ARIZONA WATER ATLAS
VOLUME 4 –UPPER COLORADO RIVER PLANNING AREA

Preface

Volume 4, the Upper Colorado River Planning Area, is the fourth in a series of nine volumes that comprise the Arizona Water Atlas. The primary objectives in assembling the Atlas are to present an overview of water supply and demand conditions in Arizona, to provide water resource information for planning and resource development purposes, and help to identify the needs of communities. The Atlas also indicates where data are lacking and further investigation may be needed.

The Atlas divides Arizona into seven planning areas (Figure 4.0-1). There is a separate Atlas volume for each planning area, an executive summary volume composed of background information, and a resource sustainability volume. "Planning areas" are an organizational concept that provide for a regional perspective on supply, demand and water resource issues. A complete discussion of Atlas organization, purpose and scope is found in Volume 1. Also included in Volume 1 is general background information for the state, a description of data sources and methods of analysis for the tables and maps presented in the Atlas, and appendices that provide information on water law, management and programs, and Indian water rights claims and settlements.

There are additional, more detailed data available to those presented in this volume. These data may be obtained by contacting the Arizona Department of Water Resources (Department).

4.0 Overview of the Upper Colorado River Planning Area

The Upper Colorado River Planning Area is composed of nine groundwater basins located in northwestern Arizona, south and east of the Colorado River. Elevation ranges from 450 feet to 8,417 feet. Most of the planning area is within Mohave County; the planning area also includes small portions of Coconino, La Paz and Yavapai counties. Parts of the Fort Mojave and Hualapai Indian Reservations are within the planning area. The 2000 Census planning area population was approximately 162,100. Basin population ranged from 823 in the Meadview Basin to over 51,500 in the Lake Mohave Basin. Lake Havasu City is the largest metropolitan area with almost 42,000 residents in 2000.

Annual cultural water demand averaged about 174,100 acre-feet (including effluent) during the period 2001-2005. Agriculture was the largest water use sector in the planning area with an annual demand of approximately 99,550 acre-feet during this period, almost entirely within the Lake Mohave Basin. Municipal demand accounted for about 52,400 acre-feet/year (AFA), and industrial demand averaged about 22,100 AFA.

Agriculture in the Lake Mohave Basin. Agriculture was the largest water use sector in the planning area with an annual demand of approximately 99,550 during 2001-2005.

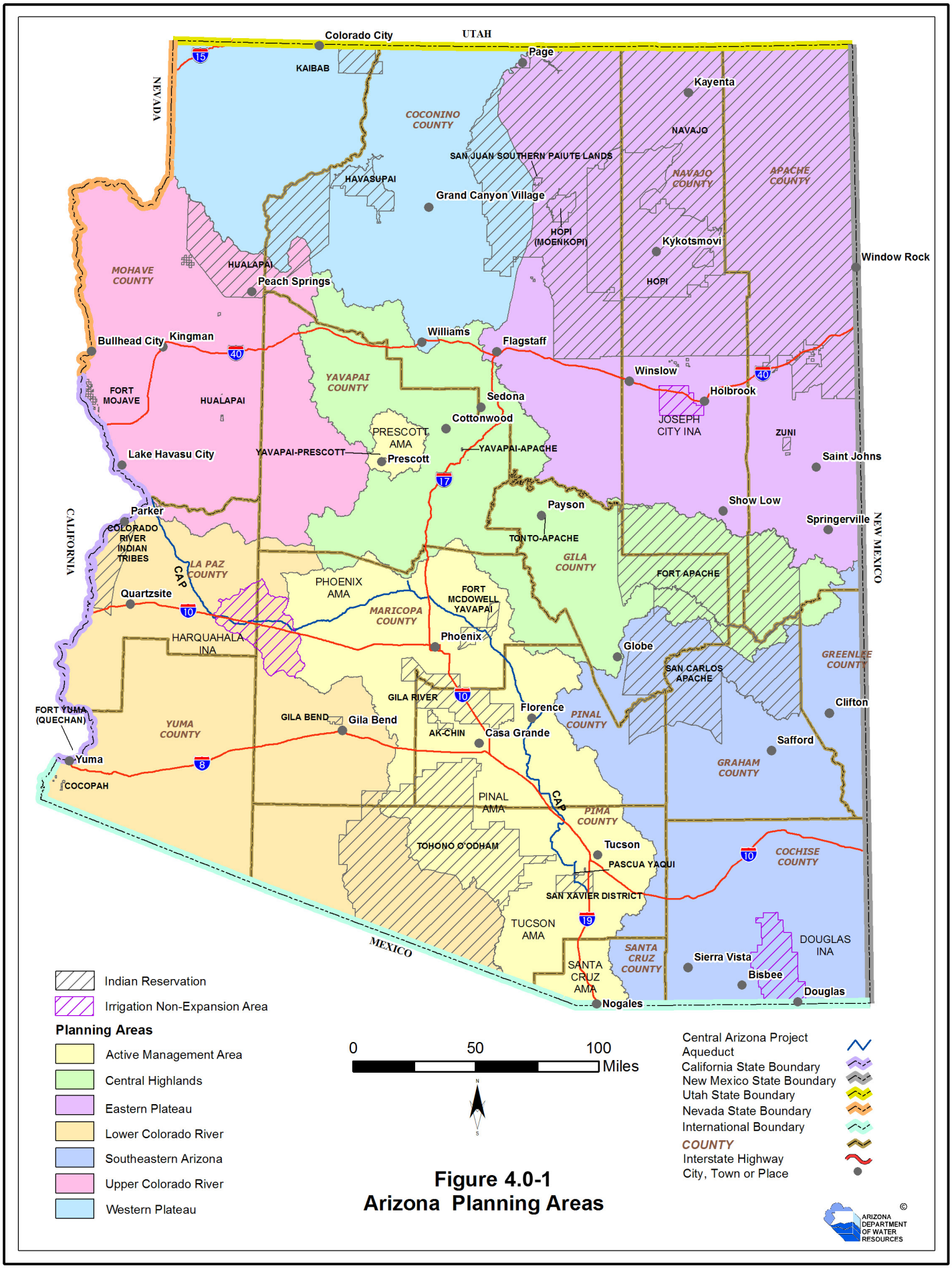
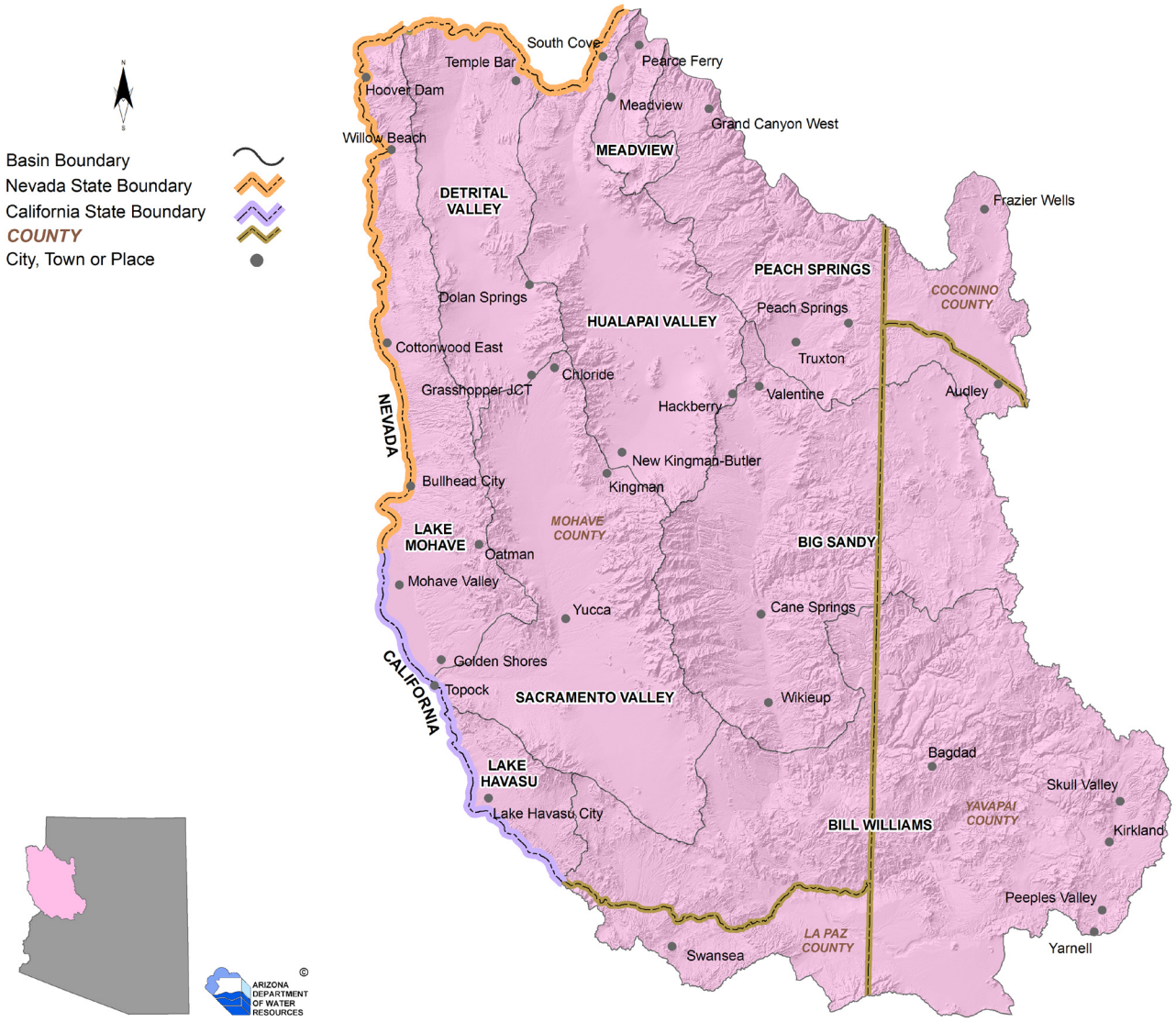


Figure 4.0-1
Arizona Planning Areas

4.0.1 Geography

The Upper Colorado River Planning Area covers about 11,860 square miles (sq. mi.) and includes the Big Sandy, Bill Williams, Detrital Valley, Hualapai Valley, Lake Havasu, Lake Mohave, Meadview, Peach Springs and Sacramento Valley basins. Basin boundaries, counties and prominent cities, towns and places are shown in Figure 4.0-2. The planning area is bounded on the north by the Colorado River, the state of Nevada and by the Western Plateau Planning Area, on the east by the Central Highlands Planning Area and the Prescott Active Management Area, on the south by the Lower Colorado River Planning Area and a portion of the Central Highlands Planning Area and on the west by the Colorado River and the states of California and Nevada. (Figure 4.0-1) The planning area includes all or part of five watersheds, which are discussed in section 4.0.2. Within the planning area, the Fort Mojave Indian Reservation encompasses about 23,500 acres and the Hualapai Indian Reservation encompasses about 553,000 acres. Elevation ranges from 450 feet along the Colorado River

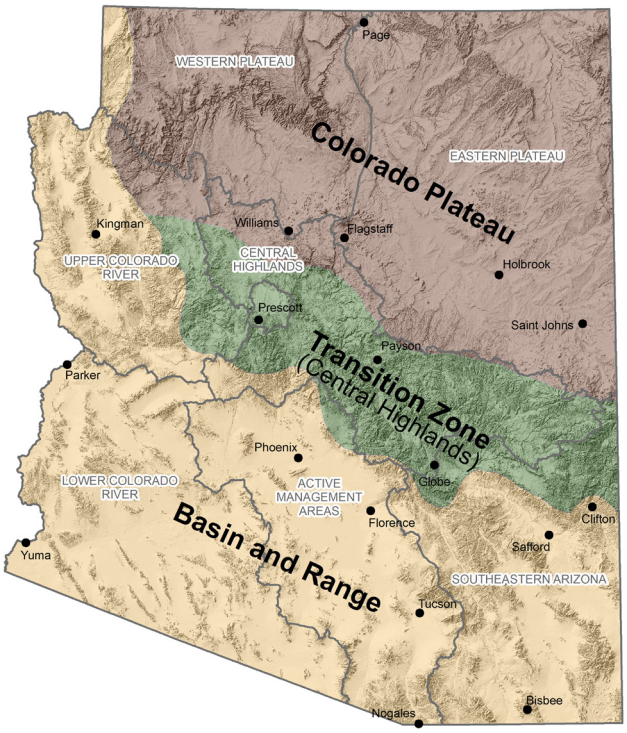
Figure 4.0-2 Upper Colorado River Planning Area



near Lake Havasu City to 8,417 feet at Hualapai Peak south of Kingman.

Arizona's three physiographic regions are found in the planning area (Figure 4.0-3). Most of the planning area is within the Basin and Range physiographic province, which is characterized by northwest-southeast trending mountain ranges separated by broad alluvial valleys. The Detrital Valley and Sacramento Valley basins are representative of this province. The northeastern portion of the planning area, primarily the Peach Springs Basin, falls within the Colorado Plateau physiographic province, characterized by high desert plateaus and incised canyons. The central eastern portion of the planning area that includes the eastern, upland areas of the Big Sandy and Bill Williams basins is located within the Central Highlands transition zone, characterized by rugged mountains of igneous, metamorphic and sedimentary rocks.

Figure 4.0-3 Physiographic Regions of Arizona



Data source: Fenneman and Johnson, 1946

Unique geographic features of the planning area include the the Colorado River and associated lakes impounded by several dams. The river and lakes influence cultural uses, groundwater conditions and habitat in a significant portion of the planning area.

4.0.2 Hydrology[1]

Groundwater Hydrology

The Upper Colorado River Planning Area is characterized by semi-arid to arid alluvial basins with few perennial streams. Anderson, Freethey and Tucci (1992) divided the alluvial basins in south-central Arizona into categories based on similar hydrologic and geologic characteristics. These categories are useful in describing general hydrologic characteristics. Although their study area does not match the Department's groundwater basins exactly, the Upper Colorado River Planning Area is included in their study area with the exception of the Peach Springs Basin. Four basin categories identified by Anderson are represented in the planning area and are discussed below: West, Colorado River, Highland and Southeast.

As shown in Figure 4.0-4, there are extensive outcrops of sedimentary and volcanic rocks of varying ages throughout the planning area. Large areas of basin-fill covered by alluvial and surficial deposits are found in the western part of the planning area, primarily in the West basins.

<u>West Basins</u>
The West Basins include the Detrital Valley, Hualapai Valley, and Meadview basins, most of the Sacramento Valley Basin and part of the Bill Williams Basin. Groundwater inflow and outflow are small and there is almost no stream baseflow. These basins contain extensive areas

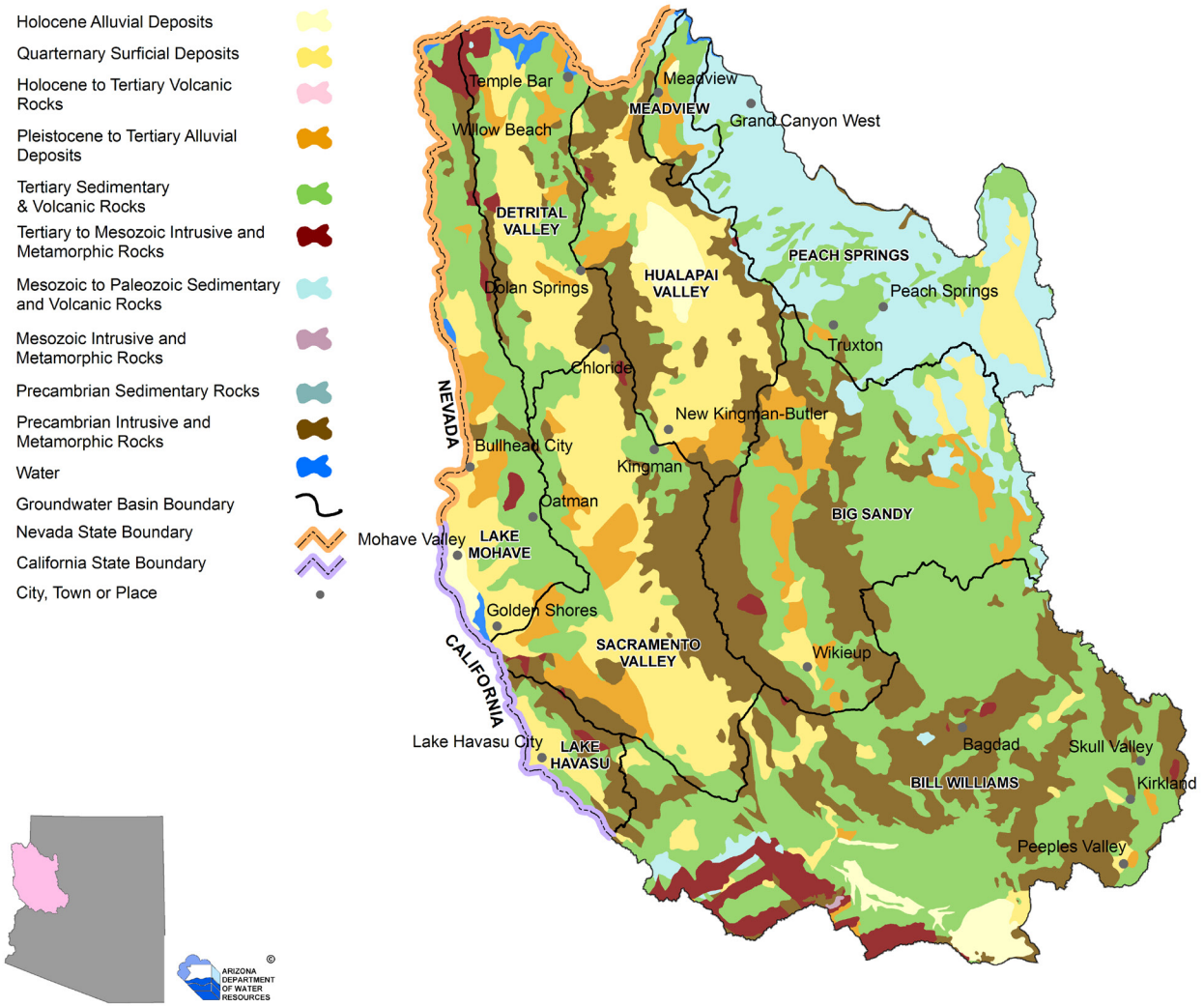
[1] Except as noted, much of the information in this section is taken from the Arizona Water Resources Assessment, Volume II, ADWR August, 1994. (ADWR 1994a)

of basin fill deposits that comprise the primary groundwater bearing unit (aquifer).

Detrital Valley Basin

The Detrital Valley Basin is characterized by a relatively long valley whose floor slopes from 3,400 feet at the southern boundary to around 1,200 feet at Lake Mead. Groundwater occurs mostly in basin-fill material and in alluvial deposits along mountain washes. Intermediate and younger basin fill are above the water table in most areas, consequently the older basin fill aquifer is the primary water supply. In the northern part of the basin, the basin fill includes clastic (weathered) sediments, limestone, and basalt flows of the Muddy Creek and Chemehueve Formations. There are extensive evaporate deposits in the older alluvium in the northern part of the basin (Anning and others, 2007). Depth to bedrock may exceed 6,000 feet at the deepest point. A clay unit may extend from 600 to 1,400 feet below land surface (bls) in the central portions of the basin, which acts as an impediment to groundwater flow and reduces the amount of recoverable groundwater due to its low specific yield. The areal extent of this unit is not well known due to lack of data (Mason and others, 2007). Groundwater flow direction is north toward Lake Mead. At the northern end of Detrital Valley water from Lake Mead infiltrates to the basin-fill aquifer and near by groundwater levels fluctuate with the levels. Depth to water may be less than 100 feet bls in this area (Anning and others, 2007).

Figure 4.0-4 Surface Geology of the Upper Colorado River Plateau Basin
(Based on Reynolds, 1988)



Detrital Valley Basin. In this basin groundwater occurs mostly in basin-fill material and in alluvial deposits along mountain washes.

Groundwater recharge is estimated at 1,000 AFA. Groundwater discharge is to springs and from relatively small well withdrawals for municipal purposes. The volume of recoverable groundwater to a depth of 1,200 feet bls is estimated to range from about 1.48 to 3.94 maf (Mason and others, 2007). The median well yield in measured wells is generally 35 gpm or less (Table 4.3-5). As shown in Figure 4.3-6, groundwater levels were relatively stable in wells measured in 1990-91 and 2003-04, although water-level measurements for different time periods show long-term declines in an area northeast of Dolan Springs (Anning and others, 2007). Water quality is suitable for most purposes although concentrations of radionuclides and arsenic that exceed drinking water standards have been measured at wells throughout the basin. (Table 4.3-6, Figure 4.3-9).

Hualapai Valley Basin

The Hualapai Valley Basin trends north-northwest and is about 60 miles long, stretching from the Hualapai Mountains to Lake Mead. The basin has relatively deep, sediments divided into three units. The younger basin fill includes recent streambed deposits in Hualapai Valley and alluvium along mountain canyons. This unit yields relatively small volumes of water to stock and domestic wells. The intermediate basin fill, which is composed of coarse-grained sands, silts and clays, is a dependable aquifer only along the valley margins where the unit intersects the water table. As with other basins in this category, the older basin fill is the primary water supply. Similar to the Detrital Valley Basin located to the west, older basin fill in the northern part of the valley includes clastic sediments, limestone and basalt flows of the Muddy Creek and Chemehueve Formations. Volcanic rocks are interbedded with the older basin fill in the southern part of the basin and yield water for municipal and domestic purposes. Groundwater flows into the central part of the basin from the south and along Truxton Wash near Hackberry (Figure 4.4-6). Surface water collects in the Red Lake playa bear the center of the basin, whereas groundwater flows to the north underneath the topographic divide near Pierce Ferry Road (Anning and others, 2007).

Groundwater recharge comes primarily from streambed infiltration and is estimated at 2,000 to 3,000 AFA (Table 4.4-4). Groundwater discharge is to several major springs and from relatively large volumes of well pumpage for municipal use by Kingman. The well pumpage is are almost three times the estimated groundwater recharge rate. Groundwater in storage estimates range widely from 3 to 21 maf. Median reported well yields are relatively high at 900 gpm (Table 4.4-4). In the central and northern part of the basin groundwater levels were relatively stable or rising between 1990-91 and 2003-04 while water levels were declining in the southern part of the basin (Figure 4.4-6). Water-level measurements over longer time periods show fluctuating water levels in the basin with long-term declines found in the area northwest of Hackberry (Anning and others, 2007). Groundwater is highly mineralized in some areas near the mountains and near Red Lake. Chromium has been detected in some wells in the basin.

Meadview Basin

The relatively small Meadview Basin is characterized by a valley formed by Grapevine Wash in the north, and a highland area, Grapevine Mesa in the south. The basin floor slopes toward Lake Mead from an elevation of about 4,400 feet to 1,400 feet. The main aquifer occurs in the Muddy Creek Formation which contains three units. The upper limestone unit yields water to springs and shallow wells. The middle sandstone unit has a high clay content that limits its ability to transmit water. The lower unit is a conglomerate with high hydraulic conductivity. Most well development has been in this lower unit. Groundwater flow is from south to north, following Grapevine Wash.

Groundwater recharge is relatively small, about 4,000 AFA, due to low rainfall and high evaporation rates. Groundwater discharge is to springs and a relatively small volume of municipal well pumpage. Groundwater in storage is estimated at 1.0 maf or less. The median measured well yield is 33 gpm (Table 4.7-5). There is little water level monitoring in the basin. Available data show water levels as deep as 931 feet bls in the southern part of the basin and declines of more than 15 feet have been measured in a well in the vicinity of Meadview during the period 1990-91 and 2003-04 (Figure 4.7-6). Groundwater quality is generally good in the basin, with elevated concentrations of radionuclides measured primarily in or near granitic areas (ADEQ, 2005).

