FISH AND WATERSHED COMMITTEE REPORT IN SUPPORT OF THE ISSUANCE OF AN INCIDENTAL TAKE PERMIT UNDER SECTION 10(a)(1)(B) OF THE ENDANGERED SPECIES ACT

HORSESHOE AND BARTLETT RESERVOIRS
VERDE RIVER, ARIZONA

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1.0 Introduction

Objective

To estimate the future impacts of operation of Horseshoe and Bartlett Reservoirs on covered fish species within the Action Area, taking into account: (1) the environmental baseline; and (2) other, coextensive causes for impacts on native fish.

The purpose of this report is to determine the impacts of future operations of Horseshoe and Bartlett reservoirs on native fish populations over the 50-year permit period covered in the Habitat Conservation Plan (HCP). To accomplish this, numerous complex and interacting ecological factors must be evaluated. The evaluation is further confounded by anthropogenic influences such as past and current land uses, water uses, intentional and accidental introduction of non-native fish species, reservoir construction and operations, and other activities. This document is a cooperative effort of a Fish and Watershed Committee (Committee) consisting of the U.S. Fish and Wildlife Service (USFWS), Arizona Game and Fish Department (AGFD), Arizona Department of Water Resources, and Salt River Project (SRP) personnel, and consultants representing SRP and the City of Phoenix. The information contained in this document was obtained from an extensive review of existing literature, agency reports, state and federal databases and discussions with local and nationally recognized experts. The document is organized into five sections that provide descriptions of the following:

- Action Area
- Environmental Baseline
- Impacts of Future Reservoir Operations

- Adverse Impacts to Native Fish
- Recommended Mitigation Strategies

2.0 Action Area

The Action Area includes all areas impacted directly or indirectly by the operations of Horseshoe and Bartlett reservoirs. Determination of the Action Area was an iterative process because the Committee first had to compile and analyze data on the physical and biological characteristics of the system, the ecology of native and non-native fishes, and the potential impacts of operation. As the analysis progressed, the following key factors became the main determinants of delineating the Action Area (the data supporting these factors are provided throughout this document).

1) The non-native fish most likely to be produced due to reservoir operations were largemouth bass, green sunfish, and carp. Other non-native species that may benefit from operations were also evaluated (Section 3.3).
2) There are significant physical impediments to fish movement (dams, diversion, natural barriers, and ephemeral reaches of streams).
3) Movement data for species that potentially benefit from reservoir operations were also considered.

Upon considering the factors above and other relevant parameters, the Action Area was determined to be the Verde River from Granite Reef Dam (confluence with the Salt River) upstream to the Allen Diversion/Tunnel at Peck's Lake near Clarkdale (Figure 2-1). Horseshoe and Bartlett reservoirs are centrally located within the Action Area. Bartlett Dam and Reservoir (Bartlett) is located 28 river miles upstream from Granite Reef Dam. Horseshoe Dam and Reservoir (Horseshoe) is 21 river miles upstream of Bartlett. Horseshoe extends for a distance of 10 river miles. The Allen Diversion is located 98 river miles upstream of the upper elevation of Horseshoe. Granite Reef was considered the lower boundary because the river is diverted into the canal system at that point. The Allen Diversion was used as the upper boundary because it is a semi-

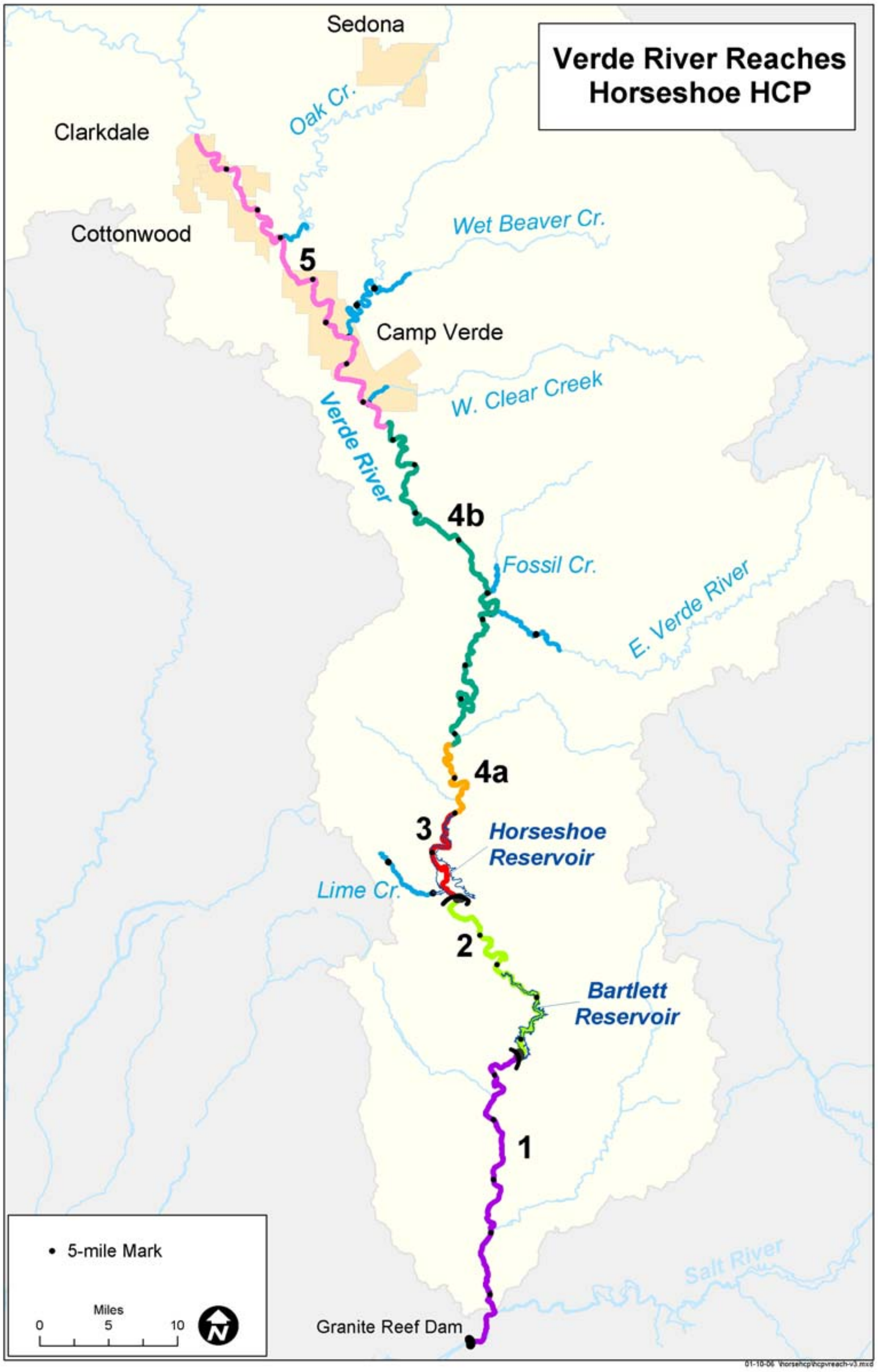
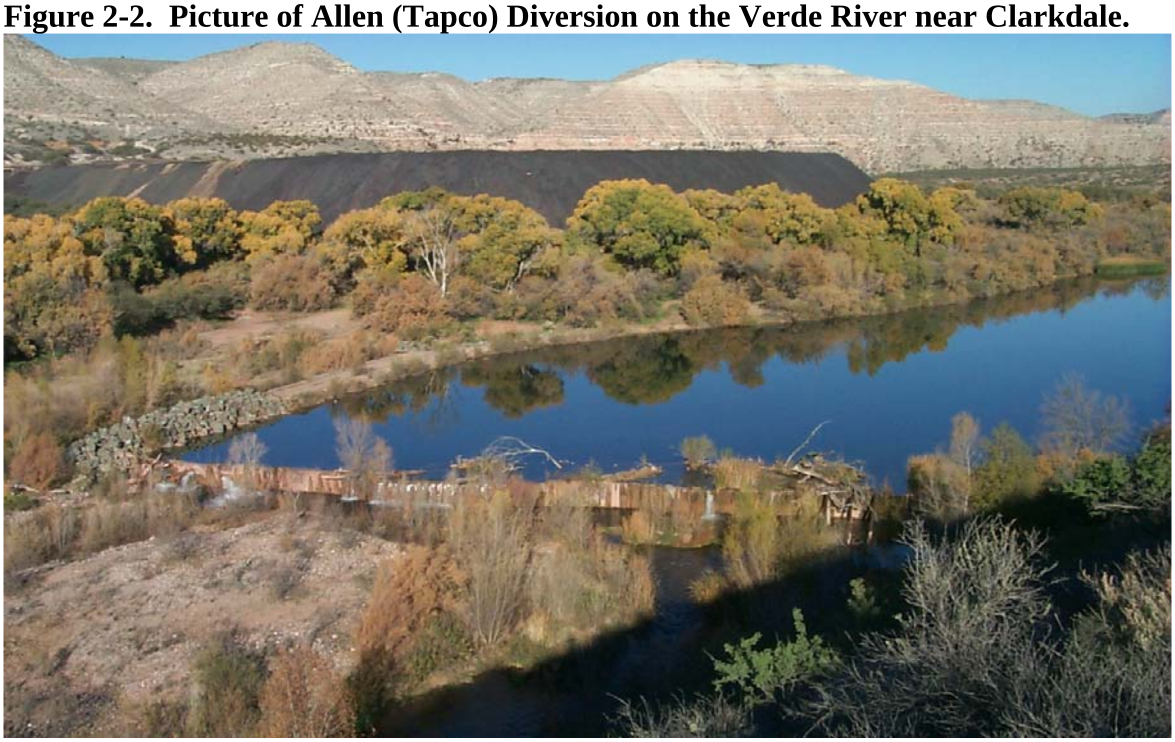


