	669.55	1,240.68	1,910.24	1,250.55	[1]296.08	[1]32.35	66.78	1,317.33	121
2005	8,141.339	522.876	8,664.215	764.91	1,224.12	1,989.03	1,463.78	[1]317.64	[1]34.58	75.65	1,539.43	123

Table 8. Public-supply withdrawals, by source, and deliveries to domestic, commercial, and industrial uses, and self-supply domestic withdrawals, total domestic use and domestic per-capita use for the upper and lower Colorado River Basin and States included in the Colorado River Basin, Southwestern United States, 1985–2010.—Continued

2010	8,962.136	481.067	9,443.205	805.01	1,290.97	2,095.98	1,446.87	[1]318.74	[1]35.96	69.55	1,516.42	139

State	Public-supply groundwater withdrawals, in thousands of acre-feet						Public-supply surface-water withdrawals, in thousands of acre-feet					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	431.61	449.78	458.91	552.83	635.88	655.86	261.38	342.31	446.16	686.75	674.45	704.38
California	9.18	1.75	4.16	4.29	5.65	4.83	1.09	3.54	2.98	0.00	0.00	0.00
Colorado	17.04	16.50	19.05	9.69	17.07	19.01	66.80	56.78	82.60	103.32	79.15	87.03
Nevada	52.73	45.67	51.92	46.22	43.34	58.84	155.83	254.66	329.30	388.20	407.81	434.05
New Mexico	5.01	5.82	6.59	6.32	5.59	5.24	11.78	16.09	17.72	19.05	22.91	25.55
Utah	40.52	35.36	30.20	48.49	56.04	59.65	6.10	13.78	12.99	24.11	20.65	25.75
Wyoming	0.83	0.98	1.63	1.70	1.35	1.58	11.77	11.51	10.43	19.26	19.15	14.20
TOTAL	556.92	555.85	572.46	669.55	764.91	805.01	514.75	698.66	902.18	1,240.69	1,224.12	1,290.97

State	Public-supply total withdrawals, in thousands of acre-feet						Public-supply commercial deliveries, in housands of acre-feet					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	692.99	792.09	905.07	1,239.58	1,310.33	1,360.24	101.33	131.24	150.84	187.91	198.38	216.76
California	10.27	5.29	7.14	4.29	5.65	4.83	2.37	0.49	0.54	([1])	([1])	([1])
Colorado	83.84	73.28	101.64	113.01	96.23	106.05	9.69	11.69	16.70	([1])	([1])	([1])
Nevada	208.56	300.33	381.23	434.42	451.15	492.89	41.93	71.08	99.83	93.92	108.85	89.95
New Mexico	16.79	21.90	24.31	25.37	28.51	30.78	2.33	5.87	6.59	([1])	([1])	([1])
Utah	46.62	49.13	43.19	72.61	76.62	85.40	3.26	3.42	14.88	14.25	10.40	11.11
Wyoming	12.60	12.49	12.05	20.96	20.49	15.78	1.26	2.37	2.23	([1])	([1])	([1])
TOTAL	1,071.68	1,254.51	1,474.64	1,910.24	1,988.97	2,095.98	162.15	226.16	291.61	[1]296.08	[1]317.64	[1]317.81

State	Public-supply domestic deliveries,in thousands of acre-feet						Public-supply industrial deliveries, in thousands of acre-feet					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	503.43	570.51	589.48	940.92	995.16	1,022.36	88.26	87.99	74.29	([1])	([1])	([1])
California	6.27	4.28	5.82	1.51	2.01	1.79	0.21	0.06	0.06	([1])	([1])	([1])
Colorado	56.86	53.18	58.46	50.39	56.87	72.57	1.14	2.15	2.51	([1])	([1])	([1])
Nevada	128.65	173.43	238.59	190.45	333.23	261.74	1.59	1.86	1.15	30.84	31.93	33.55
New Mexico	14.09	13.08	14.90	16.30	17.63	15.20	0.37	0.59	0.71	([1])	([1])	([1])
Utah	34.68	32.00	31.05	40.36	48.08	58.83	1.32	1.15	1.02	1.51	2.65	2.41
Wyoming	7.66	7.73	7.21	10.59	10.81	14.37	0.07	0.91	0.61	([1])	([1])	([1])

Table 8. Public-supply withdrawals, by source, and deliveries to domestic, commercial, and industrial uses, and self-supply domestic withdrawals, total domestic use and domestic per-capita use for the upper and lower Colorado River Basin and States included in the Colorado River Basin, Southwestern United States, 1985–2010.—Continued

TOTAL	751.63	854.22	945.51	1,250.52	1,463.78	1,446.87	92.96	94.71	80.34	[1]32.35	[1]34.57	[1]35.96

State	Total population served by public supply					
	1985	1990	1995	2000	2005	2010
Arizona	3,090.140	3,394.960	3,917.030	4,866.002	5,721.202	6,174.163
California	26.080	18.850	16.850	11.247	16.501	13.545
Colorado	287.940	279.670	327.050	327.811	413.206	473.298
Nevada	543.620	714.800	955.900	1,336.160	1,595.233	1,866.301
New Mexico	87.510	106.830	119.170	132.194	138.084	149.988
Utah	124.790	120.640	129.070	183.468	212.724	241.400
Wyoming	43.960	43.080	45.920	41.204	44.389	43.441
TOTAL	4,204.040	4,678.830	5,510.990	6,898.086	8,141.339	8,962.136

State	Self-supply domestic withdrawals, in thousands of acre-feet						Total domestic withdrawals and public-supply deliveries, in thousands of acre-feet					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	30.20	35.72	44.10	32.30	30.45	30.47	533.63	606.23	633.58	973.22	1,025.60	1,052.83
California	0.09	0.75	1.47	0.63	1.00	0.81	6.36	5.03	7.29	2.14	3.00	2.60
Colorado	3.19	4.32	5.29	18.22	12.08	11.64	60.05	57.50	63.75	68.61	68.95	84.21
Nevada	2.76	2.10	2.74	5.90	21.98	16.97	131.40	175.53	241.33	196.34	355.21	278.71
New Mexico	5.46	4.14	5.01	5.30	5.72	4.25	19.55	17.22	19.91	21.62	23.35	19.45
Utah	1.10	1.39	3.36	3.11	3.03	3.45	35.78	33.39	34.41	43.46	51.11	62.28
Wyoming	2.03	1.06	1.08	1.33	1.40	1.96	9.69	8.80	8.28	11.93	12.21	16.33
TOTAL	14.63	49.47	63.05	66.78	75.66	69.55	796.46	903.69	1,008.55	1,317.32	1,539.44	1,516.42

State	Total domestic per-capita use, in gallons per-capita daily					
	1985	1990	1995	2000	2005	2010
Arizona	145	120	90	139	129	122
California	132	162	159	76	97	77
Colorado	148	121	115	101	104	117
Nevada	227	206	514	134	160	146
New Mexico	52	83	71	65	140	51
Utah	141	120	188	131	132	197
Wyoming	111	118	73	130	122	197

[1]Incomplete data—some areas missing.

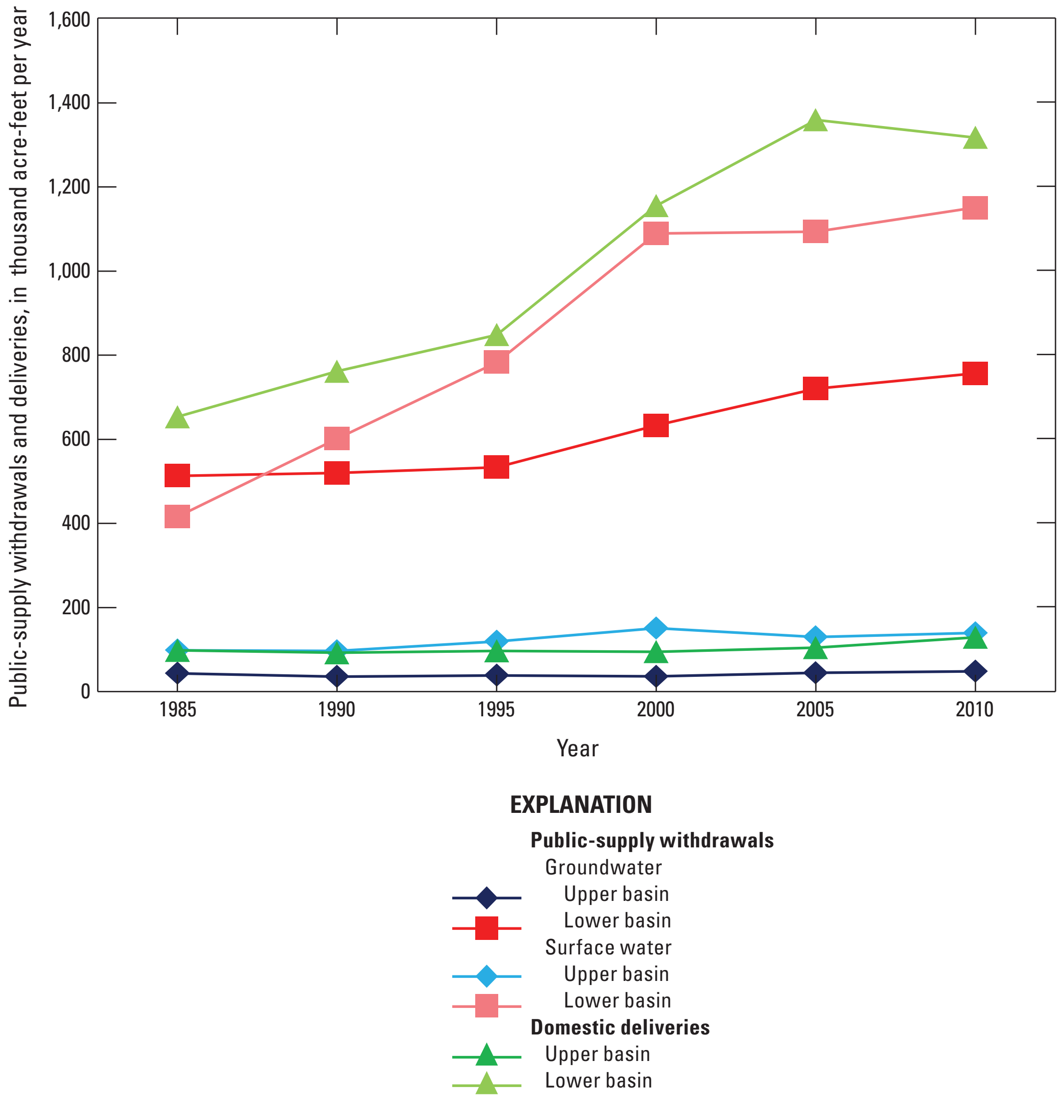


Figure 7. Public-supply withdrawals and domestic deliveries (excluding interbasin transfers) for the upper and lower Colorado River Basin, Southwestern United States, 1985–2010.

On average, Arizona accounted for about two-thirds of the total public-supply withdrawals within the CRB, followed by Nevada, which averaged 23 percent of total withdrawals from 1985 to 2010. Combined, Arizona and Nevada averaged 87 percent of total public-supply withdrawals. These percentages do not account for interbasin transfers to users outside of the CRB.

Self-Supplied Industrial and Self-Supplied Commercial

Industrial water use includes self-supplied water used for fabricating, processing, washing, diluting, cooling, sanitation, maintenance, or transporting a product at an industrial facility. It also may include water incorporated into a product, or water used for landscaping needs at a facility. An industrial facility could produce chemical and allied products, food, mining, paper and allied products, petroleum refining, and steel plants. Industrial water use does not include water used for mining activities, but would include smelting, petroleum refining, or operation of a slurry pipeline to transport material to an industrial facility. Commercial water use includes self-supplied water for hotels, restaurants, office buildings, educational institutions, prisons, governmental and military facilities, and retail sales stores. In 1990 and 1995, self-supplied commercial water use estimates included fish hatcheries.

The CRB is not a highly industrialized region in the United States; however, in the lower CRB, water use for 111 food and other manufacturing facilities located mostly in Arizona, and industrial facilities associated with mining operations in Utah and New Mexico were reported for 2010. In the upper CRB, industrial water use was reported for 20 facilities (table 9). Groundwater was the predominant source in the lower CRB, and withdrawals decreased from 59.9 taf in 1985 to 16.6 taf in 2010. Some saline groundwater withdrawals were reported in 1985, 2005, and 2010, mostly in the lower CRB (1985), but a small amount was reported in the upper CRB. Industrial surface-water withdrawals also decreased in the upper and lower CRB from 1985 to 2010 (table 9). Total water use (withdrawals and deliveries from public supply) in the CRB for industrial purposes decreased from 170.52 taf in 1985 to 67.64 taf in 2010, and were lowest in 2005.

Total commercial use (self-supply withdrawals plus public-supply deliveries) in the CRB ranged from a low of 195.29 taf in 1985, to a peak of 348.35 taf in 2010 (table 9). On average 85 percent of commercial water was provided through public-supply deliveries between 1985 and 1995. Data are incomplete for commercial deliveries from public supply in California, Colorado, New Mexico, and Wyoming between 2000 and 2010. Most of the commercial water use in the CRB has consistently occurred in the lower CRB, mostly from groundwater.

Livestock, Aquaculture, and Mining

Livestock water use includes watering at feedlots, dairies, and rangeland, as well as other on-farm needs such as cooling of facilities for animals and products, dairy sanitation and wash down of facilities, animal waste-disposal systems, and incidental water losses. Livestock includes dairy cows and heifers, beef cattle and calves, sheep and lambs, goats, hogs and pigs, horses and poultry. From 1985 to 1995, livestock water use also included some aquaculture use, which entailed the raising of fish and shellfish for food, restoration, conservation, or sport. After 2000, aquaculture water use was reported as a separate category.

From 1985 to 1995, livestock water use, including an unknown amount of aquaculture, was more than 100 taf, peaking in 1990 at 241.76 taf (table 10). From 2000 to 2010, livestock water use increased slightly in the lower CRB and decreased in the upper CRB. Aquaculture water use, which was included in the livestock category from 1985 to 1995, is the reason for the significantly higher values in the upper CRB. More surface water was used for livestock in the upper CRB (probably for aquaculture in Utah and Colorado in the earlier years) (fig. 8). Arizona had the largest withdrawals for livestock, averaging about 28 taf from 2000 to 2010, whereas any of the other six States averaged between 1 and 6 taf for the same time period.

Livestock populations show small fluxes in the upper CRB between 1985 and 1995, then a sharp decrease sharply in 2000 (table 11). Based on the estimated numbers of cattle and sheep from NASS (USDA 2015), the lower CRB had a range of 1.1 to more than 1.5 million animals between 1985 and 2010. The number of cattle and sheep was consistently greater in the lower CRB than in the upper CRB. In 2012, Arizona was ranked 12th in the nation for milk production. Most of the 90 dairies in Arizona are large, milking approximately 1,500–2,000 cows (The Arizona Experience, 2015). Temperatures in Arizona are ideal for dairy cattle for 7–8 months of the year, but temperatures in the summer months can exceed 100 °F daily. Starting in the 1990s, to alleviate heat stress on the dairy herds and prevent a loss in milk production, dairy managers began building open-sided barns for shade, and installing fans and misters to keep the cows cool.

Table 9. Self-supplied industrial and commercial withdrawals in the upper and lower Colorado River Basin and States included in the Colorado River Basin, Southwestern United States, 1985–2010.