Sacramento Valley Basin

Sloping alluvial fans extend from surrounding mountains to the north-south trending valley floor of the Sacramento Valley Basin. The valley floor generally slopes to the south with elevation ranging from more than 8,400 feet at Hualapai Peak to about 500 feet where Sacramento Wash enters the Colorado River. Older basin fill is the principal aquifer in the basin. There are fractured and faulted volcanic rocks in the vicinity of Kingman that separate this basin from the Hualapai Valley Basin. Water stored in the fractures is used as part of the municipal water supply for Kingman and for domestic wells. The fractured granite aquifer beneath the community of Chloride is insufficient to meet its needs and water must be hauled from Kingman. Groundwater flow is toward the center of the Sacramento Valley and west to the Colorado River.

Groundwater recharge is from infiltration of runoff in washes and along mountain fronts, except in the vicinity of the Colorado River where infiltration of river water is the main source of recharge. Groundwater recharge is estimated at 1,000 to 4,000 AFA. Groundwater discharge is to a number of springs and from municipal and industrial well pumpage. Groundwater in storage estimates range from 7 to 14 maf. Recent investigations using a range of specific yield values estimated 3.6 to 9.5 maf of groundwater in storage to a depth of 1,200 feet bls (Conway and Ivanich, 2008). Median well yields are between 100 and about 170 gpm (Table 4.9-6). Groundwater levels may be relatively deep with depths greater than 500 feet measured at several locations. Water levels declined in measured wells in the vicinity of Kingman and east of Topock between 1990-91 and 2003-04 (Figure 4.9-6). Water-level measurements over longer

Colorado River, Sacramento Valley Basin. Groundwater flow is toward the center of the Sacramento Valley and west to the Colorado River.

time periods show fluctuating water levels in the basin with long-term declines in the Kingman area and Golden Valley area (Anning and others, 2007).

Groundwater quality is generally good in the basin except along the base of the mountains where waters of high mineral content are common. A study conducted by ADEQ found water quality exceedences in the majority of sample sites in three areas: near the town of Chloride; in the central and southern Hualapai Mountains; and near the town of Topock (ADEQ, 1999). Concentrations of radionuclides in Chloride town wells have exceeded Safe Drinking Water Act maximum contaminant levels (City of Kingman, 2003).

Bill Williams Basin (western portion)
Anderson, Freethey and Tucci (1992) categorized most of the western portion of the Bill Williams Basin as a "West" basin, which generally corresponds to the Alamo Reservoir and Clara Peak sub-basins (see Figure 4.2-6). The area in the vicinity of the Colorado River is influenced by infiltration of river water. Groundwater in the western part of the basin occurs primarily in recent stream alluvium and basin fill. The water-bearing ability of these units varies within the basin. The stream alluvium consists of gravel, sand and silt along the Bill Williams River and its major tributaries. The main water-bearing unit is the basin fill, which is more than 5,000 feet thick in the Bullard Wash-Date Creek Area southeast of Alamo Lake State Park. Groundwater flow is toward the Bill Williams drainage.

Groundwater recharge is from streamflow and mountain front precipitation and is estimated at 32,000 AFA for the entire basin. From 10 to 23 maf of groundwater is estimated in storage. There is little groundwater development in the western portion of the basin and relatively little groundwater level data (see Figure 4.2-6). Available water level data show stable water levels. Well yields may exceed 2,000 gpm along the Bill Williams River. Arsenic and fluoride concentrations that exceed drinking water standards have been reported from this portion of the basin as well as elevated levels of cadmium near the mouth of the Bill Williams River.

Colorado River Basins
The Colorado River Basins include the Lake Havasu and Lake Mohave basins and those portions of the Sacramento Valley and Bill Williams basins in the vicinity of the Colorado River. In these areas the direction and occurrence of groundwater are influenced by the amount of streamflow in the Colorado River. Infiltration of river water is the main source of inflow to aquifers in this area. The aquifers are composed primarily of recent stream alluvium deposits that is hydraulically connected to underlying basin fill. Groundwater occurs under

Bill Williams River at Lake Havasu. The area in the vicinity of the Colorado River is influenced by infiltration and flow of river water.

unconfined conditions in both the stream alluvium and basin fill.

Lake Havasu Basin

The Lake Havasu Basin is a relatively small basin with its western boundary defined by the Colorado River. Extensive areas of the basin are covered by consolidated rock. Basin fill, consisting of sand, silt and gravel, overlies the Bouse Formation (siltstone and fine-grained sandstone) and an underlying conglomerate unit. These deposits decrease in thickness toward the basin margin. Most wells in the basin penetrate the upper 100-200 feet of the basin fill. There is a direct hydraulic connection between the basin fill and the Colorado River, with groundwater occurrence and movement near the river controlled by the elevation of Lake Havasu. The lake elevation is relatively constant with a maximum fluctuation of approximately five feet during the period 1990-2008 (USBOR, 2009).

Regional groundwater flow is north to south. Groundwater recharge is estimated at 35,000 AFA with an estimated 1.0 to 2.0 maf of groundwater in storage. Water withdrawals from wells are primarily pursuant to Colorado River entitlements. Median well yields are relatively high at 1,500 gpm. Water level data for one public supply well showed a decline of 15 to 30 feet between 1990-91 and 2003-04. Drinking water standard exceedences are primarily due to elevated concentrations of nitrate/nitrite and organics measured in the vicinity of Lake Havasu City.

Lake Mohave Basin

The Lake Mohave Basin is a long narrow basin located adjacent to the Colorado River. The principal water-bearing formations are alluvial sand, silt and gravel deposits adjacent to Lake Mohave and the Colorado River. The regional groundwater level is higher than it was prior to filling Lake Mohave upstream of Davis Dam. Groundwater flow direction is from north to south. A granite ridge extends across the Colorado River near Davis Dam, restricting recharge from the lake to the south. Groundwater is generally unconfined in the basin. Compared to groundwater recharge from the lake, mountain front recharge is negligible.

Lake Mohave Basin, Colorado River. In the Colorado River basins the direction and occurrence of groundwater are influenced by the amount of streamflow in the Colorado River.

Groundwater recharge is estimated to total 183,000 AFA. Groundwater in storage estimates vary from 1.2 to 8.0 maf. Water withdrawals from wells in the basin are primarily pursuant to Colorado River entitlements. Median well yield is 1,000 gpm reported from 96 large (>10-inch) diameter wells (Table 4.6-6). Water level change data for the period 1990-91 to 2003-04 show slight declines south of Bullhead City and an increase north of the city. The water level in these wells ranged between 337 and 427 feet bls. Elevated concentrations of to-

tal dissolved solids (TDS) and fluoride occur in welled completed along the mountain fronts. The drinking water standard for arsenic was the most frequently exceeded standard measured in the basin (Table 4.6-7). Springs, some of which are thermal, occur downstream of Hoover Dam and represent the only surface water in the basin other than the lake and the Colorado River.

Highland Basins

The aquifers of the Highland Basins, which generally encompass the northeastern portions of the Big Sandy and Bill Williams basins, consist of hydraulically connected basin fill and younger stream alluvium. These aquifers tend to be discontinuous and limited in extent. Groundwater inflow is from stream channels, mountain front recharge and adjacent consolidated rock aquifers. Groundwater outflow is due to evapotranspiration and baseflow to streams (Anderson, Freethey and Tucci, 1992).

Big Sandy Basin (northeastern portion)

In this portion of the Big Sandy Basin, generally the Fort Rock Sub-basin, (see Figure 4.1-6), the primary hydrologic unit consists of sedimentary rocks composed of Redwall Limestone (a coarse-grained, massive limestone) and the Martin Formation (a fine- to coarse-grained dolomitic limestone). The limestones form a regional aquifer that extends north and east. There is little water development in this portion of the Big Sandy Basin and groundwater flow direction has not been reported. Well yields in three wells varied from 100 to over 1,000 gpm. In this area, water levels were stable in most wells measured between 1990-91 and 2003-04, with water levels ranging from about 130 to 860 feet bls (Figure 4.1-6). Water quality measurements from three wells in the southern portion of the Fort Rock sub-basin showed drinking water exceedences of arsenic and cadmium.

Bill Williams (eastern portion)

Groundwater in the eastern portion of the Bill Williams Basin, generally the Burro Creek, Santa Maria and Skull Valley sub-basins (see Figure 4.2-6), is found in basin fill, in fractured and porous volcanic rocks and in younger stream alluvium. In the Peeples Valley area, the stream alluvium is the main water-bearing unit. An important water-bearing unit in the Copper Basin area east of Skull Valley is a 1,000-foot thick layer of volcanic rocks with reportedly high well yields in the upper 350 to 400 feet. Other sources of groundwater are from faults in granite and metamorphic rocks. Groundwater flow in the Skull Valley Sub-basin is to the southwest in the northern part, and to the northwest south of Kirkland (Figure 4.2-6).

Groundwater recharge occurs from streamflow and mountain front precipitation. Most groundwater development is in the Skull Valley Sub-basin and at Bagdad although most of the water used at Bagdad for mining operations is transported from the Big Sandy Basin near Wikieup. Well yields in this portion of the basin are generally less than those in the western portion with a number of wells yielding less than 100 gpm (Figure 4.2-8). Median well yield for the entire basin, reported from large diameter (>10 inch) wells, is 280 gpm. Water level measurements are available primarily for wells located in the Skull Valley Sub-basin. These show relatively shallow water levels in most measured wells (<100 feet bls). Water level change data was not available for most wells in the sub-basin for the period 1990-91 to 2003-04, but was relatively stable for the few wells measured during this period (Figure 4.2-6). Drinking water standard exceedences in this area are generally due to elevated concentrations of fluoride, arsenic and radionuclides.

Southeast Basins

Big Sandy Basin (western portion)

With the exception of its northeastern portion, most of the Big Sandy Basin was categorized as a “Southeast Basin” by Anderson, Freethey and Tucci (1992). This area generally corresponds to the Wikieup Sub-basin south of Interstate

Big Sandy Basin near Wikieup. In the Wikieup area, wells greater than 40 feet in depth tap the upper basin fill, which is estimated to be 300 feet deep.

10 (see Figure 4.1-6). Southeast Basins are characterized by moderately thick pre-Basin and Range sediments and an overlying layer of lower basin fill to depths of over 1,000 feet. Aquifers generally consist of two or more water-bearing units separated by a fine-grained unit that forms a leaky confining layer over the lower basin fill. Primary water development in the Big Sandy Basin is along the central valley, primarily in upper basin fill that varies from loosely consolidated silty gravel to sandy silt. The floodplain alluvium in the central valley is 30-40 feet thick and is an unconsolidated deposit of gravel and sand. In the Wikieup area, wells greater than 40 feet in depth tap the upper basin fill, which is estimated to be 300 feet deep. North of Wikieup, the upper basin fill is estimated to be 150 to 200 feet deep. Groundwater flow is generally from north to south down the central valley.

Groundwater recharge is estimated at 22,000 AFA and the volume of groundwater in storage is estimated at 9.5 to 21 maf for the entire basin (Table 4.1-6). Median well yield for the entire basin is 300 gpm reported for large (>10-inch) diameter wells and as high as 2,000 gpm at Cane Springs (Figure 4.1-8). Water levels are relatively stable with some declines measured near Wikieup and south of Valentine. Depth to water ranges from 15 feet bls along the Big Sandy River south of Wikieup to over 370 feet along Hackberry Road in the northern part of the Wikieup Sub-basin (Figure 4.1-6). Arsenic, fluoride, lead and radionuclide concentrations that exceed drinking water standards have been measured in wells and springs throughout the western portion of the basin (Figure 4.1-9). Elevated radionuclide and fluoride concentrations are found primarily along the mountain drainages (Cady, 1981).

<u>Other</u>

Peach Springs Basin

The Peach Springs Basin was not included in the study area of Anderson, Freethey and Tucci (1992). This basin is characterized by an upland area to the west, the Hualapai Plateau, composed of interbedded limestones, shales and sandstones, and by Aubrey and Truxton Valleys that are filled with recent lava flows and alluvial material (See Figure 4.8-1). The Muav Limestone is the main water-bearing unit on the Hualapai Plateau where depths to groundwater may be as much as 1,300 feet bls. Groundwater is limited to a few permeable layers in the basin's two primary valleys. In Aubrey Valley in the far northeastern part of the basin near Frazier Wells, groundwater is found in gravel beds at relatively shallow depth. In Truxton Valley, lake-bed deposits are a local source of groundwater. In other areas of the basin, Precambrian rocks, isolated volcanic rocks and local alluvial sands in washes provide small amounts of water. Groundwater flow is toward the north where it exits the basin at springs emanating from the Muav Limestone in the Grand Canyon. Groundwater flow in Aubrey Valley south of Frazier Wells may be from north to south (Myers, 1987).

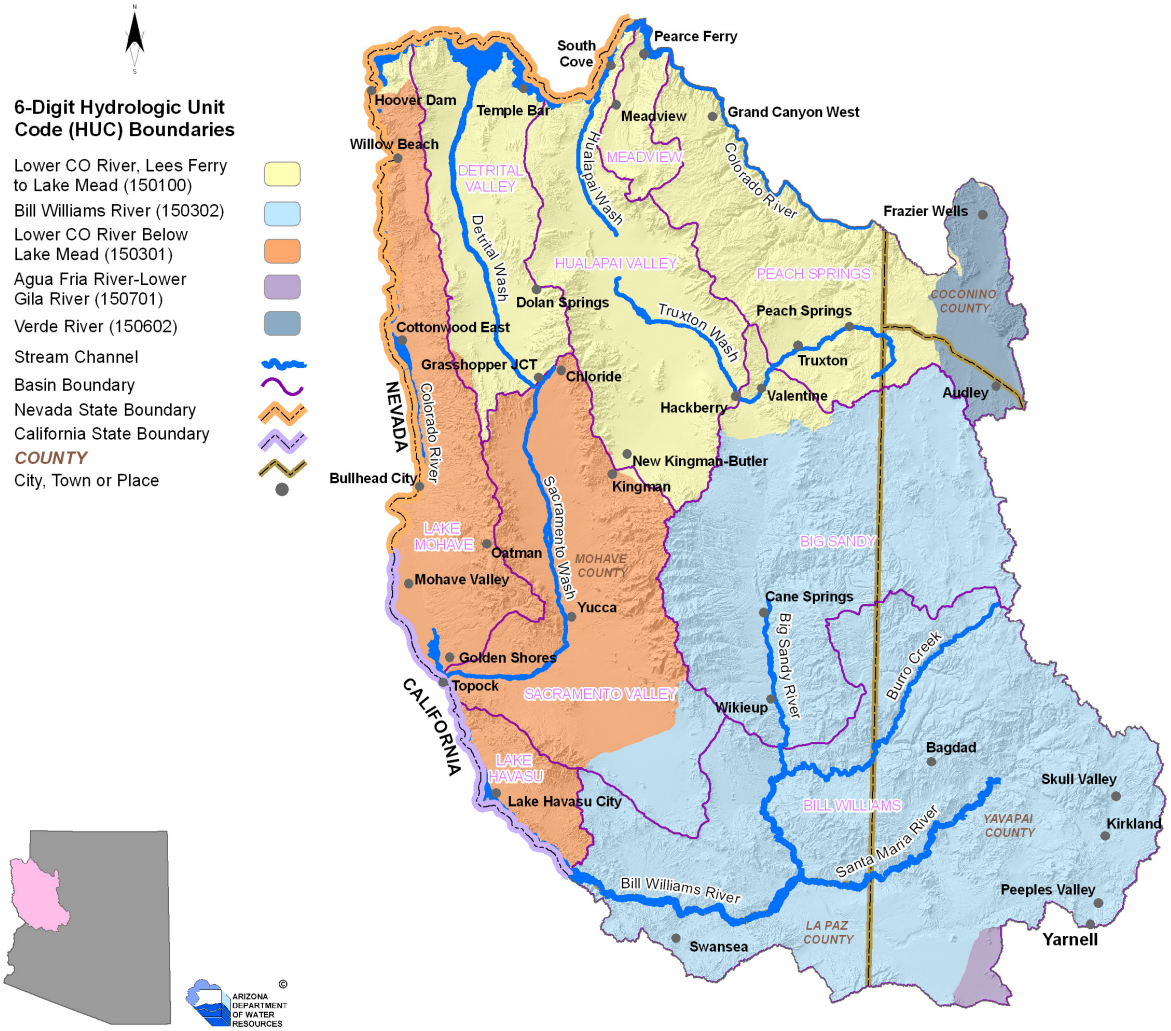
An annual groundwater recharge estimate is not available for the basin. The estimated volume of groundwater in storage ranges from 1.0 maf

to more than 4.0 maf. Data from the southern part of the basin show well yields ranging from less than 100 gpm up to 1,000 gpm. Water levels vary from 60 feet bls east of Truxton to over 1,300 feet bls northwest of Audley (Figure 4.8-7). Hydrographs of four wells in the basin show relatively stable water level conditions (Figure 4.8-6). Most of the water quality data shown in Table 4.8-7 is from springs, with arsenic most frequently exceeding the drinking water standards.

Surface Water Hydrology

The U.S. Geological Survey (USGS) divides and subdivides the United States into successively smaller hydrologic units based on hydrologic features. These units are classified into four levels. From largest to smallest these are: regions, subregions, accounting units and cataloging units. A hydrologic unit code (HUC) consisting of two digits for each level in the system is used to identify any hydrologic area (Seaber et al., 1987). A 6-digit unit code corresponds to accounting units, which are used by the USGS for designing and managing the National Water Data Network. One USGS 6-digit HUC watershed is completely within the planning area - Bill Williams River. In addition, there are portions of four others: the Lower Colorado River-Lees Ferry to Lake Mead; the Lower Colorado River below Lake Mead; the Agua Fria River-Lower Gila River; and the Verde River (Figure 4.0-5).

Figure 4.0-5 Upper Colorado River Planning Area USGS Watersheds
(USGS, 2005)



Lower Colorado River-Lees Ferry to Lake Mead Watershed

The Lower Colorado River-Lees Ferry to Lake Mead watershed is located in the Western Plateau Planning Area and in the northern portion of the Upper Colorado River Planning Area. Included within the Upper Colorado River Planning Area portion of the watershed are the Hualapai Valley and Meadview basins, almost all of the Detrital Valley Basin, all but the far eastern portion of the Peach Springs Basin and the northernmost part of the Big Sandy Basin.

The major north-flowing tributaries to the Colorado River in the Upper Colorado River Planning Area portion of the watershed are Hualapai Wash and Detrital Wash. These washes are ephemeral and contribute little to the flow of the Colorado River. The other major wash is Truxton Wash in the Peach Springs and Hualapai Valley basins, which flows north to Red Lake, a dry lake. The Colorado River is the only perennial water supply in the part of the watershed in the planning area. There is only one intermittent stream, a portion of Truxton Wash, located in Peach Springs Basin (AZGF, 1997 & 1993).

Lake Mead, created by Hoover Dam, has affected groundwater conditions in adjacent basins in the watershed. There is outflow from the lake into the surrounding aquifers. Lake Mead extends from Hoover Dam in the Lake Mohave Basin, along the planning area boundary to Peach Springs Basin. Maximum storage in Lake Mead is 29.7 maf. Of this, approximately 2.38 maf is “dead storage” - the reservoir capacity from which stored water cannot be evacuated by gravity. The average storage during the period from 1996 to 2005 was 20.3 maf.

Lake Mead National Recreation Area. Lake Mead has affected groundwater conditions in adjacent basins in the watershed. There is outflow from the lake into the surrounding aquifers.

Twenty-four major springs (springs with a measured discharge rate of 10 gpm or greater at any time) are found in the watershed, primarily located in the Peach Springs and Meadview basins. Generally, springs with the greatest discharge are located in the Hualapai Plateau in the Peach Springs Basin, where discharges of 1,730 gpm at Spencer Spring and 1,233 gpm at Meriwhitica Spring have been measured. With the exception of a number of springs measured in the early 1990s, particularly in the Peach Springs Basin, most of the spring measurements were recorded over 30 years ago and may not reflect current conditions. For example, recent discharge measurements taken at two “major” springs in the Peach Springs Basin were less than 10 gpm. (See Springs tables in each basin section.)

There is only one streamgage in the watershed at Spencer Creek near Peach Springs. Median flows at this gage are about 1,500 AFA.

Lower Colorado River below Lake Mead Watershed

This watershed covers parts of two planning areas. The northern portion is within the Upper Colorado River Planning Area (north watershed) and the southern portion is located in the Lower Colorado River Planning Area. Groundwater basins included in the north watershed are the Lake Havasu Basin and most of the Lake Mohave and Sacramento Valley basins. A very small portion of Detrital Valley Basin also lies

within the north watershed. Sacramento Wash, an ephemeral wash in the Sacramento Valley Basin, is the only major contributing tributary to the Colorado River in the north watershed. Sawmill Canyon, located at the northeastern edge of the Sacramento Valley Basin, is the only intermittent stream (Figure 4.9-5).

Parker and Davis dams have created lakes that also affect groundwater conditions along the Colorado River. Parker Dam is located in the Lower Colorado River Planning area but the lake it creates, Havasu, extends into the Upper Colorado River Planning Area. Davis Dam, north of Bullhead City, creates Lake Mohave. There is outflow from the river and lakes into the surrounding aquifers. Maximum storage in Lake Mohave is about 1.8 maf (including dead storage) and average storage from 1996 to 2005 was 1.65 maf. Maximum storage in Lake Havasu is 651,000 acre-feet (including dead storage) and average storage from 1996-2005 was about 572,000 acre-feet.

The only streamgages in the north watershed are along the Colorado River. Streamflow is largely subject to releases from upstream dams. A gage at Topock reports median annual flow of 8.9 maf, a gage below Davis Dam reports median annual flow of 8.5 maf, and median annual flows below Hoover Dam are 9.2 maf.

Twenty-four major springs are found in the north watershed. These springs are located in the northern half of the Sacramento Valley Basin and in the Lake Mohave Basin along the Colorado River immediately below Hoover Dam. Only three of the major springs have had a measured discharge rate of 100 gpm or greater. There are a relatively large number of minor springs (42) in the Sacramento Valley Basin. The most recent spring measurements were taken in 1979 and some measurements date to the 1940s.

Davis Dam. Maximum storage in Lake Mohave, created by Davis Dam, is about 1.8 maf (including dead storage) and average storage from 1996 to 2005 was 1.65 maf.

Bill Williams River Watershed

The Bill Williams watershed has a drainage area of about 5,393 sq. miles (NEMO, 2005). The watershed drains into Lake Havasu just upstream of Parker Dam near the southern boundary of the planning area. The greatest elevational range in the planning area, from 8,417 feet at Hualapai Peak to 450 feet north of Parker Dam, is found in the watershed. The watershed includes the Bill Williams Basin, most of the Big Sandy Basin and the southern portion of the Sacramento Valley Basin. The watershed is drained by the Bill Williams River and its major tributaries, the Big Sandy and the Santa Maria Rivers and by Burro Creek. A number of perennial streams exist in the watershed including segments of the Big Sandy River, the Bill Williams River, Burro Creek, Kirkland Creek, Date Creek, the

Santa Maria River, and Trout Creek. Numerous intermittent streams are also present (Figures 4.1-5 and 4.2-5).

Construction of Alamo Dam on the Bill Williams River in 1968 significantly impacted streamflow below the dam. Built as a flood-control structure, the dam is now operated in a manner to benefit downriver wildlife refuges and vegetation along the river. According to NEMO (2005), 185 miles of perennial streamflow exist in the watershed, mostly restricted to the main stem of the Bill Williams River. Water levels in the Bill Williams River below Alamo Dam are affected by the water levels in Lake Havasu. Alamo Lake is the largest lake in the watershed with about 13,400 acres of open water surface. Prior to dam construction the Bill Williams River produced some of the largest floods in Arizona history, with a peak discharge (200,000 ft^3/s) comparable to the largest known Colorado River floods (Webb and others, 2007).