Figure 2-1. Verde River Action Area and Reaches.

permanent diversion across the river that serves as a physical barrier to upstream fish movement under most conditions (Figure 2-2). Due to its distance from Horseshoe, presence of the barrier, and the data on movement and biology of non-native fish, the Committee determined that adverse impacts of non-native fish on native fish would be insignificant and discountable above this point.

The Committee also considered inclusion of Verde River tributaries in the Action Area. The Committee determined that impacts of reservoir operation needed to be assessed in all or portions of six tributaries: Lime Creek, East Verde River, Fossil Creek, West Clear Creek, Wet Beaver Creek and Oak Creek. The evaluation and selection of tributaries is further described in section 2.1.5. The Committee based the delineations on the degree to which the proposed operation of the reservoirs may be advantageous to reproduction, recruitment, and survival of non-native fish, the abundant self-sustaining populations of non-native fish currently in the river and many of its tributaries, the relative distances between the reservoirs and the tributaries identified above, and connectivity between the Verde River mainstem and its tributaries within the action area.

Figure 2-2. Picture of Allen (Tapco) Diversion on the Verde River near Clarkdale.



The Committee included a description of the factors evaluated and the process applied to determine the degree of effect, or percent responsibility, of dam operations to native fish in these tributaries.

Because environmental baseline conditions vary within the action area, the Committee divided the Action Area into five reaches (Figure 2-1) based on 1) the key factors identified above; 2) degree of anthropogenic impacts; and 3) the reach divisions used by Bonar et al. 2004 (the most recent fish study with consistent methodology among the reaches with the exception of the reach between the top elevation of Horseshoe Reservoir downstream to Bartlett Dam that was not analyzed by Bonar et al. 2004):

Reach 1. Granite Reef to Bartlett Dam – 28 miles

Reach 2. Bartlett Dam to Horseshoe Dam – 21 miles

Reach 3. Horseshoe Dam to the top elevation of Horseshoe Reservoir – 10 miles of reservoir plus 6 miles of Lime Creek

Reach 4a. Top elevation of Horseshoe Reservoir to 8 miles upstream – 8 miles

Reach 4b. 8 miles upstream of Horseshoe Reservoir to the upstream end of Wild and Scenic River section (near Beasley Flats) – 44 miles of mainstem plus 11 miles of tributaries; (8 miles of the East Verde River and 3 miles of Fossil Creek were included in this reach.)

Reach 5. Upstream end of Wild and Scenic River section to the Allen diversion at Clarkdale – 38 miles of mainstem plus 17 miles of tributaries; (2 miles of West Clear Creek, 12 miles of Wet Beaver Creek, and 3 miles of Oak Creek as a zone of influence from the confluence of the Verde) were included in this reach.

As noted above, the delineation of the Action Area was an iterative process. After reviewing the baseline information presented in Section 3.0 and summarized by reach in Section 3.6, the Committee reviewed the Action Area and determined that Reach 4 should be divided into two sub-reaches. Sub-reach 4a extended from the high waterline of the reservoir to 8 miles upstream (approximately to the confluence of the Verde River and Wet Bottom Creek, (see Section 2.1, Figure 2-1). This 8-mile boundary was based on the maximum movement recorded for largemouth bass (Section 3.3), the primary predator of native fish in the Verde River documented by Bonar et al. (2004), and it is a primary species expected to potentially benefit from reservoir operations. Reach 4b continues upstream from Wet Bottom Creek to the northern boundary of the Wild and Scenic River segment explained in Section 2.1.

2.1. Description of the Action Area

Within the Action Area, the Verde River flows through central Arizona from an elevation of around 3,300 feet at the Allen diversion dam in Clarkdale to 1,313 feet at Granite Reef Dam. Vegetation along this portion of the river and its floodplain is classified as Deciduous Riparian Woodland and Emergent Marshland, according to Brown (1973, 1982). Dominant species in the riparian woodland community type include Fremont cottonwood (*Populus fremontii*), Goodding's willow (*Salix gooddingii*), velvet ash (*Fraxinus velutina*), velvet mesquite (*Prosopis velutina*), salt cedar (*Tamarix ramosissima*), and seepwillow (*Baccharis salicifolia*). Dominant wetland plant species include cattails (*Typha* spp.), horsetail (*Equisetum* spp.), bulrushes (*Scirpus* spp.), rushes (*Juncus* spp.), spike rushes (*Eleocharis* spp.), and sedges (*Carex* spp.).

2.1.1. Geology

The Verde River flows through a variety of geologic settings from the thick Verde Formation in the Verde Valley (Reach 5) to the basalt and Precambrian granitoid outcrops found along the lower reaches of the river (Reaches 1 through 4) (Arizona Bureau of Mines 1958; Reynolds 1988). The characteristics of the Verde Formation result in a wide variation of erosion resistance, but it is generally a friable formation comprised of limestones, lake deposits, stream deposits, and some volcanic units. Where present, more resistant basalt and granite formations tend to influence the position of the river on the landscape and to constrain the channel (Arizona Bureau of Mines 1958; Reynolds 1988; Beyer 1997).

In general, the geomorphology of the Verde River reflects the geologic setting, forming broad basins through less resistant formations and narrow valleys as it flows through harder materials (Pearthree 1996). Canyon reaches, found intermittently in Reaches 1 and 4, constrain the river to a narrow valley bottom, with discontinuous pockets of floodplain material. Alluvial terraces are less common, often merging with colluvial deposits, tributary debris flow deposits, and alluvial fans to form uneven higher areas along the valley sidewalls (Beyer 1997). Structural basins, such as the Verde Valley in Reach 5, generally provide a wider valley bottom and more continuous floodplain and terrace development (Id.). Despite these variations, the river exhibits a distinct low-flow channel within a wider flood channel (Beyer 1997; MEI 2004).

2.1.2. Climate

The area is classified as a semi-arid climate, exhibiting a range of temperatures and precipitation conditions, giving rise to spatial variation in precipitation inputs to and evapotranspiration losses from the drainage basin (Beyer 1997). These conditions influence the type of vegetation and infiltration characteristics found along the river corridor. Precipitation tends to be seasonal, induced in the winter by frontal storms and in the summer by monsoon convectional events (Owen-Joyce and Bell 1983; Owen-Joyce 1984). At higher elevations in the watershed, precipitation occurs as both rain and snow, while precipitation at lower elevations tends to be primarily in the form of rain. The highest runoff commonly occurs between March and April from snowmelt. May and June tend to be the driest months. About 40% of precipitation occurs in July, August and September during short-duration, intense thunderstorms associated with monsoon patterns (Owen-Joyce 1984).

