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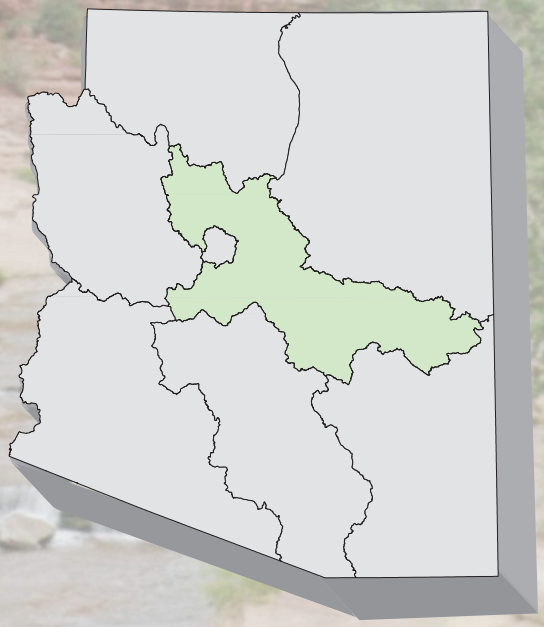
ARIZONA WATER ATLAS

Volume 5

Central Highlands Planning Area



ARIZONA WATER ATLAS
VOLUME 5 – CENTRAL HIGHLANDS PLANNING AREA

Preface

Volume 5, the Central Highlands Planning Area, is the fifth 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 5.0-1). There is a separate Atlas volume for each planning area, an executive summary volume composed of background information, and a resource sustainability assessment 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 and a summary of water supply and demand data for all planning areas. Appendices in Volume 1 describe data sources and methods of analysis, 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).

5.0 Overview of the Central Highlands Planning Area

The Central Highlands Planning Area is composed of five groundwater basins oriented east-west in central Arizona. (Figure 5.0-2) This planning area contains areas of higher elevation compared to many other parts of the state and is characterized by narrow valleys separated by steep mountain ranges. Elevation ranges from 1,500 feet to over 12,600 feet. Parts of nine counties are located within the planning area including Apache, Coconino, Gila, Graham, Greenlee, Maricopa, Navajo, Pinal, and Yavapai counties. There are four Indian reservations within the planning area; the Fort Apache (White Mountain Apache Tribe), San Carlos Apache, Tonto-Apache,and Yavapai-Apache Indian Reservations.

The 2000 Census planning area population was approximately 142,850. Basin population ranged from about 7,500 in the Tonto Creek Basin to over 88,000 in the Verde River Basin. Payson is the largest metropolitan area with

Agriculture in the Verde River Basin. In 2001-2005 the agricultural demand sector was the largest in the planning area with approximately 38,000 acre-feet per year, representing 49% of the total demand.

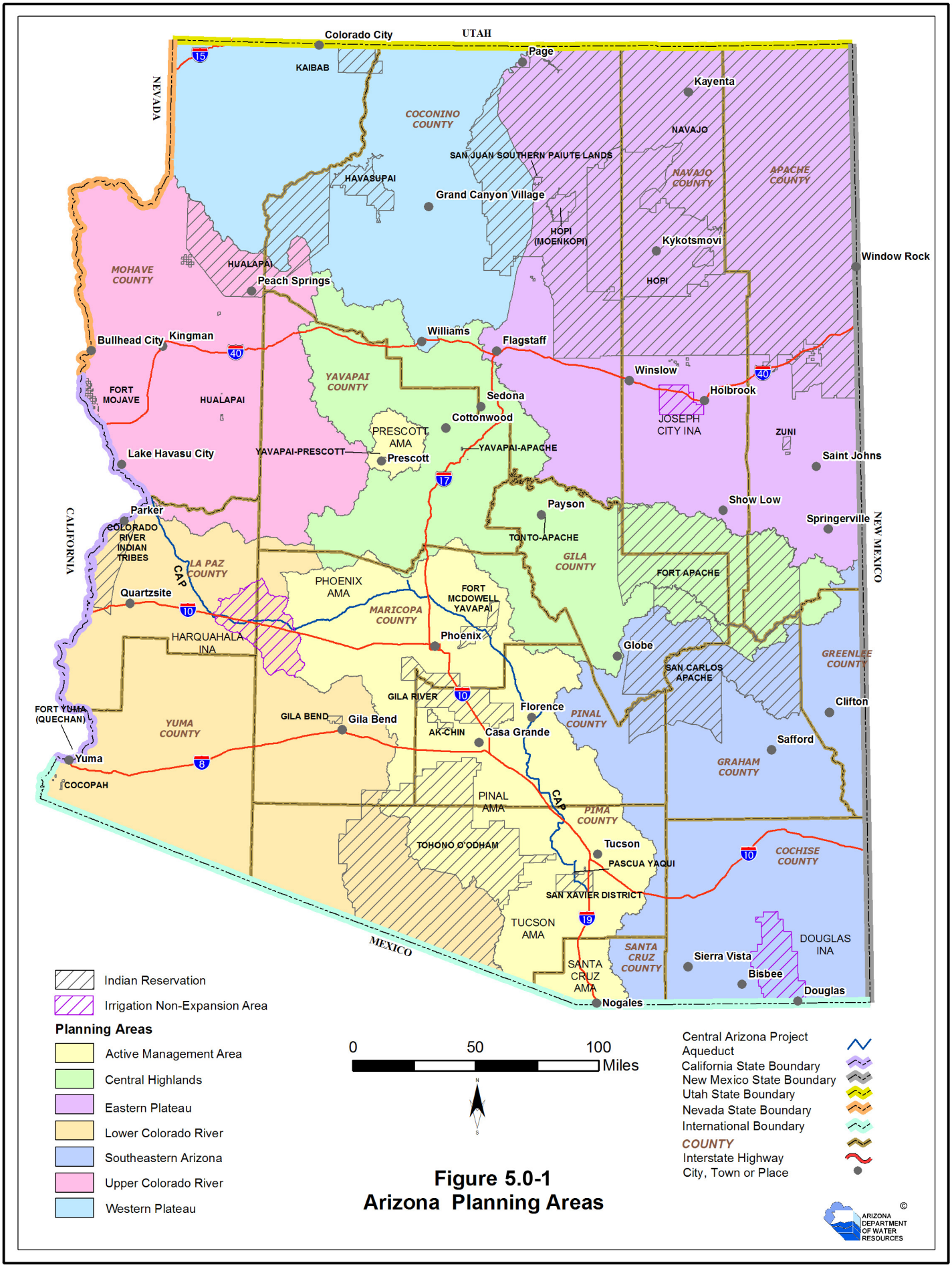


Figure 5.0-1
Arizona Planning Areas

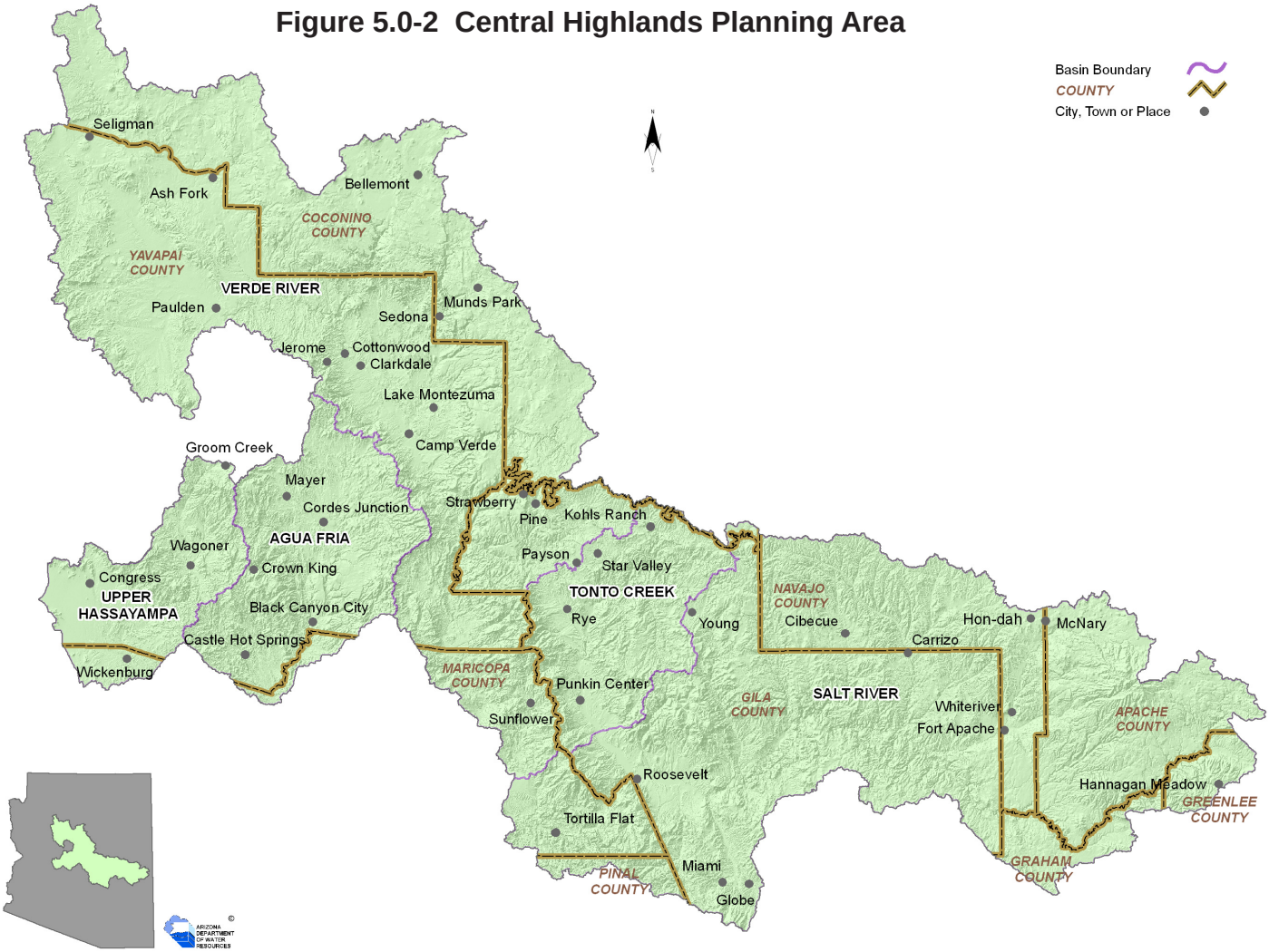
about 13,600 residents in 2000. Other population centers include Camp Verde, Cottonwood/Verde Village/Clarkdale, Globe/Miami and Sedona.

An average of about 83,200 acre-feet of water was used annually during the period 2001-2005 for agricultural, municipal and industrial uses (cultural water demand). Of this total, approximately 63% was groundwater, 36% was surface water and 1% was effluent. The agricultural sector had the largest with approximately 37,500 acre-feet of demand a year - 45% of the total demand. Demand from the municipal sector averaged about 27,400 acre-feet a year (AFA) and industrial demand averaged about 18,300 AFA.

5.0.1 Geography

The Central Highlands Planning Area encompasses about 13,900 square miles (sq. mi.) and includes the Agua Fria, Salt River, Tonto Creek, Upper Hassayampa and Verde River basins. Basin boundaries, counties and prominent cities, towns and places are shown in Figure 5.0-2. The planning area is bounded on the north by the Coconino Plateau Basin in the Western Plateau Planning Area, on the east by the Eastern Plateau Planning Area, on the south by the Southeastern Arizona Planning Area and the Phoenix Active Management Area (AMA), and on the west by the Prescott AMA and the Upper Colorado River Planning Area (Figure 5.0-1). The planning area includes all

Figure 5.0-2 Central Highlands Planning Area



or part of three watersheds, which are discussed in section 5.0.2. Within the planning area, the Fort Apache Indian Reservation encompasses about 2,500 sq. mi. and the San Carlos Apache Indian Reservation, most of which is within the Southeastern Arizona Planning Area, encompasses about 500 sq. mi. The two other reservations, Tonto-Apache and Yavapai-Apache, are relatively small, totaling only about 740 acres or 1.2 sq. mi.

Most of the planning area is within the Central Highlands transition zone, located between the Basin and Range Lowlands and Plateau Uplands Provinces (Figure 5.0-3). It is characterized by rugged mountains of igneous, metamorphic and sedimentary rocks. The extreme southwestern part of the planning area extends into the Basin and Range Lowlands physiographic province, which is characterized by northwest-southeast trending mountain ranges separated by broad alluvial valleys. The southern portions of the Agua Fria and Upper Hassayampa basins are included in this province. The northwestern part of the planning area falls within the Plateau Uplands physiographic province, which is characterized by high desert plateaus and incised canyons. Included in this province are the northern part of the Verde River Basin, and the northern edge of the Tonto Creek and Salt River basins. Elevation ranges from 1,500 feet at Saguaro Lake in the Salt River Basin to 12,633 feet at Humphreys Peak in the San Francisco Mountains at the northeastern edge of the Verde River Basin. High-elevation mountains are also found in the White Mountains in the eastern portion of the Salt River Basin where Mt. Baldy, at 11,403 feet, is the highest point.

Figure 5.0-3 Physiographic Regions of Arizona

Data source: Fenneman and Johnson, 1946

A unique geographic feature of the planning area is the Mogollon Rim, an escarpment that defines the southern boundary of the Colorado Plateau. The rim is approximately 7,000 feet in elevation with sheer drops of 2,000 feet at some locations. The rim stretches for over a hundred miles and forms much of the northeastern boundary of the planning area. The planning area contains diverse topography and a large elevational range, resulting in a wide diversity of vegetation types and ecosystems, the greatest of any planning area. Topography varies from desert basins in the Hassayampa Basin to deeply incised canyons along the Mogollon Rim and high mountain peaks. Because of the high elevations and associated higher rainfall and snowfall, this planning area contains the state's most important water producing watersheds, the Salt and Verde rivers. These watersheds contain the greatest concentration of perennial streams found in the state, which in turn support extensive riparian habitat.

5.0.2 Hydrology[1]

Groundwater Hydrology

The Central Highlands Planning Area is char-

[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)

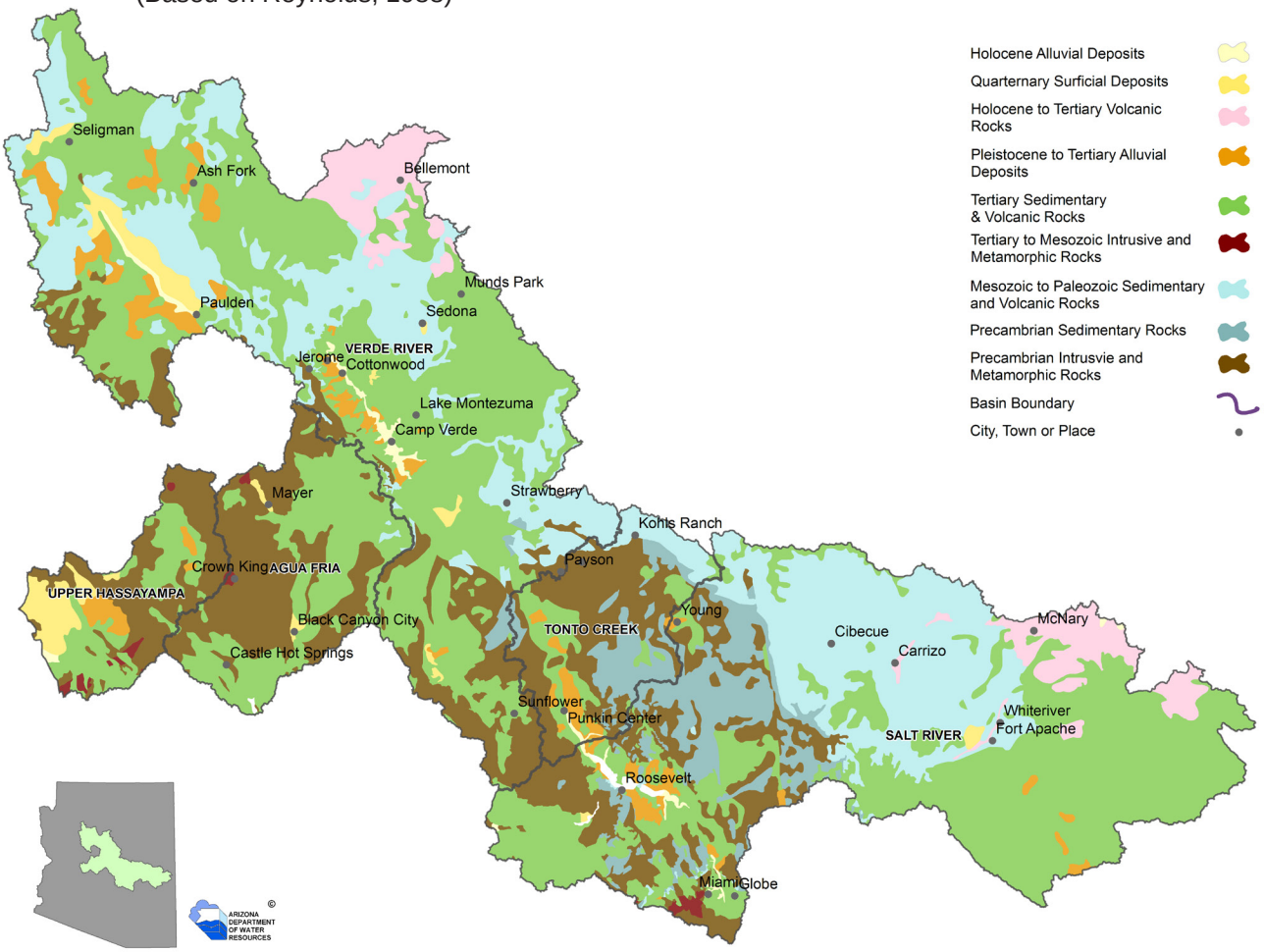
acterized by a band of mountains consisting of igneous, metamorphic and sedimentary rocks (Figure 5.0-4). High elevations, steep topography and extensive bedrock result in relatively high runoff and small water storage capabilities in the planning area as compared to alluvial basins in the southern part of the State. Alluvial and surficial deposits are relatively limited, occurring primarily in the western part of the planning area and along parts of the Verde River and Salt River drainages.

Anderson, Freethey and Tucci (1992) divided the alluvial basins in south-central Arizona into five categories based on similar hydrologic and geologic characteristics. One of these, the "Highland Basins", covers most of the planning area with the exception of the Upper Hassayampa Basin, categorized as a "West Basin", and the southern half of the Agua Fria Basin, categorized as a "Central Basin".

Highland Basins

The Highland Basins include the Salt River, Tonto Creek and Verde River basins, and the northern half of the Agua Fria Basin. Basin-fill aquifers in the highlands are limited in areal extent and are hydrologically connected with stream alluvium. Consolidated rock aquifers surround and underlie the basin-fill aquifers and contribute underflow. Basin-fill aquifers also receive inflow from stream infiltration and mountain front recharge. Where the basin-fill aquifers are discontinuous, underflow between them may be restricted (Anderson, et al., 1992).

Figure 5.0-4 Surface Geology of the Central Highlands Planning Area
(Based on Reynolds, 1988)



Agua Fria Basin (northern half)

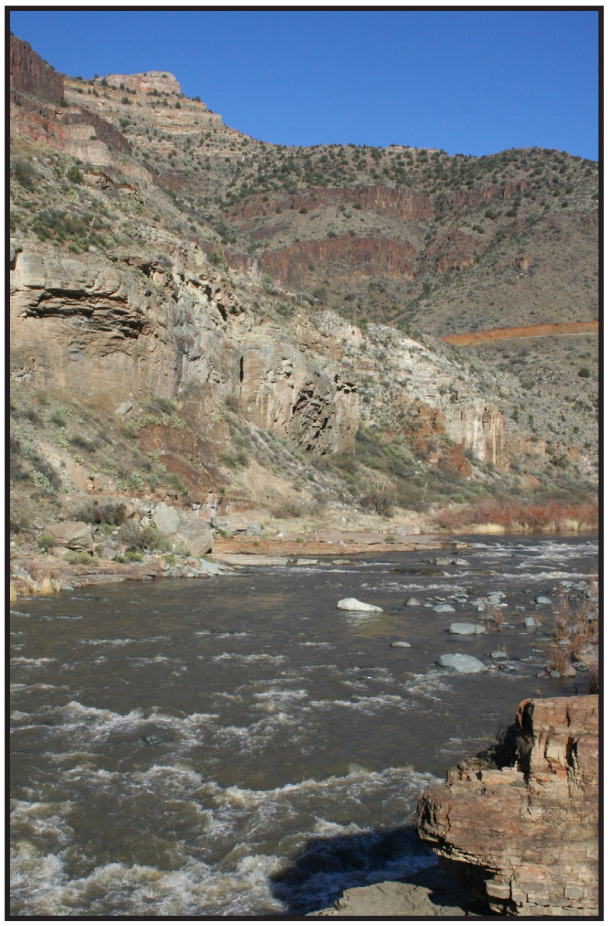
Groundwater occurs in four geologic units in the Agua Fria Basin: basin-fill sands and gravels, volcanic rocks, conglomerates and igneous and metamorphic rocks. Groundwater occurs in volcanic rocks in the northeastern section of the basin that yield relatively small volumes of water. Conglomerates are found throughout the basin and contain the largest volumes of groundwater of any of the rock units. Due to faulting, this unit is separated into smaller discrete basins separated by low permeability crystalline rocks.

Groundwater flow in the northern part of the basin is from the basin margins toward the Agua Fria River drainage and then south (Figure 5.1-7). The estimated volume of groundwater recharge for the entire basin is 9,000 AFA. Groundwater storage estimates for the basin vary from 620,000 acre-feet to 3.5 million acre-feet (maf) (Table 5.1-6). The median well yield reported on registration forms for large (>10-inch) diameter wells in the basin is 300 gpm with relatively low yields found in the vicinity of Meyer and at other locations. Water levels in basin wells measured between 1990-'91 and 2003-'04 were less than 100 feet bls. Water levels in several wells increased by as much as 15 feet during this period, but declined in wells near Cordes Junction (Figure 5.1-6). Water quality in the basin is generally good. In the northern part of the basin, arsenic was the drinking water parameter most frequently exceeded in measured wells and springs (Table 5.1-7).

Salt River Basin

The Salt River Basin is bounded on the west and southwest by the Sierra Ancha and Superstition Mountains, on the south by the Natanes Plateau and on the east by the White Mountains (see Figure 5.2-1). The Mogollon Rim, a 2,000-foot high escarpment, forms a natural groundwater divide along much of the basin's northern boundary. The Salt River Basin contains four sub-basins shown on Figures 5.2-7 and 5.2.-9: Salt River Lakes, Salt River Canyon, Black River and White River. Principal aquifers differ between the sub-basins, with basin-fill and alluvial aquifers found in the western portion of the basin and limestone and volcanic aquifers in the eastern portion.

In the northern part of the basin, groundwater flow in the C-aquifer is from north to south. Groundwater flow has not been characterized in the rest of the basin. Groundwater data are shown in Table 5.2-6. Groundwater recharge is estimated at 178,000 AFA. The only estimate of groundwater in storage is 8.7 maf or more to a depth of 1,200 feet below land surface (bls). Water level change data are available for the Globe-Miami area and near Young, in the Salt



Salt River, Salt River Basin.

River Lakes and Salt River Canyon sub-basins, respectively. Water levels in these measured wells are relatively shallow, at less than 100 feet bls. Water levels declined in all wells for which change data were available during the period 1990-'91 and 2003-'04 (Figure 5.2-7). The median well yield from large (>10-inch diameter) wells is 170 gpm. Most of the water quality measurements in the basin are in the vicinity of Globe-Miami, a copper mining center. The most commonly exceeded drinking water standard was cadmium, although other metals and fluoride concentrations were also elevated in measured wells (Table 5.2-7). Groundwater conditions in each sub-basin, from west to east, are discussed below.

Salt River Lakes Sub-basin

The Salt River Lakes Sub-basin occupies the western part of the Salt River Basin. Unconsolidated sands and gravels within the floodplains of streams and washes form an alluvial aquifer that is generally the most productive aquifer. A basin-fill aquifer underlies a large part of the sub-basin including the area around Globe, lower Tonto Creek, the Salt River reservoirs and Pinto Valley west of Miami. Along the Salt River and around Roosevelt Lake, the basin fill is up to 2,000 feet thick (ADWR, 1992). Recharge to the basin-fill aquifer occurs primarily along mountain fronts and from streams and lake infiltration. Within the sub-basin groundwater is found in granitic, metamorphic and sedimentary rocks.

In the Globe-Miami area the Gila Conglomerate, composed of semi-consolidated to consolidated basin-fill sediments, forms a local aquifer. The Gila Conglomerate is up to 4,000 feet thick in this area and provides most of the area's municipal and industrial water supply. A limestone aquifer also supplies water in the Globe-Miami area, and west of Globe several small basin-fill deposits form isolated groundwater aquifers (ADWR, 1992). Well yields are generally low in the southeast part of the sub-basin near Globe, and higher north of Globe. Granitic rocks provide small amounts of water for domestic and stock use in the sub-basin.

Mining activities in the Globe-Miami area have impacted water quality in the alluvial aquifer along Pinal Creek and Miami Wash including elevated concentrations of sulfate and metals. Drinking water standards for cadmium, chromium, fluoride, lead, other metals and for total dissolved solids (TDS) have been equaled or exceeded in a number of wells in the area.

Salt River Canyon Sub-basin

In the western portion of the Salt River Canyon Sub-basin, sedimentary and igneous rocks, similar to those in the adjacent Salt River Lakes Sub-basin, are found. The groundwater flow system is complex with disconnected recharge areas and many water-bearing zones (USGS, 2005a). The rest of the sub-basin is composed primarily of sedimentary rocks, including limestones, sandstones, siltstones, shales and thin conglomerates. These rocks are exposed along the Mogollon Rim and at other locations in the sub-basin. The Natanes Plateau, along the southern boundary of the sub-basin, is composed of volcanic rock. There is little aquifer data for the area, but based on similar rock units in other areas, there may be useable amounts of water in the Supai Formation, Redwall Limestone, Coconino Sandstone and the undivided sandstones in the sub-basin. These formations may yield moderate amounts of water, up to 100 gpm, however yields can vary widely depending on sub-surface geology (ADWR, 1992). Recharge to the sedimentary rocks occurs mainly along the Mogollon Rim.

Basin-fill and floodplain alluvial deposits are present along Cherry Creek near the western boundary of the sub-basin. The depth of basin-fill deposits in this sub-basin was estimated to be less than 400 feet thick (ADWR, 1992). The

only water level change data for the 1990-'91 to 2003-'04 time-period showed a modest water level decline in a shallow well near Young. Well yield data for the sub-basin show yields of less than 100 gpm to up to 2,000 gpm in the western part of the sub-basin (Figure 5.2-9). Water quality data are lacking for this sub-basin.

White River Sub-basin

The eastern portion of the White River Sub-basin is covered with volcanic rocks and the western portion contains sedimentary rocks similar to those found in the Salt River Canyon Sub-basin. Groundwater occurs in fracture zones and the various volcanic flows, including cinder beds. Groundwater flow in the volcanic aquifer is discontinuous and well yields and water levels may vary widely over short distances. Precipitation in the area is relatively high and recharges the volcanic aquifer through infiltration into the fractured rock. Groundwater discharged from the volcanic aquifer contributes to the baseflow of the White River. Groundwater level and water quality data are lacking for the sub-basin. The only well yield data shows a yield between 100 and 500 gpm in a well between Whiteriver and Hon-dah (Figure 5.2-9).

Black River Sub-basin

The Black River Sub-basin is covered almost entirely by volcanic rocks that include basalt flows, rhyolitic ash flows, tuffs and tuffaceous agglomerates that form layers over 3,000 feet thick in some areas. Wells in this area are generally low-yield and well depths of 400 to 800 feet are common. As in the White River Sub-basin, the volcanic aquifer is recharged through infiltration of precipitation. Discharge from the aquifer contributes to baseflow in the Black River. Groundwater level data are lacking for this sub-basin. Well yield data for two wells shows yields of less than 100 gpm in the northeastern part of the sub-basin and between 500 to 1,000 gpm south of Fort Apache. A single groundwater quality measurement taken at Hannagan Meadow showed a nitrate concentration exceeding drinking water standards.

