Arizona Department
of Water Resources
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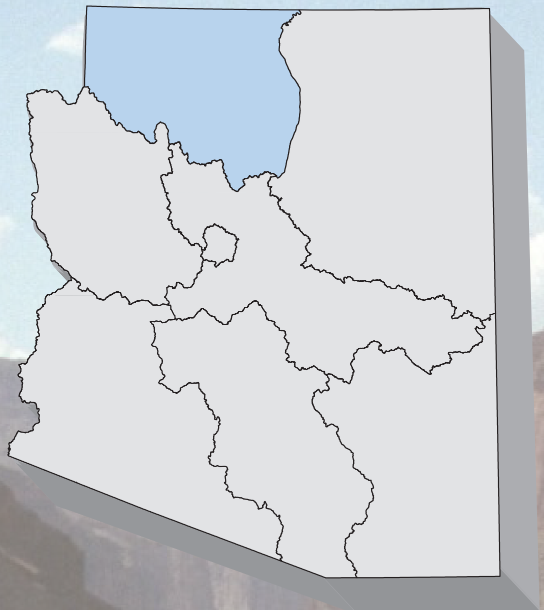
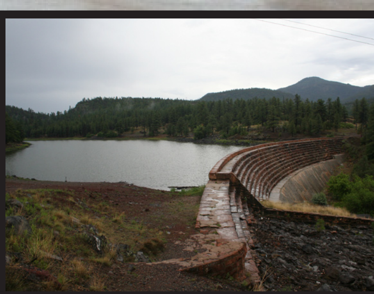
ARIZONA WATER ATLAS

VOLUME 6

WESTERN PLATEAU PLANNING AREA





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Special note about the Atlas Team
Completion of the Atlas would not have been possible without the dedicated professionals that compose the Atlas Team. Most have been involved with the project from its inception in 2003 and their contributions to the success of the project cannot be overstated.

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ARIZONA WATER ATLAS
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Preface

Volume 6, the Western Plateau Planning Area, is the sixth 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 6.0-1). There is a separate Atlas volume for each planning area, an executive summary volume composed of background information, and a resource sustainability volume. "Planning areas" are an organizational concept that provide for a regional perspective on supply, demand and water resource issues. A complete discussion of Atlas organization, purpose and scope is found in Volume 1. Also included in Volume 1 is general background information for the state, a description of data sources and methods of analysis for the tables and maps presented in the Atlas, and appendices that provide information on water law, management and programs, and Indian water rights claims and settlements.

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

6.0 Overview of the Western Plateau Planning Area

The Western Plateau Planning Area is composed of six groundwater basins located in northwestern Arizona. About half of the planning area lies in the part of Arizona north of the Colorado River referred to as the "Arizona Strip". The planning area contains large tracts of federally protected lands including almost all of Grand Canyon National Park. Elevations range from over 12,000 feet on the San Francisco Peaks to about 1,200 feet at Lake Mead. Nearly half (46%) of Coconino County and 38% of Mohave County are contained within the planning area as well as all or portions of four Indian reservations including the Havasupai, Hualapai, Kaibab-Paiute and Navajo.

The planning area is relatively sparsely populated. The 2000 Census planning area population was approximately 17,500 with basin population ranging from just 12 in the Shivwits Plateau Basin to over 9,100 in the Coconino Plateau Basin. Colorado City is the largest community with about 4,150 residents in 2006. Other population centers include Williams, Fredonia, Grand Canyon Village, the Beaver Dam/Littlefield area, and Cameron on the Navajo Reservation.

Between 2001 and 2005, an average of over 9,600 acre-feet of water was used annually in

Agriculture in the Kanab Plateau Basin. Agriculture is the largest water user in the Planning Area

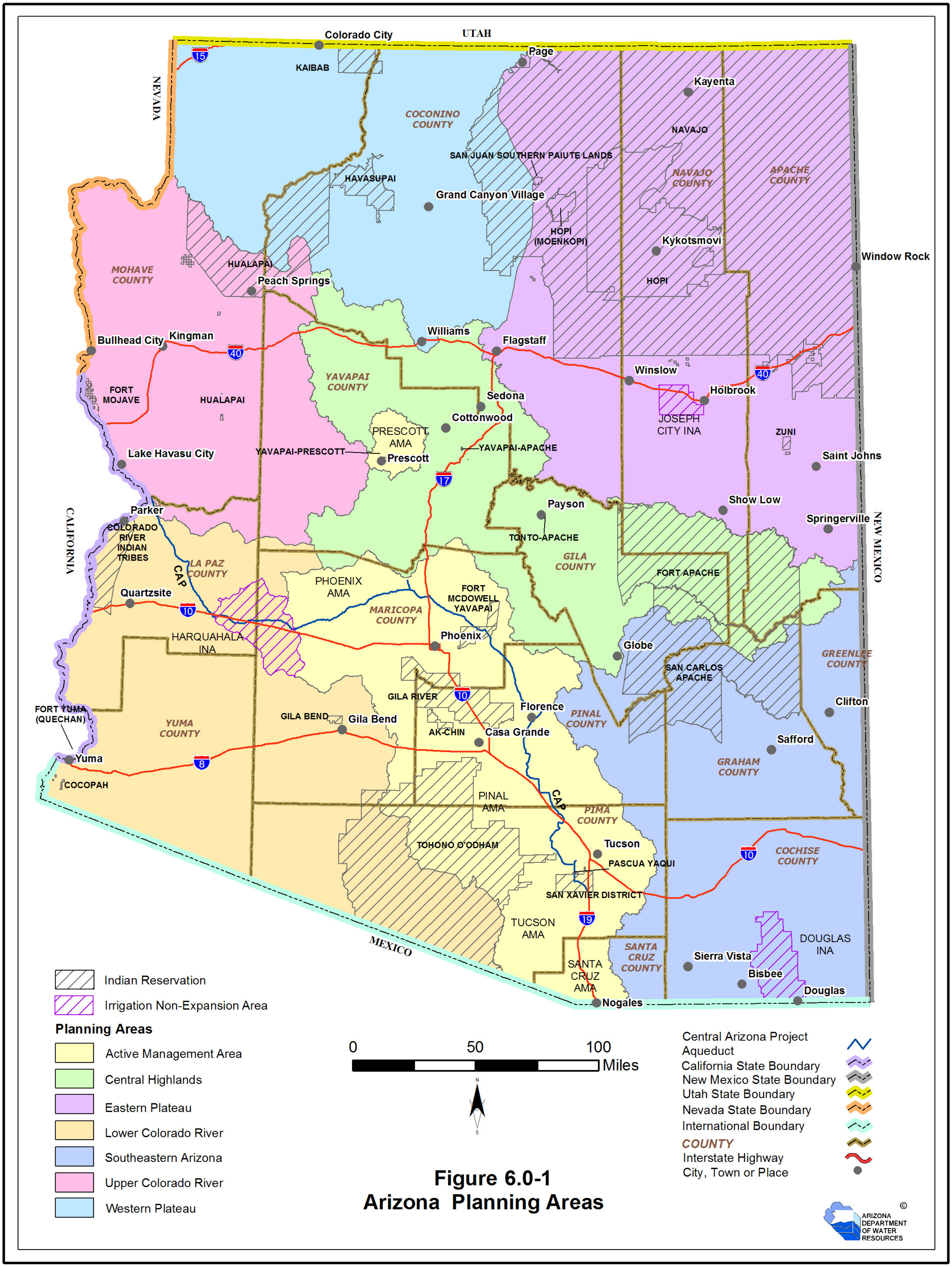


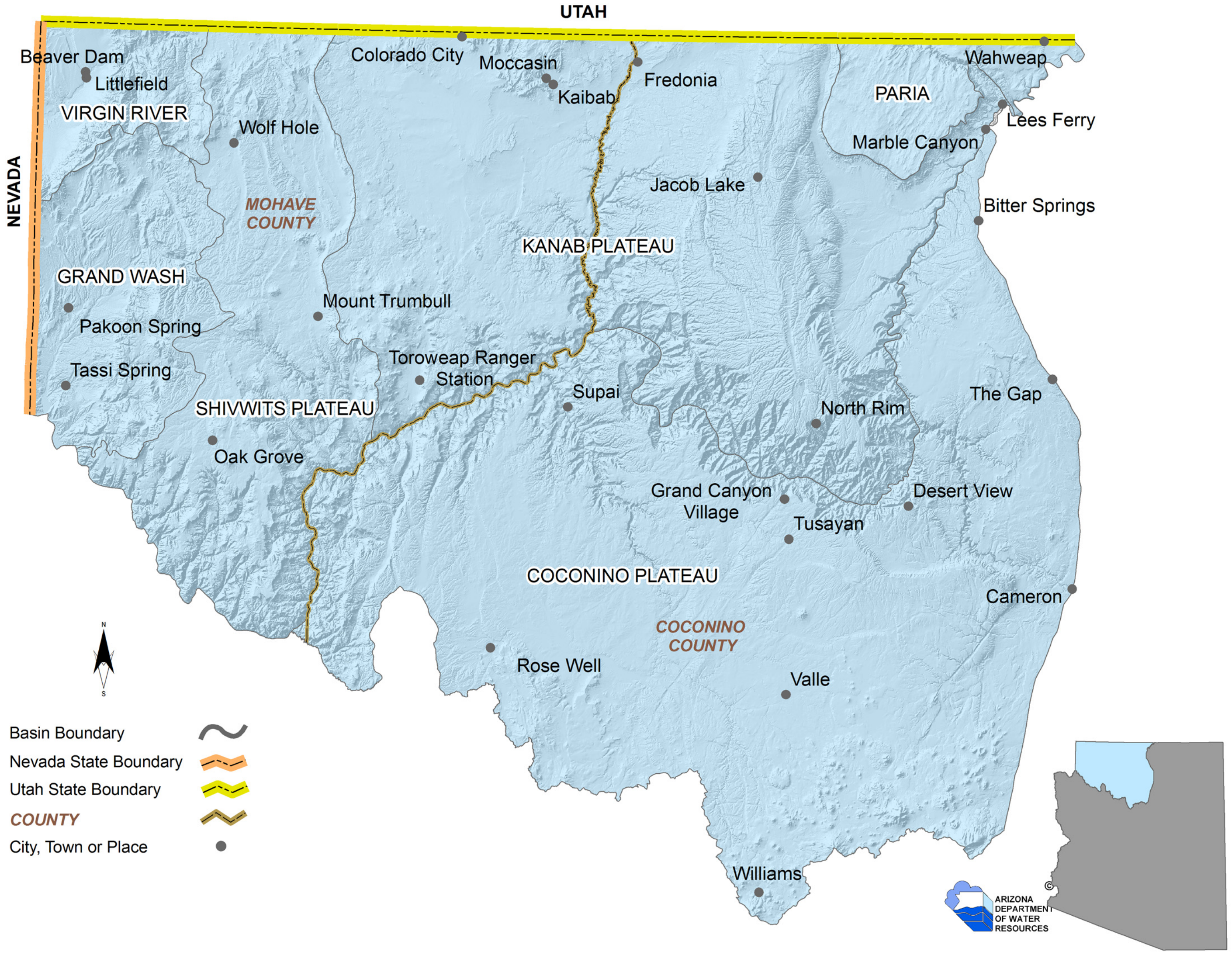
Figure 6.0-1
Arizona Planning Areas

the planning area for agricultural, municipal and industrial uses (cultural water demand). Of this total demand, approximately 6,000 acre-feet was from well pumpage, 3,300 acre-feet was from surface water diversions and almost 300 acre-feet was effluent reuse. Agriculture was the largest demand sector with approximately 4,600 acre-feet of demand a year or 52% of the total demand. The municipal sector demand averaged about 4,000 acre-feet a year (AFA) and industrial demand averaged almost 1,000 AFA.

6.0.1 Geography

The Western Plateau Planning Area covers about 13,700 square miles and includes the Coconino Plateau, Grand Wash, Kanab Plateau, Paria, Shivwits Plateau and Virgin River basins. Basin boundaries, counties and prominent cities, towns and places are shown in Figure 6.0-2. The planning area is bounded on the north by the State of Utah, on the east by the Eastern Plateau Planning Area, on the south by the Central Highlands and Upper Colorado River planning

Figure 6.0-2 Western Plateau Planning Area



areas and on the west by the State of Nevada (Figure 6.0-1). The planning area includes parts of three watersheds, which are discussed in Section 6.0.2. The Kaibab-Paiute Indian Reservation (188 square miles) and the Havasupai Indian Reservation (294 square miles) are located entirely within the planning area. In addition, the planning area includes the western portion of the Navajo Indian Reservation (1,177 square miles) and the northeastern portion of the Hualapai Indian Reservation (741 square miles) (Figure 6.0-1).

Almost all of the planning area is within the Colorado Plateau physiographic province characterized by generally horizontally stratified sedimentary rocks that have eroded into numerous incised canyons and high desert plateaus (Figure 6.0-3). The extreme western part of the planning area, encompassing the western portions of the Virgin River and Grand Wash basins, extends into the Basin and Range physiographic province, which is characterized by northwest-southeast trending mountain ranges separated by broad alluvial valleys. The Coconino Plateau Basin contains the largest elevational range in the planning area with elevations ranging from 1,400 feet where the Colorado River exits the basin in the Grand Canyon to over 12,000 feet in the San Francisco Peaks at the southeastern edge of the basin.

Figure 6.0-3 Physiographic Regions of Arizona

Data source: Fenneman and Johnson, 1946

A unique geographic feature of the planning area is the Grand Canyon, incised by the Colorado River and its tributaries over a 5-6 million year period. The average depth of the canyon is 4,000 feet over its 277 mile length, and 6,000 feet at its deepest point. Its average width is 10 miles. The geologic record at the Grand Canyon is unique in the variety of rocks and their exposure in the canyon walls, with nearly half of the earth's 4.6-billion-year history displayed (NPS, 2005).

Most rocks in the Grand Canyon date from the Paleozoic Era (550-250 million years ago) but there are scattered remnants of Precambrian Vishnu Schist as old as 2 billion years in age in the inner gorge. Western Plateau Plateau Planning Area geology including the location of Precambrian rocks in the Grand Canyon is shown in Figure 6.0-4. With the exception of Kaibab Limestone, younger Mesozoic and Cenozoic rocks (250 million years old to the present) are largely missing at Grand Canyon, having been either never deposited or worn away. The different rock layers in the canyon respond differently to erosion leading to the canyon's distinctive shape (NPS, 2005). Lava flows ranging in age from 1,000 to 1 million years old are found in the western part of the canyon.

The Grand Canyon and the Colorado River form a significant physical barrier between the Arizona Strip and the rest of the planning area and the state. Highway 89A at Navajo

Bridge and Highway 89 at Glen Canyon Dam are the only highways that span the Colorado River linking the Arizona Strip to the rest of the state. By contrast, there are a number of road links between the Arizona Strip and Utah. As a result, the Arizona Strip has strong historic, cultural and economic ties to Utah.

South and east of the Colorado River, the Coconino Plateau marks the southern edge of the Colorado Plateau which covers 130,000 square miles across southeastern Utah, northern Arizona, northwestern New Mexico, and western Colorado. The Coconino Plateau stretches east toward the Colorado River surface water divide and south to the Mogollon Rim, which is less well defined to the northwest, and defines the southern boundary of the Coconino Plateau Basin. Most of the Coconino Plateau is above 5,000 feet in elevation and consists of low hills, mesas, broad valleys and lava flows in the southern portion. The plateau is defined by large elevational changes along its margins, notably the south rim of the Grand Canyon (Bills and others, 2007).

In the northwest corner of the planning area, the Virgin River cuts through the Beaver Dam Mountains creating the Virgin River Gorge. West of the gorge, the topography abruptly changes to a broad alluvial valley with numerous washes that drain the upland and mountain areas. The Virgin Mountains, south of the river, form the southwest edge of the Colorado Plateau.

Vermilion Cliffs, Kanab Plateau Basin. The planning area includes numerous high plateaus, steep cliffs and deeply incised canyons.

Other significant geographic features are numerous high plateaus, steep cliffs, deeply incised canyons and few surface water features.

6.0.2 Hydrology[1]

Groundwater Hydrology

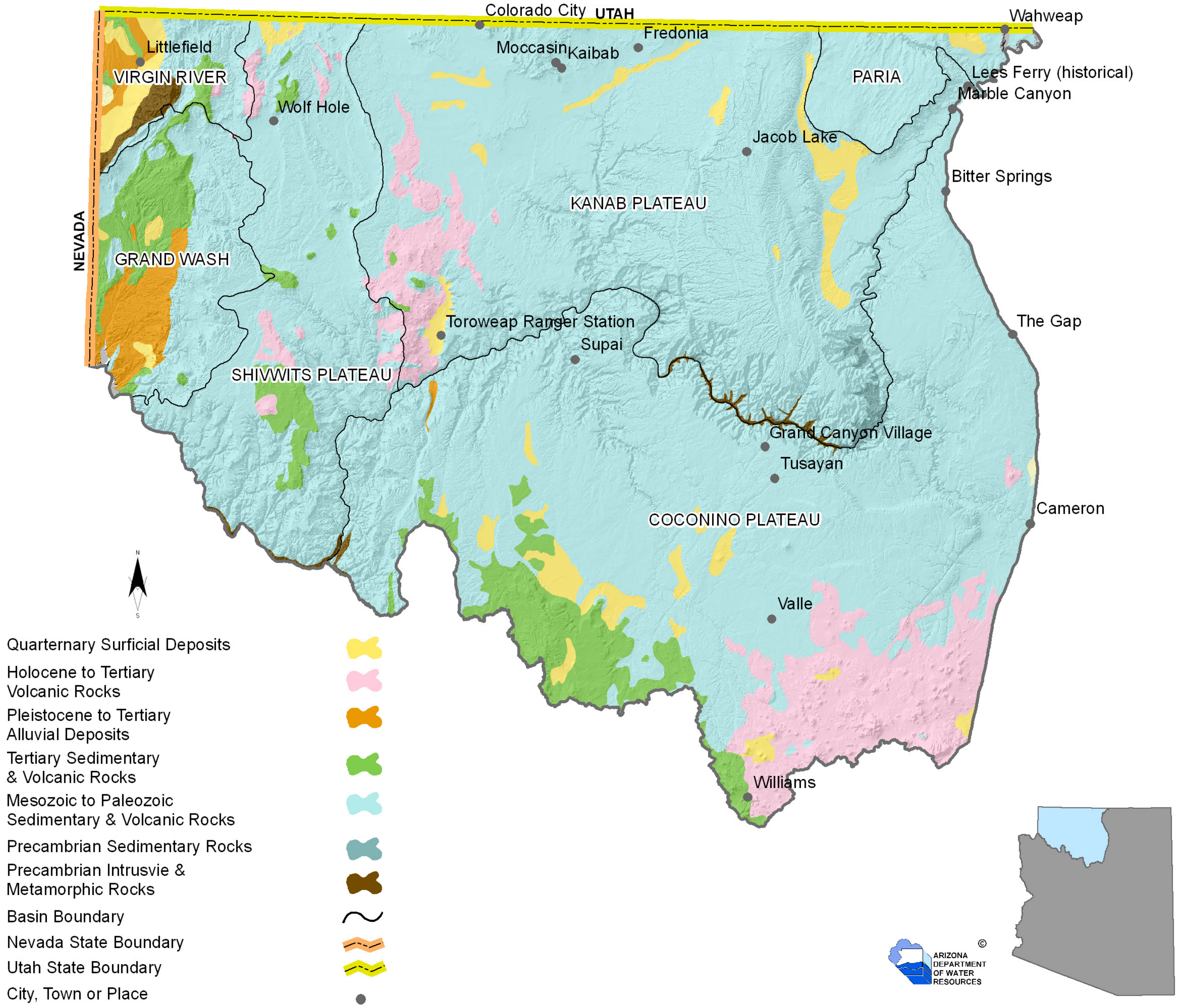
The Western Plateau Planning Area is characterized by relatively flat-lying, alternating sequences of sandstones, limestones and shales. As shown in Figure 6.0-4, Mesozoic to Paleozoic sedimentary and volcanic rocks cover most of the planning area. Faults and folds in these rocks affect groundwater movement along the regional gradient. The westernmost basins contain basin-fill sediments that consist of silt, sand and gravel. The characteristics of regional and local aquifers in the planning area are described below.

<u>Coconino Plateau Basin</u>

The Redwall-Muav (R or limestone) aquifer is the primary water-bearing unit of the Coconino Plateau Basin. The Kaibab, Coconino and Supai formations comprise the regional Coconino Aquifer (C-aquifer) that overlies the R-aquifer. The Moenkopi Formation volcanic rocks and unconsolidated sediments overlie the C- and R-aquifers and provide locally important sources of water. A generalized stratigraphic section of the Coconino Plateau that illustrates the relationship between these various units is shown on Figure 6.0-5. Perched aquifer zones in association with volcanic rocks occur primarily in the central and southern part of the basin and in consolidated sedimentary rocks west and northwest of the volcanic fields. These perched aquifers are dependent on recharge

[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 1994)

Figure 6.0-4 Surface Geology of the Western Plateau Planning Area
(Based on Reynolds, 1988)

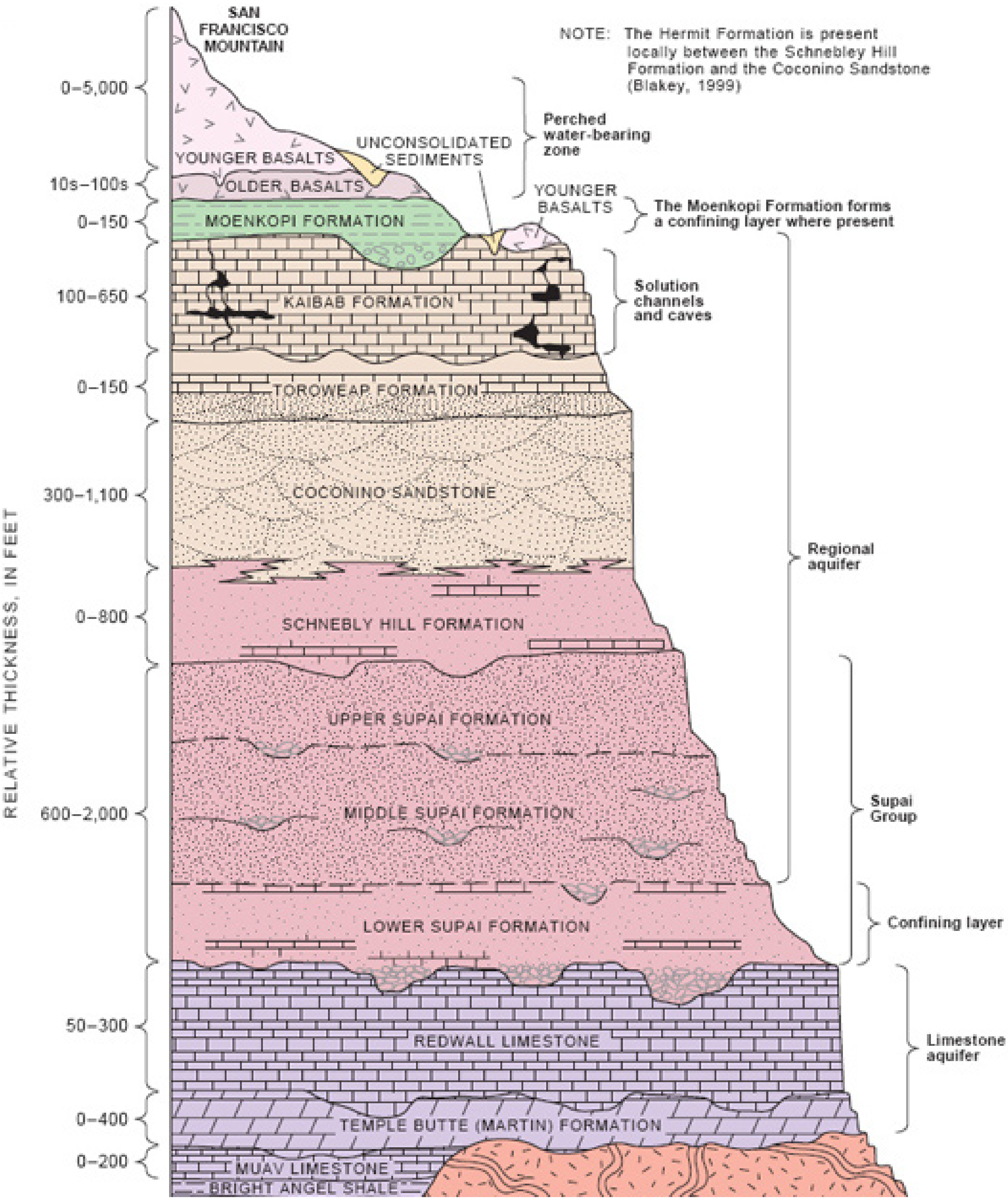


from precipitation and runoff and may be undependable water supplies. An exception is the "Inner Basin Aquifer" of the San Francisco Peaks where a water-bearing zone is contained in glacial outwash and volcanic rocks and is used by the City of Flagstaff as a water supply (USBOR, 2006).