2.1.3. Hydrology

Perennial flow in the Verde River and its major tributaries is maintained by ground water discharge from several large rock units – the Verde Formation, Coconino Sandstone, Supai Formation, Naco Formation, Redwall limestone, Martin Formation and Tapeats Sandstone (Owen-Joyce and Bell 1983). Ground water in the alluvium is hydraulically connected to the Verde River throughout the Action Area (Id.).

Ground water may also be obtained from volcanic rocks northeast of the Mogollon Rim and in the Black Hills or discharged from springs located in fractured granitic rock. Spring water emerges from the Kaibab Limestone and Toroweap formations along tributaries to Oak Creek and along West Clear Creek (Id.)

A variety of factors influence the hydrologic system of the Verde River in the Action Area. These factors include precipitation, streamflow, sub-surface flow, inflow to and outflow from an underlying ground water system, and water loss from evaporation and transpiration (Id.). Anthropogenic influences on these factors include surface water diversions, ground water pumping from the alluvial aquifer and source aquifers, and changes in watershed condition that affect run-off amount and patterns.

2.1.4. Land Use

The aquatic and riparian communities of the Verde River and its major tributaries have been and continue to be altered by impacts from land uses, water use, alteration in water quality, livestock grazing, sand and gravel extraction operations, recreation and a number of other activities described in detail later in this document. However, a portion of the river in the Action Area (Reach 4) still retains qualities that deserved the national designation of a Wild and Scenic River.

Land ownership varies throughout the Action Area. The U.S. Forest Service manages almost 69% of the river (100.5 miles), Indian tribes own 10% (15.2 miles), private entities own 21% (30.4 miles), and the State of Arizona owns less than 1% (0.35 mile). Private lands are concentrated between Clarkdale and Camp Verde in Reach 5, along Oak Creek, and along the lower reaches of Wet Beaver Creek and West Clear Creek. The Action Area crosses three National Forests: the Prescott National Forest (PNF) generally borders the west side of Reach 5; the Coconino National Forest (CNF) borders the east side of Reach 4 and 5 to Fossil Creek; and the Tonto National Forest (TNF) extends on both sides of the river from Fossil Creek to the Fort McDowell Yavapai Nation (Reaches 1, 2, 3 and 4).

2.1.5. Tributaries

All tributaries identified on the USGS 1:24,000 topographic quadrangles were evaluated for hydrologic connectivity to the Verde River (Brown et al. 1978, Valencia et al. 1993, Sullivan and Richardson 1993, Owen-Joyce and Bell 1983, Owen-Joyce 1984, Beyer 1997) and their ability to support fish populations (Weedman and Young 1997, Voeltz 2002). After this initial screening, tributaries of the Verde River examined to determine the degree of inclusion in the Action Area were Lime Creek, Oak Creek, Wet Beaver Creek, West Clear Creek, Fossil Creek and the East Verde River. With the exception of Lime Creek, all tributaries drain the north and east portions of the Verde River basin. Smaller tributaries that may support native fish, such as Tangle, Sycamore, Deadman, Camp, Alder, Wet Bottom, and Houston creeks, are hydrologically isolated from the Verde River (lower reaches are ephemeral) except during high runoff events; the Committee determined that any potential impacts to these streams attributable to the operation of Horseshoe and Bartlett would be negligible. However, the confluence area (0.125 mi) of these tributaries was included within the estimate of the Verde River mainstem reach lengths (Section 2.0).

2.1.5.1. Oak Creek

Oak Creek is located 74.8 miles from the upper end of Horseshoe in the upper portion of Reach 5. The creek is a high-elevation boulder dominated system, with higher gradients than the Verde River. Oak Creek is perennial from its source at the confluence of Sterling Canyon and Pumphouse Wash to its confluence with the Verde River. Base flow in Oak Creek is maintained by springs at Indian Gardens, Page Springs and along Spring Creek, all located above the town of Cornville. Winter base flow from springs and numerous small springs along the creek and West Fork of Oak Creek increases from 13 cfs near the headwaters to approximately 62 cfs at the Verde River (Owen-Joyce and Bell 1983). Large seasonal differences in evapotranspiration rates and numerous irrigation diversions and returns in the vicinity of Cornville have resulted in considerable variations in baseflow (Id.). No absolute barriers to movement have been identified from the confluence with the Verde River to its source.

The Committee evaluated a number of factors when determining whether to include this tributary in the Action Area. Oak Creek already has an abundant population of non-native fish and is nearly 75 miles upstream of Horseshoe, a significant distance for typical fish movement. While Oak Creek is a cool and cold water fishery with habitat less suitable to most warm water non-native species, there are a few warm water non-natives that that may be found in the lower reaches of Oak Creek. Oak Creek supports a self-sustaining trout population and AGFD operates three fish hatcheries on Oak Creek; two are dedicated to rearing trout, and one produces warmwater sportfish and native fish. AGFD stocks rainbow trout along 42 miles of the creek, including the lower portion from the source to the confluence with Spring Creek, on a monthly basis (approximately 60,000 fish/year on average). At the lower reach of the creek beginning 3 miles upstream from the confluence a large number of instream diversions occur. Based on this evaluation, the Committee determined that there was a diminishing effect on native fish progressing upstream from the confluence. Impacts on native fish due to operations were determined to be negligible above a zone of influence that extends 3 miles from the confluence because the stream has cold water temperatures, numerous water diversions, high number of non-native trout are stocked, and an abundant population of non-native fish. The zone of influence was determined following the criteria and justification outlined below:

- Reach extends to the first instream low-water road crossing located 3 miles upstream (near Oak Creek Estates)
- There are >6 water diversions upstream of this point to Page Springs hatchery (Jim Cooper, SRP Water Rights, pers. comm., Alam 1997).
- The creek is 75 miles from Horseshoe Lake
- AGFD stocks 60,000 trout a year into Oak Creek; due to cooler temperatures, the trout not removed by angling, persist in the creek.
- The reach has high value as a recreational trout fishery, thus AGFD will manage for non-native sportfish, which is unlikely to change in the future.
- Multiple diversions exist in the lower reaches and recreational use is high.
- Largemouth bass do not persist in Oak Creek
- Most of Oak Creek is considered cold water aquatic habitat
- Based on less suitable habitat for reservoir species, water diversions, high levels of trout stocking, and movement data impacts of reservoir operation are insignificant above the 3-mile low water crossing.

2.1.5.2. Wet Beaver Creek

Wet Beaver Creek is a 33-mile long tributary of the Verde River. The confluence is located near the town of Camp Verde; 64 miles upstream of the upper end of Horseshoe. The creek historically was considered to be perennial from its source at springs on the Mogollon Rim (Section 14, T15N, R7E) to the Montezuma Castle National Monument, which is 5 miles upstream from the confluence with the Verde River (Owen-Joyce and Bell 1983). Due to drought conditions in recent years, the upper reaches dried up, thus reducing the distance of perennial flow (Reger, pers. comm. 2004; Benedict, pers. comm.

2004; Rinker, pers. comm. 2004). The stream flows intermittently below the Monument (Owen-Joyce and Bell 1983). During the summer growing seasons, however, all or part of the flow approximately 9 miles above the confluence is diverted for irrigation purposes (Id.; Sullivan and Richardson 1993). The combination of diversions and interrupted (non-perennial) flow at the mouth of this creek limits the connectivity to the Verde River. Although Wet Beaver Creek water rights have not been adjudicated, use of surface water in the reach included in this Action Area is extensive. The primary surface water diversion from Beaver Creek is used to irrigate a golf course. Recently, the golf course was sold to a development company. This follows a general trend in the vicinity towards increased conversion of land to residential development. Typically, development is occurring in the form of lot splits with individual wells that extract water from the stream alluvium. (pers. comm. Greg Kornrumph, water rights specialist, SRP, 2-10-05; Janet Kelly, realtor, Coldwell Banker Real Estate, 2-10-05).

