COLORADO RIVER WATERSHED

The Colorado River watershed is located in the northern and western portions of Arizona and extends through two other planning areas known as the Upper Colorado River and Lower Colorado River planning areas. Within the Plateau planning area, the Colorado River flows southwest from Lake Powell to Lake Mead.

Colorado River Main Stem

Water in the Colorado River first enters the state and the Plateau planning area as storage in Lake Powell and is released to generate power and meet downstream requirements. The U.S. Geological Survey streamgage at Lees Ferry measures the discharge from Lake Powell's Glen Canyon Dam which is the main flow of the Colorado River into Arizona. The average flow into Arizona before the dam was built in 1963 was 12,923,000 acre-feet per year. Since construction of the dam, the flow averages 10,701,000 acre-feet per year (U.S. Geological Survey, 1989). Other gaging stations along the main stem of the Colorado River are listed in Table 10.

The main stem of the Colorado River is joined by numerous streams and springs within the Plateau planning area. The springs are the discharge points for groundwater that moves northward and southward toward the Colorado River. Most of the springs issue from the Muav and Redwall Limestones, although a few small springs issue from the Tapeats Sandstone. Some of the springs emerge in the tributary canyons and flow some distance to the Colorado River, while others emerge along or very close to the river (Johnson and Sanderson, 1968). Table 11 lists stream and spring inflow into the Colorado River from the Paria River downstream to Lake Mead. The Paria River enters the main stem of the Colorado River about 16 miles downstream from Glen Canyon Dam. It is the first tributary inflow into the Colorado River below the dam and marks the beginning of Marble Canyon.

TABLE 10
ANNUAL FLOWS FOR USGS STREAMGAGING STATIONS ON THE COLORADO RIVER (PLATEAU PLANNING AREA)

Station Name	Station Number	Period of Record	Mean Annual Flow (ac-ft)	Median Annual Flow (ac-ft)	Record Annual High Flow (ac-ft)	Record Annual Low Flow (ac-ft)
Colorado River at Lees Ferry	9380000	1922-1962	12,015,080	11,899,270	19,180,700	4,378,990
Colorado River at Lees Ferry*	9380000	1965-1990	10,422,720	8,403,320	20,411,160	7,817,040
Colorado River at Compact Point	9383000	1981-1983, 1987-1989	10,639,860	8,316,460	17,515,960	7,961,800
Colorado River near Grand Canyon	9402500	1923-1962	12,232,220	12,076,600	19,397,840	4,654,030
Colorado River near Grand Canyon*	9402500	1965-1990	10,784,620	8,873,790	20,700,680	8,251,320

*After construction of Glen Canyon Dam
Source: U.S. Geological Survey, 1992, National Water Information System.

TABLE 11
ANNUAL TRIBUTARY FLOW INTO THE COLORADO RIVER (PLATEAU PLANNING AREA)

Source	Distance Downstream from Paria River (miles)	Estimated Annual Discharge (ac-ft)
Paria River	0	21,424
Vaseys Paradise	32	2,895
Nankoweap Creek	52	1,086
Blue Springs (Little Colorado R.)	61	161,300
Clear Creek	84	1,520
Bright Angel Creek	88	25,622
Monument Creek	94	2
Crystal Creek	98	1,086
Shinumo Creek	108	6,587
Elves Chasm	116	217
Stone Creek	132	507
Tapeats Creek	134	72,380
Deer Creek	136	5,211
Kanab Creek	143	2,823
Matkatamiba Creek	147	4
Havasu Creek	157	46,780
Lava Falls	179	7,962
Diamond Creek	226	1,375
Spencer Canyon	246	1,954

Source: Johnson and Sanderson, 1968

Surface Water Resources Within Each Groundwater Basin

This section will discuss the surface water supplies for each groundwater basin within the Plateau planning area. All of the basins are within the Colorado River watershed.

Little Colorado River Plateau Basin

The northern one-third of the Little Colorado River Plateau basin drains northward toward Utah and eventually enters the San Juan River as part of the Colorado River watershed. Chinle Creek collects the majority of the surface water runoff in the northern part of the basin and flows out of Arizona into Utah. Chinle Creek sustains perennial flow for approximately six miles in Arizona before crossing the Utah border. A U.S. Geological Survey gaging station on Chinle Creek (09379200) had an average flow of 18,100 acre-feet per year since 1964 (U.S. Geological Survey, 1989). Other perennial reaches within the northern third of the basin are shown in Table 12 and displayed in Figure 11.