Tonto Creek Basin

In the Tonto Creek Basin groundwater is found in stream alluvium, basin-fill sand and gravel, Paleozoic sedimentary rocks and Precambrian igneous, metamorphic and sedimentary rocks. The primary aquifer occurs in basin fill, which underlies a large portion of the basin, from near Rye to the southern basin boundary. The basin fill consists of coarse-grained conglomerate in the lower part of the basin and along the basin margins and locally is overlain by fine-grained mudstone in the center of the basin. The conglomerate may be up to 500 feet thick. Groundwater is also found in the floodplain alluvium, which may be as much as 65 feet thick along Tonto Creek. Along this Creek, the basin

Tributary to the Black River, Salt River Basin. Discharge from the aquifer contributes to flow in the Black River.

fill and alluvial aquifers are recharged primarily by stream infiltration.

A limestone aquifer is utilized along the Mogollon Rim where groundwater movement and well yield are dependent on faults, fractures and solution cavities. Wells in the limestone aquifer generally yield less than 100 gpm. Fractured bedrock also yields small volumes of water to wells east of Payson (ADWR, 1992). These and other sedimentary-rock aquifers are recharged from precipitation on the southern edge of the Colorado Plateau (USGS, 2005a).

Groundwater flow directions are from the Mogollon Rim to the south in the C-aquifer and from north to south along the Rye Creek and Tonto Creek drainages in the alluvial aquifer (Figure 5.3-7). Natural recharge for the basin has been estimated at 17,000 to 37,000 AFA. Estimates of groundwater in storage range from 2.0 to 9.4 maf. With one exception, all wells measured in 2003-'04 had a water level below 100 feet. Water levels in wells measured between 1990-'91 and 2003-'04 were either slightly declining or slightly rising (Figure 5.3-7). The median well yield reported on registration forms for large (>10-inch) diameter wells was 120 gpm. Since most of the basin is National Forest land, there has been little basin-wide groundwater development and aquifer characteristics are not well defined. Groundwater quality is generally good, although drinking water standards for arsenic, radionuclides, nitrate and organics have been equaled or exceeded in some wells.

Verde River Basin

The Verde River Basin is a relatively large basin that encompasses part of the Coconino Plateau in its northern portion with the Mogollon Rim defining its eastern boundary. It is characterized by steep canyons, rugged mountains and by broad alluvial valleys in the north and west-central portions of the basin. The basin is divided into the Big Chino, Verde Valley and Verde Canyon sub-basins as shown in Figures 5.5-6 and 5.5-8.

Natural recharge and groundwater in storage estimates for the basin, sub-basins and local areas are listed in Table 5.5-6. Groundwater recharge estimates for the entire basin range from 107,000 AFA to more than 138,000 AFA. Groundwater in storage is estimated to range from 13 maf to more than 22 maf for the entire basin. Few water level measurements were taken in the basin in both 1990-'91 and 2003-'04 (Figure 5.5-6). Water level change measurements taken during different time periods are shown for the Big Chino Sub-basin (Figure 5.5-6A) and the Verde Valley Sub-basin (Figure 5.5-6B) and are discussed in the sub-basin sections below. Well yield varies throughout the basin with the most productive wells located in the Big Chino Sub-basin (Figure 5.5-8). The median well yield for the entire basin is 260 gpm reported on registration forms for 262 large (>10-inch) diameter wells.

A number of hydrogeologic studies of the Big Chino and Verde Valley sub-basins, and to a lesser extent the Verde Canyon Sub-basin, have been conducted and are briefly referenced here. These studies, many of them recent, contain detailed information about the groundwater and surface water systems in the basin and are referenced in this section and in the Verde River Basin references and supplemental reading. Each sub-basin is discussed below from north to south across the basin.

Big Chino Sub-basin

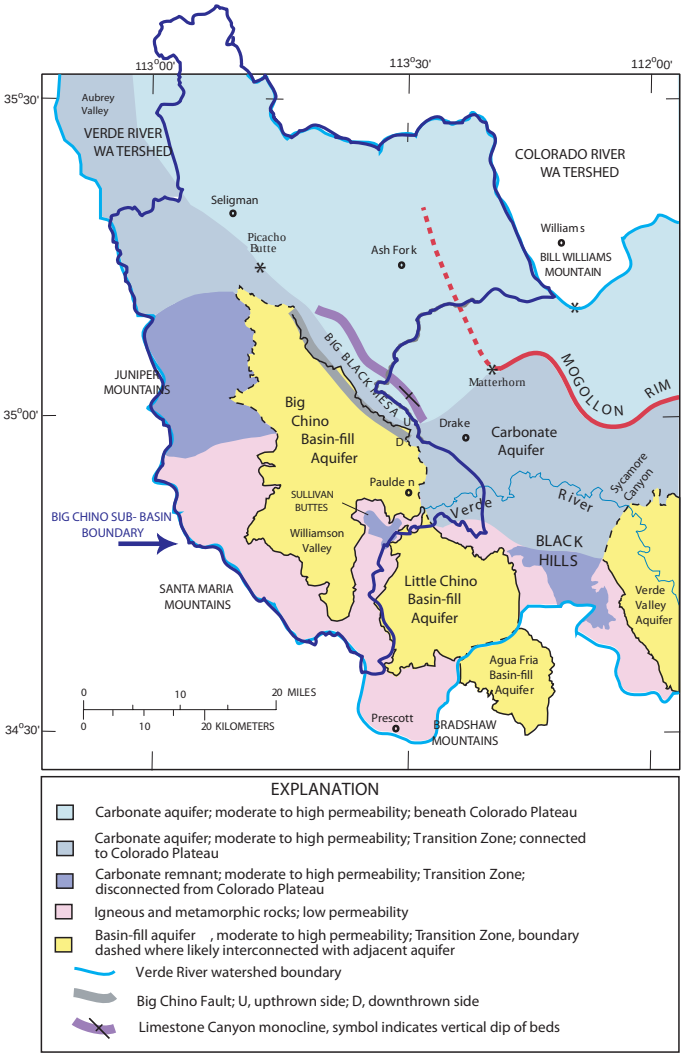
The Big Chino Sub-basin has an area of about 1,850 square miles. The principal aquifer consists of basin-fill sediments interbedded with volcanic rocks of Cenozoic age that fill the sub-basin. This basin-fill aquifer is commonly referred to as the Chino Valley Unit and is the major source of water for irrigation and domestic purposes. Chino Valley runs northwest to south-

east from Seligman to Paulden. Well yields in Chino Valley wells are commonly greater than 1,000 gpm to greater than 2,000 gpm. A carbonate aquifer comprised of Paleozoic rocks underlies most of the Big Chino Valley Sub-basin and the area north of the Verde River near Paulden. It is assumed that there is a hydraulic connection between the two aquifers in the Big Chino Valley and the Williamson Valley, which runs north-south along the southeastern sub-basin boundary. The general location of aquifers and other features are shown in the graphic from Wirt, 2005.

Groundwater occurs under unconfined and confined (artesian) conditions in the basin-fill aquifer. Artesian conditions occur primarily where buried lava flows and coarse-grained sediments are interbedded with clays and volcanic ash. In the northwesternmost part of the sub-basin, basin-fill deposits may be as much as 2,500 feet thick. Further south and west of Paulden in the Williamson Valley, the thickness of the alluvium is estimated at 2,000 feet. In the eastern part of the Big Chino Sub-basin, the carbonate aquifer is the primary regional aquifer. This aquifer is dry west of the Mesa Butte Fault, which occurs north of Drake and runs northeastward, and between Williams and the Big Chino Valley (USGS, 2006). Alluvial sands and gravels along the major washes also yield water to wells and are utilized as a local water supply in the sub-basin.

Groundwater flow in the basin-fill aquifer is toward the Big Chino Wash drainage and then south. Groundwater flow in the carbonate aquifer is toward the north (Figure 5.5-6). Recharge occurs from mountain front recharge along the Juniper and Santa Maria Mountains on the west side of the sub-basin, from Granite Mountain on the south and from Big Black Mesa and Bill Williams Mountain on the east side and from runoff in major washes. Recharge also occurs via groundwater inflow from the Little Chino Sub-basin (Prescott AMA) north of Del Rio Springs. In 1999, this groundwater inflow was estimated at 1,800 AFA (Nelson, 2002). The Williamson Valley and Paulden areas are the most arid regions in the Verde River Basin.

Groundwater outflow from the Big Chino Sub-basin occurs as base flow in the Verde River



Regional aquifers in the vicinity of the Big Chino Basin. Modified figure from Wirt, 2005

and is currently estimated at about 17,700 AFA. Base flow at the Verde River near Paulden (gage number 9503700, see Figure 5.5-4) has declined at an annual rate of about 380 AFA since the mid-1990s (USGS, 2006). The average annual recharge volume for the sub-basin was estimated at 30,300 AFA for the period 1990-2003 (Blasch and others, 2006). McGavock (2003) estimated that there was 10 maf of groundwater in storage in the sub-basin to a depth of 1,200 feet bls.

Figure 5.5-6A shows water level changes in the sub-basin from 1992 to 2003-'04 and water level elevation during 2003-'04. More than half the wells measured showed some decline although water level increases of more than 15 feet were measured in wells south of Seligman. Well yields exceeding 2,000 gpm are found along the Big Chino Wash drainage (Figure 5.5-8). Water quality is generally good in the sub-basin with some occurrence of arsenic at levels that equal or exceed the drinking water standard in wells in the Paulden area.

Verde Valley Sub-basin

The Verde Valley Sub-basin is the largest sub-basin in the Verde River Basin with an area of about 2,500 square miles. The principal aquifer is the Verde Formation, which consists of a thick sequence of tertiary limestones and sandstones. The estimated depth of the formation reaches 4,200 feet based on aeromagnetic and gravity data (USGS, 2006). The formation flanks the Verde River for some distance from the Camp Verde area to north of Cottonwood. Other aquifers include the carbonate aquifer and an alluvial aquifer located along the Verde River. The carbonate aquifer, primarily sandstone of the Supai Formation and the underlying Redwall and Martin limestones is the main groundwater supply for Sedona. Locally perched groundwater in fractured or decomposed granite and in volcanic rocks provide small amounts of water in many locations. Groundwater occurs primarily under unconfined conditions although confined conditions occur locally within the Verde Formation. All three aquifers are hydraulically connected.

Most groundwater enters the sub-basin from the Coconino Plateau. Groundwater moves through the carbonate aquifer and discharges at springs and seeps along tributaries of the Verde River, or flows into the Verde Formation and stream-channel alluvium (USGS, 2006). The Oak Creek Fault system is an important influence on the transmission of water between aquifers and to the surface, as evidenced by the large number of major springs along Oak Creek (see Figure 5.5-5). Groundwater primarily flows toward the Verde River drainage and exits the sub-basin in the southeast through alluvium and volcanic rocks along the river (Figure 5.5-6).

Groundwater recharge to the Verde Formation aquifer is from high elevation precipitation along the Mogollon Rim and on the Coconino Plateau with additional contributions from stream infiltration. The carbonate aquifer also receives recharge from high altitudes along the Mogollon Rim, and from an area between the San Francisco Peaks and Bill Williams Mountain (USGS, 2006). Most recharge comes from winter precipitation. Groundwater recharge was estimated at 167,470 AFA on average during the period 1990-2003 (Blasch and others, 2006). An estimate of groundwater in storage is not available for the sub-basin. Figure 5.5-6B shows water level changes in the sub-basin from 1994 to 2003-'04 and water level elevation during 2003-'04. More than half the wells measured showed some decline although water level increases of more than 30 feet were measured at a few scattered locations. Reported well yields generally range from less than 100 gpm to 1,000 gpm in the sub-basin (Figure 5.5-8). Groundwater is generally of good quality at most locations, although the drinking water standard for arsenic has been

equaled or exceeded in a number of wells (see Table 5.5-7).

Verde Canyon Sub-basin

There is relatively little groundwater development in the Verde Canyon Sub-basin with the exception of the Payson area. Basalt flows, conglomerates and semi-consolidated silt units cover a large part of the sub-basin. The groundwater system is complex, with disconnected recharge areas and multiple water-bearing zones. Because of its complexity, knowledge of the groundwater system is often limited to local analysis of spring and well data. Groundwater recharge originates primarily along the crest of the Mogollon Rim, where precipitation and snowmelt percolate through permeable volcanic, limestone or sandstone units (USGS 2005a). Spring discharge and stream base flow appear to be the largest components of aquifer outflow.

In Payson groundwater is withdrawn primarily from fractured and faulted granite. Most wells are shallow, although the Town of Payson has conducted exploratory drilling north of the town where deep water-bearing zones were found. A recent study suggests that a segment of the Diamond Rim fault system northeast of Payson may have groundwater supply potential (Gæaorama, 2006). The shallow water-bearing zones around Payson depend on winter recharge and are therefore very sensitive to drought. Water in deeper fracture systems in the area may be fed from the Mogollon Rim and less affected by drought. Water levels in wells measured in the Payson area in 2003-‘04 varied from 115 feet to 339 feet bls. Water levels in most of these wells declined by more than 30 feet between 1990-‘91 and 2003-‘04 (Figure 5.5-6). Well yields in the area are typically less than 500 gpm.

In Strawberry, most wells are completed in the Schnebly Hill Formation, a sandstone unit that is the major component of the “Red Rocks” of Sedona. Well yields in the area typically range from 20 to 80 gpm. An exploratory well drilled near Strawberry in 2000 encountered water in the Redwall Limestone at about 1,380 feet (Corkhill, 2000). At nearby Pine most wells are completed in the Supai Formation, which is composed of sandstone, siltstone and mudstone with some interbedded limestone. Well yields in Pine are typically lower than Strawberry and range from 10 to 30 gpm. These relatively low well yields suggest a more localized groundwater system (USGS, 2005a). Little water level change data are available with one well near Pine showing a modest water level increase between 1990-‘91 and 2003-‘04. However, a nearby domestic well experienced a decline of about 160 feet between 1993 and 2003-‘04 (Figure 5.5-7, hydrograph V). There is little water use in the southern half of the sub-basin where unconsolidated sediments are found.

Water quality is generally good in the sub-basin although the drinking water standards for arsenic, beryllium, cadmium, lead, selenium and organics have been equaled or exceeded in wells in the Payson area and for arsenic in Pine.

West Basins

The Upper Hassayampa Basin was defined by Anderson, Freethey and Tucci (1992) as a “West Basin”. These basins are generally arid and groundwater inflow and outflow are relatively small with little or no stream baseflow.

Upper Hassayampa Basin

The main aquifer in the Upper Hassayampa Basin is basin-fill deposits found along valleys between the mountains. These deposits consist of gravel, sand, silt and clay. In the mountainous, eastern part of the basin, fractured crystalline and consolidated sedimentary rocks yield small amounts of water to wells. Near Wagoner, stream deposits overlying crystalline rock are up to 135 feet thick. North of the Vulture Mountains, in

the southwestern part of the basin, the basin fill varies from a few tens of feet thick to over 1,000 feet thick near the middle of the valley.

Groundwater flow is generally from north to south. Groundwater recharge is estimated at 8,000 AFA and groundwater in storage is estimated to range from 1.0 to 1.1 maf. Water levels in wells measured in 2003-'04 varied from 20 feet bls near Wickenburg to 817 feet bls near Congress. Water level change data from wells measured in 1990-'91 and 2003-'04 show relatively stable groundwater levels (Figures 5.4-6 and 5.4-7). The median well yield in the basin was 125 gpm reported on registration forms for 61 large (>10-inch) diameter wells (Table 5.4-6). Groundwater quality is generally good although drinking water standards for arsenic and other metals have been equaled or exceeded in wells near Wickenburg.

Central Basins

The southern half of the Agua Fria Basin was categorized by Anderson, Freethey and Tucci (1992) as a "Central Basin". Central basins are characterized by deep alluvial sediments with small to moderate amounts of mountain front recharge and streamflow infiltration.

Agua Fria Basin (southern half)

The principal aquifers in the Agua Fria Basin are upper basin fill, which occurs under unconfined conditions, and sedimentary rock (conglomerate), which is found throughout the basin and contains the largest volume of groundwater. Water level data are sparse in this portion of the basin. A domestic well located in unconsolidated sediments near Black Canyon City had a measured water level of 43 feet bls in 2003-'04 (Figure 5.1-7). Well yields in the unconsolidated sediments may be as high as 1,000 gpm or more although most are less than 500 gpm (Figure 5.1-9). In Black Canyon City the Water Improvement District obtains water from wells completed in precambrian schist. The wells yield less than 20 gpm and have water levels ranging from 21 to 23 feet below ground surface (Black Canyon City, 2006). Arsenic and fluoride concentrations at levels that equal or exceed drinking water standards have been detected in springs and wells near Black Canyon City and at Castle Hot Springs.

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 code corresponds to accounting units, which are used by the USGS for designing and managing the National Water Data Network. There are portions of three watersheds in the planning area at the accounting unit level: the Agua Fria River-Lower Gila River, the Salt River and the Verde River (Figure 5.0-5).

The Agua Fria-Lower Gila River

The Agua Fria-Lower Gila River Watershed

Flood flow on the Agua Fria River near Black Canyon City.

extends from near Prescott to south of Gila Bend in the Lower Colorado River Planning Area. It includes the drainage areas of the Agua Fria River, the Hassayampa River and the Gila River from below its confluence with the Salt River to Painted Rock Dam. Within the planning area, this watershed covers the Agua Fria and the Upper Hassayampa basins.

The Agua Fria River drains an area of about 2,700 square miles with elevations ranging from 7,800 feet in the Bradshaw Mountains, which define part of its western boundary, to 1,570 feet at Lake Pleasant, which is impounded by New Waddell Dam at the southern boundary of the Agua Fria Basin. The Agua Fria River only flows below the dam when water is released during major flood events and is tributary to the Gila River a short distance downstream of the confluence of the Salt and Gila Rivers near Goodyear in the Phoenix AMA. The Agua Fria River is perennial along several reaches within the Agua Fria Basin: above Lake Pleasant south of Black Canyon City; through portions of the Agua Fria National Monument; and in the northern part of the basin (see Figure 5.1-6). Tributaries to the Agua Fria River with perennial reaches include Little Ash, Sycamore and Silver creeks. Other tributaries to the river are generally intermittent or ephemeral.

The Hassayampa River originates in the northern Bradshaw Mountains and flows through the Upper Hassayampa Basin and the

Figure 5.0-5 Central Highlands USGS Watersheds
(USGS, 2005b)

The Agua Fria River is perennial at several reaches within the Agua Fria Basin: above Lake Pleasant south of Black Canyon City; through portions of the Agua Fria National Monument; and in the northern part of the basin

Phoenix AMA to its confluence with the Gila River. The river drains a total of about 1,470 square miles. It is perennial in the northern portion of the Upper Hassayampa Basin in the vicinity of Groom Creek, and in a reach south of Wickenburg. A major fault crosses the river seven miles downstream from Wickenburg at "the Narrows", which forms the southern boundary of the basin. At this point, the entire flow of the river sinks into the streambed. The only other perennial reaches within the basin are short reaches of Minnehaha, Ash, Weaver and Antelope creeks (AGFD, 1993).

Three streamflow gages are currently active in the watershed; all located in the Agua Fria Basin. Included are real-time gages on the Agua Fria River near Humboldt, Mayer and Rock Springs. The maximum recoded annual flow in the watershed was 360,541 acre-feet at the Rock Springs gage in 1992. The median annual flow at this location is 19,692 acre-feet and the minimum annual flow was 1,528 acre-feet in 1975 (see Table 5.1-2). There are currently no operating streamflow gages in the Hassayampa River drainage of the watershed. The gage with the longest record (35 years), located north of Wickenburg, was discontinued in 1982. During its period of operation, the highest annual flow recorded was 123,076 acre-feet in 1980, and its median flow was 7,457 acre-feet (see Table 5.4-2).

There are approximately 460 total springs in the watershed. Only five springs with a discharge of 10 gpm or greater have been reported; all located in the Agua Fria Basin. Discharges from those major springs were last measured during or prior to 1982, therefore these rates may not be indicative of current conditions. The largest spring, Castle Spring, discharges approximately 340 gpm from Precambrian rocks at a temperature of 131°F. Castle Spring is located northwest of Lake Pleasant at Castle Hot Springs, reportedly Arizona's first resort, opened in 1896. The four other major springs have discharge rates less than 100 gpm and are located in the northeastern portion of the basin (see Figure 5.1-6). There are 14 minor springs (discharge of 1-10 gpm) in the watershed, also located in the Agua Fria Basin. While there are no major or minor springs reported in the Upper Hassayampa Basin, there are approximately 164 to 166 springs with a discharge of less than 1 gpm.

Within the watershed, reaches of Turkey Creek in the Agua Fria Basin, and Cash Mine Creek, French Gulch and the Hassayampa River in the Upper Hassayampa Basin have surface waters with impaired water quality. Parameters of concern include cadmium, copper, zinc, pH and lead due to mining activities in the area.

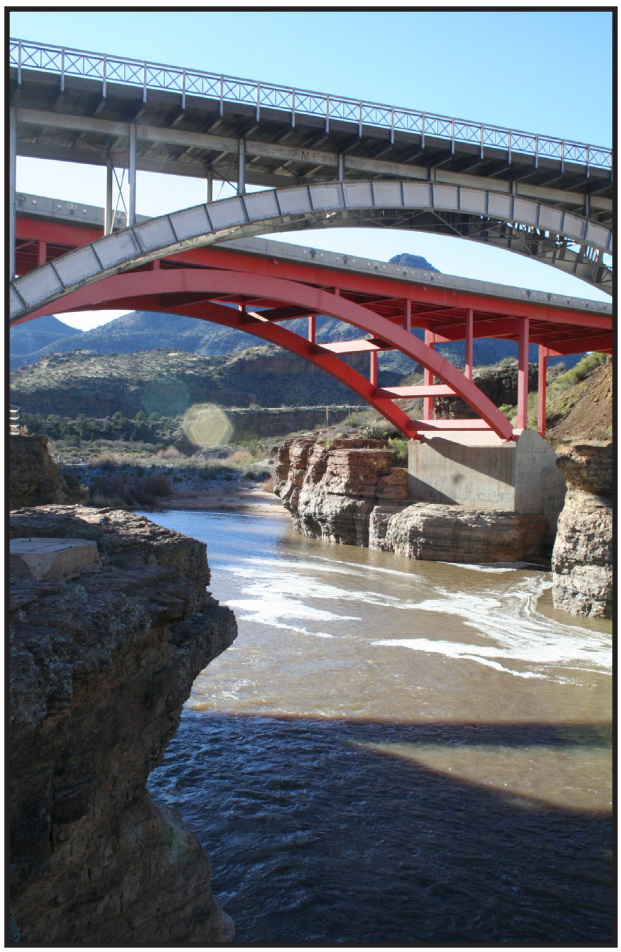
<u>The Salt River</u>

The surface water characteristics of the Salt River Watershed are influenced by precipitation patterns, topography and geology. The Salt River and Tonto Creek basins comprise most of the watershed with the exception of the westernmost part, which extends to the confluence of the Salt and Gila rivers in the Phoenix AMA. The Salt River is the largest tributary of the Gila River with a drainage area of about 5,980 square miles.

Its headwaters are the White and Black rivers that originate in the high elevations of the Salt River Basin where winter snow accumulation is critical to downstream water supplies. This area is the most prolific producer of surface water in Arizona with unit runoff values as high as 674 acre-feet/square mile (12.6 inches) in the drainage of the East Fork of the White River. (See Figure 5.2-4). By comparison, the Tonto Creek Basin has a unit runoff of about 160 acre-feet/square mile (3.1 inches). (ADWR, 1992) Within the planning area, the elevation of the watershed ranges from near 11,400 feet in the White Mountains to 1,500 feet at Saguaro Lake.

There are many perennial streams in the Salt River Watershed, particularly in the Salt River Basin (see Figures 5.2-5 and 5.3-6). The Salt River and Tonto Creek are both perennial throughout their lengths in the planning area. Numerous small streams that begin along the Mogollon Rim and the White Mountains feed tributaries of the Salt River and Tonto Creek. Perennial flow in these streams is primarily due to geologic features (e.g. joints and fractures) that cause groundwater to surface and discharge to streams.

Surface water from the watershed flows into Theodore Roosevelt Lake, and is subsequently released to a series of three downstream reservoirs along the Salt River, Apache Lake, Canyon Lake and Saguaro Lake. These reservoirs and their associated dams are operated by the Salt River Project (SRP) for the benefit of agricultural, municipal and industrial users in the Phoenix metropolitan area. Figure 5.0-6 shows the capacity of the SRP reservoir system on both the Salt and the Verde rivers. Also shown is C.C. Cragin Reservoir, formerly known as Blue Ridge Reservoir. Water stored at C.C. Cragin, located in the Eastern Plateau Planning Area, is diverted by pipeline to the East Verde River in the Verde River Watershed to supplement the



Salt River. There are many perennial streams in the Salt River Watershed, particularly in the Salt River Basin

SRP water supply and satisfy obligations to the Gila River Indian Community in accordance with the Arizona Water Settlement Act (Act). The Act also allocated 3,500 AFA from the reservoir to improve the water supply situation in northern Gila County, of which 3,000 AFA will be used by Payson. Surface water stored in the Salt and Verde reservoir system is generally not available for use in the Central Highlands Planning Area.

The Salt River system dams were constructed beginning in 1911 with completion of Roosevelt Dam. Mormon Flat Dam was completed in 1926, followed by Horse Mesa in 1927 and Stewart Mountain in 1930. Prior to dam construction, the flow in the Salt River was heavi-

Figure 5.0-6 SRP Reservoir System Capacity

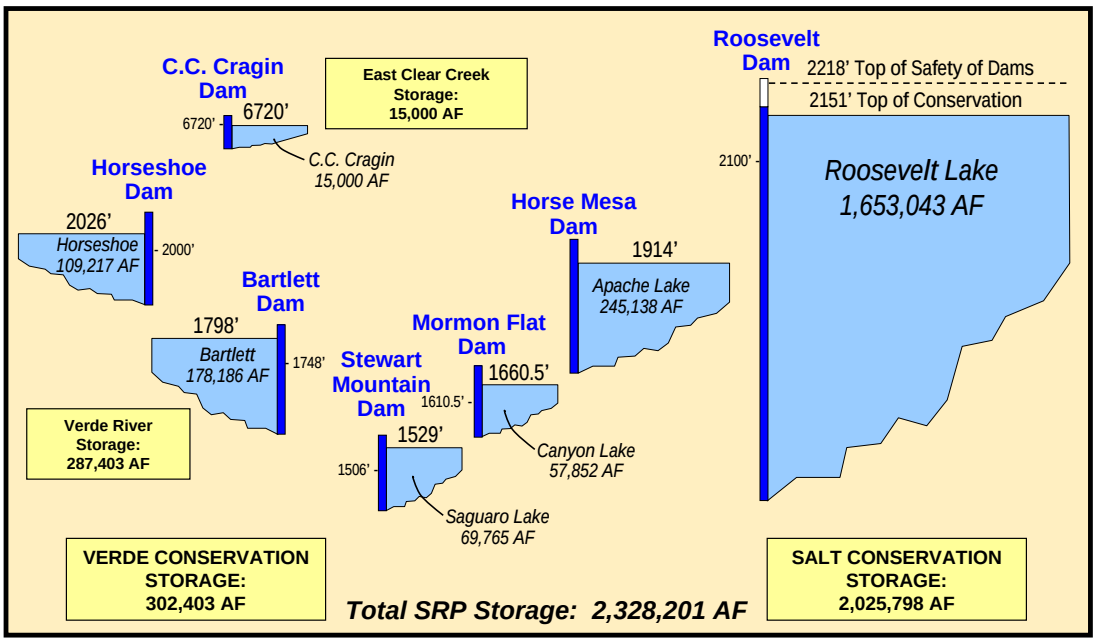


Figure courtesy of SRP (2006)

est in the spring and early summer. Flow is now regulated in response to flood control and downstream water demand. As a result, flows below the reservoirs are generally highest during June-August when water demand is greatest in the Phoenix metropolitan area or when high inflow to the reservoirs necessitates release of water from the dams. In February 1980, a wet winter combined with a storm that dropped up to ten inches of rainfall on the watershed resulted in the largest controlled flood ever to go down the Salt River. Releases from Roosevelt Dam peaked at 180,000 cfs and the water level behind the dam was inches from overflowing the crest (SRP, 2007a).