Median annual streamflow in the Bill Williams River below Alamo Dam is about 34,000 acre-feet, but a maximum annual flow of almost 702,000 acre-feet was recorded in 1993. By comparison, the median annual flow at a gage on the Santa Maria River upstream of the dam is about 10,000 af. The median annual flow recorded at a gage south of Wikieup on the other major tributary to the Bill Williams River, the Big Sandy River, is about 27,000 af.

Within the watershed, perennial streams originate from spring discharges from crystalline rocks. Most of the public water supply for the town of Bagdad comes from spring flow that discharges to Francis Creek, a tributary to Burro Creek. Twelve large springs have been identified in the watershed; the largest is located in the Big Sandy Basin where discharge from an unnamed spring south of Cane Springs measured 1,600 gpm. The largest spring in the Bill Williams Basin was measured at 228 gpm. There are no large springs

Bill Williams River near its confluence with Lake Havasu. Median annual streamflow in the Bill Williams River below Alamo Dam is about 34,000 acre-feet, but a maximum flow of almost 702,000 acre-feet was recorded in 1993

reported in the Sacramento Valley Basin portion of the watershed. Most springs are located in the vicinity of Valentine, along the Big Sandy River, and near the eastern boundary of the Bill Williams Basin. All measurements were taken prior to 1980 and some measurements are as old as 1943; therefore, the reported discharges may no longer be representative of current conditions.

Agua Fria-Lower Gila Watershed

A very small portion of this watershed extends into the southeastern portion of the Bill Williams Basin. There are no major tributaries, perennial or intermittent streams, stream gages or major springs in this area.

Verde River

A very small portion of the Verde watershed extends into the eastern portion of the Peach Springs Basin. There are no major tributaries, perennial or intermittent streams, stream gages or major springs in this area.

4.0.3 Climate[2]

The Upper Colorado River Planning Area has a distinctive bi-modal precipitation pattern found in other regions of the State, though this

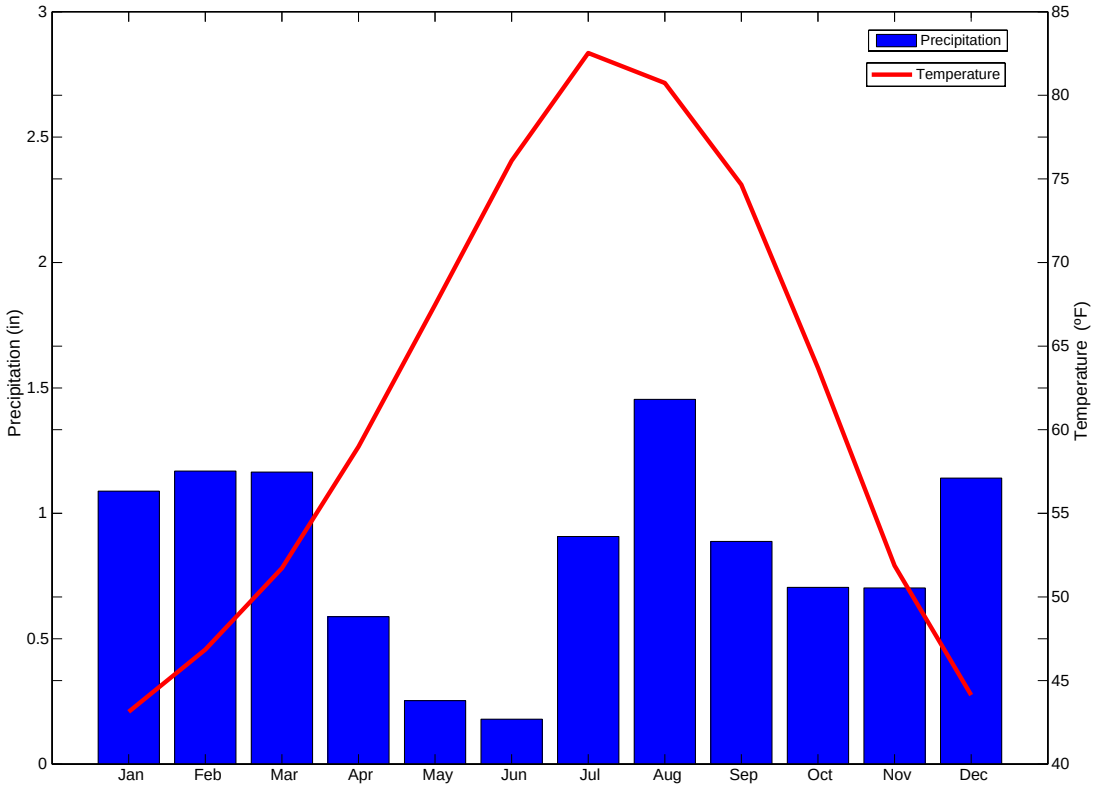
[2] Information in this section was provided by the Institute for the Study of Planet Earth, Climate Assessment for the Southwest (CLIMAS), University of Arizona, October 2006

planning area is overall relatively dry. Summer precipitation peaks in August during the summer monsoon thunderstorm season.

There is a secondary peak during December, and the May-June period is typically extremely dry. The area receives 58% of its precipitation on average during winter months (November-April), and higher elevations (e.g. Hualapai and Cerbat Mountains) typically receive some snow. From 1930-2002, average precipitation in Kingman was 10.2 inches, with 32% coming in July, August, and September (Figure 4.0-6). Average precipitation along the Colorado River is much lower, with an average of 4.9 inches recorded at Lake Havasu City from 1967-1991 and an average of 2.9 inches from 1991 to 2003. Kingman is the only location in the planning area with long-term weather records.

Precipitation patterns in Kingman are generally representative of much of the planning area. As in other areas of Arizona, precipitation is extremely variable, both spatially and temporally. For example, in 1988 Kingman recorded 13.3 inches of precipitation; in 1989 the total was 4.3 inches. This variability also may be observed on longer time scales. The 1950s and 1960s were relatively dry decades with an average annual precipitation deficit of -0.95 inches, while the 1980s was a relatively wet decade with an average annual precipitation surplus of 1.42 inches (Figure 4.0-7).

Figure 4.0-6 Average Monthly Precipitation and Temperature in Kingman, Arizona, 1930-2002

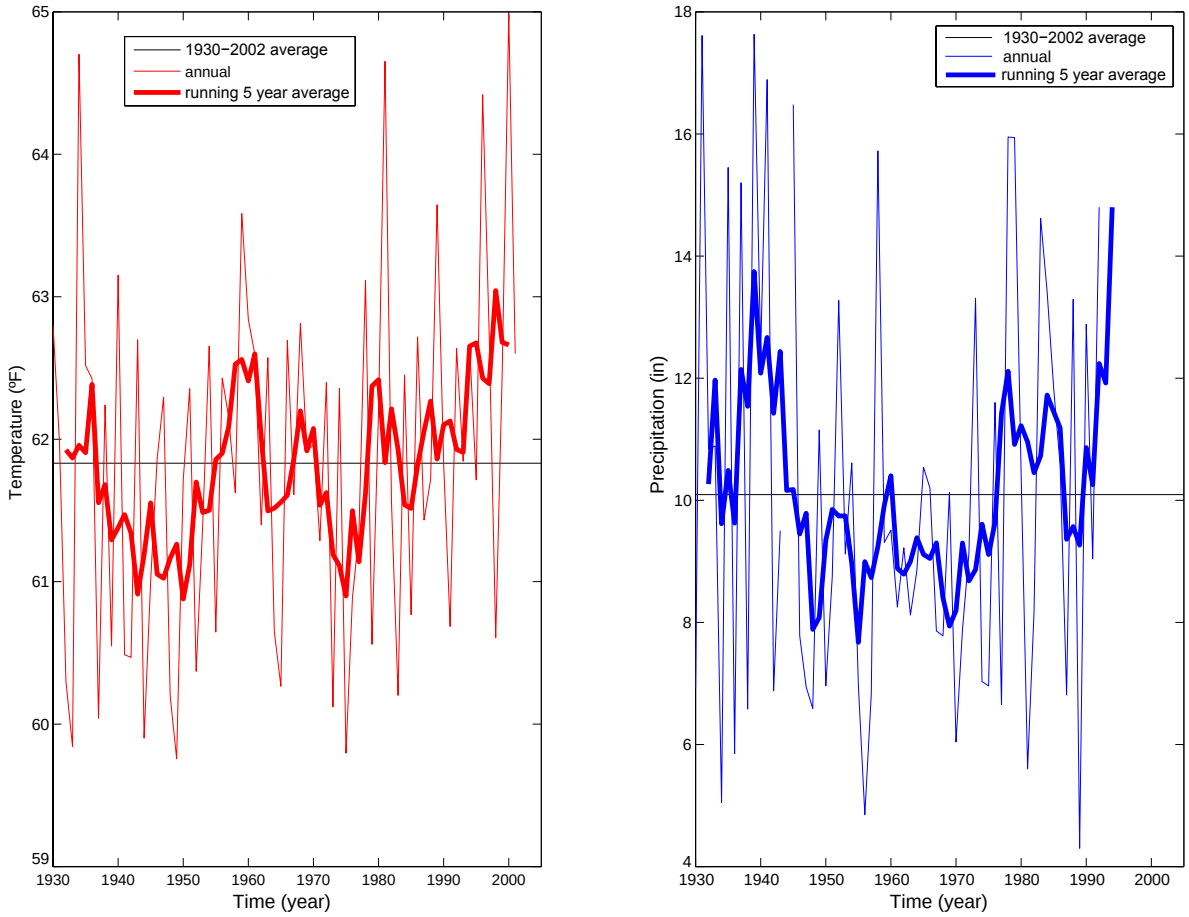


Data are from the U.S. Historical Climatology Network Figure author: CLIMAS

Winter precipitation records dating to 1000 A.D. have been reconstructed from tree rings. They show extended periods of above- and below- average precipitation in every century in the area defined by the National Oceanic and Atmospheric Administration (NOAA) as Climate Division 1, which corresponds to Mohave County (Figure 4.0-8). A climate division is a region within a state that is generally climatically homogeneous. Arizona has been divided into 7 climate divisions. In addition to Climate Division 1, the western part of Climate Division 3 (Yavapai County) and small portions of Climate Divisions 2 (Coconino, Navajo and Apache counties) and 5 (La Paz and Yuma counties) are located in the planning area.

Precipitation variability on time scales of 10-30 years likely is related to shifts in Pacific Ocean circulation patterns, such as the El Niño Southern Oscillation (ENSO) or the Pacific Decadal Oscillation (PDO). The ENSO phases, El Niño and La Niña, impact precipitation in the planning area. During El Niño episodes, there are greater chances for above-average winter precipitation as storm tracks across

Figure 4.0-7 Average Annual Temperature and Total Average Precipitation in Kingman, Arizona from 1930-2002



Horizontal lines are average temperature (61.9 °F) and precipitation (10.2 inches), respectively. Light lines are yearly values and highlighted lines are 5-year moving average values. Data are from U.S. Historical Climatology Network. Figure author: CLIMAS

North America shift farther south than normal. La Niña conditions usually are associated with below-average winter precipitation.

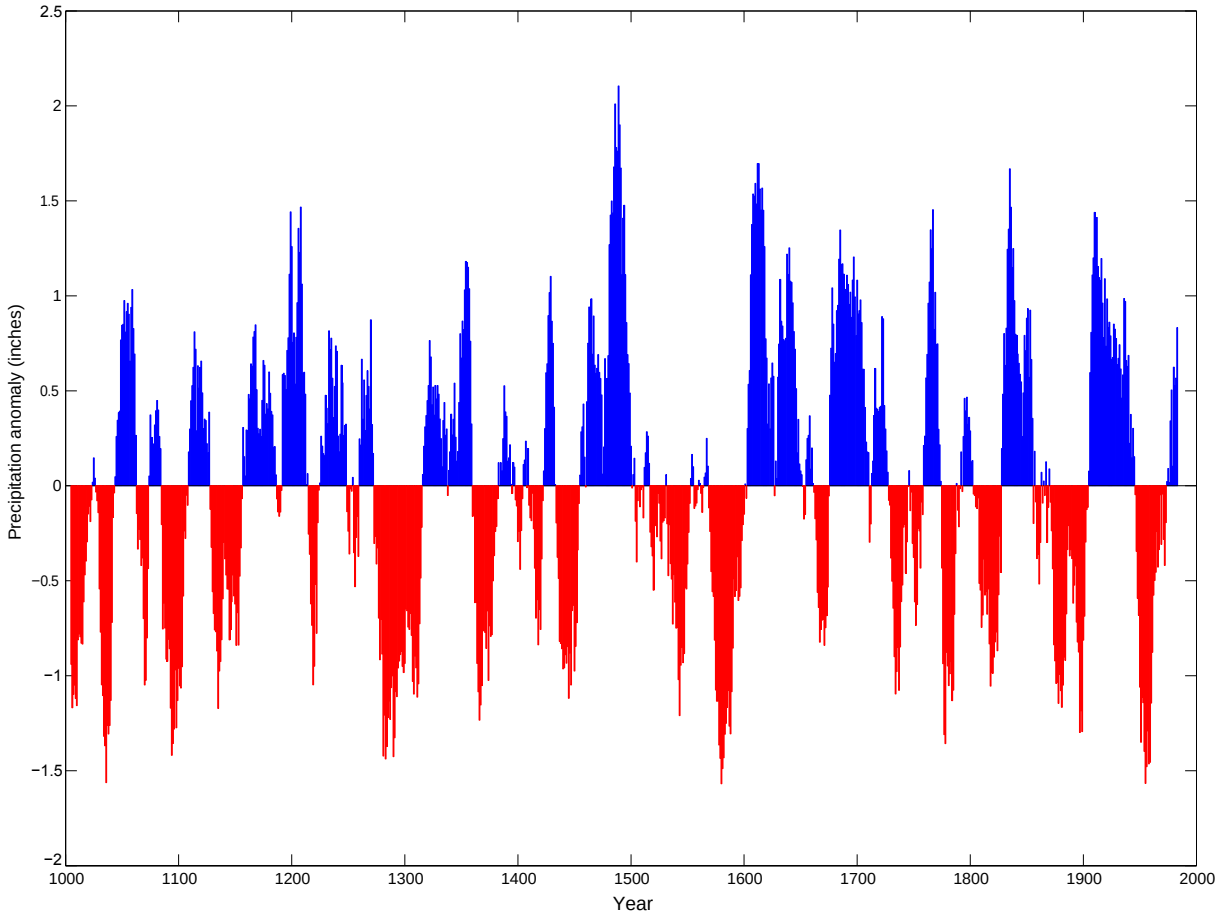
Annual average temperature in Kingman is 61.9° F, compared to the statewide average of 59.9° F. The annual average temperature in Bullhead City for the period 1977 to 2006 was 74.2°F. As in other planning areas, temperatures have been increasing the past several decades (Figure 4.0-7), consistent with global temperature trends. Some warming may be attributed to changes in land-cover resulting from population growth.

4.0.4 Environmental Conditions

Vegetation

Four of Arizona's six ecoregions are represented in the Upper Colorado River Planning Area: the Mojave Desert, Sonoran Desert, Colorado Plateau Shrublands and the Arizona Mountains Forests. (Figure 4.0-9) The planning area is diverse in terms of biotic communities, ranging from lower Colorado River Sonoran desertscrub to pine forests. Much of the area vegetation is Mohave and upland Sonoran desertscrub and

Figure 4.0-8 Arizona NOAA Climate Division 1 (Mohave County) winter (November-April) precipitation departures from average, 1000-1988, reconstructed from tree rings



Data are presented as a 20-year moving average to show variability on decadal time scales. The average winter precipitation for 1000-1988 is 5.4 inches. Data: Fenbiao Ni, University of Arizona Laboratory of Tree-Ring Research and CLIMAS. Figure author: CLIMAS.

semidesert grassland and Great Basin conifer woodland in the northeastern portion. The largest yucca species, the Joshua tree, characterizes the Mojave Desert ecoregion, a transitional desert between the higher and cooler Great Basin Desert and the lower, hotter Sonoran Desert. The Sonoran Desert ecoregion occurs in the southern part of the planning area where the saguaro is the characteristic plant and biodiversity is quite high. The Colorado Plateau Shrublands and Arizona Mountains Forests ecoregions are characterized by chaparral, conifer woodlands and higher elevation grasslands.

Rocky Mountain (Petran) and Madrean montane conifer forests commonly occur between about 7,200 to 8,700 feet in Arizona. In the planning area, most of this community is below 8,000 feet in elevation where ponderosa pine is the predominant species in areas that receive about 18 to 26 inches of annual precipitation. About half of the precipitation occurs during the growing season, which permits forests to exist on less than 25 inches of annual rainfall, making them some of the driest forests in North America (Brown, 1982). In the planning area these forests exist in only a few relatively small areas: the Hualapai Mountains south of Kingman; the northeast part of the Bill Williams Basin; and the northeast part of the Peach Springs Basin.

Great Basin conifer (piñon-juniper) woodlands cover large areas below the ponderosa pine forest at elevations between about 5,000 and 7,500 feet that receive about 12 to 20 inches of annual precipitation. Extensive stands exist in the Peach Springs Basin and the eastern part of the Big Sandy Basin as shown on Figure 4.0-9.

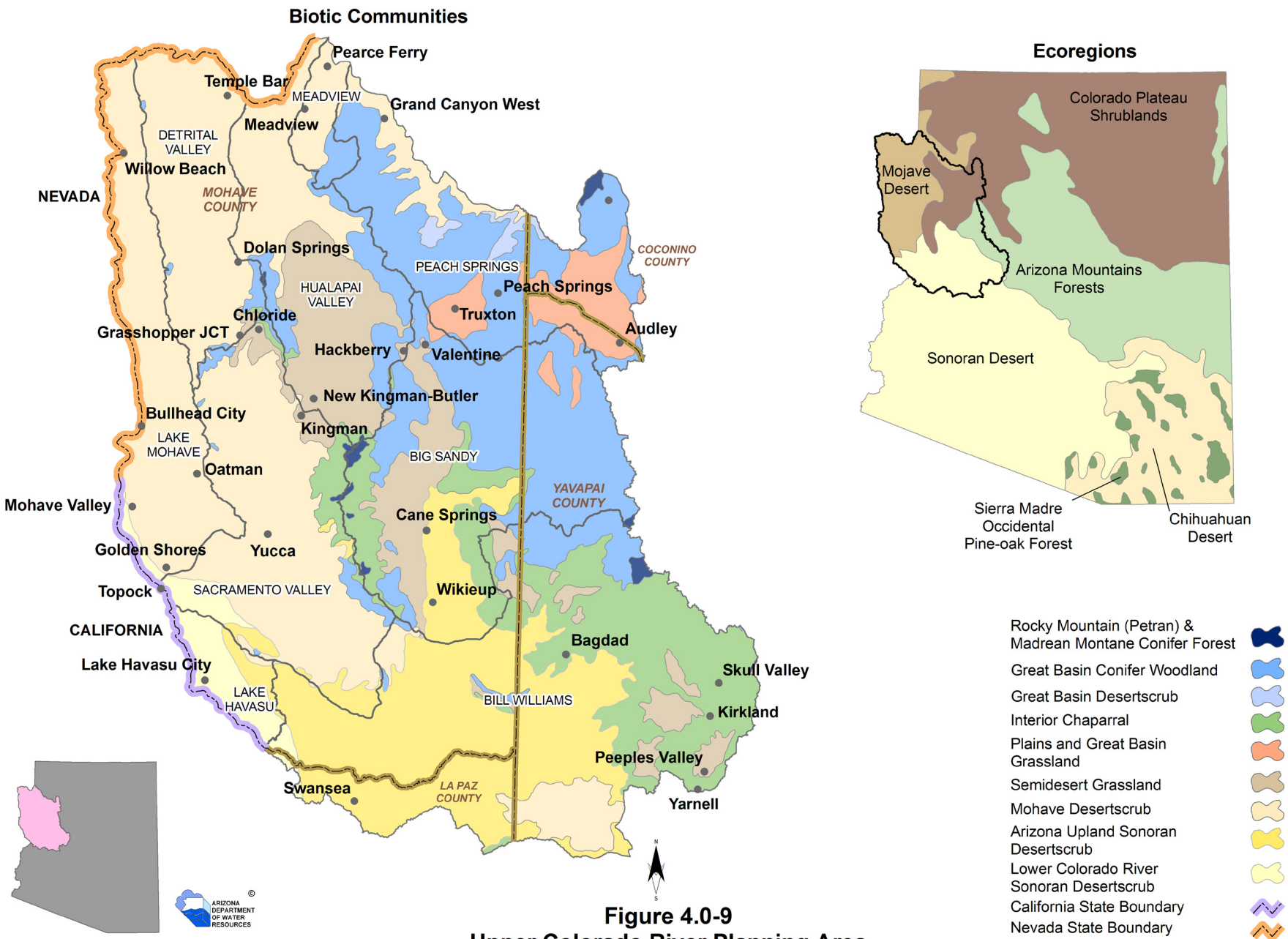
Great Basin desertscrub occurs in northern Arizona mostly at elevations of 4,000 to 6,500 feet with average rainfall of about 7 to 12 inches. This vegetative community is dominated by multi-branched, aromatic shrubs with evergreen leaves, primarily sagebrush, blackbrush and

Great Basin conifer woodland in the Peach Springs Basin.

shadscale and grasses. Great Basin desertscrub is found only in relatively small areas of the Peach Springs Basin.

At similar elevations to Great Basin desertscrub (4,000-6,000 feet), interior chaparral is found in areas that receive 13 to 23 inches of annual precipitation. This community occurs extensively in the eastern portion of the Bill Williams Basin. Chaparral consists of dense shrubs that grow around the same height with occasional taller shrubs or small trees. Chaparral communities typically are a mix of several shrubby species such as mountain mahogany, shrub live oak, and manzanita and commonly include cactus, agave, and yucca. Chaparral plants are well adapted to drought conditions.

Plains and Great Basin grasslands, primarily composed of mixed or short-grass communities, are found in the Peach Springs Basin primarily at elevations above about 4,000 feet that receive between 11 and 18 inches of annual precipitation. Semi-desert grasslands are more extensive and occur in valleys between the desert and woodlands or chaparral at elevations between 3,500 and 5,000 feet that receive 10 to 15 inches of annual precipitation. Semi-desert grasslands are found primarily in the Hualapai



Biotic Communities Source: Brown and Lowe, 1980
Ecoregions Source: Olson et al, 2001

Figure 4.0-9
Upper Colorado River Planning Area
Biotic Communities and Ecoregions

Valley, Big Sandy and eastern portion of the Bill Williams basins. Desert grasslands often contain a mixture of grasses, shrubs and small trees.

The boundary between Mohave desertscrub and Arizona Upland and Lower Colorado River Sonoran desertscrub is often difficult to discern. While many of the same plants found in the other deserts occur here, some are indicative of the Mohave Desert such as the Joshua tree and certain cacti and endemic ephemeral plants, most of which are winter annuals (Brown, 1982). The community is shrub-dominated and creosote bush and bursage are often dominant species. Mohave desertscrub covers most of the Detrital Valley, Lake Mohave and Sacramento Valley basins at elevations below about 3,500 feet that receive 5 to 11 inches of annual rainfall.