TABLE 12
PERENNIAL STREAM REACHES IN THE NORTHERN PORTION OF THE LITTLE COLORADO RIVER PLATEAU BASIN

Perennial Stream Reaches	Length (miles)
Chinle Creek	6
Oljeto Creek	3
Nokai Creek (2 reaches)	6
Piute Creek	6
Laguna Creek	32
Walker Creek	4
Teec Nos Pos Creek	3
Navajo Creek (6 reaches)	40
Lukachukai Creek (2 reaches)	8
Tsaile Creek (3 reaches)	35
Whiskey Creek (2 reaches)	15
Nazlini Creek	4
Kaibito Creek	3
Chayahi Creek	2

Source: Brown and others, 1981

The southern two-thirds of the basin are within the Little Colorado River watershed. The Little Colorado River is one of the major surface streams in the planning area and has headwaters which begin in the White Mountains as perennial flow. The river flows downstream into Lyman Lake where the flow is regulated to Zion Reservoir (Brown and others, 1981). From Zion Reservoir to Silver Creek the flow is intermittent. Most of the Little Colorado River reach from the confluence of Silver Creek to Winslow is perennial.

A majority of the streams in the Little Colorado River watershed are ephemeral or intermittent. In perennial locations, however, surface-water flow is sustained from approximately 900 springs varying from less than 10 cubic feet per second (720 acre-feet per year) in the White Mountains to 223 cubic feet per second (161,400 acre-feet per year) at Blue Spring in the Coconino Plateau basin (U.S. Department of Agriculture, 1981). Streams in the Little Colorado River watershed which exhibit perennial flow are listed in Table 13 along with the length of the perennial reach (Brown and others, 1981). Figure 11 displays the location of these reaches. Table 14 lists selected U.S. Geological Survey gaging station records for the Little Colorado River watershed within Arizona.

TABLE 13
PERENNIAL STREAM REACHES IN THE LITTLE COLORADO WATERSHED

Perennial Stream Reaches	Length (miles)
Little Colorado River	75
Silver Creek	55
Chevelon Creek	30

Willow Creek	13
East Clear Creek	25
Yeager Canyon	6
Coyote Creek	8
Kinlichee Creek	10
Brown Creek	5
Source: Brown and others, 1981	

The total storage capacity for reservoirs within the Arizona portion of the Little Colorado River watershed is estimated to be 222,900 acre-feet. Approximately half of this volume, 106,350 acre-feet, is the average storage in an average year. Storage capacities for three of the largest reservoirs in the watershed, Lyman Lake, Upper Lake Mary and Blue Ridge Reservoir are 30,600 acre-feet, 15,620 acre-feet, and 19,500 acre-feet, respectively (U.S. Department of Agriculture, 1981).

High rates of evaporation and transpiration occur within the Little Colorado River watershed because of high temperatures and low humidity. Mean annual lake evaporation rates vary from 40 inches per year near Springerville to 55 inches per year in the Holbrook area (U.S. Department of Agriculture, 1981).

The U.S. Department of Agriculture (1981) reported that 359,800 acre-feet of water were discharged out of the Little Colorado River basin. Approximately 345,600 acre-feet of this were discharged into the Colorado River. The remainder is exported out of the basin (and planning area) from two locations along the Mogollon Rim. These two annual exports are to the East Verde River from the Blue Ridge Reservoir, and to Forestdale Creek from Show Low Lake, totalling 10,900 and 3,300 acre-feet, respectively. The surface water exports are diverted by the Phelps-Dodge Corporation in exchange for water they are using in the Salt River basin (U.S. Department of Agriculture, 1981). The East Verde River in the Verde River basin and Forestdale Creek in the Salt River basin are within the Central Highlands planning area.

Surface-water contamination has occurred in the basin as a result of mining activities and rangeland/agricultural practices. As mentioned previously in the Groundwater section of this report, there has been severe radiochemical contamination in the Puerco River caused by the 1979 Church Rock uranium mine tailing pond spill in New Mexico. In the Silver Creek/Show Low area, metals and turbidity exceedances appear to have resulted from sand and gravel operations (Arizona Department of Environmental Quality, 1990).