The R-aquifer underlies the entire Coconino Plateau Basin with depths of greater than 3,000 feet below land surface (bls) in most areas (Bills and others, 2007). Relatively few wells have been completed in the R-aquifer in the basin due to its extreme depth. In the northeast part of the basin, the R-aquifer is in partial hydraulic connection with the C-aquifer through faults and other fractures. Shale units within the R-aquifer impede downward flow.

The C-aquifer, consisting of hydraulically connected sandstones, limestones and shales occurs primarily in the eastern portion of the basin. Although perched zones occur, it is largely drained of water in the rest of the

Figure 6.0-5 Generalized stratigraphic section of the Coconino Plateau, Arizona
(Bills and Flynn, 2002)



basin, coincident with the northeast-southwest trending Mesa Butte Fault (Bills and others, 2007). Infiltration of precipitation through volcanic rocks and the Kaibab Formation is the primary source of recharge to the C-aquifer.

Lateral movement of groundwater in the R- and C- aquifers occurs through fracture zones and solution cavities. In the northeastern portion of the Coconino Plateau Basin, groundwater moves relatively rapidly from the C-aquifer to the R-aquifer through solution channels and fractures (USBOR, 2006). Regional flow is generally northward toward the Grand Canyon where springs discharge along the Little Colorado and Colorado rivers and Havasu Creek (see Figure 6.1-7). Widely-spaced faults and folds also affect groundwater movement in the region. The Mesa Butte Fault and the Cataract Syncline direct flow to major discharge areas on the lower Little Colorado River at Blue Springs and in Cataract Canyon (Montgomery and others, 2000). The Blue Springs area is considered the primary groundwater drain from the Little Colorado River Basin, although the primary source of the water is not well known (Hart, and others, 2002). Local flow characteristics are poorly understood because of the complex geologic structure and because aquifer depths limit exploratory drilling and testing. The varying chemistry of springs and residence time for groundwater discharge suggests that water discharging from the R-aquifer is from many different recharge areas and follows different flow paths. (USBOR, 2006)

An annual natural recharge rate is not available for the basin. ADWR estimated that as much as 3.0 million acre-feet (maf) of water may be stored in basin aquifers based on assumptions by Montgomery and others (2000) of the plateau's area of about 10,000 sq. mi., average saturated thickness of 800 feet and an average specific yield of 0.1%. Their study area was larger than the basin but included most of it. Well yields in the basin are relatively low and depend on the occurrence of fractures, faults and solution channels. The median of well yields reported from 16 large diameter (>10 inches) wells was 45.5 gallons per minute (gpm).

Water levels in basin wells are typically quite deep. Tusayan's water supply plan reports water level depths of 2,347 and 2,425 feet in two system wells with well yields of 65-80 gpm (HydroResources, 2007). While water has been found in perched aquifers near Williams at depths less than 950 feet bls, yields from these more shallow wells are generally less than five gpm. At Williams, three of the four water system wells are drilled to depths exceeding 3,500 feet bls. Water level depths in these wells

City of Williams. At Williams, three of four water system wells are drilled to depths exceeding 3,500 feet bls.

are between 2,740 and 2,875 feet. Water in the deepest of the Williams wells is of poor quality with elevated metal concentrations, including arsenic, and high corrosivity (City of Williams, 2007).

Water quality is generally good in the basin but poor locally where there is leakage from overlying units or other factors. Water quality in the upper and middle parts of the C-aquifer is good, but generally degrades due to salts at increasing depths. Most of the water quality data shown in Table 6.1-7 is from springs where elevated levels of arsenic and total dissolved solids (TDS) were most commonly detected.

Pipe Springs National Monument. Water bearing units in this area include alluvium, Navajo Sandstone, the Kayenta and Moenave formations and the Shinarump Formation

Grand Wash Basin

The Grand Wash Basin in the western part of the planning area is located along the boundary of the Colorado Plateau and Basin and Range physiographic regions. Groundwater is found in recent stream alluvium, basin fill, and sedimentary rocks of the Muddy Creek Formation and underlying Cottonwood Wash Formation. The Muddy Creek Formation is composed of siltstones, sandstones and conglomerates with interbedded basaltic lavas in the northern part of the basin. The Cottonwood Wash Formation is composed of sandstones and siltstones.

There is a relatively well-defined basin-fill aquifer interbedded with basalt flows between Grand Wash and Gyp Wash (located west of the Grand Wash Cliffs, see Figure 6.2-1). This aquifer is underlain by the Muddy Creek Formation, which restricts the downward movement of water. This area was identified as favorable for groundwater development in a geohydrologic reconnaissance study of Lake Mead National Recreation Area conducted by the USGS (Bales and Laney, 1992).

Data on groundwater flow direction, annual natural recharge rate and groundwater in storage is not available for the basin. Recharge from precipitation or local surface runoff is assumed to be small. In the southwestern corner of the basin, surface water from Lake Mead has saturated adjacent rocks and deposits in quantities greater than pre-lake conditions. This saturated zone is estimated to extend less than half a mile inland from the lake (Bales and Laney, 1992).

Only 12 wells are registered in the basin. A median well yield is not available. Well yields were estimated to range from 0-500 feet by Anning and Duet (1994). Two wells measured in the basin report water level depths ranging from about 20 feet to over 500 feet bls (see Figure 6.2-6). Water quality is generally good although total dissolved solids concentrations equal or exceed drinking water standards at several springs (Table 6.2-4).

Kanab Plateau Basin

The Kanab Plateau Basin is characterized by high plateaus, plains and incised canyons. The basin contains a flat-lying to gently sloping sequence of alternating sandstones, limestones and shales. Groundwater is found in several aquifers composed of these sedimentary rocks, which are generally isolated and not hydraulically connected. Water bearing units in the vicinity of Pipe Spring National Monument include alluvium, Navajo Sandstone, the Kayenta and Moenave formations, and the Shinarump Formation (Truini and others, 2004). Groundwater also occurs in recent stream alluvium, including the Cane Beds area west of Moccasin.

Within the sedimentary rock aquifers, faults act as conduits for vertical and lateral groundwater movement. Major faults include the Toroweap and Sevier faults. Regional groundwater flow direction, annual natural recharge rate and groundwater storage data are not available for the basin. The median well yield reported for ten large diameter (>10gpm) wells was 70 gpm. Hydrographs are available for two basin wells - one completed in the Kayenta Formation at Moccasin, with a recent water level of 87 feet bls, and a second completed in “sedimentary rock” south of Fredonia with a recent water level of 611 feet bls (Figure 6.3-7). Elevated levels of TDS and lead have been measured at some well and spring sites (Table 6.3-7) although water quality is generally good for most uses.

Paria Basin

The geologic structure of the Paria Basin is typical of the Colorado Plateau with a gently-sloping sequence of limestone, sandstone and shale formations. The principal aquifer is the N-aquifer composed of Navajo Sandstone and the Kayenta and Moenave formations. In places on the Paria Plateau, precipitation collects in sand deposits in limited quantities and may be recovered from shallow wells (Bush and Lane, 1980). Groundwater movement is generally from south to north with discharge at springs in Paria River Canyon. Some groundwater moves south toward the Vermilion Cliffs, which form the southern basin boundary. An annual natural recharge rate is not available for the basin. Groundwater in storage is estimated at 1.5 maf.

Little groundwater development has occurred with only 12 wells registered in the basin. Department data indicate well yields ranging from 30 to 1,400 gpm with a median well yield of 520 gpm for three large diameter (>10gpm) wells. The two largest yields come from wells completed in sedimentary rocks. Water levels in basin wells are relatively deep, ranging from about 480 feet to 1,500 feet bls. Arsenic concentrations above the drinking water standard have been measured at a number of wells in the Wahweap area (see Table 6.3-7).

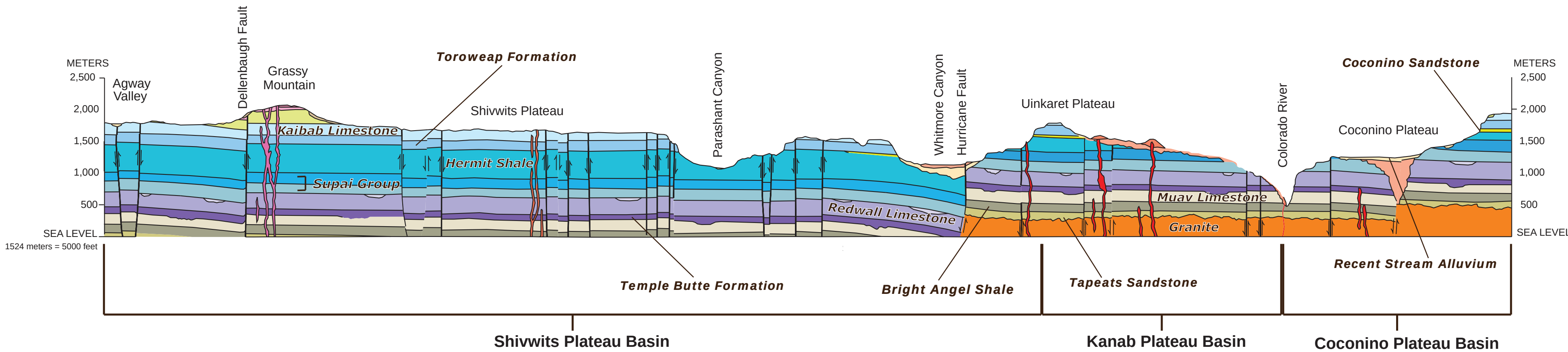
Shivwits Plateau Basin

Most of the Shivwits Plateau Basin is high plateau with elevations of 4,000 to 6,000 feet. The basin contains an alternating sequence of limestones, sandstones and shales with alluvial sands and gravels along larger washes and canyons. Figure 6.0-6 shows a cross section of the geology in the Shivwits Plateau, Kanab Plateau and the western portion of the Coconino Plateau basins. The cross section begins in the west-central portion of the Shivwits Plateau Basin (T33N, R12W) and follows a southeastern diagonal across the Shivwits Plateau and Kanab Plateau basins, ending just across the Colorado River in the Aubrey Cliffs in the Coconino Plateau Basin (T32N, R7W). The cross section provides the general location of the water bearing units beneath the region and their depth and thickness in particular areas. The diagram also shows the impact of the Hurricane Fault on the cross section occurrence of the geologic units.

Stream alluvium is the major aquifer in the basin but well yields are relatively low. A number of dry wells have reportedly been drilled into the sedimentary rocks but some encountered water in faults and fractures. Groundwater recharge occurs from infiltration of rainfall and snowmelt. Data on groundwater flow direction, annual natural recharge rate and groundwater in storage is not available for the basin.

There are only 18 registered wells in the basin. Department data indicate well yields ranging from 0 to 45 gpm with a median well yield of 5

Figure 6.0-6 Geologic cross section of the Shivwits Plateau, Kanab Plateau and Coconino Plateau Basins (modified from Billingsley and Welmeyer, 2003)



gpm for 17 large diameter (>10gpm) wells. Recent water levels in wells range from 10 feet bls to over 960 feet bls (see Figure 6.5-7). Water from springs and seeps is generally of better quality than well water, although the arsenic level at one spring exceeded the drinking water standard (Table 6.5-4).

Virgin River Basin

Located in the northwestern corner of Arizona, the Virgin River Basin contains a broad alluvial valley in the western half and the relatively high elevation Beaver Dam and Virgin Mountains in the south and east. Principal aquifers are basin fill in the Virgin River Valley and Beaver Dam Wash, and the Muddy Creek Formation. The mountainous portions of the basin are underlain by sedimentary and igneous rocks with little groundwater development.

The basin-fill aquifers are composed of a younger floodplain unit and an older underlying unit of semi-consolidated silts, sands, gravels and boulders. In the Virgin River Valley, the basin-fill aquifer contains floodplain and terrace alluvium southwest of Littlefield and includes alluvial-fan deposits from the Virgin Mountains. Groundwater is unconfined and flows toward the southwest. In Beaver Dam Wash, the basin-fill aquifer is largely isolated from other water bearing units in the basin and is also unconfined. Groundwater flow is toward the Virgin River Valley.

The Muddy Creek Formation consists of a series of siltstones, sandstones and conglomerates that is utilized as a water supply in the western part of the basin and by the City of Mesquite, Nevada adjacent to the basin along Interstate 15 (Black and Rascona, 1991). It is several thousand feet thick in places and covers the land surface over much of the basin north of the Virgin River. The Muddy Creek Formation is underlain by saturated Paleozoic carbonate rocks. South of the Virgin River, alluvial deposits from the Virgin Mountains overlie the Muddy Creek Formation.

Fault and fracture zones in the formation control groundwater movement and may have groundwater development potential (Dixon and Katzer, 2002).

Between Littlefield and the Virgin River Mountains and south of the Virgin River, a shallow, basin-fill aquifer overlies a limestone formation known locally as the Littlefield Formation. Few wells are completed in the shallow aquifer but a number of springs emanate from groundwater flowing over or through the Littlefield Formation (Black and Rascona, 1991).

Natural recharge is estimated at less than 30,000 AFA. Groundwater in storage is estimated to total 1.7 maf. Well yields range widely in the basin, as listed on Table 6.6-6, from a reported 10 gpm in the Virgin River basin-fill aquifer to over 5,000 gpm during a pump test in the Beaver Dam Wash basin-fill aquifer (Black and Rascona, 1991). The median of well yields reported from 53 large diameter (>10 inch) wells completed in the basin is 650 gpm. Water quality ranges from very good to poor, the latter due to elevated concentrations of arsenic, chloride, sulfate and total dissolved solids. Salt concentrations in groundwater increase downstream in the floodplain area along the Virgin River. Water quality data collected between 1997 and 2002 listed in Table 6.6-7 show elevated concentrations of arsenic, nitrate and radionuclides.

Virgin River Mountains and Virgin River Valley. Principal aquifers are basin fill in the Virgin River Valley and Beaver Dam Wash, and the Muddy Creek Formation.

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: Upper Colorado River-Lake Powell; Little Colorado River; and Lower Colorado River, Lees Ferry to Lake Mead (Figure 6.0-7).

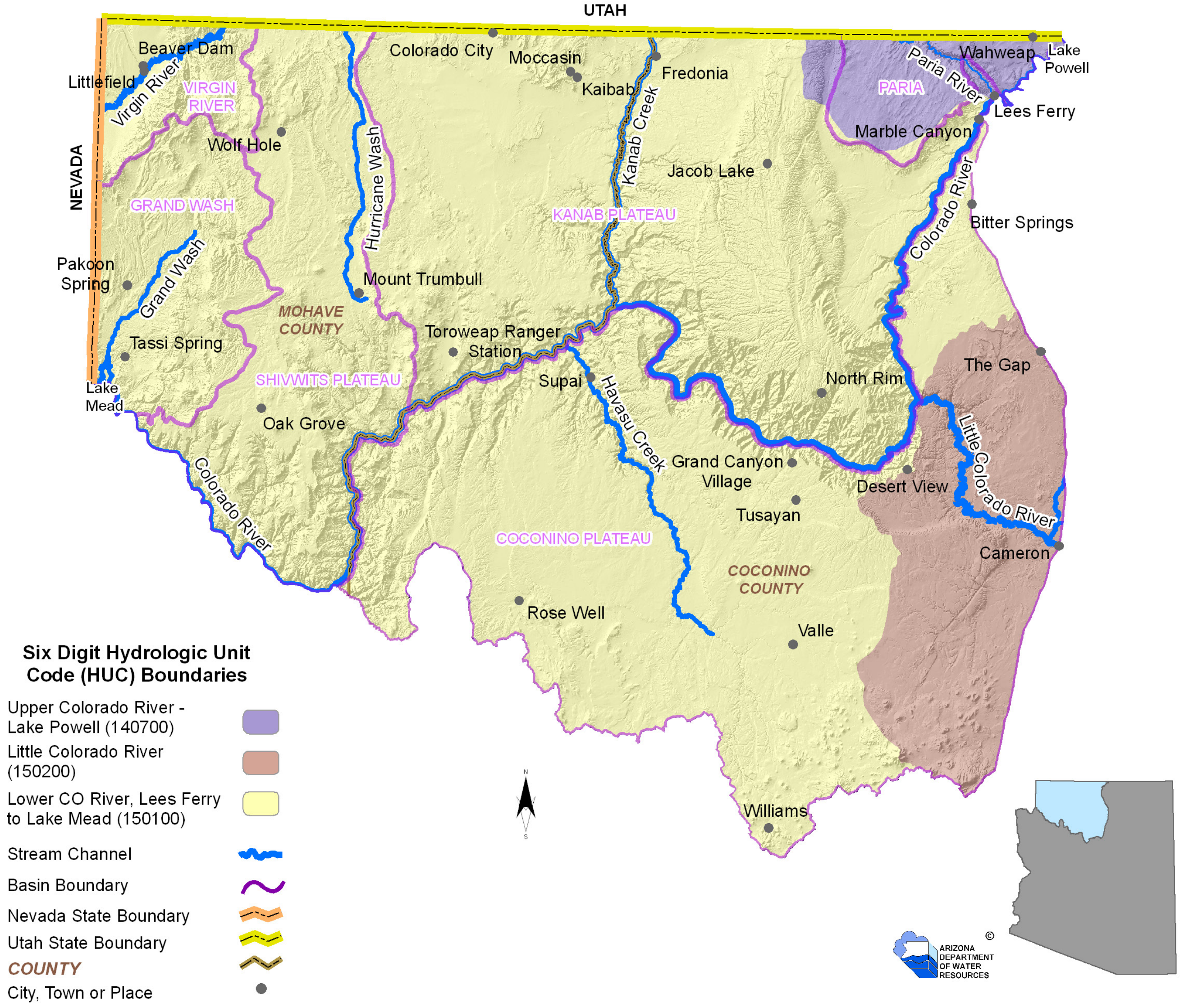
Upper Colorado River-Lake Powell Watershed

The boundary of the Upper Colorado River-Lake Powell Watershed in Arizona coincides generally with the Paria Basin boundary. It includes the Paria River Canyon and a small portion of the Kanab Plateau Basin. The Paria River originates in south-central Utah, draining an area of about 1,410 square miles before discharging to the Colorado River north of Lees Ferry. The annual flood series of the Paria River shows a decrease in flood peaks over the period 1909, 1924-2003. There have been no significant changes in basin diversions over this period, suggesting that construction of stockponds may be responsible (Webb and others, 2007).

The Paria River and the Colorado River are the only perennial streams in this portion of the watershed. The single streamflow gage in the watershed is located on the Paria River at Lees Ferry. With 79 years of record, the average annual flow is over 20,000 acre-feet and maximum flow was almost 48,000 acre-feet in 1980 (Table 6.3-2). There are two nearby gages on the west side of the Colorado River in the Eastern Plateau Planning Area; the Colorado River below Glen Canyon Dam and the Colorado River at Lees Ferry. The gage below Glen Canyon Dam was installed after dam construction and reflects regulatory/managed releases from Lake Powell. Prior to construction of the dam in 1963, the average flow was about 12.9 maf per year. The average annual flow at this gage is now 8.4 maf. Downstream, flow records at the gage on the Colorado River at Lees Ferry show an average annual flow of 20.3 maf. This gage has been in operation since 1921.

In May 1983, a heavy snowpack in the Upper Colorado River Basin combined with sudden warming and rainfall caused severe flooding along the Colorado River, forcing use of the Glen Canyon Dam spillways for the first time since dam completion in 1964. The total discharge peaked at 92,000 cubic feet per second (cfs) and the reservoir level topped out on July 15th, six feet below the crest of the dam (Hannon, 2003).

Figure 6.0-7 Western Plateau USGS Watersheds
(USGS, 2005)



By contrast, daily releases from Glen Canyon Dam in August 2009 were 13,000 cfs on average and, due to prolonged drought, the reservoir is projected to be at 65.8% capacity by the end of the water year on September 30, 2009 (USBOR, 2009). From 2000 though 2008, inflow to Lake Powell was below average in all but two years. Further, the average natural flow during this period for the Colorado River at Lees Ferry is the lowest nine-year average in over 100 years of record keeping on the Colorado River (USBOR, 2008).

Lake Powell provides water storage to meet flow obligations at Lees Ferry under the terms of the 1922 Colorado River Compact. (See Volume 1) The Compact apportioned to the Upper and Lower Basin states the beneficial consumptive use of 7.5 maf of water to each basin annually, measured at the Colorado River at the Compact Point near Lees Ferry. The reservoir has a total storage capacity of 27 maf, generally equivalent to the average annual flow of the Colorado River over a two-year period, making it the second largest reservoir in the country. The Glen Canyon Power Plant consists of eight generating units and provides most of the electrical energy generated by the Colorado River Storage Project. Total generating capacity is 1,296,000 kilowatts (USBOR, 2005).