Annual streamflow of the Salt River fluctuates widely. The nearest gage upstream from Roosevelt Lake, with a contributing drainage area of 4,306 mi^2, has been in operation since 1913. The maximum annual flow was over 2.4 maf in 1916, median annual flow has been 518,499 acre-feet and mean annual flow 644,942 acre-feet. In 2002, an extreme drought year, flow into Roosevelt Lake was at its minimum, about 153,000 acre-feet (Table 5.2-2). Except for changes due to timber harvesting and beaver removal, the upstream reaches of the river have not been significantly altered (Tellman et al., 1997). Typically, timber harvesting and fire in mature forests temporarily increases watershed yields due to elimination of the plant cover. As woody and herbaceous vegetation becomes established, streamflows decline. Recent severe fires in the basin resulted in significant increases in peak flow at several locations. (Neary, et al., 2003)

In the Tonto Creek Basin there is one currently operating, real-time streamflow gage located near the community of Roosevelt north of Gun Creek. The maximum annual flow at this point was more than 469,000 acre-feet in 1978. The median annual flow has been about 66,000 acre-feet since 1940. Similar to the record low flow in the Salt River, the minimum annual flow was about 2,900 acre-feet in 2002 (Table 5.3-2).

There are a relatively large number of major springs in the Salt River Watershed. In the Tonto Creek Basin, several major springs are located below the Mogollon Rim where groundwater is discharged from southward dipping rocks of a limestone aquifer. Tonto Spring at the headwaters of Tonto Creek is the largest spring in the Tonto Creek Basin with a measured discharge of 1,291 gpm. Its flow has been relatively stable, and its isotopic and specific-conductance data are similar to those for Fossil Springs in the Verde River Watershed. This suggests that the same limestone aquifer supplies both springs, which are located approximately 20 miles apart (USGS, 2005a). In the Salt River Basin, a high concentration of major springs occurs near McNary, where springs emanate from fractured basalt. Alchesay Spring, which issues from the Supai Formation along the North Fork of the White River, has the greatest reported discharge measurement in the watershed (over 9,000 gpm). Travertine deposition due to high concentrations of calcium carbonate in source waters occurs at this spring and at Warm Spring along the Salt River (ADWR, 1992).

Several lakes and streams in the watershed have impaired water quality. Reaches of Tonto Creek and Christopher Creek in the Tonto Creek Basin have exceeded standards for E. coli and nitrate. The entire reach of Pinto Creek in the Salt River Basin has exceeded the standard for copper due to mining activities in the area. Two lakes in the Salt River Basin have impaired waters including Canyon Lake (dissolved oxygen) and Crescent Lake (high pH) (see Tables 5.2-7 and 5.3-7).

Verde River

Most of the Verde River watershed, and its major watercourse, the Verde River, is located within the boundaries of the Verde River Basin. Within the planning area, the elevation of the Verde River watershed ranges from about 12,600 feet at Humphrey's Peak to about 1,750

Verde River near Paulden Gage, Verde River Basin. The Central Highlands Planning Area contains the state's most important water producing watersheds, the Salt River and the Verde River which contain the greatest concentration of perennial streams in the state.

feet at Bartlett Dam. The entire watershed encompasses about 6,188 sq. mi. and extends into the Phoenix AMA to the confluence of the Verde River with the Salt River. The upper parts of the watershed include Big Chino Wash, which originates east of the Aubrey Cliffs northwest of Seligman, and Oak Creek which originates on the Coconino Plateau in the northeastern part of the watershed. Big Chino Wash is an ephemeral stream that flows southeasterly to Sullivan Lake while Oak Creek is a perennial stream that merges with the Verde River south of Cottonwood.

The Verde River originates in a steep-walled volcanic rock canyon near Paulden below Sullivan Lake Dam (now almost entirely filled with sediment). Springs feed the headwaters near the upper end of Stillman Lake. The lake is a narrow, 3,900 foot-long, 20-acre impoundment formed from sediment deposited in the river at the Granite Creek confluence causing the river to back-up in its channel. (USFWS, 2007). Just below the confluence with Granite Creek, a large diffuse spring network, including Big Chino Spring and Sullivan Lake Spring, sustain perennial flow in the river. A USGS study found that discharge from the springs below Sullivan Lake Dam are derived from three groundwater sources; the western part of the Coconino Plateau, the Big Chino Sub-basin and the Little Chino Sub-basin (part of the Prescott AMA) (USGS, 2006). Another USGS study used geochemical data to estimate the various base flow contributions to the Verde River. It reported that 80-86% of the base flow is from the Big Chino Sub-basin, 14% from the Little Chino Sub-basin, 10-15% from the Devonian-Cambrian zone of the regional carbonate aquifer and <6% from the Mississippi-Devonian sequence of the regional carbonate aquifer (USGS, 2005c).

Below Granite Creek, the Verde River flows eastward to Perkinsville, southeastward to Fossil Creek, then southward through two reservoirs, Horseshoe and Bartlett, before its confluence with the Salt River. Bartlett Dam was constructed between 1936-1939 to store water for irrigation and other uses in the Phoenix metropolitan area. Ten miles upstream, Horseshoe Dam was completed in 1946 by Phelps Dodge for the Salt River Valley Water Users' Association under a water exchange agreement. Both reservoirs are operated by SRP.

The Verde River is perennial throughout its length from just below Sullivan Lake Dam. Almost all the major perennial tributaries to the river drain areas to the north and east. In addition to Oak Creek, other major tributaries are Wet Beaver Creek, West Clear Creek, Sycamore Creek (at Fort McDowell) and East Verde Riv-

Sullivan Lake Dam, Verde River Basin. The Verde River is perennial throughout its length from just below Sullivan Lake Dam.

er. Stream flows in the watershed can be substantial given the relatively high elevation and associated high rainfall and snowfall. Several stream gages on the Verde and its tributaries have reported annual maximum flows exceeding one million AFA. These gages are the Oak Creek gage near Cornville, the Verde River below Tangle Creek above Horseshoe Dam gage and the Verde River at Bartlett Reservoir near Cave Creek gage. The median flows at these gages are about 531,000 acre-feet, 131,000 acre-feet and 245,000 acre-feet, respectively (see Table 5.5-2). The lowest flow reported at the Oak Creek gage was about 214,500 acre-feet in 1956.

Many major and minor springs occur in the Verde River Basin (see Table 5.5-5) including Fossil Springs, near Strawberry, with a total discharge of over 21,000 gpm. Fossil Springs consist of several dozen discharge points with most of the flow emanating from about a half dozen points. The largest of the springs reportedly issues from the Fossil Springs fault while other springs issue from the Naco Formation near its contact with the underlying Redwall limestone (Gæaorama Inc., 2006). The Naco Formation consists of interbedded grayish limestone and limey claystone and is located between the overlying Supai Formation and the Redwall limestone in this area. The chemistry of the springs below the Mogollon Rim is characteristic of water from the Coconino Aquifer, suggesting its source. Fossil Springs contain elevated concentrations of calcium, magnesium, and bicarbonate as well as chloride and sulfate (USGS, 2005a). Calcium carbonate precipitates out below the springs and forms travertine dams along Fossil Creek.

Major springs also occur along upper and lower Oak Creek. In the north half of Oak Creek Canyon, water moves along fractured rock of the Oak Creek fault zone to discharge at springs along the creek (Owen-Joyce, 1983). Several springs are also found along lower Oak Creek, south of Camp Verde and below the Mogollon Rim north of Payson. Here, water infiltrating through sedimentary rocks discharges at springs along the face of the rim at fractures or at the interface of permeable and less permeable rocks.

Impaired surface waters in the Verde Watershed occur along the East Verde River (selenium), Oak Creek (E. coli), Pecks and Stoneman lakes (dissolved oxygen, high pH and nutrients), Whitehorse Lake (dissolved oxygen) and along reaches of the Verde River (turbidity). (See Table 5.5-7 and Figure 5.5-9).

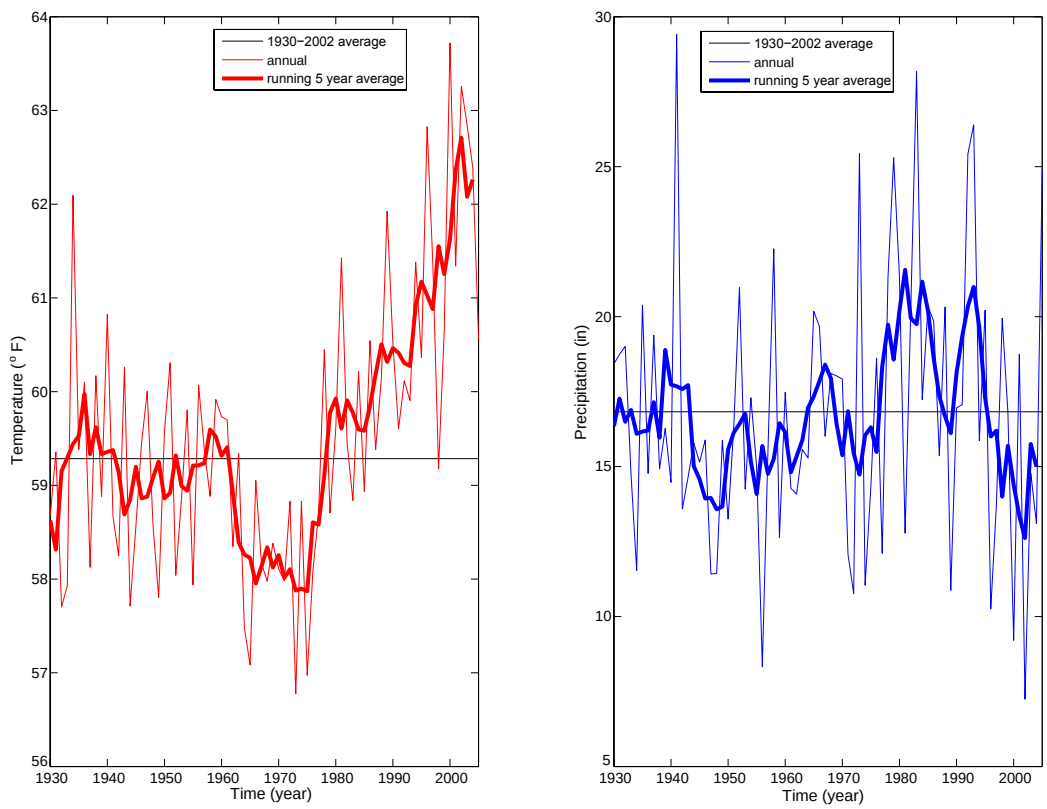
Oak Creek, Verde River Basin. In the north half of Oak Creek Canyon, water moves along fractured rock of the Oak Creek fault zone to discharge at springs along the creek

5.0.3 Climate[2]

The high country of the Mogollon Rim is a significant topographic barrier to regional airflow, making the climate of the Central Highlands Planning Area wetter and cooler than the rest of the state. The area-weighted average of water-year precipitation for the National Oceanic and Atmospheric Administration (NOAA) Arizona Climate Divisions 3 and 4 (covers Yavapai and Gila counties, respectively) is 16.8 inches, which is greater than the statewide average of 12.1 inches. A climate division is a region within a state that is generally climatically homogeneous. Arizona is divided into seven climate divisions.

The area-weighted average water-year temperature for the planning area is 59.3°F, compared to the statewide average of 59.9°F. While average temperatures are slightly cooler than the statewide average, they have been warming during the last 70+ years (Figure 5.0-7). Recent studies show an observed increase, throughout much of the West, in the fraction of winter precipitation falling as rain, rather than snow, at low-to-middle elevations (up to around 8,000 feet). If this trend continues, the timing, amount and distribution of spring runoff is likely to be affected.

Figure 5.0-7 Average Temperature and Total Precipitation in the Central Highlands Planning Area from 1930-2002



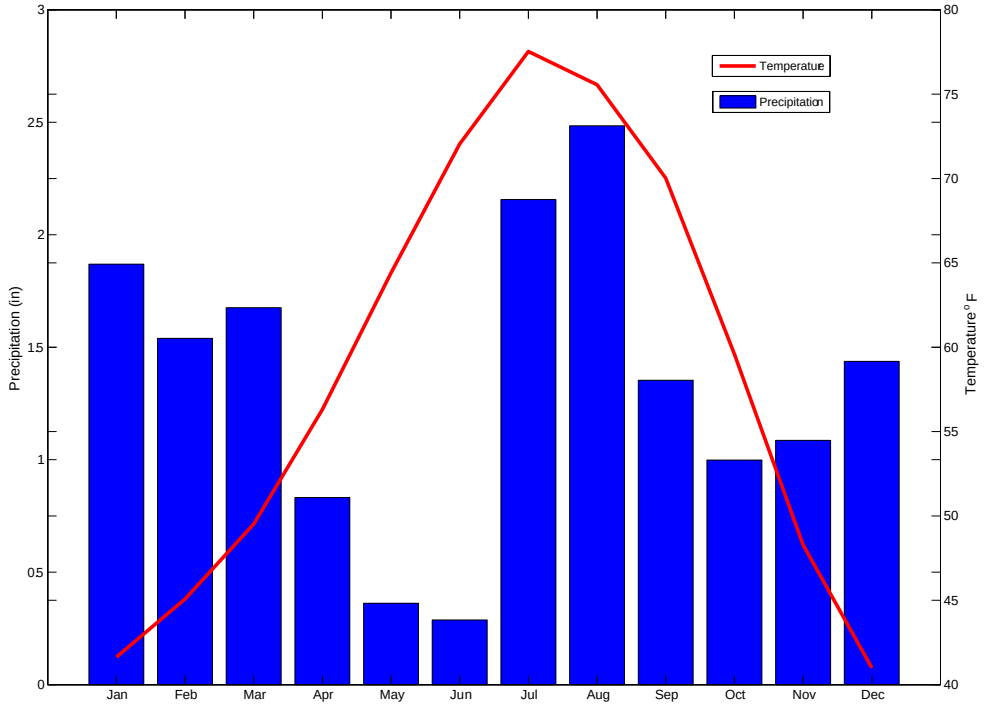
Horizontal lines are average temperature and precipitation, respectively. Light lines are yearly values and highlighted lines are 5-year moving average values, Data are from U.S. Historical Climatology Network. Figure author: CLIMAS

[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

Precipitation in the Central Highlands Planning Area has a bi-modal pattern (both winter and summer precipitation peaks) characteristic of Arizona (Figure 5.0-8); however, the planning area receives a greater fraction of its precipitation during the winter months than, for example, southeastern Arizona. During winter, precipitation comes during the passage of frontal storm systems moving west-to-east guided by the jet stream, typically located north of Arizona, but occasionally traversing the state. As moist air masses encounter the Mogollon Rim they are lifted and cooled, which condenses water vapor and enhances precipitation. Winter precipitation stored as snow is important for planning area water resources. Cooler temperatures and less intense sunlight during winter combine to reduce evaporation, and, in most years, allow snow cover to persist until spring, when gradually melting snow replenishes surface water supplies.

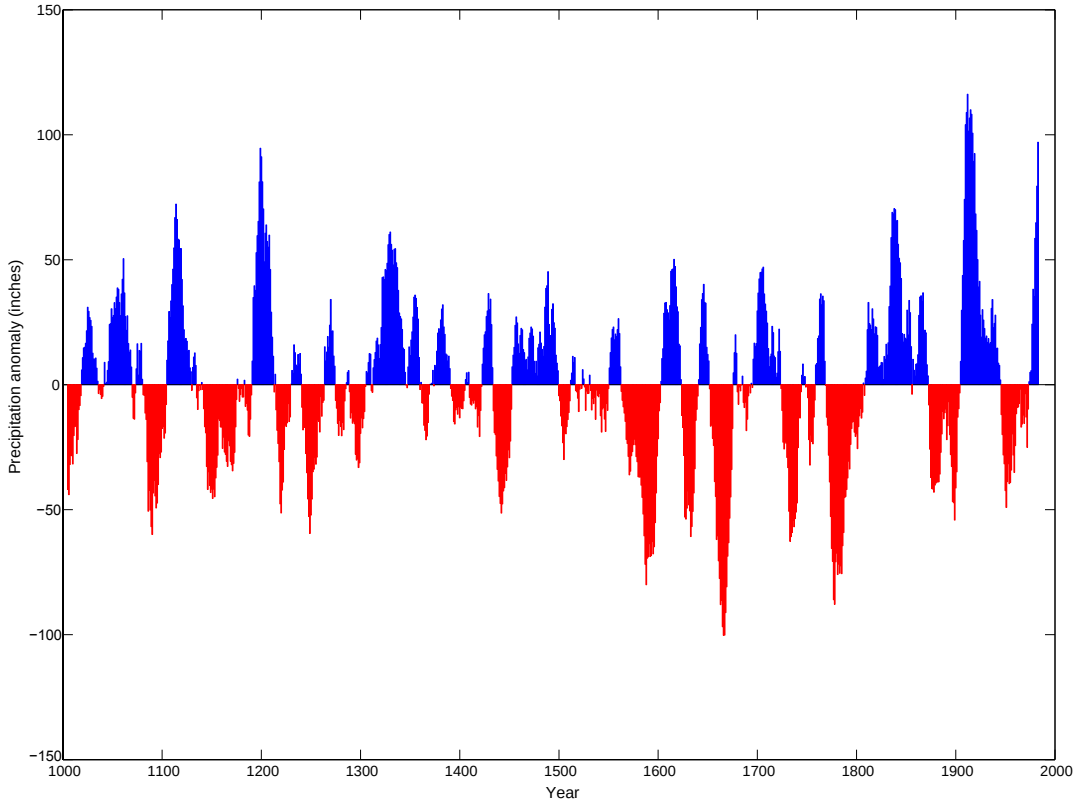
During the summer monsoon season, atmospheric circulation shifts and brings moisture from the south and east to the planning area. Storms during this season are driven primarily by convection (heat-driven upward motion), aided by topography, which can force air parcels upward to heights where water vapor condenses. Summer convective thunderstorms tend to occur in spatially scattered cells. Many storms originate over the high elevations in the Central Highlands Planning Area and move downward and outward over the deserts. The planning area receives over 37% of its annual precipitation during July-September, which helps replenish streamflow and recharge groundwater aquifers, especially in the shallow fractured aquifers

Figure 5.0-8 Average Monthly Precipitation and Temperature in the Central Highlands Planning Area 1930-2002



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

Figure 5.0-9 Arizona NOAA Climate Divisions 3 & 4 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. Data: Fenbiao Ni, The University of Arizona Laboratory of Tree-Ring Research and CLIMAS. Figure author:CLIMAS

near Payson. However, summer precipitation is generally less hydrologically effective than winter precipitation because of greater evaporation rates and the spatial discontinuity of the storms.

Figure 5.0-9 shows long-term changes in area-weighted average winter (November-April) precipitation for NOAA Arizona Climate Divisions 3 and 4 based on three-ring reconstructions. The record indicates recurrent drought in each century, with notable winter dry periods in the mid-1100s, late 1500s, late 1600s, and late 1700s. Notable winter wet periods include the early 1200s, the mid-1800s, and early 1900s. Precipitation variability on time scales of 10-30 years is likely related to shifts in Pacific Ocean circulation patterns, though recent research also points to the influence of the North Atlantic Ocean. Shorter-term variations can be attributed to ocean-atmosphere variations related to the El Niño-Southern Oscillation. During El Niño episodes, there are greater chances for above-average winter precipitation, as storm tracks across North America are shifted farther south than normal. La Niña conditions are reliably associated with below-average winter precipitation.

5.0.4 Environmental Conditions

Environmental conditions reflect the effects of geography, climate and cultural activities and may be a critical consideration in water resource management and supply development. Discussed in this section is vegetation, riparian protection through the Arizona Water Protection Fund Program, instream flow claims, threatened and endangered species, public lands protected

from development as national monuments, wilderness areas and preserves and unique and other managed waters.

Vegetation[3]

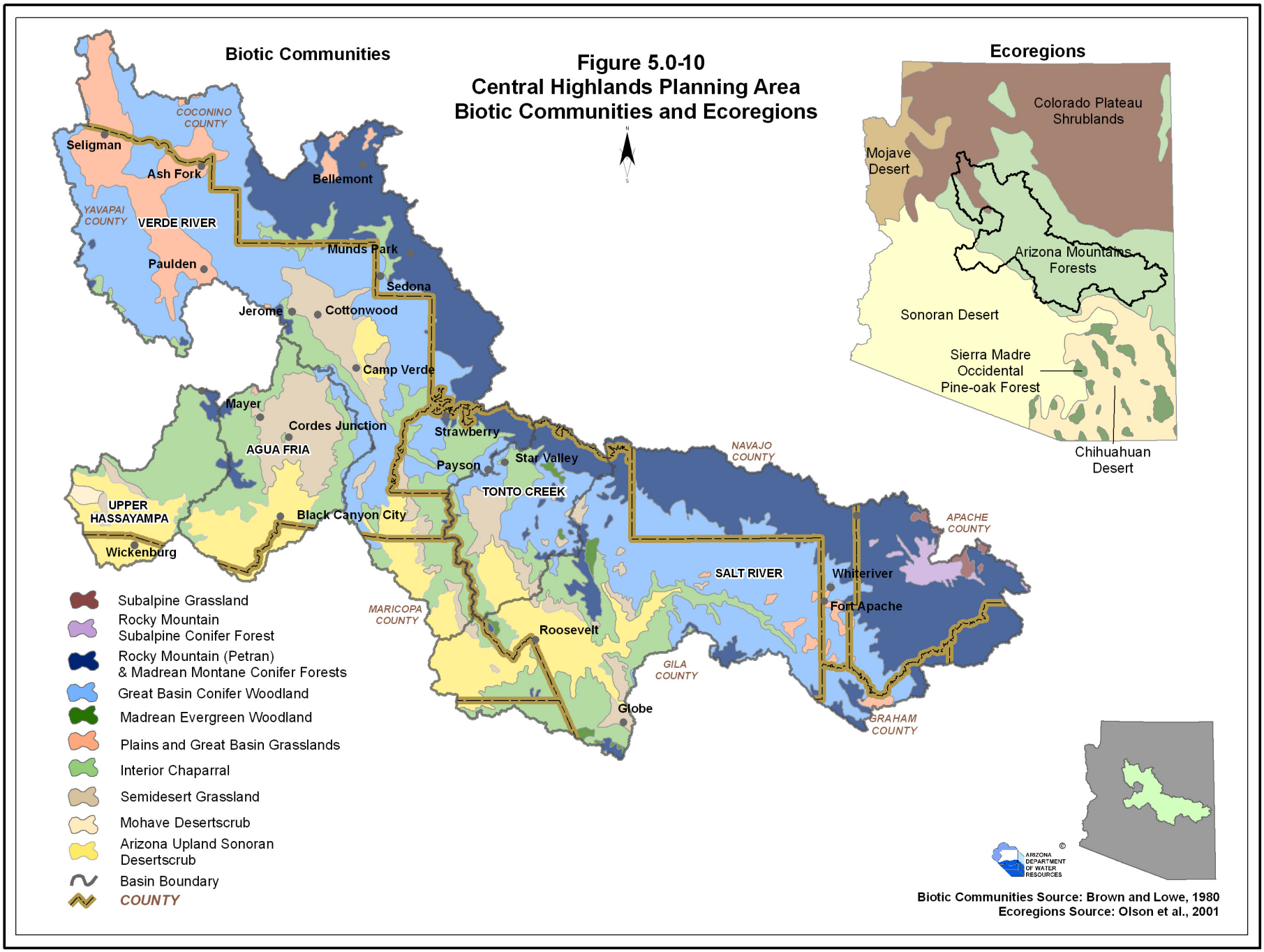
Three of Arizona's five ecoregions are included in the planning area: the Arizona mountains forests, which cover most of the area, the Sonoran Desert in the southwest, and an extension of the Colorado Plateau shrublands in the norther Verde River Basin. Because of the wide elevation range in the planning area, there are many biotic communities, ranging from Sonoran desertscrub in the Upper Hassayampa Basin to subalpine grassland and subalpine conifer forest in the high elevations of the Salt River and Verde River basins. A very small area of alpine tundra is found above 12,000 feet on the San Francisco Peaks in the Verde River Basin (this small area is not distinguishable on Figure 5.0-10). Much of the planning area is covered by Rocky Mountain and Madrean montane conifer forests, interior chaparral and Great Basin conifer woodlands.

Areas of subalpine grassland and subalpine forests are found at high elevations in the White Mountains and on the San Francisco Peaks. The subalpine conifer forests are limited to relatively small isolated mountaintop stands at elevations of 8,500 to almost 12,000 feet with annual precipitation from 30 to 40 inches a year. These forests consist of dense stands of fir, spruce and aspen trees. Bristlecone pine stands occur at elevations around 11,000 feet on the San Francisco Peaks (Brown, 1982). Significant stands of aspen occur in places, especially in areas that have been burned. Natural fires are relatively uncommon in subalpine conifer forests (Grahame and Sisk, 2002). Recent surveys of aspen sites show that low-elevation dry sites on the Coconino National Forest (<7,500 feet) experienced 95% mortality since 2000. Sites surveyed on the Apache-Sitgreaves National Forest above 7,500 feet showed 40% mortality in both mid-and high-elevation sites. Researchers found that while insects and disease were associated with the mortality, they appeared to be secondary agents on already drought-stressed trees (USDA, 2008)

Rocky Mountain (Petran) and Madrean montane conifer forests commonly occur between about 7,200 to 8,700 feet. Above 8,000 feet in areas that receive from 25 to 30 inches of annual rainfall, the forest contains a mix of conifers that may include Douglas-fir, white fir, limber pine, blue spruce and white pine, with ponderosa pine on warmer slopes. Aspen and Gambel oak are prominent in these forests following disturbances. Below 8,000 feet in areas that receive about 18 to 26 inches of annual precipitation, the mix of species gives way to almost pure stands of ponderosa pine. The forest stretching from near Flagstaff along the Mogollon Rim to the White Mountains region is the largest ponderosa pine forest on the continent (Grahame and Sisk, 2002). 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 extend

Rocky Mountain (Petran) and Madrean montane conifer forest, Clover Springs Area, Verde River Basin.

[3] Except as noted, information in this section is from Brown and Lowe, 1980 and from AZGF, 2004.


Biotic Communities
Figure 5.0-10
Central Highlands Planning Area
Biotic Communities and Ecoregions
Ecoregions
COCONINO COUNTY
Seligman
Ash Fork
Bellemont
YAVAPAI COUNTY
VERDE RIVER
Munds Park
Paulden
Sedona
Jerome
Cottonwood
Camp Verde
Mayer
Cordes Junction
AGUA FRIA
Strawberry
Payson
Star Valley
TONTO CREEK
NAVAJO COUNTY
UPPER HASSAYAMPA
Black Canyon City
Wickenburg
APACHE COUNTY
SALT RIVER
Whiteriver
Fort Apache
MARICOPA COUNTY
Roosevelt
GILA COUNTY
Globe
GRAHAM COUNTY
Subalpine Grassland
Rocky Mountain Subalpine Conifer Forest
Rocky Mountain (Petran) & Madrean Montane Conifer Forests
Great Basin Conifer Woodland
Madrean Evergreen Woodland
Plains and Great Basin Grasslands
Interior Chaparral
Semidesert Grassland
Mohave Desertscrub
Arizona Upland Sonoran Desertscrub
Basin Boundary
COUNTY
Colorado Plateau Shrublands
Mojave Desert
Arizona Mountains Forests
Sonoran Desert
Sierra Madre Occidental Pine-oak Forest
Chihuahuan Desert
ARIZONA DEPARTMENT OF WATER RESOURCES
Biotic Communities Source: Brown and Lowe, 1980
Ecoregions Source: Olson et al., 2001

across the entire northern boundary and are also found at higher elevations in other locations in the planning area (Figure 5.0-10).