The Arizona Department of Environmental Quality (1990) has reported high turbidity levels in the Little Colorado River related to rangeland management practices and natural background levels. High levels of metals from abandoned uranium mines and unknown sources were also reported. In general, surface water quality tends to degrade in a downstream direction. This results from the inflow of highly-concentrated salt water from springs, and an increase in sediment concentration. Three areas in the basin, St. Johns, Woodruff, and Joseph City, use poor quality surface water for irrigation. In Joseph City, where total dissolved solids are high, the irrigation of salt-tolerant crops is successful because of naturally-occurring gypsum present in the soil. At Woodruff, surface water is pumped from the Little Colorado River and supplemented by wells to mitigate the periodic high sediment concentrations. St. Johns uses salty water from the Little Colorado River downstream from Salado Springs (U.S. Department of Agriculture, 1981).

TABLE 14
ANNUAL FLOWS FOR USGS STREAMGAGING STATIONS IN THE LITTLE COLORADO RIVER WATERSHED

Station Name	Station Number	Period of Record	Mean Annual Flow (ac-ft)	Median Annual Flow (ac-ft)	Record Annual High Flow (ac-ft)	Record Annual Low Flow (ac-ft)
Little Colorado River at Greer	9383400	1961-1982	11,580	8,580	27,505	4,340
Little Colorado River above Lyman Res. near St. Johns	9384000	1941-1990	16,650	11,150	52,110	2,099
Little Colorado River above Zion Res. near St. Johns	9386030	1975-1990	7,960	6,150	19,540	3,110
Show Low Creek near Lakeside	9390500	1954-1990	10,130	7,220	41,260	1,160
Show Low Creek below Jaques Dam near Show Low	9392000	1956-1990	6,320	2,900	34,740	1,450
Silver Creek near Snowflake	9393500	1951-1990	13,030	8,110	49,940	2,030
Little Colorado River at Woodruff	9394500	1906, 1930-1933 1936-1990	37,640	30,830	116,530	6,950
Puerco River near Chambers	9396100	1973-1990	754,920	679,650	1,351,330	105,670
Little Colorado River near Joseph City	9397300	1973-1990	646,490	573,250	993,780	385,790
Chevelon Creek near Winslow	9398000	1917-1919 1930-1933 1936-1972	36,430	28,810	104,950	5,550
Clear Creek near Winslow	9399000	1930-1933 1936-1978 1980-1990	57,290	44,590	196,150	4,730
Moenkopi Wash at Moenkopi	9401260	1977-1990	7,680	5,440	13,460	1,560

Source: U.S. Geological Survey, 1992, National Water Information System

Paria River Basin

The Paria River basin is located in north-central Arizona and is bounded on the north by the Arizona and Utah state line. The Paria River originates in south-central Utah a few miles south of Cannonville. It drains an area of approximately 1,410 square miles in both Utah and Arizona and enters the Colorado River near Lees Ferry. The Paria is perennial from the Utah border to the Colorado River, a distance of about 25 miles (Figure 12). The U.S. Geological Survey has maintained a

streamgage (09382000) on the Paria River, 1.1 miles upstream from the mouth, since 1923. The average discharge for 64 years of record is 21,450 acre-feet per year (U.S. Geological Survey, 1989). All other streams within the Paria River basin are ephemeral and flow only in response to precipitation events.

Kanab Plateau Basin

The Kanab Plateau basin is located in north-central Arizona, between the Colorado River and the Utah state line. The main drainage across the basin is Kanab Creek which originates near Bryce Canyon, Utah, and flows south to the Colorado River. Kanab Creek is perennial where it crosses into Arizona and flows about five miles to Fredonia where it becomes ephemeral. The U.S. Geological Survey has maintained a streamgage (09403600) on Kanab Creek just north of the state line since 1979. The average flow into Arizona for the eight years of record is 11,740 acre-feet per year (U.S. Geological Survey, 1989). Table 15 lists the perennial reaches for streams within the Kanab Plateau basin. Figure 12 shows the location of these reaches. All other streams within the basin are ephemeral and only flow in response to precipitation events.