[All values are in thousands of acre-feet. Upper and lower Colorado River Basin and States included in the Colorado River Basin are shown in figure 1. **Abbreviations:** GW, groundwater; SW, surface water; DEL, public-supply deliveries]

Colorado River Basin	1985				1990				1995				2000				2005				2010			
	GW	SW	DEL	Total	GW	SW	DEL	Total	GW	SW	DEL	Total	GW	SW	DEL	Total	GW	SW	DEL	Total	GW	SW	DEL	Total
	Industrial																							
Upper basin	[1]1.65	6.87	1.87	8.74	3.22	2.79	4.91	10.92	2.69	4.47	4.67	11.83	5.52	2.38	1.01	8.91	[1]6.14	1.67	0.98	2.65	[1]7.14	2.86	1.38	4.24
Lower basin	[1]59.92	9.12	91.09	100.22	55.24	0.56	89.80	145.60	47.04	6.17	75.67	128.88	19.52	5.61	31.34	56.47	15.77	7.76	21.68	57.13	16.60	5.08	34.58	56.26
Total	61.67	16.00	92.96	108.96	58.46	3.35	94.71	156.52	49.73	10.64	80.34	140.71	21.91	7.99	32.35	65.38	25.04	9.43	34.58	59.78	23.74	7.94	35.96	60.50
	Commercial																							
Upper basin	5.97	1.39	15.71	23.07	6.26	0.75	20.92	27.93	6.23	0.75	27.64	34.62	1.10	4.29	5.44	10.83	1.24	4.20	4.17	9.61	1.32	5.66	4.15	11.13
Lower basin	25.24	0.53	146.45	172.22	25.35	7.07	213.67	246.09	24.94	8.41	263.96	297.31	16.92	0.01	290.64	307.57	21.52	0.00	313.47	334.99	23.55	0.00	314.59	338.14
Total	31.21	1.92	162.16	195.29	31.61	7.82	234.59	274.02	31.17	9.16	291.60	331.93	18.02	4.30	296.08	318.40	22.76	4.20	317.64	344.60	24.87	5.66	317.82	348.35

State	Industrial fresh groundwater withdrawals						Industrial saline groundwater withdrawals						Industrial total surface-water withdrawals						Industrial total withdrawals					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	49.50	43.85	44.01	17.75	14.81	14.48	9.35	0.00	0.00	0.00	0.00	0.00	0.81	0.00	0.00	0.00	0.00	0.00	59.66	43.85	44.01	17.75	14.81	14.48
California	0.21	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.02	0.00	0.00	0.00
Colorado	0.19	1.64	1.41	0.39	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	1.54	0.70	0.58	0.22	0.85	0.85	1.73	2.33	2.00	0.62	0.87	0.87
Nevada	0.72	8.30	1.68	0.58	0.31	0.50	0.00	0.00	0.00	0.00	0.00	0.00	8.32	0.56	6.18	5.61	1.93	5.08	9.04	8.86	7.86	6.19	2.24	5.58
New Mexico	0.01	1.11	1.59	1.04	1.74	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.19	1.91	2.23	1.87	5.83	0.92	0.20	3.02	3.82	2.91	7.57	2.50
Utah	1.00	3.41	0.96	4.53	3.14	4.41	0.02	0.00	0.00	0.00	0.15	0.21	5.03	0.09	1.65	0.00	0.36	0.53	6.05	3.50	2.61	4.53	3.50	5.15
Wyoming	0.56	0.16	0.04	0.74	1.75	2.53	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.10	0.01	0.28	0.46	0.56	0.67	0.26	0.06	1.02	2.21	3.09
Total	52.19	58.46	49.73	25.03	21.77	23.53	9.37	0.00	0.00	0.00	0.15	0.21	16.00	3.35	10.65	7.98	9.43	7.94	77.56	61.81	60.38	33.01	31.20	31.68

State	Public-supply industrial deliveries						Total industrial withdrawals and public-supply deliveries					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	88.26	87.99	74.29	([1])	([1])	([1])	147.92	131.84	118.30	17.75	14.81	14.48
California	0.21	0.06	0.06	([1])	([1])	([1])	0.43	0.06	0.08	0.00	0.00	0.00
Colorado	1.14	2.15	2.51	([1])	([1])	([1])	2.87	4.48	4.51	0.62	0.87	0.87
Nevada	1.59	1.86	1.15	30.84	31.93	33.55	10.63	10.72	9.01	37.03	34.17	39.13
New Mexico	0.37	0.59	0.71	([1])	([1])	([1])	0.57	3.61	4.53	2.91	7.57	2.50
Utah	1.32	1.15	1.02	1.51	2.65	2.41	7.38	4.65	3.63	6.04	6.14	7.56
Wyoming	0.07	0.91	0.61	([1])	([1])	([1])	0.74	1.17	0.66	1.02	2.21	3.09
Total	92.96	94.71	80.34	32.35	34.57	35.96	170.53	156.52	140.72	65.37	65.77	67.64

Table 9. Self-supplied industrial and commercial withdrawals in the upper and lower Colorado River Basin and States included in the Colorado River Basin, Southwestern United States, 1985–2010.—Continued

State	Commercial groundwater withdrawals						Commercial surface-water withdrawals						Commercial total withdrawals						Public-supply commercial deliveries					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	18.79	19.91	23.27	15.87	20.44	22.69	0.13	0.00	0.00	0.00	0.00	0.00	18.92	19.91	23.27	15.87	20.44	22.69	101.33	131.24	150.84	187.91	198.38	216.76
California	0.02	0.10	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.04	0.10	0.00	0.00	0.00	0.00	2.37	8.92	0.54	([1])	([1])	([1])
Colorado	5.65	6.05	6.05	1.03	1.14	1.20	0.13	0.50	0.50	4.14	4.20	5.63	5.78	6.56	6.56	5.17	5.35	6.83	9.69	11.69	16.70	([1])	([1])	([1])
Nevada	6.27	4.76	0.95	0.35	0.44	0.56	0.37	7.06	8.40	0.00	0.00	0.00	6.64	11.83	9.35	0.35	0.44	0.56	41.93	71.08	99.83	93.92	108.85	89.95
New Mexico	0.17	0.63	0.76	0.76	0.71	0.28	0.00	0.16	0.17	0.17	0.00	0.03	0.17	0.78	0.93	0.93	0.71	0.31	2.33	5.87	6.59	([1])	([1])	([1])
Utah	0.00	0.00	0.01	0.00	0.04	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.15	3.26	3.42	14.88	14.25	10.40	11.11
Wyoming	0.33	0.15	0.12	0.00	0.00	0.00	1.26	0.10	0.09	0.00	0.00	0.00	1.58	0.25	0.21	0.00	0.00	0.00	1.26	2.37	2.23	([1])	([1])	([1])
Total	31.22	31.60	31.18	18.01	22.77	24.87	1.92	7.82	9.16	4.30	4.20	5.66	33.14	39.43	40.33	22.32	26.97	30.54	162.15	234.59	291.61	296.08	317.64	316.82

State	Total commercial withdrawals and public-supply deliveries					
	1985	1990	1995	2000	2005	2010
Arizona	120.25	151.14	174.11	203.79	218.82	239.45
California	2.41	9.02	0.54	([1])	([1])	([1])
Colorado	15.47	18.25	23.26	5.17	5.35	6.83
Nevada	48.56	82.91	109.17	94.26	109.29	90.51
New Mexico	2.50	6.66	7.52	0.93	0.71	0.31
Utah	3.26	3.42	14.89	14.25	10.45	11.25
Wyoming	2.84	2.61	2.44	([1])	([1])	([1])
Total	195.29	274.02	331.94	318.40	344.61	349.27

[1]Some saline groundwater withdrawals are included in the value.

Table 10. Livestock and aquaculture withdrawals in the upper and lower Colorado River Basin and States included in the Colorado River Basin, Southwestern United States, 1985–2010.

[All values are in thousand acre-feet (taf). Upper and lower Colorado River Basin and States included in the Colorado River Basin are shown in figure 1. **Abbreviations:** GW, groundwater; SW, surface water; na, not available]

Colorado River Basin	[1]1985			[1]1990			[1]1995			2000			2005			2010		
	GW	SW	Total	GW	SW	Total	GW	SW	Total	GW	SW	Total	GW	SW	Total	GW	SW	Total
Livestock																		
Upper basin	4.41	39.22	43.63	5.96	125.46	131.42	4.92	56.20	61.12	5.34	12.44	17.78	3.18	8.68	11.86	3.59	8.81	12.40
Lower basin	29.21	48.65	77.86	34.10	76.23	110.33	36.22	7.66	43.88	27.26	0.49	27.75	29.07	0.45	29.52	30.89	0.53	31.42
Total	33.62	87.87	121.49	40.06	201.70	241.76	41.14	63.90	105.45	32.60	12.93	45.53	32.25	9.12	41.38	34.48	9.34	43.82
Aquaculture																		
Upper basin	na	na	na	Included in livestock and commercial						66.92	28.96	95.88	48.65	38.06	86.71	56.54	41.42	97.96
Lower basin	na	na	na							43.61	15.13	58.74	41.62	13.82	55.44	44.66	8.71	53.37
Total	na	na	na							110.53	44.09	154.62	90.27	51.88	142.15	101.20	50.13	151.33

State	Livestock groundwater withdrawals						Livestock surface-water withdrawals						Livestock total withdrawals					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	27.49	27.72	32.45	26.46	28.33	30.22	40.43	53.60	0.00	0.00	0.00	0.00	67.92	81.32	36.13	26.46	28.33	30.22
California	0.08	4.04	1.96	0.00	0.00	0.00	0.56	1.87	2.51	0.00	0.00	0.00	0.64	5.91	4.47	0.00	0.00	0.00
Colorado	1.55	1.84	1.76	2.86	1.28	1.35	31.24	74.28	7.86	6.06	3.44	3.54	32.79	76.12	9.62	8.92	4.72	4.89
Nevada	0.76	0.20	0.76	0.43	0.30	0.20	4.48	20.09	0.91	0.00	0.00	0.00	5.25	20.29	1.67	0.43	0.30	0.20
New Mexico	1.14	2.50	1.82	1.13	0.86	1.14	7.47	25.30	5.61	0.43	0.34	0.43	8.61	27.80	7.42	1.56	1.20	1.57
Utah	2.21	3.17	1.73	1.00	0.92	0.96	2.02	24.47	41.95	4.20	3.62	3.53	4.23	27.64	43.67	5.20	4.54	4.50
Wyoming	0.39	0.59	0.66	0.73	0.56	0.61	1.67	2.09	1.80	2.24	1.73	1.84	2.06	2.68	2.47	2.97	2.29	2.44
Total	33.62	40.06	41.14	32.60	32.25	34.48	87.87	201.70	60.63	12.93	9.12	9.34	121.49	241.76	105.45	45.53	41.38	43.82

State	Aquaculture groundwater withdrawals						Aquaculture surface-water withdrawals						Aquaculture total withdrawals					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona				43.57	41.56	44.29				8.61	8.61	8.71				52.18	50.16	53.00
California				0.00	0.00	0.00				0.00	0.00	0.00				0.00	0.00	0.00
Colorado				0.06	0.12	3.91				23.22	37.60	40.94				23.27	37.72	44.85
Nevada				0.00	0.00	0.00				5.61	3.36	0.00				5.61	3.36	0.00
New Mexico				0.03	0.07	0.37				0.92	1.85	0.00				0.95	1.92	0.37
Utah				66.63	48.30	52.32				5.26	0.00	0.00				71.89	48.30	52.32
Wyoming				0.24	0.22	0.31				0.48	0.46	0.48				0.72	0.68	0.80
Total				110.53	90.27	101.20				44.09	51.88	50.13				154.62	142.15	151.33

[1]Includes some aquaculture..

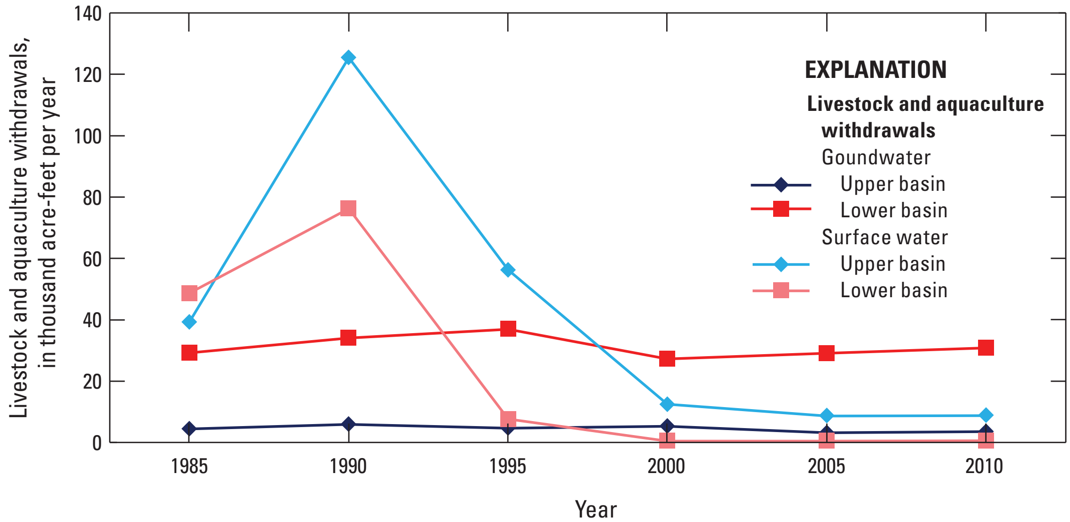


Figure 8. Livestock and aquaculture withdrawals from 1985 to 1995, and only livestock withdrawals from 2000 to 2010 in the upper and lower Colorado River Basin, Southwestern United States.

Table 11. Estimated number of cattle and sheep in the upper and lower Colorado River Basin, Southwestern United States, 1985–2010.

[Data from U.S. Department of Agriculture (2015). Upper and lower Colorado River Basin are shown in figure 1]

Year	Estimated number of cattle and sheep		Year	Estimated number of cattle and sheep	
	Upper basin	Lower basin		Upper basin	Lower basin
1985	1,305,600	1,564,450	2000	888,536	1,140,000
1990	1,328,900	1,343,700	2005	736,622	1,128,000
1995	1,111,756	1,201,150	2010	765,936	1,309,100

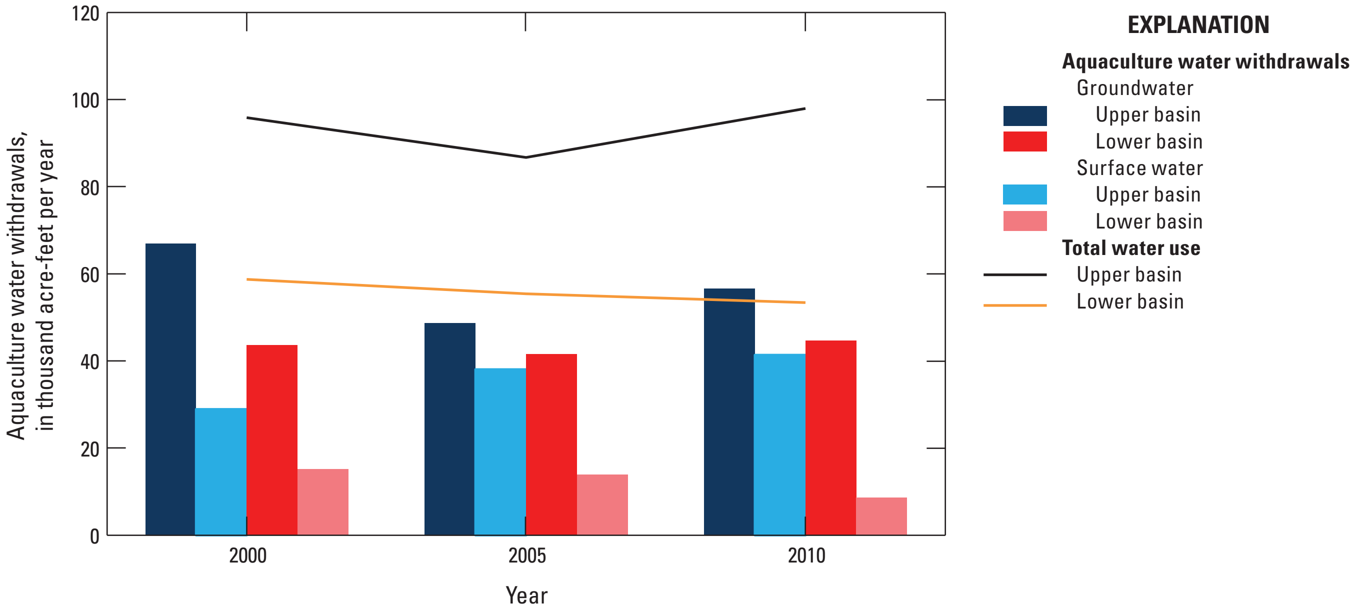
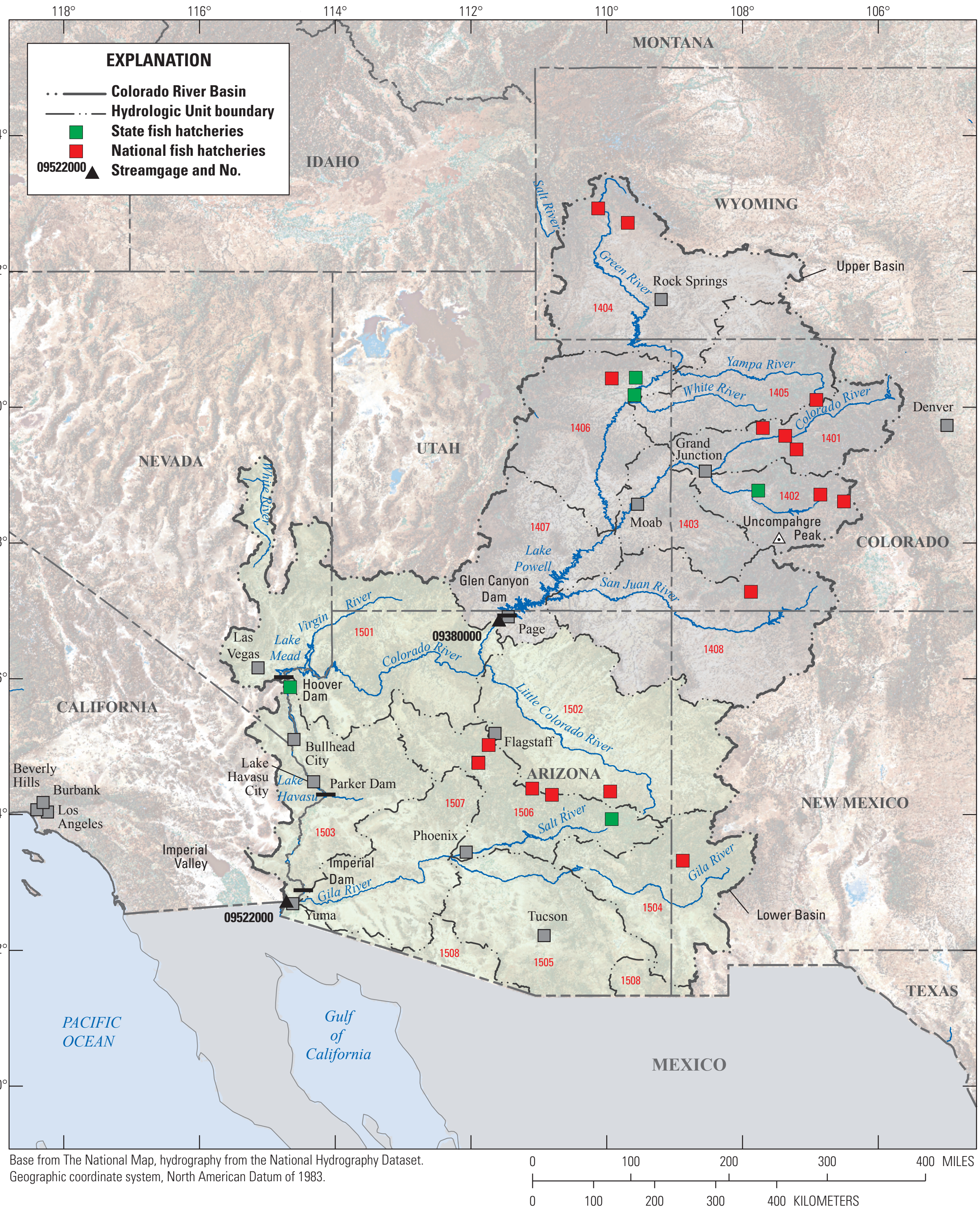