Two subdivisions of the Sonoran desertscrub region exist in the planning area-the Lower Colorado River Valley subdivision and the Arizona Upland subdivision. The Lower Colorado River Valley subdivision is the hottest and driest of the Sonoran desertscrub subdivisions. It covers most of the Lake Havasu Basin and smaller areas of adjacent basins (Figure 4.0-9). Intense competition for water results in widely spaced plants and more concentrated vegetation along drainage channels. In some areas the soil is covered by a single layer of tightly packed pebbles known as “desert pavement” that restricts plant types to ephemeral species. Characteristic plants include creosote bush, bursage, saltbush, and mixed, more diverse vegetation along washes including blue palo verde, ironwood and jojoba. Also commonly found in the subdivision are several types of cholla and other cacti. (Brown, 1982)

The Arizona Upland subdivision occurs primarily on slopes and sloping plains at elevations of 980 to over 3,000 feet where it merges with interior chaparral or semidesert grassland. This subdivision receives between 8 to 16 inches of average annual precipitation. It is the dominant biotic community in the Bill Williams Basin. Vegetation is scrubland or low woodland in appearance with blue and foothill palo verde, ironwood, mesquite and cat-claw acacia as common tree species. Cacti are extremely important in this subdivision including saguaro, organ pipe, cholla and barrel cacti. (Brown, 1982)

Riparian vegetation has been mapped along some perennial watercourses in the planning area including the Colorado, Bill Williams, Big Sandy and Santa Maria rivers and along smaller watercourses including Date, Trout and Burro creeks (Figure 4.0-10).

Webb and others (2007) studied changes in riparian vegetation along a number of watercourses in the southwestern United States. Watercourses studied in the Upper Colorado River Planning Area include Lake Mead, Lake Mohave, Lake Havasu, the Bill Williams River, Big Sandy River, and the Santa Maria River. Historically, locally lush riparian vegetation existed along reaches of the Colorado, particularly at major tributary confluences, although most of the now submerged river corridor was either barren sand or bedrock (Webb and others, 2007). With construction of dams on the river,

Riparian vegetation along the Bill Williams River.

new habitat has formed including cottonwood and willow, and tamarisk along reservoir margins. Fluctuating reservoir elevations and high salinity favor tamarisk. The mouth of the Bill Williams River at the Colorado River historically supported a considerable amount of riparian vegetation including cottonwood-willow. Lake Havasu now inundates the mouth of the river, supporting a 2,300 acre riparian zone including a cottonwood-willow forest and 500 acres of cattail marshes designated as the Bill Williams National Wildlife Refuge that extends 12 miles upstream. This area is also supported from releases of water from Alamo Dam, which completely regulates flow in the river downstream from the dam. Beaver dams are now common and riparian vegetation has increased substantially in many places.

The floodplain of the Big Sandy River upstream from Wikieup supports dense riparian vegetation including cottonwood and tamarisk. Downstream from Burro Creek, native and non-native vegetation have increased from historic observations. At the confluence of the Santa Maria River and the Big Sandy River, riparian vegetation, including tamarisk, has increased but also native species, particularly cottonwood and black willow. (Webb and others, 2007)

Arizona Water Protection Fund Programs

Six riparian restoration projects in the Upper Colorado River Planning Area have been funded by the Arizona Water Protection Fund Program (AWPF) through 2008. The objective of the AWPF program is to provide funds for protection and restoration of Arizona's rivers and streams and associated riparian habitats. There are funded projects in three of the nine planning area basins. Four projects have been funded in the Bill Williams Basin and one each in the Big Sandy and Lake Mohave basins. A list of projects and types of projects funded in the Upper Colorado River Planning Area through 2008 is located in Appendix A of this volume. (A description of the program, a complete listing of all projects funded, and a reference map is found in a Volume 1 Appendix).

Instream Flow Claims

Seven claims for instream flow water rights have been filed in the Upper Colorado River Planning Area, listed in Table 4.0-1 and shown on Figure 4.0-10. An instream flow right is a non-diversionary appropriation of surface water for recreation and wildlife use. Claims were filed only in the Bill Williams and Big Sandy

Table 4.0-1 Instream flow claims in the Upper Colorado River Planning Area

Map Key	Stream	Applicant	Application No.	Permit No.	Certificate No.	Filing Date
1	Big Sandy River	BLM (Phoenix)	33-96348.0	Pending	Pending	2/8/1994
2	Bill Williams River	U.S. Fish & Wildlife Service	33-96300.0	96300	96300	9/13/1993
3	Bill Williams River	BLM (Phoenix)	33-94245.0	Pending	Pending	4/4/1988
4	Burro Creek	BLM (Phoenix)	33-89119.0	Pending	Pending	4/3/1984
5	Francis Creek	BLM (Phoenix)	33-96510.0	Pending	Pending	4/3/1984
6	Kirkland Wash	W & L Collier Ranch LP	33-95476.1	95476	95476	9/13/1990
7	People's Canyon Creek	BLM (Phoenix)	33-90410.0	90410	NA	3/24/1986

Source: ADWR 2008a
NA = Not Applicable

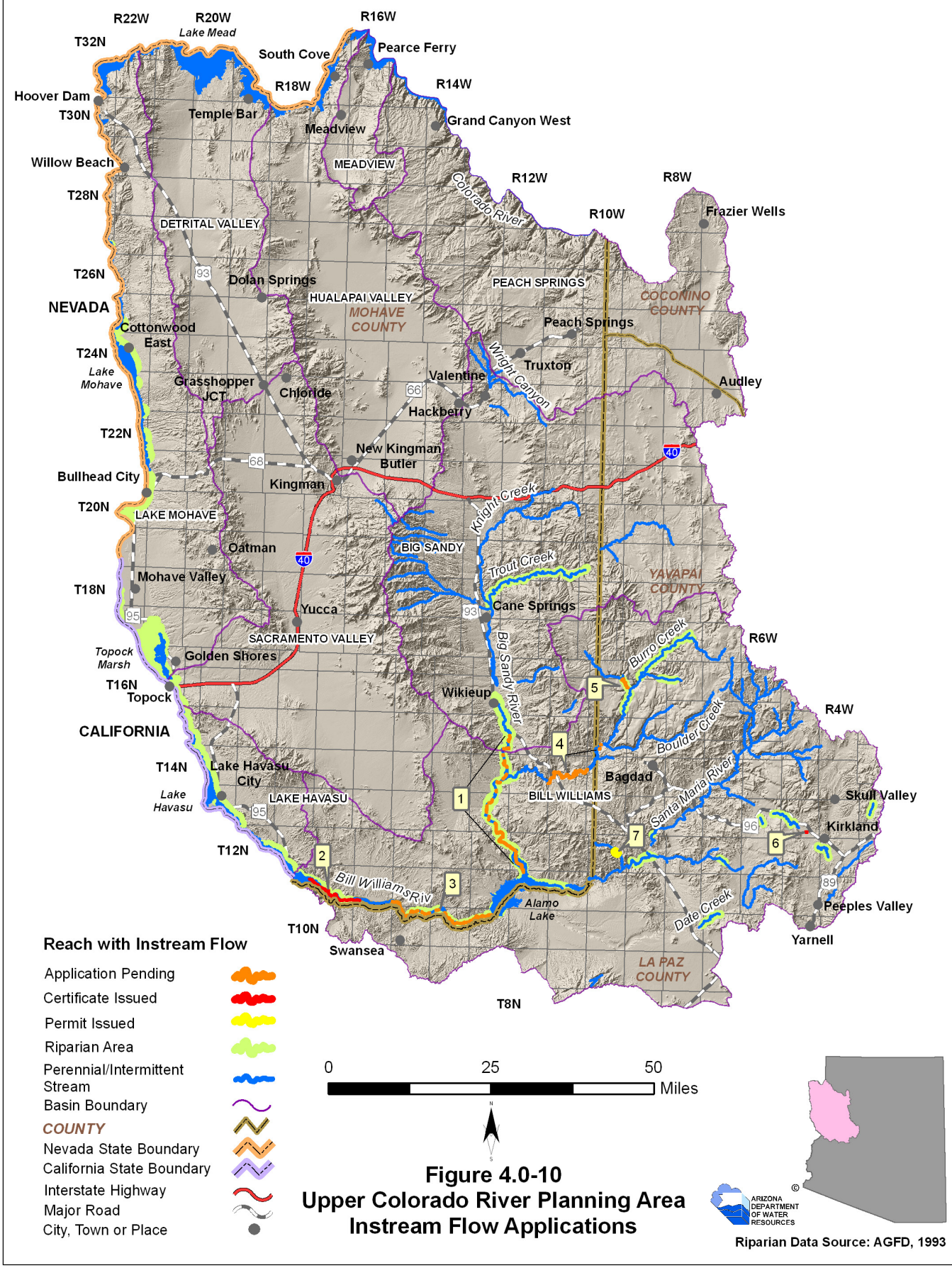


Figure 4.0-10
Upper Colorado River Planning Area
Instream Flow Applications

basins on six different watercourses. Permits or certificates were issued for claims on the Bill Williams River, Kirkland Wash and People's Canyon Creek.

Threatened and Endangered Species

A number of listed threatened and endangered species may be present in the Upper Colorado River Planning Area. Those listed by the U.S. Fish and Wildlife Service (USFWS) as of 2008 are shown in Table 4.0-2. Presence of a listed species may be a critical consideration in water resource management and supply development in a particular area. The USFWS should be contacted for details regarding the Endangered Species Act (ESA), designated critical habitat and current listings.

Actions related to operation of the Lower Colorado River water delivery and electrical power generation systems by both federal and non-federal entities may affect listed species and habitat or contribute to the listing of additional species in the future. The ESA directs Federal agencies to support the conservation of listed threatened and endangered species and to make sure that their actions do not jeopardize the continued existence of listed species or result in adverse modification of critical habitat. To comply with the requirements of the ESA, state and federal water and power interests created the Lower Colorado River Multi-Species Conservation Program (LCR MSCP). The LCR MSCP is a cooperative, Habitat Conservation Program that identifies specific measures to address the needs of 26 threatened, endangered and other species that rely on habitat associated with the lower Colorado River (USDOI, 2004).

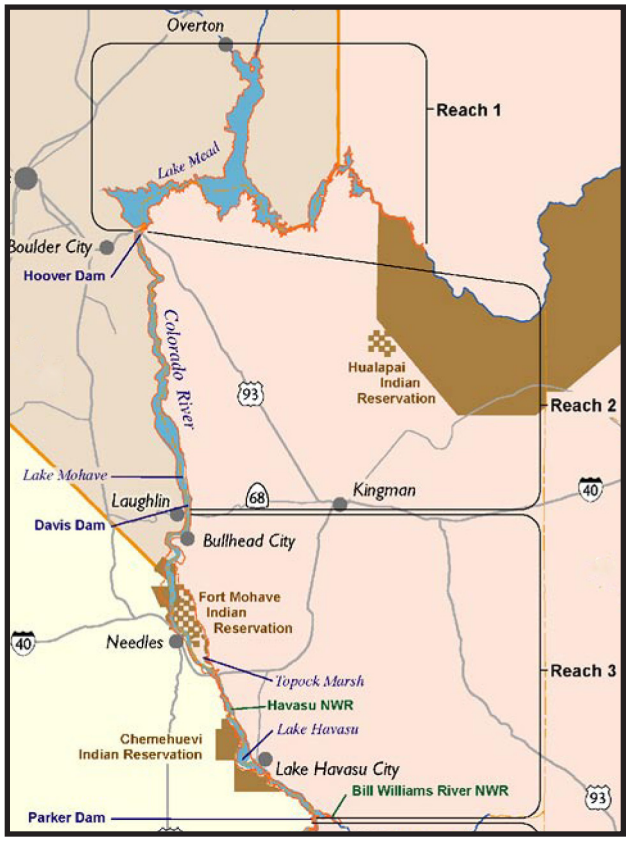
Table 4.0-2 Threatened and endangered species in the Upper Colorado River Planning Area[3]

Common Name	Threatened	Endangered	Elevation/Habitat
Arizona cliffrose		X	< 4,000 ft/ white soils of tertiary limestone lakebed deposits
Bald eagle	X		Varies/large trees or cliffs near water
Bonytail chub		X	<4,000 ft/warm, swift, turbid mainstem rivers of the Colorado River area
California brown pelican		X	Varies/lakes and rivers
California condor		X	Varies/high desert canyon lands and plateaus
Desert pupfish		X	<5,000 ft/shallow springs, small streams and marshes
Desert tortoise, Mohave population	X		500-5,100 ft/Mohave desertscrub north and west of the Colorado River
Gila topminnow		X	<4,500 ft/small streams, springs and cienegas
Hualapai mexican vole		X	3,500-7,000 ft/grass forb habitats in ponderosa pine
Mexican spotted owl	X		4,100-9,000 ft/canyons and dense forests
Razorback sucker		X	<6,000 ft/riverene and lacustrine areas, not in fast water
Southwestern willow flycatcher		X	<8,500 ft/cottonwood/willow and tamarisk vegetation along rivers and streams
Yuma clapper rail		X	<4,500 ft/fresh water and brackish marshes

Source: USFWS 2008, AZGF 2008

[3] An "endangered species" is defined by the USFWS as "an animal or plant species in danger of extinction throughout all or a significant portion of its range," while a "threatened species" is "an animal or plant species likely to become endangered within the foreseeable future throughout all or a significant portion of its range."

Figure 4.0-11 LCR MSCP Reaches in the Upper Colorado River Planning Area



Source: USDOI 2004

Its purposes include: 1) protection of habitat while ensuring current river water and power operations; 2) addressing the needs of listed species under the ESA; and 3) reduction of the likelihood of listing additional species along the river (USBOR, 2007a). LCR MSCP reaches 1-3 are within the planning area and their general location is shown in Figure 4.0-11.

The LCR MSCP also addresses compliance with the "take" provisions of the ESA.[4] Incidental take of a listed species, as the result of carrying out an otherwise lawful activity, is not allowed without acquiring a permit from the U.S. Fish and Wildlife Service. The LCR MSCP documents the extent of the incidental take related to river operations and maintenance activities by both Federal and non-Federal entities and includes measures to avoid, minimize and mitigate the effect of the take (USDOI, 2004).

Implementation of the LCR MSCP began in 2005. The program area extends from the full pool elevation of Lake Mead to the Southern International Boundary with Mexico, a distance of 400 river miles and includes the historical floodplain of the Colorado River (USBOR, 2007a). The LCR MSCP is intended to serve as a coordinated and comprehensive conservation approach for a 50-year period and therefore includes measures for species not currently listed that may become listed in the future. Implementation of the program is funded by a partnership of state, Federal and other public and private stakeholders in Arizona, California and Nevada. The plan will create riparian, marsh and backwater habitat for six federally listed species and 20 other native species including conservation programs for razorback sucker and bonytail chub, both federally listed endangered species.

The LCR MSCP for the Lake Mead area includes conservation measures for two plants listed by the State of Nevada, for conservation of relict leopard frog, and for conservation of a number of riparian obligate species. In addition, razorback sucker larvae are collected from Lake Mead and raised to a size less vulnerable to predation prior to release back into the lake.

Lake Mohave functions as a genetic refuge for razorback sucker. Under the LCR MSCP for the Lake Mohave area, razorback sucker larvae are collected and reared prior to release back into that lake or elsewhere, including Lake Havasu. Suitable habitat within Havasu NWR adjacent to Topock Marsh is maintained for southwestern willow flycatcher and Yuma clapper rail. In addition, Beal Lake, just west of Topock Marsh, is managed as a refuge for native razorback sucker and bonytail chub. There is experimental planting to create cottonwood-

[4] As defined by the ESA, take means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in other conduct." (16 U.S.C. section 1531[18])

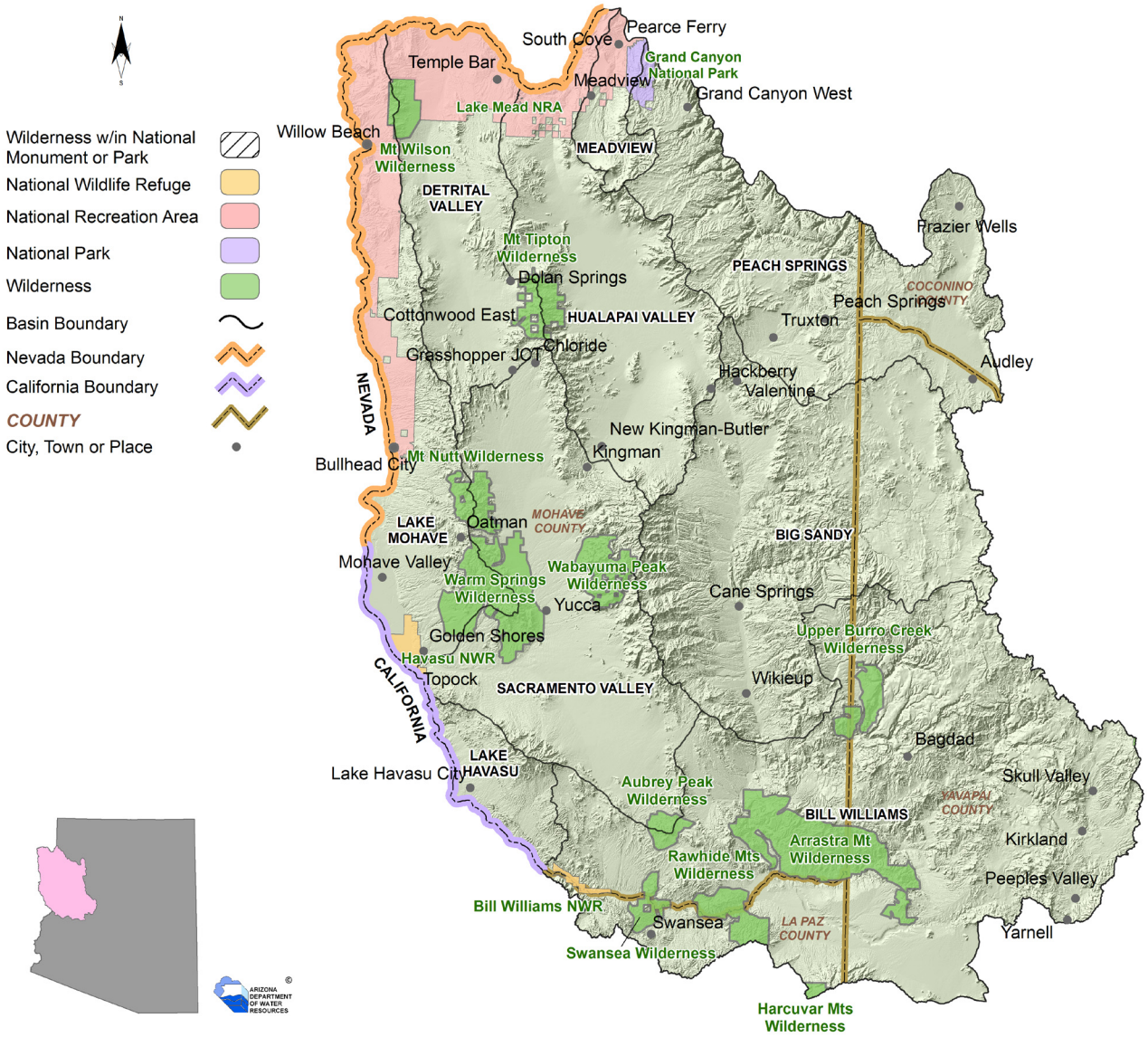
willow habitat suitable for southwest willow flycatcher and other riparian obligate species on lands adjacent to Beal Lake.

Recreation Areas, Wildlife Refuges and Wilderness Areas

The Upper Colorado River Planning Area contains most of the Lake Mead National Recreation Area (NRA), two national wildlife refuges (NWR) and 11 wilderness areas administered by the Bureau of Land Management (BLM). The southwestern portion of Grand Canyon National Park is located along the Meadview-Peach Springs basin boundary. These protected areas are shown in Figure 4.0-12.

A significant portion of the Lake Mead NRA, created in 1964 and administered by the National Park Service, is located in the northwestern portion of the planning area. The NRA stretches from Davis Dam at Bullhead City in the Lake Mohave Basin to the western boundary of Grand Canyon National Park in Meadview Basin and includes Lake Mead, Lake Mohave, the Colorado River and adjacent areas.

Figure 4.0-12 Upper Colorado River Protected Areas
(Wilderness Data Source: National Atlas of the United States, Land Ownership Data Source: ALRIS 2004)



NRA lands also are located in Detrital Valley and Hualapai Valley Basins.

The two national wildlife refuges in the planning area are the Havasu NWR in the Lake Havasu Basin and the Bill Williams River NWR in the Bill Williams Basin. The Havasu NWR, managed by the USFWS, was established in 1941 at the time of construction of Parker Dam as a refuge for migratory birds and other wildlife. The refuge protects 30 river miles of the Colorado River from Needles, CA to Lake Havasu City and contains one of the last remaining natural stretches of the lower Colorado River through the 20-mile long Topock Gorge. A portion of the refuge in Arizona is designated as the Needles Peak Wilderness. The Bill Williams River NWR, located along the Bill Williams River at its confluence with Lake Havasu, includes lands originally set aside as Havasu NWR and additional lands purchased by USFWS since then. The refuge protects one of the last stands of natural cottonwood-willow habitat along the lower Colorado River (USFWS, 2002). The refuge provides habitat for at least two endangered species, the Yuma clapper rail and the southwestern willow flycatcher (NEMO, 2005).

Bill Williams River, Bill Williams Basin. This reach within the Bill Williams River National Wildlife Refuge is one of seven reaches in the planning area with an instream flow claim.

Not shown on Figure 4.0-12, Alamo Wildlife Area, managed by Arizona Game and Fish, is located at the confluence of the Big Sandy, Santa Maria, and Bill Williams Rivers. The area includes lands withdrawn and acquired by the U.S. Army Corps of Engineers for Alamo Lake at the time of construction of Alamo Dam in 1968. Arizona State Parks manages Alamo Lake State Park on the south shore of Alamo Lake.

The Bill Williams River Corridor Steering Committee coordinates activities related to the operation of Alamo Dam and management of resources from Alamo Lake downstream along the Bill Williams River to Lake Havasu. In general, water is released in a manner that mimics natural flooding to promote establishment of native riparian woodland vegetation, including cottonwood and willow, and to ensure sufficient baseflow to support riparian vegetation between Alamo Dam and Lake Havasu.

A prominent feature of the planning area is the large number of wilderness areas administered by the Bureau of Land Management. These areas are designated under the 1964 Wilderness Act to preserve and protect the designated area in its natural condition. Designated areas, their size, basin location and a brief description are listed in Table 4.0-3. Wilderness areas represent about 6% of the total planning area lands and almost 12% of the lands within the Bill Williams Basin.

Table 4.0-3 Wilderness areas in the Upper Colorado River Planning Area

Wilderness Area	Acres	Basin	Description
Arrastra Mountain	129,800	Bill Williams	Includes portions of the Big Sandy and Santa Maria Rivers, and Peoples Canyon riparian area, classified as a unique water.
Aubrey Peak	15,400	Bill Williams	Mohave/Sonoran Desert transition zone, volcanic formations, caves and tinajas
Mt. Nutt	27,660	Lake Mohave, Sacramento Valley	Highest portions of the Black Mountains, steep canyons, bighorn sheep
Mt. Tipton	30,760	Detrital Valley, Hualapai Valley	Highest peaks in the Cerbat Mountains and Cerbat Pinnacles
Mt. Wilson	23,900	Detrital Valley	Most prominent range in Hoover Dam area, bighorn sheep
Rawhide Mountains	38,470	Bill Williams	8 miles of the Bill Williams River and gorge
Swansea	16,400	Bill Williams	Buckskin Mountains and 6 miles of Bill Williams River
Tres Alamos	8,300	Bill Williams	Colorful Tres Alamos monolith and Black Mountains
Upper Burro Creek	27,440	Bill Williams	Perennial, lower elevation stream, basalt mesas. Francis Creek, and Burro Creek from Francis Creek to Boulder Creek, are classified as unique waters.
Wabayuma Peak	40,000	Sacramento Valley	One of highest peaks in region, wide range of ecosystems
Warm Springs	112,400	Lake Mohave, Sacramento Valley	Black Mesa, canyons and springs
Total Acres	**470,530**		

Source: BLM 2008

Unique Waters

Several “unique waters”, designated by the Arizona Department of Environmental Quality (ADEQ) pursuant to A.A.C. R18-11-112, as having exceptional recreational or ecological significance and/or providing habitat for threatened or endangered species, have been identified in the planning area. Designated unique waters include sections of Peoples Canyon, Francis Creek and Burro Creek in the Bill Williams Basin.