The high elevation subalpine and montane conifer forests receive much of their annual precipitation as snow. Because of forest density, sunlight reaches the ground and snow melts slowly, releasing snowmelt gradually to streams. Snowfall accumulations in this area of the state are critical to the Phoenix metropolitan area water supply.

Great Basin conifer (piñon-juniper) woodlands cover areas below the ponderosa pine forest at elevations between about 5,000 and 7,500 feet that receive about 10 to 20 inches of annual precipitation. Extensive stands exist throughout the planning area as shown on Figure 5.0-10. Bark beetle infestations have affected large areas of piñon pine in the White Mountains in recent years although activity decreased in most areas in 2007 (USDA, 2008).

Madrean evergreen woodland occurs in small areas in the eastern part of the Tonto Creek and western part of the Salt River basins at elevations of about 5,000 to 6,000 feet. This mild winter-wet summer woodland consists of evergreen oak, juniper and piñon pine. This community is more commonly found in southeastern Arizona and the Sierra Madre of Mexico. In this northern reach it occurs above or within interior chaparral and below and along drainages within the Great Basin conifer woodland (Brown, 1982).

Plains and Great Basin grasslands, primarily composed of mixed or short-grass communities, occur in several parts of the planning area at elevations between 5,000 and 7,000 feet that receive between 11 and 18 inches of annual precipitation. These areas are located primarily in Chino Valley and in small areas on the Fort Apache Indian Reservation south of Fort Apache. The piñon-juniper woodland is often intermixed with this grassland.

Interior chaparral is found at lower elevations (4,000-6,000 feet) in areas that receive 13 to 23 inches of annual precipitation. 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.

Semi-desert grasslands occur in valleys between the desert and woodlands or chaparral at elevations between 3,500 and 5,000 feet that receive annual precipitation of 10 to 15 inches. Semi-desert grasslands are found in the Upper Hassayampa and Agua Fria basins and south of Payson in the Tonto Creek Basin. Desert grasslands often contain a mixture of grasses, shrubs and small trees.

A small extension of Mohave desertscrub is found in the western part of the Upper Hassayampa Basin. While many of the same plants found in the other Arizona 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 is typically found at elevations

Interior chaparral, Salt River Basin.

below about 3,500 feet that receive 5 to 11 inches of annual rainfall.

Arizona Upland Sonoran desertscrub covers parts of the planning area below about 3,500 feet in the Upper Hassayampa, Agua Fria, Tonto Creek and Salt River basins. The community 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 with average annual precipitation between 8 to 16 inches. 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, cholla and barrel cacti. (Brown, 1982)

Extensive reaches of riparian vegetation occur throughout the planning area. Areas that have been mapped along perennial streams are shown in Figure 5.0-12. Along the Verde River and several of its tributaries, riparian vegetation is composed of mixed broadleaf, cottonwood-willow, mesquite and strand vegetation (riparian obligate plants adapted to periodic flooding, scouring, or soil deposition). Conifer-Oak riparian obligate habitat is found at higher elevations along West Clear Creek and the East Verde River. Mixed broadleaf, mesquite and strand vegetation is found along three perennial reaches of the Agua Fria River. Two tributaries to the Agua Fria River, Little Ash Creek and Sycamore Creek also contain significant mixed broadleaf vegetation (NEMO, 2006). In the higher elevation headwaters area of the Black River, riparian habitat is composed of wet meadow, mountain scrub and conifer-oak vegetation. At lower elevations mixed broadleaf and strand vegetation are found along the Black River. Along the Salt River, riparian vegetation is composed of mesquite, strand and tamarisk. In the Tonto Creek Basin, mixed broadleaf, cottonwood-willow, strand and mesquite vegetation are found along Tonto Creek. Along the Hassayampa River at Wickenburg, riparian vegetation consists of cottonwood-willow, mesquite and strand while conifer-oak and mixed broadleaf are found at the Hassayampa River headwaters.

In their study of the change in riparian vegetation in the southwest, Webb and others (2007) remarked that "The Verde River….has the largest number of species of woody riparian vegetation that we observed…" They found that riparian vegetation had generally increased along the entire length of the Verde River and its tributaries, following a series of large floods between 1891 and 1940. They noted that riparian vegetation along the Salt River had increased somewhat upstream from Roosevelt Dam despite a number of severe floods between 1978 and 1995. Riparian vegetation also increased along the Agua Fria River upstream from New Waddell Dam. Riparian vegetation along the Hassayampa River was also found to have increased at several sites although the impact of drought, resulting in mortality of young trees, was noted near the downstream end of the Hassayampa River Preserve south of Wickenburg.

Several years of drought combined with high tree densities resulted in the largest outbreak of pine bark beetle populations ever recorded in Arizona during 2002 – 2004. This outbreak

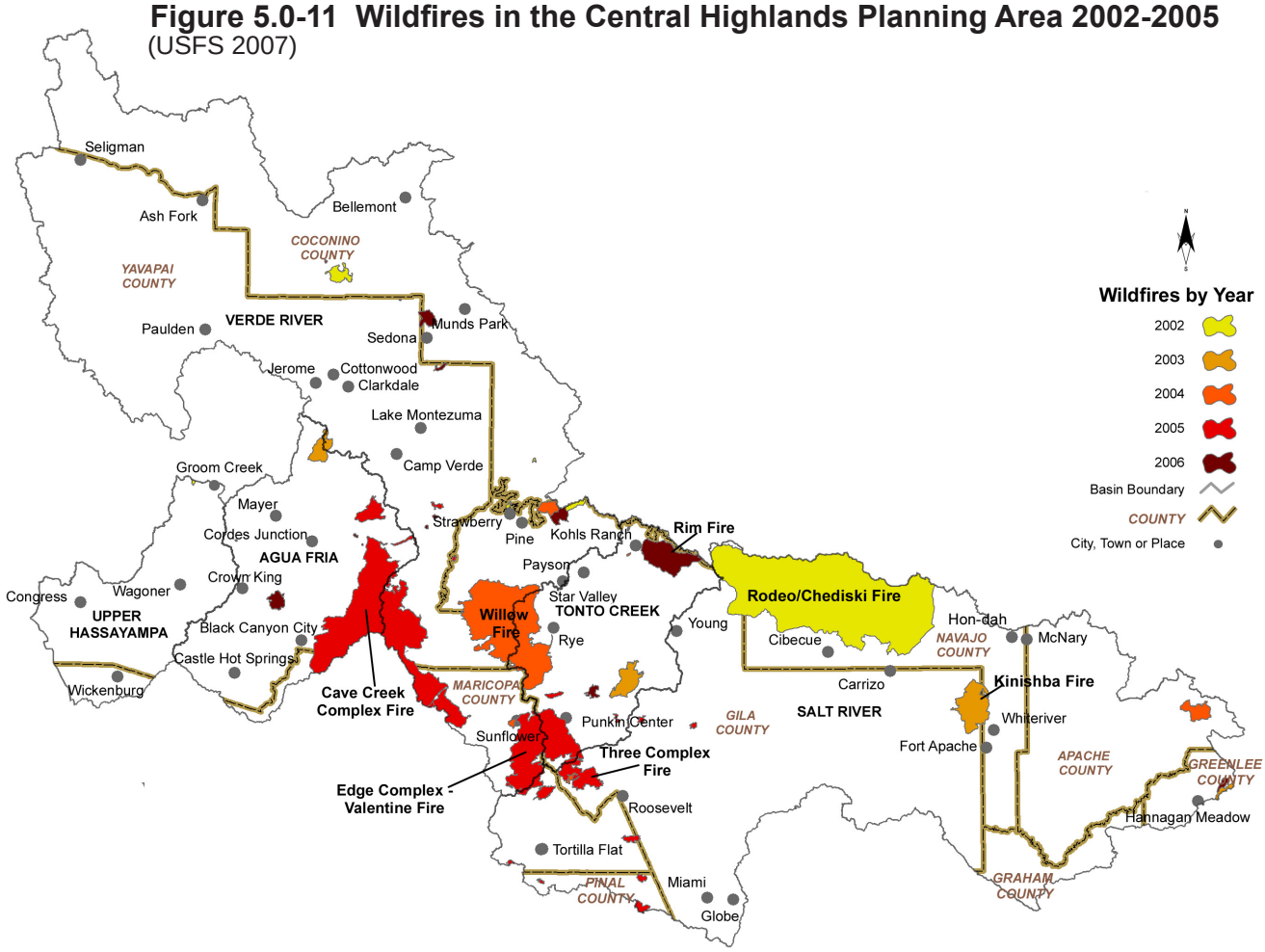
Riparian vegetation along the Agua Fria River.

killed millions of piñon and ponderosa pine trees. In 2003 bark beetle mortality was detected on about 763,000 acres in Arizona and New Mexico, with most of the mortality occurring in Arizona (USFS, 2003). Areas most affected were trees at the lower end of their elevational range. Drought conditions improved in 2004 and 2005, and mortality decreased substantially as a result of both higher precipitation and because many of the trees in the most susceptible areas were already dead.

Based on aerial surveys conducted in 2004 by the U.S. Forest Service, there were several areas of ponderosa pine infestation in the planning area. Areas with substantial bark beetle-caused ponderosa pine mortality occurred on parts of the Fort Apache Indian reservation, on lands west and north of the reservation, areas southwest of Bellemont, and areas west of Interstate 17 in the vicinity of Crown King. Data from aerial surveys recorded 2.1 million acres of piñon-juniper woodland and 1.3 million acres of ponderosa pine were affected in Arizona and New Mexico during 2002 – 2004 (USDA, 2007).

Wildfire risk increases with the number of dead trees in the landscape, which provide fuel for fires. There were several major wildfires in the Central Highlands Planning Area during the severe drought years between 2002 and 2005 (see Figure 5.0-11). The Rodeo-Chediski fire in 2002, Arizona's largest ever, consumed about 462,600 acres, much of it in the north-central part of the Salt River Basin. The Willow Fire (2004) burned almost 120,000 acres southwest of Payson in the Tonto Creek and Verde River basins and the Cave Creek Complex Fire (2005)

Figure 5.0-11 Wildfires in the Central Highlands Planning Area 2002-2005
(USFS 2007)



burned 243,800 acres in the east-central part of the Agua Fria Basin and adjacent areas in the Verde River Basin and Phoenix AMA.

In the Southwest, fire can be among the most significant watershed disturbance agents, particularly to peak stream flows. In areas severely burned by the Rodeo-Chedeski Fire, peak flows were as much as 2,350 times greater than previously measured, the highest known post-fire peak flow in the Southwest. Increased peak flows can degrade stream channels and make them unstable, increase sediment production and cause flood damage. (Neary and others, 2003) Drought, wildfire and long-term climate change involving warmer temperatures with earlier springs and less snow cover could result in vegetative changes in the planning area with implications for runoff, infiltration and water supplies.

Arizona Water Protection Fund Programs

The objective of the Arizona Water Protection Fund (AWPF) program is to provide funds for protection and restoration of Arizona's rivers and streams and associated riparian habitats. Twenty-eight riparian restoration projects in the Central Highlands Planning Area have been funded by the AWPF through 2008. Nineteen of these projects were funded in the Verde River Basin, primarily involving research, fencing and stream restoration on the Verde River. Four projects were funded in the Salt River Basin including restoration projects on Cherry Creek, Canyon Creek and at Lofer Cienega. Two stream restoration projects in the Agua Fria Basin on Ash Creek and Lynx Creek, and an erosion research and fencing and revegetation project in Dakini Valley in the Tonto Creek Basin have also been funded. In the Upper Hassayampa Basin, one project has been funded involving a constructed wetland. A list of projects and project types funded in the Central Highlands Planning Area through 2008 is found 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 Volume 1.

Instream Flow Claims

An instream flow water right is a non-diversionary appropriation of surface water for recreation and wildlife use. An application to appropriate public water for instream flow purposes moves through a number of administrative steps culminating in the Department's approval or rejection of the application. Streamflow measurement data, a study that substantiates the streamflow volume requested and quantifies the relationship between the claimed beneficial use(s) and the requested streamflow rates are required before the Department will issue a permit to appropriate. Following approval of a permit, the permit holder has four years to demonstrate that the instream flow right is being used in a manner consistent with the terms of the issued permit. After the permit holder submits proof of the appropriation, the Department issues the permit holder a Certificate of Water Right (CWR) with a priority date that relates back to the date of the application. A CWR evidences a perfected surface water right that is superior to all other surface water rights with a later priority date, but junior to all right with an earlier (older) priority date. All permits and certificates are for specific uses at specific places and are endorsed with the priority date and extent and purpose(s) of the right(s). The right must be beneficially used or it may be subject to abandonment and forfeiture.

Thirty-nine applications for instream flow claims have been filed in the Central Highlands Planning Area. The applications are listed in Table 5.0-1 and shown on Figure 5.0-12. Claims have been filed in all the basins in the planning area and 11 certificates have been issued. Certificates have been issued for claims on: Ash Creek in the Agua Fria Basin; Christo-

Table 5.0-1 Instream Flow Claims in the Central Highlands Planning Area

Map Key	Stream	Applicant	Application No.	Permit No.	Certificate No.	Filing Date
1	Apache Creek	Prescott National Forest	33-96801.0	Pending	Pending	7/22/2005
2	Ash Creek	BLM (Phoenix)	33-96411.0	96411	96411	1/5/1995
3	Big Bug Creek	Prescott National Forest	33-96802.0	Pending	Pending	7/22/2005
4	Canyon Creek	Tonto National Forest	33-96816.0	Pending	Pending	9/30/2005
5	Cherry Creek	Tonto National Forest	33-96609.0	Pending	Pending	6/30/1999
6	Christopher Creek	Tonto National Forest	33-96575.0	96575	96575	4/23/1998
7	Cienega Creek	Prescott National Forest	33-96803.0	Pending	Pending	7/22/2005
8	Coon Creek	Tonto National Forest	33-96742.0	Pending	Pending	6/18/2003
9	East Verde River	Tonto National Forest	33-90310.0	90310	90310	11/26/1985
10	Fossil Creek	Tonto National Forest	33-96622.0	Pending	Pending	12/1/1999
11	Foster Creek	Coconino National Forest	33-95370.0	Pending	Pending	2/2/1990
12	Haigler Creek	Tonto National Forest	33-96571.0	Pending	Pending	10/31/1997
13	Hassayampa River	Nature Conservancy	33-92304.0	92304	92304	1/20/1987
14	Jones Creek	Coconino National Forest	33-95371.0	Pending	Pending	2/2/1990
15	Oak Creek	Coconino National Forest	33-90106.0	Pending	Pending	7/29/1985
16	Pinto Creek	Tonto National Forest	33-89109.0	89109	89109	12/14/1983
17	Rarick Canyon	Coconino National Forest	33-90109.0	Pending	Pending	7/29/1985
18	Red Creek	Tonto National Forest	33-96743.0	Pending	Pending	6/18/2003
19	Reynolds Creek	Tonto National Forest	33-96570.0	96570	96570	10/31/1997
20	Sheepshead Creek	Coconino National Forest	33-90111.0	Pending	Pending	7/29/1985
21	Spring Creek	Coconino National Forest	33-90114.0	90114	90114	7/29/1985
22	Spring Creek	Tonto National Forest	33-96815.0	Pending	Pending	9/28/2005
23	Sycamore Creek	Coconino National Forest	33-90113.0	Pending	Pending	7/29/1985
24	Sycamore Creek	Tonto National Forest	33-96509.0	96509	96509	5/15/1996
25	Sycamore Creek	Prescott National Forest	33-96804.0	Pending	Pending	7/22/2005
26	Tangle Creek	Tonto National Forest	33-96743.0	Pending	Pending	1/31/2007
27	Tonto Creek	Tonto National Forest	33-96684.0	Pending	Pending	11/15/2000
28	Turkey Creek	Prescott National Forest	33-96708.0	Pending	Pending	1/29/2002
29	Verde River	Tonto National Forest	33-90309.0	90309	90309	11/26/1985
30	Verde River	Prescott National Forest	33-94374.0	Pending	Pending	12/2/1988
31	Verde River	Phelps Dodge Corp.	33-96760.0	Pending	Pending	6/3/2004
32	Verde River	Nature Conservancy	33-96876	Pending	Pending	7/18/2008
33	Verde River	Arizona Game & Fish	33-96877	Pending	Pending	8/6/2008
34	Walker Creek	Coconino National Forest	33-90108.0	Pending	Pending	7/29/1985
35	Walnut Creek	Prescott National Forest	33-96800.0	Pending	Pending	7/22/2005
36	West Clear Creek	Coconino National Forest	33-90110.0	90110	90110	7/29/1985
37	West Clear Creek	Johnson, James A.	33-96178.0	Pending	Pending	3/20/1992
38	Wet Beaver Creek	Coconino National Forest	33-90112.0	90112	90112	7/29/1985
39	Workman Creek	Tonto National Forest	33-96618.0	Pending	Pending	10/26/1999

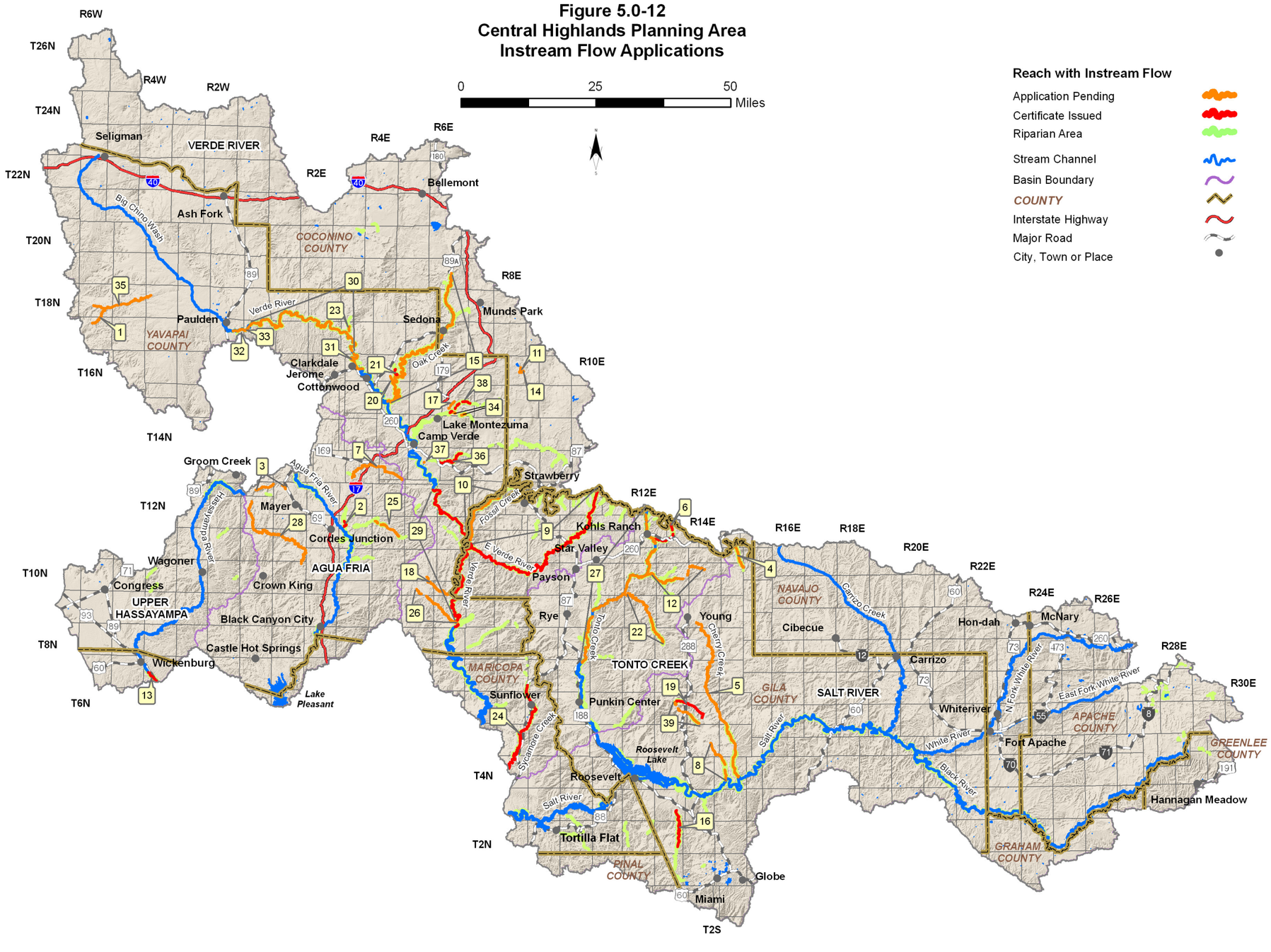


Figure 5.0-12
Central Highlands Planning Area
Instream Flow Applications
0
25
50
Miles
Reach with Instream Flow
Application Pending
Certificate Issued
Riparian Area
Stream Channel
Basin Boundary
COUNTY
Interstate Highway
Major Road
City, Town or Place
R6W
T26N
R4W
R2W
T24N
Seligman
VERDE RIVER
R4E
R6E
T22N
R2E
Bellemont
Ash Fork
Big Chino Wash
COCONINO COUNTY
T20N
R8E
T18N
Paulden
Verde River
Sedona
Munds Park
YAVAPAI COUNTY
Oak Creek
R10E
T16N
Clarkdale
Jerome
Cottonwood
Lake Montezuma
Camp Verde
T14N
Groom Creek
Agua Fria River
Strawberry
T12N
Mayer
Fossil Creek
R12E
R14E
Kohls Ranch
Cordes Junction
Star Valley
R16E
R18E
R20E
R22E
Wagoner
Hassayampa River
E Verde River
Payson
T10N
Congress
AGUA FRIA
Crown King
NAVAJO COUNTY
Carrizo Creek
UPPER HASSAYAMPA
Black Canyon City
Rye
Tonto Creek
Young
Cherry Creek
Cibecue
Hon-dah
R24E
R26E
McNary
T8N
Castle Hot Springs
TONTO CREEK
Carrizo
R28E
Wickenburg
MARICOPA COUNTY
Sunflower
Punkin Center
GILA COUNTY
SALT RIVER
Whiteriver
N Fork White River
East Fork White River
R30E
T6N
Lake Pleasant
Sycamore Creek
Salt River
APACHE COUNTY
Fort Apache
White River
GREENLEE COUNTY
Roosevelt Lake
T4N
Roosevelt
Black River
Hannagan Meadow
Tortilla Flat
T2N
GRAHAM COUNTY
PINAL COUNTY
Globe
Miami
T2S
ARIZONA DEPARTMENT OF WATER RESOURCES
©
Riparian Data Source: AGFD, 1993

pher Creek in the Tonto Creek Basin; the East Verde River, Spring Creek, Sycamore Creek (near Sunflower), the Verde River, West Clear Creek and Wet Beaver Creek in the Verde River Basin; the Hassayampa River in the Upper Hassayampa River Basin; and Pinto Creek and Reynolds Creek in the Salt River Basin. Some of the certificates cover extensive reaches of the streams as shown on Figure 5.0-12.

Threatened and Endangered Species

A number of listed threatened and endangered species may be present in the Central Highlands Planning Area. Those listed by the U.S. Fish and Wildlife Service (USFWS) as of 2008 are shown in Table 5.0-2. 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.

In the Salt River watershed, SRP has developed the Roosevelt Habitat Conservation Plan (Plan) to minimize and mitigate the impacts of operation of Roosevelt Dam and Lake to the southwestern willow flycatcher, bald eagle, Yuma clapper rail and western yellow-billed cuckoo (a candidate for ESA protection). Under the plan, SRP will acquire and protect at least 1,500 acres of riparian habitat in perpetuity along the San Pedro, Verde, and Gila rivers, or other river systems in Arizona, and implement other conservation measures to protect up to

Table 5.0-2 Threatened and endangered species in the Central Highlands Planning Area

Common Name	Threatened	Endangered	Elevation/Habitat
Apache (Arizona) Trout	X		>5000 ft./cold mountain streams
Arizona Agave		X	3,000 ft./steep, rocky granite slopes, or level hilltops, near chaparral; New River and Sierra Ancha Mountains
Arizona Cliff-rose		X	<4,000 ft./white soils of tertiary limestone lakebed deposits
Arizona hedgehog cactus		X	3,700-5,200 ft./ecotone between interior chapparal and madrean evergreen woodland
Bald Eagle	X		Varies/large trees or cliffs near water
California Brown Pelican		X	Varies/lakes and rivers
Chiricahua Leopard Frog	X		3,300-8,900ft./streams, rivers, backwaters, ponds and stock tanks
Desert pupfish		X	<5,000 ft./shallow springs, small streams and marshes. Tolerates saline and warm water
Gila Chub		X	2,000-5,500 ft./pools, springs, cienegas and streams
Gila topminnow		X	<4,500 ft./small streams, springs and cienegas and vegetated shallows

[4] 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."

Table 5.0-2 Threatened and endangered species in the Central Highlands Planning Area (Cont)

Common Name	Threatened	Endangered	Elevation/Habitat
Gila trout	X		5,000-10,000 ft./small, high mountain streams
Lesser long-nosed bat		X	<6,000 ft./desert scrub with agave and columnar cacti
Loach Minnow	X		<8,000ft./benthic species of small to large perennial streams
Mexican Gray Wolf		X	4,000-12,000 ft. /chapparal, woodland and forests
Mexican Spotted Owl	X		4,100-9,000 ft./canyons and dense forests with multi-layered foliage structure
Razorback sucker		X	<6,000 ft./riverine and lacustrine areas; not in fast moving water
San Francisco Peaks groundsel	X		>10,900 ft./Alpine tundra
Southwestern Willow Flycatcher		X	<8,500 ft./cottonwood-willow and tamarisk along rivers and streams
Spikedace	X		<6,000 ft./moderate to large perennial streams with gravel cobble substrates
Yuma Clapper Rail		X	<4,500 ft./Fresh water and brackish marshes

Source: USFWS 2008, AZGF 2008

750 additional acres of habitat. The Plan also includes rescue of bald eagle eggs and nestlings whose nests are threatened by inundation, monitoring of the species and habitat at Roosevelt Lake and in the mitigation areas, and other measures. Following SRPs commitment to implementation of the Plan, the U.S. Fish and Wildlife Service issued a 50-year permit to SRP to "take" endangered southwestern willow flycatchers, threatened bald eagles, endangered Yuma clapper rails and yellow-billed cuckoos incidental to operation of Roosevelt Dam and Lake.[5] (USFWS, 2003)

A habitat conservation plan (HCP) has also been adopted for Horseshoe and Bartlett reservoirs on the Verde River. Drought conditions resulted in establishment of riparian species in the Horseshoe storage space that became colonized by a population of southwestern willow flycatchers and other covered species that may be adversely impacted by refilling the reservoir. The HCP will minimize and mitigate for take of the covered species by operating Horseshoe to maintain the riparian forest, acquiring 200 acres of replacement habitat and other actions (73 Federal Register 62525 et seq.).

National Monuments, Wilderness Areas and Preserves

Four national monuments that protect prehistoric dwellings are located in the planning area (see figure 5.0-13). Montezuma Castle, Tonto and Tuzigoot National Monuments are small sites containing cliff dwellings or pueblos. Ton-

[5] 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])

to National Monument is located along Tonto Creek in the Salt River Basin while the others are located in the Verde Valley in the Verde River Basin. Agua Fria National Monument, administered by the Bureau of Land Management, covers 71,700 acres in the Agua Fria Basin (see Figure 5.1-2). It contains at least 450 prehistoric sites, four major settlement areas and the Agua Fria River canyon, which contains a perennial reach of the river.