Figure 9. Water withdrawals for aquaculture in the upper and lower Colorado River Basin, Southwestern United States, 2000–2010.

In the warmer months, cooling systems in these "Arizona style" barns run 24 hours a day (Alamri, 2015), presenting an additional water demand beyond the hydration needs of the livestock and the necessary dairy sanitation needs. In the upper CRB, prolonged temperatures greater than 100 °F are not as common as in the lower CRB, and there is less need to reduce dairy herd heat stress, and less need for the cooling water use.

Aquaculture, reported separately from other livestock beginning in 2000, used more water in the upper CRB than in the lower CRB, averaging almost 94 taf in the upper CRB and about 56 taf in the lower CRB from 2000 to 2010 (table 10). Between 2000 and 2010, groundwater accounted for about two-thirds of the total water use for aquaculture. Groundwater withdrawals for aquaculture in the upper CRB decreased overall from 2000 to 2010, while surface-water withdrawals generally increased. Groundwater withdrawals in the lower CRB increased overall from 2000 to 2010, and surface-water withdrawals decreased (fig. 9). Utah, Arizona, and Colorado account for the three largest withdrawal States for aquaculture. There are Federal and State fish hatcheries in Utah (4), Arizona (8), and Colorado (8) (fig. 10). There is a total of 14 fish hatcheries in the upper CRB, and 9 in the lower CRB. The larger number of hatcheries in the upper CRB probably accounts for the larger amount of water use.

Water use for mining includes the process of extraction of minerals, such as coal, gold, sands and gravels, crude petroleum, and natural gas. This category includes water used for quarrying, milling of mined materials, and injection of water for secondary oil recovery, or unconventional oil and gas recovery (hydraulic fracturing). Mining water use does not include water used in processing, such as smelting, refining petroleum, or pipeline slurries, which are classified as an industrial use.



Base from The National Map, hydrography from the National Hydrography Dataset.
Geographic coordinate system, North American Datum of 1983.

Figure 10. Federal and State fish hatcheries in the Colorado River Basin, Southwestern United States.

Total water use for mining, including saline water, was greater in the lower CRB, and in select years (1990, 1995, and 2005) the lower CRB withdrawals were more than twice the upper CRB withdrawals (table 12). Groundwater was the primary source for mining in the lower CRB, and from 1985 to 1995 was also greater than surface water in the upper CRB. Mining withdrawals, generally freshwater, across the CRB showed a decreasing trend since 1990 (fig. 11). The decrease in mining withdrawals may be partially a result of mine closures; in Nevada the total number of reported active mines in the State (including areas outside of the CRB) in 1986 was 341 (Schilling, 1986) and in 2010, 126 active mining operations (Davis, 2011) were reported. In 1985, Colorado had 103 active mining operations in the CRB; in 2010 there were 13. In Arizona, 108 mines and quarries (Arizona Department of Mines and Mineral Resources, 1985) were reported as active in 185, and in 2010, there were 24 active major mines (Niemuth, 2010).

In the lower CRB, water-use management, conservation practices and best management practices (BMP) were initiated at many mining facilities following the passage of Arizona's regulatory programs: Arizona Department of Water Resources First Management Plan (finalized in 1985), and the Arizona Department of Water Quality Aquifer Protection Permit program (many permits were developed and issued in the early 1990s) (Robert Miller, ASARCO, written commun., 2015). Some of the BMPs (Singh, 2010) that were implemented at the Arizona mines include:

1. Reduced water loss from tailing impoundments by depositing tailings upslope from the free water surface in impoundments to reduce seepage.
2. Created stilling basins to minimize surface area and reduce water loss by evaporation.
3. Reclaimed tailings impoundment water and recycle.
4. Minimized water used for leaching.

Water used in the leaching process, prior to the BMPs, was applied through either flood or sprinkler irrigation methods, where losses of leaching fluids could be as great as 60 percent (Mular and others, 2002). As part of the BMPs, mines in Arizona are conserving water through a method "borrowed" from agriculture—drip leach systems, and minimizing (although not eliminating) evaporative loss. In addition to the decrease in the number of active major mines in Arizona, water conservation, management and BMPs likely account for the decrease in mining water use in the lower CRB since 1990.

Saline groundwater, often a byproduct of the oil and gas drilling process, was used predominantly for reinjection into the oil and gas wells in the upper CRB. From 1985 to 2010, saline groundwater withdrawals averaged from 14.2 to 23.1 taf from mining of oil shales in Wyoming and Colorado. In Arizona, saline withdrawals were less than 1 taf in all years except 1995, when saline withdrawals were 13.3 taf.

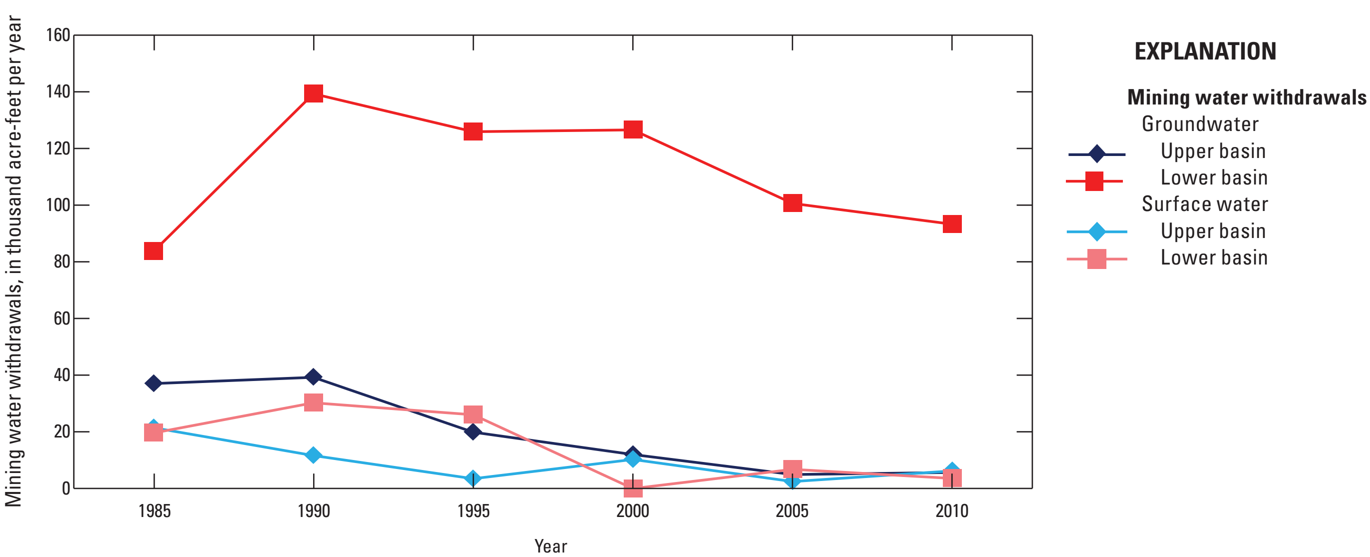


Figure 11. Water withdrawals for mining in the upper and lower Colorado River Basin, Southwestern United States, 1985–2010.

Table 12. Mining withdrawals in the upper and lower Colorado River Basin and States included in the Colorado River Basin, Southwestern United States, 1985–2010.

[All values are in thousands of acre-feet (taf). Upper and lower Colorado River Basin and States included in the Colorado River Basin are shown in figure 1]

Colorado River Basin	Mining											
	Ground-water, fresh	Ground-water, saline	Surface water	Total mining withdrawals	Ground-water, fresh	Ground-water, saline	Surface water	Total mining withdrawals	Ground-water, fresh	Ground-water, saline	Surface water	Total mining withdrawals
	1985				1990				1995			
Upper basin	41.51	30.73	24.08	96.32	44.02	31.35	13.07	88.45	22.34	16.21	3.92	42.47
Lower basin	93.86	0.11	[1]22.04	116.01	156.20	0.63	[1]34.09	190.92	141.21	13.32	[1]31.79	186.32
Total	135.37	30.84	46.12	212.33	200.22	31.98	47.16	279.37	163.55	29.53	35.72	228.79
	2000				2005				2010			
Upper basin	13.43	64.77	11.48	89.68	5.57	54.57	2.76	51.36	6.36	54.48	6.98	67.82
Lower basin	141.93	0.00	0.00	141.93	112.83	0.07	7.54	120.44	104.60	0.01	3.96	108.57
Total	155.36	64.77	11.48	231.61	118.40	54.64	10.30	171.80	110.96	54.49	10.94	176.39

State	Mining groundwater, fresh, withdrawals						Mining groundwater, saline, withdrawals					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	74.77	142.38	133.61	120.57	98.27	97.09	0.01	0.62	13.31	0.00	0.00	0.00
California	0.04	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Colorado	10.60	10.07	7.81	9.19	2.96	2.26	24.83	24.55	14.40	15.85	11.54	13.15
Nevada	1.14	0.49	0.90	17.61	10.76	3.49	0.00	0.01	0.01	0.00	0.07	0.01
New Mexico	25.54	14.05	7.15	4.26	3.80	4.18	0.00	0.00	0.00	0.00	0.00	0.00
Utah	7.02	6.30	7.07	1.73	1.08	2.90	1.97	0.01	0.00	0.11	0.22	8.00
Wyoming	16.25	26.94	7.01	2.00	1.54	1.03	3.92	6.79	1.80	48.81	42.81	33.33
Total	135.37	200.22	163.55	155.36	118.40	110.96	30.84	31.98	29.53	64.77	54.64	54.49

State	Mining-surface water, fresh, withdrawals						Mining total withdrawals					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	15.02	[1]32.63	[1]27.96	0.00	0.00	0.00	89.80	175.83	177.45	120.57	98.27	97.09
California	[1]0.03	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00
Colorado	5.83	0.86	0.39	9.41	1.39	4.11	41.26	35.48	22.61	34.45	4.35	19.53
Nevada	0.15	1.26	1.26	0.00	7.54	2.15	1.29	1.76	2.16	17.61	18.37	6.56
New Mexico	8.08	1.74	0.08	0.08	0.16	2.52	33.62	15.78	7.23	4.34	3.96	6.70
Utah	2.43	1.04	0.95	1.30	0.67	1.79	11.42	7.35	8.03	3.14	1.97	12.70
Wyoming	14.57	9.43	2.50	0.70	0.54	0.36	34.75	43.16	11.31	51.50	44.88	34.72
Total	46.12	47.16	35.72	11.48	10.30	10.94	212.33	279.36	228.79	231.61	171.80	176.39

[1]Includes some saline withdrawals.

Irrigation

Irrigation water use includes water that is applied by an irrigation system to sustain plant growth in all agricultural and horticultural practices. Water for irrigation can be self-supplied, or delivered from irrigation or ditch companies, cooperatives, and government agencies. Reclaimed wastewater used for irrigation of crops or turf/landscaped areas, such as parks, golf courses, or cemeteries, is included in this category. Reclaimed wastewater is treated effluent that is delivered to a beneficial use (irrigation) rather than returned to the hydrologic system. All other withdrawals are considered freshwater, and irrigated acres are reported by three types of irrigation systems: sprinkler, micro-irrigation, and surface (flood).

Total irrigation withdrawals inside the CRB (excluding interbasin transfers) averaged 14,530 taf and accounted for the largest offstream water use in the CRB, averaging 85 percent of total withdrawal from all categories in the CRB from 1985 to 2010. Considering irrigation withdrawals (excluding interbasin transfers) to irrigate lands totally within the CRB, for 2010, the ranking for States in descending order is Arizona, Colorado, Wyoming, Utah, California, New Mexico, and Nevada. If the 500,000 acres of irrigated lands in the Imperial Valley in California, with the over 3,124 taf interbasin transfers (table 5) for the All-American Canal are considered, then California is shifted up to third place behind Arizona and Colorado.

Slightly more than one-half of total irrigation withdrawals within the CRB occurred in the upper CRB, averaging 55 percent from 1985 to 2010. Surface-water and groundwater withdrawals (excluding interbasin transfers), and reclaimed wastewater use in the upper and lower CRB, are shown in table 13 and figure 12. From 1985 to 2010, total irrigation withdrawals (excluding interbasin transfers) decreased in the upper and lower CRBs, with a larger decrease in the lower CRB.

Excluding interbasin transfers, far more surface water than groundwater was withdrawn in both the upper and lower CRB, but in the upper CRB, surface water averaged about 98 percent (1985–2010) of the total irrigation withdrawals in that area, whereas in the lower CRB, surface water averaged 61 percent of total irrigation withdrawals in that area. Surface-water withdrawals increased in the upper CRB and decreased in the lower CRB from 1990 to 2005. In contrast, from 2005 to 2010, surface-water withdrawals decreased in the upper CRB and increased in the lower CRB (fig. 12*A*).

Over the 25-year period, total groundwater withdrawals fluctuated, by as much as 27 percent between 2005 and 2010, but overall decreased 30 percent (fig. 12*A*). In the Western United States, including the States in the CRB, groundwater is often used for irrigation to supplement a shortfall in surface water (Arizona Department of Water Resources, 2016). Streamflow in the CRB from 2000 to 2005 was mostly lower than earlier years (table 2), and groundwater was used to make up the deficit to produce crops in the lower CRB.

In the CRB, reclaimed wastewater is used to supplement irrigation for golf courses, parks, cemeteries, and thermoelectric power generation cooling. Reclaimed wastewater used for irrigation in 1985 and 2010 was 41.8 and 150 taf, respectively (table 13). Nearly all reclaimed wastewater was used in the lower CRB (fig. 12*B*), especially in Arizona and Nevada. For irrigated agricultural acres in the Phoenix area, about 20 percent of the irrigation water requirements were met by reclaimed wastewater (Middle and others, 2013). From 1985 to 2010, the lower CRB averaged 139 taf, with the largest reported use (205.75 taf) in 1990 (fig. 12*B*). In the upper CRB, reclaimed wastewater averaged 0.86 taf and peaked in 2010, when 1.31 taf was used mostly to irrigate golf courses.