Presently, the creek has an abundant population of non-native fish. However, two of the primary reservoir species, carp and largemouth bass, have not been detected in the creek (AGFD 2004a; C. Benedict pers. comm. 2005), and habitat may be a limiting factor for some of the species that prefer lentic habitats (D. Weedman pers comm. 2005). In addition, AGFD stocks rainbow trout in the 5-mile reach below the USGS gaging station. Upper reaches of the creek are considered to be a coldwater fishery. Due to the distance between Horseshoe and the confluence with Wet Beaver Creek, limited hydrologic connectivity, abundant non-native fishes in the creek, the gradual change to a coldwater fishery at higher elevations, and the spatially and temporally intermittent nature of the uppermost reaches, the Committee determined that the potential impacts to native fishes in the creek be negligible above a zone of influence that extends 12 miles from the confluence with the Verde River. The zone of influence was determined following the criteria outlined below:

- Reach extends to first instream diversion located 12 miles upstream from the confluence near Montezuma’s Castle.
- There are 7 water diversions in that area - at that point the impact goes to zero.
- The creek is >55 miles upstream from the reservoir

- This creek is diverted during the spring and summer growing season lowering hydrological connectivity, and potential for ingress of non-native fish.
- The reach is managed by AGFD as recreational trout fishery and supports a significant non-native fish community at present.
- Based on less suitable habitat, limited fish movement, current management emphasis, and water diversions any impacts from reservoir operations are insignificant above the 12-mile point.

2.1.5.3. West Clear Creek

West Clear Creek flows into the Verde River near the southern end of the Town of Camp Verde. The creek's confluence with the Verde River is located 54.8 miles upstream of Horseshoe. It begins as a perennial stream at the confluence of Clover Creek and Willow Creek (GSRBM: Section 33, T14N, R9E) and flows in a westerly direction for approximately 37 miles before its confluence with the Verde River (Owen-Joyce and Bell 1983). Owen-Joyce and Bell (1983) measured a flow of 1.88 cfs at the headwaters and 19 cfs at the USGS gaging station located 11 miles upstream from the confluence, but base flow at this gage averages 16 cfs. As with Beaver Creek, diversions for irrigation occur downstream from Highway 260 (less than 4 miles from the confluence) and often fully deplete the flow of the creek, particularly during the peak irrigation period (Id.). In fact, all surface water rights in West Clear Creek are fully appropriated under the Hance Decision.[1] Approximately 15 miles upstream from the confluence, a 50-foot waterfall provides a natural barrier to upstream movement of fish (Reger, pers. comm. 2004).

Presently, the creek has an abundant population of non-native fish. However, two of the primary reservoir species, carp and largemouth bass, have not been detected in the creek (AGFD 2004a; C. Benedict pers. comm. 2005). AGFD stocks rainbow trout at a location approximately 10 miles upstream from the confluence. The numbers of trout stocked vary each year depending on the amount of water in the stream, with more fish being stocked when stream flows are higher and less during drier years. Due to the distance between Horseshoe and West Clear Creek, limited perennial connectivity, and

[1] In the District Court of the Fourth Judicial District of the Territory of Arizona, in and for the County of Yavapai, George W. Hance, et al. vs. Wales Arnold, et al., No. 4772.

abundant non-native fishes in the creek, the Committee determined that the potential for impacts from reservoir operations to native fish in the creek was very small and diminishes to negligible above a zone of influence that extends 2 miles from the confluence with the Verde River. This zone of influence is further supported by the following the criteria outlined below:

- Stream reach at confluence is intermittent during the growing season
- At 1.3 miles upstream there is an infiltration basin which captures subflow of the river because the stream dries during the growing season.
- At 1.96 miles there is the first of 3 water diversions; we extended the zone of influence of the reservoir to this first surface flow diversion.
- The creek is >55 miles upstream from the reservoir
- This creek is diverted during the spring and summer - lowering hydrological connectivity, and potential for ingress of non-native fish.
- The reach is managed by AGFD as recreational trout fisheries and provides habitat that is less suited for most warm water reservoir species.
- Based on less suitable habitat, limited fish movement, current management emphasis, and water diversions any impacts from reservoir operations are insignificant above the 2-mile point.

2.1.5.4. Fossil Creek

Fossil Creek is a perennial stream with its confluence at 31.5 miles upstream of Horseshoe that originates at Fossil Springs on the Mogollon Plateau north of Strawberry. Several other small springs discharge into the creek channel but contribute very little to the base flow (Sullivan and Richardson 1993). Until recently, the creek was diverted 14 miles upstream of the confluence for the Childs-Irving hydroelectric plant. In November 2004, a fish barrier was constructed on the creek, 3 miles upstream of the confluence, prior to the full return of diverted flows to the stream channel in June 2005 (USGS 2005). In October and November 2004, a number of agencies conducted a stream renovation and repatriation project that removed non-native fish above the barrier, and returned the native fish salvaged from the creek (desert and Sonora Sucker, Gila chub, and speckled dace). The agencies are considering reintroduction of other non-listed and listed fish into Fossil Creek above the fish barrier. Full flows were returned in 2005, reconnecting the creek to the Verde River. Because Fossil Creek flows perennially into the Verde River and because there is the potential for native fish to move downstream of the barrier as the populations expand, the Committee included the portion of Fossil Creek from the confluence to the fish barrier (3 miles) in the Action Area. Because the fish assemblage for this portion of Fossil Creek is similar to the mainstem Verde River, the Committee evaluated this portion of the creek as having the same degree of effect as the mainstem in Reach 4b.

2.1.5.5. East Verde River

The confluence of the East Verde River is located 25 miles upstream of the upper end of Horseshoe, originating along the Mogollon Rim and flowing for 53 miles to its confluence with the Verde River (Sullivan and Richardson 1993). In the past, intermittent stream flows in the upper reaches have been supplemented by water piped over from the Blue Ridge Reservoir on the north side of the Mogollon Rim. This supplemental water has been discontinued for an indefinite period.

On recent stream survey trips, TNF personnel found dry stretches of streambed occurring intermittently from upstream of Pine Creek (15 miles from confluence) to a mile or so from the headwaters (Nelson, pers. comm. 2004). Flows in this 38-mile stretch could be defined as interrupted perennial. Additionally, a series of small waterfalls creates a physical barrier approximately 8 miles upstream from the confluence (Figure 2-3). Above the waterfalls, the stream is diverted at Doll Baby Ranch for irrigation, and just upstream of the ranch another small waterfall exists. Because these barriers impede upstream fish movement, the Committee included 8 miles of the East Verde River upstream from the confluence in the impacts analysis.

Figure 2-3. Series of small waterfalls that impede upstream fish movement on the East Verde River approximately 8 miles upstream from the confluence with the Verde River.

2.1.5.6. Lime Creek

Lime Creek drains into Horseshoe from the west. Perennial flow begins about one-half mile downstream from Lime Cabin Spring, approximately 6 miles upstream from the reservoir's high elevation mark. However, the length of the perennial reach varies with changes in spring discharge and runoff. The remaining distance to the reservoir is considered to be ephemeral. This ephemeral reach creates a physical barrier between the reservoir and the creek, except when the lake is full and the ephemeral reach is flowing in response to a runoff event. Although this creek does not have a hydrologic connection to the river because of this ephemeral reach, it is included in the Action Area because its channel enters directly into the reservoir. When high flow events in the creek are coupled with high reservoir levels that create a temporary connection, native fish may be washed down toward the reservoir and be consumed by non-native fish. The Committee included

6 miles of this tributary in the Action Area, from the beginning of spring-fed flows to the top elevation of Horseshoe.

3.0 Environmental Baseline

For purposes of Section 7 of the ESA, the environmental baseline includes "the past and present impacts of all federal, state or private actions and other human activities in the Action Area, the anticipated impacts of all proposed federal projects in an Action Area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process" (50 CFR § 402.02). Existing conditions evaluated in this report include all impacts of past and present activities (actions), even if some of the impacts of the actions have not yet been fully manifested. The environmental baseline reflects that current environmental conditions are derived in large part from historical stocking and fish management actions, and permanent artificial facilities (Horseshoe and Bartlett dams, protected banklines, levees, diversion structures) along the lower Verde River. The impacts of these permanent facilities on covered species are considered irreversible and are not appropriately considered an effect of the activities covered by this HCP. Also included in this section is a discussion of the current status and natural history/biology of native and non-native fish in the Action Area. These data are needed to determine the influence of operations on non-native recruitment and survival, and how these factors may impact native species. Other past and present human activities such as livestock grazing, recreation, mining, and natural events (e.g., floods, fires) also influence the current status of native species and condition of their habitat within the Action Area.