There are no major springs (>10gpm) in the watershed although springs reportedly have supported domestic and stock watering uses in the Paria Basin (Bush and Lane, 1980). The Paria River has been identified as an impaired reach for its entire 29-mile length in Arizona, due to a high concentration of suspended sediments (ADEQ, 2005a), see Figures 6.3-10 and 6.4-9.

<u>The Little Colorado River Watershed</u>

The Little Colorado River Watershed extends over a large portion of northeastern Arizona, including most of the Eastern Plateau Planning Area. Within the Western Plateau Planning Area, this watershed covers the eastern portion of the Coconino Plateau Basin from The Gap and Desert View south toward Flagstaff. The Little Colorado River is the major drainage in the entire Coconino Plateau Basin, flowing east to west to join the Colorado River. The only perennial flow in this portion of the watershed is a 13-mile stretch of the Little Colorado River below Blue Springs.

Lake Powell near Wahweap. From 2000 though 2008, inflow to Lake Powell was below average in all but two years.

An active gage on the Little Colorado River at Cameron has been in operation since 1947. Flow is highest in the winter at this gage, with a median annual flow of over 138,000 acre-feet. Maximum annual flow at this gage was over 603,000 acre-feet in 1993 (see Figures 6.1-4 and 6.1-5 and Table 6.1-2).

The springs in the lower reach of the Little Colorado River, about 13 miles upstream of its confluence with the Colorado River, are sometimes collectively referred to as Blue Springs. Other sources refer to the main spring as Blue Spring. Discharge from the Blue Springs area is estimated at over 101,000 gpm, or about 164,000 AFA (Table 6.1-5). These springs emanate from solution channels in the R-aquifer while the discharge is thought to be downward leakage from the C-aquifer (Leake and others, 2005).

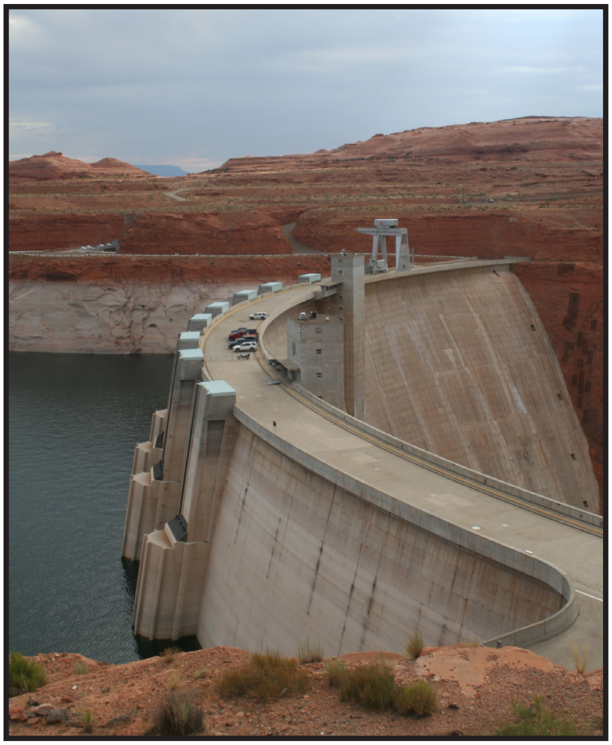
Lower Colorado River, Lees Ferry to Lake Mead Watershed

Most of the Western Plateau Planning Area is included in the Lower Colorado River, Lees Ferry to Lake Mead Watershed, which extends into the Upper Colorado River Planning Area. The watershed is drained by the Colorado River, which flows southwest from Lake Powell to Lake Mead. There are a number of perennial streams in the Kanab Plateau Basin that flow to the Colorado River including Kanab, Bright Angel, Nankoweap, Shinumo and Tapeats Creeks. None of these streams have flow gages. In the Coconino Plateau Basin, major perennial tributaries are Havasu and Diamond creeks. West of Diamond Creek, the only perennial flows are the Virgin River, which flows through the planning area from its headwaters in Utah to Lake Mead in Nevada, and an approximately one-mile reach of a tributary, Beaver Dam Wash.

Flow in the Colorado River downstream from Lake Powell is controlled by releases from Glen Canyon Dam, which has significantly impacted flow volumes and historic seasonal variations in flow as mentioned in the previous watershed discussion. There are five streamflow gages along the Colorado River in this watershed. The three easternmost gages are located above the Little Colorado River and near Bright Angel Creek (see Figure 6.3-5). These gages have varying periods of record and show average annual flows of 8.5 to 11.2 maf a year. A gage with 79 years of record (Colorado River near Grand Canyon, Table 6.3.2), the only pre-dam gage, has the highest mean flow (11.2 maf) and highest maximum flow of 20.5 maf in 1984. The two westernmost gages are located near Havasu Creek and Diamond Creek (see Figure 6.1-5) and are post-dam gages. The only currently operating gage (above Diamond Creek) has a similar flow regime to the other post-dam gages in the watershed with a mean flow of 10.4 maf and a maximum flow of 15.97 maf (Table 6.1-2).

Prior to construction of the Glen Canyon Dam, flow in the Colorado was highly unpredictable with wide year-to-year variability and spring flooding. Operation of the dam for electrical generation requires large water releases with daily and weekly fluctuations and releases during historically low flow seasons. Provisions of the Record of Decision (1996) for the Glen Canyon Dam Final EIS and the Glen Canyon Dam Operating Criteria (1997) set restrictions on daily and hourly flows. The maximum flow may not exceed 25,000 cfs except for beach/habitat-building flows, habitat maintenance flows, or when necessary during above average hydrologic conditions. Minimum flows are restricted to 5,000 to 8,000 cfs depending on the time of day. Further, daily fluctuation limits are 5,000 cfs to 8,000 cfs depending on monthly release volumes. (USBOR, 2008)

A tree-ring-based reconstruction of over 500 years of Colorado River streamflow found as many as eight droughts similar in severity to the



Glen Canyon Dam. Flow in the Colorado River downstream from Lake Powell is controlled by releases from the dam.

2000-2004 drought period. The reconstruction also suggests that the last 100-year period was wetter than the average for the last five centuries, and that average annual flows regularly vary from one decade to the next by more than 1.0 maf. The most severe sustained drought (based on the lowest 20-year average) in the Upper Colorado River basin apparently occurred in the last part of the 16th century. (Meko and others, 2007)

The other major river in the watershed is the Virgin River, which drains an area of about 6,100 square miles. The river flows from its headwaters north of Zion National Park in Utah to Lake Mead. Prior to construction of Hoover Dam it flowed to the Colorado River. Now, its lower 20-30 mile former reach has been inundated by the Overton Arm of Lake Mead. Dixon and Katzer (2002) estimated the Virgin River outflow to Lake Mead at 132,000 AFA.

The entire reach of the Virgin River within Arizona is perennial (AGFD, 1997). Reportedly, there were historic periods of no flow in the Virgin River above the Littlefield Springs (Figure 6.6-6), a collection of eight springs located over a distance of seven miles between the Narrows and Littlefield gages (see Figure 6.6-5 for gage location). These periods of no flow were determined from a gage installed upstream of the Littlefield Springs (1951-1956 and 1976) and were caused by irrigation diversions near St. George, Utah and seepage losses near Bloomington, Utah. (Trudeau and others, 1983) Substantial seepage losses from the Virgin River to the groundwater system between the near St. George and Bloomington gages were reported by Trudeau (1979). This reach begins about a half mile north of the Arizona border and extends to St. George. However, post-1990 gage data and seepage measurements suggest that the historical seepage losses to the groundwater system in Utah are no longer occurring (Cole and Katzer, 2000).

In Arizona, seepage losses between 10 to 35 cfs were estimated upstream of the Narrows gage (Cole and Katzer, 2000). Flow lost from the Virgin River to the groundwater system reenters the river via discharge from the Littlefield Springs. Measuring discharge rates at the springs is difficult because they are located in the Virgin River channel and can only be observed during low flow when the sediment load is near zero (Dixon and Katzer, 2002). An estimated 20 to almost 70 cfs (14,500 to 50,700 AFA) reenters the Virgin River via springs and groundwater discharge between the Narrows and Littlefield gages (Cole and Katzer, 2000). Since 1998 average annual flow in the Virgin River above the Narrows gage has been about 92,600 acre-feet. Below the Narrows gage, average annual flow increases to 174,502 acre-feet at the Littlefield gage, with a 72 year period of record.

The short perennial reach of Beaver Dam Wash is supported by springs that collectively discharge over 1,100 gpm. Beaver Dam Wash discharges to the Virgin River north of the Littlefield gage.

A number of major springs issue from the Redwall and Muav limestones and to a lesser extent, the Tapeats Sandstone, in the vicinity of the Colorado River in the Kanab Plateau

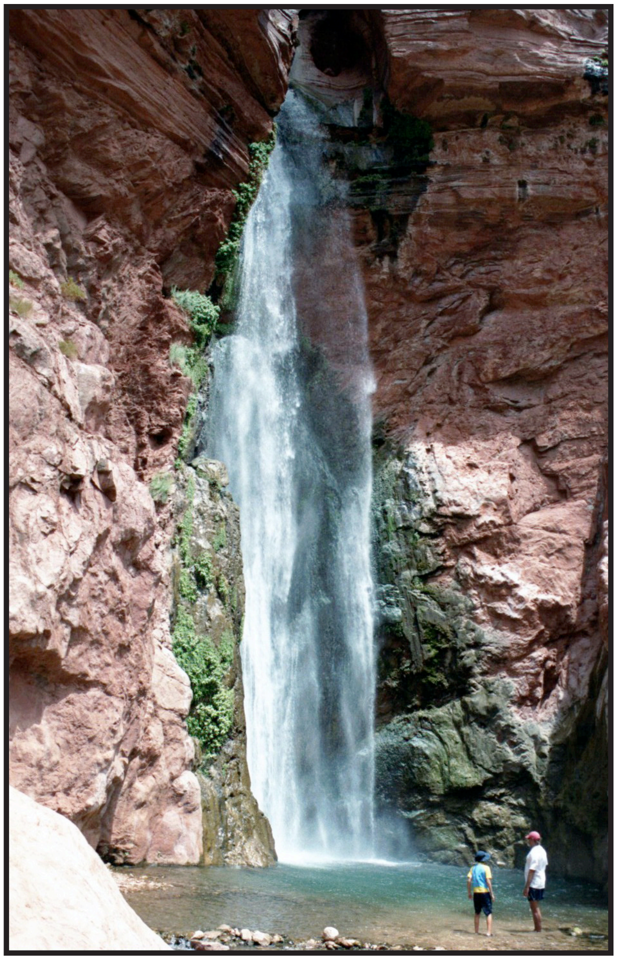
Virgin River near Littlefield. Average annual flow in the Virgin River above the Narrows gage is about 92,600 acre-feet.

and Coconino Plateau basins. The largest are Havasu Springs in the Coconino Plateau Basin with a discharge of about 28,500 gpm, and Tapeats Spring in the Kanab Plateau Basin with a discharge of about 18,700 gpm. Havasu Creek is perennial below Havasu Spring, located upstream of the village of Supai, and contains moderate levels of calcium, magnesium and bicarbonate from the springs. Calcium carbonate precipitates out of the spring water, forming travertine deposits along the creek bottom/bed.

A major flash flood event occurred on Havasu and Cataract Creeks from August15th- 17th, 2008, causing severe damage to Supai Village and nearby campgrounds on the Havasupai Reservation and stranding tourists and residents. Estimated flood flows were 6-7000 cfs. In response, two streamflow and precipitation gages were installed upstream to provide timely and accurate flood warnings to the Havasupai Nation and campgrounds along Havasu Creek.

Roaring Springs, located 3,000 feet below the North Rim, emanates from a cave in the Muav Limestone above the intersection of the Roaring Springs and Bright Angel faults. It has a discharge of almost 2,000 gpm and is the water supply for the North and South Rims of Grand Canyon National Park (USBOR, 2002).

A group of major springs with discharge rates between 11 and 90 gpm are found in the vicinity of Moccasin and Kaibab in the north-central part of the Kanab Plateau Basin. Studies at Pipe Spring National Monument indicate that spring discharge is from a sandstone unit of the Kayenta Formation. Fine-grained sediments below the unit create a confining layer that restricts vertical water movement and forces groundwater to move along bedding planes and fractures in the Navajo Sandstone and the upper unit of the Kayenta Formation. In the monument, discharge at Pipe Spring declined between 1976 and 2003 but increased at Tunnel Spring for reasons that are unclear. The combined spring discharge declined about 0.5 gpm per year between 1986 and 2001 (Truini and others, 2004).



Deer Creek Falls, created by Deer Creek Spring (3,542 gpm) in the Kanab Plateau Basin. A number of major springs issue from the Redwall and Muav limestones and to a lesser extent, the Tapeats Sandstone, in the vicinity of the Colorado River in the Kanab Plateau and Coconino Plateau basins.

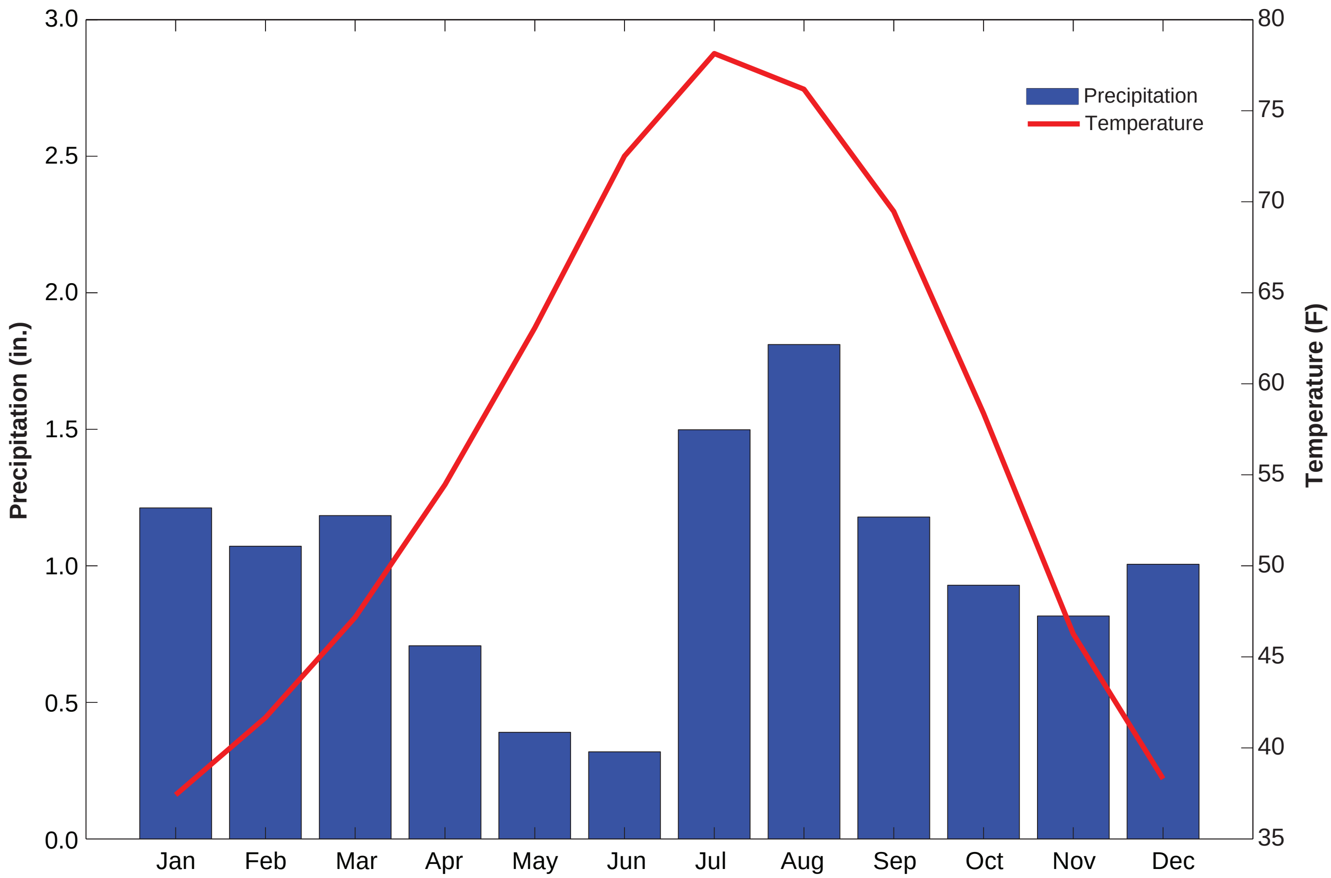
A handful of major springs are found in the other basins in the watershed. In the Grand Wash Basin, three major springs, (Tassi, Whiskey and an unnamed spring) discharge from the basin-fill aquifer where it overlies a confining unit, the Muddy Creek Formation (Bales and Laney, 1992). This may be the case with other springs in the basin. The only major spring in the Shivwits Plateau Basin, with a measured discharge of 331 gpm is found at the mouth of Spring Canyon at the Colorado River.

There are two impaired stream reaches in the watershed. Twenty-eight miles of the Colorado River from Parashant Canyon to Diamond Creek are impaired due to selenium and suspended sediment concentrations (Table 6.1-7). These same constituents are responsible for the impairment designation of ten miles of the Virgin River from Beaver Dam Wash to Big Bend Wash (Figure 6.6-10).

6.0.3 Climate[2]

The average annual temperature of the Western Plateau Planning Area (57.9°F) is somewhat cooler than the statewide average (59.5°F). Average annual precipitation in the planning area is 12.1 inches, the same as the statewide average. Annual totals vary widely across the area, from 6-9 inches at low elevations (less than 5,000 ft.) and rain shadow stations such as Wahweap, Fredonia, and Beaver Dam, to greater than 20 inches at Williams and Bright Angel Ranger Station in Grand Canyon National Park. On average, the Western Plateau Planning Area exhibits the bi-modal precipitation pattern characteristic of Arizona (see Figure 6.0-8); however, the northwestern part of the planning area, near the borders of Nevada and Utah, exhibits a stronger late winter peak, whereas the eastern and southern part of the area shows a stronger summer peak.

Figure 6.0-8 Average monthly precipitation and temperature from 1930-2002



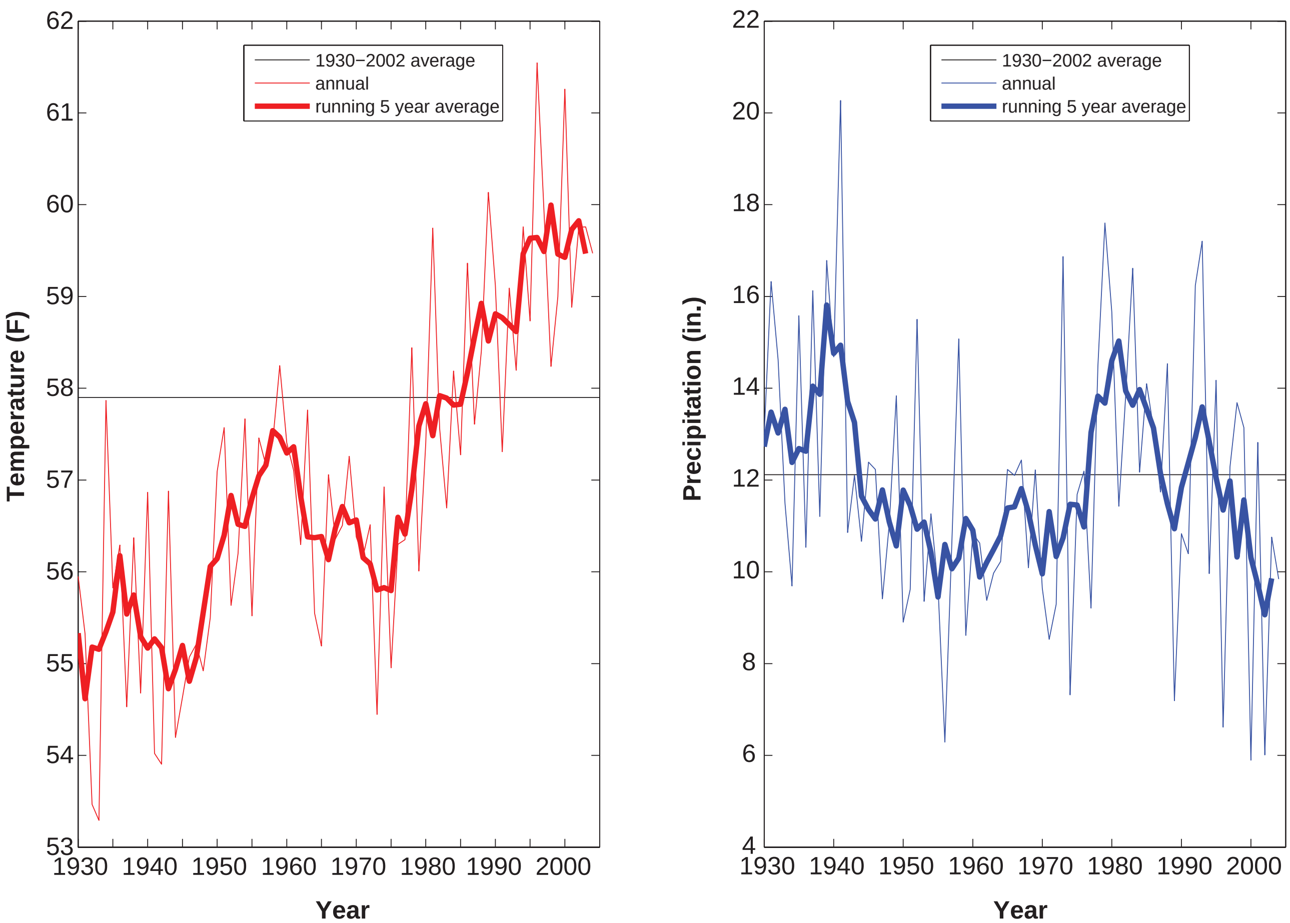
Data are from the Western Regional Climate Center. Figure author: CLIMAS

[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, September 2007

Frontal storm systems moving west-to-east, guided by the jet stream, deliver the area's winter and spring precipitation. Summer monsoon thunderstorms arrive later in this part of the state than elsewhere, and August is clearly the peak month, on average, for summer precipitation. However, year-to-year summer precipitation variability is pronounced, with some years showing July peaks. The area shows a strong response to the El Niño-Southern Oscillation, with El Niño winters registering wet conditions 52% of the time and dry conditions less than 30% of the time; La Niña winters are dry 54% of the time and wet only 21% of the time.

Average annual temperatures in the Western Plateau Planning Area have been increasing since the 1930s, and especially rapidly since the mid-1970s (see Figure 6.0-9). The long-term trend is superimposed on decadal variability generated primarily by Pacific Ocean and atmosphere variations. Decadal variations are particularly obvious in the instrumental record of precipitation. Drought conditions are apparent for the decades of the 1940s-early 1970s and since the mid-1990s, whereas the 1930s and mid-1970s through the mid-1990s were relatively wet.