Irrigated lands are reported according to the type of irrigation system that is used and are classified into surface (flood), sprinkler, or micro-irrigation. Total irrigated lands in the CRB averaged about 2.7 million acres, and more irrigated lands were consistently located in the upper CRB. In descending order, the States with the most irrigated lands, entirely within the CRB, were Arizona, Colorado, Wyoming, Utah, California, New Mexico, and Nevada. The upper CRB averaged 56 percent of total irrigated lands and ranged from about 1.71 million acres (1995) to 1.46 million acres (1990). The lower CRB decreased from about 1.22 million acres in 1990 to 1.15 million acres in 2010. In 1985 and 1990, the number of irrigated acres in the upper and lower CRB remained fairly steady, but in 1995 total irrigated lands in the upper CRB increased by about 0.15 million acres, and decreased by 0.34 million acres in the lower CRB. Since the peak in 1995, total irrigated lands have decreased in the CRB (table 13; fig 13). Far more lands were irrigated with surface (flood) systems in the CRB, comprising from 77 to 87 percent of total irrigated lands. Micro-irrigation systems are predominantly in the lower CRB, mostly in Arizona.

Surface- or flood-irrigation systems were the predominant system to irrigate agricultural and turf acres in the CRB (table 13; fig. 13). From 1985 to 2010, the flood systems decreased and sprinkler systems increased, but overall the flood systems still represented from 73 to 87 percent of total irrigated lands in the CRB. The upper CRB is predominantly flood irrigated and those flood-irrigated acres accounted for 40 to 50 percent of the CRB total irrigated acres. In 1985, the upper CRB had over 10 times more flood-irrigated acres than sprinkler, and in 2010 there were only about three times as many. In the lower CRB, flood-irrigated lands remained steadier over time. Lands using micro-irrigated systems are small in the upper CRB, less than 1,500 acres reported in 1995, 2005, and 2010. However, the lower CRB showed an increase in micro-irrigated acres; with 0 acres up until 1990 and then more than 28,000 acres in 2010 (table 13).

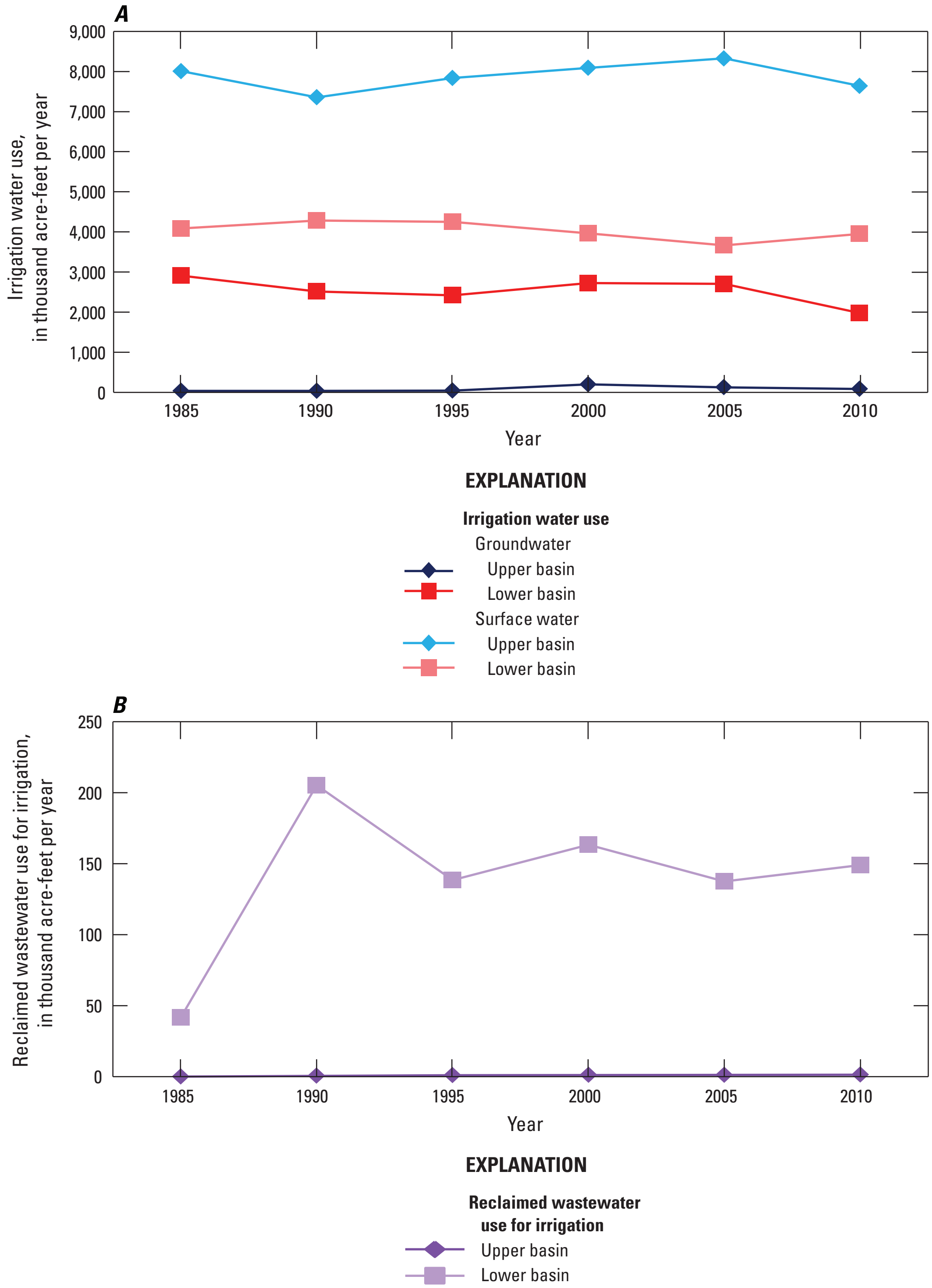


Figure 12. Fresh water (*A*) and reclaimed wastewater (*B*) used for irrigation in the upper and lower Colorado River Basin, Southwestern United States, 1985–2010.

Table 13. Irrigation withdrawals, consumptive use, and irrigated acres by system type in the upper and lower Colorado River Basin and in States included in the Colorado River Basin, Southwestern United States, 1985–2010.

[Upper and lower Colorado River Basin and States included in the Colorado River Basin are shown in figure 1]

Colorado River Basin	Withdrawals, in thousands of acre-feet					Irrigated lands, in thousands of acres			
	Ground-water	Surface water	Total withdrawals	Consumptive use	Reclaimed wastewater	Sprinkler	Flood	Micro-irrigation	Total
					1985				
Upper basin	38.13	8,005.04	8,043.16	2,486.40	0.07	111.76	1,344.79	0	1,456.55
Lower basin	2,905.43	4,084.80	6,990.23	4,050.67	41.73	222.62	956.62	0	1,179.24
Total	2,943.56	12,089.84	15,033.39	6,537.07	41.80	334.38	2,301.41	0	2,635.79
					1990				
Upper basin	36.11	7,354.40	7,390.51	2,509.74	0.50	233.00	1,326.07	0	1,559.07
Lower basin	2,514.73	4,281.68	6,796.41	4,561.49	205.24	233.36	982.33	0	1,215.69
Total	2,550.84	11,636.08	14,186.92	7,071.23	205.75	466.36	2,308.40	0	2,774.76
					1995				
Upper basin	41.50	7,838.81	7,880.30	2,596.12	1.00	236.03	1,471.96	0.12	1,708.11
Lower basin	2,420.95	4,249.35	6,664.61	4,402.22	138.44	214.34	952.38	16.34	1,183.06
Total	2,462.44	12,088.16	14,544.92	6,998.35	139.44	450.37	2,424.34	16.46	2,891.17
					2000				
Upper basin	197.31	8,091.98	8,289.29	2,176.98	1.12	289.25	1,193.35	0.00	1,482.60
Lower basin	2,725.96	3,960.48	6,686.44	4,812.53	163.24	229.92	962.20	14.33	1,206.45
Total	2,923.27	12,052.47	14,975.73	6,989.51	164.36	519.17	2,155.55	14.33	2,689.05
					2005				
Upper basin	124.53	8,325.57	8,449.80	1,982.38	1.18	332.33	1,153.57	0.14	1,486.04
Lower basin	2,703.76	3,665.29	6,369.05	4,565.26	137.48	264.39	868.13	21.35	1,153.87
Total	2,828.29	11,990.85	14,818.85	6,547.64	138.66	596.72	2,021.70	21.49	2,639.91
					2010				
Upper basin	84.98	7,642.16	7,727.14	2,431.93	1.31	337.31	1,169.86	4.82	1,583.62
Lower basin	1,973.30	3,948.33	5,921.63	4,061.47	148.95	216.57	900.39	28.40	1,145.36
Total	2,058.23	11,590.49	13,648.77	6,493.40	150.26	553.88	2,070.25	33.22	2,657.35

Table 13. Irrigation withdrawals, consumptive use, and irrigated acres by system type in the upper and lower Colorado River Basin and in States included in the Colorado River Basin, Southwestern United States, 1985–2010.—Continued

State	Irrigation groundwater withdrawals, in thousands of acre-feet						Irrigation surface-water withdrawals, in thousands of acre-feet					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	2,797.75	2,304.44	2,335.44	2,665.53	2,612.80	1,898.85	3,385.61	3,638.50	3,501.06	3,079.02	2,891.05	3,223.41
California	24.80	133.02	15.68	0.00	0.00	0.00	503.07	537.84	611.35	743.40	625.27	573.48
Colorado	21.84	22.88	23.97	125.01	69.96	16.68	5,958.25	5,400.44	5,624.29	5,467.35	5,534.90	4,771.98
Nevada	40.84	44.39	34.98	22.62	21.84	27.46	73.25	51.79	33.52	26.04	15.35	6.52
New Mexico	30.14	24.58	32.88	31.32	61.60	38.94	446.20	445.42	369.12	331.61	349.64	368.01
Utah	19.93	18.21	14.21	13.95	14.98	15.44	794.68	654.70	764.16	889.47	1,168.49	991.08
Wyoming	8.26	3.32	5.29	64.84	47.12	60.90	928.78	907.39	1,184.65	1,515.57	1,406.16	1,656.00
Total	2,943.56	2,550.84	2,462.44	2,923.27	2,828.29	2,058.23	12,089.84	11,636.08	12,088.16	12,052.47	11,990.85	11,590.49

State	Irrigation total withdrawals, in thousands of acre-feet						Irrigation consumptive use, in thousands of acre-feet					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	6,183.36	5,942.94	5,830.81	5,744.54	5,503.85	5,122.26	3,550.03	3,987.25	3,806.04	4,263.41	4,093.34	3,552.21
California	527.87	670.86	627.03	743.40	625.27	573.48	350.25	476.54	501.03	522.76	426.19	[1]392.17
Colorado	5,980.09	5,423.32	5,648.26	5,592.37	5,604.56	4,788.67	1,255.59	1,253.61	1,398.50	1,456.44	1,222.47	937.28
Nevada	114.08	96.18	68.49	48.66	37.18	33.99	78.50	66.64	39.35	0.00	0.00	[1]26.16
New Mexico	476.35	470.00	402.00	362.93	411.24	409.28	230.30	273.28	227.39	134.25	224.32	235.07
Utah	814.61	672.90	778.38	903.41	1,183.46	1,006.51	593.15	491.15	419.78	0.00	0.00	663.73
Wyoming	937.04	910.71	1,189.94	1,580.41	1,453.28	1,716.90	479.25	522.76	606.25	612.66	581.31	686.77
Total	15,033.39	14,186.92	14,544.92	14,975.73	14,818.85	13,648.77	6,537.07	7,071.23	6,998.35	6,989.51	6,547.64	6,493.40

State	Total irrigated acres, in thousands of acres						Reclaimed wastewater, in thousands of acre-feet					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	1,023.01	1,042.20	1,013.19	1,005.44	978.94	993.16	32.13	202.44	129.05	159.32	134.90	144.42
California	104.30	133.10	124.10	145.75	121.71	109.49	4.54	0.00	0.00	0.00	0.00	0.00
Colorado	768.90	767.31	867.98	708.78	770.56	770.71	0.00	0.00	0.22	0.00	0.12	0.00
Nevada	26.53	22.50	18.70	12.88	9.16	10.85	5.07	3.18	8.56	3.46	2.17	1.47
New Mexico	99.07	113.75	91.17	92.62	102.31	100.09	0.00	0.00	0.00	0.00	0.00	0.00
Utah	292.78	272.81	283.70	333.74	306.69	331.94	0.07	0.12	1.60	1.58	1.58	4.37
Wyoming	321.20	423.09	492.33	389.84	350.54	412.74	0.00	0.00	0.00	0.00	0.00	0.00
Total	2,635.79	2,774.76	2,891.17	2,689.05	2,639.91	2,728.98	41.80	205.75	139.44	164.36	138.78	150.26

[1]Consumptive use from Simplified Surface-Energy Balance operational model.

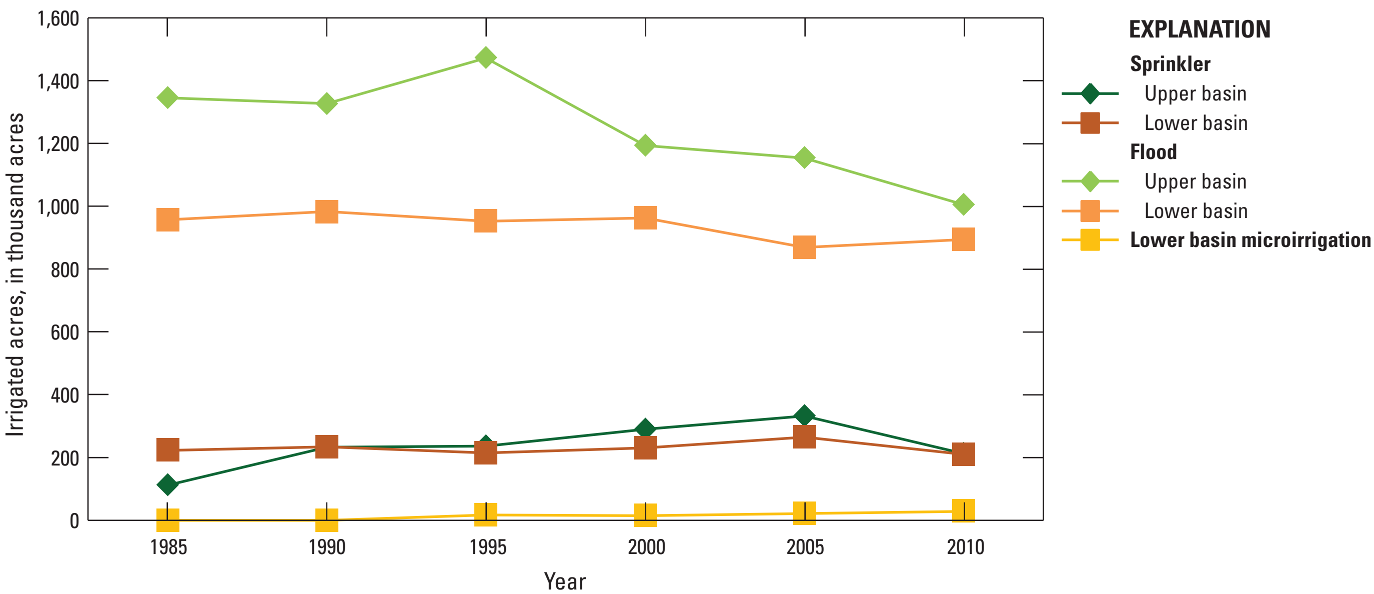


Figure 13. Irrigated acres in the upper and lower Colorado River Basin, Southwestern United States, 1985–2010.

As mentioned in section, "Methods," a new remote-sensing approach was used to estimate ETa (surrogate for consumptive use; CU) using the SSEBop model and 30-m Landsat satellite data (2010). A comparison of the CU estimates of irrigated croplands using SSEBop model data and modified Blaney-Criddle from USGS compilation work in the CRB (where both datasets were available) revealed on average a 25 percent difference. In both the upper and lower CRBs, the SSEBop model consistently estimated a lower CU (table 14). Comparison of CU from irrigated croplands in each of the CRB States (except California, Nevada, and New Mexico) showed lower SSEBop estimates that ranged from 3.6 to 59 percent difference. The Blaney Criddle estimates that were compared to the SSEBop data in this effort were derived by USGS compilation work, which included irrigated acres in 2010, and used various other climate data from weather stations in each drainage basin in the vicinity of crops. These Blaney Criddle data are not the same as Reclamation's Blaney Criddle data (Bruce and others, 2018), but these data were compared to the Reclamation data and explained in that companion report.