3.1. Current Native and Non-native Fish Distribution in the Action Area

Bonar et al (2004) conducted the most recent study of the composition, density and standing crop of fishes in the Verde River mainstem. The Committee relied heavily on the results of their research because it was the most current data that utilized standardized sampling among reaches. Where data were lacking (i.e., reservoirs, and tributaries), information was based on best available and/or most recent sampling effort.

Overall, six species of native fish and 12 species of non-native fish are regularly found and have reproducing or extant adult (stocked) populations in the mainstem Verde River within the Action Area (Bonar et al. 2004; Valdez 2004; AGFD 2004a) (Table 3-1). Other native fishes that occur in the tributary streams within the Action Area include speckled dace and Gila topminnow. Spikedace and loach minnow, both native fish, are extirpated from the Action Area, but it is foreseeable they could be reintroduced into tributary streams in the Action Area for recovery purposes are were therefore included as covered species in the HCP. A stocking program for Colorado pikeminnow and razorback sucker has been ongoing since 1981; however, few adult fish have been recaptured, spawning or recruitment has not been documented, and survival is thought to be low. Hyatt (2004) declared the presence of non-native fish to be the primary reason for the lack of success of this 25 year Colorado pikeminnow and razorback sucker stocking program. The major concentrations of these two species tended to be near the stocking locations at Childs and Beasley Flats.

Overall, Bonar et al. (2004) found that non-native fishes were approximately 2.6 times denser per 100 m^2 of river than native fishes, and their standing crop was approximately 2.8 times that of native fishes per 100 m^2 of river. Bonar et al. (2004) discovered that red shiner were the most commonly encountered nonnative fish species in the Verde River by almost four-fold and found the species to be present throughout the Verde River year-around, but noted the highest numbers in the reach between Beasley Flat to Sheep Bridge above Horseshoe Reservoir in riffle habitats. Reaches above Horseshoe (Reaches 4 and 5) have resident self-sustaining populations of bass, green sunfish, catfish, and carp (Figure 3-1) with a low, unstable native fish community, which results in fewer observed native fish predation observations in sampling results for this reach. Reaches below Bartlett Lake (Reach 1) had both high native and non-native fish abundance, which resulted in more frequent observations of non-native predation on native fish according to Bonar et al. (2004) sampling results.

Table 3-1. Native and non-native fish relative abundance in the Action Area (Verde River and selected tributaries).

Origin	Species	Reach				
		1	2	3	4	5
Native	Colorado pikeminnow		S, R[1]	S, R[2]	S, U	S, R
	Desert sucker	C			C	C
	Gila topminnow			T, C		
	Longfin dace	C		T, U	T, U	T, U
	Razorback sucker			S, R	S, U	
	Roundtail chub	U			U	U
	Sonora sucker	C			C	C
	Speckled dace				T, U	T, U
Non-native	Bluegill	U	C	U	C	C
	Brown trout					T, U
	Channel catfish	C	C	U	C	U
	Common carp	C	C	C	C	C
	Flathead catfish	U	C	U	U	U
	Green sunfish	C	C	U	C	C
	Largemouth bass	C	C	U	C	C
	Mosquitofish	C	C	C	C	C
	Rainbow trout	S				S
	Red shiner	C	C	C	C	C
	Rockbass					T, R
	Smallmouth bass		U		C	C
	Threadfin shad	R	C		R	
	Tilapia	C	U			
	Goldfish			C		
	Yellow bullhead	U	R		T, C	U

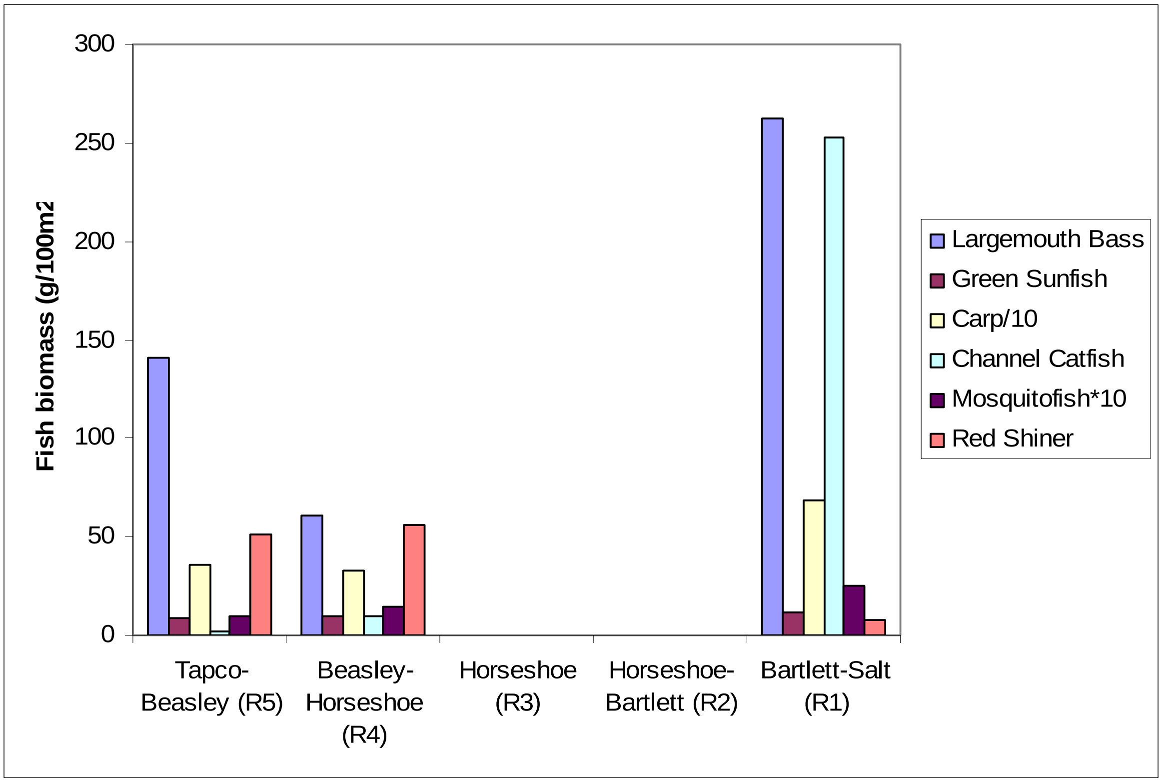
C = Common; U= Uncommon; R = Rare; S = Stocked; T = Found only in tributary.

[1] Few records of Colorado pikeminnow caught by anglers below Horseshoe.

[2] Colorado pikeminnow were found in reservoir in 1996; the species was not found during the most recent sampling.

Sources: Bonar et al. 2004, Robinson 2005, Weedman pers. comm. 2004, Bryan, et al. 2000.

Figure 3-1. Abundance (biomass) of selected non-native fish in the mainstem Verde River in the Action Area.



Note: R1-R5 denotes reaches of Action Area; reaches 2 and 3 were not sampled; carp biomass was divided by 10 and mosquitofish biomass was multiplied by 10 to scale abundance with other species.
Source: Bonar et al. 2004.

3.1.1. Fish Community Composition by Reach

Reach 1: (Granite Reef – Bartlett Dam). Bonar et al. (2004) found the highest densities of desert sucker (*Catostomus clarki*) and Sonora sucker (*Catostomus insignis*) in this reach compared to other reaches of the Verde River. Similarly, Bryan et al. (2000) documented large populations of both species and longfin dace. Bonar et al. (2004) reported relatively low densities of roundtail chub. The native fish are somewhat more abundant in a short reach of the Verde River just below Bartlett Dam. Bryan et al. (2000) also found roundtail chub and observed spawning activity. Based on size/age class structure of the chub population, most recruitment probably coincides with large flood events (see section 3.4.1). Both researchers found abundant and self-sustaining populations of largemouth bass, mosquitofish, red shiner, channel catfish, flathead catfish, and common carp. Bonar et al. (2004) reported the highest densities in Reach 1 compared to other reaches for common carp, mosquitofish, and *Tilapia*. Other non-native species documented included green sunfish, bluegill, rainbow trout (found close to stocking site), and one threadfin shad.