TABLE 15
PERENNIAL STREAM REACHES IN THE KANAB PLATEAU BASINPERENNIAL STREAM REACHES IN THE KANAB PLATEAU BASIN

Perennial Stream Reaches	Length (miles)
Kanab Creek (2 reaches)	12
Tapeats Creek	3
Thunder River	4
White Creek	5
Shinumo Creek	5
Crystal Creek	8
Phantom Creek	7
Bright Angel Creek	10
Nankoweap Creek	4
North Canyon Wash	4

Source: Brown and others, 1981

Coconino Plateau Basin

The eastern and northeastern portions of the basin are drained by the Little Colorado River and its tributaries. The Little Colorado River joins the Colorado River in the Grand Canyon. Havasu and Cataract Creeks drain the central and western parts of the basin; Havasu Creek is the lower reach of Cataract Creek and joins the Colorado River near the west boundary of Grand Canyon National Park. Several small tributaries drain directly into the Colorado River along the northern and western edges of the basin (McGavock and others, 1986).

Nearly all streams in the basin are ephemeral or intermittent and only flow in response to rainfall or snowmelt; a few streams contain perennial flow that is maintained by groundwater discharge (McGavock and others, 1986). Table 16 lists perennial stream reaches for the Coconino Plateau basin, and Figure 12 displays the location.

TABLE 16
PERENNIAL STREAM REACHES IN THE COCONINO PLATEAU BASINPERENNIAL STREAM REACHES IN THE COCONINO PLATEAU BASIN

Perennial Stream Reaches	Length (miles)
Havasu Creek	10
Little Colorado River	13
Diamond Creek	12
Matkatamiba Creek	1
Granite Park	2
Elves Chasm	1
Monument Creek	1
Source: Brown and others, 1981	

The Little Colorado River is the largest surface flow in the Coconino Plateau basin. Within the basin, perennial flow in the river begins at Blue Springs, approximately 10 miles upstream from the Colorado River confluence. In 1968, Johnson and Sanderson reported a discharge at Blue Springs of 100,000 gallons per minute (161,300 acre-feet per year).

Havasu Creek is the next largest surface flow in the basin. Havasu Spring occurs as a series of seeps that emerge from the bottom of Havasu Canyon along several branches of Havasu Creek. The seeps are within a quarter of a mile of each other about 10 miles upstream from the mouth of Havasu Creek (Figure 12). Discharge measurements at the Spring were reported to be 29,000 gallons per minute (46,780 acre-feet per year) (Johnson and Sanderson, 1968). All other surface flow in the basin is from springs that flow into the Colorado River at several locations. These tributaries are Diamond Creek, Elves Chasm, Matkatamiba Canyon, and Monument Creek.

Havasu Creek contains moderate quantities of dissolved solids ranging from about 600 milligrams per liter (mg/l) at the headwaters to about 380 mg/l at the mouth. Calcium, magnesium and bicarbonate are the principal components of the dissolved matter. The difference in dissolved solids concentrations between the creek and spring samples is the result of water precipitating calcium carbonate. Bicarbonate in solution is reduced from 574 mg/l at the headwaters of the creek to 304 mg/l at the mouth indicating the extent of travertine deposits in the creek channel (Johnson and Sanderson, 1986). Travertine deposits are formed by calcium carbonate deposition from spring waters.

Shivwits Plateau Basin

The Shivwits Plateau basin is located north of the Colorado River in northwestern Arizona. The northern half of the basin drains northward into Utah, and the southern half drains south into the Colorado River and Lake Mead. There are no perennial reaches in the entire basin. All of the drainages are ephemeral and only flow in response to precipitation events.

Virgin River Basin

The Virgin River basin is located in the northwest corner of Arizona and forms the border with Nevada to the west and Utah to the north.

The Virgin River watershed drains an area of approximately 6,107 square miles in Utah, Nevada and Arizona and enters Lake Mead in Clark County, Nevada (U.S. Department of Agriculture, 1951). The Virgin River and Beaver Dam Wash contain the only perennial flows within the Virgin River basin. The surface flow of the Virgin River completely disappears into the riverbed before the river enters Arizona from Utah. Surface flow reappears about five miles above Littlefield, Arizona, due to springs flowing into the river channel (Keith and others, 1977). Since 1929, the U.S. Geological Survey

has maintained a streamgage on the Virgin River at Littlefield (09415000). The average discharge for 58 years of record is 174,600 acre-feet per year (U.S. Geological Survey, 1989). The Virgin River is perennial from Littlefield to the Nevada border, a distance of approximately 20 miles (Brown and others, 1981). Beaver Dam Wash is perennial for about one mile above its confluence with the Virgin River near Littlefield.

Grand Wash Basin

The Grand Wash basin is located in northwestern Arizona north of Lake Mead. There are no perennial streams in the entire basin. All of the drainages are ephemeral and flow south toward Lake Mead.