In addition to the long-term drought in the CRB, which has significantly reduced the amount of streamflow available for irrigation, there are anthropogenic reasons for the decrease in irrigation withdrawals. The U.S. Department of Agriculture Environmental Quality Incentives Program (EQIP) (Lee and Plant, 2013) has helped to facilitate the conversion of less-efficient surface-irrigation systems to more-efficient sprinkler systems in both the upper and lower CRB. In 2010, the EQIP provided subsidies to offset the cost of implementing and converting 5.2 million acres in the CRB (Lee and Plant, 2013). The increase in micro-irrigation acres, which can have efficiencies that exceed 90 percent (Lee and Plant, 2013) and require 20–50 percent less water than sprinkler systems (U.S. Environmental Protection Agency, 2015), is also contributing to reduced withdrawals in the lower CRB. Finally, both the decrease in withdrawals and number of irrigated acres in all CRB States is also a result of transfers (the largest of which are temporary) of water rights from agricultural uses to municipalities. These alternative agricultural transfer methods, such as rotational fallowing of irrigated lands when water rights are temporarily leased to municipalities (Colorado Water Institute, 2010), have had the effect of reducing irrigated acres and irrigation withdrawals.

Thermoelectric Power

Water for thermoelectric power is used offstream, via withdrawals, to generate electricity with steam-driven turbine generators. Withdrawals from 2000 to 2010 were reported by cooling-system type, either once-through or recirculating, and prior to 2000, withdrawals were reported by fuel type (fossil, nuclear, geothermal). For this report, withdrawals are distinguished only by water source (groundwater or surface water) and by location (upper and lower CRB). Reclaimed wastewater that is delivered to thermoelectric powerplants is combined with withdrawals from groundwater and surface water for a combined total use for thermoelectric power generation.

Total thermoelectric withdrawals, including reclaimed wastewater, for thermoelectric power generation averaged about 2 percent of total withdrawals for all categories in the CRB, and were greater in the upper CRB from 1985 to 2005

Table 14. Estimates of consumptive use from Blaney Criddle and Operational Simplified Surface Energy Balance (SSEBop) models in the upper and lower Colorado River Basin and States included in the Colorado River Basin, Southwestern United States, 2010.

[Upper and lower Colorado River Basin and States included in the Colorado River Basin are shown in figure 1. **Abbreviations:** taf, thousand acre-feet; na, not applicable]

Colorado River Basin	Blaney Criddle or compilation consumptive use, estimated (taf)	Consumptive use, SSEBop (taf)	Percent difference
Upper basin	2,431.93	1,974.56	20.8
Lower basin	4,061.47	3,126.12	26.0
Total	6,493.40	5,100.68	24.0
State			
Arizona	3,552.21	2,710.62	26.9
California[1]	na	392.17	na
Colorado[1]	937.28	904.56	3.5
Nevada[1]	na	[1]23.33	na
New Mexico[1]	235.07	104.17	55.7
Utah[1]	663.73	591.96	11.4
Wyoming[1]	686.77	373.88	59.0
Total	6,075.06	5,100.69	

[1]SSEBop data in only upper basin parts of New Mexico.

(fig. 14). In 2010, total thermoelectric withdrawals in the lower CRB exceeded those in the upper, but only by 11 taf, due to an increase in Arizona. On average, consumptive use for thermoelectric power accounted for about 80 percent of the total thermoelectric withdrawals from 1985 to 2010. Total consumptive use in the upper CRB was incomplete, and diverged from a trend that closely followed withdrawals from 1985 to 1995.

Surface water was the primary source for thermoelectric power in the upper CRB; for 1985–1995, surface water accounted for 100 percent of the withdrawals (fig. 14). Beginning in 2000, a small amount of groundwater (11 taf) was used in Utah in the upper CRB. In the lower CRB, and except for 1990, groundwater was the primary source for thermoelectric power, and for most years (1985, 1995, 2000, and 2005), groundwater accounted for about 65 percent of lower CRB thermoelectric withdrawals. Use of reclaimed wastewater was only documented in the lower CRB and for the Palo Verde nuclear generating station outside of Phoenix, Arizona. Reclaimed wastewater for thermoelectric power was first reported in 1995 and averaged 69 taf from 1995 to 2010. In the CRB overall, water use for thermoelectric power decreased after 2000, except for groundwater withdrawals in the lower CRB. Groundwater use for thermoelectric power increased by 53 taf after 1995 (table 15).

The Cameo coal-fired powerplant in Colorado (HUC 14010005; Colorado Headwaters-Plateau) was a facility with a “once-through” cooling system, which used a large amount of water to flow through the plant, but did not consumptively use a large amount of water. In this HUC, about 50 taf was used for thermoelectric power from 2000 to 2005, but the Cameo plant was reported to be decommissioned in 2011, and the 2010 reported withdrawals were nearly 0. The Cameo plant was one of a number of older coal-fired powerplants that was closed instead of being retrofitted or remodeled to comply with the EPA Mercury and Air Toxics Standards (U.S. Environmental Protection Agency, 2016), or in-state regulations on carbon dioxide emissions (Denver Business Journal, 2008). The closure decreases the need for withdrawals (and consumptive use) and is part of a trend towards retiring older (circa 1950 and 1960) coal-fired plants (U.S. Energy Information Administration, 2014). The remaining thermoelectric plants are more modern (post-1970) and generally have the more efficient recirculating cooling systems or have been converted to natural gas turbines that are cooled using air. Systems using recirculating water or air use less water overall. Some of the withdrawal and consumptive-use decreases in the upper CRB are attributed to a combination of coal-fired plant closures in Colorado and the conversion to air-cooled natural gas plants (fig. 14).

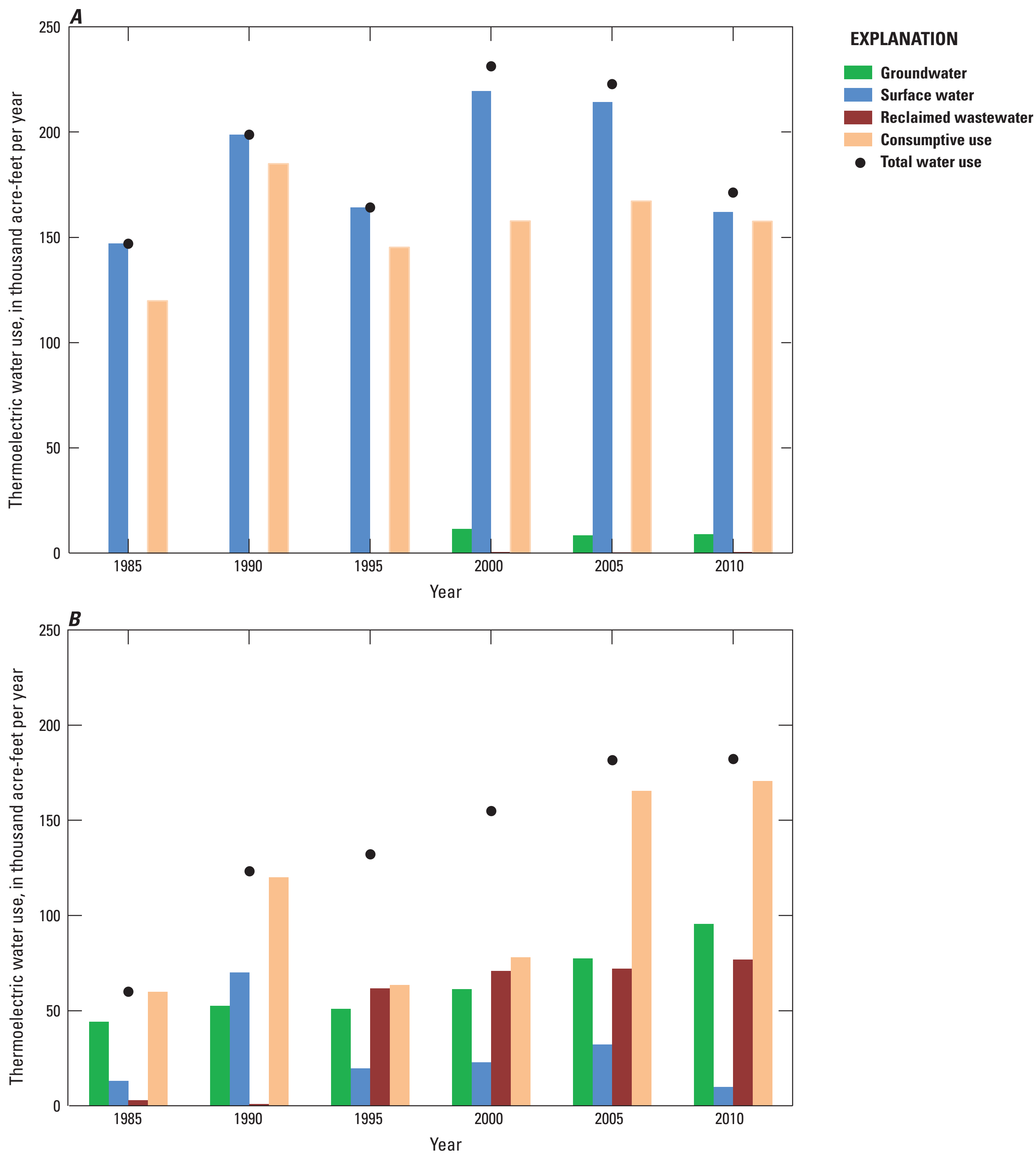


Figure 14. Water withdrawals and reclaimed wastewater deliveries for thermoelectric power generation in the (*A*) upper and (*B*) lower Colorado River Basin, Southwestern United States, 1985–2010.

Table 15. Thermoelectric withdrawals, deliveries, reclaimed wastewater and consumptive use, and power generation in the upper and lower Colorado River Basin and States included in the Colorado River Basin, Southwestern United States, 1985–2010.

[Upper and lower Colorado River Basin and States included in the Colorado River Basin are shown in figure 1. **Abbreviations:** GWh, gigawatt-hour; taf, thousand acre-feet]

Upper Colorado Basin	Ground-water (taf)	Surface water (taf)	Total withdrawals, reclaimed wastewater, and deliveries (taf)	Consumptive use (taf)	Total power (GWh)	Ground-water (taf)	Surface water (taf)	Total withdrawals, reclaimed wastewater, and deliveries (taf)	Consumptive use (taf)	Total power (GWh)	Ground-water (taf)	Surface water (taf)	Total withdrawals, reclaimed wastewater, and deliveries (taf)	Consumptive use (taf)	Total power (GWh)
	1985					1990					1995				
Upper basin	0.00	147.05	147.05	119.76	70,672	0.00	198.73	198.74	184.94	91,361	0.00	164.22	164.22	145.27	94,014
Lower basin	44.08	[1]13.15	[2]59.98	[1]59.84	28,196	52.42	[1]69.98	[2]123.29	[1]119.98	54,020	50.89	19.58	[2]132.14	63.45	62,360
Total	44.08	160.20	207.03	179.60	98,868	52.42	268.71	322.03	304.92	145,380	50.89	183.80	296.36	208.72	156,374
	2000					2005					2010				
Upper basin	11.49	219.55	[2]231.36	157.76	103,584	8.33	214.21	[2]222.84	167.14	105,088	8.82	162.02	[2]171.26	157.59	95,088
Lower basin	61.32	22.69	[2]154.88	78.12	78,759	77.35	32.18	[2]181.66	165.42	91,440	95.59	9.86	[2]182.26	170.59	75,492
Total	72.81	242.24	386.24	235.88	182,343	85.68	246.39	404.50	332.56	196,528	104.40	171.87	353.52	328.18	170,580

State	Thermoelectric groundwater withdrawals (taf)						Thermoelectric surface-water withdrawals (taf)					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	36.59	46.99	46.75	56.01	67.72	86.63	[1]28.41	[1]69.20	22.20	29.31	43.18	30.42
California	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Colorado	0.00	0.00	0.00	0.00	0.00	0.00	19.26	23.57	23.91	67.35	68.21	22.36
Nevada	8.35	4.94	4.15	5.31	4.85	5.54	7.98	21.47	19.58	22.11	15.22	3.41
New Mexico	0.03	0.48	0.00	0.00	4.78	3.42	53.65	44.86	51.96	50.50	50.96	47.38
Utah	0.00	0.00	0.00	11.49	8.33	8.82	21.78	74.63	33.64	31.24	31.30	31.02
Wyoming	0.00	0.00	0.00	0.00	0.00	0.00	29.12	34.98	32.51	41.72	37.52	37.28
Total	44.08	52.42	50.89	72.81	85.68	104.41	160.20	268.71	183.80	242.24	246.39	171.87

Table 15. Thermoelectric withdrawals, deliveries, reclaimed wastewater and consumptive use, and power generation in the upper and lower Colorado River Basin and States included in the Colorado River Basin, Southwestern United States, 1985–2010.—Continued

State	Thermoelectric total withdrawals, reclaimed wastewater, and deliveries (taf)						Thermoelectric consumptive use (taf)					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	64.10	116.19	128.98	154.50	177.47	193.25	64.10	112.88	60.29	82.24	166.77	184.30
California	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Colorado	19.26	23.57	23.91	67.35	68.21	22.36	15.64	18.80	18.47	0.00	18.77	22.32
Nevada	19.08	27.31	25.36	29.11	25.64	9.56	18.94	27.31	25.36	24.62	20.09	6.84
New Mexico	53.68	45.34	51.96	50.50	55.74	51.13	36.35	40.98	43.11	47.61	52.84	48.07
Utah	21.78	74.64	33.64	43.06	39.93	39.94	21.38	73.82	33.27	43.06	39.93	39.94
Wyoming	29.12	34.98	32.51	41.72	37.52	37.28	23.18	31.13	28.22	38.36	34.16	26.71
Total	207.03	322.03	296.36	386.24	404.50	353.52	179.60	304.92	208.72	235.88	332.56	328.18

State	Thermoelectric power (GWh)					
	1985	1990	1995	2000	2005	2010
Arizona	26,173	55,866	65,294	78,576	92,138	86,670
California	0	0	0	0	0	0
Colorado	9,961	12,353	12,511	14,079	15,041	14,112
Nevada	9,256	14,348	13,877	19,558	15,550	3,580
New Mexico	22,582	24,444	24,783	27,307	30,798	25,878
Utah	13,701	19,136	20,330	21,281	21,607	20,173
Wyoming	17,195	19,232	19,578	21,543	21,394	20,168
Total	98,868	145,380	156,374	182,343	196,528	170,580

[1]Includes some saline surface water in lower basin.

[2]Includes reclaimed wastewater and deliveries.

Power production was greater in the upper CRB where an average of 31,000 gigawatt hours (GWh) more power was produced from 1985 to 2000 as compared to the lower CRB. In 2005 and 2010, the average difference in power production was smaller, at about 17,000 GWh; however, the upper CRB continued to have more power generation. In both the upper and lower CRB, power generation increased from 1985 to 2005, following the pattern of increased demand from increasing populations. Power generation in both the upper and lower CRB decreased from 2005 to 2010.

Hydroelectric Power

Hydroelectric power is predominantly an instream water use because water is directed through turbines in dams located directly on streams or rivers. However, there are a few pumped storage generation facilities that pump water up-gradient (offstream) and allow it to flow back through the turbines when power is needed. These facilities are small, generating an average of 13 GWh, and for this report, the water use and power generation for these are combined with instream water use and power generation plants. For the most part, water used for hydroelectric power is non-consumptive; however, there are evaporative losses from reservoirs that are not accounted for in this report.

Water used for hydroelectric power, on average, accounted for 75 percent of total water use for all categories from 1985 to 2010. The largest amount of hydroelectric power water use and power generation occurred in 1985 (about 72,550 taf and about 21,600 GWh) (table 16; fig. 15), but since 1985, both total water use and power generation have decreased in the CRB with more than 36 percent less water use and nearly 50 percent less power generation in 2010, as compared to 1985. Both the upper and lower CRB showed similar upward and downward patterns in power generation over the 5-year cycles (fig. 15). In contrast, water use fluctuated in opposing directions of power generation during some years. Hydroelectric power generation decreased significantly in both the upper and lower CRB from 1985 to 1990. Since 1995, power generation decreased to about 11,180 GWh in 2010, and the water used to generate that power decreased after 2000 to about 46,080 taf in 2010.