Reach 2: AGFD completed the most recent surveys of Bartlett Lake in 1991-1994, 1996-1997, and 2003 (Weedman, pers comm. 2004). Overall, the lake has healthy and abundant self-sustaining populations of non-native fish, primarily largemouth bass, black crappie, green and redear sunfish, bluegill, threadfin shad, channel and flathead catfish, and common carp. The reservoir is actively managed as a sport fishery by AGFD; artificial habitat structures were added in the 1990s to enhance the recreational fishery. No native fish have been documented in the reservoir in recent surveys. No data exist concerning the fish population between Bartlett and Horseshoe. However, based on angler use and its location between the reservoirs, the fish community is thought to be dominated by non-native species including largemouth bass, channel and flathead catfish, and green sunfish.

Reach 3: Robinson (2005) conducted fish sampling in Horseshoe in late spring and early fall of 2005 to determine community composition and population structure. He found that common carp and goldfish comprised 89% of the fish community. Other species that were captured but had low abundance were red shiner, green sunfish, largemouth bass, channel catfish, and flathead catfish (Table 3-2). Based on size structure of the population, a healthy reproducing population of common carp persist in the reservoir. The number of individuals of other species captured was too low to infer recruitment or population status. During spring sampling, seven adult male razorback suckers were captured in the upper end of the reservoir. Based on size, these suckers were probably stocked either in the winter of 2004 or 2005 and were flushed down from the stocking site during winter high flow events. The fish were ripe and tuberculate; thus, they had spawned or were getting ready to spawn. No other native fish were captured in the reservoir.

Table 3-2. Fish species captured in Horseshoe in Reach 3, April 4-7, 2005

Species	Captured	Percent
Razorback	7	0.9%
Goldfish	19	2.5%
Common carp	666	86.5%
Red shiner	9	1.2%
Green sunfish	21	2.7%
Bluegill	1	0.1%
Largemouth bass	24	3.1%
Channel catfish	21	2.7%
Flathead catfish	2	0.3%
Total	770	100%

Source: Robinson 2005.

Reach 4: Bonar et al. (2004) reported 15 fish species in this reach. Four native fish were captured (razorback, desert, and Sonora suckers, and roundtail chub). They reported that razorback sucker density was the highest in this reach compared to other reaches due to stocking. Eleven non-native species were documented. Of those non-native species listed in Table 3-1, *Tilapia*, threadfin shad, and yellow bullhead were not found. Largemouth bass was present within the reach but its overall biomass was less than Reaches 1 and 5. Green sunfish had similar biomass among the reaches sampled, and carp biomass was similar to Reach 5, but less than Reach 1. Both Rinne et al (1998) and Bonar et al (2004) reported that native species generally comprise less than 20% of the fish community in this segment of the river.

Reach 5: Fish community composition was similar to reach 4, but the biomass of largemouth bass and smallmouth bass biomass was higher. Yellow bullhead were also found in this reach. Razorback sucker was not found, but Colorado pikeminnow (stocked), desert and Sonora sucker, and roundtail chub were detected. Rainbow trout are stocked during winter months for recreational angling between Tuzigoot National Monument and Bridgeport Bridge (Sullivan and Richardson 1993) and near Camp Verde. Of the reaches analyzed by Bonar et al. (2004), non-native fish had the highest standing crop in this reach.

3.1.2. Verde River Tributaries – Fish Community Assemblage

Fish composition for tributaries included in the Action Area was compiled from the AGFD Nongame Fish database (AGFD 2004a) using sampling records after 1985, published reports, AGFD Sportfish stocking program records, and communication with fisheries experts.

Reach 1: Granite Reef – Bartlett Dam. No connected perennial tributaries.

Reach 2: Bartlett Dam – Horseshoe Dam. No connected perennial tributaries.

Reach 3: Horseshoe. No connected perennial tributaries in this reach; however, Lime Creek drains directly into Horseshoe. As previously discussed, Lime Creek is spring-fed and runs perennially for a variable distance. The lower reaches are ephemeral. Because of its location and the occasional connection that may occur during a high flow event and because of the presence of native fish in the perennial portion, the Committee has included that tributary in its evaluation. Surveys by AGFD (Voeltz. 2005) documented Gila topminnow and longfin dace in the upper reaches of Lime Creek. Nonnative fish (i.e., green sunfish, goldfish) have been periodically detected in the lower reaches of the creek downstream of occupied topminnow habitat, but have been repeatedly extirpated probably due to large floods or drying of the stream during droughts (Voeltz. 2005).

Reach 4: Horseshoe – Beasley Flat. Two tributaries along this reach are partially included in the Action Area. Both the East Verde River and Fossil Creek have perennial flows at their confluences with the Verde River.

East Verde River. Current information on fish species composition in the East Verde River is not well documented. Ash flows from recent catastrophic wildfires that occurred in the watershed resulted in fish kills in the East Verde and downstream portions of the mainstem Verde River (Warnecke, pers. comm. 2004). The impact to the fish community in the East Verde River is unknown.

Prior to that time, non-native fish were reported to be dominant in the confluence area (AGFD 2004a). Fish species composition included red shiner, smallmouth bass, largemouth bass, green sunfish, redear sunfish, bluegill, and fathead minnow (Table 3-3). Native species included roundtail chub, desert sucker, Sonoran sucker and razorback sucker. Additional native species found below the ponderosa pine level included longfin dace, speckled dace, desert sucker and Sonora sucker (USFWS 1989).

Voeltz (2002) reports headwater chub in the East Verde River above Weber Creek, which is upstream of the Action area. Girmendonk and Young (1997) cite collection records of roundtail chub throughout in the East Verde. Based on proximity to the Verde River, the lower portions of the East Verde River, which are included in the Action Area, were considered potential roundtail chub habitat. Sullivan and Richardson (1993) reported that aquatic habitat diversity within 1 mile of the confluence with the Verde was relatively low and that refugia and foraging areas for aquatic species were minimal due to a lack of emergent vegetation, thus large chub populations are not expected to persist. Girmendonk and Young (1997) reported samples in the middle portions of the East Verde River (upstream of Doll Baby Ranch, and outside the Action Area) found no chubs and the habitats were dominated by non-native fish (largemouth bass, green sunfish). The headwaters of the East Verde (upstream of the Action area) are maintained as a put-and-take trout fishery for primarily rainbow trout; although brook trout are also present (AGFD 2004a; Sullivan and Richardson 1993).

Table 3-3. Native and non-native fish species documented in the East Verde River.

Species	Year Detected[1]	Notes
Native species		
Desert sucker	2000	
Roundtail chub	1995	Girmendonk and Young (1997)
[Headwater chub]	2000	Upstream (out of) Action Area; Voeltz (2002)
Longfin dace	2000	
Razorback sucker	1988	
Sonora sucker	1997	
Speckled dace	2000	
Non-native species		
Bluegill	1991	
Fathead minnow	1997	
Green sunfish	2000	
Red shiner	2000	
[Rainbow trout]	2004	Stocked as sportfish upstream of Action Area.
Smallmouth bass	2000	
Yellow bullhead	2000	

[1] Unless noted, sampling record from AGFD Nongame Branch Fish Database (AGFD 2004a) since 1980.

Fossil Creek. Fisheries data indicate that Fossil Creek supports a wide variety of aquatic species. Data from reaches in the Verde River upstream and downstream of Fossil Creek indicate that non-native fish such as carp, red shiner, flathead catfish, channel catfish, yellow bullhead, mosquitofish, smallmouth bass, largemouth bass, green sunfish, and bluegill occur in the vicinity of the confluence of Fossil Creek (AGFD 2004a) and could establish or occupy the lower reaches of Fossil Creek. Native species occurring near the confluence include roundtail chub, desert sucker and Sonora sucker (AGFD 2004a; Heritage Data Management System).

In November 2004, a fish barrier was constructed by the U.S. Bureau of Reclamation approximately 3 miles upstream from the confluence. The barrier is part of the Fossil Creek native fish restoration project and will prevent fish from moving upstream into Fossil Creek from the Verde River mainstem. Non-native fish were removed from the stream reaches above the barrier. Roundtail chub, speckled dace, headwater chub, and desert and Sonora suckers were salvaged and restocked into Fossil Creek following renovation. In the future, managers may introduce other native species (e.g., spikedace, loach minnow, Gila topminnow, desert pupfish, razorback sucker, and Colorado pikeminnow). The stream reach downstream from the barrier is expected to contain non-native fish into the foreseeable future due to existing populations and its perennial connection to the mainstem Verde River.