4.0.5 Population

Census data for 2000 show about 162,100 residents in the Upper Colorado River Planning Area. Arizona Department of Commerce (ADOC) population projections forecast that the planning area population will double by 2030, to about 323,100 residents. Historic, current and projected populations for each basin are shown in the basin cultural water demand tables. Projections may not accurately reflect the most recent proposed developments, which include large master-planned communities in the Detrital Valley and Hualapai Valley basins.

As listed in Table 4.0-4 the most populous basins reported in the 2000 Census were Lake Mohave (51,549), Lake Havasu (44,591), Hualapai Valley (37,544), and Sacramento Valley (17,575). The remaining basins had a combined population of less than 10,000 residents. The 2000 Census population of the Fort Mojave Reservation was 773, with 1,353 residents on the entire Hualapai Indian Reservation.

Listed in Table 4.0-5 are incorporated and unincorporated communities in the planning area with 2000 Census populations greater than 1,000 and their growth rates for two time periods. Only three incorporated communities exist within the planning area, Lake Havasu City, Bullhead City, and Kingman. Communities are listed from highest to lowest population according to the 2000 Census. Mohave County was the fastest growing county in Arizona between 1990 and 2000, growing at a rate of 65.8% during that period. The planning area population, which includes parts of other counties, grew by 71% during this time. Mohave County is the fourth most "urban" county in the state, with 75% of its residents residing in "urban clusters," defined by the U.S. Census Bureau as densely settled areas with a population of 2,500 to 49,999. Communities with more than 1,000 residents grew at a rate of 58% compared to 184% outside these areas between 1990 and 2000.

Table 4.0-4 2000 Census population of the Upper Colorado River Planning Area and Indian Reservations

Basin/*Reservation*	2000 Census Population
Lake Mohave	51,549
Fort Mojave	*773*
Lake Havasu	44,591
Hualapai Valley	37,544
Sacramento Valley	17,575
Bill Williams	4,691
Peach Springs	1,780
Hualapai	*1,353*
Detrital Valley	1,373
Big Sandy	1,142
Meadview	823

Source: U.S. Census Bureau 2006

London Bridge in Lake Havasu City, Lake Havasu Basin. Lake Havasu City is the largest city in the Planning Area with a 2000 Census population of 41,938.

Population Growth and Water Use

Growing Smarter and Local Planning

The State has limited mechanisms to address the connections between land use, population growth and water supply. The Growing Smarter Plus Act of 2000 (Act) is a legislative attempt to link growth and water management planning. It requires counties with a population greater than 125,000 (2000 Census) to include a water resources element in their comprehensive plans. Both Mohave and Yavapai counties fit the population criteria. There is little population or water development within the Yavapai County portion of the planning area. The Mohave County water resources element includes an overview of water resources, information on wells, surface water flows, water quality, Colorado River entitlement holders, water issues and projected water use.

The Act requires that 23 communities outside AMAs include a water resources element in their general plans. For the Upper Colorado River

Table 4.0-5 Communities in the Upper Colorado River Planning Area with a 2000 Census population greater than 1,000

Communities	Basin	1990 Census Pop.	2000 Census Pop.	Percent Change 1990-2000	2006 Pop. Estimate[1]	Percent Change 2000-2006	Projected 2030 Pop.
Lake Havasu City	Lake Havasu	24,363	41,938	72%	54,610	30%	103,093
Bullhead City	Lake Mohave	21,951	33,769	54%	39,930	18%	57,391
Kingman	Sacramento Valley	12,722	20,069	58%	27,635	38%	50,872
New Kingman-Butler	Hualapai Valley	11,627	14,810	27%	16,651	12%	22,911
Mohave Valley	Lake Mohave	6,962	13,694	97%	17,587	28%	30,826
Golden Valley	Lake Mohave	2,619	4,515	72%	5,611	24%	9,340
Desert Hills	Lake Havasu	1,700	2,183	28%	2,462	13%	3,412
Dolan Springs	Detrital Valley	1,090	1,867	71%	2,316	24%	3,845
Bagdad	Bill Williams	1,858	1,578	-15%	1,578	0%	1,578
Total >1,000		84,892	134,423	58%	168,380	25%	283,268
Other		9,722	27,645	184%	26,928	-3%	40,079
Total		**94,614**	**162,068**	**71%**	195,308	21%	**323,347**

[1] 2006 populations are estimated for incorporated areas and projected for unicorporated areas.
Source: Arizona Department of Commerce, 2006 & 2007, U.S. Census Bureau 2006

Planning Area these communities are Bullhead City, Kingman and Lake Havasu City.

The Bullhead City water resource element focuses on Colorado River entitlements within its planning area and identifies as goals: 1) to acquire water resources to meet anticipated future needs; and 2) to continue water conservation measures. The Kingman water resource element discusses its groundwater supplies in the Hualapai Valley and Sacramento Valley basins, future wellfield development and potential use of alternative supplies, including effluent. The Lake Havasu City General Plan includes policies to acquire additional water supplies and implement water conservation strategies to ensure that implementation of the general plan, which guides development, does not negatively impact Lake Havasu City's water resources. Completed plans are listed in basin references in this volume.

Water System Plans and Annual Reports

Beginning in 2007, all community water systems in the state were required to submit Annual Water Use Reports and System Water

Plans. The reports and plans are intended to reduce community water system vulnerability to drought, and to promote water resource planning to ensure that water providers are prepared to respond to water shortage conditions. In addition, the information will allow the State to provide regional planning assistance to help communities prepare for, mitigate and respond to drought. An Annual Water Use Report must be submitted each year by the systems that includes information on water pumped, diverted and received, water delivered to customers, and effluent used or received. The System Water Plan must be updated and submitted every five years and consist of three components, a Water Supply Plan, a Drought Preparedness Plan and a Water Conservation Plan. By January 1, 2008, all systems were required to submit plans. By the end of 2008, plans had been submitted by 34 community water systems in the planning area. Almost all of the larger systems submitted plans and were used to prepare this document. Annual water report information and a list of water plans are found in Appendix B.

Water Adequacy Program

The Department's Water Adequacy Program also relates water supply and demand to growth to some extent, but does not control growth. Developers of subdivisions outside of AMAs are required to obtain a determination of whether there is sufficient water of adequate quality available for 100 years. If the supply is inadequate, lots may still be sold, but the condition of the water supply must be disclosed in promotional materials and in sales documents. Legislation adopted in June 2007 (SB 1575) authorizes a county board of supervisors to adopt a provision, by unanimous vote, that requires a new subdivision to have an adequate water supply in order for the subdivision to be approved by the platting authority. If adopted, cities and towns within the county may not approve a subdivision unless it has an adequate water supply. If the county does not adopt the provision, the legislation allows a city or town to adopt a local adequacy ordinance that requires a demonstration of adequacy before the final plat can be approved. To date, no counties, cities or towns in the planning area have adopted the provisions of SB 1575.

Subdivision adequacy determinations (Water Adequacy Reports), including the reasons for inadequate determination, are provided in basin tables and maps and are summarized in Table 4.0-6. Also shown in the basin sections are approved applications for an Analysis of Adequate Water Supply (AAWS). This application is typically associated with large, master planned communities. During 2005 to 2007, there was considerable development activity in the northwestern part of the planning area. This area is relatively near Las Vegas, NV, then one of the fastest growing communities in the United States. The completion of a bridge across the Colorado River south of Hoover Dam, slated for 2010, will facilitate access to the area from Las Vegas. AAWS applications for a number of large developments in the planning area have been approved by the Department. As of the end of 2008 a total of 19 applications totaling more than 421,800 lots had been approved. Approved applications include approximately: 51,000 lots

White Hills Road, Detrital Valley Basin. During 2005-2007 there was considerable development activity occurring in the northwestern part of the planning area.

in the Detrital Valley Basin; 259,900 lots in the Hualapai Valley Basin; and 110,300 lots in the Sacramento Valley Basin. Information regarding the status of pending and approved applications is available at the Department's website.

The service areas of eight water providers in the planning area are designated as having an adequate water supply. A service area designation exempts subdivisions from demonstrating water adequacy if served by the provider. Designation information and the general location of designated service areas are also shown in basin maps and tables. As of December, 2008, designated providers included:

- Cerbat Water Company (Cerbat Ranches, Hualapai Valley Basin)
- Golden Valley Water Improvement District (Golden Valley, Sacramento Valley Basin)
- Joshua Valley Utility Company (Meadview, Meadview Basin)
- City of Kingman (Hualapai Valley and Sacramento Valley Basins)
- Lake Havasu City (Lake Havasu Basin)
- Valley Pioneer Water Company (Golden Valley, Sacramento Valley Basin)
- City of Bullhead City (Arizona-American Water Works, Bermuda Water Company, North Mohave Valley Corporation; Lake Mohave Basin)
- Walnut Creek Water Company (Walnut Creek Estates, Sacramento Valley Basin)

As of April 2009, an application was pending to modify the designation of the Golden Valley Water Improvement District. The designation modification for the City of Bullhead City was approved in 2008. It is planning to become a water provider and applied to modify its des-

Table 4.0-6 Water adequacy determinations in the Upper Colorado River Planning Area

Basin	Number of Subdivisions	Number of Lots[1]	Lots w/Adequate Determination	Lots w/Inadequate Determination	Approx. Percent of Lots w/ Inadequate Determination
Big Sandy	4	>608	UNK	608	UNK
Bill Williams	8	>264	>264	0	0%
Detrital Valley	29	>6,090	0	>6,090	100%
Hualapai Valley	50	>19,393	10,969	>8,424	43%
Lake Havasu	14	>1,697	>1,697	UNK	UNK
Lake Mohave	265	>32,802	>32,530	272	1%
Meadview	5	4,793	0	4,793	100%
Peach Springs	2	51	0	51	100%
Sacramento Valley	32	>4,415	1,200	>3,215	73%
TOTAL	**409**	**>70,113**	**>46,660**	**>23,453**	**33%**

Source: ADWR 2008b
[1] Data on number of lots are missing for some subdivisions, actual number is larger (>)
UNK = Unknown

ignation to reflect that change. Prior to modification it was designated pursuant to A.R.S. 45-108D, which allows designation of a city or town without it being a water provider if it has a Colorado River allocation and other conditions are met.

4.0.6 Water Supply

Water supplies in the Upper Colorado River Planning Area include Colorado River water, other surface water, groundwater, and effluent. Colorado River water is the primary water supply in the Lake Havasu and Lake Mohave basins. It is also used to meet environmental water demands for the Havasu National Wildlife Refuge in the Sacramento Valley Basin. Elsewhere, groundwater is the primary water supply. A discussion of Colorado River water entitlements and accounting is presented here. Subsequent water supply and demand discussions and basin chapters report the use of Colorado River water as either groundwater, if it is pumped from a well within the hydraulically connected aquifer, or as surface water when it is directly diverted from the river.

Colorado River Water

Decree Accounting

The right or authorization to beneficially use Colorado River water is defined as an entitlement. Entitlements held by Colorado River water users are created by decree of the United States Supreme court in Arizona v. California et al. (Decree), through a contract with the Secretary of the Interior (Secretary) under Section 5 of the Boulder Canyon Project Act (BCPA) of December 21, 1928, or by Secretarial reservation.

Table 4.0-7 shows the average annual Colorado River water that was consumptively used within each basin in the planning area based on an accounting system established by Decree. Article V of the Decree directs the U.S. Bureau of Reclamation (Reclamation) to prepare an annual report of diversions from the mainstream, return flows to the mainstream that makes water available for downstream consumptive use in the U.S. or in satisfaction of the Mexican Treaty obligation, and the consumptive use of such water. The Article V report lists diversions

Colorado River, Bill Williams Basin. Water supplies in the Upper Colorado River Planning Area include Colorado River water, other surface water, groundwater, and effluent.

Table 4.0-7 Arizona v California Decree accounting of the consumptive use of Colorado River water in the Upper Colorado River Planning area (in acre-feet/year)

Basin/Year [1]	1971-75	1976-80	1981-85	1986-90	1991-95	1996-00	2001-03 [2]	Current Entitlement
Bill Williams								
Agricultural	None							
Industrial	None							
Municipal	0	0	0	0	20	18	26	84
Environmental	None							
Detrital								
Agricultural	None							
Industrial	None							
Municipal	0	0	0	0	116	146	126	Unspecified
Environmental	None							
Lake Havasu								
Agricultural	None							
Industrial	None							
Municipal	5,554	8,075	8,872	11,604	13,376	15,053	14,619	29,254
Environmental [3]	14,300	14,064	7,828	15,456	15,927	12,561	7,577	16,317
Lake Mohave								
Agricultural	20,209	47,172	73,885	83,109	96,123	107,700	82,639	144,535
Industrial	216	220	158	103	80	0	0	175
Municipal	295	298	581	6,062	7,857	9,669	9,328	44,192
Environmental [3]	14,300	14,064	7,828	15,456	15,927	12,561	7,577	16,317
Sacramento								
Agricultural	None							
Industrial	None							
Municipal	None							
Environmental [3]	8,066	7,934	4,416	8,719	8,984	7,086	4,274	9,205
TOTAL	62,939	91,826	103,567	140,507	158,409	164,793	126,167	260,079
Central Arizona Project [4]	0	0	33,502	499,917	717,514	1,330,109	1,596,626	Unspecified

Notes:

[1] The reported consumptive use for individual users may not cover an entire 5 year period; the averages are based on the years of record.

[2] In 2003, the United States Bureau of Reclamation (Reclamation) began deducting unmeasured return flows from individual divertors. Prior to this time, Reclamation only deducted the total unmeasured return flow from the total Lower Basin diversions.

[3] The Havasu National Wildlife Refuge spans an area in the Lake Mohave, Lake Havasu, and Sacramento Valley basins. Consumptive use has been prorated based on the percentage of refuge land area in each basin.

[4] The Central Arizona Project diverts water out of Lake Havasu (located in the Lake Havasu Basin) for multiple uses in Maricopa, Pinal, and Pima counties.

and return flowe separately by diverter for each lower basin state.

According to the Article V report, consumptive use of Colorado River water in the planning area for agricultural, municipal, industrial and environmental purposes averaged 107,923 AFA for the 2001-2005 time period. Table 4.0-7 lists the total quantities of Colorado River water diverted by surface water diversions, in-river pumps, or pumped from wells assumed to be located within the hydraulically connected aquifer of the Colorado River. When determining consumptive water use, the Article V accounting system considers measured return flow and estimates of unmeasured return flows to the mainstream.

Reclamation has made a preliminary delineation of the lateral and vertical extent of the Colorado River aquifer to provide a basis for accounting of withdrawals against river water allocations. On July 16, 2008, Reclamation proposed to develop a rule for Regulating Non-Contract Use of Colorado River Water in the Lower Basin (73 Federal Register 40916 et seq.) to prevent non-contract Colorado River water use from depleting the river and taking water from holders of Colorado River water entitlements. Reclamation's most current assessment indicates that most existing non-contract water use results

from water withdrawn from wells located within the hydraulically connected aquifer of the Colorado River or from river pumps. The proposed rule would establish a methodology that Reclamation would use to determine if a well pumps Colorado River water and a process for a water user to appeal a subsequent finding (USBOR, 2008). As of June 2009, Reclamation had not adopted a rule.

Because of the complexity of the accounting system and its unique methodology that includes return flow and other considerations, the surface water and groundwater discussions in this overview section and the cultural water demand tables in sections 4.2, 4.3, 4.5, 4.6 and 4.9 (those basins that utilize this supply), reflect the amount of water pumped from wells and diverted from streams. This approach is comparable to that used for other planning areas. The tables do not attempt to distinguish whether the water is used pursuant to the Colorado River entitlement system.

Entitlement Priority Levels

Rights to Colorado River water include the following priority levels in the State of Arizona:

a. 1st Priority: Satisfaction of Present Perfected Rights as defined in the Arizona v. California decree;

b. 2nd Priority: Satisfaction of Secretarial Reservations and Perfected Rights established prior to September 30, 1968;

c. 3rd Priority: Satisfaction of entitlements pursuant to contracts between the United States and water users in Arizona executed on or before September 30, 1968 (2nd and 3rd priority are coequal);

d. 4th Priority: i) Contracts, Secretarial Reservations and other arrangements between the U.S. and water users in Arizona entered into after September 30, 1968, for a total quantity not to exceed 164,652 acre-feet of diversions annually and ii) contract No. 14-06-W-245, dated December 15, 1972, as amended, between the United States and the Central Arizona Project (CAP). Entitlements having a 4th priority as described in (i) and (ii) are coequal;

e. 5th Priority: Unused Arizona entitlement; and

f. 6th Priority: Surplus water

In general, the lower priority entitlements will be the first to be impacted when the Secretary declares a shortage on the Colorado River system. Within the planning area, entitlement holders with a first priority or present perfected rights include the Fort Mojave Indian Reservation and several private entities within the Mohave Valley Irrigation and Drainage District. Second and third entitlement holders (which are coequal during a shortage), include Havasu National Wildlife Refuge, Bureau of Reclamation (Davis Dam), and the National Park Service. Fourth priority entities include Arizona-American Water Company (Lake Havasu), Bullhead City, Golden Shores Water Conservation District, Lake Havasu City, Mohave Water Conservation District, Mohave Valley Irrigation and Drainage District, and the Mohave County Water Authority. Lake Havasu

Agriculture on the Fort Mojave Indian Reservation. Within the planning area, entitlement holders with a first priority or present perfected rights include the Fort Mojave Indian Reservation and several private entities within the Mohave Valley Irrigation and Drainage District.

City and the Mohave County Water Authority also have fifth and sixth priority entitlements.

Mohave County Water Authority

The Mohave County Water Authority (MCWA) was organized pursuant to A.R.S.§ 45-2201 primarily for the purpose of acquiring the city of Kingman's unused 18,500 acre-feet entitlement and making it available to other authority members for municipal and industrial water uses. MCWA members include Arizona-American Water Company (Havasu), Bullhead City, Golden Shores Water Conservation District, Kingman, Lake Havasu City, Mohave County, Mohave Valley Irrigation and Drainage District and Mohave Water Conservation District. As well as providing other services and functions, MCWA can acquire additional water supplies, including effluent, and it may store, recharge and recover these supplies for the benefit of Mohave County water users. MCWA can also assist members with the development and operation of water diversion, conveyance, treatment, storage and recharge facilities and the development of augmentation and conservation programs.

Arizona Water Banking Authority

The Arizona Water Banking Authority (AWBA) was created in 1996 to protect Arizona's Colorado River interests and to provide for interstate water banking opportunities. Among its statutory authorities is the requirement to reserve a reasonable number of long-term storage credits developed with general fund appropriations for the benefit of Municipal and Industrial (M&I) water users located near the Colorado River (on-river users), during times of shortage. Fourth priority on-river Colorado River M&I water users have no alternate water supply during times of shortage. Regardless of whether water is diverted directly from the Colorado River or pumped from wells within the hydraulically connected river aquifer, the limit of an entity's water right is its Colorado River entitlement. On January 1, 1998, the AWBA adopted 420,000 acre-feet as the reasonable number of long-term storage credits for on-river M&I "firming." Contractors may recover this firmed or stored water in times of shortage. (See Volume 1 for more information on the AWBA).

The manner in which the general fund credits would be reserved, and then recovered and distributed during a shortage, has long been an issue of concern to the on-river users. In recognition of the concerns, the AWBA and the MCWA entered into the Agreement to Firm Future Supplies (Agreement to Firm). The Agreement to Firm recognizes that the MCWA can enter into subcontracts with on-river M&I water users having the same priority as the CAP. These are the same water users for whom the AWBA must firm M&I supplies. Upon execution of the subcontracts and payment of the appropriate fees, the AWBA would reserve the appropriate quantity of long-term storage credits as described in the Agreement to Firm.

The parties executed the Agreement to Firm on February 4, 2005. The MCWA offered all entities in Mohave County the option to participate in the Agreement. Subcontract entities included in the Agreement to Firm are Arizona State Parks, Bullhead City, Lake Havasu City, and

Colorado River, Lake Mohave Basin.

Mohave Water Conservation District. Pursuant to the Agreement to Firm, 230,280 acre-feet of the current 396,499 acre-feet of credits in the General Fund Account were transferred to a sub-account in MCWA's name. The remaining credits in the General Fund Account could still be available to firm on-river supplies.

Drought

The Colorado River reservoirs are operated in accordance with the Colorado River Basin Project Act of 1968 (P.L. 90-537). Hydrologic conditions in the Colorado River Basin affect reservoir operation. The Colorado River Basin experienced five consecutive years of extreme drought during water years 2000-2004 and, while there was above average inflow to Lake Powell and record-breaking tributary flows in the Lower Colorado Basin in 2005, there was below average streamflow in 2006 and 2007 (USBOR, 2006a and 2007c). During this period, storage in Colorado River reservoirs dropped from near capacity to 54 percent of capacity by the end of 2007. Conditions improved somewhat in 2008 but by April 2009 Lake Powell water levels were at 52% of capacity.

Reclamation lacked specific guidelines to address the operation of Lake Mead and Lake Powell during drought. To address this situation, in February 2007, Reclamation released a draft environmental impact statement on proposed adoption of specific interim guidelines for Lower Basin shortages and coordinated operation of the two reservoirs. The Final EIS was adopted in November 2007 and the Record of Decision was signed in December (USDOI, 2007). One of the purposes of the guidelines is to provide greater predictability regarding the amount of annual water deliveries to mainstream Colorado River water users in the Lower Division states (USBOR, 2007a). The effect of drought and other hydrologic conditions on water levels in Lake Mead is shown in Figure 4.0-13. Lowering water levels have resulted in closure

Black Canyon below Hoover Dam, Lake Mohave Basin. The Colorado River Basin experienced five consecutive years of extreme drought during water years 2000-2004.