The lower CRB had more hydroelectric power generation and associated water use than the upper CRB; however, the power generation in the upper CRB has been increasing as generation in the lower CRB was decreasing, to the extent that both were nearly equal in 2005 and 2010. The upper CRB has about twice the number of powerplants than the lower CRB, but generation capacity, primarily because of Hoover Dam, was consistently larger in the lower CRB. The hydroelectric facility in Hoover Dam, although de-rated in 2014 from the initial 2.074 GWh, as of 2015 had a listed generation capacity of 1.592 GWh (E&E Publishing, 2014; Arizona Water Resource, 2015). The de-rating was due to declining inflows and water levels in Lake Mead caused by prolonged drought in the CRB. The hydroelectric plant at Hoover Dam continues to be the largest rated hydroelectric plant in the CRB, but because of the current CRB drought conditions, power production from the plant is expected to continue to fall.

Water used to generate power in the upper and lower CRB has nearly mimicked the pattern of power generated (fig. 15), especially in the upper CRB. Hydroelectric water use in the upper CRB was largest in 1985 (23,960 taf) and decreased in 1990 (13,340 taf), then increased again in 1995 and decreased to 15,430 taf in 2010. Mean annual streamflow in the Colorado River (table 2; fig. 15) at the Lees Ferry streamgage mimics the trends in water used to generate hydroelectric power in the upper CRB. There was less of a consistent pattern for water used for hydropower generation and streamflow in the lower CRB, which most likely reflects regulation of water releases from Lakes Powell and Mead.

Water used for offstream power generation facilities include water that is pumped to upstream locations, stored, and used to generate power at a later date. This type of water use was reported in 1995 in Colorado (about 500 taf), California (about 350 taf), and Arizona (about 31 taf). From 2000 to 2010, these uses were reported in only Utah (about 35, 51, 33 taf, respectively). These values do not reflect interbasin transfers. Power generation at offstream facilities represented a very small percentage of total power generation for those years in those States. All of these offstream power generation water use and power values are included in the totals.

The NWUSP does not compute evaporative losses; however, Reclamation accounts for it in the Consumptive Use and Losses reports for the upper CRB (Bureau of Reclamation, 2012b). Reservoir evaporation for the three largest bodies of water in the lower CRB (Mead, Mohave, and Havasu) were computed using data from Reclamation’s Hydrologic Database System for years from 1985 to 2010 (Rich Eastland, Reclamation, written commun., 2016). Total lower CRB reservoir evaporation averaged 1,165 taf and ranged from a low of about 900 taf in 2010 to about 1,330 taf in 1985. Lake Mead accounted for no less than about two-thirds of the total lower CRB reservoir evaporation, followed by Lake Mohave, then Lake Havasu.

Table 16. Water use and power generation at hydroelectric power facilities in the upper and lower Colorado River Basin and States included in the Colorado River Basin, Southwestern United States, 1985–2010.

[Upper and lower Colorado River Basin and States included in the Colorado River Basin are shown in figure 1. Values may not sum to totals because of independent rounding. **Abbreviations:** GWh, gigawatt-hour; taf, thousand acre-feet]

Colorado River Basin	1985			1990			1995		
	Total hydropower-generation water use (taf)	Total power generation (GWh)	Total number of power plants	Total hydropower-generation water use (taf)	Total power generation (GWh)	Total number of power plants	Total hydropower-generation water use (taf)	Total power generation (GWh)	Total number of power plants
	1985			1990			1995		
Upper basin	23,956.04	9,916.62	20	13,344.48	4,764.73	21	[1]20,044.53	[1]7,220.80	22
Lower basin	48,590.66	11,686.02	10	38,894.84	6,642.31	23	[1]26,254.95	[1]9,740.12	19
Total	72,546.70	21,602.64	30	52,239.33	11,407.04	44	[1]46,299.49	[1]16,960.92	41
	2000			2005			2010		
Upper basin	[1]17,583.30	[1]6,232.21	20	[1]15,423.48	[1]4,747.58	24	[1]15,438.12	[1]5,340.88	23
Lower basin	34,901.73	7,500.47	12	28,194.21	5,044.72	12	30,638.78	5,841.98	12
Total	[1]52,485.03	[1]13,732.68	32	[1]43,617.70	[1]9,792.30	36	[1]46,076.90	[1]11,182.86	35

State	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
	Total hydroelectric generation water use (taf)[1]						Total hydroelectric generation power (GWh)[1]					
Arizona	40,666.72	35,648.79	[1]23,726.67	25,163.68	22,156.67	23,218.22	13,944.41	8,179.62	[1]7,959.86	8,307.52	5,822.46	6,710.34
California	14,601.70	7,692.51	[1]7,119.01	7,758.02	6,163.12	6,375.91	1,094.25	489.79	[1]460.19	516.20	410.08	414.85
Colorado	6,415.31	3,554.41	[1]6,380.33	5,809.18	4,618.03	4,926.63	1,574.15	715.49	[1]1,551.27	988.51	923.58	1,136.83
Nevada	9,264.73	3,437.17	5,639.43	10,479.11	8,129.10	9,224.23	4,308.66	1,597.26	6,270.91	3,286.27	2,111.61	2,388.34
New Mexico	0.00	401.18	1,187.54	1,250.53	579.58	652.02	0.00	111.68	121.34	140.50	65.09	73.15
Utah	1,358.71	710.55	1,436.07	[1]1,216.51	[1]1,169.21	[1]1,087.90	667.45	284.20	535.29	[1]436.43	[1]400.03	[1]421.11
Wyoming	239.54	794.72	810.44	808.01	801.97	592.00	13.72	29.00	62.06	57.25	59.45	38.24
Total	72,546.70	52,239.33	[1]46,299.49	[1]52,485.03	[1]43,617.70	[1]46,076.90	21,602.64	11,407.04	[1]16,960.92	[1]13,732.68	[1]9,792.30	[1]11,182.86

[1]Includes some water used for off-stream power generation (pumped storage).

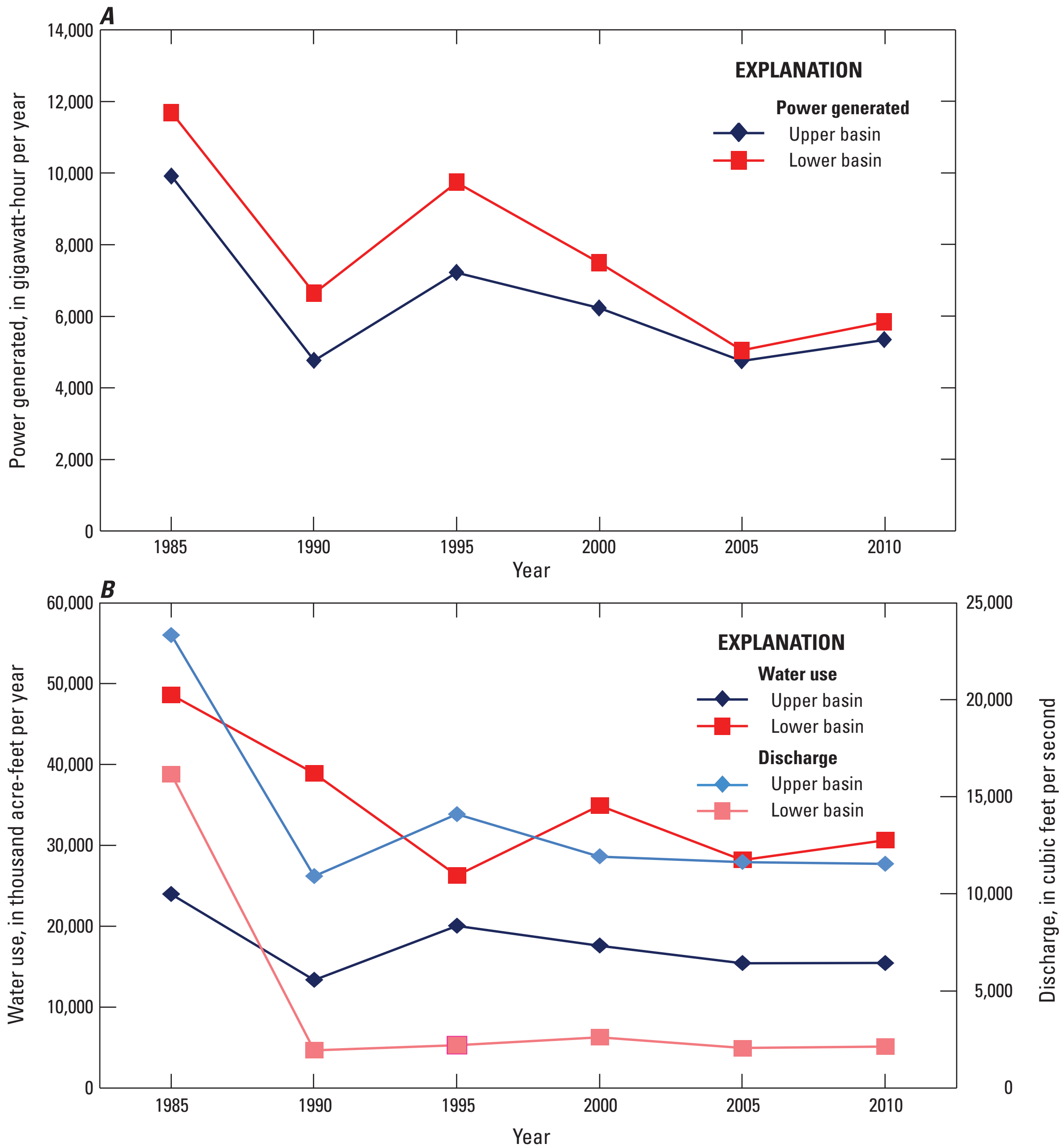


Figure 15. Power generated from hydroelectric facilities (*A*), and water used at hydroelectric facilities and discharges to the Colorado River (*B*) in the upper and lower Colorado River Basin, southwestern United States, 1985–2010.

Wastewater Returns

Water that has been treated and released by a municipal or industrial facility, either privately or publicly owned, is considered wastewater return. Reclaimed wastewater is the treated wastewater that has been diverted for a beneficial use rather than being returned directly to the hydrologic system. These data were not reported in all drainage basins of the study area.

Overall, wastewater returns in the CRB increased from 1985 to 2010 nearly six-fold (fig. 16; table 17). Wastewater returns for 1985 and 1995 are admittedly low, likely because of missing industrial wastewater return data on the USGS database for facilities in Colorado for those years. From 2000 to 2010, total CRB wastewater returns decreased only about 2 percent, concurrent with a population growth of about 27 percent (table 5). Since 2000, CRB States ranked (in descending order) for volume of wastewater return are Colorado, Arizona, Nevada, New Mexico, Wyoming, Utah, and California. Again, only the parts of California within the CRB are considered for this statement.

After 2000, wastewater returns in the upper CRB decreased, and withdrawals for public supply decreased or remained steady, even though population increased. Most of the wastewater returns in the upper CRB are from plants in Colorado (table 17). One explanation for the seemingly diverging patterns since 2000, with decreasing wastewater returns and increasing populations is how stormwater flows were reported at municipal wastewater facilities. For example, Grand Junction in Colorado made changes to split stormwater flows from municipal effluent flows—thereby eliminating stormwater flows being piped and treated in the publicly owned wastewater treatment plants, and reducing the wastewater returns that were reported. Stormwater flows are sent to retention ponds where sediment is allowed to settle before returning to the Colorado River (Jay Vancil, City of Grand Junction, oral commun., 2015). The separated stormwater flows were not accounted for in the wastewater return estimates.

Wastewater returns in the lower CRB also increased from 1985 to 2010 (fig. 16; table 17), similar to trends in the upper CRB, including the lower estimates in 1985 and 1995. Wastewater returns from lower CRB treatment facilities increased about 55 percent from 1995 to 2010. The largest population increase in the lower CRB occurred from 1995 to 2000 (24 percent), which corresponded with an increase in wastewater returns of 17 percent.

Reclaimed wastewater use was first reported in 1995 and ranged from a high of 230 taf in 1990 to a low of 102 taf in 2000 (fig. 16). Reclaimed wastewater use has been incomplete or inconsistently reported in past summaries, but is becoming an increasingly important source of water, especially in Arizona and Nevada (table 17). Much more reclaimed wastewater use was reported in the lower CRB than the upper CRB, primarily in Arizona and Nevada (table 15). Reclaimed wastewater use will undoubtedly increase in the future, especially for major metropolitan areas in the Western United States. In arid to semi-arid areas experiencing prolonged droughts, cities are implementing cost and water-saving measures such as those already used in Las Vegas, Nevada, and Tucson and Phoenix, Arizona. Facilities in Las Vegas recycles and reuses 94 percent of the water that is put down drains (Fishman, 2014), with most returns going back to Lake Mead via the Las Vegas Wash. Tucson and Phoenix reuse reclaimed wastewater for irrigating golf courses, parks, and crops, and in Tucson, providing reclaimed wastewater for industrial use (City of Phoenix, 2015; City of Tucson, 2015). In addition to irrigation and industrial uses, reclaimed water in the lower CRB is used extensively for cooling water at the Palo Verde Nuclear Generating Station (U.S. Environmental Protection Agency, 2015).

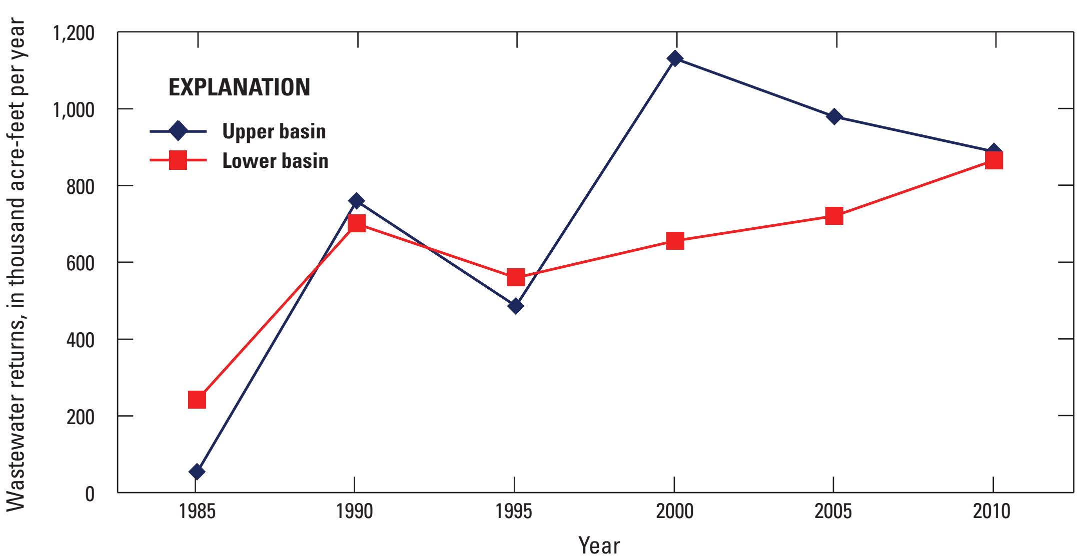


Figure 16. Wastewater return to the upper and lower Colorado River Basin, Southwestern United States, 1985–2010.

Table 17. Wastewater returns and reclaimed wastewater use in the upper and lower Colorado River Basin and States included in the Colorado River Basin, Southwestern United States, 1985–2010.