Reach 5: Beasley Flat – Allen Diversion. Portions of three tributaries along this reach are included in the Action Area— West Clear Creek, Wet Beaver Creek, and Oak Creek. Both West Clear Creek and Wet Beaver Creek have interrupted perennial connections to the river. Oak Creek has a year-round perennial connection to the Verde River.

West Clear Creek. According to Sullivan and Richardson (1993), the lower portion of West Clear Creek has a moderate potential to support a diversity of aquatic species, based on substrate, hydrology, and vegetative characteristics. They report that the suitability of this area to support aquatic species is limited by the degree of disturbance caused by anthropogenic stressors such as residential development, grazing, and sand and gravel mining activities on private lands within 1 mile of the confluence. Irrigation diversion ditches near the mouth of West Clear Creek also decrease the habitat potential because they cause the creek to run dry near the confluence during summer months (Id.).

AGFD has been stocking this creek with rainbow trout at a location just above the diversions. Trout are stocked in the winter months. The number of trout stocked depends on the amount of water in the stream during any given year, with more trout stocked during years when flows are higher, and fewer stocked during dry years. Over the past 5 years, more than 17,000 rainbow trout have been stocked in this creek.

Five native fish species are found in West Clear Creek (Table 3-4). Non-native species include rainbow trout, smallmouth bass, yellow bullhead, and few green sunfish and channel catfish. No largemouth bass or carp have been detected (C. Benedict pers comm. 2005).

Table 3-4. Native and non-native fish species with extant populations in West Clear and Wet Beaver Creeks.

Species	Year Detected[1]	Notes
Native species		
Roundtail chub	1998	Voeltz (2002); abundant population found in 1998 above natural barrier, few found below barrier; C. Benedict, D. Weedman (pers comm.)
Longfin dace		C. Benedict, D. Weedman (pers comm.)
Speckled dace		C. Benedict, D. Weedman (pers comm.)
Desert sucker		C. Benedict (pers comm.)
Sonora sucker	1987	AGFD 2004a, C. Benedict, D. Weedman (pers comm.)
Non-native species		
Rainbow trout	2004	Stocked as sportfish and self-sustaining population; C. Benedict, D. Weedman (pers comm.)
Smallmouth bass	1988	AGFD 2004a, C. Benedict, D. Weedman (pers comm.)
Green sunfish		C. Benedict (pers comm.)
Channel catfish		C. Benedict (pers comm.)
Yellow bullhead		C. Benedict (pers comm.)
Red Shiner		Minckley (1993)
Mosquitofish		Minckley (1993)

[1] Unless noted, sampling record from AGFD Nongame Fish Database (AGFD 2004a) since 1980, blanks indicate pers comm. with fish experts from recent surveys.

Wet Beaver Creek. Although Wet Beaver Creek is a perennial tributary of the Verde River, most of the water is diverted about 5 miles upstream from the confluence for irrigation purposes. This restricts the movement of fish in the creek and may kill those fish stranded by receding waters (Sullivan and Richardson 1993).

Five native fish species are found in Wet Beaver Creek (Table 3-4). Non-native species include rainbow and brown trout, smallmouth bass, yellow bullhead, channel catfish, and green sunfish. No largemouth bass or carp have been found in the creek (C. Benedict pers. comm.). Limited suitable habitat for carp and largemouth bass may be precluding their establishment in Wet Beaver Creek (Weedman, pers. comm. 2005). AGFD stocks Wet Beaver Creek with rainbow trout during winter months in a 5-mile section downstream from the USGS stream gage, approximately 15 miles from the confluence. The number of trout stocked depends on the amount of water in the stream during any given year, with more trout stocked during years when flows are higher, and fewer stocked during dry years. Over the past 5 years, nearly 18,000 rainbow trout have been stocked in this creek.

Oak Creek. Oak Creek is a tributary dominated by non-native fish species (Table 3-5). Recent surveys conducted by AGFD found a number of non-native fish (Table 3-5) but did not detect largemouth bass (C. Benedict pers. comm. 2005); however, largemouth have been found in the past (Minckley 1993). Native fish found in Oak Creek include roundtail chub, speckled dace, desert sucker, and Sonora sucker. Forest Service records from 1988 indicate that longfin dace also previously occurred in Oak Creek but has not been found in since 1983 (Sullivan and Richardson 1993).

The upper portion of Oak Creek is currently managed for rainbow trout and brown trout. AGFD stocks rainbow trout in the creek on a monthly basis. In the 5-year period from 1999 through 2003, more than 310,000 trout were stocked in Oak Creek.

Based on an evaluation of physical and biological characteristics of the lower portion of Oak Creek, Sullivan and Richardson (1993) determined that the lower reaches have the potential to support those fish species that are found in the Verde River near the confluence. However, the presence of diversion ditches in these reaches is likely to reduce the potential for this reach to support a diversity of fish species because of diminished flows (Adamus et al. 1991).

Table 3-5. Native and non-native fish species documented in Oak Creek.

Species	Year Detected[1]	Notes
Native species		
Desert sucker	2000	
Longfin dace	1995	
Roundtail chub	2002	Voeltz (2002)
Sonora sucker	2000	
Speckled dace	1996	
Non-native species		
Bluegill	1995	
Brown trout	2000	
Channel catfish	2002	Voeltz (2002)
Flathead catfish	1989	
Green sunfish	1996	
Mosquitofish	1996	
Red shiner	1996	
Smallmouth bass	2000	
Rainbow trout	2004	Stocked as sportfish
Rock Bass	2000	
Warmouth sunfish	1995	
Largemouth bass	1970	Minckley (1993)
Common carp		

[1] Unless noted, sampling record from AGFD Nongame Branch Fish Database (AGFD 2004a).

3.2. Native Fish Community

The following discussion reviews the natural history, federal status, and population dynamics of both the native and non-native fish communities within the Action Area.

3.2.1. Colorado Pikeminnow – Federally Listed as Endangered, Experimental Nonessential Population

The Colorado pikeminnow (*Ptychocheilus lucius*) (also known as the squawfish) is a large, dusky-green minnow that is slender bodied with gold flecks on the dorsal surface and has a long and slender head with a large mouth. The species is endemic to the Colorado River Basin of the southwestern United States. Pikeminnow attain a maximum size of approximately 6 feet total length and can weigh up to approximately 80 pounds. Characterized as a “big river” generalist species, adult pikeminnow occur in turbid, deep, and strong current habitats, whereas juvenile and subadult pikeminnow are known to prefer backwater habitat with no current and often a silt/sand substrate (Sublette et al. 1990). Adults migrate long distances (up to 124 miles) to and from spawning areas (Lucas and Baras 2001).

Spawning behavior in the Colorado pikeminnow is initiated by increasing water temperatures and decreasing flow. The period in Arizona when these conditions are present, and pikeminnow spawn, is generally considered to occur early July through mid August or when water temperatures range between 64˚F and 77˚F at depths of approximately 3 feet (Minckley 1973; Sublette et al. 1990; USFWS 1993; Moyle 2002; AGFD 2003a). Riffles and/or rapids with cobble or gravel substrates are preferred as spawning habitat (Sublette et al. 1990).

The Colorado pikeminnow was included on the List of Endangered Species issued by the Office of Endangered Species on March 11, 1967 (32 FR 4001), was considered endangered under provisions of the Endangered Species Conservation Act of 1969 (16 U.S.C. 668aa), and is protected under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.) as an endangered species. Recovery goals were published in 2002 which supplemented the Recovery Plan (USFWS 2002b). There is no critical habitat for this species in Arizona. A final rule for a section 10(j) experimental non-essential population of pikeminnow in the Salt and Verde rivers in Arizona was published July 24, 1985 (50 FR 30188) (USFWS 1985). Threats include stream diversions, impoundments, reservoir operations, and predation by and competition with non-native fishes (AGFD 2003a). Bonar et al. (2004) counted only 2 individuals during their sampling effort from March 2002 through January 2003 in the Verde River. Both individuals were observed within the reach between Clarkdale and Beasley Flat.