Figure 6.0-9 Average annual temperature and total annual precipitation for the Western Plateau Planning Area from 1930-2002



Horizontal lines are average temperature (57.9 °F) and precipitation (12.1 inches), respectively. Light lines are yearly values and highlighted lines are 5-year moving average values. Data are from the Western Regional Climate Center. Figure author: CLIMAS.

Winter precipitation records dating to 1000 A.D., estimated from tree-ring reconstructions, show extended periods of above and below average precipitation in every century (Figure 6.0-10). Notably dry periods include the late 1500s, which feature the driest decade in this part of the state, and the late 1200s. The Western Plateau Planning Area was relatively wet during the late 1400s, early 1600s, and early 1900s.

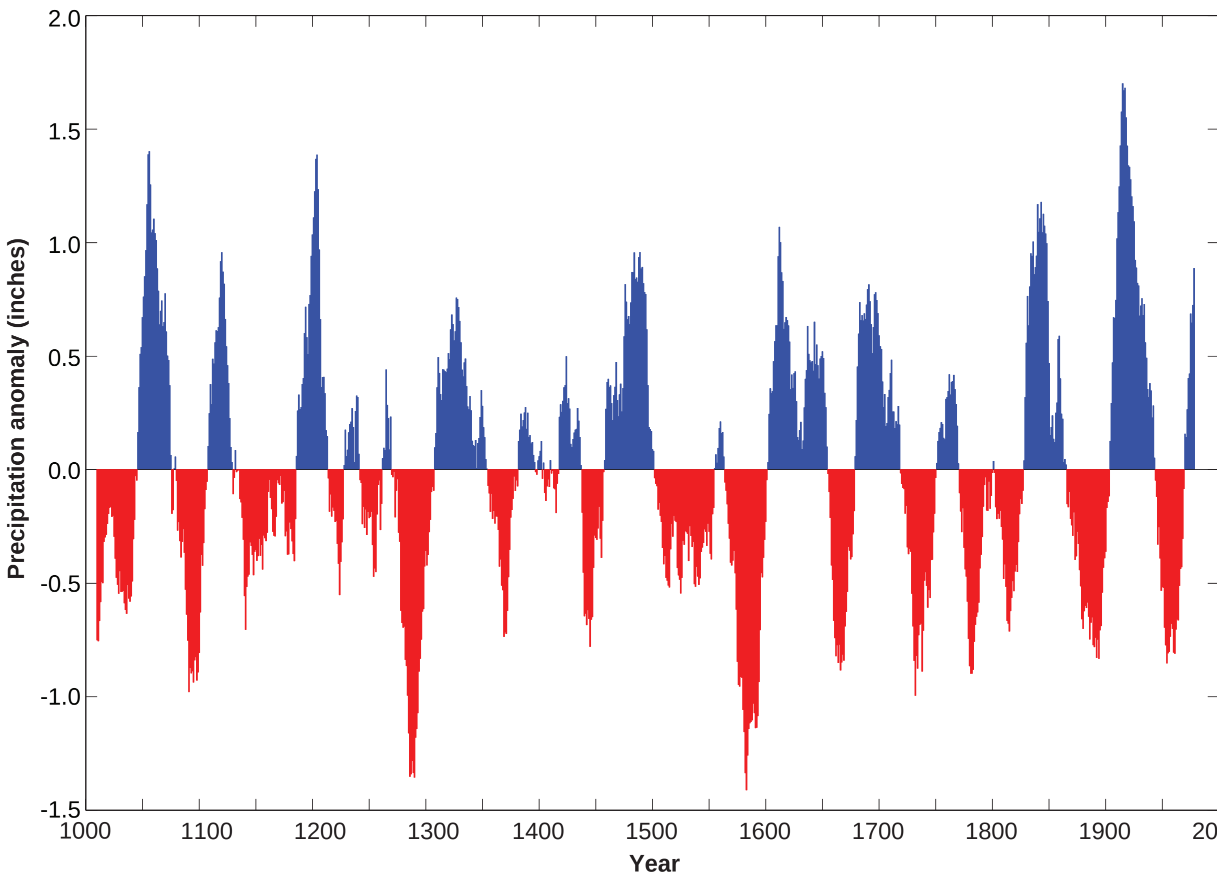
6.0.4 Environmental Conditions

Environmental conditions reflect the geography, climate and cultural activities in an area 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 parks, monuments, recreation areas and wilderness areas, and managed waters.

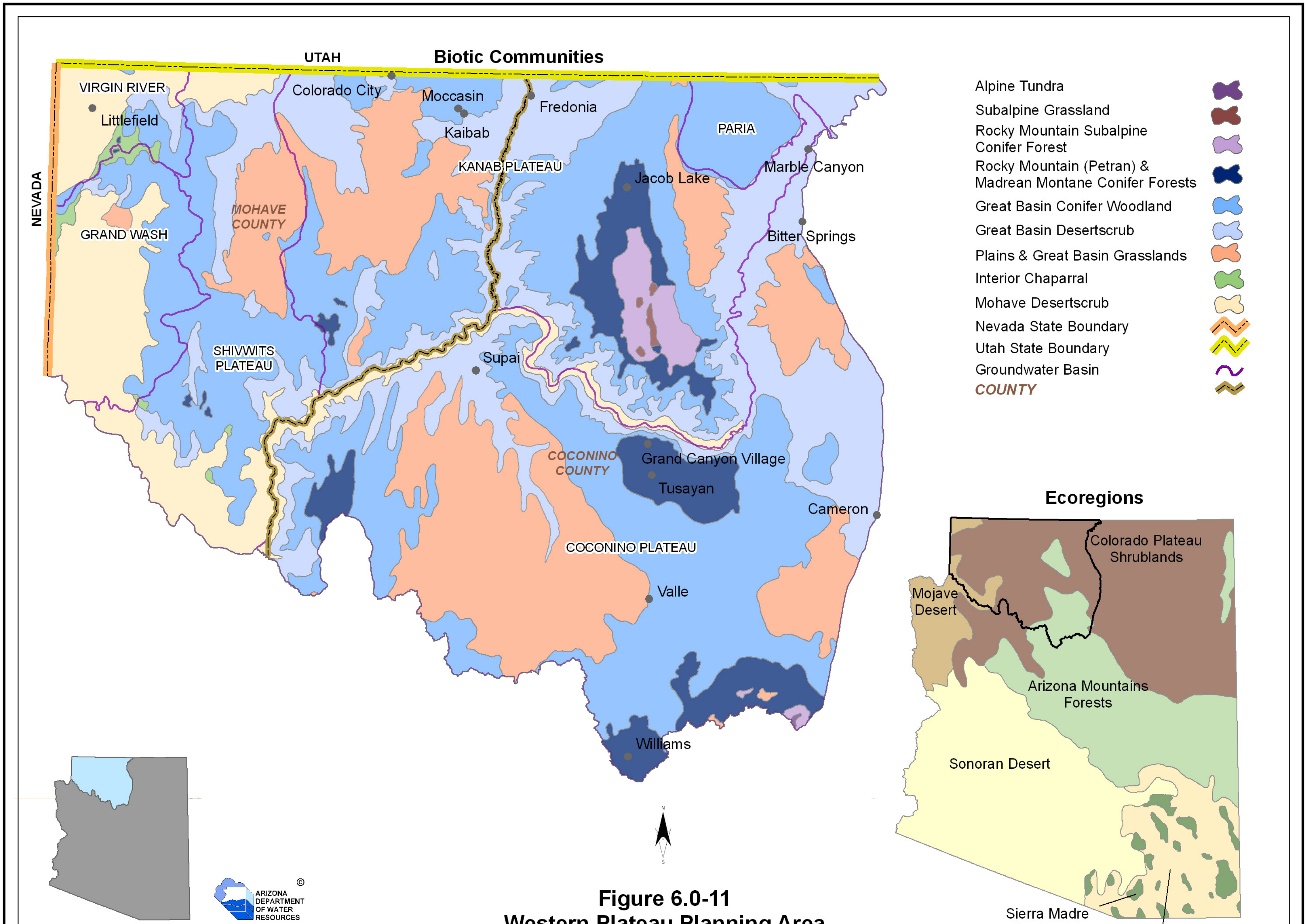
Vegetation

Information on ecoregions and biotic (vegetative) communities in the planning area are shown on Figure 6.0-11. Three of Arizona's six ecoregions are included in the planning area: the Colorado Plateau Shrublands, which covers most of the area, the Mojave Desert in the western portion, and the Arizona Mountains Forests ecoregion in the eastern section. Biotic communities range from Mohave desertscrub in the western part of the planning area and along the Colorado River to a small area of alpine tundra in the Coconino Plateau Basin.

Figure 6.0-10 Winter (November-April) precipitation departures from average, 1000-1988



Data are presented as a 20-year moving average to show variability on decadal time scales. Data: Fenbiao Ni, University of Arizona Laboratory of Tree-Ring Research and CLIMAS. Figure author: CLIMAS.



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

Figure 6.0-11
Western Plateau Planning Area
Biotic Communities and Ecoregions

Much of the planning area is covered by Great Basin conifer woodland and plains and Great Basin grassland.

Alpine tundra communities are found only at the highest elevations on the San Francisco Peaks, generally over 12,000 feet. The Peaks are the southernmost climatic alpine area in the United States. Because of the relatively harsh climate, only specially-adapted species can survive. Plants are commonly small and ground-hugging and include mosses, lichens and herbs. An area of the Peaks has been closed to travel to protect an endemic groundsel (Senecio franciscanus), a threatened species. Small areas of subalpine grassland are also found on the San Francisco Peaks and on the Kaibab Plateau at elevations above 8,500 feet that receive from 30 to 45 inches of annual rainfall (Grahame and Sisk, 2002).

High elevation subalpine conifer forests are limited to relatively small isolated mountaintop stands on the Kaibab Plateau and the San Francisco Peaks area 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 and receive much of their annual precipitation as snow. Summer precipitation is also a substantial component of annual precipitation. 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 with patchy crown fires occurring about every several hundred years, and surface fires occurring every 15 to 30 years (Graham and Sisk, 2002).

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, particularly on the Kaibab Plateau and at the south rim of the Grand Canyon. 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).

Great Basin conifer (piñon-juniper) woodlands cover large areas below the ponderosa pine forest at elevations between about 5,000 and 7,500

Rocky Mountain (Petran) and Madrean Montane Forest near Jacob Lake, Kanab Plateau Basin.

feet that receive about 10 to 20 inches of annual precipitation. Extensive stands exist throughout the planning area as shown on Figure 6.0-11. Piñon pine dominates at higher elevation while junipers are the dominant species at lower and drier areas that may include open grasslands. Bark beetle infestations have killed large areas of piñon pine southeast of Valle and smaller areas south of the South Rim in the Coconino Plateau Basin.

Plains grasslands, primarily composed of mixed or short-grass communities, are widespread in the planning area at elevations above about 4,000 feet that receive between 11 and 18 inches of annual precipitation. These areas are located primarily in the Coconino Plateau, Kanab Plateau and Shivwits Plateau basins. On the Arizona Strip, Great Plains grassland, which is drier and receives a larger percentage of annual rainfall in the winter and spring, transitions with plains grasslands (Brown, 1982). Native bunchgrasses have been largely replaced by Eurasian annual species such as cheatgrass due to grazing and fire-suppression practices (Grahame and Sisk, 2002).

Interior chaparral occupies mid-elevation foothill, mountain slopes and canyons in the Virgin Mountains in the Virgin River and Grand Wash basins, and in several isolated locations in the southern part of the Shivwits Plateau Basin. It is found in areas between about 3,500 and 6,000 feet in elevation that receive 15 to 25 inches of annual precipitation (Brown, 1982). Chaparral consists of dense shrubs that grow around the same height with occasional taller shrubs or small trees. Typical shrubby species are mountain mahogany, shrub live oak, and manzanita. Chaparral plants are well adapted to drought conditions.

Great Basin desertscrub occurs in northern Arizona mostly at elevations of 4,000 to 6,500 feet where an average of about 7 to 12 inches of rainfall occurs. This vegetative community is dominated by multi-branched, aromatic shrubs with evergreen leaves, primarily sagebrush, blackbrush and shadscale. Great Basin desertscrub is found in all basins in the Western Plateau Planning Area except the Paria Basin. In addition to shrubs, vegetation consists primarily of grasses. Grazing has heavily impacted native grasses in this community, which have been replaced by exotic species including cheatgrass. Cheatgrass is highly flammable, and where it is a significant component of sagebrush stands, the incidence of fire is greatly increased (Brown, 1982).

Mohave desertscrub covers a transitional zone between the higher and cooler Great Basin desert and the lower, hotter Sonoran desert. It is found along the Colorado River and in the western part of the planning area at elevations below about 3,500 feet. While many of the same plants found in the other deserts occur here, some are found only in the Mohave Desert such as the Joshua tree. The Mohave Desert is rich in endemic ephemeral plants, most of which are winter annuals (Brown, 1982).

There are reaches of riparian vegetation along the major watercourses in the planning area including the Colorado River, Kanab Creek, Paria River and Virgin River. Prior to construction of Glen Canyon Dam, the Colorado River supported a “sparse” riparian ecosystem above the high water zone of 100,000 cfs. Following con-

Mohave desertscrub in the Virgin River Basin.

struction, the new high water zone lowered and there was die-off in the upslope areas. However a mix of native and non-native species has increased in the new zone under the more stable conditions and higher year-round low flows. Riparian vegetation has also increased in tributary canyons. (Webb and others, 2007)

Within the alluvial reaches of Kanab Creek, thick stands of coyote willow that historically grew have been replaced by a mix of native and non-native trees growing in the channel. Downstream in Kanab Canyon large floods and low baseflow precludes establishment of significant riparian vegetation. Along the Paria River upstream of its confluence with the Colorado River tamarisk, coyote willow and scattered cottonwood are found. Historically, willow and some cottonwood were present in this reach (Webb and others, 2007). Downstream from the Virgin River Gorge to Lake Mead, extensive stands of native and non-native vegetation exist along the Virgin River. Tamarisk is predominant downstream of Littlefield (Webb and others, 2007). Dixon and Katzer (2000) estimated that nearly 10,000 acre-feet of water is used by phreatophytes along the Virgin River from the Littlefield gage to the state line.

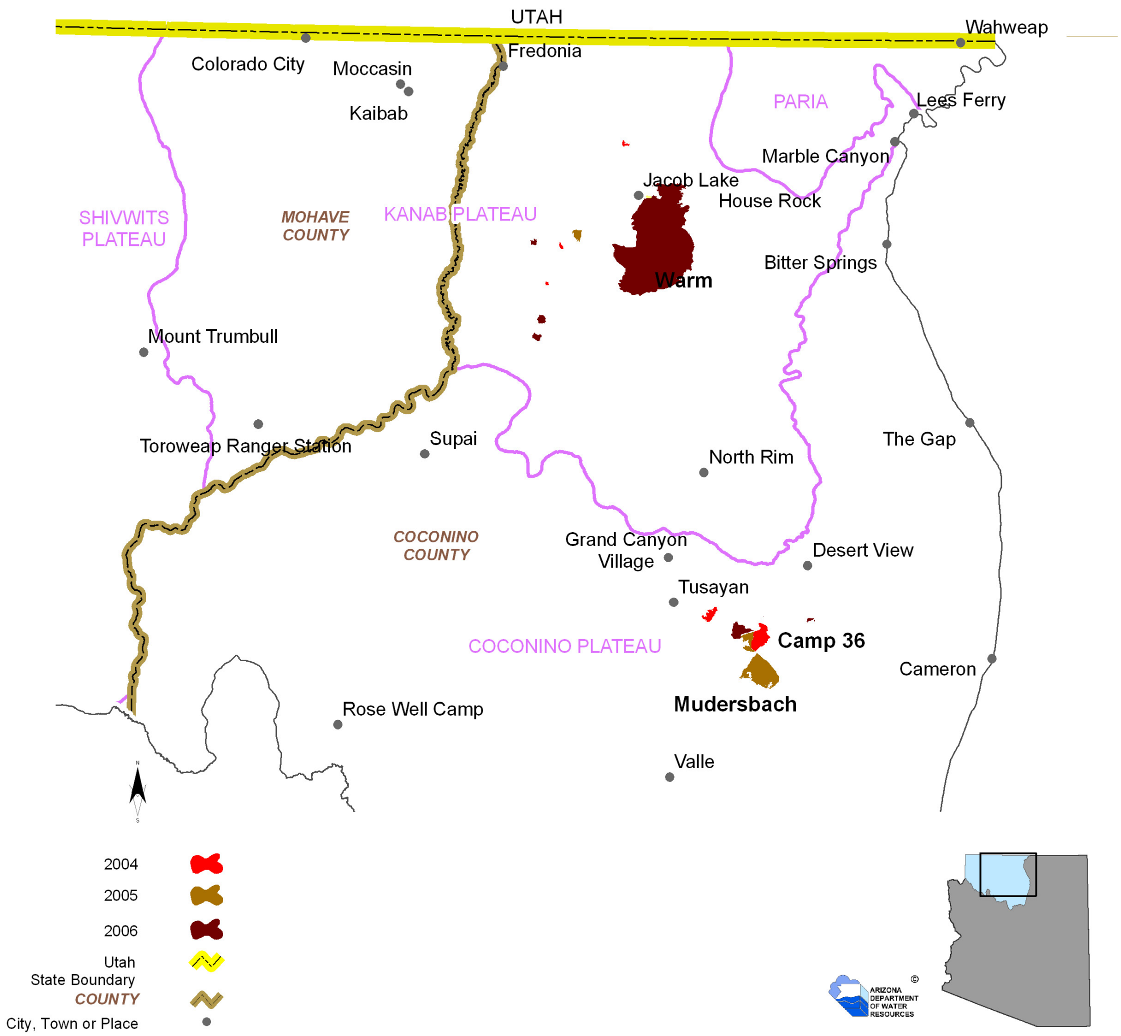
Several years of drought combined with high tree densities resulted in the largest outbreak of pine bark beetle populations ever recorded in Arizona forests during 2002 – 2004. Based on aerial surveys conducted in 2004 by the U.S. Forest Service, substantial bark beetle-caused ponderosa pine mortality occurred in a swath of forest stretching northeast from Williams and on forest lands south of the South Rim of the Grand Canyon. While drought conditions improved in 2004 and 2005, Ponderosa pine mortality due to Ips beetles increased in 2006, with 6,850 acres infested on the Kaibab National Forest. Other beetle species have also attacked trees on the Kaibab Plateau and on the San Francisco Peaks (USDA, 2006). By 2008, bark beetle activity had decreased substantially with only 560 affected acres in the Kaibab National Forest. However, almost 67,000 acres of aspen damage by defoliating insects was observed on the Kaibab in that year. Study plots were established in Arizona in 2003-2004 to monitor the impacts from bark beetle infestations on fuel loading and fire behavior. Preliminary analysis shows that mortality plots have significantly higher fuel loads than areas with no mortality. (USDA, 2008)


Vegetation along the Virgin River south of Beaver Dam/Littlefield.

Mortality rates of 60 to 95 percent in low elevation aspen groves, around 7,000 feet, has been observed on the Kaibab and Coconino national forests. Sudden Aspen Death (SAD) is believed caused by a combination of factors including drought and warmer temperatures that make trees more vulnerable to pests and pathogens. Fire exclusion is also thought to be a factor in longer term decline of aspen throughout the western U.S. Research is being conducted on the Kaibab National Forest to determine the cause of SAD and determine whether aspen are permanently disappearing from its lower elevation range. (Stevens, 2009)

A number of major wildfires occurred in the Western Plateau Planning Area during the severe drought years between 2002 and 2006 (see Figure 6.0-12). The largest was the lightning-

Figure 6.0-12 Wildfires in the Central Highlands Planning Area 2002-2005
(USFS 2007a)



caused Warm Fire, which consumed about 40,000 acres on the central Kaibab Plateau in 2006. Of the area burned, about 30 percent was identified as having high burn severity related to soil and watershed conditions (USFS, 2007b). In the Southwest, fire can be among the most significant watershed disturbance agents, particularly to peak stream flows. 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 Spring season and less snow cover could result in vegetative changes in the planning area with implications on 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. Eleven projects have been funded in the planning area through 2008. Six projects were funded in the Coconino Plateau Basin involving research, restoration and exotic species control. Three projects in the Kanab Plateau Basin and one each in the Grand Wash and Paria basins were also funded involving restoration, research, revegetation, exotic species control and watershed enhancement. A list of projects and types of projects funded in the Western Plateau Planning Area through 2008 is found in Appendix A. A description of the program, a complete listing of all projects funded, and a reference map is found in Volume 1 and on the Department's website.

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 rights 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.

Seven applications for instream flow claims were filed by the Bureau of Land Management in the Virgin River Basin. Applications are listed in Table 6.0-1 and instream flow reaches are shown on Figure 6.0-13. Six applications have been filed on reaches of the Virgin River and one has been filed on a reach of Beaver Dam Wash. All applications are currently pending.