[All values are in thousands acre-feet (taf). Upper and lower Colorado River Basin and States included in the Colorado River Basin are shown in figure 1. Values may not sum to totals because of independent rounding]

Colorado River Basin	1985		1990		1995		2000		2005		2010	
	Wastewater return flow	Reclaimed wastewater	Wastewater return flow	Reclaimed wastewater	Wastewater return flow	Reclaimed wastewater	Wastewater return flow	Reclaimed wastewater	Wastewater return flow	Reclaimed wastewater	Wastewater return flow	Reclaimed wastewater
Upper basin	53.42	0.00	759.83	0.50	485.75	1.96	1,129.86	0.00	979.16	0.00	887.93	0.81
Lower basin	241.40	0.00	700.20	257.73	560.05	242.82	656.26	114.33	720.62	117.40	865.39	147.58
Total	294.82	0.00	1,460.03	258.23	1,045.80	244.78	1,786.07	114.33	1,699.78	117.40	1,753.32	148.39

State	Wastewater returns from public facilities						Reclaimed wastewater from public facilities					
	1985	1990	1995	2000	2005	2010	1985	1990	1995	2000	2005	2010
Arizona	139.92	611.53	401.99	396.48	413.71	471.60	0.00	253.09	234.15	96.50	101.18	131.40
California	3.43	3.58	4.45	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Colorado	33.28	699.77	463.24	1,004.43	870.78	725.87	0.00	0.00	0.22	0.00	0.00	0.00
Nevada	91.89	116.48	142.76	222.06	264.97	309.33	0.00	4.85	8.56	17.84	16.22	16.98
New Mexico	8.97	8.98	13.34	115.12	115.15	175.32	0.00	0.17	0.24	0.00	0.00	0.00
Utah	12.39	13.93	14.37	11.20	15.56	17.12	0.00	0.12	1.60	0.00	0.00	0.00
Wyoming	4.94	5.75	5.65	35.66	19.62	54.08	0.00	0.00	0.00	0.00	0.00	0.00
Total	294.82	1,460.02	1,045.80	1,786.07	1,699.78	1,753.32	0.00	258.23	244.78	114.33	117.40	148.39

Summary

The Colorado River Basin (CRB) drains 246,000 square miles and includes parts of California, Colorado, Nevada, New Mexico, Utah, and Wyoming, and all of Arizona. It flows into Mexico at the terminus of its 1,450-mile course. This report is a compilation of water-use estimates for water uses in drainage basins (HUC 8) of the CRB from 1985 to 2010. The U.S. Geological Survey (USGS) defines *water use* as the interaction of humans with the hydrologic cycle, and includes the movement or disposition of water via withdrawals, deliveries, consumptive use, reclaimed wastewater, instream use (hydroelectric), and wastewater returns. Water-use data are reported for public supply, domestic, commercial, industrial, irrigation, livestock, mining, aquaculture, hydroelectric and thermoelectric power generation, and wastewater returns. *Water use* means water withdrawals from groundwater or surface-water sources (including an interbasin transfer), of fresh or saline quality, and deliveries to a customer (i.e. domestic homes from public suppliers), and water that is temporarily unavailable (consumptive use, such as evapotranspiration, or water in plants or animals), and wastewater returns to a water resource. Water transported outside of the CRB (interbasin transfers) is considered exported and is not accounted for in any category of use within the CRB, but are summarized and included in total water-use discussions because it is a type of diversion.

Methods used to compile water-use data in the Colorado River Basin Focus Area Study are the same as those used for the USGS national water-use compilations. The national compilations contain spatially varying aggregated data using information collected by numerous private, local, State, and Federal entities, and standard methods and techniques to compile and aggregate these data have been in use since 1995. Both reported and estimated withdrawal data are aggregated in this report by category, by State, and for the upper and lower CRB (based on HUC-8 level data) for 1985–2010, in 5-year intervals.

Total withdrawals in the CRB (excluding interbasin transfers) averaged about 17 million acre-feet (maf) from 1985 to 2010, peaking at about 17.76 maf in 2000, and reaching the lowest level of 16.43 maf in 1990. More surface water was used in the CRB than groundwater, averaging about 78 percent of the total, and its use increased less than 2 percent over 25 years, while groundwater accounted for the remaining 12 percent of the total withdrawals. However, over the same time period, groundwater withdrawals decreased about 12 percent in the CRB. Total withdrawals (excluding interbasin transfers) were about evenly split between the upper and lower CRB. The upper CRB was almost solely dependent on surface water (98 percent), and although the lower CRB withdrew more surface water than groundwater, in some years, groundwater accounted for nearly one-half the total withdrawals. When interbasin transfers are included, the lower CRB accounted for 55–58 percent of total withdrawals in the CRB.

Interbasin transfers have a substantial effect on streamflow in the Colorado River. There were 34 interbasin transfers that conveyed approximately 5,830, 5,194, and 5,183 thousand acre-feet (taf) out of the CRB in 2000, 2005, and 2010, respectively. In each of these 3 years, the Colorado River Aqueduct and All-American Canal conveyed from 4,130 to 4,896 taf and accounted for 80–84 percent of total interbasin transfers, more than any of the other interbasin transfers. The Colorado River Aqueduct sends water primarily to Southern California for municipal use, serving about 19 million people in 15 cities. The All-American Canal provides water to irrigate nearly 500,000 acres in the Imperial Valley in California. Transfers to the Colorado Front Range were from 10 to 12 percent of total interbasin transfers. Water conveyed through canals in Wyoming in each of the 3 years was less than 20 taf, the smallest amount of water transferred out of the CRB.

Intrabasin transfers are conveyances of water across drainage basins or State boundaries within the CRB, but the water does not leave the CRB. There are many intrabasin transfers in the CRB, but this report lists 11 intrabasin transfers, mostly in Colorado, but the largest is the Central Arizona Project (CAP), which conveyed more than 1,000 taf of water each year in 2000, 2005, and 2010 to irrigate nearly 1 million acres in Maricopa, Pinal, and Pima Counties, and to provide municipal water for Phoenix and Tucson. In 2010, interbasin and intrabasin transfers were 24 and 11 percent of the total water withdrawals (21.7 maf) in the CRB, respectively. The larger transfers were in the lower CRB.

Total population in the CRB increased from 4.56 to 9.44 million people from 1985 to 2010. Most of the population was located in the lower CRB, with 86 percent of the total in 1985 and 90 percent of the total in 2010. Arizona accounted for at least 67 percent of the total population in the CRB over the 25-year period of evaluation. Las Vegas, Phoenix, and Tucson are the largest cities in the CRB. The largest percentage of increase (23 percent) in the total population in the CRB occurred from 1995 to 2000.

Public-supply withdrawals provided most of the potable water supply, which could be used for indoor or outdoor purposes. Total withdrawals for public supply in the CRB averaged about 1,632 taf from 1985 to 2010. Most public-supply withdrawals occurred in the lower CRB and surface-water was the predominant source. Arizona's public-supply population averaged 67 percent of the total public-supply population in the CRB from 1985 to 2010. Deliveries from public-supply systems to domestic users are reported by drainage basin for all years in this report. However, deliveries to commercial, industrial, and thermoelectric users are reported for all areas from 1985 to 1995 and for some drainage basins for 2000–2010.

Total domestic withdrawals in the CRB (deliveries plus self-supply withdrawals) increased from 93 percent from 1985 to 2010. Domestic gallons per-capita daily (gpcd) in the CRB ranged from about 144 gpcd in 1985 to about 121 gpcd in 2000. When comparing gpcd rates for the upper and lower CRB, people in the lower CRB, on average, used about 5 gpcd less water for domestic purposes (128 gpcd) as compared to those in the upper CRB (133 gpcd).

Per-capita daily use for the entire CRB fluctuated between the reporting years, but decreased overall, indicating that people used less water per person in 2010 as compared to 1985. Arizona accounted for two-thirds of the total public-supply withdrawals (excluding interbasin transfers), followed by Nevada, which averaged 23 percent of total withdrawals from 1985 to 2010. Combined, these two States averaged about 87 percent of total public-supply withdrawals in the CRB.

The CRB is not a highly industrialized region in the United States; however, 111 food and other manufacturing facilities, located in Arizona, and industrial water use associated with mining operations in Utah and New Mexico, were reported for 2010. In the upper CRB, industrial water use was reported for 20 facilities, but more of the total industrial water use occurred in the lower CRB. Groundwater was the predominant source for industrial supply in the lower CRB. Some saline groundwater withdrawals were reported in 1985, 2005, and 2010.

Total commercial use (self-supply withdrawals plus public-supply deliveries) in the CRB ranged from a low of about 195 taf (1985) to about 348 taf (2010), and 85 percent of commercial water was provided through public-supply deliveries; however, data are incomplete for commercial deliveries from public supply in California, Colorado, New Mexico, and Wyoming. Eighty-eight percent of total commercial water use in the CRB was reported as groundwater sources in the lower CRB.

From 1985 through 1995, livestock water use included some aquaculture use, which entails the raising of fish and shellfish for food, restoration, conservation, or sport. After 2000, aquaculture water use was reported as a separate category. Livestock water use peaked in 1990, but these values include aquaculture use of some unknown quantity. From 2000 to 2010, livestock water use increased slightly in the lower CRB, where cattle and sheep populations outnumbered populations in the upper CRB. More surface water was used for livestock (probably for aquaculture) from 1985 and 1995, but after 2000, more groundwater was used. Arizona had the largest livestock use of all CRB States.

On average, aquaculture used more water in the upper CRB than the lower from 2000 to 2010; groundwater accounted for two-thirds of the total water used for aquaculture during those years. Utah, Arizona, and Colorado had the three largest withdrawals for aquaculture of the seven CRB States. Overall, total aquaculture water use from 2000 and 2010 in the upper CRB slightly increased while in the lower CRB it slightly decreased, possibly due to the larger number of hatcheries in the upper CRB.

Water use for mining, including saline water, was greater in the lower CRB, and in select years (1990, 1995, and 2005), lower CRB withdrawals were more than twice the upper CRB withdrawals. Groundwater was the primary source for mining in the lower CRB. Mining withdrawals, generally freshwater, across the CRB have decreased since 1990. Saline groundwater, often a byproduct of the oil and gas drilling process, was used predominantly for reinjection into oil and gas wells in the upper CRB.

Irrigation used more surface water than groundwater in both the upper and lower CRB, and in the upper CRB, irrigation comprised about 98 percent of the total withdrawals (excluding interbasin transfers, and hydroelectric, which is an instream use) (1985–2010), whereas in the lower CRB, irrigation comprised an average of 61 percent of total withdrawals. From 1990 to 2005, surface-water withdrawals increased in the upper CRB and decreased in the lower CRB. Then, after 2005, the trends reversed and surface-water withdrawals decreased in the upper CRB and increased in the lower CRB. Groundwater withdrawals increased in both the upper and lower CRB from 1995 to 2005 then decreased in 2010.

Reclaimed water is used to irrigate golf courses, parks, cemeteries and some crops, as well as for groundwater recharge and industrial cooling. Use of reclaimed water increased from 1985 to 2010. More reclaimed wastewater is used in the lower CRB; however, its use in the upper CRB was on the rise, and its use was mostly for golf courses. Although some drainage basins in the upper CRB are missing estimates from 2000 to 2005, irrigation consumptive-use estimates are available for all years for the lower CRB. From 1985 to 1995, and for 2010, consumptive use was greater in the lower CRB. However, in the upper CRB more than twice the amount of water was applied than was consumptively used. Consistent with decreasing withdrawals in the lower CRB since 2000, consumptive use estimates have also decreased.

The average number of irrigated acres (1985–2010) for any system type (flood, sprinkler, or micro-irrigation) was greater in the upper CRB than in the lower CRB. Irrigation systems in the upper CRB moved towards more efficient sprinkler systems from 1985 to 2010. In 1985, the upper CRB had 10 times more acres irrigated by flood systems than sprinkler systems; and, in 2010, there were five times as many flood-irrigated acres as sprinkler acres. After 1995, upper CRB flood-irrigated acres decreased sharply and sprinkler acres increased. Use of micro-irrigated systems in the upper CRB was small, and the lower CRB has had an increase in micro-irrigated acres over the 25 years.

Total water withdrawals for thermoelectric power generation were greater in the upper CRB from 1985 through 2005. By 2010, withdrawals in the lower CRB exceeded withdrawals in the upper CRB, but only slightly. Thermoelectric consumptive use in the lower CRB closely follows the trends for total thermoelectric withdrawals. Thermoelectric consumptive use in the upper CRB was incomplete, and after 2000 diverged from a pattern that closely followed withdrawals from 1985 to 1995. Surface water was the primary water source for thermoelectric use in the upper CRB, while groundwater was the primary source for thermoelectric in the lower CRB (excluding 1990). During 1985 and 1995–2005, groundwater accounted for about 65 percent of the water used for thermoelectric in the lower CRB. Reclaimed water use for thermoelectric power generation was only documented for the Palo Verde nuclear generating station in the lower CRB outside of Phoenix, Arizona. Water use for this facility was first reported in 1995 and averaged 69 taf from 1995 to 2010. In the CRB overall, water use for thermoelectric generation decreased after 2000, except for groundwater withdrawals in the lower CRB. Power production at thermoelectric plants was greater in the upper CRB from 1985 to 2000; after 2005, the difference in power production from the upper and lower CRB was small with slightly more use in the upper CRB. In both the upper and lower CRB, water use for power generation increased from 1985 to 2005.

From 1985 to 2010, water use for hydroelectric power generation decreased. Overall, there was more power generation and water use in the lower CRB, but power generation in the upper CRB increased from 1985 to 2010 and decreased in the lower CRB. During 2005 and 2010, water used for power generation was about equal in the upper and lower CRB. The upper CRB had more than twice the number of powerplants as compared to the lower CRB, but the generation capacity, primarily because of Hoover Dam, and water use was larger in the lower CRB. Water used for offstream power generation facilities included water pumped to upstream locations, stored, and used to generate power later. Offstream water use was reported in California and Colorado, and a small amount was reported for Arizona in 1995 and for Utah in 2000–2010.

Overall, wastewater returns in the CRB increased nearly six-fold from 1985 to 2010. In 1985 and 1995, wastewater returns were low, likely because of missing large facilities in the database for those years. From 2000 to 2010, total CRB wastewater returns increased about 2 percent, corresponding with a 27 percent increase in population. Since 2000, CRB States ranked (in descending order) for wastewater returns were Colorado, Arizona, Nevada, New Mexico, Wyoming, Utah, and California. Overall, wastewater returns in the lower CRB increased from 1985 to 2010.

Reclaimed wastewater is derived from wastewater treatment plants and used for industrial, irrigation, or thermoelectric cooling purposes. Reclaimed wastewater was first reported in 1995 and ranged from a high of 230 taf in 1990 to a low of 102 taf in 2000. Reclaimed wastewater use was incomplete or was inconsistently reported, but is becoming an increasingly important source of water. The lower CRB used more reclaimed wastewater than the upper CRB, nearly all of it in Arizona and Nevada. Facilities in Las Vegas recycled 94 percent of their municipal water; Tucson and Phoenix used reclaimed wastewater for irrigating golf courses, parks, and crops; and Tucson also used reclaimed wastewater for industrial purposes. In addition to irrigation and industrial uses, reclaimed water in the lower CRB is used extensively as cooling water at the Palo Verde Nuclear Generating Station in Arizona.

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Glossary

Terminology used in this report, as well as Bruce and others (2018): U/R, shared USGS/Reclamation; U, USGS only; R, Reclamation only.

- **Basin Transfers**
  - Diversion from the Colorado River System to areas outside or within the drainage area. These diversions are reported as exports regardless of the type of use. The CUL Report divides exports into two subcategories, (1) outside system (interbasin) and (2) within system (intrabasin). The outside system includes the water that is removed from the Colorado River System while the within system subcategory includes water that is moved between reporting areas but does not leave the Colorado River System. The within system total will always be zero since an export from one reporting area is an import to another. The actual consumptive use of the Exports within system water is included in other categories such as Irrigated Agriculture. (see trans-basin diversions) **(R)**
  - The human-induced movement of surface water from one hydrologic unit to another, other than the natural downstream surface-water drainage in a stream network. Hydrologic units are defined under the Watershed Boundary Dataset (WBD, http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/water/watersheds/dataset/?cid=nrcs143_021616). Depending on scale (ex. 2-digit versus 8-digit Hydrologic Unit Codes – HUCs), basin transfers could be designated as interbasin (outside of) or intrabasin (within) with respect to the designated Hydrologic Unit scale. **(U)**
- **Beneficial Consumptive Use (R)**
  - The consumption of water brought about by human endeavors including use of water for municipal, industrial, agricultural, power generation, export, recreation, fish and wildlife, and other purposes, along with the associated losses incidental to these uses.
- **Beneficial Use (U)**
  - A legal term used to denote the authority or right to utilize real property, including water, in any lawful manner to gain a profit, advantage, or enjoyment from it. In a non-legal sense, it is the use of water to benefit people or nature and therefore, satisfies some or all of the needs for a particular type of use, such as irrigation.
- **Colorado River Basin**
  - Defined in the Colorado River Compact of 1922 as all of the drainage area of the Colorado River System and all other territory within the United States of America to which waters of the Colorado River System shall be beneficially applied. **(R)**
  - The region encompassed by all natural surface-water hydrologic drainage areas that fall within Hydrologic Unit Codes (HUCs) that begin with ‘14’ or ‘15’ as defined in the Watershed Boundary Dataset (WBD, see definition for Hydrologic Unit). Publication describing the Watershed Boundary Dataset can be found at http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_021581.pdf. **(U)**
- **Colorado River Basin Tributaries**
  - All rivers or streams that are located in hydrologic basins that naturally drains into the Colorado River. These areas entail all drainages that have HUCs that begin with ‘14’ or ‘15’ in the first two-digit numbering scheme. **(U)**
  - Reclamation excludes the main stem (mainstream) below Lee Ferry from the above definition. **(R)**

- **Colorado River System (R)**
  - Defined in the Colorado River Compact of 1922 as that portion of the Colorado River and its tributaries within the United States of America.
- **Consumptive Use**
  - Water that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise not available for immediate use. In terminology used by the USGS it does not include interbasin transfers. **(U)**
  - A depletion of surface water or groundwater due to human-caused activity, including interbasin transfers. For agriculture, consumptive use is the sum of net irrigation requirement plus incidental use **(R)**
  - As defined for the purposes of Lower Basin Water Accounting Report – Diversions from the stream less such return flow thereto as is available for consumptive use in the United States or in satisfaction of the Mexican treaty obligation. **(R)**
- **Conveyance Loss (U)**
  - Conveyance loss is defined by USGS as water that is lost in transit from a pipe, canal, conduit, or ditch by leakage or evaporation. Generally, the water is not available for further use; however, leakage from an irrigation ditch, for example, may percolate to a groundwater source and be available for further use. (see incidental use)
- **Depletion (U)**
  - The act of using more water than is available or naturally sustainable, either from surface water or groundwater sources. Some western states define depletion as water that is sent elsewhere (out of the state, drainage basin, etc.) to meet demands that are not met by available water resources. (see beneficial consumptive use)
- **Diversion (U/R)**
  - The act of removing water from a surface-water body or groundwater resource to be used elsewhere. It entails physically removing or redirecting water from a surface-water body, such as a canal diversion from a reservoir or river for purposes of irrigation, or a well that pumps water from the ground to be delivered to customers elsewhere.
- **Effective Precipitation (R)**
  - Precipitation occurring during the growing season that is available to meet ET requirements of crops. It does not include precipitation lost through deep percolation below the root zone or through surface runoff.
- **Evapotranspiration (ET)**
  - Also called ET, is the sum of the amount of water lost to the atmosphere from evaporation and transpiration from soil surfaces and plant leaves. It includes water lost from ground surface, evaporation from the capillary fringe of the groundwater table, and the transpiration of groundwater by plants whose roots tap the capillary fringe of the groundwater table, and evaporation from the plant leaves. **(U)**
  - The amount of water used by vegetative growth in transpiration and building of plant tissue, together with evaporation from soil and plant surfaces in a specified time period **(R)**
- **Free Water Surface (FWS) evaporation (R)**
  - Commonly estimated by multiplying the observed pan evaporation by a coefficient.
- **Groundwater (U/R)**
  - Water that lies beneath the surface of the ground in pores and crevices in rock and soil. It is derived from water that flows or seeps downward and saturates soil and rock, and is the supply to spring and wells.