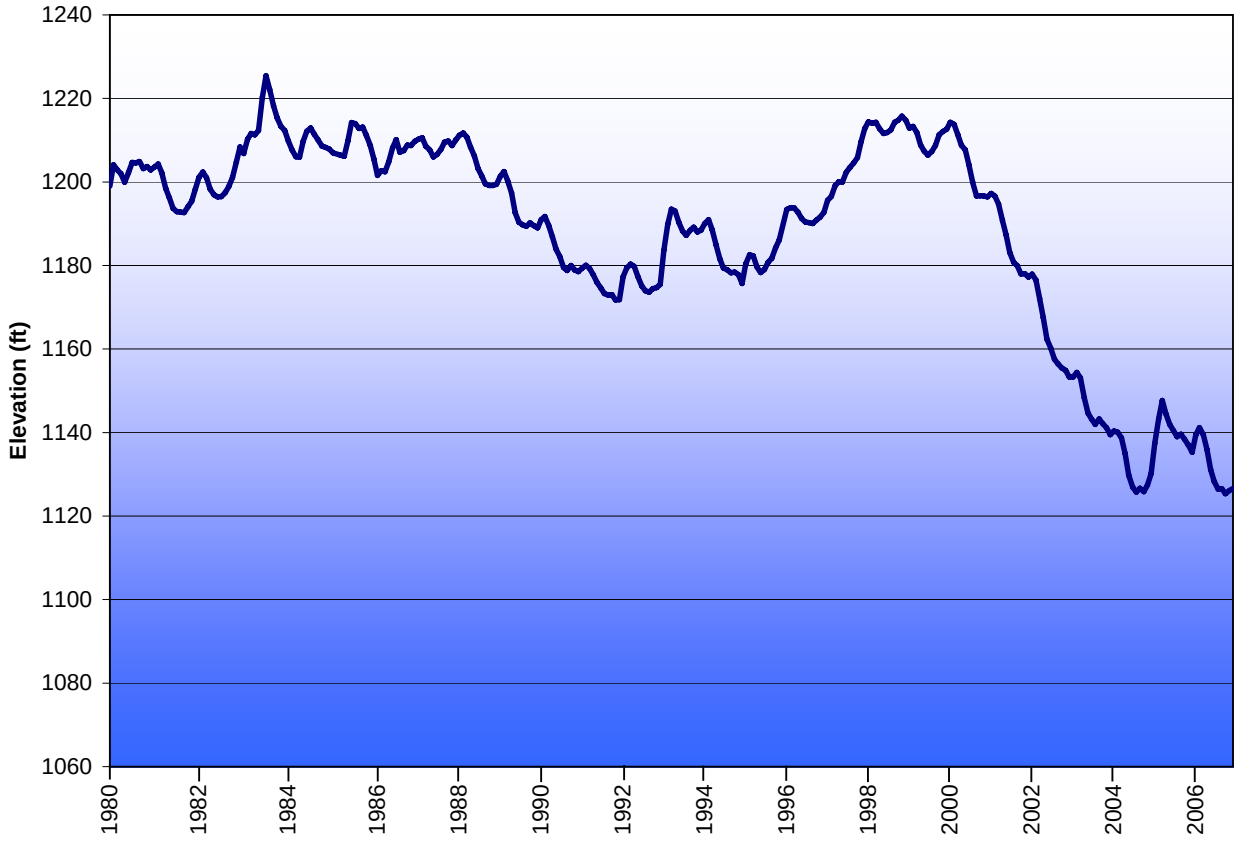
and relocation of boat marinas at Lake Mead, and formation of a rapid at Pearce Ferry which had been a boat ramp.

Surface Water

An average of about 69,800 AFA of surface water was used during 2001-2005, which constitutes about 39% of the total water supply during this period. Surface water diverted from the Colorado River was the primary water supply in the Lake Mohave Basin (69,000 AFA) where it was the principal supply for agricultural and industrial use, particularly by the Fort Mojave Indian Tribe. About 500 acre-feet of surface water from springs near Bagdad in the Bill Williams Basin provided a municipal and industrial supply for the town of Bagdad and the Bagdad mine. Small volumes of surface water, diverted from the Colorado River, are used in the Detrital Valley and Lake Havasu basins. Surface water may have been used elsewhere but records are not available. There are few springs in proximity to water demand centers and, with the exception of the Colorado River, perennial streams are located only in the Bill Williams and Big Sandy basins. The volume of surface water, groundwater and effluent used in the planning area is shown in Figure 4.0-14.

Legal availability of a surface water supply is an important consideration. As described in detail in Appendix C, the legal framework and process under which surface water right applications and claims are administered and determined is complex. Rights to surface water are subject

Figure 4.0-13 Lake Mead End of Month Elevation 1980-2007

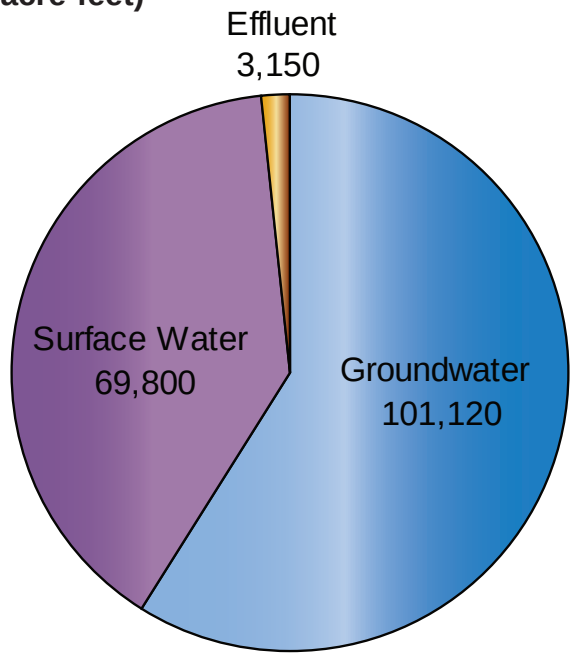


Source: USBOR, 2007c

to the doctrine of prior appropriation which is based on the tenet "first in time, first in right". This means that the person who first put the water to a beneficial use acquires a right that is superior to all other surface water rights with a later priority date. Under the Public Water Code, beneficial use is the basis, measure and limit to the use of water. Each type of surface water right filing is assigned a unique number as explained in Appendix C and shown in Table 4.0-8. A Certificate of Water Right (CWR) may be issued if the terms of the permit to appropriate water (3R, 4A, or 33, and in certain cases 38), are met. CWRs retain the original permit application number. However, the act of filing a statement of claim of rights to use public waters (36) does not in itself create a water right.

Surface water rights may also be determined through judicial action in state or federal court in which the court process establishes or confirms the validity of the rights and claims and ranks them according to priority. Court decreed rights are considered the most certain surface water right. A court decree, Arizona v. California 373 U.S. 546 (1963), confirmed the apportionment of waters from the mainstem of the Colorado River to the Lower Basin States, set Arizona's allotment of Colorado River water at 2.8 maf and reserved irrigation water for reservations along the river including the CRIT and Fort Mohave reservations in the planning area.

Figure 4.0-14 Average Annual Water Supply Utilized in the Upper Colorado River Planning Area, 2001-2005 (in acre-feet)



Total Demand = 174,070 acre-feet

Arizona has two general stream adjudications in progress to determine the nature, extent and priority of water rights across the entire river systems of the Gila River and the Little Colorado River. The Upper Colorado River Planning Area is outside of the stream adjudication boundaries.

Table 4.0-8 summarizes the number of surface water right filings in the planning area. The methodology used to query the Department's surface water right and statement of claimant (SOC) registries is described in Appendix C. Of the 9,916 filings that specify surface water diversion points and places of use in the planning area, 1,223 CWRs have been issued to date. Most of these are located in the Bill Williams (713) and Big Sandy (301) basins. Figure 4.0-15 shows the location of surface water diversion points listed in the Department's surface water rights registry. The numerous points reflect the large number of stockponds and reservoirs that have been constructed in the planning area as well as diversions from streams and springs. Locations of registered wells, many of which are referenced as the basis of claim in SOCs are also shown in Figure 4.0-15.

The location of surface water resources for each basin are shown on surface water condition maps and maps showing perennial and intermittent streams and major springs in sections 4.1 to 4.9. Basin tables list data on streamflow, flood ALERT equipment, reservoirs, stockponds and springs.

Table 4.0-8 Inventory of surface water right and adjudication filings in the Upper Colorado River Planning Area[1]

Basin	Type of Filing							Total
	BB[2]	3R[3]	4A[3]	33[3]	36[4]	38[5]	39[6]	
Big Sandy	0	80	81	75	743	205	0	**1,184**
Bill Williams	0	111	136	326	1,492	5,595	0	**7,660**
Detrital Valley	0	2	6	4	58	41	0	**111**
Hualapai Valley	0	5	34	15	103	73	0	**230**
Lake Havasu	0	0	2	1	6	0	0	**9**
Lake Mohave	0	0	11	9	75	1	0	**96**
Meadview	0	0	6	1	20	14	0	**41**
Peach Springs	0	25	0	13	70	111	0	**219**
Sacramento Valley	0	1	34	12	279	40	0	**366**
Total	**0**	**224**	**310**	**456**	**2,846**	**6,080**	**0**	**9,916**

Notes:

[1] Based on a query of ADWR's surface water right and adjudication registries in February 2009 . A file is only counted in this table if it provides sufficient information to allow a point of diversion (POD) to be mapped within the basin. If a file lists more than one POD in a given basin, it is only counted once in the table for that basin. Numerous surface water right filings are not counted here due to unsufficient information on POD locations. However, multiple filings for the same POD are counted.

[2] Court decreed rights; not all of these rights have been identified and/or entered into ADWR's surface water rights registry.

[3] Application to construct a reservoir, filed before 1972 (3R); application to appropriate surface water, filed before 1972 (4A); and application for permit to appropriate public water or construct a reservoir, filed after 1972 (33).

[4] Statement of claim of right to use public waters of the state, filed pursuant to the Water Rights Registration Act of 1974.

[5] Claim of water right for a stockpond and application for certification, filed pursuant to the Stockpond Registration Act of 1977.

[6] Statement of claimant, filed in the Gila or LCR General Stream Adjudications.

Groundwater

Groundwater is a major water supply in the planning area, meeting 59% of the water demand during the period 2001-2005. (Some of this water was pumped pursuant to a Colorado River entitlement). The location of registered exempt and non-exempt wells is shown in Figure 4.0-15. Groundwater met 92% of the municipal demand, 83% of the industrial demand and 35% of the agricultural demand during this time period and averaged about 101,000 AFA. Groundwater is found at varying depths in the planning area, generally in the 200 to 600-foot range although water levels of more than 1,000 feet bls are found in the Hualapai Valley, Peach Springs and northern Sacramento Valley basins. Groundwater is pumped from basin fill in most basins with the exception of the Meadview and Lake Mohave basins. Recent stream alluvium is a potentially important aquifer in the Big Sandy, Bill Williams, Detrital Valley and Lake Mohave basins. Sedimentary rocks are principal aquifers in five north and northeastern basins including the Big Sandy, Detrital Valley, Hualapai Valley, Peach Springs and Meadview basins. In the Bill Williams and Sacramento Valley basins, aquifers in volcanic rock are also utilized. Groundwater is limited due to water quality and quantity problems at the town of Chloride, north of Kingman. Groundwater is the primary or only water supply in most basins with the exception of the Lake Mohave Basin where large volumes of surface water are diverted for agricultural and industrial use.

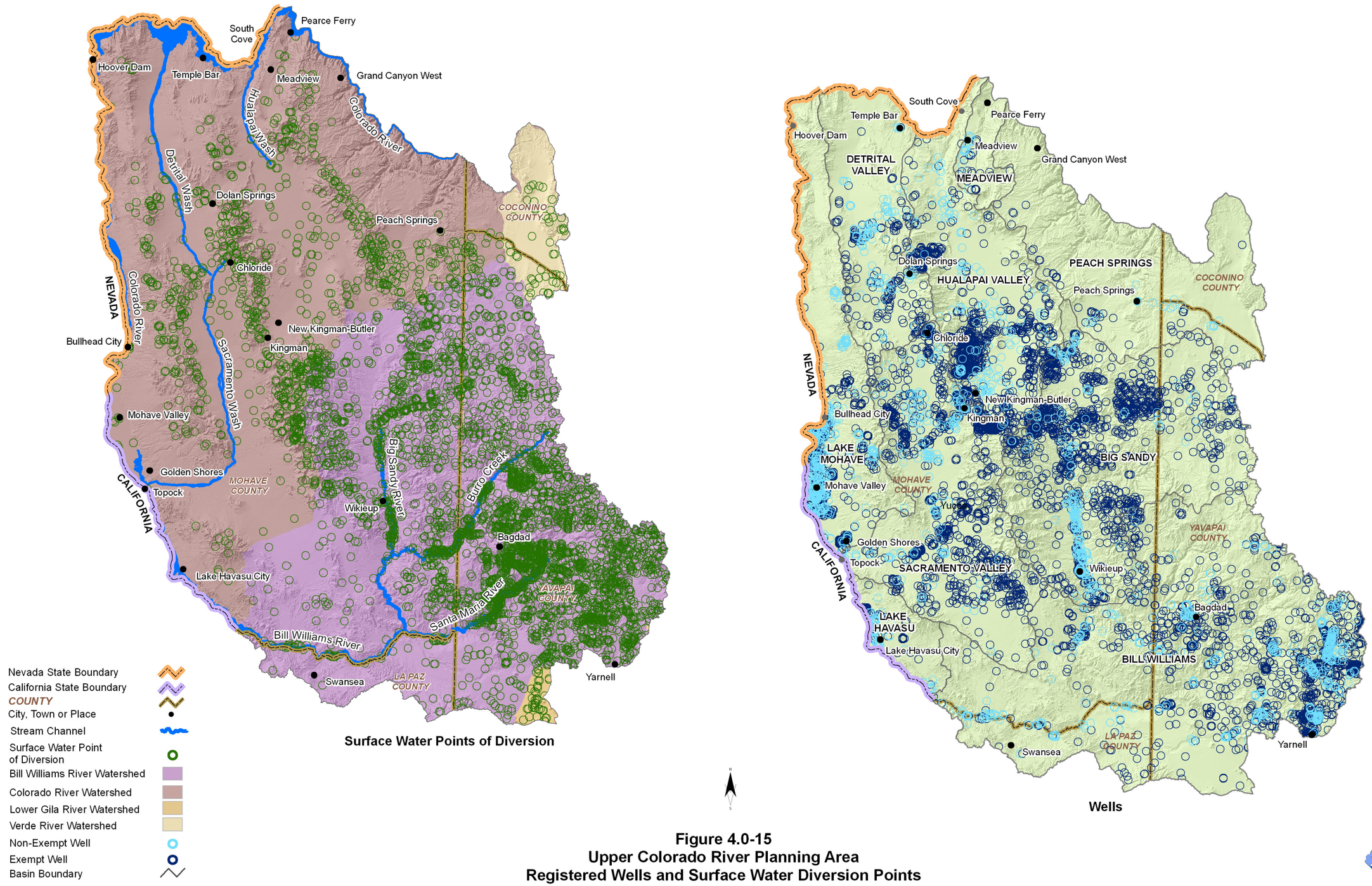


Figure 4.0-15
Upper Colorado River Planning Area
Registered Wells and Surface Water Diversion Points

Well yields appear to be sufficient for most uses in the planning area. Median well yields from large (>10-inch) diameter wells ranged from approximately 35 gpm in Detrital Valley and Meadview basins to more than 1,000 gpm in Lake Havasu and Lake Mohave basins where most wells are in proximity to the Colorado River. Yields from large wells in the Hualapai Valley Basin were also relatively high, with a median of 900 gpm. In other basins median well yields range from 100 gpm in the Sacramento Valley Basin to 300 gpm in the Bill Williams Basin. Estimated volumes of groundwater in storage may be relatively limited to meet future demands in some areas especially given low groundwater recharge rates.

The USGS, in conjunction with the Department, in light of proposed land developments, recently conducted investigations of groundwater conditions in the Detrital Valley, Hualapai Valley and Sacramento Valley basins. As a result, the Department released revised estimates of the volume of groundwater in storage in the Detrital Valley and Sacramento Valley basins. Groundwater storage estimates to a depth of 1,200 feet bls in these basins are: 1.4 to 3.7 maf in the Detrital Valley, 5 to 5.3 maf in the Hualapai Valley, and 7 to 8.3 maf in the Sacramento Valley.

The Department's Groundwater Site Inventory (GWSI) database, the main repository for statewide groundwater well data, is available on the Department's website (www.azwater.gov). The GWSI database contains of over 42,000 records of wells and over 210,000 groundwater level records statewide. GWSI contains spatial and geographical data, owner information, well construction and well log data, and historic groundwater data including water level, water quality, well lift and pumpage records. Included are hydrographs for statewide Index Wells and Automated Groundwater Monitoring Sites (Automated Wells), which can be searched and downloaded to access local information for planning, drought mitigation and other purposes.

Approximately 1,700 wells are designated as Index Wells statewide out of over 43,700 GWSI sites (GWSI sites are primarily wells but include other types of sites such as springs and drains). Typically, Index Wells are visited once each year by the Department's field staff to obtain a long-term record of groundwater level fluctuations. Approximately 200 of the GWSI sites are designated as Automated Wells. These systems measure water levels 4 times daily and store the data electronically. Automated wells are established to better understand the water supply situation in areas of the state where data are lacking. These devices are located based on areas of growth, subsidence, type of land use, proximity to river/stream channels, proximity to water contamination sites or areas affected by drought.

Automated Groundwater Monitoring Site in the Hualapai Valley Basin.

Volume 1 of the Atlas shows the location of Index Wells and Automated Wells as of January 2009. At that time there were a total of 93 Index Wells and nine Automated Wells in the Planning Area. The Automated Wells are located in the Hualapai Valley, Sacramento Valley, Detrital Valley, Bill Williams and Meadview basins. The most updated maps of Index and Automated wells may be viewed at the Department's website.

Information on major aquifers, well yields, estimated natural recharge, estimated water in storage, aquifer flow direction, and water level changes are found in groundwater data tables, groundwater conditions maps, hydrographs and well yield maps for each basin in the basin sections.

Effluent

Effluent is a potential water supply at locations throughout the planning area, with about 10,200 acre-feet produced annually. Currently, about 3,100 AFA of effluent is used in the Lake Havasu and Lake Mohave basins for turf irrigation. Approximately 3,300 acre-feet of effluent was produced in the Lake Havasu Basin in 2008 and in 2006 more than 2,400 acre-feet was used. Lake Havasu City is evaluating new sources of effluent demand as well as effluent recharge.

Approximately 3,100 acre-feet of effluent is produced in the Lake Mohave Basin each year. Within the basin, Bullhead City annually delivers about 600 acre-feet of effluent and Arizona-American Water Company delivers about 180 acre-feet.

The Kingman-Hilltop Wastewater Treatment Plant, located in the Hualapai Valley Basin, generates about 1,800 acre-feet of effluent per year which is currently disposed in a wetland and evaporation ponds. The treatment system that serves the community of Peach Springs consists of a sewer with secondary treatment and disposal in evaporation ponds and unlined impoundments. There are four wastewater treatment plants in the Sacramento Valley Basin, one in Kingman, one at the Griffith power plant and two in the vicinity of Franconia, located about midway between Topock and Yucca. Information is available on only two plants in the basin, which produced a total of about 400 acre-feet of effluent, that was disposed in evaporation ponds or in a watercourse.

View of the City of Kingman from the Hualapai Valley Basin. Effluent is not currently reused in the Hualapai Valley or Sacramento Valley Basins.

No wastewater treatment facilities were identified by the Department in the Big Sandy, Bill Williams or Meadview basins. A facility exists at Temple Bar in the Detrital Valley Basin but information on the volume of wastewater treated and the disposal method(s) was not available to the Department.

Contamination Sites

Sites of environmental contamination may impact the availability of water supplies. An inventory of Department of Defense (DOD), Superfund (Environmental Protection Agency designated sites), Resource Conservation and Recovery Act (RCRA), Water Quality Assurance Revolving Fund (state designated WQARF sites), Voluntary Remediation Program (VRP), and Leaking Underground Storage Tank (LUST) sites was conducted for the planning area. Of these various contamination sites only LUST and VRP sites are found in this planning area. Table 4.0-9 lists VRP sites, their contaminants and affected media, and respective basins. The location of all contamination sites in the planning area is shown on Figure 4.0-16.

There are five active VRP sites, primarily associated with crude oil contamination of soil. The VRP is a state-administered and funded voluntary cleanup program. Any site that has soil and/or groundwater contamination, provided that the site is not subject to an enforcement action by another remediation program, is eligible to participate. To encourage participation, ADEQ provides an expedited process and a single point of contact for projects that involve more than one program (Environmental Law Institute, 2002).

There are 153 active LUST sites including 60 sites in the Kingman area in the Sacramento Valley Basin, 30 sites in and around Bullhead City in the Lake Mohave Basin, and 47 sites in the vicinity of Lake Havasu City in the Lake Havasu Basin.

4.0.7 Cultural Water Demand

Cultural water demand in the Upper Colorado River Planning Area is shown in Figure 4.0-17. As shown, agricultural demand is the largest use sector at approximately 99,550 AFA due

Table 4.0-9 Contamination sites in the Upper Colorado River Planning Area

SITE NAME	MEDIA AFFECTED AND CONTAMINANT	GROUNDWATER BASIN
Voluntary Remediation Sites		
Inactive Bruce Mine	Groundwater-copper, zinc, pH, other metals or organic contaminants	Bill Williams
Juniper Pump Station	Soil-crude oil	Big Sandy
New Kingman Pump Station	Soil-crude oil	Big Sandy
Oatman Pump Station	Soil-crude oil	Lake Mohave
Old Kingman Pump Station	Soil-crude oil	Sacramento Valley