Threatened and Endangered Species

A number of listed threatened and endangered species[3] may be present in the Western Plateau Planning Area. Those listed by the U.S. Fish and Wildlife Service (USFWS) as of 2008 are shown in Table 6.0-2. Presence of a listed species may be a critical consideration in water resource management and supply development

Table 6.0-1 Instream Flow Claims in the Western Plateau Planning Area

Map Key	Stream	Applicant	Application No.	Permit No.	Certificate No.	Filing Date
1	Beaver Dam Wash	BLM (Arizona Strip)	33-94843.0	Pending	Pending	8/24/1989
2	Virgin River	BLM (Arizona Strip)	33-94819.0	Pending	Pending	6/1/1989
3	Virgin River	BLM (Arizona Strip)	33-94865.0	Pending	Pending	10/20/1989
4	Virgin River	BLM (Arizona Strip)	33-96159.0	Pending	Pending	12/23/1991
5	Virgin River	BLM (Arizona Strip)	33-94866.0	Pending	Pending	10/20/1989
6	Virgin River	BLM (Arizona Strip)	33-96134.0	Pending	Pending	10/30/1991
7	Virgin River	BLM (Arizona Strip)	33-96133.0	Pending	Pending	10/30/1991

Source: ADWR 2008a

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

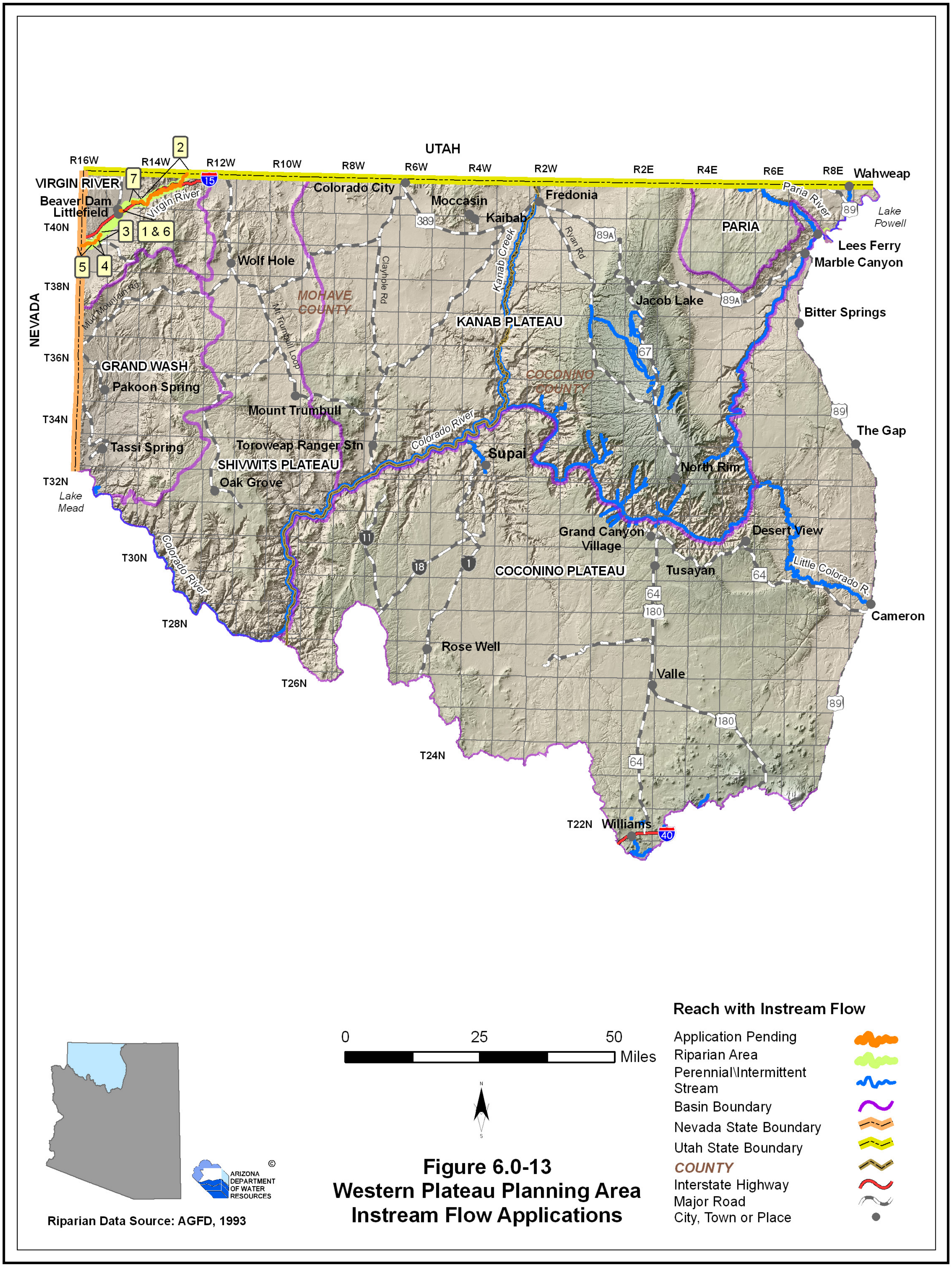


Figure 6.0-13
Western Plateau Planning Area
Instream Flow Applications

Table 6.0-2 Endangered Species in the Western Plateau Planning Area

Common Name	Threatened	Endangered	Elevation/Habitat
Brady Pincushion Cactus		X	3,400-5,200 ft,/Gravelly alluvium with sparse vegetation on gently sloping benches and terraces
Bald Eagle	X		Varies/Large trees or cliffs near water
California Brown Pelican		X	Varies/Lakes and rivers
California Condor		X	2,000-6,500 ft,/Steep terrain with rock outcroppings, cliffs and caves
Desert Tortoise (Mohave Population)	X		1,000-4,000 ft./Sandy loam to rocky soils in valleys, bajadas and hills
Holmgren Milk-Vetch		X	2,480-2,999 ft./Skirt edges of hill and plateau formations slightly above or at the edge of drainage areas
Humpback Chub		X	1,530-4,400 ft,/Turbulent, high gradient, canyon-bound reaches of large rivers
Jones' Cycladenia	X		4,000 to 6,800 ft/ Mixed desert shrub and scattered piñon-juniper communities
Kanab Amber Snail		X	3,200 ft./Marshes watered by springs and seeps at the base of sandstone cliffs or limestone
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
Sentry Milk-Vetch		X	7,000-7,960 ft/Uppermost layer of Kaibab limestone that is weathered in small, shallow pockets and networks of small cracks
Siler Pincushion	X		2,800-5,800 ft./Low red or gray gypsiferous badlands
Southwestern Willow Flycatcher		X	<8,500 ft./Cottonwood-willow and tamarisk along rivers and streams
Virgin River Chub		X	1,540-2,360 ft/Swift but not turbulent reaches of the Virgin River
Welsh's Milkweed	X		4,700-6,250 ft./Open, sparsely vegetated sand dunes or sagebrush, juniper, pine and oak communities
Woundfin		X	1,900-10,000 ft./Swift parts of silty streams
Yuma Clapper Rail		X	<4,500 ft./Fresh water and brackish marshes

Source: USFWS 2008, USDOI 2007

in a particular area. The USFWS should be contacted for details regarding the Endangered Species Act (ESA), designated critical habitat and current listings.

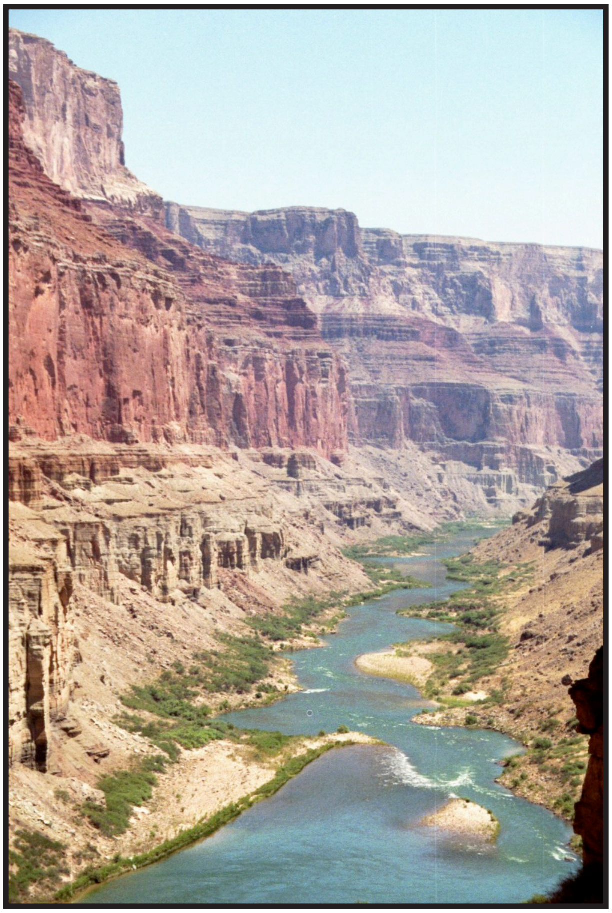
A unique example of endangered species management in the planning area is that of the California condor. Considered one of the most endangered birds in the world, condors were placed on the federal endangered species list in 1967. In 1987, with only 22 individuals known to exist, a controversial decision was made to bring all remaining condors into captivity in order to conduct a captive breeding program with the goal of reintroducing the species to the wild. Beginning in 1996, six to ten birds have been released each year from the Vermilion Cliffs in the Paria Basin. As of July 2009 there were 75 condors in Arizona. This reintroduction was conducted under a special provision of the ESA that allows for the designation of a nonessential experimental population. Under this designation, endangered species protections are relaxed, providing greater flexibility for management of a reintroduction program (AZGF, 2006).

National Parks, Monuments, Recreation Areas and Wilderness Areas

The Western Plateau Planning Area has the greatest acreage of federally protected areas as parks, monuments, recreation areas and wilderness areas of any planning area. It contains almost all of Grand Canyon National Park, three national monuments and small parts of two national recreation areas. In total there are 2.68 million acres of protected federal lands in the planning area, accounting for 31% of the land area. The Grand Canyon and Grand Canyon-Parashant National Monument make up most of the total with more than two million combined acres.

Nine wilderness areas are entirely within the planning area as well as part of two others (see Figure 6.0-14). 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 6.0-3. Five wilderness areas are within the boundaries of national monuments.

Grand Canyon National Park, a World Heritage Site, encompasses 1,218,375 acres. It was given Federal protection in 1893 as a Forest Reserve and later as a National Monument, and achieved National Park status in 1919. It receives almost five million visitors each year. Water for both the North and South Rims of the Park come from Roaring Springs, located 3,000 feet below the North Rim, and transported via pipeline to both rims (see Section 6.0.7) (USBOR, 2002). Park lands exist in every groundwater basin except



Colorado River through the Grand Canyon within Grand Canyon National Park.

Table 6.0-3 Wilderness areas in the Central Highlands Planning Area

Wilderness Area	Acres	Basin	Description
Beaver Dam Mountain	19,600	Virgin River	Rugged mountains, alluvial plains and several miles of the Virgin River
Cottonwood Point	6,860	Kanab Plateau	Navajo sandstone cliffs, canyons and pinnacles, willow and cottonwoods in wetter canyons
Grand Wash Cliffs*	37,030	Grand Wash	Marks transition zone between Colorado Plateau and Basin and Range provinces and contains many canyons
Kachina Peaks	18,615	Coconino Plateau (part)	Mt. Humphreys and only arctic-alpine vegetation in the state
Kanab Creek	68,340	Kanab Plateau	Kanab Creek and a maze of water and wind carved fins, knobs and potholes
Kendrick Mountain	6,510	Coconino Plateau	Remnant of San Francisco Mountain volcanic field
Mt. Logan*	87,900	Grand Wash	Basalt ledges, cinder cones and large eroded amphitheater
Mt. Trumbull*	7,880	Kanab Plateau	Large basalt-capped mesa
Paiute*	87,900	Grand Wash, Virgin River	Virgin Mountains and canyons
Paria Canyon-Vermilion Cliffs*	112,500	Kanab Plateau, Paria (part)	Paria Canyon and Vermilion Cliffs, red rock amphitheaters, sandstone arches, towering walls and hanging gardens
Saddle Mountain	40,610	Kanab Plateau	Nankoweap Rim, narrow drainage bottoms and steep scarp slopes.
Total	**493,745**		

Source: BLM 2006, USFS 2007c
*Wilderness areas are within the boundaries of a National Monument

the Virgin River and Paria basins, stretching from the confluence of the Little Colorado and Colorado Rivers west to Lake Mead. (See land ownership maps in the basin sections).

The Grand Canyon is of great geologic significance, with a record of three of the four eras of geological time, a rich and diverse fossil record, a huge variety of geologic features and rock types, and numerous caves containing extensive geological, paleontological, archeological and biological resources. Incised by the Colorado River, the Canyon is considered one of the finest examples of arid-land erosion in the world, averaging 4,000 feet deep for its entire 277 miles (NPS, 2005).

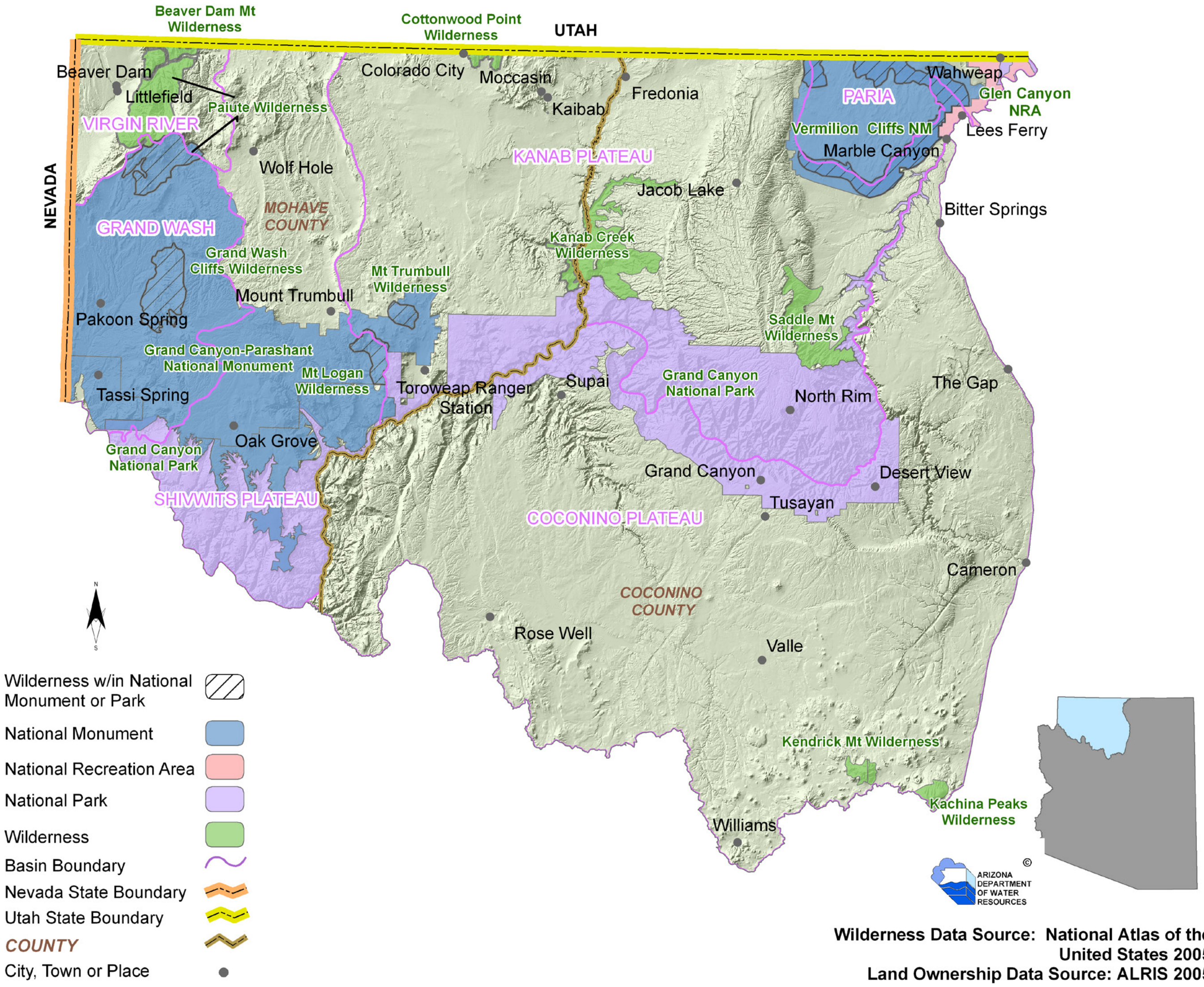
The Park also serves as an ecological refuge, with relatively undisturbed remnants of dwindling ecosystems, including desert riparian communities. It is home to numerous rare, endemic, and federally protected plant and animal species (NPS, 2007).

Construction and operation of Glen Canyon Dam has significantly altered Colorado River flows and sediment deposition, wildlife and habitat along the river in Grand Canyon National Park. A number of studies and actions have been taken and are underway to manage releases from the dam to protect the Park's resources and to mitigate the impact of dam operations (see "Managed Waters" below).

The Grand Canyon-Parashant National Monument was created by Presidential Proclamation in January 2000. At 1.05 million acres, it is described in the Proclamation as a geological treasure and as a "vast, biologically diverse, impressive landscape…" The physical remoteness of the monument has helped preserve important biological and archeological resources. The monument encompasses the lower portion of the Shivwits Plateau Basin, considered an important watershed for the Colorado River and the Grand Canyon, almost all of Grand Wash Basin and a small area north of Toroweap in the Kanab Plateau Basin (USDOI, 2007). The Monument is jointly administered by the National Park Service (NPS), (211,100 acres) and the Bureau of Land Management (BLM), (808,727 acres).

In November 2000, President Clinton also established the Vermilion Cliffs National Monument by proclamation. Encompassing 294,000 acres, the entire monument is within Arizona. Most of the Paria Plateau Basin and adjoining lands in the Kanab Plateau Basin are within the monument boundaries. The monument was established to protect geologic features including the 2,500-foot deep Paria Canyon, the Paria Plateau, the spectacular cross-bedded sandstones at Coyote Buttes and the 3,000-foot Vermilion Cliffs escarpment, the Arizona release site of the endangered California condor.

Figure 6.0-14 Federally Protected Areas in the Western Plateau Planning Area



Wilderness Data Source: National Atlas of the United States 2005
Land Ownership Data Source: ALRIS 2005

The Arizona Strip Proposed Plan/Final Environmental Impact Statement (FEIS), released in March 2007, serves multiple functions. It is a revised Resource Management Plan for the Arizona Strip Field Office of the BLM, a new management plan for the Vermilion Cliffs National Monument and a new management plan for the Grand Canyon-Parashant National Monument. It is also a Proposed General Management Plan/Final EIS for the NPS portion of the Grand Canyon-Parashant National Monument, since that monument is jointly administered by the BLM and NPS.

The Proposed Plan/FEIS describes and analyzes five alternatives for managing over 3.3 million acres of lands. Major issues include management of access and management of areas having wilderness characteristics, protection of natural and cultural resources, management of livestock grazing, and recreation (BLM, 2007). Three final management plans and four records of decision signed by the BLM and NPS were completed in 2008. Both national monuments are withdrawn from mineral entry while grazing is allowed with adjustments to meet management objectives. Further evaluation of routes in the entire area will continue for several years (USDOI, 2007).

Pipe Spring National Monument, established in 1923, is located in the Kanab Plateau Basin south of Kaibab and Moccasin. It is a cultural park occupied by several cultures over a period of about 2,000 years due to the occurrence of springs, which have supported farming and ranching activities. There are four springs within the monument boundaries: West Cabin, Main, Spring Room and Tunnel. Main Spring and Spring Room have man-made discharge points constructed by Mormon pioneers and are believed to represent the flow of the original natural spring known as Pipe Spring. Since 1976, NPS staff has measured spring discharge on a monthly basis due to concerns about declines in discharge rates (Truini and others, 2004).

Lake Powell and Wahweap, Paria Basin.

About 3% of the 1.2 million-acre Glen Canyon National Recreation Area is located in the northeastern corner of the Paria Basin. The Recreation area was created by Congress in 1972 to provide for recreational use of Lake Powell and adjacent lands and to preserve scenic, scientific, and historic features. It surrounds and includes Lake Powell from Lees Ferry to the Orange Cliffs in Utah. The principal recreation area development within the planning area is Wahweap, which includes a marina, campground and visitor center. Fluctuations in the lake level affect recreational activities. Since designation of the Grand Canyon-Parashant National Monument, the only remaining portion of the Lake Mead National Recreation Area in the planning area is Lake Mead itself.

Managed Waters

The Colorado River is among the most managed rivers in the United States. The river is impounded behind Glen Canyon Dam, which is managed for both electrical generation purposes and to store water to meet flow obligations at Lees Ferry under the terms of the 1922 Colorado River Compact. As a result, the river's flow and the ecosystem it supports have been fundamentally altered. The Colorado River was a warm, sediment-laden river that historically carried a daily average of 275,000 tons of sediment through the Grand Canyon. Water temperature varied through the year and large spring floods and varying flow patterns deposited sediment along the riverbanks and provided habitat, including calm spawning pools, for a number of native fish species. Operation of the dam for electrical generation requires large water releases during historically low flow seasons with daily and weekly fluctuations. The flow regime is governed by the Record of Decision for the Glen Canyon Dam EIS and the Glen Canyon Operating Criteria (see section 6.0.2). The water released from the bottom of the reservoir is now consistently cold year round and considerably less sediment is now carried downstream, impacting beach building along the riverbank. Vegetative communities, wildlife and native fish have been affected by the modified river flow (Tellman and others, 1997). The Colorado pike minnow and bonytail chub no longer occur in the Grand Canyon, and the humpback chub and razorback sucker are listed as endangered species.

Beginning in 1982, the Bureau of Reclamation initiated the multi-agency interdisciplinary Glen Canyon Dam Environmental Studies to evaluate the impact of Glen Canyon Dam and how its operation could be modified to address wildlife and recreational values downstream of the dam. In 1989, work on an EIS began to consider options for the operation of the dam. The EIS was completed in 1995 and findings indicated that there were a number of uncertainties regarding the downstream impact of water releases from the Dam. While the EIS was being developed, Congress passed the Grand Canyon Protection Act (Act) of 1992 (Public Law 102-575), which required operation of the dam in a manner that would protect and mitigate adverse impacts to Grand Canyon National Park and Glen Canyon National Recreation Area. In compliance with this Act, the EIS proposed an adaptive management process to monitor and assess the effects of dam operations on downstream resources. (USBOR, 2007a)

In 1997, Secretary of Interior (Secretary), Bruce Babbitt, established an Adaptive Management Program (AMP) to "provide an organization and process for cooperative integration of dam operations, downstream resource protection and management, and monitoring and research information…". Critical to the program is the Glen Canyon Adaptive Management Work Group (AMWG), a federal advisory committee. The AMWG incorporates stakeholders into the decision-making process and makes recommendations to the Secretary on how to protect resources. The group completed a draft strategic plan in 2001 and current focus includes recovery of humpback chub, management of sediment resources and experimental releases of water from Glen Canyon Dam (USBOR, 2007a). Before release of the EIS, the Secretary authorized an artificial flood in the Grand Canyon that would mimic historic spring flows,

Colorado River through the Grand Canyon.

in order to help build beaches and habitat. The flood temporarily restored beaches and improved backwater habitat, but pre-flood conditions quickly returned.

As part of the AMP effort, the Bureau of Reclamation completed a scoping report in March 2007 for the Glen Canyon Dam Long-term Experimental Plan EIS. The proposed plan would implement a long-term program in the Colorado River below the dam that could potentially involve dam operations, modifications to the dam's intake structures and other management actions such as removal of non-native fish (USBOR, 2007a).

Unlike the Colorado River, the Virgin River flows uninterrupted from its headwaters above Zion National Park to Lake Mead. Water is diverted from the Virgin River for municipal and agricultural needs in Utah and for agricultural use in Arizona. This river, particularly its upper reaches, is recognized for its recreational and scenic values. Segments of the Virgin River and a number of tributaries totaling 165 miles within Zion National Park were added to the Federal Wild and Scenic River System in March, 2009. It is the only designated system in Utah. 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. Under the Act the river area must be managed in a manner that protects and enhances its "outstandingly remarkable values" (NWSR, 2007).

6.0.5 Population

The Western Plateau Planning Area is the most sparsely populated planning area in the state although there are some rapidly growing areas. Census data for 2000 show almost 17,500 residents in the planning area. Arizona Department of Economic Security (DES) population projections suggest that the planning area population will more than double by 2030, to about 35,000 residents. Historic, current and projected basin population is shown in the cultural water demand tables for each basin in sections 6.1-6.6.