- **Hydrologic Basin**
  - The land area that drains water to a stream, river, or lake. It is a land feature that can be identified by tracing a line along the highest elevations between two areas on a map, often a ridge. Also referred to as a watershed or drainage basin. There are varying scales of hydrologic basins and they are depicted in maps that illustrate the boundaries and the numerical codes for the areas, referred to as hydrologic units. **(U)**
  - See Colorado River System. **(R)**
- **Hydrologic Unit (U/R)**
  - A Water Resources Council subdivision of the United States into a hierarchical classification of hydrologic drainage basins of successively smaller and smaller size, with assigned identification numbers that are called hydrologic unit codes (HUC). The HUCs are based on the hierarchical nesting of 2-digits identifying the drainage basins of varying scale. The four basic classifications for the areas in decreasing scale are: regions, sub-regions, accounting units, and cataloging units. Each HUC consists of two to eight digits based on the four levels of classifications in the hydrologic unit system. The first level of classification (regions) uses the first two digits of the HUC, and identifies 21 water-resources regions. The second level of classification entails using the next two digits making a 4-digit number, and identifies the sub-regions. There are 222 sub-regions in the US. The levels continue and build on the hierarchical system and identify increasingly small hydrologic basins. (Adapted from Seaber et.al., 1987, Hydrologic Unit Maps: U.S. Geological Survey Water-Supply Paper 2294, 63 p. http://pubs.usgs.gov/wsp/wsp2294/pdf/wsp_2294.pdf)
  - Today, with the use of Geographic Information Systems technology (GIS), a nationally consistent geospatial dataset known as the Watershed Boundary Dataset (WBD) is available. It has further sub-divided the HUCs that now provides 10-digit and 12-digit HUCs that identify even small drainage areas. The WBD is available and maintained online at http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/water/watersheds/dataset/
- **Incidental Use (R)**
  - Consumptive use that can be attributed to meeting the net irrigation requirement. These losses include phreatophyte growth in and along canals and laterals and evaporation from the canals and laterals.
- **Instream Use v. Offstream Use (U)**
  - Instream use is a water use that occurs "in-situ", without being withdrawn or diverted. For example, hydroelectric power generation or navigation are beneficial uses of water that occur in the channel. Other instream uses include water used for water-quality improvement, fish propagation, or recreation. Sometimes called in-channel use. Offstream use is a water use that occurs after water is diverted or withdrawn from the source, for purposes such as public supply, industrial, irrigation, livestock, thermoelectric power generation, and other uses. Sometimes called off-channel use.
- **Interbasin Transfers**
  - Interbasin transfer is a term that is used to indicate there is an altered hydrologic regime. It refers to the transport of water out of the natural hydrologic flow regime. For this report, interbasin transfers are those quantities of water that are artificially moved from one hydrologic basin to another via pipes, tunnels, canals or pumps that are constructed, maintained and managed by man for the purposes of supplying water to meet demand in a hydrologic basin outside of the one that it originates in. The quantities and timing of the movement of water through the artificial channels are highly regulated via compacts, contracts, and laws. (U)
  - See Basin Transfers **(R)**

- **Intrabasin Transfers**
  - Intrabasin transfer is a term that is used to indicate there is an altered hydrologic regime. It refers to the transport of water out of the natural hydrologic flow regime. For this report, intrabasin transfers are those quantities of water that are artificially moved from on hydrologic basin to another via pipes, tunnels, canals, or pumps that are constructed, maintained and managed by man for the purposes of supplying water to meet demands in a hydrologic basin outside of the one that it originates in. The quantities and timing of the movement of water through the artificial channels are highly regulated via compacts, contracts and laws. These transfers for this report, represent water that is moved from one sub-region (HUC-4) to another, but the water is used and remains within the Colorado River Basin. **(U)**
- **Irrigation Water Requirement (U)**
  - IWR (Irrigation Water Requirement) is the quantity of water that is necessary to supplement natural precipitation and soil moisture for healthy crop growth. Net irrigation water requirement (NIWR) is that amount of water needed to meet plant needs based on climate, soils and cropping pattern data. Gross irrigation water requirement (GIWR) is NIWR plus that amount of water that is lost in transit while getting water to the crops, and uses information about irrigation system efficiency and conveyance losses. (see Net Irrigation Requirement (NIR))
- **Law of the River (R)**
  - A term that collectively refers to the numerous compacts, federal laws, court decisions and decrees, contracts and regulatory guidelines that are used to manage and oversee operation of the Colorado River. The documents stipulate how water is apportioned, regulated, managed and used among the seven basin states and Mexico.
- **Lower Colorado River Basin**
  - Watersheds of hydrologic basins that are defined as downstream of Lee Ferry. Lee Ferry, located in Arizona, is a point on the mainstream one mile below the mouth of the Paria River. The Colorado River Compact (1922) divided the Colorado River Basin into two sub-basins—the "Upper Basin" and the "Lower Basin," with Lee Ferry as the division point on the river. For purposes of water use reporting the Lower Basin has been further subdivided into Main Stem and Tributary areas which are defined individually. **(R)**
  - The region downstream of the confluence of the Colorado and Paria rivers encompassed by all natural surface-water hydrologic drainage areas that fall within Hydrologic Unit Codes (HUCs) that begin with '15' as defined in the Watershed Boundary Dataset. **(U)**
- **Lower Colorado River Main Stem (Corridor) (R)**
  - Also termed the Lower Colorado River Mainstream. Those geographic areas in close proximity to the Colorado River in the Lower Colorado River basin, located below Lee Ferry. Lee Ferry, located in Arizona, is a point on the mainstream one mile below the mouth of the Paria River.
- **Lower Colorado River Tributaries**
  - All rivers or streams that are located in hydrologic basins that naturally drain into the Colorado River below Lees Ferry (USGS gage site). These areas or identified by HUCs that begin with '15' in the first 2-digit number scheme. **(U)**
  - All rivers or streams that are located in hydrologic basins that naturally drain into the Colorado River below Lee Ferry excluding the geographic areas included in the Lower Colorado River Main Stem. Lee Ferry, located in Arizona, is a point on the mainstream one mile below the mouth of the Paria River. Note Lee Ferry and Lees Ferry are not the same location. **(R)**

- **Natural Flow (R)**
  - Calculated as gaged flow corrected for the effects of upstream reservoirs and depletions.
- **Net Irrigation Requirement (R)**
  - NIR (Net Irrigation Requirement) is the quantity of water, exclusive of effective growing season precipitation, winter precipitation stored in the root zone, or ground water that is required to be applied by irrigation to meet the ET needs of the crop. It also may include water requirements for germination, frost protection, prevention of wind erosion, and plant cooling. Crop consumptive use is that amount of water needed to meet plant needs based on climate, soils and cropping pattern data. Irrigation consumptive use is defined as the NIR plus incidental uses. (see Irrigation Water Requirement (IWR))
- **Non-Consumptive Use (U)**
  - A term used to refer to water that is used without diminishing the available supply. It includes water that is withdrawn for use that is not consumed or lost. For example, hydroelectric power generation is considered by USGS to be a non-consumptive use. However, no typical non-consumptive use of water is entirely non-consumptive because there are losses, for instance, evaporation associated with maintaining a reservoir at a specified elevation to support hydroelectric power generation.
- **Point of Diversion (U)**
  - The point of diversion is that point on the surface of the earth where water is diverted from a surface or groundwater source for an intended use. A main canal headgate or irrigation diversion on a river, or a well is a point of diversion.
- **Point of Use (U)**
  - The point of use is the location where the water is applied for the intended use, such as a crop field, or an industrial plant. The point of use may, or may not be near the point of diversion.
- **Return Flow**
  - Water that reaches a groundwater or surface-water source after release from the point of use, or the point of treatment, and thus becomes available for further use. **(U)**
  - As defined for the purposes of Lower Basin Water Accounting Report – Water, diverted from the mainstream of the Colorado River, that returns to the mainstream by surface or subsurface means and which is available for use by other water users in the U.S. or in satisfaction of the Mexican Treaty obligation. **(R)**
- **Runoff Salvage (R)**
  - Water that was consumptively used before the reservoir came into existence. This includes water used by natural vegetation or people living on the site.
- **Shortage Lands (R)**
  - Irrigated lands that normally do not receive a complete irrigation season of water. This may be due to inadequate diversion and storage facilities or because of junior (low priority) water rights.
- **Surface Water**
  - Water on the surface of the ground, such as a lake, reservoir, river, pond, floodwater, or open body of water. **(U)**
- **Trans-Basin Diversion (Exports) (R)**
  - See Basin Transfers

- **Upper Colorado River Basin**
  - The region upstream of the confluence of the Colorado and Paria rivers encompassed by all natural surface-water hydrologic drainage areas that fall within Hydrologic Unit Codes (HUCs) that begin with '14' as defined in the Watershed Boundary Dataset. **(U)**
  - Watersheds of hydrologic basins that are defined as upstream of Lee Ferry. Lee Ferry, located in Arizona, is a point on the mainstream one mile below the mouth of the Paria River. The Colorado River Compact (1922) divided the Colorado River Basin into two sub-basins—the "Upper Basin" and the "Lower Basin," with Lee Ferry as the division point on the river. **(R)**
- **Water Loss (U/R)**
  - Water that is unavailable for immediate use due to reservoir or channel evaporation, ET from phreatophyte growth along channels, and operational inefficiencies. (see also consumptive use, ET, conveyance loss, and incidental use)
- **Water Use**
  - In a restrictive sense, the term refers to water that is withdrawn for a specific purpose, such as crop irrigation. **(U)**
  - More broadly, water use pertains to the interaction and influence that humans have on the hydrologic cycle, and includes elements such as diversion or withdrawals, transfers, deliveries, consumption and return flows throughout the processes of use. (**U, R**)
- **Water Use Categories (R)**

  Water use categories are only reported in Reclamation Consumptive Use Reports.
  - <u>Agriculture</u>
    - <u>Irrigation</u>: water used in association with irrigated agricultural lands where either surface or groundwater is supplied. Includes incidental consumptive use of water associated with irrigation.
    - <u>Stock Pond Evaporation</u>: water that is evaporated from the stock pond.
    - <u>Livestock</u>: the daily amount of water consumed by an animal. Incidental uses or waste are not <u>taken into account</u>.
  - <u>Municipal and Industrial</u>
    - <u>Minerals</u>: water used for extraction of mineral.
    - <u>Thermal Electric Power</u>: water used in the powerplant and to transport material to the plant (such as coal slurry pipeline).
    - <u>Municipal and Industrial Other Uses</u>: water used for urban, rural, and other industrial uses not included in mineral resource and thermal electric use.
  - <u>Basin Transfers (Exports)</u>
    - <u>Interbasin (Outside System)</u>: water that is removed from the Colorado River System (the hydrologic basin)
    - <u>Intrabasin (Within System)</u>: water that is moved between reporting areas but does not leave the Colorado River System. The actual consumptive use of the Exports Within System are included in other categories such as Agriculture or Municipal and Industrial.
  - <u>Reservoir Evaporation Loss</u>: water that is evaporated from all human-made water bodies except stock ponds and main stem reservoirs. Includes accounting for precipitation and salvage.
  - <u>Main Stem Reservoir Evaporation</u>: a subset of reservoirs for which reservoir evaporation loss is charged to either the Upper or Lower Basin, but not to individual states. The Upper Basin main stem reservoirs include Flaming Gorge, Blue Mesa, Morrow Point, and Lake Powell. Lower Basin main stem reservoirs are Lake Mead, Lake Mohave, Lake Havasu, Senator Wash, and "other". The "other" reservoirs include the reservoirs behind the Headgate Rock, Palo Verde, Imperial, Laguna, and Morelos diversion dams.

- **Water Use Categories (U)**
  - Public Supply: water withdrawn and treated to established standards by public and private entities and delivered to homes, businesses, or other entities for daily use as well as to public facilities for public use.
  - Domestic: water for residential household uses such as drinking, cooking, cleaning, bathing and sanitary functions. It also includes outdoor residential uses such as lawn and garden irrigation. The water may come from either a self-supplied source (usually a well) or a publicly supplied source such as a municipality or public water purveyor.
  - Commercial: water used at a commercial establishment such as a shop, office, hospital or school. Water may be provided by a self-supplied source or publicly supplied, and typically uses potable water, except for cases where non-potable water may be used for outdoor irrigation at a commercial establishment.
  - Industrial: water used for industrial processes such as fabrication, washing, and cooling, as well as water that is incorporated into a product. Water may be self-supplied by a resource on site, or delivered to the industrial facility from a water supplier.
  - Livestock: water used in association with livestock operations such as feedlots, dairies, or poultry farms, and is exclusive of aquatic animal rearing operations (see aquaculture). The water is used for various on-farm purposes such as watering, cooling, cleaning, and sanitation. Water is self-supplied from surface or groundwater sources.
  - Mining: water used for the extraction of minerals in the form of solids, liquids and gases, including quarrying, milling, washing, screening and floatation of mined materials, as well as re-injecting extracted water for secondary oil recovery. Water is self-supplied from surface or groundwater sources.
  - Aquaculture: water used in association with the raising of aquatic organisms such as finfish and shellfish for food, restorations or conservation purposes. Aquaculture production includes controlled feeding, sanitation, and harvesting procedures in ponds, flow-through raceways, cages, net pens or tanks. Water is self-supplied from surface or groundwater sources.
  - Irrigation: water that is applied by an irrigation system to support crop and pasture growth, or to maintain vegetation on recreational lands such as parks and golf courses. It includes water applied for pre-irrigation, frost protection, chemical application, weed control, and various other purposes, as well as that amount of water necessary to meet on-site (field) demand after losses incurred during transport such as conveyance losses.
  - Thermoelectric Water Use: water used in the process of generating electricity with steam-driven turbine generators at facilities that burn fuels such as natural gas, oil, or nuclear generating facilities. Water is used for cooling and maintenance processes and typically is self-supplied, except where a publicly-owned municipality or industry may provide some water.
  - Hydroelectric Water Use: water used in the generation of electricity at plants where the turbine generators are driven by falling water.
  - Reservoir Evaporation: water that is evaporated from a reservoir surface.
  - Wastewater Return Flow: water that is treated and returned to a water body or groundwater source. It may be released from a publicly-owned treatment works (POTSW) or an industrial facility that treats the water it uses before releasing it.
- **Water Withdrawal (U)**
  - Water removed from a groundwater or surface-water source for use.

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