Sources: ADEQ 2006a, ADEQ 2006b

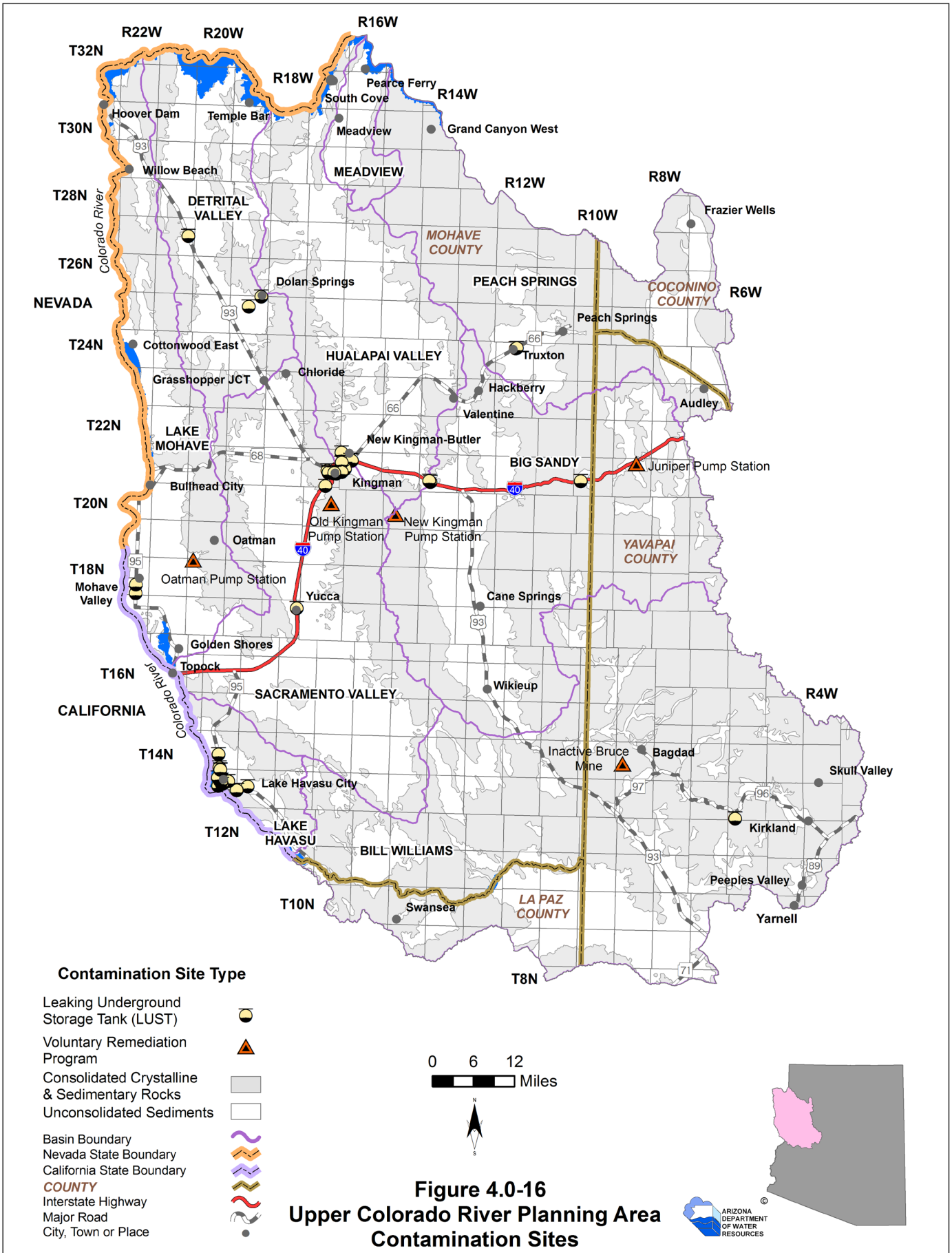


Figure 4.0-16
Upper Colorado River Planning Area Contamination Sites

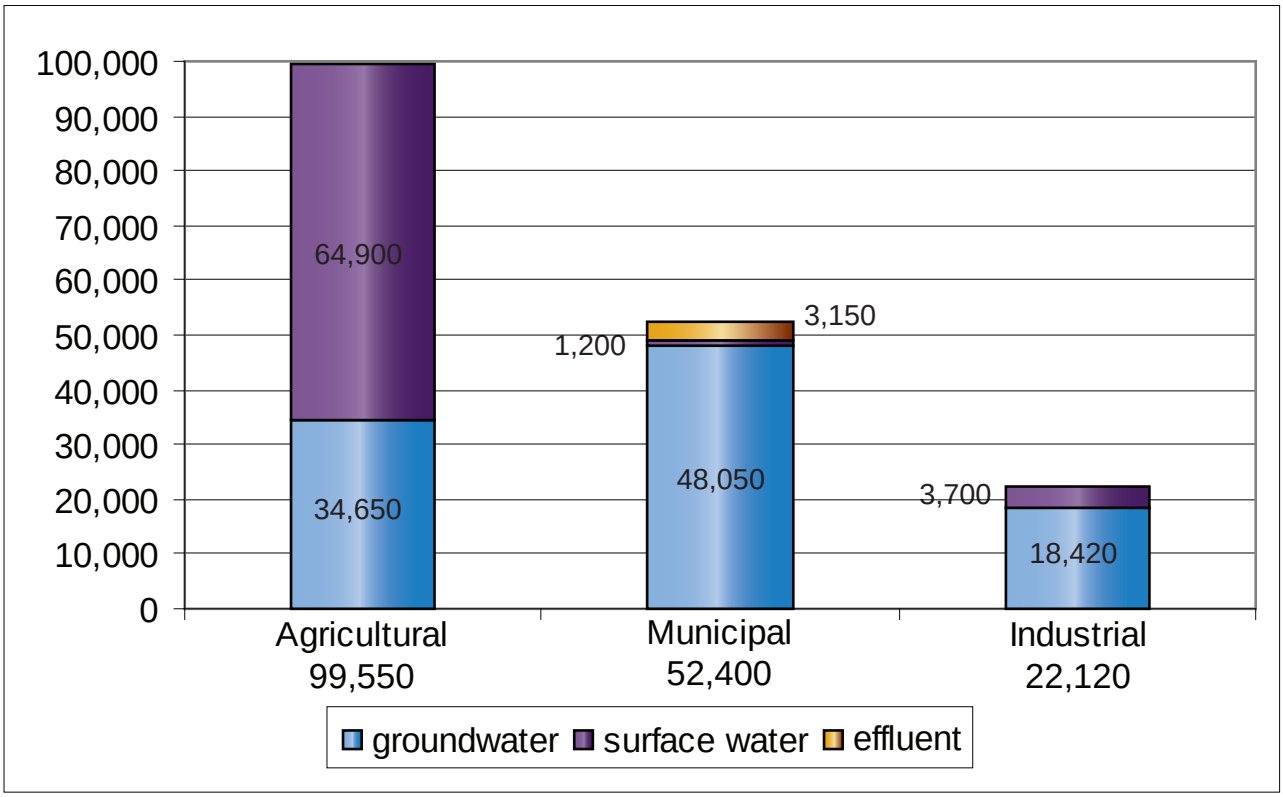
almost entirely to farming in the Lake Mohave Basin. Municipal demand is the next largest water demand sector with approximately 52,400 AFA met primarily by groundwater. Industrial demand, mainly for mining, is about 22,100 AFA. Total demand averaged approximately 174,100 AFA during the period from 2001-2005.

The volume of cultural demand varies substantially between the planning area basins and ranges from about 150 AFA in the Meadview Basin to about 118,800 AFA in the Lake Mohave Basin (see Figure 4.0-18).

Tribal Water Demand

The Fort Mojave Indian reservation includes lands in Arizona, Nevada and California but almost 70% of its land base (23,500 acres), is located within Arizona in the Lake Mohave Basin. The Tribal headquarters are located in Needles, CA. In Arizona, the tribal population is approximately 800 and the primary water demand is farming. A small casino, with associated services is located in Mohave Valley while a large hotel/casino and golf course are located in Laughlin, NV. The Fort Mojave Tribal Utilities Authority serves about 850 customers in parts of Mohave Valley. The Bermuda Water Company provides municipal service to parts of Fort Mojave. In 2005, the tribal utility pumped about 260 acre-feet of groundwater (ACC, 2005). In 1999, the tribe entered into an agreement to allow construction of a gas-fired power plant on the reservation. The South Point Energy Center came on line in 2001 and was the first "merchant plant" built by an independent power company on tribal land (Calpine, 2001). All power generated is sold on the open market. Fort Mojave receives electricity generated at Parker Dam. The South Point plant is designed to capture waste heat to generate a second phase of electricity, making it 40% more efficient than

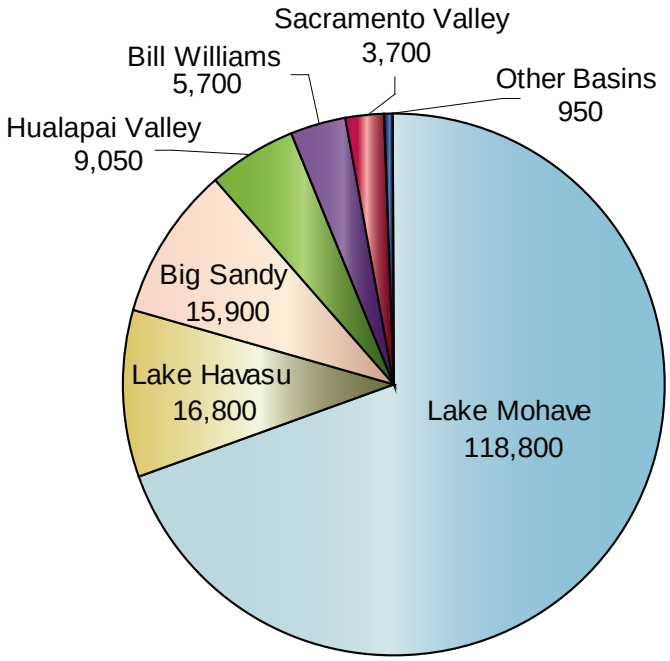
Figure 4.0-17 Average Annual Upper Colorado River Planning Area Cultural Water Demand by Sector, 2001-2005 (in acre-feet)



older natural gas plants. Water use is estimated at 4,000 AFA of surface water (BIA, 1998).

The Hualapai Indian Reservation encompasses about 552,800 acres in the planning area, primarily in the Peach Springs Basin. There also are small tracts of tribal lands in the Big Sandy, Hualapai Valley and Meadview basins. The reservation, created in 1883, has a current population of about 1,500. Peach Springs is the tribal capital. Tribal water use is estimated to be less than 300 AFA. The tribal economy is based on cattle ranching, tourism, timber sales and big game hunting. The Hualapai Department of Public Works operates water and sewer systems in Peach Springs. The Hualapai Water Resource Program develops non-community water sources and is responsible for a wetland and water quality monitoring program. The Range Water Program performs water pipeline maintenance to cattle districts. (Hualapai Tribe, 2007)

Figure 4.0-18 Average Annual Basin Water Demand, 2001-2005 (in acre-feet)



The Hualapai Nation operates a tourist development at Grand Canyon West where a glass walkway, "Skywalk", extends 70 feet beyond the canyon edge almost a mile above the Colorado River. Water is an issue at the site and is currently trucked in. The tribe anticipates further development at the site, requiring a local source of water (Cart, 2007). The tribe has considered drilling a local well, extending a water pipeline 26 miles from wells on the west side of the Reservation, or pumping water to the rim from the Colorado River. An exploratory well drilled near Grand Canyon West located water at more than 2,600 feet with an estimated flow of just 12 gpm (Hualapai Tribe, 2007).

While the U.S. asserted tribal claims to the Colorado River in Arizona v. California, the Court only decided the claims of those tribes below Hoover Dam. There presently is no court action pending to adjudicate any Hualapai claims.

Municipal Demand

Average municipal demand for 2001-2005 was about 52,400 AFA; 32% of the total cultural water demand. Municipal water demand is summarized by groundwater basin and water supply in Table 4.0-10. Water pumped from wells is the primary water supply for municipal use throughout the planning area as reflected in the cultural water demand tables for each basin. An average of 48,050 AFA of groundwater was used during the period 2001-2005. The largest volume of municipal groundwater use is in the Lake Mohave Basin with 18,800 AFA of demand, 39% the total groundwater use. About 1,200 AFA of surface water is used for municipal purposes. The town of Bagdad in the Bill Williams Basin may use up to 500 acre-feet of surface water diverted from springs as a primary municipal supply. About 3,100 acre-feet of effluent is used annually for turf irrigation.

Principal municipal demand centers are Lake Havasu City, Bullhead City, and the Kingman area. There is little population or municipal demand in a number of basins including the Big Sandy, Detrital Valley, Meadview and Peach Springs basins. Municipal demand on the Fort Mojave and Hualapai reservations is estimated at less than 300 AFA.

Only nine water providers in the planning area served 450 acre-feet of water or more in 2000 or 2006. These providers and their demand in selected years are listed in Table 4.0-11 and are discussed below. Municipal utilities serve Lake Havasu City and the City of Kingman while other communities, including Bullhead City, are served by private water companies. Bullhead City is served by Arizona-American Water Company, Bermuda Water Company and North Mohave Valley Water Company. In 2007, the City acquired the legal authority to become a municipal water provider and serves Laughlin Ranch on the east side of the city.

Municipal water utilities have more flexible water rate-setting ability than private water companies, which are regulated by the Arizona Corporation Commission. In addition, municipal utilities have the authority to enact water conservation ordinances. These authorities may enable municipal utilities to better manage water resources within water service areas. Water provider issues are discussed in section 4.0.8.

With two exceptions, all golf courses in the planning area are served from a municipal water supply. All golf courses are listed in Table 4.0-12 with estimated demand and source of water. Golf courses that irrigate with water pumped entirely from facility wells are considered "industrial" golf courses and this use is accounted for as an industrial demand. Demand was not reported for a number of golf courses and in those cases estimates are based on turf water needs, elevation and duration of the irrigation season. Most golf courses are located in the Lake Havasu or Lake Mohave basins. There are two golf courses in the Kingman area in the Hualapai Valley Basin, and one in Bagdad in the Bill Williams Basin.

Fifty-six percent of the golf course demand in the planning area is met with effluent. Effluent is utilized in Bullhead City, Lake Havasu City and in Mohave Valley. In the Lake Havasu Basin, two facilities used 100% effluent in 2006: London Bridge Golf Course, and Nautical/Havasu Island Inn Golf Club. In addition, some effluent was delivered to Refuge Golf Course (amount not known) and about 100 acre-feet of effluent was used for other turf irrigation. In the Lake Mohave Basin, about 720 acre-feet of effluent is used to irrigate three golf courses and one park. Bullhead City delivers about 475 acre-feet of effluent per year to Chaparral Country Club and Laughlin Ranch, and about 65 AFA to Rotary Park. Arizona-American Water Company delivers about 180 acre-feet of effluent per year to the Riverview Golf

Table 4.0-10 Average annual municipal water demand in the Upper Colorado River Planning Area, 2001-2005 (in acre-feet)

Basin	Groundwater	Surface Water	Effluent[1]	Total
Big Sandy	<300	0	0	150
Bill Williams	950	500	0	1,450
Detrital Valley	<300	<300	0	300
Hualapai Valley[2]	8,900	0	0	8900
Lake Havasu	16,500	<300	2,433	19,083
Lake Mohave	18,800	400	715	19,915
Meadview	<300	0	0	150
Peach Springs	350	0	0	350
Sacramento Valley	2,100	0	0	2,100
Total Municipal	48,050	1,200	3,148	52,398

Sources: USGS 2007, ADWR 2007
Notes:
[1] Effluent figures are for golf course and other turf irrigation in 2006
[2] The City of Kingman in the Sacramento Valley Basin obtains most of its water from well fields in the Hualapai Valley Basin

Table 4.0-11 Water providers serving 450 acre-feet or more of water per year in 2000 or 2006, excluding effluent, in the Upper Colorado River Planning Area

Water Provider	1991 (acre-feet)	2000 (acre-feet)	2006 (acre-feet)
Bill Williams			
Phelps Dodge Bagdad, Inc, Utilties Dept.	871	749	445
Lake Havasu			
Lake Havasu City	11,961	14,630	14,534
Lake Mohave			
Arizona American Water-Mohave Water (Bullhead City)	4,012	6,220	6,733
Bermuda Water Company (Bullhead City)	915	951	3,883
Golden Shores Water Company	353	452	492
North Mohave Valley Water (Bullhead City)	269	642	1,148
Willow Valley Water (Mohave Valley)	542	455	395
Sacramento Valley			
City of Kingman	5,950	7,294	9,078
Valley Pioneers Water Company	316	500	688

Sources: ADWR 2004, ADWR Community Water System 2006 Annual Reports
Notes:
1991 and 2000 demand for the Town of Bagdad may include some industrial demand by the Bagdad Mine.

Course. It is anticipated that effluent use for turf irrigation will increase in the planning area since Colorado River contract entitlements are capped and growth continues.

Freeport McMoRan Copper and Gold, Inc. Utilities Department

The Town of Bagdad is a mining community served water by Freeport McMoRan Copper and Gold, Inc. Utilities (Freeport McMoRan) formerly Phelps Dodge, Inc. Utilities. The reported groundwater withdrawal in 2006 was 445 acre-feet, and 991 acre-feet in 2007. Six wells and 2 emergency wells serve the community of approximately 1,600 residents. The system water plan for Freeport McMoRan refers to water from Francis Creek Springs as "the primary source of potable water" for the town of Bagdad, but this is not reported on the CWS annual reports (Malcolm Pirnie, 2006). Either this water is used entirely at the mine site or the actual water use by the town is larger. Freeport McMoRan reported 82% of its deliveries to residential customers, 6% to commercial and 12% to turf. In addition to the main town site, Freeport McMoRan serves the Sycamore Springs Mobile Home Park from 2 wells. Commercial customers include shopping centers and a school. Turf includes a nine-hole golf course, a park and school playing fields. Treated effluent is reportedly used for industrial purposes at the mine.

Lake Havasu City

Lake Havasu City is the largest community in the planning area and a popular tourist destination with a 2006 population of almost 56,000. In 2006, it reported 14,534 acre-feet of Colorado River water withdrawn primarily from one well. Approximately 65% of this was delivered to single family residential customers, 6% to multi-family, 11% to commercial, 9% to turf and 8% to other. Its total gallon per capita per day rate in 2005 was 240 (Lake Havasu City, 2006). Lake Havasu City is engaged in an aggressive wastewater system expansion program to convert the majority of residences within the city limits to a conventional sewer system. This expansion included construction of the Northwest Regional WWTP, completed in 2007. The three treatment plants treated about 3,300 acre-feet in 2008 (Table 4.5-8). In 2005, approximately 2,400 acre-feet of effluent was used to irrigate two golf courses and landscaping and in 2006, effluent deliveries began to the Refuge Golf Course. The City is seeking additional sources of water to meet future demands since its Colorado River entitlement is insufficient. It has secured additional water supplies from the AWBA and MCWA and is exploring options to acquire more. Water conservation and effluent recharge and recovery are considered potential future supplies.

Table 4.0-12 Golf courses in the Upper Colorado River Planning Area (c. 2008)

Facility	Basin	# of Holes	Demand (acre-feet)	Water Supply
Mesa View Golf Club	Bill Williams	9	120	Groundwater
Cerbat Cliffs Golf Course	Hualapai Valley	18	423	Groundwater
Valle Vista Country Club	Hualapai Valley	18	423	Groundwater
Bridgewater Link/Queens Bay	Lake Havasu	9	220	Groundwater
London Bridge Golf Course	Lake Havasu	36	1,288	Effluent
Nautical/ Havasu Island Inn Golf Club	Lake Havasu	18	560	Effluent
Refuge Golf Course	Lake Havasu	18	441	Groundwater/Effluent
Chaparral Country Club	Lake Mohave	9	172/48	Groundwater/Effluent
Desert Lakes Golf Club*	Lake Mohave	18	441	Groundwater
El Rio Country Club*	Lake Mohave	18	441	Groundwater
Laughlin Ranch	Lake Mohave	18	425	Effluent
Riverview Golf Club	Lake Mohave	9	178	Effluent
Total Demand			**5,180**	

Source: ADWR 2008c, USBOR 2006c
Notes:
* These golf courses are served by their own wells and considered to be industrial users

Arizona American Water-Mohave Water

Arizona American Water is the largest of the three large systems that serve Bullhead City. It serves all but the southern and northern portions of the city. In 2006 it withdrew approximately 6,700 acre-feet of water from six wells. In that year it served almost 5,200 acre-feet to residential customers and 1,500 acre-feet to non-residential customers. The system has an emergency interconnection with the Bermuda Water Company.

Bermuda Water Company

Bermuda Water Company, the second largest system serving Bullhead City, serves the southern portion of the city, most of Fort Mojave Mesa and the northern portion of Mohave Valley. It withdrew 3,883 acre-feet of water from 8 wells in 2006. Of this total, 318 acre-feet was delivered to other utilities located at Fort Mojave and Mohave Valley. Within its service area it delivered 3,264 acre-feet to single family residences, 106 acre-feet to turf and 151 acre-feet to commercial customers.

North Mohave Valley Water

The third large system serving Bullhead City serves the northern part of the city. It withdrew 1,148 acre-feet of water from seven wells in 2006. Of this, 674 acre-feet was delivered to residential customers and 415 acre-feet to commercial and construction customers.

Golden Shores Water Company

Golden Shores Water Company (GSWC) serves the Town of Golden Shores located in the far southern portion of the Lake Mohave Basin. The water system has approximately 1,516 connections in an eight square mile service area. In 2006 it withdrew 492 acre-feet from four of its five wells to serve primarily residential customers.

Willow Valley Water Company

The Willow Valley Water Company consists of two systems that are not interconnected: the larger King Street System and the Lake Cimarron System. The systems are about three miles apart. The water company service area covers 2,700 acres of non-contiguous sections dispersed within Fort Mojave Indian Reservation lands. In 2006 the systems withdrew approxi-

mately 395 acre-feet of water from 3 of 6 company wells. Of this, 342 acre-feet was delivered to residential customers and 28 acre-feet to non-residential customers.

City of Kingman

The second largest water provider in the planning area, the City of Kingman Municipal system serves Kingman and New Kingman-Butler. The community straddles the Sacramento Valley/ Hualapai Valley basin boundary. Kingman/New Kingman-Butler is a rapidly growing area with a number of large master planned communities planned in the area. It has a service area of over 46 square miles and provides water service to over 44,000 residents. Kingman has a contract with Mohave County to provide water service to over 9,000 connections outside the city limits (City of Kingman, 2007).

In 2006, Kingman reported groundwater withdrawals of 9,078 acre-feet from 14 wells. Of this, 5,123 acre-feet was delivered to residential customers and 3,381 acre-feet to non-residential customers. Most of the water is pumped from a well field in the southern part the Hualapai Valley Basin. A smaller portion, approximately 400-500 AFA, is pumped from wells completed in volcanic rock of the Sacramento Valley Basin. Although Kingman had a Colorado River water entitlement of 18,500 AFA, it transferred the allocation to the Mohave County Water Authority since the costs of physically transferring the water was not economically feasible. In exchange for the transfer, the City of Kingman receives revenue for development of its groundwater resources (City of Kingman, 2003).

The City of Kingman operates the Hilltop and Downtown Wastewater Treatment Plants that together produce over 2,000 acre-feet of effluent per year, primarily from the Hilltop plant in the Hualapai Valley Basin. Presently, effluent is not reused and is disposed of in a watercourse, evaporation pond and wetland (Tables 4.4-7 and 4.9-9)

Valley Pioneers Water Company

Valley Pioneers Water Company (VPWC) serves approximately 2,200 residential connections and 70 non-residential customers in Golden Valley, located east of Kingman along Highway 68. In 2006 it withdrew 688 acre-feet of water from three wells and served almost 500 acre-feet to residential customers and 160 acre-feet to commercial customers. In 2007 VPWC withdrew 930 acre-feet of water and delivered 218 acre-feet of water to the Mineral Park Mine in addition to deliveries to its residential and commercial customers. If needed, an emergency water supply is available from Golden Valley Improvement District #1, located west of Valley Pioneers (VPWC, 2007).

Agricultural Demand

Average agricultural demand for 2001-2005 was about 99,550 AFA; 56% of the total cultural water demand. Ninety-six percent of the agricultural demand occurred in the Lake Mohave Basin where principal crops include cotton, alfalfa, hay and wheat. Relatively small amounts of agricultural water demand were reported in the Big Sandy and Bill Williams basins. Surface water and groundwater use for agriculture in selected years for the entire planning area is shown in Table 4.0-13. As shown, total agricultural demand declined by 9,500 acre-feet between 1991 and 2005. About 65% of the ag-

Agriculture in the Bill Williams Basin

4.0-13 Agricultural demand in the Upper Colorado River Planning Area

	1991-1995	1996-2000	2001-2005
	Water Use (acre-feet)		
Big Sandy			
Groundwater	<300	<300	<300
Bill Williams			
Groundwater	15,600	4,200	4,100
Lake Mohave			
Surface Water	56,600	68,100	64,900
Groundwater	36,700	35,600	30,400
TOTAL	109,050	108,050	99,550

Source: USGS 2007, ADWR 2005

ricultural demand was met with surface water during the period 2001-2005.

In the Lake Mohave Basin, agricultural irrigation occurs in the Mohave Valley on the Fort Mojave Indian Reservation and on private lands located within the Mohave Valley Irrigation and Drainage District (MVIDD). In the southern end of the valley, tribal and district lands are interspersed in a checkerboard pattern. About 15,000 acres of reservation lands were recently under cultivation (ITCA, 2003), which may include non-Indian agricultural lessees. There are a total of about 31,500 acres within the MVIDD boundaries, of which about 3,800 acres are reported in cultivation. MVIDD does not divert or deliver water to its water users. District farmers operate and maintain their own production wells, pumps and distribution systems (ADWR, 1998).

Agricultural demand in the Lake Mohave Basin has increased substantially since the early 1970s when less than 20,000 AFA was used. Since 1990, annual agricultural demand has remained relatively constant, with up to 103,700 AFA used on average during the 1996-2000 time period. The increase is primarily due to Fort Mojave Indian agricultural water use. It is estimated that approximately 60-65% of the total current irrigation demand is attributable to tribal irrigation.

In the Big Sandy and Bill Williams basins irrigation is primarily for pasture. Irrigation in the Big Sandy Basin has been estimated at less than 300 acre-feet of groundwater per year since 1991, consisting of small pasture in the vicinity of the Big Sandy River. In the Bill Williams Basin, irrigation has declined from an average of 15,600 AFA during the 1991-1995 period to just 4,100 AFA during the 2001-2005 time period. This decline is primarily a result of cessation of farming at Planet Ranch, downstream from Alamo Dam, where flooding in 1993 washed out much of the irrigation infrastructure. Reportedly, only one cotton farm remains along the Bill Williams River below Alamo Dam. Most of the other remaining agricultural lands are located in the vicinity of Kirkland and Skull Valley (see Figure 4.2-10).