The 2000 Census populations for each basin and Indian reservation, from highest to lowest, are listed in Table 6.0-4. The most populous basin is the Coconino Plateau with about 9,200 residents in 2000. The Shivwits Plateau and Grand Wash basins have very low populations with 12 and 15 residents in 2000, respectively.

Table 6.0-5 lists incorporated and unincorporated communities in the planning area with 2000 Census populations greater than 500 and growth rates for two time periods. Communities are listed from highest to lowest population in 2000. The planning area population grew by 35% between 1990 and 2000. There are only three incorporated communities in the planning area, Colorado City, Fredonia and Williams. Relatively rapid growth has occurred in several areas including Beaver Dam/Littlefield, Colorado City, Valle and Cameron. The

Table 6.0-4 2000 Census population in the Western Plateau Planning Area

Basin/*Reservation*	2000 Census Population
Coconino Plateau	9,164
Havasupai	*650*
Navajo	*3,068*
Kanab Plateau	6,233
Kaibab-Paiute	*196*
Virgin River	1,532
Paria	528
Grand Wash	15
Shivwits Plateau	12
Total	**17,484**

Table 6.0-5 Communities in the Western Plateau Planning Area with a 2000 Census population greater than 500

Communities	Basin	1990 Census Pop.	2000 Census Pop.	Percent Change 1990-2000	2006 Pop. Estimate	Percent Change 2000-2006	Projected 2030 Pop.
Colorado City*	Kanab Plateau	2,426	3,334	37%	4,150	24%	7,302
City of Williams*	Coconino Plateau	2,532	2,842	12%	3,170	12%	4,068
Grand Canyon Village CDP	Coconino Plateau	1,499	1,460	-3%	1,460	0%	1,460
Cameron CDP[1]	Coconino Plateau	1,011	1,231	22%	1,339	9%	2,236
Beaver Dam/Littlefield	Virgin River	762	1,053	38%	NA	--	NA
Town of Fredonia*	Kanab Plateau	1,207	1,036	-14%	1,120	8%	1,335
Tusayan CDP	Coconino Plateau	NA	562	NA	605	8%	714
Valle	Coconino Plateau	123	534	334%	NA	--	1,010
Total >500		9,560	12,052	26%	NA	--	NA
Other		3,382	5,432	61%	NA	--	NA
Total		**12,942**	**17,484**	35%	**22,894**	--	**35,266**

Source: DES 2006, U.S. Census Bureau 2006, USBOR 2006
NA = not available
CDP = census designated place
* = incorporated communities
[1] = part of population may reside in Eastern Plateau Planning Area

unincorporated areas of Beaver Dam/Littlefield and nearby Scenic, Arizona, are experiencing growth in large part due to their proximity to growth in Mesquite, Nevada. Mesquite experienced an annual growth rate of almost 12% between 2000 and 2008 (Hardcastle, 2008), fueled by development of retirement communities and its growing popularity as a resort destination.

Population Growth and Water Use

Arizona 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. Of the two counties in the planning area, only Mohave County fit the size criteria in 2000. The Mohave County water resources element will develop a water budget for each of the groundwater basins in the county and will prioritize this effort based on growth potential, water availability, number of wells and other factors (Freilich, Leitner & Carlisle, 2005). However, the County's key water issues and planning efforts are related primarily to that part of the County south of the Colorado River. Although not required by law to include a water resources element in the county's comprehensive plan, Coconino County has done so. The County Plan emphasizes conservation in tandem with resource development and recognizes the importance of incorporating climatic variability into water resource planning (Coconino County, 2003).

The Act also requires that twenty-three communities outside AMAs include a water resources element in their general plans. In the Western Plateau Planning Area this requirement applies only to Colorado City. Plans must consider water demand and water resource availability in conjunction with growth, land use and infrastructure.

Beginning in 2007, all community water systems in the state were required to submit Annual Water Use Reports and System Water Plans to the Department. 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 18 systems including City of Williams, Colorado City, Fredonia, Grand Canyon National Park and HydroResources-Tusayan and were used to prepare this document. Annual water report information and a list of water plans are found in Appendix B.

Main Street, Williams. City of Williams is one of 18 systems in the planning area that has submitted a water system plan to the Department.

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. As of September 2009, no counties or towns in the planning area have adopted this provision.

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 6.0-6. As shown, 86 subdivisions with over 5,400 lots were reviewed for an adequacy determination through 2008. All subdivisions were found to have an inadequate water supply in the Coconino Plateau Basin while all subdivisions were found to have an adequate supply in the Paria Basin.

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 only AAWS determinations in the planning area are in the Virgin River Basin where two applications totaling 27,700 lots have been approved.

No water providers in the planning area are designated as having an adequate water supply for their entire service area as of the date of publication of this document. However, an application for a designation of adequate water supply was pending for Beaver Dam Water Company as of September 2009. A service area designation exempts subdivisions from demonstrating water adequacy if served by the provider.

6.0.6 Water Supply

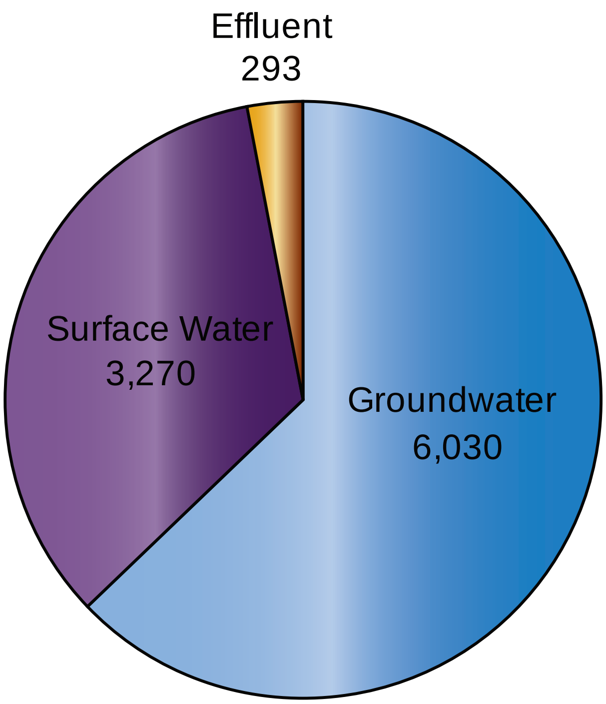
Water supplies in the Western Plateau Planning Area include groundwater, surface water and effluent. As shown on Figure 6.0-15, groundwater is the primary water supply, accounting for about 63% of the demand. Surface water is used for agricultural irrigation in the Virgin River and Kanab Plateau basins and for municipal use in the Coconino Plateau and Kanab Plateau basins. It is estimated that about 34% of the total water demand is met with surface water. Effluent is utilized for golf course irrigation and for landscape irrigation, toilet flushing and other uses in the Coconino Plateau Basin, contributing 3% of the planning area's water supply. 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

Table 6.0-6 Water adequacy determinations in the Western Plateau Planning Area as of 12/2008

Basin	Number of Subdivisions	Number of Lots	Lots w/ Adequate Determ.	Lots w/ Inadequate Determ.	Approx. Percent of Lots w/ Percent Inadequate Determ.
Coconino Plateau	53	2,050	0	2,050	100%
Grand Wash	none	none	none	none	none
Kanab Plateau	9	360	201	159	44%
Paria	9	1,356	1,356	0	0%
Shivwits Plateau	none	none	none	none	none
Virgin River	15	1,643	1,617	26	2%
Total	**86**	**5,409**	**3,174**	**2,235**	**41%**

Source: ADWR 2008b

Figure 6.0-15 Average Annual Water Supply Utilized in the Western Plateau Planning Area, 2001-2005 (in acre-feet)



accounted for as groundwater. This is reflected in the cultural water demand tables in each basin section.

Surface Water

About 3,300 AFA of surface water diverted from streams or springs was used on average in the planning area during 2001-2005. Surface water is used primarily for agricultural irrigation but also as a municipal and industrial water supply. Surface water availability is subject to drought and legal access to supplies.

Surface water from Roaring Springs, located 3,000 feet below the North Rim of the Grand Canyon, is the primary water supply for both the North and South Rims. Spring water is pumped to the North Rim from the Roaring Springs pump station and delivered via the Trans-Canyon Pipeline. The Trans-Canyon Pipeline delivers water by gravity flow to Indian Gardens, located below the South Rim, where it is pumped from the Indian Garden pump station through a directional bore hole to water storage tanks on the South Rim. A small portion of the water flowing to Indian Gardens is diverted from the pipeline to Phantom Ranch and Cottonwood Campground. The pipeline has experienced failures an average of 10 to 12 times a year due to washouts during high flow events and bends in the pipeline. For this reason, the Park is studying alternatives to provide reliable, long-term water supplies. Potential alternatives that have been identified include construction of wellfields, diversion of Colorado River water to the South Rim, trucking in water, construction of an infiltration gallery and pumping plant on Bright Angel Creek to supply the South Rim and Phantom Ranch, and other alternatives (USBOR, 2002). There are concerns regarding use of current and future supplies and potential impacts on seeps and springs in the Grand Canyon. Several Arizona Water Protection Fund Projects have funded studies to help research these impacts.

In the Coconino Plateau Basin, the City of Williams historically relied on surface water stored in five small reservoirs with a combined storage capacity of 893 million gallons (2,740 acre-feet). The reservoirs, constructed between 1892 and 1952, collect inflow from snowmelt. Evaporation and seepage from the reservoirs is substantial, with losses greater than the city's annual demand. Two dry years in a row can result in significant stress to the supply system. When surface water supplies were seriously impacted in 1996 the City began a well drilling program to supplement its surface water supplies during periods of shortage (Pinkham and Davis, 2002). As a result and due to ongoing drought, the community utilized primarily groundwater in recent years.

Havasu Creek, which flows from springs emanating from the Redwall-Muav Formations, is a water supply for the Havasupai Tribe at

Agriculture in Havasu Canyon. Surface water is used as both a municipal and agricultural supply on the Havasupai Reservation.

Supai. Surface water is used as both a municipal and agricultural supply on the reservation.

In the Kanab Plateau Basin surface water is a supply at several location. Surface water from Kanab Creek, diverted between Kanab Dam and Fredonia Dam has been used for irrigation in the Fredonia area (ADWR, 1998). The USGS conducted an investigation in 2008 and found 413 acres irrigated with surface water. The Arizona Strip Partnership (now inactive) identified the lack of sufficient surface water supplies for agriculture as an issue in Fredonia. Part of Fredonia's municipal water supply may be surface water delivered from Utah. Jacob Lake Lodge on the Kaibab Plateau uses about seven acre-feet of spring water a year from Warm Spring. Surface water from springs has also been a supply for Twin City Water (Colorado City), although current use is not reported, and for Badger Creek Water in the small community of Vermilion Cliffs. In addition, Marble Canyon Company has a Colorado River diversion entitlement of 70 AFA.

The springs at Pipe Springs National Monument have historically been used for domestic, ranching and farming purposes. A pipeline from Tunnel Spring conveys water outside the monument to maintain water-use agreements with the local cattleman's association. In 1971, a well was drilled outside the monument to meet the growing needs of the monument and the Kaibab-Paiute Indian Tribe (Truini and others, 2004).

In the Virgin River Basin, a small amount of surface water is diverted from Beaver Dam Wash for golf course irrigation. In 2000, about 1,700 acres in the Littlefield area were in cultivation and surface water from the Virgin River was the primary agricultural water supply. However, due to subsequent flood damage and conversion to domestic uses, agricultural acreage has declined significantly. A USGS investigation in 2007 showed only 42 acres of irrigated land in the basin. Surface water was no longer being diverted for agricultural use; all remaining lands were irrigated with groundwater.

In addition to physical availability, the legal availability of a surface water supply is also an important consideration in water management. As described in detail in Appendix C, the legal framework and process under which surface water right applications and claims are administered and determined is complex. Rights to surface water are subject to the doctrine of prior appropriation which is based on the tenet "first in time, first in right". This means that the person who first put the water to a beneficial use acquires a right that is superior to all other surface water rights with a later priority date. Under the Public Water Code, beneficial use is the basis, measure and limit to the use of water. Each type of surface water right filing is assigned a unique number as explained in Appendix C and shown in Table 6.0-7. 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. The act of filing a statement of claim of rights to use public waters (36) does not in itself create a water right.

Arizona has two general stream adjudications in progress to determine the nature, extent and priority of water rights across the entire river systems of the Gila River and the Little Colorado River. Pertinent to the Western Plateau

Planning Area, the Little Colorado River (LCR) Adjudication area extends into the eastern portion of the Coconino Plateau Basin. The LCR Adjudication is being conducted in the Superior Court of Arizona in Apache County. The LCR Adjudication was initiated by a petition filed by Phelps Dodge Corporation in 1978. It now covers 27,000 square miles and includes three watersheds (Lower Little Colorado River, Upper Little Colorado River and Silver Creek), 5 Indian tribes (Hopi, Navajo, Zuni, Fort Apache and San Juan Southern Paiute) and over 3,000 parties. All parties who claim to have a water right within the river system are required to file a statement of claimant (SOC) (39) or risk loss of their right. This includes reserved water rights for public lands and Indian reservations which for the most part, have not been quantified or prioritized. Results from the Department's investigation of surface water right and adjudication filings are presented in Hydrographic Survey Reports (HSRs); none of which include lands in the Western Plateau Planning Area.

Table 6.0-7 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 3,947 filings that specify surface water diversion points and places of use in the planning area, 1,227 CWRs have been issued to date. Figure 6.0-16 shows the general 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 6.0-16.

Table 6.0-7 Inventory of surface water right and adjudication filings in the Western Plateau Planning Area[1]

Basin	Type of Filing							Total
	BB[2]	3R[3]	4A[3]	33[3]	36[4]	38[5]	39[6]	
Coconino Plateau	0	73	31	209	468	549	324	**1,654**
Grand Wash	0	16	26	24	97	69	0	**232**
Kanab Plateau	0	199	90	202	309	425	0	**1,225**
Paria	0	32	5	1	34	27	0	**99**
Shivwits Plateau	0	88	33	105	181	172	0	**579**
Virgin River	0	7	22	13	88	28	0	**158**
Total	**0**	**415**	**207**	**554**	**1,177**	**1,270**	**324**	**3,947**

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. Several surface water right and adjudication filings are not counted here due to unsufficient locational information. 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 claimant of rights 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.

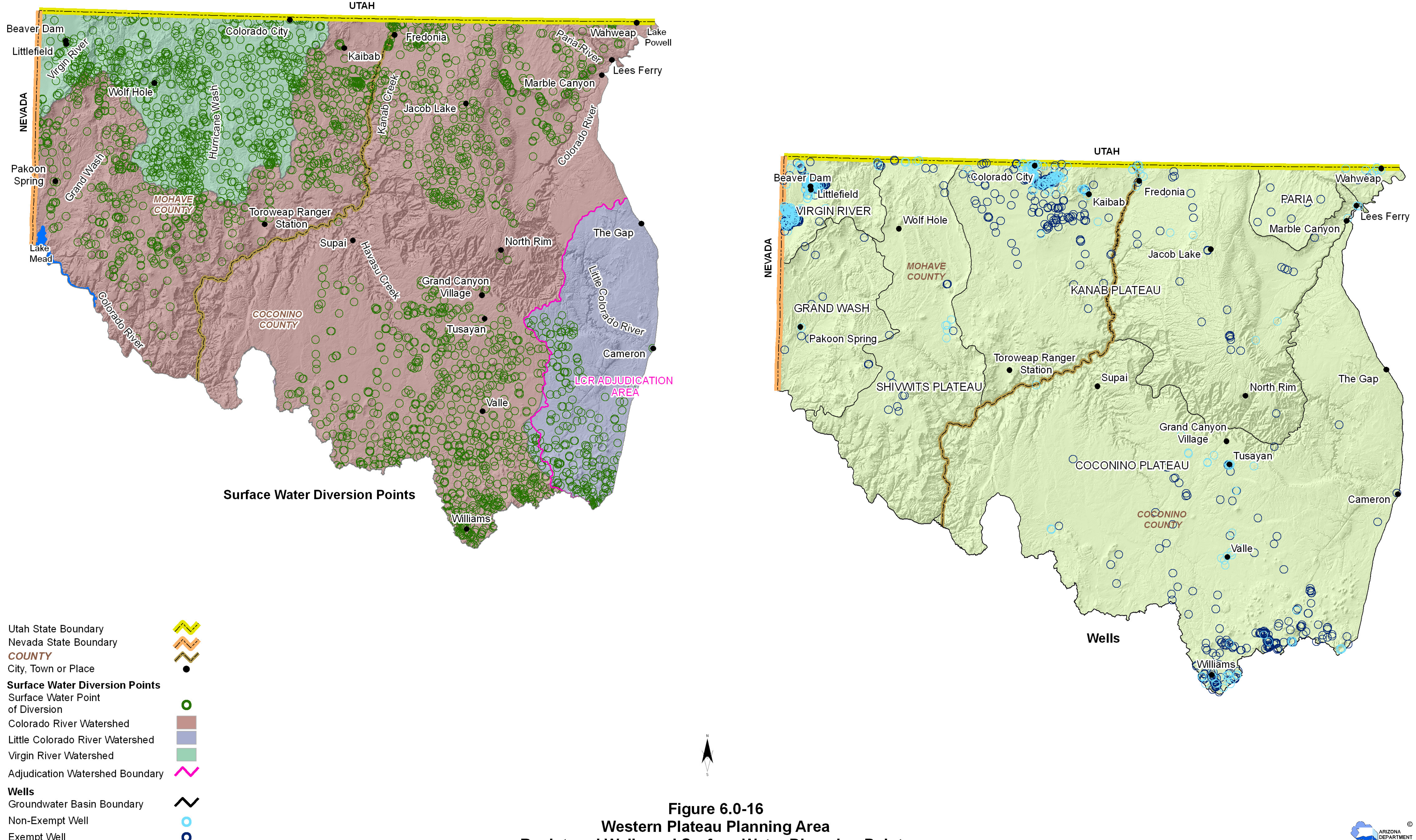


Figure 6.0-16
Western Plateau Planning Area
Registered Wells and Surface Water Diversion Points

As listed in Table 6.0-7, surface water rights may also be determined through judicial action in state or federal court in which the court process establishes or confirms the validity of the rights and claims and ranks them according to priority. Court decreed rights are considered the most certain surface water right. The single major court determination in the planning area is Arizona vs California (1963) which apportioned waters from the mainstem of the Colorado River to the Lower and Upper Basin States and allocated 2.8 maf a year to Arizona. It also reserved water for certain Indian Tribes (none in the planning area) and included provisions for release of water from reservoirs controlled by the United States under normal, surplus and shortage conditions, which includes Lake Powell in the planning area.

Each year, the Secretary is required to declare whether the Colorado River water supply is in a normal, surplus or shortage condition for the Lower Division States (Arizona, California, Nevada). Until 2007, Reclamation lacked specific guidelines to address the operation of Lake Mead and Lake Powell during drought. Following multiple years of drought and decreasing water supplies in storage, in May 2005 the Secretary directed that the Bureau of Reclamation develop guidelines for the operations of Lake Powell and Lake Mead under low reservoir conditions. To address this situation, Reclamation released a Final EIS: Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations of Lakes Powell and Mead (USBOR, 2007b). The Record of Decision was signed in December, 2007. One of the purposes of the guidelines is to provide greater predictability regarding the amount of annual water deliveries to mainstream Colorado River water users in the Lower Division states.

Final EIS reservoir management under shortage conditions includes: adoption of guidelines

Lake Powell, Paria Basin.

to identify under what circumstances the Secretary would reduce the annual amount of water available to the Lower Division States from Lake Mead below 7.5 maf/year; define the coordinated operation of Lake Mead and Lake Powell to improve operations under low reservoir conditions; allow for storage and delivery of conserved water in Lake Mead to increase the flexibility of meeting water needs under drought and low storage conditions; and determine those conditions under which the Secretary may declare the availability of surplus water for use within the Lower Division States. (USBOR, 2007b).

The location of surface water resources for each basin in the planning area are shown on surface water condition maps, and maps showing perennial and intermittent streams and major springs. Tables with data on streamflow, flood ALERT equipment, reservoirs, stockponds and springs are also presented in the basin sections (6.1 – 6.6).

Groundwater

Groundwater is the principal water supply for municipal, industrial and agricultural users in the planning area where it is pumped from relatively shallow local aquifers or from deep regional aquifers. Groundwater pumpage averaged about 6,000 AFA during the period 2001 to 2005. Aquifer depth is a significant factor in groundwater availability in the area since it is both expensive to drill wells and to pump water to the surface. Groundwater is pumped from depths exceeding 2,000 feet bls at Tusayan and Williams. In addition, well yields from sedimentary rocks of the deep regional aquifers are generally low unless fractures or faults are encountered. The median well yield of 16 large diameter (>10 inch) wells in the Coconino Plateau Basin completed in sedimentary rock aquifers is about 45 gpm.

Areas of unconsolidated sediments are relatively limited as shown on the groundwater conditions maps for each basin in sections 6.1-6.6. Extensive areas of unconsolidated sediments that comprise basin-fill aquifers are found only in the western portions of the Virgin River and Grand Wash basins. Other basin-fill aquifers in the planning area are generally narrow and bordered by low water yielding consolidated rocks. Areas of relatively high well yield include basin-fill deposits and the Muddy Creek Formation in the Virgin River Basin with a median well yield of 650 gpm based on data from 53 wells (Table 6.6-6).

Few hydrologic studies have been conducted in the planning area and as a result, there is uncertainty regarding groundwater resources including recharge rates and groundwater in storage. Estimates of aquifer recharge are only available for the Virgin River Basin and estimates of groundwater in storage are only available for the Coconino Plateau, Paria and Virgin River basins.

Well data provide information on local groundwater conditions. 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 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.

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

Automated Well in the Virgin River Basin 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 14 Index Wells in the planning area, primarily in the Virgin River Basin. Of these, one is an Automated Well located west of Littlefield. Updated maps showing the location of Index and Automated wells may be viewed at the Department's website.

Most large communities in the planning area rely on groundwater supplies. Although groundwater may be difficult to access in many parts of the planning area, it is more reliable than the limited surface water supplies, particularly during drought. Since 1999, the City of Williams has drilled four wells, three of which have static water levels greater than 2,700 feet bls, as a backup to their surface water supplies. Some of the well drilling attempts have been unsuccessful. As of 2002, Williams had spent about seven million dollars to drill six wells, three of which are producing (Pinkham and Davis, 2002). The City currently has four operational wells but one yields only 40 gpm, and another has poor water quality with elevated concentrations of dissolved oxygen, metals and arsenic. Tusayan relies on two 3,000-foot deep wells in the Redwall-Muav Aquifer as its primary water supply but also maintains a fleet of semi-tankers for emergency trucking of water if necessary (HydroResources, 2007). Groundwater is also a supply for two industrial golf courses in the Virgin River Basin.