All or portions of 21 wilderness areas, encompassing 788,000 acres, are also found within the planning area. Wilderness 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 of the area are listed in Table 5.0-3 and shown on Figure 5.0-13. All wilderness areas are located on National Forest Service lands with the exception of the Hassayampa River Canyon Wilderness which is administered by the Bureau of Land Management. Most of the wilderness areas protect riparian habitat, rivers and streams and are located in the Verde River Basin.

The Hassayampa River Preserve, located south of Wickenburg, was established in 1986 by The Nature Conservancy. The preserve protects spring-fed Palm Lake, a four-acre pond and marsh habitat that attracts water birds and provides habitat for endangered fish. The Hassayampa River is perennial within the preserve and supports lush streamside habitat.

Figure 5.0-13 Wilderness Areas in the Central Highlands Planning Area
(Wilderness Data Source: National Atlas of the United States 2005, Land Ownership Data Source: ALRIS 2006)

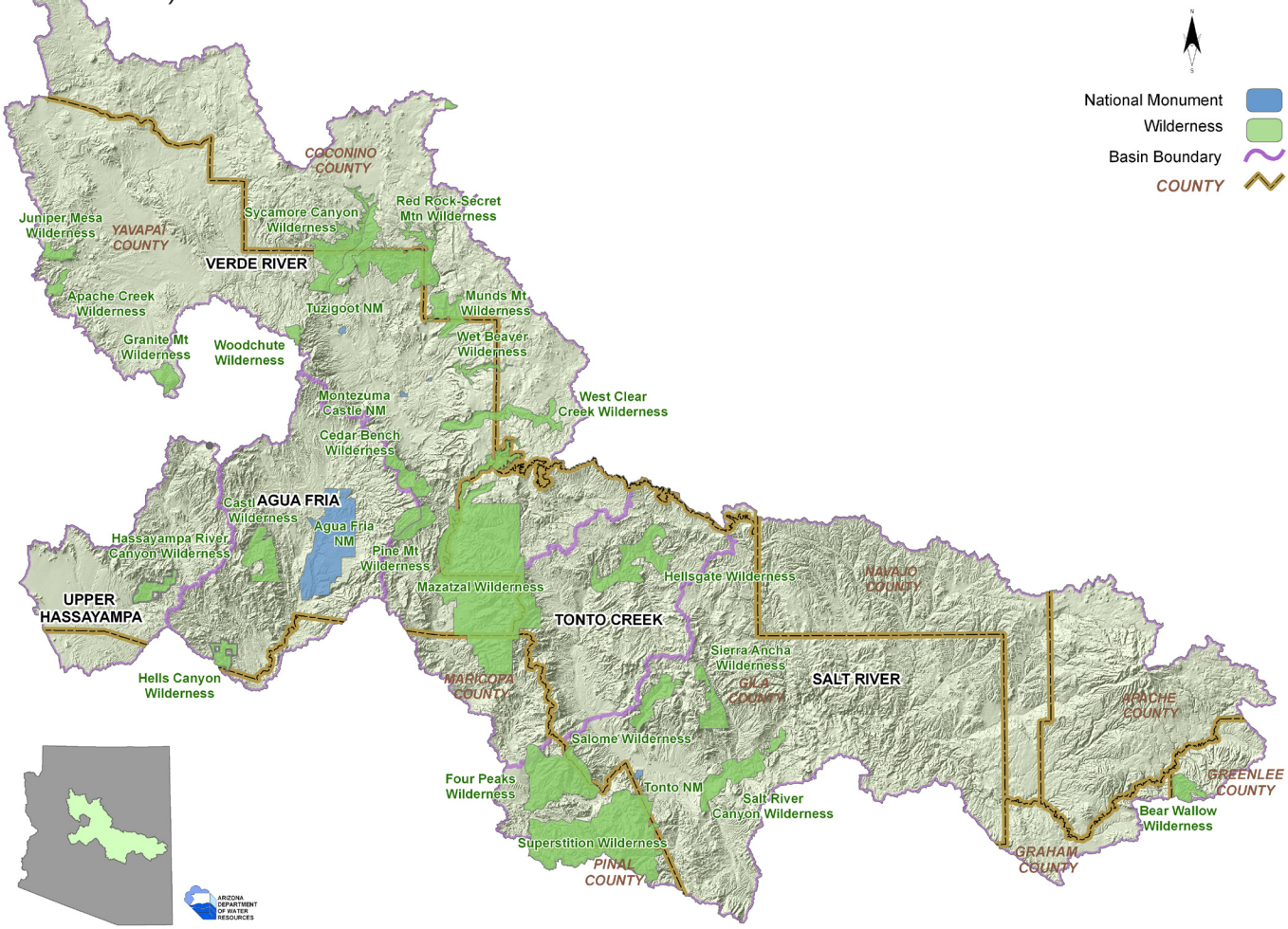


Table 5.0-3 Wilderness areas in the Central Highlands Planning Area

Wilderness Area	Acres	Basin	Description
Apache Creek	5,488	Verde River	Three springs and important riparian area including Apache Creek
Bear Wallow	11,336	Salt River (part)	Alpine forest of mixed conifers and aspens. Bear Wallow drainage with rich streamside habitat.
Castle Creek	25,536	Agua Fria	Bradshaw Mountains, prominent granite peaks, vegetation range from saguaro to pine
Cedar Bench	16,127	Verde River	Located along Verde Rim, borders portion of Verde Wild and Scenic River
Fossil Creek	10,400	Verde River	Extremely diverse riparian area, 1,600 foot deep canyon, travertine deposits, springs
Granite Mountain	9,747	Verde River	Mountain characterized by granite boulders, some the size of a house, stacked one atop the other to elevations that exceed 7,600 feet.
Hassayampa River Canyon	11,840	Upper Hassayampa	Includes several miles of the Hassayampa River and riparian habitat.
Hellsgate	37,399	Tonto Creek	Major canyon, Tonto Creek with deep pools of water and impassable falls
Juniper Mesa	7,708	Verde River	Flat topped mesa, great variety of wildlife
Mazatzal	250,053	Verde River, Tonto Creek	Mazatzal Mountains, chaparral and pine vegetation with narrow, vertical walled canyons. Includes portion of Verde Wild and Scenic River
Munds Mountain	18,069	Verde River	Munds and Lee mountains, Jacks, Woods and Rattlesnake canyons, Courthouse Butte and Bell Rock
Pine Mountain	20,100	Agua Fria, Verde River	Island of tall timber, surrounded by brush-covered desert mountains with hot, dry mesas and deep canyons.
Red Rock Secret Mountain	48,263	Verde River	Red rock pinnacles, arches and slot canyons, rock art and prehistoric dwellings
Salome	18,515	Salt River	Upper/perennial reaches of Salome Creek and Workman Creek
Salt River Canyon	32,088	Salt River	Portions of the Salt River and spectacular canyon
Sierra Ancha	21,007	Salt River	Box canyons, high cliffs, prehistoric dwellings
Superstition	160,135	Salt River (part)	Rugged mountains, rock formations, large vegetation range, prehistoric dwellings, riparian habitat
Sycamore Canyon	57,916	Verde River	Large canyon with desert riparian area. Extends from near Williams to Verde Valley
West Clear Creek	15,267	Verde River	Deep, narrow canyon with many pools of water
Wet Beaver Creek	6,178	Verde River	Major canyon in red rock rim country
Woodchute	5,553	Agua Fria	Views, ponderosa pine, pinon and juniper
Total Acres in Planning Area	**788,000**		

Source: BLM 2006, USFS 2007

Approximately 1,000 acres of land at the headwaters of the Verde River are protected by the Arizona Game and Fish Department and The Nature Conservancy. These lands include the Verde River Springs Preserve (TNC) and the Upper Verde River Wildlife Area (AZGF). (TNC, 2008)

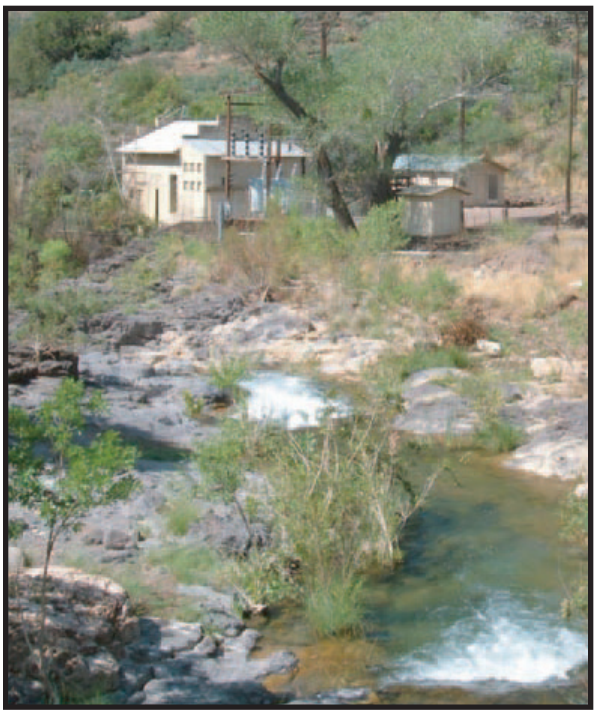
Unique and Other Managed Waters

Several "unique waters", designated by the Arizona Department of Environmental Quality (ADEQ) pursuant to A.C.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. These include:

- Oak Creek, including the West Fork of Oak Creek in the Verde River Basin
- Snake Creek, from its headwaters to its confluence with the West Fork of the Black River in the Salt River Basin
- Hay Creek, from its headwaters to its confluence with the West Fork of the Black River in the Salt River Basin
- Stinky Creek, from the Fort Apache Indian Reservation boundary to its confluence with the West Fork of the Black River in the Salt River Basin
- Bear Wallow Creek, from its headwaters to the boundary of the San Carlos Indian Reservation in the Salt River Basin.

Other managed surface water in the planning area include two streams designated as Wild and Scenic Rivers and a lake. Congress adopted the Wild and Scenic Rivers Act in October 1968 to preserve selected rivers that possess "outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values" in their free-flowing condition for the benefit of present and future generations. About 40 miles of the 170-mile long Verde River has been designated a Wild and Scenic River. The Scenic River Area begins about six miles south of Camp Verde and extends to the boundary of the Mazatzal Wilderness in T11N, R6E; a reach of 18.3 miles. South of this reach, the Wild River Area continues for another 22.2 miles to the river's confluence with Red Creek within section 34, T9½N, R6E (see Figure 5.5-4). Under the Act the river area must be managed in a manner that protects and enhances its "outstandingly remarkable values" (NWSR, 2007)

In 2004, Arizona Public Service Company surrendered a license from the Federal Energy Regulatory Commission to operate hydroelectric power plants at Irving and Childs on Fossil Creek in the Verde River Basin near Strawberry. As part of the decommissioning they agreed to remove project features and restore the landscape. These two historic power plants were constructed beginning in 1908 and operated by turbines driven by water diverted from Fossil Creek. This diversion captured most of the natural spring fed flow of the creek and fundamentally changed the character of the stream. The springs that supply the base flow



Irving Power Plant and Fossil Creek, Verde River Basin.

of Fossil Creek are rich in calcium carbonate that precipitates out and forms travertine dams. Without the natural flow and travertine deposition the stream was no longer a series of pools impounded by travertine dams. Following restoration of flow, native fish were removed and non-native fish eradicated from the stream in order to reestablish fish native to the system. In March 2009, 16.8 miles of Fossil Creek became only the second watercourse in the state to be designated as a Wild and Scenic River. This designation requires that the USFS prepare a management plan to protect the creek.

Stillman Lake is a narrow, 20-acre water body in the Verde River Basin formed above a natural sediment dam near the headwaters of the Verde River south of Paulden and below Sullivan Dam. The Arizona Game and Fish Department, U.S. Fish and Wildlife Service, and the Bureau of Reclamation are working together to manage Stillman Lake for native fish by eliminating non-native species. A draft Environmental Impact Assessment was released in March 2007 that proposed using a chemical piscicide to remove non-native fish and then restock the lake with native species (USFWS, 2007). In May 2009, a decision and finding of no significant impact for the environmental assessment was released, finding that the best alternative was that proposed in the Assessment. (USFWS, 2009)

5.0.5 Population

The 2000 Census populations for each basin and Indian reservation in the planning area, listed from highest to lowest, are shown in Table 5.0-4. The most populous basin by far is the Verde River Basin with more than 88,000 residents or 62% of the planning area total. The 2005 estimated population of the Verde River Basin was almost 102,000 residents. Historic, current and projected basin populations are shown in the basin cultural water demand tables. The Census 2000 planning area population was about 142,850 and Arizona Department of Economic Security (DES) population projections forecast another 100,000 residents by 2030 (see Table 5.0-5).

Shown in Table 5.0-5 are incorporated and unincorporated communities in the planning area with 2000 Census populations greater than 1,000 and growth rates for two time periods. Communities are listed from highest to lowest population in 2000 and their location is shown on Figure 5.0-14. The planning area population grew by 38.5% between 1990 and 2000 and by 16.6% between 2000 and 2006. A number of communities lack data for 1990 or 2006, but it appears that there has been considerable growth in smaller communities in the planning area. Of note is the large number of communities in this planning area with populations between 1,000 and 5,000. Many of these

Table 5.0-4 2000 Census population in the Central Highlands Planning Area

Basin/Reservation	2000 Census Population
Verde River	88,242
Yavapai-Apache	*743*
Salt River	31,381
Fort Apache	*10,385*
San Carlos Apache	*Unk*
Upper Hassayampa	10,479
Agua Fria	8,210
Tonto Creek	7,537
Tonto Apache	*132*

Unk = Unknown

Table 5.0-5 Communities in the Central Highlands Planning Area with a 2000 Census population greater than 1,000

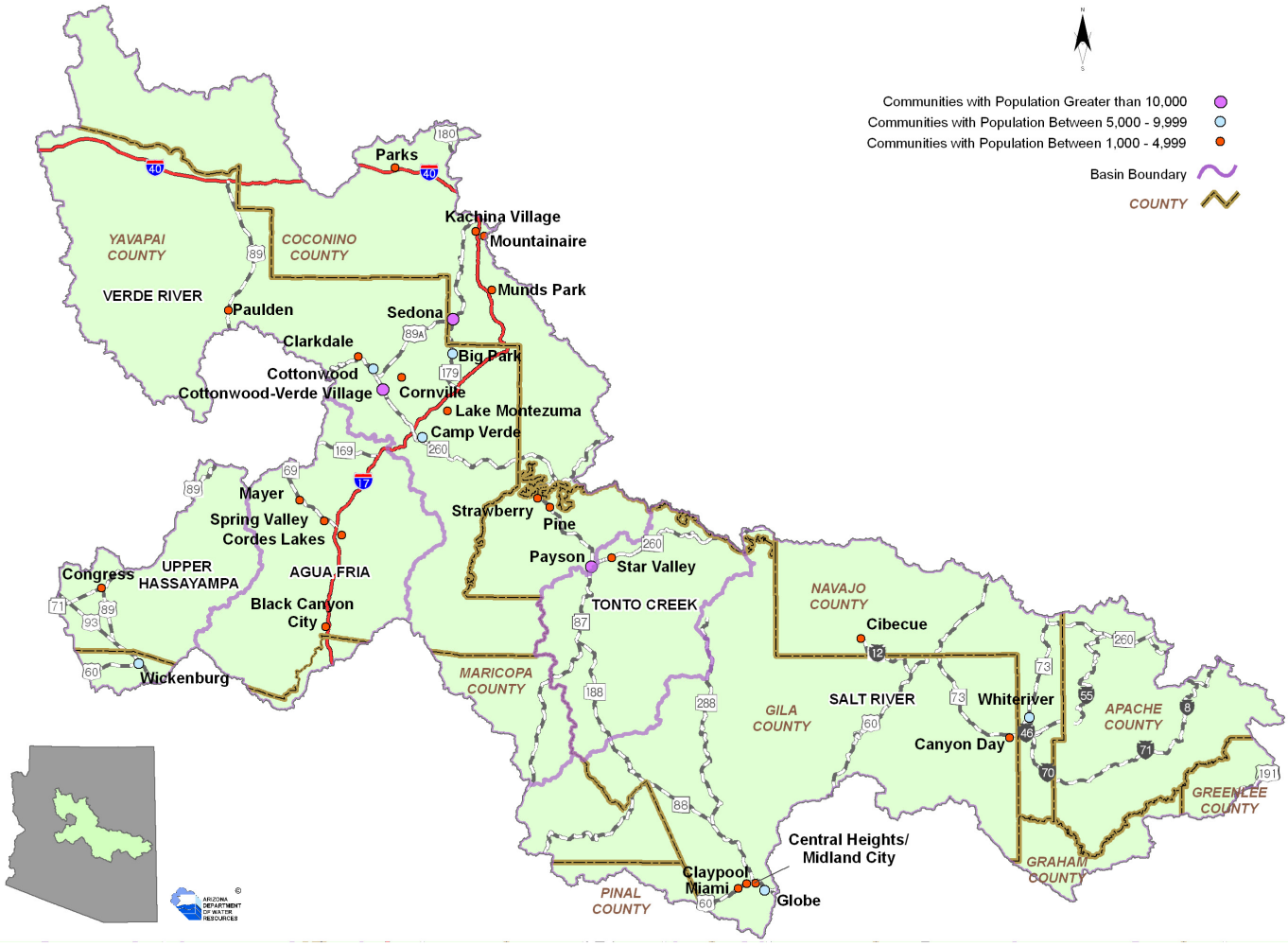
Communities	Basin	1990 Census Pop.	2000 Census Pop.	Percent Change 1990 2000	2006 Pop. Estimate	Percent Change 2000-2006	Projected 2030 Pop.
Payson*	Verde River	8,377	13,620	62.6%	15,812	16.1%	22,631
Cottonwood-Verde Village	Verde River	7,037	10,610	50.8%	11,328	6.8%	18,765
Sedona*	Verde River	7,720	10,192	32.0%	11,080	8.7%	13,776
Camp Verde*	Verde River	6,243	9,451	51.4%	11,779	24.6%	19,131
Cottonwood*	Verde River	5,918	9,179	55.1%	11,201	22.0%	17,584
Globe*	Salt River	6,062	7,486	23.5%	7,497	0.1%	8,614
Big Park	Verde River	3,034	5,245	72.9%	6,566	25.2%	10,735
Whiteriver	Salt River	3,775	5,220	38.3%	5,931	13.6%	8,409
Wickenburg*	Upper Hassayampa	4,515	5,082	12.6%	6,195	21.9%	12,340
Clarkdale*	Verde River	2,144	3,422	59.6%	3,680	7.5%	4,712
Paulden	Verde River	NA	3,420	--	5,342	56.2%	11,411
Lake Montezuma	Agua Fria	1,841	3,344	81.6%	4,237	26.7%	7,059
Cornville	Verde River	2,089	3,335	59.6%	4,075	22.2%	6,413
Black Canyon City	Agua Fria	1,811	2,697	48.9%	3,224	19.5%	4,887
Central Hts./Midland City	Salt River	2,969	2,694	-9.3%	NA	--	NA
Kachina Village	Verde River	1,711	2,664	55.7%	3,302	23.9%	4,888
Cordes Lakes	Agua Fria	NA	2,058	--	2,877	39.8%	5,462
Miami*	Salt River	2,018	1,936	-4.1%	1,959	1.2%	2,100
Pine	Verde River	1,181	1,931	63.5%	NA	--	NA
Claypool	Salt River	1,942	1,794	-7.6%	NA	--	
Congress	Upper Hassayampa	NA	1,717	--	2,272	32.3%	4,026
Mayer	Agua Fria	NA	1,408	--	1,602	13.8%	2,254
Sun Valley/Star Valley	Tonto Creek	NA	1,536	--	2,973	93.6%	5,237
Cibecue	Salt River	1,254	1,331	6.1%	NA	--	1,382
Munds Park	Verde River	NA	1,250	--	1,876	50.1%	3,433
Parks	Verde River	NA	1,137	--	1,550	36.3%	2,575
Canyon Day	Salt River	857	1,092	27.4%	NA	--	NA
Strawberry	Verde River	630	1,028	63.2%	NA	--	NA
Spring Valley	Agua Fria	NA	1,019	--	1,332	30.7%	2,321
Mountainaire	Verde River	NA	1,014	--	1,222	20.5%	1,738
Total >1,000		UNK	117,912	--	UNK	---	UNK
Remainder		UNK	24,938	--	UNK	---	UNK
Total		**103,150**	**142,850**	38.5%	**166,632**	16.6%	**243,585**

Source: DES, 2005; U.S. Census Bureau, 2006; AZCommerce, 2008a and 2008b; Wickenburg, 2003
Notes: 2006 population is 2006 estimate for incorporated communities and 2006 projection for unincorporated communities
Gila and Maricopa county projections are limited
NA = not available
* = incorporated communities

smaller communities are "satellite" communities of nearby incorporated areas; e.g. Kachina Village, Munds Park, Parks and Mountainaire are all located near Flagstaff, just outside of the planning area. There were eight incorporated communities within the planning area in 2000. The community of Star Valley, east of Payson, incorporated in 2005 due to concerns that the Town of Payson would take water from that area to serve new developments (Payson Roundup, 2005). In 2006 Payson was the largest community in the planning area with more than 15,800 residents, followed by Cottonwood-Verde Village, Sedona, Camp Verde, Cottonwood and Globe. The median age in many communities is considerably older than the state average of 34.2 years. Sedona, Congress, Big Park, Black Canyon City, and Clarkdale had median ages of over 45 reported in the 2000 Census.

Rapid growth occurred in several areas between 1990 and 2000 census including Big Park, Payson, Pine/Strawberry, Lake Montezuma and the Verde Valley communities of Cottonwood, Camp Verde, Clarkdale and Cornville. The Verde Valley area population represents about 32% of the population of Yavapai County (Dava & Associates, 2003). Between 2000 and 2006, Star Valley east of Payson, grew by almost 94%, the fastest growth rate reported in the planning area. Population projections for 2030 are not currently available for a number of communities; however, the planning area population is projected to increase by 46% by 2030.

Figure 5.0-14 Communities with a 2000 Census Population Greater than 1,000 in the Central Highlands Planning Area



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. A legislative attempt to link growth and water management planning is the Growing Smarter Plus Act of 2000 (Act), which requires that counties with a population greater than 125,000 (2000 Census) include planning for water resources in their comprehensive plans. Yavapai, Maricopa and Pinal counties fit the population criteria. There is relatively little population or water development within the Maricopa and Pinal county sections of the planning area. About 4,800 square miles (35%) of Yavapai County is located within the planning area, the largest area of any of the nine counties located within it. The Yavapai County water resources element includes an overview of the watersheds in the county, a statement of goals and objectives regarding water supply, water quality and protection of water resources, and an evaluation of existing water use data. Also included is a discussion of the Yavapai County Water Advisory Committee (WAC), a group tasked with development of a regional water management strategy that helps support the water resource goals in the general plan. (Dava & Associates, Inc., 2003).

City of Sedona, Verde River Basin. Sedona is one of five communities in the Central Highlands Planning Area required to have a water resources element in their general plan.

The Act also requires that twenty-three communities outside AMAs include a water resources element in their general plans. In the Central Highlands Planning Area this requirement applies to the communities of Camp Verde, Clarkdale, Cottonwood, Globe, and Sedona. As of August 2009 all communities had completed a water resource element. Plans must consider water demand and water resource availability in conjunction with growth, land use and infrastructure. References to completed plans are listed in basin references in this volume and may contain useful information for water resource planning.

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 systems' 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 94 community water systems in the planning area. 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, which 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. In September 2008 the Town of Clarkdale adopted the provisions of SB 1575.

Subdivision adequacy determinations (Water Adequacy Reports), including the reason for the inadequate determination, are provided in basin tables and maps and are summarized in Table 5.0-6. 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.

The service areas of seven water providers in the planning area have been designated as having an adequate water supply. If a subdivision is served by one of these designated water providers, a separate adequacy determination is not required. As of May, 2009 these included:

- City of Globe
- Town of Wickenburg
- Little Park Water Company (Village of Oak Creek)
- Big Park Water Company (Village of Oak Creek)
- American Ranch Domestic Water Improvement District (American Ranch Development near Prescott)
- Verde Santa Fe Water Company (Verde Santa Fe Development at Cornville)
- CDC Wickenburg Water, LLC (Wickenburg Ranch Estates)

Table 5.0-6 Water adequacy determinations in the Central Highlands Planning Area as of 12/2008

Basin	Number of Subdivisions	Number of Lots[1]	Number of Adequate Determinations	Number of Inadequate Determinations	Approx. Percent Inadequate
Agua Fria	15	>1,177	>973	204	17%
Salt River	17	>968	106	>862	89%
Tonto Creek	62	4,305	441	3,864	90%
Upper Hassayampa	28	2,235	1,896	339	15%
Verde River	430	>32,053	>24,218	>7,835	24%
TOTAL	**552**	**>40,617**	**>27,634**	**>12,983**	**32%**

Source: ADWR 2008b

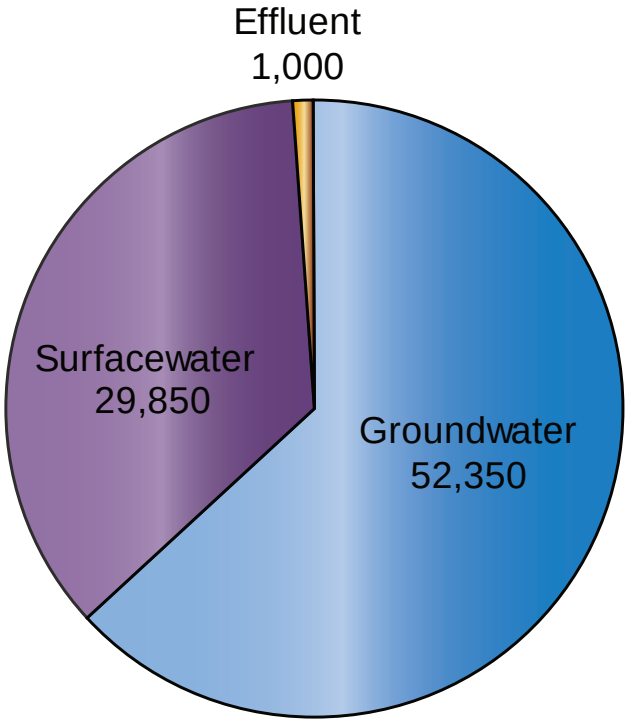
Notes:

[1] Data on number of lots are missing for some subdivisions; actual number is larger

5.0.6 Water Supply

Water supplies in the Central Highlands Planning Area include surface water, groundwater and effluent. Central Arizona Project (CAP) water diverted from the Colorado River via the CAP canal is stored in the planning area but is not utilized within it. Surface water from local streams is used extensively for agricultural irrigation in the Verde River Basin and to some extent in the Salt River Basin where it is also diverted to meet mining demand, primarily outside of the planning area. It is estimated that about 36% of the total water demand in the planning area is met with surface water. Groundwater is the primary water supply in the planning area, accounting for about 63% of the demand. Effluent is utilized for golf course irrigation in the Tonto Creek and Verde River basins, contributing 1% of the planning area's water supply.

Figure 5.0-15 Average Annual Water Supply Utilized in the Central Highlands Planning Area, 2001-2005 (in acre-feet)



Total Demand = 83,200

For purposes of the Atlas, water diverted from a watercourse or spring is considered surface water and if it is pumped from wells it is accounted for as groundwater. This is reflected in the cultural water demand tables in each basin section.

Central Arizona Project Water

New Waddell Dam, located on the Agua Fria River in the Phoenix Active Management Area, stores CAP water in Lake Pleasant located in the Agua Fria Basin. This water is not a direct supply for the planning area. The dam also stores Agua Fria River water and provides flood control. In the winter, water is pumped from the CAP canal to Lake Pleasant. When demand increases in the summer, water is released through the same canal to downstream CAP contractors within the Central Arizona Water Conservation District (CAWCD) service area; Maricopa, Pima and Pinal counties.