Industrial Demand

Industrial demand averaged approximately 22,100 AFA during the period 2001-2005; 13% of the total cultural water demand. Industrial water demand in the planning area includes mining, electrical power generation, dairy/feedlot and golf course irrigation served by a facility water system. If these use categories are served by a municipal water system they are accounted for as municipal demand. Industrial demand is summarized in Table 4.0-14 for selected time-periods.

Mining is the largest industrial user in the planning area, primarily due to activities at the Freeport McMoRan (formerly Phelps Dodge) Bagdad Mine in the Bill Williams Basin. Most of the water used at the mine is pumped from a series of wells along a 10-mile reach of the Big Sandy River north of Wikieup in the Big Sandy Basin, and delivered via pipeline to the mine site. A relatively small volume of surface water (probably <500 AFA) from Francis Creek springs and wells in the vicinity of Bagdad may

Table 4.0-14 Industrial demand in the Upper Colorado River Planning Area

	1991-1995	1996-2000	2001-2005
Type	**Water Use (acre-feet)**		
Mining Total	**16,740**	**17,800**	**16,610**
Big Sandy			
Groundwater	16,200	16,800	15,600
Bill Willams			
Groundwater	<300	<300	<300
Hualapai Valley			
Groundwater	<300	<300	<300
Lake Havasu			
Groundwater	30	130	70
Lake Mohave			
Groundwater	60	70	90
Peach Springs			
Groundwater	<300	<300	<300
Sacramento Valley			
Groundwater	<300	350	400
Power Plant Total	**0**	**0**	**4,900**
Lake Mohave			
Surface Water	0	0	3,700
Sacramento Valley			
Groundwater	0	0	1,200
Golf Course Total	**0**	**440**	**530**
Lake Mohave			
Groundwater	0	440	530
Dairy/Feedlot Total	**0**	**0**	**80**
Sacramento Valley			
Groundwater	0	0	80

Source: ADWR 2008d, USGS 2007

also be used at the mine site or provide water for potable use in the company town of Bagdad. The volume of water used at the mine is proprietary and recent estimates were based on reported copper production and known processing methods.

Claims were first staked at the Bagdad Mine property in 1882 with open pit mining beginning in 1945. Historically, mining operations were relatively small-scale due to the low grade copper ore. However, advances in ore processing have resulted in increased copper production at the site. Estimated water use has increased from approximately 2,000 AFA in the early 1970s to an estimated 15,600 AFA on average. The mine consists of a porphyry copper open-pit copper mine and concentrator. Molybdenum is a by-product of the mining operation. The site is recognized as the world's first commercial-scale concentrate leach processing facility (beginning in 2003) and is the longest continuously operating SX/EW (solution extraction/electrowinning) plant in the world (since 1970). Phelps Dodge Corporation acquired the property in 1999 from Cyprus Amax Minerals Co. (Freeport McMoRan, 2007).

The Mineral Park Mine, located in the Sacramento Valley Basin northwest of Kingman, operated a milling operation from 1964 to 1980 that produced a total of 646.4 million pounds of copper, 46.8 million pounds of molybdenum and 5 million ounces of silver as concentrate. Milling operations ceased in 1980 due to changes in ownership and low metals prices. Mercator Minerals Ltd. recently acquired the property and plans to increase copper production from the current level of approximately 6 million pounds of copper per year through a phased expansion to include enlarging the existing SX/EW plant capacity and eventual construction of a milling operation to process copper-molybdenum resources found at lower depths (Mercator Minerals, 2005). Mercantor Minerals commenced crushing and stacking ore in late 2008 and shipped the first molybdenum concentrates from the mine in 2009 to a roasting facility in Tucson (Reuters, 2009). Current water use is about 220 AFA, delivered from Valley Pioneers Water Company.

The only other mining activities in the planning area are associated with small mines/quarries, principally sand and gravel operations in the Hualapai Valley, Lake Havasu, Lake Mohave and Peach Springs basins. Some of these operations are identified on the cultural demand maps for these basins. Water is used for aggregate washing, dust control, vehicle washing, and

equipment cooling. Typically, relatively little water is consumed at these sites.

Four power plants operate in the planning area. The hydroelectric plants at Hoover Dam and Davis Dam in the Lake Mohave Basin are not considered direct consumers of water so their associated water demand is not included in Table 4.0-14. However, they are prominent industrial facilities in the planning area and are briefly described below.

The Hoover Dam and power plant were authorized by the Boulder Canyon Project Act of 1928 with electrical generation as one of its purposes. The power plant generators are used primarily to generate a low-cost peaking resource. The demand for Hoover power generation is seasonal, with the low-demand period in the winter months, and is a direct function of river flow and downstream water demands. The power plant generators operate in conjunction with the Davis and Parker power plants to provide maximum power generation with efficient use of water resources. The plant has a net generation capacity of more than 4,700,000 megawatt hours (MWh) (USBOR, 2006b). Davis Dam was authorized under provisions of the Reclamation Project Act of 1939. Power generated from this power plant is marketed to wholesale customers in Arizona, Southern California, and Southern Nevada after priority use power obligations have been met. Davis generation is the direct result of downstream irrigation needs. Net power generation is about 969,000 MWh (USBOR, 2005).

The South Point power plant is located on the Fort Mojave Indian Reservation in the Lake Mohave Basin. The 540-megawatt natural gas-fired plant with two gas-combustion turbines began operations in 2001. It is operated as a "merchant plant", meaning that the energy generated at the plant is sold on the open market. The Fort Mojave Tribe has a 50-year lease with Calpine, an independent power company, for both the site and the water that the plant uses. The average annual use during 2001-2005 was estimated at about 3,700 AFA of Fort Mojave Indian Colorado River entitlement water (BIA, 1998).

The 600-megawatt Griffith power plant, also a merchant plant, is located about 15 miles southwest of Kingman. It began commercial operation in January 2002 and was sold in May,

Bagdad Mine, Bill Williams Basin. Mining is the largest industrial water user in the planning area.

2006 to LS Power Equity Partners. An estimated 1,200 acre-feet of groundwater is used at the plant each year.

Because of the relative remoteness of the area and its proximity to regional power grids, the Upper Colorado River Planning Area has become an attractive location for new power plants including solar and wind. As of May 2009 there were plans for four solar plants in the planning area. The two largest are a 340-megawatt plant northwest of Kingman and a 200-megawatt facility south of Kingman. Two smaller facilities have been proposed in the Yucca area and in the Detrital Valley Basin. (Associated Press, 2009)

LS Power has proposed construction of a 175-megawatt gas-fired peaking plant adjacent to the Griffith plant. The source of water would be a portion of the groundwater already allocated to the Griffith plant through the Mohave County Water Authority. A 720-megawatt plant proposed in the Big Sandy Basin near Wikieup was turned down by the Arizona Corporation Commission (ACC) in November, 2001 primarily due to concerns about environmental impacts. It was the first plant to be denied a certificate by the ACC (ACC, 2001).

There are two "industrial" golf courses in the planning area, both located in the Lake Mohave Basin. Industrial courses receive at least some water from facility wells and not from a municipal water provider. The Desert Lakes Golf Club and El Rio Country Club (opened in 2005) are considered industrial facilities. Industrial groundwater demand was 530 AFA during the period 2001-2005. The Riverview Golf Club was an industrial facility but now uses municipal effluent as shown in Table 4.0-12.

A dairy operated in the Sacramento Valley from 1947 to 2005. During that time, the dairy facility used about 76 acre-feet of groundwater a year.

South Point power plant, Lake Mohave Basin.

4.0.8 Water Resource Issues in the Upper Colorado River Planning Area

Water resource issues have been identified in the Upper Colorado River Planning Area by community watershed groups, through the distribution of surveys, and from other sources. Planning and conservation efforts, watershed groups and studies and results from water provider surveys are discussed in this section.

Planning and Conservation

Mohave County was the fastest growing county in Arizona between the 1990 and 2000 Census and proposed developments in the northwestern part of the planning area are causing concerns about the availability of water supplies to meet future needs. Mohave County has indicated it will oppose developments without a demonstration of adequate water supply although it has not adopted the provision, authorized through legislation in 2007 (SB 1575), that would require a demonstration of adequacy. General and comprehensive plans and the water supply plans mentioned in Section 4.0.5 help planning area jurisdictions and water systems better prepare for the challenges associated with rapid growth.

Lake Havasu City has had a water conservation plan for a number of years credited with reducing per capita water use. Components include an increasing block rate water rate structure, low water use landscape requirements for certain lot sizes, no-turf policy for commercial, industrial and multi-family property and effluent reuse (Lake Havasu City, 2006). The City of Bullhead City also has a water conservation program and has entered into subcontract agreements with the three water companies that serve water within the City to implement water conservation practices. Practices include turf restrictions, an incentive program to use reclaimed water and leak detection and repair. There is an incentive program to retrofit existing homes and commercial buildings with low-flow plumbing fixtures (USBOR, 2006c). The City also offers a Landscape Rebate Program to convert grass to low water use plants.

The Hualapai Tribe has adopted several ordinances to protect water resources including a Water Resource Ordinance to ensure water quality, a Wetlands Protection and Preservation Ordinance, and a Drought Contingency Plan that establishes drought declaration criteria and identifies response actions (Hualapai Tribe, 2007).

Watershed Groups and Studies

There are two groups in the planning area that have been formed to address a variety of water resource issues, the Northwest Arizona Water Council and the Mohave County Water Authority (MCWA). MCWA was organized pursuant to A.R.S.§ 45-2201 primarily for the purpose of acquiring the city of Kingman's unused 18,500 acre-feet entitlement and making it available to other authority members for municipal and industrial water uses (see Section 4.0.6). A complete description of participants, activities and issues is found in Appendix D. Primary issues identified by the two groups are summarized as follows:

Growth:

- Large master-planned communities planned in Detrital Valley, Hualapai Valley and Sacramento Valley basins as a result of completion (2010) of the bypass bridge across the Colorado River
- Unregulated lot splits

Water Supplies and Demand:

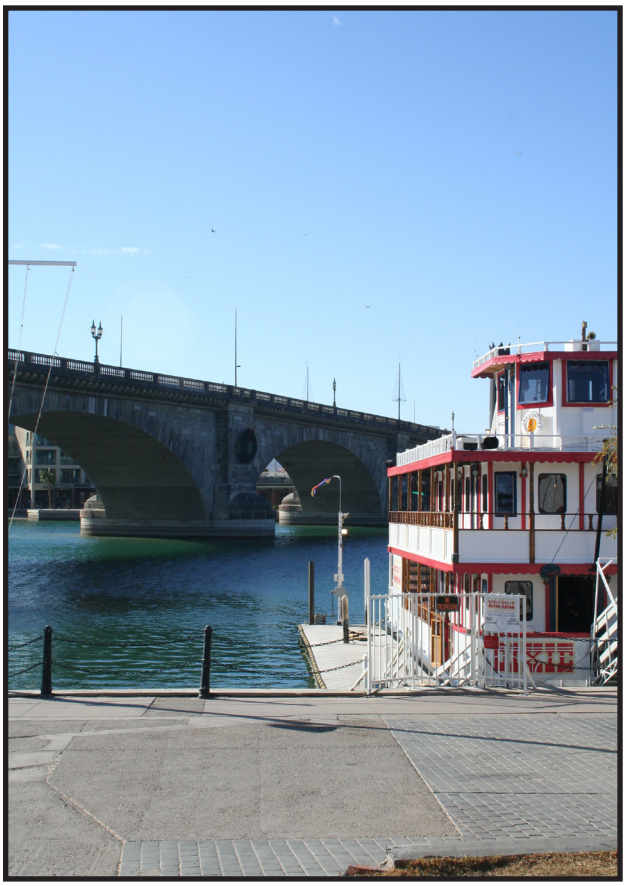
- Limited groundwater data
- Limited groundwater and Colorado River water supplies

Legal:

- Concerns regarding proposed development that may use Colorado River water

Water Quality:

- Concerns related to mining activities
- Concerns regarding hexavalent chromium



Lake Havasu City.

Funding:

- Limited funding resources for planning, projects, infrastructure, and studies

Drought:

- Impacts on private water companies and water haulers
- Vulnerability of surface and groundwater supplies

Other:

- Potential for subsidence due to rapid growth

In addition, the large number of exempt wells and the lack of control or regulation of exempt wells have been identified as a concern in Mohave County. Related to this are the large number of "Legacy Lots", formed many years ago in the Sacramento Valley basin that lack service from a water company and are served by private wells or hauled water.

In response to concerns by local governments, water providers and citizens groups about the impacts of groundwater development, the Department, in collaboration with the USGS and with funding assistance from Mohave County, began conducting hydrogeologic investigations in 2005 to improve the understanding of water resources in three basins within the planning area; the Detrital Valley, Hualapai Valley and Sacramento Valley basins. These investigations will assess existing data collection networks and examine the current state of knowledge of the groundwater system; improve understanding of geologic units and their relationship to groundwater storage and movement; improve knowledge of groundwater budget factors including recharge and storage; evaluate groundwater quality; establish a hydrologic monitoring network for on-going assessment of the aquifer; and inform the hydrologic community and area residents about hydrologic conditions (USGS, 2006). To date, several reports have been completed including preliminary estimates of groundwater in storage for the Detrital Valley Basin (Mason and others, 2007) and the Sacramento Valley Basin (Conway and Ivanich, 2008). In addition the USGS released a report in 2007 on groundwater occurrence, movement and water level changes in all three basins (Anning and others, 2007).

Hoover Dam bypass bridge under construction. There is concern in the planning area about large master-planned communities planned as a result of completion (2010) of the bypass bridge.

The Natural Resources Conservation Service (NRCS) has produced a rapid watershed assessment (RWA) for the Detrital Wash Watershed. An RWA is a concise report containing information on natural resource conditions and concerns at the 8-digit HUC level. They are intended to provide sufficient information and analysis to generate an appraisal of the conservation needs of the watershed as well as serve other uses. (Reports are available online at http://www.az.nrcs.usda.gov/technical/rwa.html).

Arizona NEMO (Non-point Education for Municipal Officials) has produced a watershed based plan for the Bill Williams Watershed that characterizes and classifies watershed features. The goal of NEMO is to educate land use decision makers to make choices and take actions that will lessen nonpoint source pollution and protect natural resources. (Plans are available online at http://www.srnr.arizona.edu/nemo/).

As mentioned previously, all community water systems in Arizona are required to submit a water system plan as part of the State's Drought Preparedness Plan. The system water plan includes a water supply plan, water conservation plan, and drought preparedness plan. Water providers are required to develop the plan to ensure they reduce their vulnerability to drought and prepare to respond to potential water shortage conditions.

As part of implementation of the State Drought Plan, Local Drought Impact Groups (LDIGs) are being formed, as necessary, at the county level and a Mohave County group has been established. LDIGs are voluntary groups that will coordinate drought public awareness, provide impact assessment information to local and state leaders and implement and initiate local drought mitigation and response actions. These groups are coordinated by local representatives of Arizona Cooperative Extension and County Emergency Management and supported by ADWR's Statewide Drought program. Information on LDIGs may be found at the department's website.

Issue Surveys

The Department conducted a rural water resources survey in 2003 to compile information for the public and help identify the needs of growing communities. This survey was also intended to gather information on drought impacts for incorporation into the Arizona Drought Preparedness Plan, adopted in 2004. Questionnaires were sent to almost 600 water providers, jurisdictions, counties and tribes. The Department completed a report of the findings from the survey in 2004 (ADWR, 2004).

There were 18 water provider and jurisdiction respondents in the Upper Colorado River Planning Area, and 11 numerically ranked issues. Respondents were asked to rank 18 issues. Insufficient future water supplies was the primary concern of most respondents as shown in Table 4.0-15. Infrastructure issues, which include aging infrastructure and inadequate capital to pay for infrastructure improvements, were ranked among the top five issues by many respondents.

Table 4.0-15 Water resource issues ranked by survey respondents in the Upper Colorado River Planning Area

Issue	Percent of 2003 respondents that ranked issue as one of the top 5 (of 18)	Percent of 2004 respondents reporting issue was a moderate or major concern
Inadequate storage capacity to meet peak demand	27%	30%
Inadequate well capacity to meet peak demand	9	26
Inadequate water supplies to meet current demand	18	13
Inadequate water supplies to meet future demand	64	35
Infrastructure in need of replacement	45	39
Inadequate capital to pay for infrastructure improvements	36	44
Drought related water supply problems	18	39

Source: ADWR, 2004

Note: 2003 respondents consist of 10 water providers and 1 jurisdiction. 2004 respondents included 23 water providers

The Department conducted a second, more concise survey of water providers in 2004. This was done to supplement the information gathered in the previous year in support of developing the Arizona Water Atlas, and to reach a wider audience by directly contacting each water provider. Through this effort, 30 water providers in the Upper Colorado River Planning Area, with a total of approximately 69,000 service connections, were willing to participate and provide information on water supply, demand, infrastructure and to rank a list of seven issues.

Water providers were asked to rank issues from 0 to 3 with 0 = no concern, 1 = minor concern, 2 = moderate concern and 3 = major concern. Of the 30 water providers that responded to this survey, 23 ranked issues. Although responses to the 2003 questionnaire are not directly comparable to the 2004 survey due to differences in the form and wording of the surveys, responses indicate that concerns regarding inadequate supplies to meet future demands and infrastructure problems rank high among all respondents.

4.0.9 Groundwater Basin Water Resource Characteristics

Sections 4.1 through 4.9 present data and maps on water resource characteristics of the fourteen groundwater basins in the Southeastern Arizona Planning Area. A description of the data sources and methods used to derive this information is found in Appendix A of Volume 1 of the Atlas. This section briefly describes general information that applies to all of the basins and the purpose of the information. This information is organized in the order in which the characteristics are discussed in Sections 4.1 through 4.9.

Geographic Features

Geographic feature maps are included to provide general orientation to principal land features, roads, counties and cities, towns and places in the groundwater basin.

Land Ownership

The distribution and type of land ownership in a basin has implications for land and water use. Large amounts of private land typically translate into opportunities for land development and associated water demand, whereas public lands are typically maintained for a specific purpose or multi-use with little associated water use. State owned land may be sold or traded, and is often leased for grazing and farming. The State Enabling Act of 1910 and the Act that established the Territory of Arizona in 1863 set aside sections 2, 16, 32 and 36 in each township to be held in trust by the state for specified purposes, which are identified for each basin (ASLD, 2006).

Climate

Climate data including temperature, rainfall, evaporation rates and snowfall are critical components of water resource planning and management. Averages and year to year variability, seasonality of precipitation and long-term trends are all important factors in demand and supply planning.

Surface Water Conditions

Depending on physical and legal availability, surface water may be an important water supply in some basins. Stream gage, flood gage, reservoir, stockpond and runoff contour data provide information on physical availability of this supply. Seasonal flow information is relevant to seasonal supply availability. Annual flow volumes provide an indication of potential volumetric availability.

Criteria for including stream gage stations in the basin table are that there is at least one year of record, and annual streamflow statistics are included only if there are at least three years of record. There are different types of stations and

those that only serve repeater functions were not included.

Flood gage information is presented to direct the reader to areas where flooding has been or may be a problem. Large reservoir storage information includes data on the amount of surface water stored in large reservoirs, its uses and ownership. The number and capacity of small reservoirs is also provided as well as the number of stockponds in each basin. The number of stockponds is a general indicator of small-scale surface water capture and livestock demand. Runoff contours reflect the average annual runoff that can be expected in tributary streams over a particular area.

Perennial and Intermittent Streams and Major Springs

A map of perennial and intermittent streams is provided for each basin. For some basins, more than one source of information was used. Stream designations may not reflect current conditions in some cases. Spring data was compiled from a number of sources in an effort to develop as comprehensive a list as possible. Spring data is important to many researchers and to the environmental community due to their importance in maintaining habitat, even from small discharges.

Groundwater Conditions

Several indicators of groundwater conditions are presented for the basin. Aquifer type can be a general indicator of aquifer storage potential, accessibility of the supply, aquifer productivity, water quality and aquifer flux. Well yield information for large diameter wells is provided and is generally measured when the well is drilled and reported on completion reports. It was assumed that large diameter wells were drilled to produce a maximum amount of water and, therefore, their reported pump capacities are indicative of the aquifer's potential to yield water to a well. However, many factors can affect well yields including well design, pump size and condition and the age of the well. Reported well yields are only a general indicator of aquifer productivity and specific information is available from well measurements conducted as part of basin investigations.

Natural recharge is typically the least well known component of a water budget. Many of the estimates in the Atlas are derived from studies of larger geographic areas and all deserve further study. Similarly, estimates of storage are based on rough estimates and considerably more studies are needed in most basins. Components of storage include aquifer depth and specific yield.

Water level data is from measured wells, usually collected during the period when the wells were not actively being pumped or only minimally pumped. Depth to water measurements are shown on mapped wells if there was a measurement taken during 2003-2004. The basin hydrographs show water-level trends for selected wells over the 30-year period from January 1975 to January 2005. Not all basins have a sufficient number of representative hydrographs.

The flow directions that are shown generally reflect long-term, regional aquifer flow in the basin and are not meant to depict temporary or local-scale conditions. However, flow directions in some basins indicate how localized pumping has altered regional flow patterns.

Water Quality

Water quality conditions impact the availability of water supplies. Water quality data was compiled from a variety of sources as described in Volume 1, Appendix A. The data indicate areas where water quality exceedences have previously occurred, however additional areas of concern may currently exist where water quality samples have not been collected or sample results were not reviewed by the Department

(e.g. samples collected in conjunction with the ADEQ Aquifer Protection Permit programs). It is important to note also that the exceedences presented may or may not reflect current aquifer or surface water conditions.

Cultural Water Demand

Cultural water demand is an important component of a water budget. However, without mandatory metering and reporting of water uses, accurate demand data is difficult to acquire. Municipal demand includes water company and domestic (self-supplied) demand estimates. Basin demand information is from several sources in order to prepare as accurate an estimate as possible. Annual demand estimates have been averaged over a specific time period. This provides general trend information without focusing on potentially inaccurate annual demand estimates due to incomplete data.

Locations of major cultural water uses are primarily from a 2004 USGS land cover study using older satellite imagery that may not represent recent changes. The cultural demand maps provide only general information about the location of water users.

Effluent generation data was compiled from several sources to provide an estimate of how much of this renewable resource might be available for use. However, effluent reuse is often difficult both logistically and economically since a potential user may be far from the wastewater treatment plant.

Water Adequacy Determinations

Information on water adequacy and inadequacy determinations for subdivisions, with the reason for the inadequacy determination provides information on the number and status of subdivision lots. Listing the reason for the inadequacy identifies which subdivisions have a demonstrated physical or legal lack of water or may have elected not to provide the necessary information to the Department. Briefly, developers of subdivisions outside of AMAs are required to obtain a determination of whether there is sufficient water of adequate quality available for 100 years. If the supply is determined to be inadequate, lots may still be sold, but the condition of the water supply must be disclosed in promotional materials and in sales documents.

In addition to these subdivision determinations for which a water adequacy report is issued, water providers may apply for adequacy designations for their entire service area. If a subdivision is to be served water from one of these water providers, then a separate adequacy determination is not required. (See Section 4.0-5)

Developers of large, master-planned communities outside of AMAs may apply for an Analysis of Adequate Water Supply (AAWS). This type of application is generally used to prove that water will be physically available for the master-planned community. AAWS are issued based on the development plan or plat. If an AAWS is issued for groundwater, it reserves a specific volume of water for 10 years (for purposes of further adequacy reviews) only for the specific property that is the subject of the AAWS.

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