Santa Fe Reservoir, City of Williams. City of Williams historically relied on surface water stored in five small reservoirs. Since 1999, the city has drilled four wells to supplement surface water supplies.

Groundwater is an agricultural water supply in the Beaver Dam area in the Virgin River Basin and in the Kanab Plateau Basin at Colorado City, Fredonia, and Moccasin/Kaibab. Groundwater use for agricultural irrigation is declining in the planning area.

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.

Effluent

Due to the relatively limited groundwater and surface water supplies in the Coconino Plateau Basin, innovative reuse of effluent is occurring at several locations. About 3% of the total water demand was met by effluent during the 2001-2005 time period for golf course irrigation and municipal uses totaling almost 300 AFA. Effluent supplies the water requirements of the Elephant Rock Golf Course at Williams. Effluent treated at the South Grand Canyon Treatment Plant (SGCTP) is used at Tusayan for toilet flushing in hotels and businesses and for landscape irrigation. At Grand Canyon Village, effluent from the SGCTP is reused for toilet flushing, landscape irrigation and other uses including fire fighting in 2007. Effluent generated and treated at Valle is used for landscape irrigation and fire protection (Pinkham and Davis, 2002).

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), Superfund (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. Of these various contaminated sites, LUST and VRP sites are found. Table 6.0-8 lists the contaminant and affected media and the basin location of the single VRP site. The location of all contamination sites in the planning area is shown on Figure 6.0-17.

The active VRP site is a heliport site at Tusayan in the Coconino Plateau Basin where soil and groundwater has been contaminated with hydrocarbons and jet fuel. 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 also 27 active LUST sites in the planning area including 11 sites at Fredonia, six at Jacob Lake, five at Williams, three at Tusayan, and one each at Cameron and Wahweap.

Elephant Rock Golf Course in Williams.

Table 6.0-8 Contamination site in the Western Plateau Planning Area

SITE NAME	MEDIA AFFECTED AND CONTAMINANT	GROUNDWATER BASIN
Voluntary Remediation Sites		
Heliport Lease Lot #1, Grand Canyon	Soil, Groundwater - Jet A Fuel, Hydrocarbons	Coconino Plateau

Sources: ADEQ 2006a, ADEQ 2006b

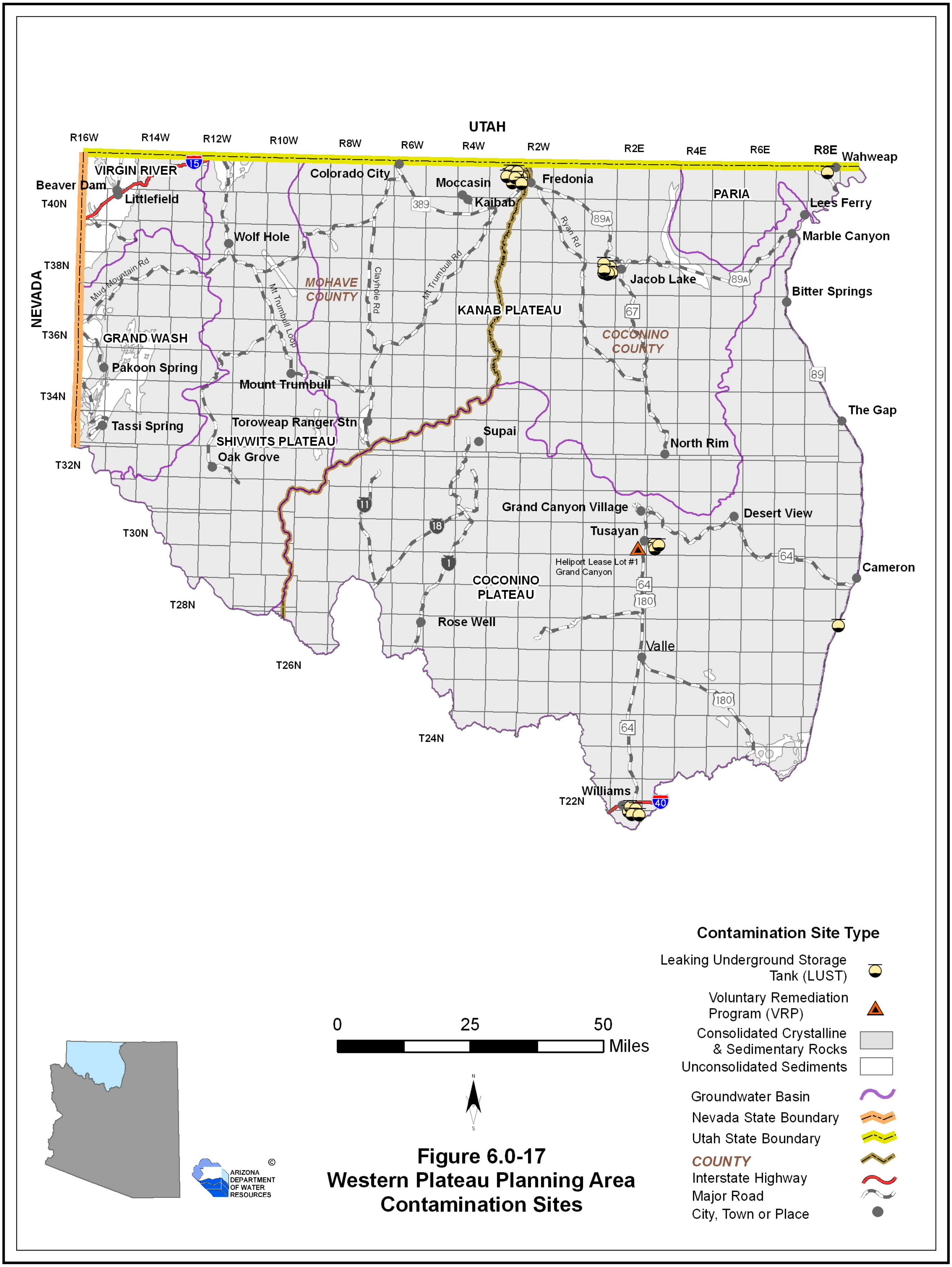


Figure 6.0-17
Western Plateau Planning Area
Contamination Sites

6.0.7 Cultural Water Demand

Total cultural water demand in the Western Plateau Planning Area averaged approximately 9,600 AFA during the period 2001-2005. As shown in Figure 6.0-18, the agricultural demand sector was the largest use sector with approximately 4,600 AFA of demand, 48% of the total. With the exception of small pastures, agricultural demand occurs only in the Kanab Plateau and Virgin River basins. Approximately 57% of agricultural demand was met by groundwater during 2001-2005. Municipal demand represented about 42% of the total planning area demand with an average of approximately 4,000 AFA during the period 2001-2005. Municipal demand was primarily met by groundwater and the municipal sector was the only sector that utilizes effluent. Industrial demand, primarily related to golf course irrigation, accounted for more than 900 AFA, 10% of the total demand during this period. Tribal water demand is included in these totals.

Cultural demand volumes varied substantially between planning area basins, ranging from 150 AFA in several basins to over 4,500 AFA in the Virgin River Basin during 2001-2005 (see Figure 6.0-19).

Tribal Water Demand

The largest Indian reservation in the planning area in terms of size is the western portion of the Navajo Reservation, which is also the largest reservation in Arizona. All of the Havasupai

Figure 6.0-18 Average Annual Western Plateau Planning Area Cultural Water Demand by Sector, 2001-2005 (in acre-feet)

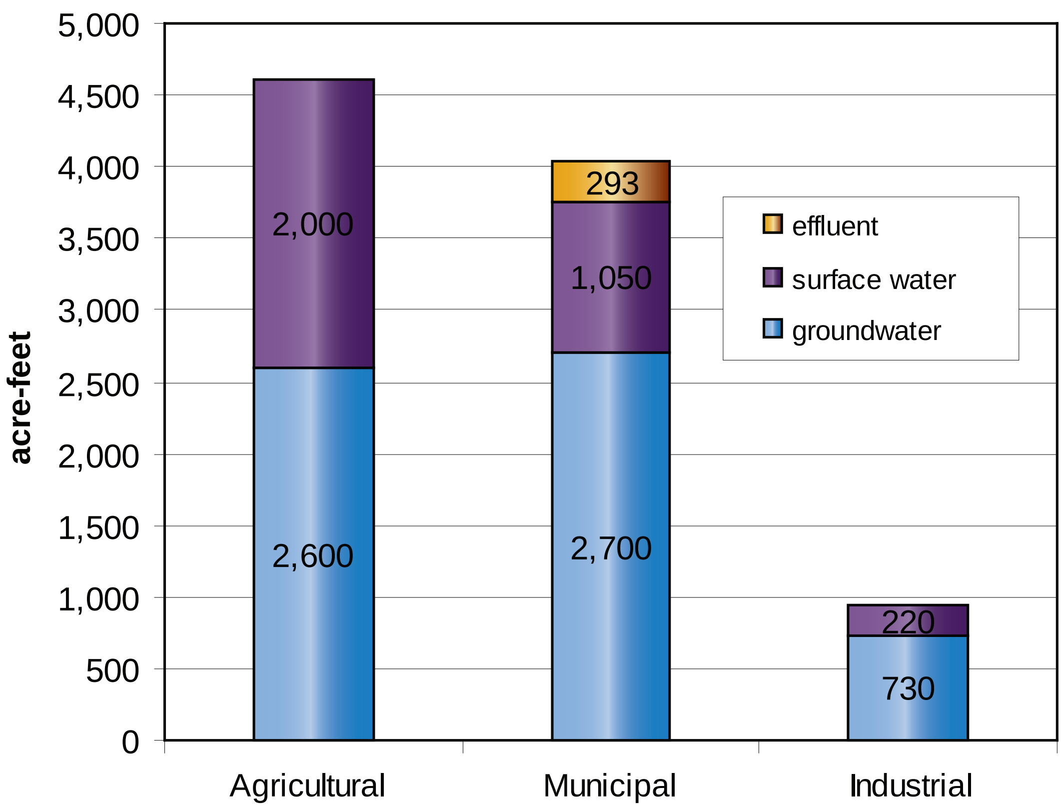
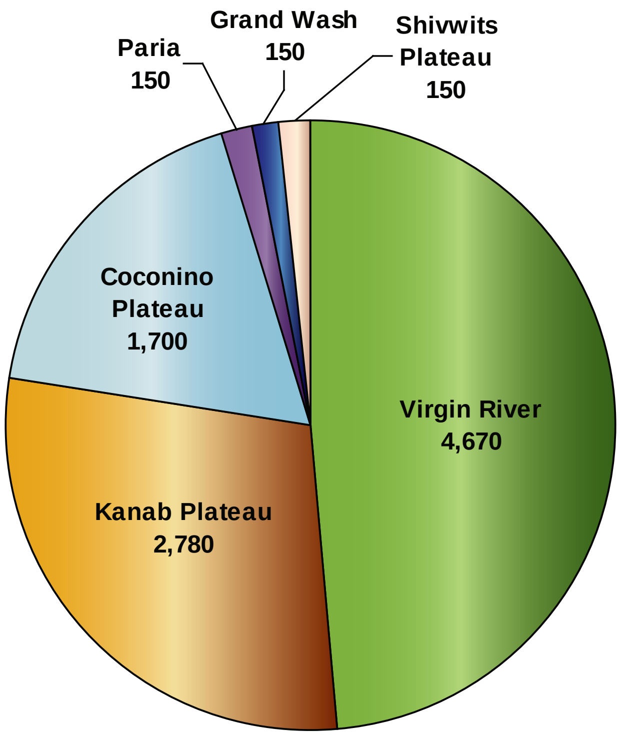


Figure 6.0-19 Average Annual Basin Water Demand, 2001-2005 (in acre-feet)



and Kaibab-Paiute reservations and the eastern portion of the Hualapai Reservation are also within the planning area. The portion of the Hualapai Reservation within the planning area is sparsely populated and its water demand is not known.

Total tribal water demand in the planning area in 2000 was estimated to be approximately 360 AFA with individual tribal estimates listed in Table 6.0-9. More recent demand estimates are not available to the Department. Water demand on the portion of the Navajo Reservation within the planning area is associated with domestic and tourism-related uses at several communities, primarily Cameron but also Gray Mountain, Cedar Ridge and Bodeway (The Gap). Stockwatering is also a likely use. Approximately 250 acre-feet has been used annually in this area (USBOR, 2006).

The Kaibab-Paiute Reservation contains five villages, the largest of which is Kaibab. This Tribe maintains its tribal headquarters, a visitor's center and other services adjacent to Pipe Springs National Monument near the village of Kaibab. The tribal economy is centered on livestock and tourism as well as agriculture. The Tribe owns a 1,300 tree fruit orchard and may expand agricultural activities (ITCA, 2003). Water demand in 2000 is estimated at approximately 56 AFA (ADWR, 2007). The nearby community of Moccasin is not located on reservation land and has been the site of the Mohave County Consolidated Court for over 50 years, serving all of Mohave County north of the Colorado River.

The Havasupai use surface water from Havasu Creek and wells completed in shallow stream alluvium along the creek to support the community of Supai and tourism activities. There is also a small amount of farming on the reservation and stock watering. Tourism is the economic base for the tribe with more than 12,000 annual visitors to nearby Havasu Falls (ITCA, 2003). Water demand in 2000 was likely less than 50 AFA (ADWR, 2007).

Municipal Water Demand

Municipal water demand is summarized by groundwater basin and water supply in Table 6.0-10. Average annual demand during 2001-2005 was approximately 4,000 acre-feet. Sixty-seven percent of the municipal demand is met by groundwater. Surface water is used in the

Table 6.0-9 Tribal Water Demand in the Western Plateau Planning Area in 2000 (in acre-feet)

	Agricultural	Municipal
Kaibab-Paiute	46	10
Navajo	0	250
Havasupai	UNK	50
Hualapai	UNK	UNK

UNK= Unknown
Source: ADWR 2007a

Coconino Plateau Basin by Williams and Grand Canyon National Park-South Rim, and in the Kanab Plateau Basin by Grand Canyon National Park-North Rim, Jacob Lake and in the vicinity of Marble Canyon. Effluent is used for golf course irrigation in Williams, toilet flushing and irrigation at Tusayan and Grand Canyon Village and irrigation and fire protection at Valle.

Primary municipal demand centers are Beaver Dam/Littlefield, Colorado City, Fredonia, Grand Canyon National Park, Tusayan and Williams. Five water providers in the planning area served 100 acre-feet or more of water in 2006. These providers and their demand in 1992, 2000 and 2006 are listed in Table 6.0-11. Although Fredonia used about 440 acre-feet of water in 2003, its water supply is from Utah, thus it is not included in the table. It is estimated that about 65% of the planning area population is served by a water provider. In 2006, municipal utilities served the communities of Fredonia and Williams. 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 6.0.8.

City of Williams

Until recently, the City of Williams was completely reliant on surface water. Due to drought conditions that impacted surface water supplies, Williams has developed a groundwater system to use during periods when reservoir levels are low or to blend with surface water to aid in water treatment. Annual water demand and supply fluctuates from year to year. In 2006, Williams diverted 155 acre-feet of surface water and withdrew 389 acre-feet of groundwater. In 2007, just 85 acre-feet of surface water was diverted and 512 acre-feet of groundwater was pumped.

Municipal uses include residential, commercial and the only municipal golf course in the planning area. In 2006 Williams delivered 184 acre-feet to residential customers and 305 acre-feet to non-residential customers. The Elephant Rock Golf course used 153 acre-feet of effluent

Table 6.0-10 Average annual municipal water demand in the Western Plateau Planning Area, 2001-2005 (in acre-feet)

Basin	Groundwater	Surface Water[1]	Effluent[2]	Total
Coconino Plateau	500	900	293	1,693
Grand Wash	<300			<300
Kanab Plateau	1,600	<300		1,750
Paria	<300			<300
Shivwits Plateau	<300			<300
Virgin River	<300			<300
Total Municipal	2,700	1,050	293	4,043

Sources: USGS 2007, ADWR 2008c

Notes: Volumes <300 acre-feet assumed to be 150 acre-feet for computation purposes

[1] Reflects water utilized within the basin. The Cultural Demand Tables for the Kanab Plateau and Coconino Plateau basins in Sections 6.1.8 and 6.3.8 reflect water withdrawn in the basins.

[2] Includes golf course, turf irrigation and municipal reuse in Tusayan, Grand Canyon Village and Williams in 2006.

Table 6.0-11 Water providers serving 100 acre-feet or more of water per year in 2006, excluding effluent, in the Western Plateau Planning Area

Basin/Water Provider	1992 (acre-feet)	2000 (acre-feet)	2006 (acre-feet)
Coconino Plateau Basin			
City of Williams	450	620[1]	543
Grand Canyon National Park Water Utility	NA	528	574[2]
South Rim System	*NA*	*465*[3]	*510*
North Rim System	*NA*	*63*	*64*
HydroResources-Town of Tusayan	135	125	153
Kanab Plateau Basin			
Centennial Park DWID - Colorado City	NA	NA	346[4]
Twin City Water Company - Colorado City[5]	NA	NA	976
Virgin River Basin			
Beaver Dam Water Company	5	39	160[4]

Sources: CWS annual reports for 2006 & 2007, City of Williams 2007, Coconino County 1997, Pinkham and Davis 2002

[1] Williams began using groundwater in 2000.

[2] Grand Canyon National Park System Water Plan, 2006; from average daily demand for North and South Rim systems. Diversion from Roaring Springs, in the Kanab Plateau Basin was 883 acre-feet.

[3] Based on potable water production, Pinkham and Davis, 2002

[4] 2007 data from CWS annual report

[5] Twin City Water Company may include water from wells in Utah.

NA = Not Available

for irrigation in 2006, its only water supply that year.

As the "Gateway to the Grand Canyon", tourism is an important part of the local economy with hotels, restaurants, gas stations and other services. Williams maintains a metered standpipe for water haulers, restricted to households built as of June 2000. In 2000, Williams had 495 registered non-commercial water hauling customers. Some of the water used in the unincorporated residential community of Red Lake, located north of Williams, is hauled from Williams. Use of the standpipe service by commercial haulers is restricted during drought (Pinkham and Davis, 2002). Expansion of both its water and wastewater treatment plants may be needed in the near future. Because much of the area surrounding Williams relies on hauled water and delivers septic tank waste to the city wastewater treatment plant, the City is in the position of providing these services outside of its service area.

<u>Grand Canyon National Park</u>

Grand Canyon National Park, with about five million visitors a year and a year round population of almost 1,500 at Grand Canyon Village on the South Rim, is one of the largest municipal users in the planning area. Seasonal employees at Grand Canyon Village increase the summer population by about 40%. The Village includes a school, medical clinic, fire station, administrative offices and other services in addition to hotels, restaurants and campgrounds. The South Rim receives most of the Park's visitors and uses almost 90% of the water. By contrast, the North Rim is closed from mid-October to mid-May, has limited services compared to the South Rim and receives one-tenth the number of visitors. (Pinkham and Davis, 2002)

Grand Canyon National Park Water Utility services all the developed areas within the Park boundaries using water transported from Roaring Springs located below the North Rim in the Kanab Plateau Basin. The utility serves the

Grand Canyon Village. Photo courtesy of the National Park Service

South Rim, Desert View, North Rim, Roaring Springs, Phantom Ranch and Indian Gardens (NPS, 2006). It also provides a relatively small volume of hauled water to the U.S. Forest Service-Tusayan. In 2006, 883 acre-feet of water was diverted at Roaring Springs, however this was not all delivered. Excess water diverted at Roaring Springs and transported to the South Rim by the Trans-Canyon Pipeline overflows at Indian Gardens and returns to the Colorado River. Of the water diverted, almost 600 acre-feet entered the North and South Rim systems in 2006. Of this, 432 acre-feet was reported delivered to customers on both Rims; 105 acre-feet to residential and 327 acre-feet to commercial customers. In addition, 3 acre-feet was delivered to the U.S. Forest Service-Tusayan Ranger Station. The utility does not separately report North and South Rim water deliveries on its Community Water System annual report. The estimated demand for each system shown in Table 6.0-10 is based on average daily demands reported by the Park in its System Water Plan (NPS, 2006).

The South Rim Wastewater Treatment Plant generated about 463 acre-feet of effluent in 2006. Water is treated to ADEQ A+ standards and has been reused for toilet flushing at the visitor center and employee rest rooms, to wash down portions of a kennel, for the railroad steam engine, dust control, revegetation efforts and on a small amount of turf at the El Tovar Lodge. While the reclaimed water distribution system is relatively extensive, on-site plumbing is incomplete (Pinkham and Davis, 2002). In 2006, 37 acre-feet of effluent was used for firefighting and 140 acre-feet was used for landscaping, toilet flushing and construction.

<u>Tusayan</u>

The small, unincorporated community of Tusayan is located about a mile south of the entrance to the South Rim of Grand Canyon National Park. It is surrounded by public land and has a population of about 600. Tusayan's economy is based on tourism including hotels, restaurants, an airport and visitor service establishments (Pinkham and Davis, 2002).

HydroResources-Tusayan serves approximately three-quarters of the water demand at Tusayan utilizing two 3,000-foot deep wells that produce 65 to 80 gpm. Other water systems are ADOT, which serves the Grand Canyon Airport, and Anasazi Water (HydroResources, 2007). However, both systems received water from HydroResources in 2006 and 2007. The community relied on small local wells and hauled water prior to 1995 when the deep wells and reclaimed water began to be used (Pinkham and Davis, 2002). For example, in 1992 Tusayan water was provided by the Canyon Squire Inn well (64 acre-feet), and water hauled from Williams and Bellemont (40 acre-feet) and Grand Canyon National Park (30 acre-feet) (USDA, 1999).

Anasazi Water has one well, and in addition to receiving water from HydroResources, it may use a relatively small amount of hauled water from Williams or Valle. Both HydroResources and Anasazi Water wholesale water to the Tusayan Water Development Association, which bills water customers, but does not operate the water systems. The two systems are interconnected to ensure uninterrupted service to the community and HydroResources owns a well in Valle from which water may be trucked to Tusayan in an emergency.

HydroResources withdrew 153 acre-feet of water in 2006 and delivered 19 acre-feet to Anasazi Water and 6 acre-feet to ADOT. Within its service area, it served 10 acre-feet to residential customers and 116 acre-feet to non-residential customers. All water used indoors in Tusayan is treated at the South Rim Wastewater Treatment Plant. Effluent is used extensively for toilet flushing and irrigation. In 2001, almost 70 acre-feet of effluent was used at Tusayan (Pinkham and Davis, 2002). Although annual effluent use volumes are not reported by HydroResources on its Community Water System annual report, the utility reported that 30-40% of its former groundwater withdrawals have been replaced by effluent (HydroResources, 2007).