Six municipal and industrial water providers or water users and three Indian Tribes in the planning area were allocated an entitlement of CAP water (Table 5.0-7). In order to physically acquire water under their respective subcontracts, it was anticipated that subcontractors located outside of the CAP service area would exchange their CAP entitlement for a locally available surface water supply that was held by a downstream senior water right holder located within the CAP service area. The CAP entitlements held by Indian Tribes could also be included in any future, potential water settlement.

Due to environmental issues associated with the potential exchange of its CAP entitlement for East Verde River water rights held by SRP, the town of Payson chose to sell its CAP entitlement to the City of Scottsdale. The transfer process was completed in 1994. The money ac-

Table 5.0-7 CAP subcontractors and transferred entitlements in the Central Highlands Planning Area[1]

CAP Subcontractor	CAP Entitlement (acre-feet)	CAP Entitlement Transferred (acre-feet)	Gross Proceeds from Transfer[1]
Camp Verde Water System, Inc.	1,443	1,443	$1,443,000
Cottonwood Water Works, Inc.	1,789	1,789	$1,789,000
Mayer Domestic Water Improvement District	332	332	$332,000
Town of Payson	4,995	4,995	$4,995,000
Phelps Dodge Miami, Inc.	2,916		
Pine Water Co.	161		
San Carlos Apache Tribe	61,645		
Tonto-Apache Tribe	128		
Yavapai-Apache Tribe	1,200		

[1] Does not reflect the reduction associated with equivalency charges and capital costs due to CAWCD or other fees associated with the entitlement transfer actions.

quired from the sale was deposited into a trust fund managed by the U.S. Bureau of Reclamation for the purpose of developing alternative water supplies for Payson.

In response to the proposed transfer of Payson's CAP subcontract to Scottsdale, the Department developed a transfer policy to govern the transfer of a CAP entitlement from a subcontractor located outside of the CAP service area. Subsequent to the adoption of this policy, Camp Verde Water System, Inc., Cottonwood Water Works, Inc. and the Mayer Domestic Water Improvement District decided to transfer their subcontracts to Scottsdale. Monies resulting from the sale of these entitlements were also placed in separate trust fund accounts for each entity. Table 5.0-7 lists the entitlement volumes that were eventually transferred to Scottsdale and the gross proceeds that resulted from the respective transactions.

In accordance with each trust fund agreement, the Department provides oversight regarding expenditures from these accounts to ensure that trust fund monies are used to defray expenses associated with "designing, constructing, acquiring and/or developing an alternative water supply in an amount which may include, but is not limited to, a combined net increase" in the subcontractor's "water system capacity to replace the CAP allocation" that it sold.

Plans regarding the CAP entitlements held by Phelps Dodge Miami, Inc. and Pine Water Company are not known. The San Carlos Apache Tribe leases a portion of its CAP allocation to the City of Scottsdale and as exchange water for use by Freeport McMoRan at Morenci in the Southeastern Arizona Planning Area. The Tonto-Apache and the Yavapai-Apache tribes have no current uses or exchanges.

Surface Water

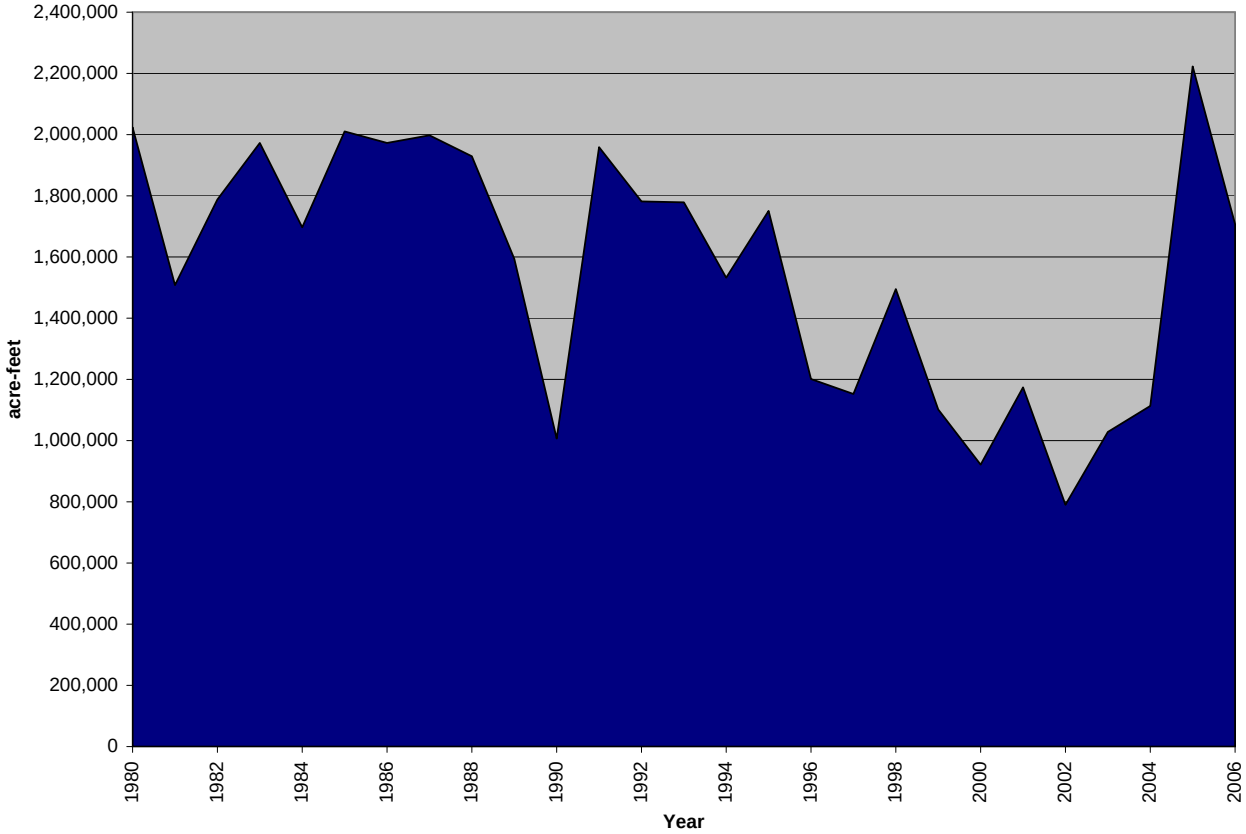
Surface water in the planning area is subject to complex legal conditions which affect use of the supply. Discussed in this section are the surface water supplies that are physically available, the legal framework that regulates its use and a discussion of the surface water rights system in Arizona.

Physical Supplies

The Salt and Verde rivers, as well as the Gila River located south of the planning area, are the primary in-state sources of surface water in Arizona. Relatively high elevations along the Mogollon Rim and in the White Mountains, with associated rainfall and snowfall, make the Salt and Verde watersheds extremely productive. However, because flows in the Salt and Verde rivers are strongly influenced by precipitation, the quantity of flow and water levels in reservoirs along the rivers can fluctuate widely due to climatic variations.

Dams and reservoirs on the Salt and Verde rivers are operated by SRP to store and release water for the benefit of agricultural, municipal and industrial users in the Phoenix metropolitan area. These supplies are generally not available for use in the planning area except for small amounts used for recreation and other purposes at each reservoir. The water stored in the SRP reservoir system illustrates the relationship between downstream water demand and precipitation and snowfall in the watershed. As shown in Figure 5.0-16, storage has fluctuated as water is collected and then released to meet water demands. For example, the impact of drought conditions can be observed during 1989 and again beginning in the late 1990s, and storage recov-

Figure 5.0-16 Water Stored on May 1st in SRP Reservoirs on the Verde and Salt Rivers, 1980-2006



ery is seen in 2005 following a wet winter. As of July 1, 2009, storage in the Salt River system was 94% of capacity.

The total capacity of the SRP reservoir system is shown on Figure 5.0-6. Capacity on the Salt River system is over 2.0 maf, primarily at Roosevelt Lake. The capacity of the reservoir was increased by 20% with completion of a 77-foot dam heightening project in 1996. By comparison, the Verde River system reservoirs are considerably smaller with a storage capacity of about 302,000 acre-feet and average annual inflows exceeding storage capacity. Consequently, the Verde reservoirs are managed to minimize the potential for spill during the winter months, with releases of water during the fall, winter and spring (Ester and Reigle, 2001). Storage volumes in the Verde River reservoirs, particularly in Horseshoe Lake, have been reduced to almost zero at times during recent drought years. On June 1, 2007, storage in the total Verde system had been reduced to 27% of capacity but by June 1, 2009 had increased to 63% of capacity.

In addition to providing a major source of water to the Phoenix metropolitan area, surface water generated in the planning area is an important supply for cultural water uses in the Salt River, Tonto Creek and Verde River basins where it also supports extensive riparian habitat. In the Verde River Basin surface water is used for golf course irrigation and springs supply Jerome's municipal water supply. Surface water is diverted from the Verde River for agricultural use primarily in the Verde Valley Sub-basin of the Verde River Basin where most farming occurs along the river. During periods of drought, surface water shortfalls are met by groundwater pumping. (ADWR, 2000) Reportedly, a relatively small volume of surface water is also utilized for irrigation in the Big Chino Valley (WAC, 2004).

Agriculture in the Verde River Basin. Surface water is diverted from the Verde River for agricultural use primarily in the Verde Valley Sub-basin of the Verde River Basin where most farming occurs along the river.

In the Salt River drainage upstream of the Salt River reservoirs, surface water diversions are primarily for irrigation from Tonto Creek and its tributaries and along the Salt River. At elevations above 4,000 feet, surface water from springs and streams has supplied small irrigated parcels (ADWR, 1992). It is not known if surface water availability has been an issue for surface water users upstream of Roosevelt Dam during periods of drought. A relatively small amount of surface water has been diverted from Pinal Creek for operations at the Miami Mine in the Salt River Basin. Larger volumes of surface water, often more than 5,000 AFA have been transferred from the Salt River Basin via the Black River to the Morenci Mine in the Southeastern Arizona Planning Area pursuant to water exchange agreements described below.

The location of surface water resources are shown on surface water condition maps and maps showing perennial and intermittent streams and major springs for each basin. Data on streamflow, flood ALERT equipment, reservoirs, stockponds and springs are listed in tables in the Water Resource Characteristics sections for each basin.

Legal Availability

Ongoing water rights adjudications, court decrees, water exchange agreements, settlements and state statutes all affect the use of surface water supplies in the planning area and are discussed below. In addition, environmental laws, instream flow rights and environmental protection designations assign surface water supplies to environmental purposes. These are discussed further in Section 5.0.4 and include the Endangered Species Act and associated habitat conservation plans, and the designation of waterways as preserves, wild and scenic rivers and unique waters.

In Arizona rights to surface water are subject 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. The surface water rights system is further discussed in a later sub-section.

Arizona has two general stream adjudications in progress to determine the nature, extent and priority of water rights across the entire Gila River and Little Colorado River systems. The adjudications will recognize existing water right settlements and decrees (see discussion below) and adjudicate all remaining water rights claims in the river systems. Pertinent to the Central Highlands Planning Area, the Gila River Adjudication is being conducted in the Superior Court of Arizona in Maricopa County. The Gila Adjudication was initiated by petitions filed by several parties in the 1970's, including Salt River Project, Phelps Dodge Corporation and the Buckeye Irrigation Company. The petitions were consolidated in 1981 into a single proceeding. The Gila Adjudication includes seven adjudication watersheds - Upper Salt, San Pedro, Agua Fria, Upper Gila, Lower Gila, Verde, and Upper Santa Cruz. The entire Upper Salt, Agua Fria and almost all of the Verde adjudication watersheds and part of the Lower Gila adjudication watershed are within the planning area boundaries (see Figure 5.0-17). These watersheds do not coincide with the 6-digit HUC watersheds discussed previously and shown in Figure 5.0-5. The entire Gila Adjudication includes over 24,000 parties.

Several court determinations currently affect surface water supply availability in the planning area including the Verde Ditch, Kent and Benson-Allison decrees. The Verde Ditch extends approximately 17 miles along the Verde River from north of I-17 to south of Camp Verde. The Verde Ditch Decree (1909) proportionately divided ownership and maintenance responsibilities of the Verde Ditch without reference to a priority date or use. It also stipulates that water in the lower portion of the ditch be one third of the flow of the upper portion to ensure adequate supplies for all ditch owners. The Kent Decree (1910) determined that almost 240,000 irrigable acres in the Salt River Valley had a right to water diverted from the Salt and Verde rivers and included certain tribal provisions, but did not establish rights along the Verde River. Determination of Verde River water rights has been included in the Gila Adjudication proceedings. The Benson-Allison Decree (1917) concerns lands in the Phoenix AMA that are entitled to divert water from the Salt, Agua Fria and Gila rivers.

Certain legal agreements and settlements that operate within the Central Highlands Planning Area allow for the movement of surface water between groundwater basins and planning areas. As previously mentioned, surface water stored in the Salt and Verde reservoirs are primarily allocated for use outside of the planning area. In addition, surface water from the Black

River in the Salt River Basin is diverted for use in the Southeastern Arizona Planning Area. Pursuant to complex exchange agreements with the San Carlos Apache Tribe, SRP and the Central Arizona Project, Freeport McMoRan (previously Phelps Dodge) diverts surface water from the Black River for use at the Morenci Mine. The Freeport McMoRan surface water diversions are located at the Black River Pump Station and conveyed over the Natanes Plateau and into Willow Creek. In 2005, approximately 5,372 acre-feet were diverted from the Black River for this purpose. In 2007, this volume was only 271 acre-feet.

To compensate downstream water users for diversions from the Black River, Phelps Dodge historically diverted water into the Central Highlands Planning Area from two locations in the Little Colorado River Planning Area; Show Low Lake and Blue Ridge Reservoir (now C.C. Cragin Reservoir). Water from Show Low Lake, located five miles south of the Town of Show Low, was transferred to Forestdale Creek, a tributary to the Salt River. This transfer ceased in 2005 with Phelps Dodge's decision to permanently abandon its Show Low Lake water rights, and transfer its property interests in Show Low Lake and dam to the City of Show Low. The Salt River Basin water demand table takes into account both the water removed from and replaced into the Salt River Basin.

C.C. Cragin Reservoir, located approximately 25 miles north of Payson, was acquired by SRP from Phelps Dodge Corporation in February 2005 as part of the Arizona Water Settlement Act. The reservoir satisfies obligations to the Gila River Indian Community, and will be used to supplement SRP's water supply and to assist in improving the water supply situation in northern Gila County in accordance with the Act (SRP, 2007b). The Town of Payson has a long-term agreement with SRP to utilize a portion of

C.C. Cragin Reservoir, Photo courtesy of SRP

the water stored at C.C. Cragin Reservoir as a water supply for the town. It proposes to construct a $30 - $40 million pipeline and treatment plant to transport and deliver 3,000 acre-feet of water annually to the community. Another 500 acre-feet is dedicated to other northern Gila County communities. Water diverted from C.C. Cragin Reservoir that passes through the Verde River Basin (via East Verde River) and is not used in the basin, is not reflected in the surface water use estimates and water demand table for the Verde River Basin.

In addition to the Arizona Water Settlement Act, a tribal water rights claim that affects water supply availability in the planning area is the White Mountain Apache Tribe Water Rights Quantification Act (Act). The Act was introduced in 2009 to resolve the tribe's water claims and provide a reliable drinking water supply. If adopted as introduced, it would allocate an annual water right of 52,000 AFA to the tribe through a combination of surface water and CAP water. It would also authorize funding for a needed drinking water project, the Miner Flat Project. The project consists of a small dam, reservoir and pipeline, estimated to cost approximately $128 million.

Surface water supply availability may also be affected by state statute. Arizona Revised Statutes (A.R.S. 45-555) allows the transportation of groundwater pumped from the Big Chino Sub-basin into the Prescott AMA. There are concerns that increased groundwater withdrawals in this sub-basin may contribute to reduced flows in the headwaters of the Verde River and affect availability of surface water. The relative contribution of the proposed pumping to Verde River flow is the matter of considerable debate (see Groundwater section below).

Surface Water Right System

In addition to rights to surface water that exist through decrees, settlements, agreements and statutes, there are many existing uses whose rights have not been adjudicated. 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. Each type of surface water right filing is assigned a unique number as explained in Appendix C and shown in Table 5.0-8. All parties who use water or claim to have a water right within the river system are required to file a statement of claimant or SOC (39) in the adjudication, or risk loss of their right. This includes reserved water rights for public lands and Indian reservations, of which only some have been quantified or prioritized. Other surface water right filings are discussed below.

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. Statements of claim of right to use public waters (36) have also been filed, but their filing does not in itself create a water right. Surface water rights can also be determined

Table 5.0-8 Inventory of surface water right and adjudication filings in the Central Highlands Planning Area[1]

Basin	Type of Filing							Total
	BB[2]	3R[3]	4A[3]	33[3]	36[4]	38[5]	39[6]	
Agua Fria	0	27	104	208	1,153	518	2,792	**4,802**
Salt River	1	17	162	96	2,235	712	4,294	**7,517**
Tonto Creek	0	15	79	37	678	341	2,353	**3,503**
Upper Hassayampa	0	48	76	130	718	210	1,963	**3,145**
Verde River	0	180	204	426	3,733	2,147	14,041	**20,731**
Total	**1**	**287**	**625**	**897**	**8,517**	**3,928**	**25,443**	**39,698**

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.

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.

Table 5.0-8 summarizes the number of surface water right and adjudication filings in the planning area. The methodology used to query the Department's surface water right and SOC registries is described in Appendix C. Of the 39,698 filings that specify surface water diversion points and places of use in the planning area, 3,184 CWRs have been issued to date. Figure 5.0-17 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 5.0-17.

Results from the Department's investigation of surface water right and adjudication filings are presented in Hydrographic Survey Reports (HSRs). Within the Central Highlands Planning Area, a preliminary HSR has been published for the Upper Salt River Watershed (ADWR, 1992).

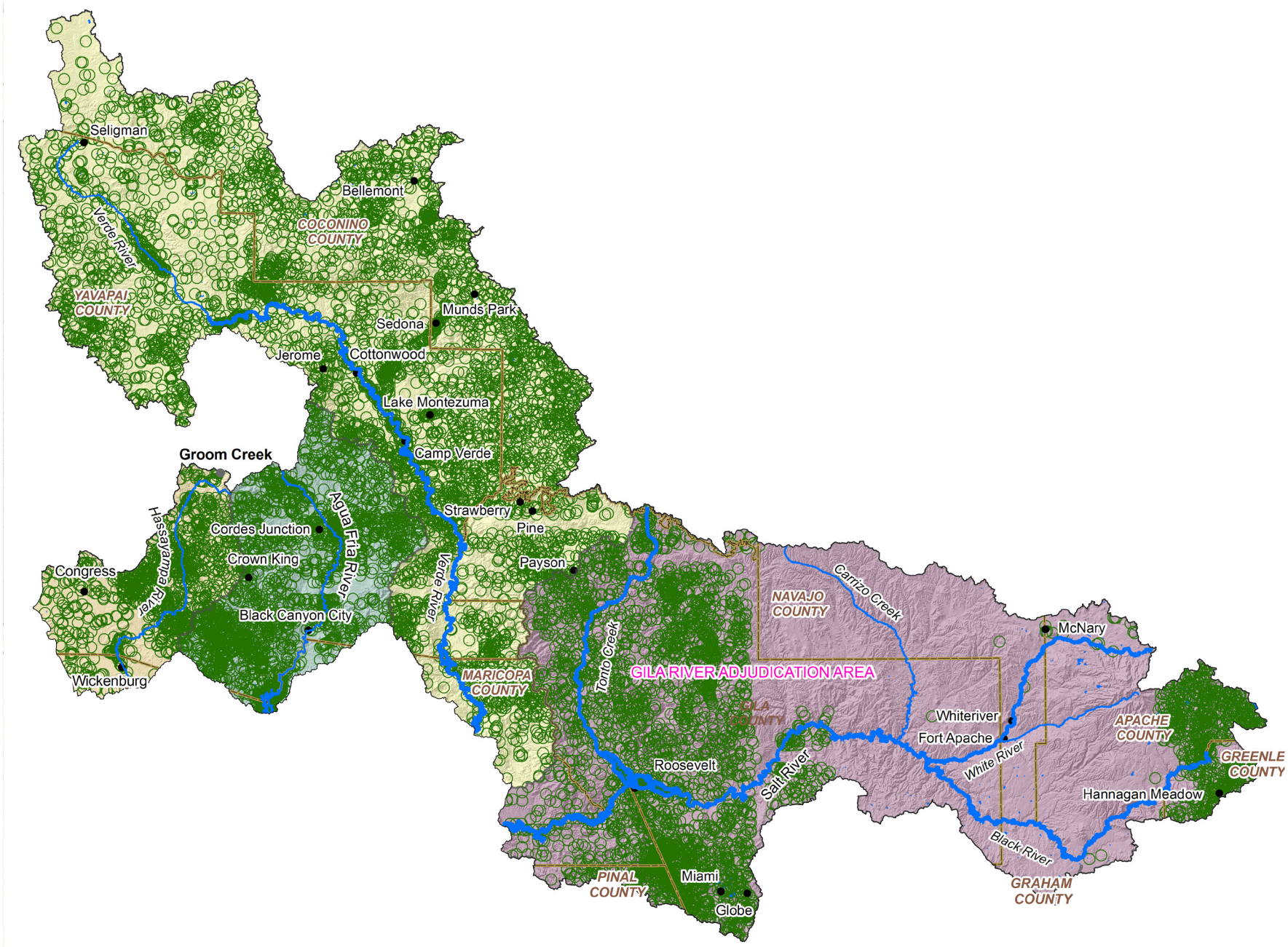
The location of surface water resources are shown on surface water condition maps and maps showing perennial and intermittent streams and major springs for each basin, and in basin tables that contain data on streamflow, flood ALERT equipment, reservoirs, stockponds and springs in the Water Resource Characteristics sections for each basin.

Groundwater

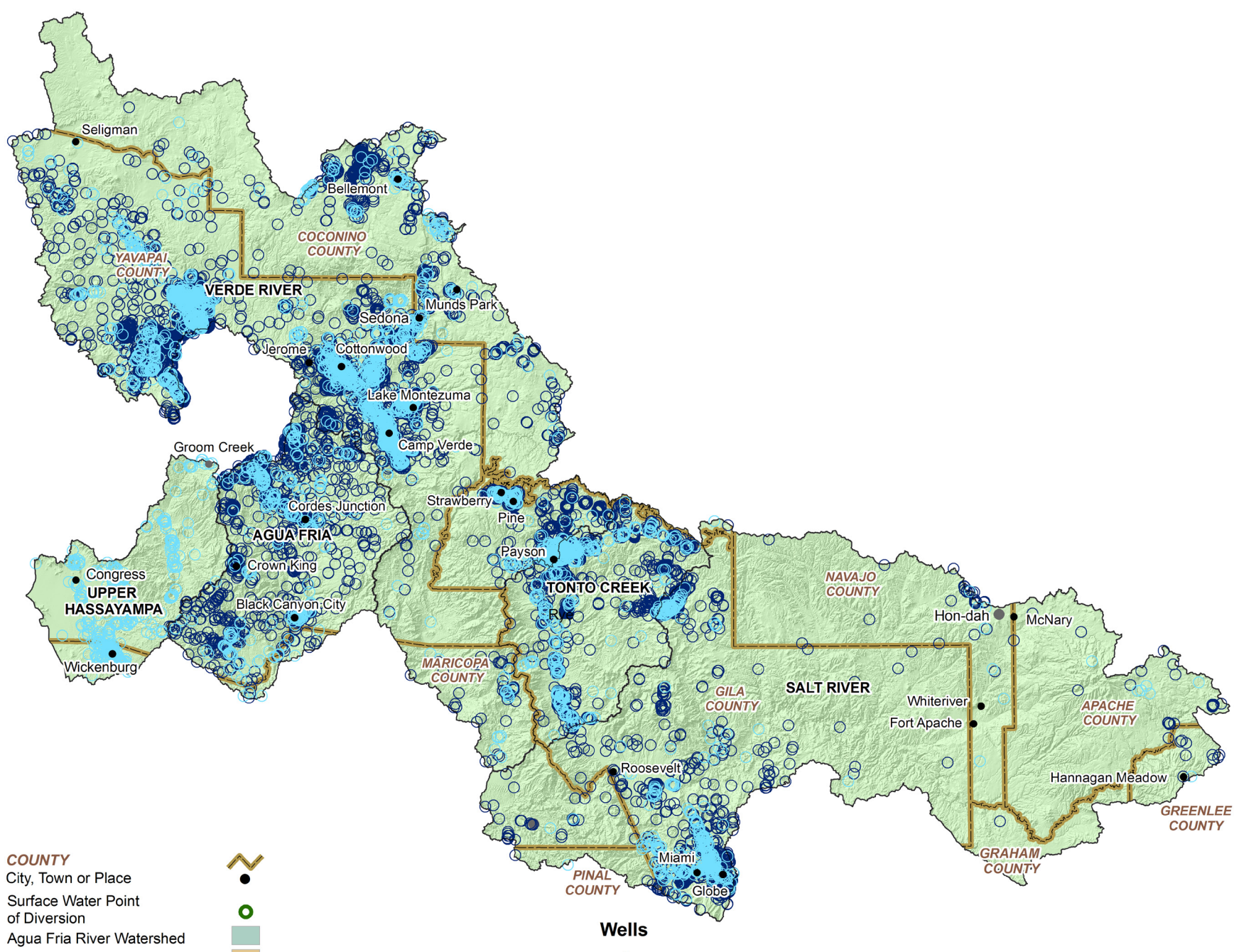
Compared to the deep alluvial basins found in the southern part of Arizona, high elevations, steep topography and extensive areas of bedrock in the Central Highlands Planning Area translate into relatively minimal groundwater storage capabilities and high runoff. These conditions result in limited, drought-sensitive water supplies for some communities, such as Pine, Strawberry, Payson, Black Canyon City and Mayer. Areas of unconsolidated sediments are relatively limited as shown on the groundwater conditions maps for each basin in sections 5.1-5.5. Many basin-fill aquifers in the planning area are narrow and surrounded by low water yielding consolidated rocks. Areas of relatively high water yield include basin-fill deposits in the Big Chino Sub-basin, Verde Valley Sub-basin, north of Globe in the Salt River Lakes Sub-basin and near Wickenburg in the Upper Hassayampa Basin.

In much of the northern half of the Agua Fria Basin, parts of the Salt River Basin including the entire eastern portion, and the Verde Canyon Sub-basin, groundwater occurs in volcanic rocks that yield relatively small volumes of water. These conditions pose groundwater supply challenges for Payson and other communities in the planning area. In Pine, Strawberry and near Globe, groundwater is found in relatively low yield sedimentary rocks.

Water availability problems resulted in an ACC-imposed moratorium on the installation of any new meters by Pine Water Company in 2006. Recently, deep wells in the area have encountered a more productive aquifer than that found in the currently utilized shallow wells. In July 2009 the Pine/Strawberry Water Improvement District voted to purchase Brooke Utilities, which serves the communities, with the intent to obtain water from deeper, more productive wells. (Payson Roundup, 2009)



Surface Water Diversion Points



Wells

Figure 5.0-17
Central Highlands Planning Area
Registered Wells and Surface Water Diversion Points

ARIZONA DEPARTMENT OF WATER RESOURCES ©

Sedimentary rocks with moderate yields are found in the southern half of the Agua Fria Basin, while Precambrian schist near Black Canyon City yields relatively small volumes of water to wells.

Although groundwater supplies may be limited in some areas, it is the primary water supply in the planning area. Well pumpage averaged about 52,350 AFA during the period 2001 to 2005.

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 geologic 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.

Automated Groundwater Monitoring Site in the Upper Hassayampa Basin.

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 four 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.

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 156 Index Wells and 13 Automated Sites in the Central Highlands Planning Area. The latter are located in all but the Salt River Basin. Updated maps showing the location 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 Water Resource Characteristics sections.

Transportation of groundwater between groundwater basins is prohibited in Arizona unless specifically allowed in statute. In 1991, the Arizona statutes were amended to allow certain governmental entities to transport groundwater from the Big Chino Sub-basin of the Verde River groundwater basin into the Prescott AMA. Under A.R.S. 45-555(E), the City of Prescott can withdraw and transport an amount not to exceed 14,000 AFA from the Big Chino Sub-basin into the Prescott AMA. The actual volume that can be transported during a year depends on several factors listed in the statute. With respect to the City of Prescott's 2007 Application for Modification of Designation of Assured Water Supply, the Director of ADWR issued a determination that recognized 8,067.4 acre-feet per year as the volume of groundwater Prescott is legally entitled to transport from the Big Chino Sub-basin under A.R.S. § 45-555(E). This decision and order is currently under appeal with the Office of Administrative Hearings and the Director's final decision is expected in late 2009.

In addition to the groundwater the City of Prescott is allowed to transport under A.R.S. § 45-555(E), cities and towns in the Prescott AMA are allowed to withdraw groundwater associated with historically irrigated acres (HIA) in the Big Chino Sub-basin and transport the groundwater into the Prescott AMA. (A.R.S. §45-555 (A) through (D)) The Department will make a determination regarding the volume of groundwater that a city or town can transport from HIA lands after it has finalized Administrative Rules for this process. The allotment associated with HIA is three acre-feet per acre per year.

An important issue facing the Central Highlands Planning Area is the potential for additional groundwater withdrawals from the Big Chino Sub-basin to reduce flows in the headwaters area of the Verde River with possible environmental impacts associated with reduced flows and the construction of pipelines and other infrastructure to transport the groundwater. Although a number of studies have been conducted to investigate the connection of Big Chino Sub-basin groundwater with the headwaters of the Verde River, the relative contribution of the various potential sources is still a matter of speculation (McGavock, 2003).

Effluent

Effluent is a water supply for golf course irrigation in the Tonto Creek and Verde River basins, totaling about 1,000 acre-feet within the planning area. Effluent used in the Tonto Creek Basin is generated in the Verde River Basin at the American Gulch WWTP (Table 5.5-9). Data were not available to the Department for all wastewater treatment facilities. From data that were available, it appears that limited volumes of effluent are produced in the Agua Fria and Tonto Creek basins. Approximately 2,600 acre-feet are generated in the Salt River Basin, primarily on the White Mountain Apache Reservation and at Globe and Miami. In the Upper Hassayampa Basin, the Wickenburg wastewater treatment plant generates about 580 acre-feet of effluent a year. About 6,200 acre-feet of effluent is generated annually in the Verde River Basin, primarily at facilities located in Cottonwood, Kachina Village, Payson and Sedona. Effluent is discharged to watercourses, wildlife areas, evaporation ponds and infiltration basins. The Town of Clarkdale wastewater treatment plant discharges effluent onto mine tailings for dust control (USBOR, 2003). In total, about 9,500 acre-feet of effluent are currently generated annually within the planning area.

Contamination Sites

Sites of environmental contamination may impact the use of some water supplies. An inventory of Department of Defense (DOD), Resource Conservation and Recovery Act (RCRA), Su-

perfund (Environmental Protection Agency designated sites), Water Quality Assurance Revolving Fund (WQARF, state designated sites), Voluntary Remediation Program (VRP) and Leaking Underground Storage Tank (LUST) sites was conducted for the planning area. All are found in the planning area. Table 5.0-9 lists the contaminant and affected media and the basin location of each site except LUST sites. The location of all contamination sites is shown on Figure 5.0-18.

The Iron King Mine and Humboldt Smelter Superfund site was listed in September 2008. The mine was active from 1904 until 1969 and extracted lead, gold, silver, zinc and copper. More recently, fertilizer was made from the tailings. The mine site covers about 153 acres and includes tailings, retention ponds and mine shafts. The adjacent smelter site occupies about 182 acres of tailings, smelter ash and slag. The smelter operated from the late 1800s until the early 1960s. Contaminants are a result of the mining and smelter activities and include arsenic, lead and other metals. A remedial investigation and a feasibility study to evaluate remedial actions are underway. (EPA, 2009)

There is one DOD site, Camp Navajo, located near Bellemont in the Verde River Basin. This site was used for over 50 years for land disposal of excess, obsolete and unserviceable munitions where they were destroyed by burning or by detonation. The site is being cleaned up

Table 5.0-9 Contamination sites in the Central Highlands Planning Area

SITE NAME	MEDIA AFFECTED AND CONTAMINANT	GROUNDWATER BASIN
Superfund Sites		
Iron King Mine and Humbolt Smelter	Soil, Groundwater - Arsenic, Lead, Other Metals	Verde River
Department of Defense Sites/Resource Recovery and Conservation Act (RCRA) Sites		
Camp Navajo, Bellemont	Soil, Groundwater - Metals, Volatile Organic Compounds, Solvents, White Phosphorous, Unexploded Ordnance	Verde River
WQARF Sites		
Payson PCE	Groundwater - Tetrachloroethene (PCE)	Verde River
Tonto/Cherry	Groundwater - Tetrachloroethene (PCE) and trichloroethene (TCE)	Verde River
Pinal Creek	Groundwater, Surface Water - Metals, Radiochemicals, TDS, Acidity	Salt River
Voluntary Remediation Sites		
APS Globe Manufactured Gas Plant	Soil, Groundwater - Hydrocarbons, Cyanide, Arsenic, Lead	Salt River
Former Bunker C AST Location	Soil - Total petroleum hydrocarbons, Polycyclic aromatic hydrocarbons	Verde River
Former Shell Service Station	Groundwater - PAHs (Benzo(a)pyrene)	Verde River

Sources: ADEQ 2006a, ADEQ 2006b

Camp Navajo, Verde River Basin. This site was used for over 50 years for land disposal of excess, obsolete and unserviceable munitions where they were destroyed by burning or by detonation.

according to RCRA standards under the DOD's Installation Restoration Program. The RCRA program regulates the management of hazardous waste handlers which includes generators, transporters and facilities for treatment, storage and disposal (ADEQ, 2002).

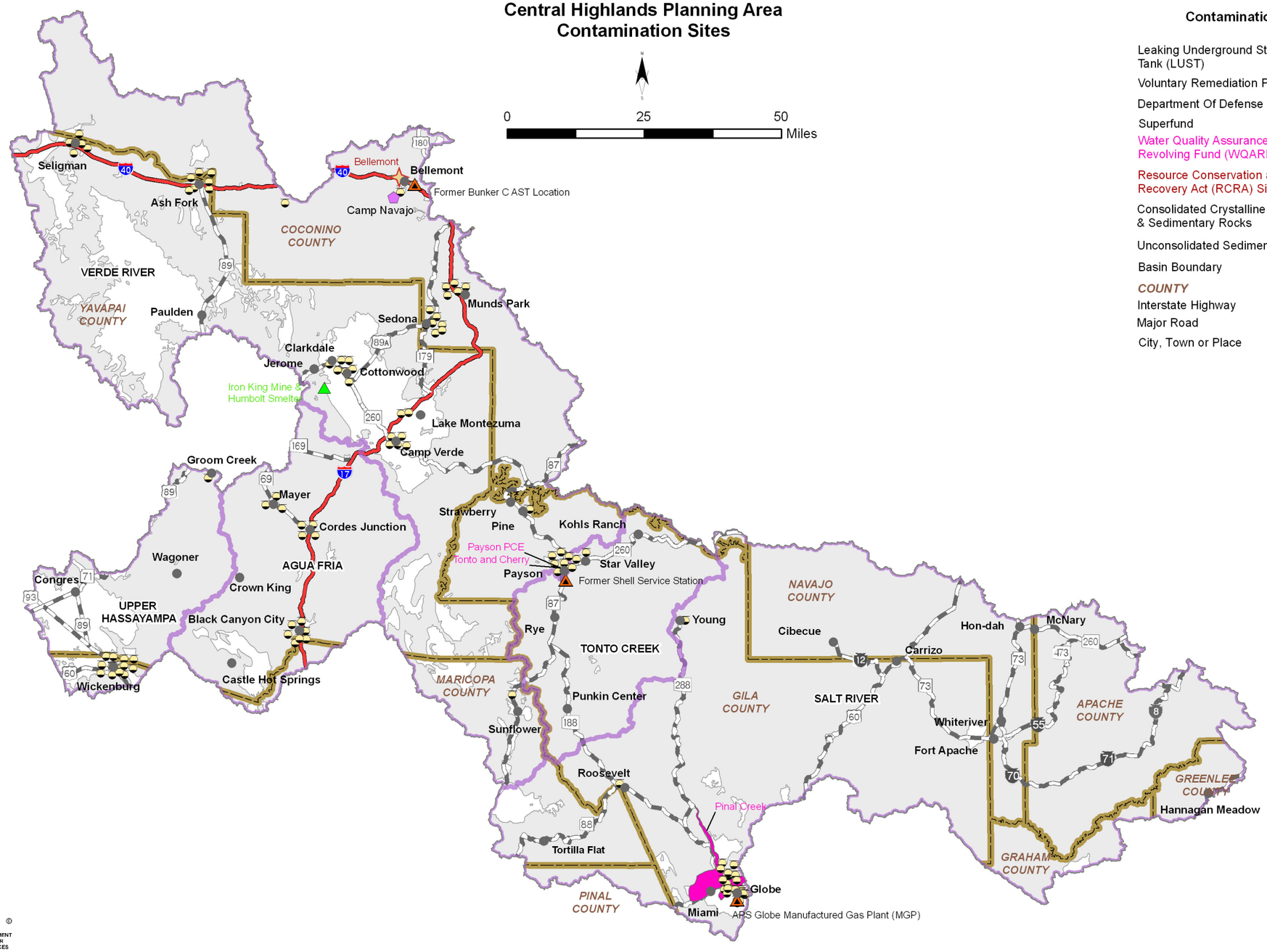
The Pinal Creek WQARF Site, located in the vicinity of Miami-Globe, is contaminated from mining and mineral processing in the area that began in 1878. Groundwater contamination was first observed in the 1930s in the alluvial aquifer of Miami Wash. By the time the first area-wide investigation of groundwater and surface water was conducted in 1979-81, there was widespread contamination. By the end of 2007, approximately 107 million pounds of heavy metals had been removed from area aquifers. Following treatment, this water was released to Pinal Creek, reused for mining purposes, or evaporated at the mines. As a result of remediation activities, the perennial and ephemeral reaches of Pinal Creek, Miami Wash and Bloody Tanks Wash were removed from the State's list of impaired water bodies. Site-wide monitoring is on going including monthly sampling of 80-100 wells, four surface water sites and treated effluent at the Lower Pinal Creek treatment plant .(ADEQ, 2008)

There are also two WQARF sites in the Payson area. At the Payson PCE site, groundwater is contaminated with tetrachloroethene (PCE). Two groundwater treatment systems capture and treat the contaminated water, which following treatment is delivered to the town as drinking water. The treatment system will operate until approximately 2033 or until PCE concentrations are below the Aquifer Water Quality Standard (AWQS). (ADEQ, 2009a) PCE and trichloroethene (TCE) contaminate groundwater at the Tonto and Cherry site where well monitoring and soil gas surveys have been conducted. A Proposed Remedial Action Plan and Record of Decision (ROD) were completed in 2008. PCE concentrations have been decreasing as the compound naturally breaks down and all domestic drinking water wells at the site are now below the AWQS. (ADEQ, 2009b)

Four active VRP sites are located in the planning area with hydrocarbon and metal contamination of soil, groundwater and surface water. 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 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 regulatory program (Environmental Law Institute, 2002).

There are 143 active LUST sites in the planning area. Thirty one sites are located near Globe in the Salt River Basin, 22 sites are located in and around Wickenburg in the Upper Hassayampa Basin, 21 sites occur in the vicinity of Payson and Star Valley in the Verde River and Tonto Creek basins, and there are ten sites near Clarkdale and Cottonwood in the Verde River Basin. Ash Fork, Black Canyon City, Camp Verde, Munds Park, Sedona and Seligman each contain another 5 to 10 sites.

Figure 5.0-18
Central Highlands Planning Area
Contamination Sites



5.0.7 Cultural Water Demand

Cultural water demand in the Central Highlands Planning Area averaged approximately 83,200 AFA during the period from 2001 to 2005. As shown in Figure 5.0-19, the agricultural demand sector was the largest use sector with approximately 37,500 acre-feet of demand, 45% of the total. Most agricultural demand was located in the Verde River and Salt River basins. About 62% of the agricultural demand was met by surface water diverted primarily from the Verde and Salt rivers and from Tonto Creek. Municipal demand was the second largest water demand sector with about 33% of the total planning area demand or an annual average of 27,400 acre-feet during the period 2001-2005. Municipal demand is primarily met by groundwater. Industrial demand, mainly related to mining, accounted for 18,300 acre-feet, 22% of the total average demand during this period. Almost all the surface water diverted for industrial purposes, about 5,700 AFA during 2001-2005, was transported out of the planning area for use at the Morenci Mine in the Southeastern Arizona Planning Area.

As shown in Figure 5.0-20 basin demand varied substantially in the planning area. More than half of the water demand in the planning area was in the Verde Basin, 29% is in the Salt River Basin and the remaining basins have smaller and comparable volumes of water demand.

Several recent studies provide detailed information on irrigation water use in the Verde River Basin. The Verde River Watershed Study Report (ADWR, 2000) contains information on water demand for most of the basin. The Yavapai County Water Advisory Committee (WAC)

Figure 5.0-19 Average Annual Central Highlands Planning Area Cultural Water Demand by Sector, 2001-2005 (in acre-feet)

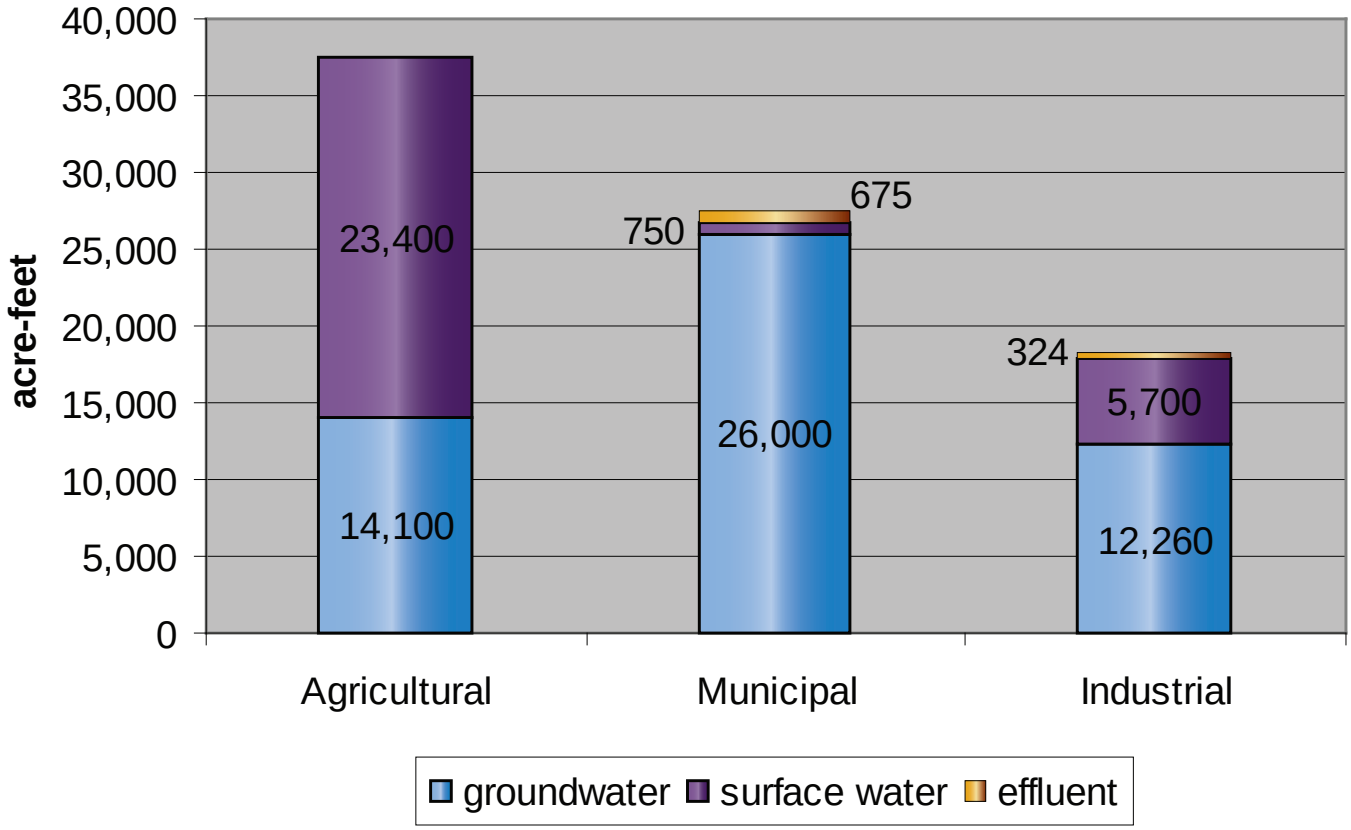
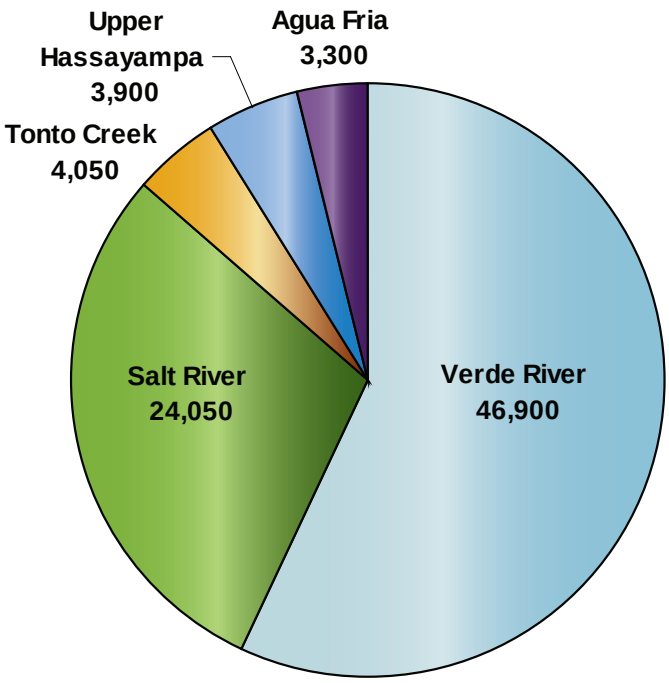


Figure 5.0-20 Average Annual Basin Water Demand, 2001-2005 (in acre-feet)



completed a water use study of the Big Chino Sub-basin in 2004 and participated in a USBOR study of the Verde Valley in 2003 that are useful sources of water demand information.

Tribal Water Demand

The largest Indian reservation in the planning area is the Fort Apache (White Mountain Apache Tribe), the fourth largest reservation in terms of size within Arizona. Although the northern part of the San Carlos Apache Indian Reservation is within the planning area directly south of the Fort Apache Indian Reservation, almost all its population and water demand is in the Southeastern Arizona Planning Area.

Water demand on the Fort Apache Indian Reservation is associated with domestic and agricultural uses as well as a number of tribal enterprises including timber industries, a ski resort and a casino/hotel at Hon-dah. In 2006, there were approximately 12,000 tribal members residing on the reservation with about 5,900 residents at Whiteriver, the tribal capital. Other residents reside in smaller communities and on rural lands. Water service is provided to an unknown number of customers by the Whiteriver Regional System.

Production from system wells has declined over the last few years, resulting in summer drinking water shortages. The tribe plans to construct a relatively small diversion project on the North Fork of the White River in 2009 and is pursuing a long term water development project, the Miner Flat Project, through the White Mountain Apache Tribe Water Rights Quantification Act introduced in 2008 The settlement would also allocated 52,000 AFA through a combination of surface water and CAP (Kyl, 2008).

There are no recent agricultural surface water demand estimates available for the Fort Apache Reservation. Table 5.0-10 shows an estimate from the 1992 Preliminary HSR for the Upper Salt River Watershed. Agricultural groundwater demand is estimated at approximately 200 AFA. (USGS, 2007)

Water demand on the San Carlos Apache Reservation portion within the planning area is assumed to be primarily due to agricultural irrigation of orchard crops. Using agricultural and industrial demand estimates in the Hydrograph-

Table 5.0-10 Estimated water demand on the for Apache and San Carlos Apache Indian Reservations, c. 2005 (in acre-feet)

	Agricultural (groundwater/ surface water)	Municipal (groundwater/ surface water)
Fort Apache	200/3690	700/60[1]
San Carlos Apache	0/70	0
Total	200/3760	700/60

Sources: ADWR 1992, Truini et al 2005, USGS 2007

[1] Assumes 94 gpcd at Whiteriver and 40 gpcd elsewhere. Commercial demand outside of Whiteriver not included. Sixty acre-feet of surface water is used at Cedar Creek.

ic Survey Report for the Upper Salt River Watershed, (ADWR 1992) and per capita assumptions derived from a 2005 study by Truini et al. (2005) on other reservations, it is estimated that the annual demand of the two largest tribes in the planning area was about 4,500 acre-feet (Table 5.0-10).

The Tonto Apache and Yavapai-Apache Indian Reservations and tribal populations are relatively small and demand estimates were not available to the Department. The Tonto Apache Indian Reservation is the smallest land base reservation in Arizona at 85 acres. Principal water demands are associated with the Mazatzal Casino and restaurant, and tribal offices. Water service is provided by the Tonto Apache Water System. The 656-acre Yavapai-Apache Indian Reservation is located on five separate parcels with its tribal headquarters at Middle Verde. This parcel is served water by the Middle Verde Indian Water System while other parcels are served by private water companies that also serve adjacent, non-reservation lands. Tribal lands include irrigated farmland, residences and commercial businesses. The tribe operates the Cliff Castle Casino and motel north of Camp Verde (see Figure 5.5-2). (ITCA, 2003)

Municipal Demand

Municipal demand is summarized by groundwater basin and water supply in Table 5.0-11. Average annual demand during the period 2001 to 2005 was 27,425 acre-feet. Ninety-five percent of this demand was met by groundwater. A small amount of surface water is used in the Salt River Basin at Salt River lake facilities and on the Fort Apache Indian Reservation at Cedar Creek, a small community southeast of Carrizo. In the Verde River Basin surface water is used at several locations including the Beaver Valley Water Company, Bonita Water Company (Payson), Camp Navajo, Kohl's Ranch, Pine Water Association, Stoneman Lake Water Company and the Town of Jerome, which uses about 80 AFA of the 400 AFA it diverts from 12 springs (Town of Jerome, 2008). Effluent is used for turf irrigation in the Verde River and Tonto Creek basins.

Primary municipal demand centers are located around Cottonwood, Globe-Miami, Payson, Sedona and Wickenburg. Municipal demand in the Verde River Basin accounts for 59% of the total municipal demand. By comparison, there is relatively little municipal water demand in the Agua Fria Basin. It is estimated that about eleven percent of the planning area population is not served by a municipal water provider.

Eight water providers served 450 acre-feet or more in 2006 for a total of 14,158 acre-feet. Their demand in 1991, 2000 and 2006 are shown in Table 5.0-12 and discussed briefly below. Prior to 2006, municipal utilities served only Globe, Payson and Wickenburg. Beginning in 2005, the City of Cottonwood began acquisi-

Table 5.0-11 Average annual municipal water demand in the Central Highlands Planning Area, 2001-2005 (in acre-feet)

Basin	Groundwater	Surface Water	Effluent[1]	Total
Agua Fria	1,800			1,800
Salt River	4,000	<300[2]		<4150
Tonto Creek	2,400		215	2,600
Upper Hassayampa	2,600			2,600
Verde River	15,200	600	460	16,260
Total Municipal	26,000	750	675	27,425

Sources: USGS 2007, ADWR 2008c

[1] Effluent figures are for golf course and other turf irrigation in 2006

[2] Assume 150 acre-feet for computation purposes

Table 5.0-12 Water providers serving 450 acre-feet or more of water per year in 2006, excluding effluent, in the Central Highlands Planning Area

Basin/Water Provider	1991 (acre-feet)	2000 (acre-feet)	2006 (acre-feet)
Salt River			
Arizona Water Company-Miami	1,031	1,194	968
City of Globe	1,446	1,558	1,603
Upper Hassayampa			
Town of Wickenburg	1,249	1,717	1,944
Verde River			
Arizona Water Company - Sedona	1,764	2,816	3,332
Big Park Water Company - Village of Oak Creek	539	799	879
Camp Verde Water System Inc.	248	357	472
City of Cottonwood (Cottonwood Water Works, Clemenceau W.C., Verde Santa Fe, Cordes Lakes Cottonwood Systems)	NA	NA	3,145
Cottonwood Water Works - Cottonwood and Clarkdale	1,321	2,065	NA
Cordes Lakes Water Company	590	1,128	NA
Town of Payson	1,089	1,550	1,815

Sources: ADWR 2007 and 2004

Notes: City of Cottonwood acquired several systems in 2006. The combined system withdrawals are shown for all years)

Payson and Globe receive water from outside their basins.

NA=not applicable

tion of the four private water companies serving the town; Clemenceau Water Company, Cordes Lakes Water Company (Cottonwood Systems), Cottonwood Water Works and the Verde Santa Fe Water Company. By 2007, the City of Clarkdale had acquired the Cottonwood Water Works system serving Clarkdale. Municipally-owned systems 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 5.0.8.

Arizona Water Company-Miami

The towns of Miami-Claypool are served by Arizona Water Company. About 87% of the approximately 3,250 connections are residential. The Miami water system is served by 17 wells and has a two-way emergency interconnection with the City of Globe. Water levels in wells ranged from 109 feet to 860 feet below land surface in 2006. (Arizona Water Company, 2007a) In 2006, 968 acre-feet was pumped from 13 wells. Of this total, 641 acre-feet was delivered for residential use, 245 for commercial use and 10 for “other”.

City of Globe

The City of Globe has an adequate water supply designation and serves about 7,700 customers from five active wells. Four of these wells are located in the Safford Basin in the Southeastern Arizona Planning Area. About two-thirds of the water demand is residential and one-third is non-

Arizona Water Company Offices in Miami ,Arizona.

residential. The City has a water conservation plan that it credits with helping to keep water demand in check. Water levels in wells ranged from 40 feet to 650 feet below land surface in 2005. (City of Globe, 2005) In 2006, Globe withdrew 1,603 acre-feet from five wells and delivered 938 acre-feet to residential, 353 acre-feet to commercial, 60 acre-feet to turf and 90 acre-feet to "other".

Town of Wickenburg

The Wickenburg municipal water system serves groundwater to about 5,100 residents. In 2007 it withdrew almost 1,730 acre-feet from four wells. Of this, 895 acre-feet was delivered to residential customers, 630 to commercial and 204 to "other". It operates the Wickenburg WWTP which treated 444 acre-feet of effluent in 2007, all of which was discharged to infiltration ponds.

Arizona Water Company-Sedona

Arizona Water Company serves the town of Sedona. The system has 14 active wells and about 5,500 connections, of which 78% are residential. Sedona has a high percentage of seasonal residents, and daily visitors contribute to a relatively high use rate of 244 gallons per capita per day (gpcd) (USBOR, 2003). The system also serves commercial customers and turf facilities. The service area includes central Sedona from Red Rock Loop Road to east of downtown. The Valley Vista "sub-system" serves an area south of Verde Valley School Road, mostly west of Highway 179. Arizona Water Company maintains an emergency two-way interconnection with the Oak Creek Water Company. Groundwater depth average about 220 feet in utility wells. (Arizona Water Company, 2007b) In 2006, 3,332 acre-feet was withdrawn from nine wells. Of this total, 2,077 acre-feet was delivered to residential customers, 938 to commercial customers and 58 to "other".