ADOT-Grand Canyon Airport operates a rainwater collection system consisting of 5 acres of Hypalon plastic, which provides potable water to the terminal, office, hangar facilities and a dozen homes. However, ongoing drought conditions have required the purchase of water from HydroResources-Tusayan (GCNP Airport, 2008). The airport has also used reclaimed water for irrigation (Pinkham and Davis, 2002).

Colorado City

Colorado City is located in the Kanab Plateau Basin in Mohave County on the northern border of Arizona, adjacent to Hildale, Utah. The two communities have close cultural and economic ties, with nearly half of the population employed in Hildale. The community was initially settled by ranchers in the early 1900's but around 1930 a religious group from Utah settled in the area and played a major part in shaping the present-day community (USDOI, 2007).

Colorado City is the largest community and municipal demand center in the planning area with a 2006 population of more than 3,300 and water demand of over 1,300 acre-feet served by two systems; Centennial Park Domestic Water Improvement District (DWID) and Twin City Water Works (TCWW). The wastewater treatment plant in Colorado City was closed in 2002 and wastewater is now treated at a plant in Hildale.

Most of Colorado City is served water pumped from wells owned by TCWW, which also serves Hildale Utah. TCWW owns five wells in Arizona and additional system wells may be located in Utah. The City buys water wholesale from TCWW, treats it to drinking water standards, and delivers it to customers through its water delivery infrastructure. Based on verbal communication with system representatives, about two-thirds of the water delivered by TCWW is used in Colorado City, totaling approximately 976 acre-feet in 2006. Municipal uses include residential, commercial and light manufacturing but Colorado City does not separately report these deliveries.

The southeastern part of Colorado City is served by Centennial Park DWID, which operates three wells and serves domestic customers. Centennial Park DWID does not have an interconnection to another system and is not completely metered. In 2007 it reported withdrawals of 346 acre-feet.

Beaver Dam/Littlefield

The communities of Beaver Dam, Littlefield, Scenic and the surrounding area in the Virgin River Basin are experiencing development due primarily to the nearby rapidly growing community of Mesquite, Nevada. These communities provide housing for much of Mesquite's workforce and for retirees (USDOI, 2007). The area is served by private water systems or domestic wells. The largest system is Beaver Dam Water Company, which reported

Beaver Dam, Virgin River Basin

withdrawals of 160 acre-feet from three wells in 2007. (Withdrawals in 2006 were from engineering estimates and are much greater than metered 2007 and 2008 data). It delivered almost 139 acre-feet to residential customers and 21 acre-feet to non-residential customers in 2007. Beaver Dam East DWID withdrew 13 acre-feet of groundwater from one well in 2006 and served residential customers only. The area is anticipated to experience population growth with associated increases in municipal demand.

<u>Other Communities</u>

Fredonia, in the Kanab Plateau Basin, is the largest town in Coconino County on the Arizona Strip. It was founded in 1885 with an economy based on agriculture, timber and mining. A sawmill operation at Fredonia closed in 1995 and tourism, government activities and agriculture are the primary current economic activities. The population of Fredonia declined between 1990 and 2000 by about 14% but is now slowly increasing.

In 2007 Fredonia reported that all water used was transported by pipeline from Utah and did not report the volume or type of water supply delivered. In 2003, about 440 acre-feet of water was served by the Town of which about half was reported delivered from Utah. Approximately 160 acre-feet of effluent is produced at Fredonia but not reused.

Valle, located between Williams and Tusayan, is a small but rapidly growing community that grew by 334% between 1990 and 2000. It is served by two water systems with wells over 3,000 feet deep. One of these systems is owned by the Grand Canyon Inn, which also operates a wastewater treatment plant and a standpipe for water haulers. The Inn uses wastewater to irrigate landscaping at the hotel and for fire protection. Water demand data are not available for this system.

The other system, HydroResources-Valle, serves the Grand Canyon Valle Airport, a mobile home park and operates two standpipes for water haulers. In 2006 it withdrew 35 acre-feet from one well. This system is not interconnected to any other system and emergency water is hauled from Tusayan. A small wastewater treatment plant serves users on this system and effluent is used to irrigate a ballpark.

The area surrounding Valle is primarily composed of large lot development without sewer or water service. Most residents must haul water and use septic systems for wastewater disposal. Despite the lack of services, there has been significant subdivision activity in the area (Pinkham and Davis, 2002).

Agricultural Demand

Agricultural demand in the planning area averaged about 4,600 AFA during 2001-2005, primarily for pasture irrigation (Table 6.0-12). Aside from small domestic pastures and gardens, agricultural irrigation is found only in the Kanab Plateau and Virgin River basins. Note that the data source for the cultural demand maps in the groundwater basin sections is from satellite imagery collected between 1999 and 2001 and may not accurately represent more recent agricultural demands in the planning area.

There is considerably less irrigation in the Kanab Plateau Basin now than historic levels. From 1976 through 1990 approximately 2,000 acre-feet of groundwater was pumped annually (Table 6.3-8) and between 1,400 to 1,850 acres of alfalfa, pasture and a minor amount of grain and corn were historically irrigated with surface water from Kanab Creek. (ADWR, 1998) By 2007, the USGS estimated approximately 1,400 acre-feet of water was used for irrigation.

In the Fredonia area, surface water from Kanab Creek was historically diverted between Kanab Dam and Fredonia Dam, primarily within the boundaries of the Fredonia Consolidated Irrigation and Manufacturing Company District. The District owns and operates the Fredonia Dam, constructed in 1918, and a concrete-lined distribution ditch. District lands are located mainly east of Kanab Creek south of the town (ADWR, 1998). The USGS conducted a field survey of the area in 2007 and found 413 acres flood irrigated with surface water and 65 acres sprinkler irrigated with groundwater with a total demand of 676 AFA (Table 6.0-13).

Table 6.0-12 Agricultural water demand in the Western Plateau Planning Area

	1991-1995 (acre-feet)	1996-2000 (acre-feet)	2001-2005 (acre-feet)
Kanab Plateau			
Groundwater	1,500	1,500	<1,000
Surface Water	<1,000	<1,000	<1,000
Total	2,000	2,000	1,000
Virgin River			
Groundwater	7,800	8,300	2,100
Surface Water	5,800	6,200	1,500
Total	13,600	14,500	3,600

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

The USGS observed 72 acres of irrigation at Colorado City in 2007 with an associated demand of 262 acre-feet (Table 6.0-13). Large fallow areas, previously irrigated with center pivot systems, were observed in the Colorado City area in summer 2007. At Moccasin, the USGS found about 129 acres of irrigation, primarily alfalfa in 2007. There is a small amount of agricultural activity, including a 1,300-tree fruit orchard, on the Kaibab-Paiute Indian Reservation with an estimated groundwater demand of about 50 AFA.

Table 6.0-13 Active agricultural acres in the Kanab Plateau (2008) and Virgin River (2007) basins

Region	Basin	Crop Type	Acres	Irrigation System	Water Type	Water Withdrawal (Acre-Feet)
Colorado City	Kanab Plateau	Rye Grass	60	Sprinkler	Groundwater	232
		Corn	12			30
Fredonia	Kanab Plateau	Rye Grass	413	Flooded	Surface Water	425
			24	Sprinkler	Groundwater	95
		Alfalfa	41			156
Moccasin	Kanab Plateau	Alfalfa	114	Center Pivot	Groundwater	442
		Rye Grass	8	Sprinkler		31
		Oats/Grass Mix	5			19
		Corn	2			4
		Orchard	0.16	Flooded		1
		Vegetables	0.09			1
Beaver Dam/Littlefield	Virgin River	Alfalfa	38	Sprinkler	Groundwater	147
		Pistachio	4	Drip		10

Source: USGS 2009

In the Virgin River Basin, irrigation demand declined from an annual average of 14,500 acre-feet during the period 1996-2000 to an annual average of 3,600 acre-feet during 2001-2005. This decline occurred due to flood damage along the Virgin River and Beaver Dam Wash and to urbanization. By 2005, it was estimated that about 525 acres were still in production in the Littlefield/ Beaver Dam area (Kyle Spencer, NRCS, personal communication 3/25/05). However, when the USGS conducted a field investigation of the area in 2006, it found just 42 acres in active production, primarily alfalfa, with an associated demand of 157 acre-feet.

Industrial Demand

Industrial demand in the planning area was relatively low, averaging about 950 AFA during the period 2001-2005. As summarized in Table 6.0-14, quantified industrial demand in the planning area consists of golf courses served by facility water systems and a small dairy. There are two industrial golf courses in the Virgin River Basin. The Meadowayne Dairy, located on the north side of Colorado City in the Kanab Plateau Basin is estimated to have an annual demand of about 30 acre-feet.

Golf course demand is listed in Table 6.0-15. Hamilton Ranch Golf Course is located in the community of Beaver Dam. Flooding in 2006 washed out all but 8 holes. Irrigation of the existing course uses about 220 AFA of groundwater and surface water diverted from Beaver Dam Wash. The other industrial golf course, The Palms, located in Scenic adjacent to the Nevada state line, is an 18-hole course that uses about 440 AFA of groundwater. The only other golf course in the planning area is Elephant Rock, a municipally-served golf course at Williams with an annual demand of about 150 acre-feet of effluent.

Table 6.0-14 Industrial demand in the Western Plateau Planning Area

	1991-1995	1996-2000	2001-2005
Type	Water Use (acre-feet)		
Golf Course Total	**920**	**920**	**920**
Virgin River			
Groundwater	700	700	700
Surface Water	220	220	220
Dairy/Feedlot Total	**30**	**30**	**30**
Kanab Plateau			
Groundwater	30	30	30

Source: ADEQ 2005b, ADWR 2008c, USGS 2007

There is additional industrial demand in the planning area not reflected in Table 6.0-14, primarily sand and gravel operations in the Virgin River Basin and elsewhere. Some of the operations are identified on the cultural demand maps. Water is used for aggregate washing, dust control, vehicle washing and equipment cooling. Typically, relatively little water is consumed at these sites.

Table 6.0-15 Golf course demand in the Western Plateau Planning Area (c 2006)

Facility	Basin	# of Holes	Demand (acre-feet)	Water Supply
Elephant Rock Golf Club	Coconino Plateau	18	150	Effluent
Hamilton Ranch*	Virgin River	8	220	Groundwater/ Surface Water
The Palms Golf Course*	Virgin River	18	441	Groundwater

Source: ADWR 2008c
Notes:
* These golf courses are served by their own wells and, therefore, considered to be industrial users
Flooding in 2006 washed out all but eight holes at the Hamilton Ranch Golf Course

The three mines shown on the Kanab Plateau Basin cultural demand map (Figure 6.3-11) are currently (2009) inactive uranium mines owned by Denison Mines that have received aquifer protection permits from ADEQ. The Arizona One Mine, about 35 miles south of Fredonia received its final permit in 2009, allowing mining to resume. The two other mines, Canyon and Pinenut, require additional permits before work can commence. (McKinnon, 2009) A number of mining companies are currently exploring the Arizona Strip and claiming breccia pipes for uranium mining. The highest grade uranium deposits in the United States occur in breccia-pipe environments in northwest Arizona.[4] It is anticipated that if developed, these mining operations would involve minimal water use. Water is used primarily in ore processing, which would occur elsewhere. The minor amount of water needed for mining on site would come from stormwater collection and/or shallow groundwater encountered in perched aquifers on site (Nyals Neimuth, ADMMR, personal communication, 6/07).

There are concerns about uranium mining near the Grand Canyon and the Colorado River due to potential impacts to air and water quality (McKinnon, 2009). In July, 2009 Interior Secretary Salazar enacted a two-year moratorium on new mining claims on almost 1 million acres of federal lands north of the Grand Canyon. The moratorium was imposed to further study the risks associated with mining and evaluate whether to withdraw the lands from new mining claims for an additional 20 years (USDOI, 2009).

6.0.8 Water Resource Issues in the Western Plateau Planning Area

Water resource issues in the Western Plateau Planning Area have been identified in water resource studies, by community watershed groups, through surveys, and from other sources. Studies, planning, conservation activities, watershed groups and results from water provider surveys are discussed in this section.

The Colorado River is a significant political, social and planning barrier, as well as a physical barrier, and the area south of the River has different water resource concerns compared to areas north of the river. North of the River, the Arizona Strip is sparsely populated with few population centers. Colorado City, the largest community, has not identified any significant water resource issues. The Virgin River Basin is somewhat physically isolated from the rest of the Arizona Strip, and while experiencing rapid population growth, contains no incorporated communities. As a result, most of the water resource planning activities have occurred south of the Colorado River in the Coconino Plateau Basin.

Studies, Planning and Conservation

A number of water resource studies have been conducted in the planning area south of the Colorado River. Studies have been conducted in response to environmental concerns, growth and limited water supplies. A primary objective has been to better understand the water supply, water demand and hydrology of the area in order to develop a regional approach to water resource planning. A major effort has been the North Central Arizona Water Supply Study, which was completed in 2006 and involved the cooperation of the Bureau of Reclamation, Navajo Nation, Hopi Tribe, Havasupai Tribe, the Grand Canyon Trust, City of Williams, the City of Flagstaff, the City of Page, Coconino County, the Department of Water Resources, the USGS and USFWS. The next step for

[4] A breccia pipe is a vertical pipe-like column of broken rock. On the Colorado Plateau in northwestern Arizona, these pipes formed when sedimentary rocks collapsed into solution cavities in the underlying Redwall limestone. Mineralizing fluids passing through the pipes deposited metallic minerals, sometimes including uranium. A typical pipe is about 300 feet in diameter and can extend as much as 3,000 feet. (Wenrick, 2007)

this group is to secure funding to conduct a feasibility study to evaluate water supply alternatives. Other notable studies provide detailed information on cultural water supplies and demand in the Coconino Plateau Basin. These include: North Central Arizona Water Demand Study, (Pinkham and Davis, 2002), Grand Canyon National Park Water Supply Appraisal Study (USBOR, 2002) and the EIS for Tusayan Growth (USDA, 1999).

On the Arizona Strip, an EIS for the Grand Canyon-Parashant and Vermilion Cliffs national monuments and for other BLM lands (BLM, 2007) provides a comprehensive study of much of the area north of the Colorado River. While the focus of the EIS is on land management to preserve the objectives of the monuments and other areas, water resources and demands are included as a component of the cooperative management of the area.

The National Park Service has conducted numerous studies and management activities in Grand Canyon National Park and Glen Canyon National Recreation Area. The water resources of the Park have been of particular concern given development on the South Rim and nearby areas and the potential impact of associated water development activities on seeps and springs in the Grand Canyon. Development and implementation of new management strategies through the Adaptive Management Program will affect the environmental conditions downstream of Glen Canyon Dam throughout much of the planning area. (USBOR, 2007a) There is significant interplay between resource development and environmental needs in the planning area given the amount of federally protected lands as parks, monuments, recreation areas and wilderness areas.

Because of relatively scarce water supplies, communities have made extraordinary efforts to develop new water supplies and reuse existing resources such as effluent and graywater. As mentioned previously, Grand Canyon Village and the community of Tusayan have taken extreme measures to conserve existing resources and reuse effluent for multiple purposes, including widespread use of effluent for toilet flushing. The rainwater harvesting system at the Tusayan airport is unprecedented in Arizona. The City of Williams and Tusayan's well drilling programs are excellent examples of local efforts to improve supply reliability and better utilize available resources. The City of Williams water conservation program includes incentives to retrofit old plumbing fixtures and install drought tolerant landscaping and several other water systems in the planning area provide water conservation information to customers.

Shivwits Plateau Basin. Most of the planning area is sparsely populated and as a result, most of the water resource planning activities have occurred south of the Colorado River in the Coconino Plateau Basin.

As mentioned in Section 6.0.5, by January 2008, all large (>1,850 customers) community water systems were required to submit System Water Plans. Small systems were required to submit plans by January 2008. The 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. Within the planning area plans have been submitted by 18 systems including the City of Williams, Colorado City, Town of Fredonia, Grand Canyon National Park, HydroResources-Tusayan and Beaver Dam Water Company.

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

The Mohave County Comprehensive Plan water resources element includes development of a water budget for each of the groundwater basins in the county and will prioritize this effort based on growth potential, water availability, number of wells and other factors (Freilich, Leitner & Carlisle, 2005). However, the County's key water issues and planning efforts are focused on the part of the County south of the Colorado River. The Coconino Comprehensive Plan emphasizes conservation in tandem with resource development and recognizes the importance of incorporating climatic variability into water resource planning (Coconino County, 2003). In addition, Coconino County has adopted individual Area Plans including three in the planning area: Tusayan, Valle and Red Lake (located north of Williams) which include a discussion of water and wastewater infrastructure. However, these area plans all date from the 1990s.

An application from Wind River Resources L.L.C. to transport groundwater from the Virgin River Basin to Mesquite Nevada in 2005 was recently an important issue for the area. The application proposed to transport water from Beaver Dam Wash pursuant to A.R.S. § 45-291 et seq. The statute allows for transportation of groundwater out of state, conditional on several criteria. The proposal included construction of three wells in the Mormon Wells area along Beaver Dam Wash. The proposal was to initially withdraw 800 AFA and up to 14,000 AFA by 2045, and transport it to the Virgin Valley Water District in Mesquite. The Director of the Department denied the application in November 2007.

Another issue involving the Virgin River is related to Colorado River shortage sharing as discussed previously in Section 6.0-6. The Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lakes Powell and Mead (Guidelines), provide for the conservation of Colorado River water by creating the Intentionally Created Surplus (ICS) program. The ICS program provides flexibility in the delivery of Colorado River water by allowing Colorado River contractors to add water to the system through conservation, system efficiency improvements, or importation to be released in the future by the Secretary of Interior to the State (Arizona, California or Nevada) that added the water (ADWR, 2009).

One of the categories of ICS is Tributary Conservation ICS. This category allows a water user to fallow water rights in tributaries of the Colorado River that were in use prior to the effective date of the Boulder Canyon Project Act (BCPA) (1929) and transport this water to

Virgin River through Virgin River Gorge.

the Colorado River for credit. This allows an entity to develop some water resources that were formerly identified as "in-state water" by conveying them to the Colorado River for current or future use (SNWA, 2008).

Regarding the Virgin River, an agreement to the Guidelines, the "Southern Nevada Water Authority Virgin and Muddy Rivers Tributary Conservation, Intentional Created Surplus (ICS) Project", allows the Southern Nevada Water Authority to temporarily forego development of Virgin River water rights received after the BCPA was enacted while it pursues long-term Colorado River augmentation. Under the agreement, irrigation rights granted to Nevada prior to the BCPA will be used. SNWA, which has purchased many of these rights, will fallow the land and let the amount not consumed flow into Lake Mead through the Virgin River or its tributaries where the water will be withdrawn directly from the lake, without building a new pipeline (SNWA, 2008). Five percent of the water conserved under the Tributary Conservation ICS program is left in Lake Mead to increase the water supplies for the system. Flow in the Virgin River will not be impacted through Arizona under the SNWA agreement (Gelt, 2004).

Watershed Groups

Several watershed groups affiliated with the Department's Rural Watershed Initiative Program have formed to address water resource issues. The two active groups, the Coconino Plateau Water Advisory Council and the Northern Arizona Municipal Water Users Association, include not only part of the Western Plateau but also part of the Eastern Plateau and Central Highlands planning areas. A watershed group previously existed in the Fredonia area, (the Arizona Strip Partnership), but is no longer active. A list of participants, activities and issues for all watershed groups in the planning area is found in Appendix D.

Primary issues identified by the Arizona Rural Watershed Initiative groups that pertain to the planning area are summarized as follows:

Growth:
- Unregulated lot splits
- 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 current and projected demands
- Numerous water haulers with few hauling stations that are sometimes cut-off during drought

- Brackish groundwater (Arizona Strip)
- Interstate stream issues (Arizona Strip)
- Inadequate surface water supplies for agriculture (Arizona Strip)

Legal:
- Unresolved Indian water rights claims

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 water companies

Drought:
- Drought sensitive surface water supplies

Environmental:
- Potential for groundwater development to impact springs in Grand Canyon and Havasupai and Hualapai Indian Reservation water supplies

Other:
- Unsafe dams (Williams and Fredonia)

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 to incorporate into the Arizona Drought Preparedness Plan, adopted in 2004. Questionnaires were sent to almost 600 water providers, jurisdictions, counties and tribes, and a report of the findings from the survey was subsequently completed (ADWR, 2004).

Only one water provider in the planning area responded to the 2003 survey. 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, ten water providers in the Western Plateau Planning Area, with a total of approximately 2,400 service connections, participated and provided information on water supply, demand, and infrastructure and ranked a list of seven issues. There were five respondents from the Virgin River Basin, three from the Kanab Plateau Basin and two from the Coconino Plateau Basin.

Table 6.0-16 Water resource issues ranked by survey respondents in the Western Plateau Planning Area

Issue	Percent of 2004 respondents reporting issue was a moderate or major concern
Inadequate storage capacity to meet peak demand	43%
Inadequate well capacity to meet peak demand	14
Inadequate water supplies to meet current demand	43
Inadequate water supplies to meet future demand	43
Infrastructure in need of replacement	29
Inadequate capital to pay for infrastructure improvements	71
Drought related water supply problems	29

Source: ADWR, 2005b

Water providers were asked in the 2004 survey to rank seven issues from 0 to 3 with 0 = no concern, 1 = minor concern, 2 = moderate concern and 3 = major concern. All water providers responded, but two reported no concerns. Results are summarized in Table 6.0-16 for the eight providers that ranked issues of concern. The most highly ranked issue, inadequate capital for infrastructure improvements, was identified primarily by respondents located in the Virgin River Basin. Inadequate storage was primarily an issue in the Kanab Plateau Basin.

6.0.9 Groundwater Basin Water Resource Characteristics

Sections 6.1 through 6.6 present data and maps on water resource characteristics of the six groundwater basins in the Western Plateau Planning Area. A description of the data sources and methods used to derive this information is found in Appendix A of Volume 1 of the Atlas. This section briefly describes general information that applies to all of the basins and the purpose of the information. This information is organized in the order in which the characteristics are discussed in Sections 6.1 through 6.6.

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 specified purposes, which are identified for each basin (ASLD, 2006).

Climate

Climate data including temperature, rainfall, evaporation rates and snowfall are critical components of water resource planning and management. Averages and year to year variability, seasonality of precipitation and long-term 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. The stream order used is the Cartographic order, similar to ‘stream level’ used by the USGS to categorize streams in its National Hydrography Dataset (NHD). This method assigns Level 1 to the principal stream in a drainage area, major tributaries are assigned Level 2, minor tributaries are assigned Level 3, etc.

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

ADEQ Aquifer Protection Permit programs). It is important to note also that the exceedences presented may or may not reflect current aquifer or surface water conditions.

Cultural Water Demand

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

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

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

Water Adequacy Determinations

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

In addition to these subdivision determinations for which a water adequacy report is issued, water providers may apply for adequacy designations for their entire service area. If a subdivision is to be served water from one of these water providers, then a separate adequacy determination is not required. (See Section 6.0-5).

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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