Big Park Water Company

Big Park Water Company serves the Village of Oak Creek, an unincorporated community south of Sedona along Highway 179. It has about 2,800 connections, of which 91% are residential, and a per capita rate of about 198 gpcd (USBOR, 2003). It does not serve turf facilities. Depth to water in the seven system wells averages about 390 feet and water levels are reportedly stable. Big Park Water Company has an interconnection with Little Park Water Company. (BPWC and LPWC, 2007) Both companies have designations of Adequate Water Supply. In 2007, Big Park withdrew almost 880 acre-feet of water from six wells and delivered 0.3 acre-feet to Little Park Water Company, 684 acre-feet to residential and 150 acre-feet to commercial customers.

Camp Verde Water System, Inc.

The Camp Verde Water System is a private water company consisting of the larger Mongini System and smaller Verde River Estates System. There is no physical interconnection between

the two systems. There are a total of four active wells that serve both systems. In 2006, 460 acre-feet was withdrawn by the Mongini System, which served 265 acre-feet to residential and 183 acre-feet to commercial customers. Twelve acre-feet was withdrawn by the Verde River Estates System of which eight acre-feet was delivered to residential customers in 2007.

Cities of Cottonwood and Clarkdale

Prior to 2006, Cottonwood Water Works and Cordes Lakes Water Company were the two large private water companies serving the City of Cottonwood. The Cottonwood Water Works system also served the community of Clarkdale with a combined 4,600 connections of which 97% were residential. The Cordes Lakes Water Company served a population of almost 7,700 consisting of six separate systems in the Verde Village area. (A separate, smaller Cordes Lakes Water Company System serves the community of Cordes Lakes in the Agua Fria Basin). The estimated gpcd rate of Cottonwood was about 148 gpcd and Clarkdale about 193 gpcd (USBOR, 2003).

In 2006, the City of Cottonwood acquired four systems: Cottonwood Water Works, Cordes Lakes, Clemenceau and Verde Santa Fe. These systems withdrew a total of about 3,150 acre-feet of water from 28 wells in 2006. Separate deliveries to residential and non-residential customers were not reported on the 2006 Community Water System annual reports. In 2009, the City received a Designation of Adequate Water Supply for its water service area.

In 2007, The City of Clarkdale acquired the Cottonwood Water Works-Clarkdale system which served about 3,000 people and pumped about 400 acre-feet in 2006 (Cottonwood Water Works, 2007).

Town of Payson

The Town of Payson pumps groundwater from 32 active wells to about 14,000 residents. Most wells are located in the Verde River Basin and some are in the Tonto Creek Basin. It also supplies water to parts of the Tonto Apache Indian Reservation. The town estimates that there are also about 300 to 400 domestic wells operating within its service area. Because the local granite aquifer has limited storage capacity, Payson is drought-sensitive and dependent on sufficient rainfall and snowmelt for an adequate drinking water supply (City of Payson, 2007). Payson monitors water levels in its wells regularly to gauge water supply availability and has aggressive water conservation, effluent reuse and drought programs. Water levels in wells trigger the town's drought response. Payson's water demand declined by 7% between 2002 and 2003, which it attributes to conservation efforts (Maguire, 2005). In 2006 Payson withdrew 1,815 acre-feet from 35 wells. It delivered 31 acre-feet to the Tonto Apache Indian Reservation, 1,299 acre-feet to residential customers and 390 acre-feet to commercial customers.

About 80% of Payson's population is connected to the Northern Gila County Sanitary District sewer system that provides wastewater treatment for Payson and much of the surrounding area. Current system inflows are about 800,000 gallons daily, or 50% of capacity. The District's effluent is used for a variety of irrigation projects and ground water recharge, including the Green Valley Lake project. The 48-acre Green Valley Park was developed jointly by the Town of Payson Water Department and the Sanitary District. Treated effluent from the district's water treatment plant fills a 10.5-acre lake used for boating and fishing and adjacent irrigated areas and recreational facilities. (Payson Regional Economic Development Corporation, 2006) Another effluent recharge project, Rumsey Park, is in the pilot phase.

Table 5.0-13 Golf courses in the Central Highlands Planning Area (c. 2008)

Facility	Basin	# of Holes	Demand (acre-feet)	Water Supply
Cobre Valley Country Club - Globe*	Salt River	9	211	Groundwater
Chaparral Pines Golf Course - Payson	Tonto Basin	18	108/107	Groundwater/Effluent
Rim Golf Course - Payson	Tonto Basin	18	108/108	Groundwater/Effluent
Los Caballeros Golf Club - Wickenburg	Upper Hassayampa	18	423	Groundwater
Wickenburg Country Club	Upper Hassayampa	9	211	Groundwater
Beaver Creek Country Club - Lake Montezuma*	Verde River	18	490	Surface Water
Canyon Mesa Golf Course - Sedona*	Verde River	9	113	Groundwater
Forest Highlands	Verde River	36	150/150	Groundwater/Effluent
Oak Creek Country Club - Village of Oak Creek*	Verde River	18	701	Groundwater
Payson Golf Course - Payson	Verde River	18	132/309	Groundwater/Effluent
Pine Shadows - Cottonwood*	Verde River	9	98	Groundwater
Pinewood Country Club - Munds Park*	Verde River	18	270/269	Surface Water/Effluent
Poco Diablo Golf Course - Sedona*	Verde River	9	34	Surface Water
Sedona Golf Resort - Sedona*	Verde River	18	456	Groundwater
Seven Canyons Four Seasons Golf Course - Sedona	Verde River	18	423	Groundwater
Talking Rock - Northwest of Prescott*	Verde River	18	400	Groundwater
Verde Santa Fe - Cottonwood*	Verde River	18	401/55	Groundwater/Effluent

Source: ADWR 2000, ADWR 2008c
Notes:
* These golf courses are served by their own wells and considered to be industrial users

Golf course demand by municipal and industrial facilities, basin location and source of water is listed in Table 5.0-13. Total golf course demand was about 5,700 acre-feet in 2008, almost 7% of the total planning area demand. Effluent is an important water supply for golf course irrigation, accounting for 17% of the golf course demand in 2006. Municipal water providers served about 2,200 acre-feet to golf courses in 2008. Of this, 1,555 was groundwater and almost 680 acre-feet was effluent. Golf courses with their own facility wells, considered "industrial users", used about 2,400 acre-feet of groundwater, 800 acre-feet of surface water and 300 acre-feet of effluent in 2008. The demand of these golf courses is included in the industrial category. Most golf courses are located in the Verde River Basin.

Agricultural Demand

Agricultural demand in the planning area averaged about 37,500 AFA, or 45% of the total cultural demand during the 2001-2005 time-period. Most irrigation was for pasture. As listed in Table 5.0-14, there is agricultural demand in all basins but most (72%) was located in the Verde River Basin.

An estimated 6,400 acres were in agricultural production in the Verde River Basin, primarily in the Big Chino and Verde Valley sub-basins. Total demand was estimated at 27,100 AFA. The predominant crop grown was pasture, which is typically deficit irrigated. Groundwater was the primary supply in the Big Chino Sub-basin while surface water was predominantly utilized in the Verde Valley Sub-basin. Approximately 11,000 AFA of groundwater was withdrawn during 2001-2205 basin wide (USGS, 2007). An additional 15,200 AFA was diverted in the Verde Valley Sub-basin and 700 AFA in the Big Chino Sub-basin during this period. Detailed maps showing recent and historic irrigation in the Big Chino and Verde Valley sub-basins and much of the Verde Canyon Sub-basin are found

Table 5.0-14 Agricultural water demand in the Central Highlands Planning Area

	1991-1995 (acre-feet)	1996-2000 (acre-feet)	2001-2005 (acre-feet)
Agua Fria			
Groundwater	1,300	1,300	1,500
Total	1,300	1,300	1,500
Salt River			
Groundwater	<1,000	<1,000	<1,000
Surface Water	6,400	6,400	6,400
Total	6,900	6,900	6,900
Tonto Creek			
Groundwater	<1,000	<1,000	<1,000
Surface Water	1,000	1,000	1,000
Total	1,500	1,500	1,500
Upper Hassayampa			
Groundwater	<1,000	<1,000	<1,000
Total	<1,000	<1,000	<1,000
Verde River			
Groundwater	8,100	8,400	11,100
Surface Water	11,500	12,500	16,000
Total	19,600	20,900	27,100

Source: USGS 2007, ADWR 2005
Notes: Volumes <1,000 acre-feet assumed to be 500 acre-feet for computational purposes

in the Verde River Watershed Study Report (ADWR, 2000). This study also includes a description of the irrigation associations, including information on acreage, water supply and facilities. More recent maps of irrigated lands are found in the WAC and BOR Reports (WAC, 2004 and USBOR, 2003).

Most recent irrigation in the Big Chino Sub-basin is located along Big Chino Wash about 15 miles northwest of Paulden, along Williamson Valley Wash and near Paulden. A smaller number of acres have been irrigated in the Walnut Creek area near the western sub-basin boundary. Irrigation methods were predominantly flood or sprinkler irrigation. Pasture was the most prevalent crop as well as alfalfa, small grains and corn. (WAC, 2004)

About 30 irrigation associations recently diverted surface water in the Verde Valley Sub-basin. Most of the irrigated lands in the sub-basin were located along the Verde River or its major tributaries. During drought, approximately 1,200 irrigation wells in the Verde Valley may have been used to meet irrigation demands. Agricultural lands were located primarily along the Verde River north and south of Camp Verde, where a number of ditch companies have served water to about 2,800 acres. Irrigated lands were also located near the communities of Cornville and Page Springs. Pasture was grown on about two-thirds of the irrigated land. Other crops included alfalfa, corn, wheat, vegetables and orchards. (ADWR, 2000)

Although agricultural demand estimates are uncertain in parts of the planning area due to a lack of both reporting and recent field studies, it does appear that agricultural demand has declined in the Verde River Basin compared with demand prior to 1990. Agricultural demand may continue to decline in part due to groundwater transportation activities. In 2004, the City of Prescott, in partnership with the Town of Prescott Valley, purchased the JWK Ranch in the Big Chino Sub-basin for the anticipated purpose of retiring agricultural use and pumping groundwater to the Prescott Active Management Area pursuant to A.R.S.§ 45-555. The final determination of the allowable transportation volume has not been made.

Small areas of irrigated acreage were located in the Agua Fria Basin north of Cordes Junction and in the Upper Hassayampa Basin north of Wagoner (see Figures 5.1-11 and 5.4-10). An estimated 1,500 AFA of groundwater was withdrawn during 2001-2005

In the Tonto Creek Basin the Gisela Community Ditch Association has delivered surface water

diverted from Tonto Creek through a 3-mile long ditch to about 144 acres near the community of Gisela, east of Rye (see Figure 5.3-10). Reportedly, much more water was diverted than used due to system configuration, but the excess was assumed to return to the creek. Agricultural lands consisted of pasture and orchard. Some acreage may have been irrigated with groundwater. (ADWR, 1992) A relatively small amount of groundwater-supplied irrigation also occured in the lower reaches of Tonto Creek. A total of 1,500 AFA of groundwater and surface water was used during 2001-2005. The USGS recently estimated that about 270 acres were actively farmed in the Tonto Creek Basin (USGS 2007).

Annual agricultural demand in the Salt River Basin was estimated at about 7,200 acre-feet between 2001-2005 and was primarily associated with pasture irrigation for livestock raising operations. Most of the irrigated areas were in Pleasant Valley near Young and near the community of Fort Apache. An estimated 3,200 acre-feet of demand was located on non-reservation lands with about 650 acres in production. Approximately 2,700 acre-feet of surface water and 500 acre-feet of groundwater were used. Historically, small tracts of irrigated land were located throughout the basin including along the Salt River upstream of Roosevelt Lake, north of Globe and in the White Mountains. Recent field investigations have not been conducted in this basin and the USGS National Gap Analysis Program did not identify irrigated acreage in these areas (see Figure 5.2-10). Agricultural demand on the Fort Apache Indian Reservation was estimated to be about 3,700 acre-feet of surface water with 1,050 acres in production. Only about 20 acres were irrigated with surface water and 200 acre-feet of groundwater on the portion of the San Carlos Apache Indian Reservation located in the planning area, with an associated demand of about 70 AFA. (ADWR, 1992)

Industrial Demand

Industrial demand in the planning area averaged almost 18,300 AFA during the period 2001-2005. As summarized in Table 5.0-15, industrial demand consists of mining (including sand and gravel operations and cement production), golf course irrigation served by facility water systems and a dairy. These same use categories that are served

Table 5.0-15 Industrial water demand in the Central Highlands Planning Area

	1991-1995	1996-2000	2001-2005
Type/Basin	**Water Demand (acre-feet)**		
Mining Total	**17,900**	**14,100**	**14,160**
Salt River			
Groundwater	10,300	7,300	7,860
Surface Water[2]	6,300	6,600	4,900
Tonto Creek			
Groundwater	0	200	200
Verde River			
Groundwater	1,300	0	1,200
Golf Course Total	**2,910**	**3,010**	**3,334**
Salt River			
Groundwater	210	210	210
Verde River[1]			
Groundwater	1,900	2,000	2,000
Surface Water	800	800	800
Effluent	UNK	UNK	324
Dairy/Feedlot Total	**790**	**790**	**790**
Upper Hassayampa			
Groundwater	790	790	790
Total	**21,600**	**17,900**	**18,300**

Source: ADEQ 2005, ADMMR 2005, ADWR 2000, ADWR 2008c, USGS 2007
UNK = Unknown
[1] Two golf courses also received effluent, see Table 5.0-9 for more information.
[2] Most of the surface water diverted for mining in the Salt River Basin

by a municipal water system are accounted for as municipal demand. There was likely other industrial demand in the planning area associated with additional sand and gravel operations and other types of industrial uses that are not reflected in Table 5.0-15 due to a lack of data.

Most of the industrial demand during the 2001-2005 time period was copper mining-related operations in the Salt River Basin and surface water exported from the basin via the Black River to the Morenci Mine in the Southeastern Arizona Planning Area. Average mining demand during 2001-2005 was comparable to that during 1996-2000 although the proportion of surface water utilized declined. Mining activity has, however declined from pre-1996 levels. Water use by the mining sector varies depending on the quantity of material mined and how it is processed. Outside of the AMAs, water use by mines is generally not required to be disclosed. Mining has been an important industry in the planning area for many years with a number of mines commencing operation in the late 1800s and early 1990s. Historically significant mines no longer in operation include the Vulture Gold Mine near Wickenburg that was in production sporadically for about a hundred years beginning in 1864, and the United Verde Mine at Jerome/Clarkdale, which operated from 1876 to 1953. The United Verde Mine was at one time the largest copper mine in Arizona, producing three million pounds of copper per month. A number of smaller mining operations were located around Crown King and north of Castle Hot Springs in the Agua Fria Basin. While some existing mines have been out of production in recent years, mining may resume at some sites (e.g. Miami) if determined to be economically feasible.

Mining operations at the Miami Mine, currently owned by Freeport-McMoRan, began in 1910. Active mining has ceased and current (2009) activity involves smelter operations and a copper rod mill that produces continuous-cast copper rod used as the feedstock for the wire and cable industry. A planned 2008 restart of the mine was postponed due to economic conditions and the mine continues to be held on a care and maintenance status. (Freeport-McMoRan, 2009)

The BHP Pinto Valley Division includes the Pinto Valley Mine and the Miami Unit. The Pinto Valley Mine, an open-pit mine located northwest of Miami, began operation in 1974. Sulfide mining and milling operations ceased in 1998 although mining of a limited amount of waste rock continued. Full copper mining operations resumed in 2007, however by 2009, mining operations had been suspended and operations returned to care and maintenance (Home, 2009). The Miami Unit is a leach operation that recovers copper from the old Miami mine block cave area and leaching of the Miami No. 2 tailings pile (Phillips and others, 2000). The Miami unit is currently on care and maintenance status, although the SXEW unit is processing leach solutions that continue to be cycled through the leachable materials (Mining Technology, 2009).

The Quadra Carlota Copper Mine, an open pit mine located about six miles west of Miami, reopened in 2008. It produced ore intermittently from 1929 to 1964 (Mindat, 2009). The existing mine is a heap leach-solvent extraction-electrowinning (SXEW) operation that produces copper cathode. With an 11-year mine life, up to 75 million pounds per year of copper cathode may be produced (Quadra Mining LTD., 2009). Anticipated water use at the mine is estimated at 650 AFA (M3 Engineering & Techology Corp., 2006).

Available data for the most recent year (2007) show an estimated groundwater demand by mines in the Salt River Basin of approximately 7,200 acre-feet: 6,460 acre-feet at the Freeport-McMoran Miami Mine; 20 acre-feet at the BHP

Magma Miami Mine and 756 acre-feet at the BHP Pinto Valley Mine. There was no reported surface water use in the Miami area from 2004-2007. Annual water demand for 2001-2007 by each mine, as well as diversions from the Salt River Basin to the Morenci Mine are listed in Table 5.0-16.

In addition to metal mining, sand and gravel and cement operations are included in the mining category. During 2001-2005, an average of approximately 1,200 AFA of groundwater was used in the Verde River Basin by several sand and gravel operations and Phoenix Cement, a manufacturer of Portland Cement located near Clarkdale. A cement plant has recently commenced operations near Drake, northwest of Paulden, that may use about 80 acre-feet of water per year (Wirt, 2005).

As shown in Table 5.0-13, ten of the seventeen known golf courses in the planning area are "industrial" courses located primarily in the Verde River Basin. Industrial golf courses receive at least some water from facility wells and not from a municipal water provider. During 2001-2005, an average of more than 3,300 AFA was used by industrial golf courses. Of this total, groundwater demand averaged about 2,200 AFA. Three courses used a total of almost 800 acre-feet of surface water annually and two courses used a total of about 324 acre-feet of municipal effluent a year.

Cobre Golf Course, Salt River Basin. This golf course is one of the 10 golf courses in the basin served by its own wells and considered to be an "industrial" course.

The Parker Dairy, located east of Congress in the Upper Hassayampa Basin, began operations in 1987. It houses over 7,000 dairy cows and has an estimated annual groundwater demand of about 800 acre-feet.

5.0.8 Water Resource Issues in the Central Highlands Planning Area

A number of complex water resource issues exist in the Central Highlands Planning Area. Issues have been identified in water resource studies, by community watershed groups, through the distribution of surveys, and from other sources. Issues and planning, conservation and research activities are discussed in this section.

Table 5.0-16 Industrial mining demand in the Salt River Basin, 2001-2007

		2001	2002	2003	2004	2005	2006	2007
Mine	**Water supply**	**Water Demand (acre-feet)**						
Freeport-McMoran Miami[1]	groundwater	8,513	7,092	6,460	6,460	6,460	6,460	6,460
	surface water	54	14	119	na	na	na	na
BHP Miami	groundwater	na	na	na	na	300	20	20
BHP Pinto Valley	groundwater	483	425	367	586	899	945	756
Freeport-McMoRan Morenci (diversions to the Southeastern Arizona Planning Area)	surface water	5,314	5,219	6,448	5,245	5,372	4,970	271

1 2004-2007 demand not reported. Shown is demand estimated by the USGS
na = not available
Source: ADWR 2008

Planning and Conservation

Many communities in the planning area are facing rapid population growth in a region of the state where physical and legal access to water supplies creates significant challenges. These challenges have resulted in the formation of several community watershed groups, water resource studies and planning and drought response and water conservation efforts. Yavapai County is a major governmental entity in the planning area with the largest county land base. Because the County had a population of over 125,000 in the 2000 Census, it is required to include a water resource element in its General Plan. Its plan recognizes the need for public education and sees the county's role as a facilitator of sound water resource management practices. The Yavapai County Board of Supervisors, along with cities, towns, tribes and the Department of Water Resources created the Yavapai County Water Advisory Committee (WAC) to provide a water management strategy for Yavapai County. The goals of the county's general plan as they compare with the activities of the WAC are included in Yavapai County's General Plan.

The City of Cottonwood acquired private water companies to improve water resource management. The town is a participant in the WAC as are a number of communities in the Verde River Basin including Sedona, Clarkdale and Camp Verde.

The Town of Payson is the largest community in the planning area. Because its water system is drought sensitive and the community faces rapid population growth, the Town has undertaken a variety of water resource management activities. It has adopted ordinances that place conservation and no-impact requirements on new developments including prohibitions on swimming pools, turf and evaporative coolers in buildings over 3,000 square feet. It also imposes a water-development impact fee on new development. New residential subdivisions are limited to 20 lots and builders must provide their own sources of water without impacting Payson's water supplies (Maguire, 2005). Payson has a conservation water rate structure, a water conservation education program and a drought plan. Supply augmentation activities include using effluent for turf irrigation and groundwater recharge, and development of a program to transport 3,000 acre-feet of water from C.C. Cragin reservoir to Payson as provided for under the Arizona Water Rights Settlement Act.

Verde River Basin southwest of Sedona.

Local Drought Impact Groups (LDIGs) are county-level voluntary groups created to 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. To date, a group has been formed in Yavapai County. More information on LDIGs may be found at http://www.azwater.gov/dwr/drought/LDIG.html.

Watershed Groups and Studies

Several groups have formed in the planning area to address water resource issues. Among the most active groups are the Citizens Water Advocacy Group, Coconino Plateau Water Advisory Group, Mogollon Highlands Partnership, Northern Arizona Municipal Water Users Association, Upper Agua Fria Watershed Partnership, Verde Valley Water Users, Inc., Verde Watershed Association and the Yavapai County Water Advisory Committee. In 2005, Congress passed the Northern Arizona Land Exchange and Verde River Partnership Act, but to date no appropriations to fund the partnership have been made. A description of those groups that are part of the Department's Rural Watershed Initiative Program, including participants, activities and issues, is found in Appendix D. Two of the groups mentioned above and listed in Appendix D encompass more than one planning area. Primary issues identified by these groups that pertain to the Central Highlands Planning area are summarized as follows:

Growth:
- Unregulated lot splits
- Proposed growth in Mayer, Bensch Ranch, Spring Valley and elsewhere
- Thousands of private domestic wells and more pending
- Significant projected growth

Water Supplies and Demand:
- Limited and deep groundwater supplies
- Access to water development on public lands
- Limited groundwater data
- Limited supplies to meet projected demands
- Limited water resources to meet current demands
- Environmental, supply, treatment, transportation and financing costs associated with augmentation from C.C. Cragin reservoir
- Seasonal demand/peaking problems
- Potential impacts resulting from the transfer of Big Chino water to Prescott and Prescott Valley

Legal:
- Private water companies and domestic water improvement district conflicts
- Interbasin transfer conflicts resulting from Payson's ability to pump from two separate basins
- Unresolved Indian Water Rights settlements
- Subflow decision and impact on legal access to water

Water Quality:
- Water quality issues in Verde Valley
- Potential impacts from septic systems
- Ability to meet new arsenic standard

Funding:
- Limited funding resources for planning, projects, infrastructure and studies
- High cost of water augmentation projects
- Costs associated with hauling water
- Infrastructure needs for private and public water companies

Drought:
- Drought sensitive groundwater and surface water supplies
- Drought sensitivity in Pine and Strawberry

Environmental:
- ESA issues involving groundwater usage impacts on perennial streams
- Critical habitat area in Verde Valley for Willow Flycatcher
- Environmental issues pertaining to Fossil Creek and the Verde River
- Invasive species

Other:
- Poorly constructed and maintained infrastructure in some areas
- Competition between watershed groups for funding and technical support

A number of studies have been conducted in parts of the planning area, particularly in the Verde River Basin. Many of these studies were undertaken as a result of initiatives by watershed groups and communities. Some of the noteworthy regional studies have been mentioned in previous sections and an extensive list of studies are included in the references and suggested reading section found at the end of each basin section in this volume. In addition, several studies are in process or have recently been finalized. The USBOR along with Gila County, the Town of Payson and a number of participating agencies is finalizing the Mogollon Rim Water Resources Management Study, which covers the Payson, Pine, Strawberry and Star Valley area. Northern Arizona University used USGS geophysical data to construct a 3-D geologic model that represents the subsurface geologic framework within the Big Chino Subbasin and Prescott AMA. The model aids in understanding how groundwater flows within and between these areas (Fry, 2006) The USBOR in cooperation with Yavapai County WAC and the Department are in the process of developing the Central Yavapai Highlands Water Resource Management Study. The study group includes WAC members, NGOs and state and federal agencies.

The Natural Resources Conservation Service (NRCS) has produced a rapid watershed assessment (RWA) for three watersheds in the planning area: the Agua Fria River, Carrizo Creek and Hassayampa River watersheds. These watersheds extend beyond the planning area boundaries. 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 watershed based plans for the Salt, Upper Agua Fria and Verde Watersheds. These plans characterize and classify 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/).

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 36 water provider and jurisdiction respondents in the Central Highlands Planning Area, and 24 numerically ranked issues. Respondents were asked to rank 18 issues. Infrastructure issues, particularly inadequate capital to pay for infrastructure improvements, were ranked among the top five issues by many respondents. Future water supply concerns and drought problems also ranked relatively high (Table 5.0-17). At the time of the survey, concerns about the utility's ability to meet the new arsenic standard (with a compliance date of 2006) and lowering water tables near wells ranked relatively high as concerns; 33% and 25% respectively.

In a separate question, about half of respondents noted at least one drought impact. Primary drought impacts noted were increased demand, increased peak demand and lowered groundwater levels.

The Department conducted another, 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, 74 water providers in the Central Highlands Planning Area, with a total of approximately 60,600 service connections, were willing to participate and provide information on water supply, demand and infrastructure and to rank a list of seven issues.

Water providers were asked to rank 7 issues from 0 to 3 with 0 = no concern, 1 = minor concern, 2 = moderate concern and 3 = major concern. Of the 74 water providers that responded to the survey, 66 ranked issues. These respondents include some of the largest water providers in the planning area including the City of Globe, Payson Water Company, Big Park Water Company and City of Cottonwood.

Responses to the 2003 questionnaire are not directly comparable to the 2004 survey due to differences in the form and wording of the surveys. In addition, water quality and groundwater level conditions were not included as issues in the 2004 survey. Nevertheless, responses to certain issues are similar as shown in Table 5.0-16. The 2004 responses indicate that issues related to infrastructure, drought and inadequate supplies to meet future demands are the most prevalent concerns. The identification of drought related water supply problems was particularly the case for respondents in the Verde River Basin.

5.0.9 Groundwater Basin Water Resource Characteristics

Sections 5.1 through 5.5 present data and maps on water resource characteristics of the groundwater basins in the Central Highlands Planning Area. A description of the data sources and methods used to derive this information is

Table 5.0-17 Water resource issues ranked by survey respondents in the Central Highlands 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	8%	13%
Inadequate well capacity to meet peak demand	4	18
Inadequate water supplies to meet current demand	8	15
Inadequate water supplies to meet future demand	29	32
Infrastructure in need of replacement	21	36
Inadequate capital to pay for infrastructure improvements	33	38
Drought related water supply problems	21	38

Source: ADWR, 2004

Note: 2003 respondents consist of 19 water providers and 5 jurisdictions. 2004 respondents included 66 water providers

found in Section 1.3 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 5.1 through 5.5.

Geographic Features

Geographic features maps are included to present a 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 federal lands are typically maintained for a purpose with little associated water use. State owned land may be sold or traded, and is often leased for grazing and farming. The extent of state owned lands is due to a number of legislative actions. 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 educational purposes. Other legislation authorized additional state trust lands for specified purposes, which are identified for each basin (ASLD, 2006).

Climate

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

Surface Water Conditions

Depending on physical and legal availability, surface water may be a potential supply in a basin. 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.

Surface water maps display runoff contours and the location of reservoirs and gages. Also shown are 1st and 2nd order streams, and 3rd order streams with gages.

Criteria for including stream gage stations in the basin tables 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 sources of additional precipitation and flow information that can be used in water resource planning. Large reservoir storage information provides data on the amount of water stored in the basin, its uses, and ownership. Because of the large number of small reservoirs, and less reliable data, individual small reservoir data is not provided. The number of stockponds is a general indicator of small scale surface water capture and livestock demand. Runoff contours reflect the average annual runoff in tributary streams. They provide a generalized indication of the amount of runoff that can be expected at a particular geographic location.

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 accurately 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 each 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 Section 1.3. 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 5.0-5)

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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