3.2.2. Razorback Sucker - Federally Listed as Endangered with Critical Habitat

The razorback sucker (*Xyrauchen texanus*) is the only representative of the genus *Xyrauchen* and is distinguished by the sharp-edged, bony keel that rises abruptly behind the head. The body is robust with a short and deep caudal peduncle (Bestgen 1990). The razorback sucker may reach lengths of 3.3 feet and weigh between 11 and 13 pounds

(Minckley 1973). Razorback suckers are long-lived. Historically, they occurred at elevations ranging from 181 to 5,000 feet (McCarthy and Minckley 1987; AGFD 2003b).

Adult razorback suckers use most riverine habitat types, although there may be an avoidance of whitewater type habitats. Main channel habitats used tend to be low velocity ones such as pools, eddies, nearshore runs, and channels associated with sand or gravel bars (Bestgen 1990). Backwaters, oxbows, sloughs, and flooded bottomlands adjacent to the main channel also used by this species.

Data from radio-telemetered razorback suckers in the Verde River indicate that they used shallower depths and slower velocities than in the Upper Basin of the Colorado River. They avoided depths of less than 1.3 feet, but selected depths between 2.0 and 3.9 feet. Their behavior likely reflected a reduced availability of deeper waters compared to the larger Upper Basin rivers. However, their use of slower velocities (mean = 0.1ft/sec) may have been influenced by rearing in hatchery ponds. Similar to the Upper Basin, razorback suckers were found most often in pools or runs over silt substrates, avoiding substrates of larger material (Clarkson et al. 1993).

Razorback suckers also use reservoir habitat, where the adults may survive for many years. In reservoirs, they use all habitat types, but prefer backwaters and the main impoundment (USFWS 1998). Much of the information on spawning behavior and habitat comes from fishes in reservoirs where observations can readily be made. Habitat needs of larval and juvenile razorback suckers are reasonably well known. In reservoirs, larvae are found in shallow backwater coves or inlets (USFWS 1998). In riverine habitats, captures have involved backwaters, creek mouths, and wetlands. These environments provide quiet, warm water where there is a potential for increased food availability. During higher flows, flooded bottomland and tributary mouths may provide these types of habitats.

Spawning takes place in the late winter to early summer along gravelly shorelines or bays, when water temperatures range from 50˚F to 70˚F at depths ranging from 1 to 20 feet (Minckley 1973; Sublette et al. 1990; USFWS 1993; Moyle 2002; AGFD 2003b). One female is joined by 2 to 12 males that nudge the female with their heads to entice gamete release marked by vibrating movements and a subsequent cloud of silt and sand (Minckley 1973).

Razorback sucker diet varies depending on life stage, habitat, and food availability. Larvae feed mostly on phytoplankton, small zooplankton, and in riverine environments, on midge larvae. Adults taken from riverine habitats were found to have had diets consisting chiefly of immature mayflies, caddis flies, and midges, along with algae, detritus, and inorganic material (USFWS 1998).

Razorback suckers are somewhat sedentary; however, several studies note that these fish can move a considerable distance in a year's time (USFWS 1998). Spawning migrations have been observed or inferred in several locales (Minckley 1973; Osmundson and Kaeding 1989; Bestgen 1990; Tyus and Karp 1990). During the spring spawning season, razorbacks may travel long distances in both lacustrine and riverine environments, and exhibit some fidelity to specific spawning areas (USFWS 1998). In the Verde River, radio-tagged and stocked razorback suckers tend to move downstream after release. Larger fish did not move as far from the stocking site as did smaller fish (Clarkson et al. 1993).

The razorback sucker is adapted to widely fluctuating physical environments characteristic of rivers in the pre-settlement Colorado River Basin. Adults can live 45 to 50 years; they reach maturity between 2 and 7 years of age (Minckley 1983), and apparently produce viable gametes even when quite old. The ability of razorback suckers to spawn in a variety of habitats, flow, and over a long season are also survival adaptations. In the event of several consecutive years with little or no recruitment, the demographics of the population might shift, but future reproduction would not be compromised. Average fecundity recorded in studies ranges from 46,740 to 100,800 eggs per female (Bestgen 1990). With a varying age of maturity, and the fecundity of the species, it would be possible to quickly repopulate after a catastrophic loss of adults.

Despite these adaptations, razorback sucker populations were impacted by large-scale ecological changes in southwestern river systems that resulted in alteration of river conditions and habitats to which the razorback was adapted. Dam construction, irrigation dewatering, channelization, pesticides and pollutants, and introduction and proliferation of exotic fish species caused these changes.

The razorback sucker was listed as endangered under the ESA on October 23, 1991. Recovery goals published in 2002 supplemented the 1998 Recovery Plan (USFWS 2002b). Critical habitat was designated in 15 river reaches in the historical range of the razorback sucker on March 21, 1994, which included the Verde River from the PNF boundary to Horseshoe Dam (46 river miles). Primary constituent elements for the species described in the Federal Register upon designation were addressed within three general categories: water, physical habitat, and biological environment (USFWS 1994). Under the general category of "water," the Federal Register describes,

> *"…A quantity of water of sufficient quality (i.e., temperature, dissolved oxygen, lack of nutrients, turbidity, etc.) that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life stage [for razorback sucker]"* (USFWS 1994).

The discussion under "physical habitat" describes,

> *"…areas of the Colorado River system that are inhabited or potentially habitable by fish for use in spawning, nursery, feeding, and rearing, or corridors between these areas. In addition to river channels, these areas also include bottom lands, side channels, oxbows, backwaters, and other areas in the 100-year floodplain, which when inundated provide spawning, nursery, feeding and rearing habitats, or access to these habitats"* (USFWS 1994).

Lastly, the critical habitat designation describes the following criteria under "biological environment,"

> *"Food supply, predation, and competition are important elements of the biological environment and are considered components of this constituent element. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation and competition, although considered normal components of this environment, are out of balance due to introduced non-native fish species in many areas"* (USFWS 1994).

Reintroduction efforts were initiated in the Verde River in 1980s and have continued periodically since that time. Razorback suckers are generally stocked at Beasley Flats and Childs (Reach 4). Early on, millions of razorback larvae were stocked and it is assumed that none of these fish survived due to predation or other factors. In 1993, managers began stocking larger individuals at lengths of at least 12" (Hyatt 2004). Initially, very few stocked fish were recaptured in subsequent years, despite considerable monitoring effort. Loss of these fish was due primarily to predation from non-native fishes within hours after stocking (Marsh and Brooks 1989; Hyatt 2004). Laboratory tests indicated that larger sub-adult or adult suckers (>12 in.) may have a better chance of avoiding predators and surviving (Johnson et al. 1993). Between 1994 and 2003, 19,745 adult razorback suckers were released into the Verde River near the Childs power plant (Weedman 2003). During the last several years, the increase in the number of razorback suckers captured during monitoring efforts has been steady (Jahrke and Clark 1999).

Clarkson et al. (1993) noted high infestation levels of the non-native parasite *Lernaea cyprinacea* (anchorworm) on reintroduced razorbacks in the Verde River near Perkinsville. They suspected that high levels of parasitism increased mortality of the reintroduced fish and considered that this could represent another obstacle to reestablishment of the species. Robinson et al. (1998) found that levels of parasitism on both native and non-native fishes were higher at Perkinsville than at Childs, but rated all fishes examined as "healthy," and concluded that parasitism was not seriously impacting Verde River fishes.

Bonar et al. (2004) encountered 17 razorback suckers during the 2002-2003 field season within the reach between Beasley Flats to Horseshoe Dam of the Verde River. The AGFD stocking location for razorback suckers, near the Childs power plant, occurs within this reach. No razorbacks were encountered elsewhere in the Verde River during the Bonar et al. field season (Bonar et al. 2004).

3.2.3. Desert Sucker – No Status

The desert sucker (*Catostomus clarki*) is a commonly encountered species in the Verde River, occurring at elevations ranging from 480 to 8,840 feet in elevation (AGFD

2003b). Its physical appearance is marked by dark green to tan lateral and dorsal regions, which fades to silvery yellow on the lower lateral region. Desert suckers have a broadly rounded snout oriented downward for bottom feeding and achieve an average, overall maximum size of almost 13 inches in total length and just under 2 pounds in weight (Sublette et al. 1990).

As juveniles these suckers feed primarily on chironomid larvae and on plant detritus throughout their life using specially adapted jaws for scraping. Juvenile desert suckers remain in quiet, low or no flow shallow water until they mature and assimilate into faster flowing stream habitats (Sublette et al. 1990; AGFD 2003c). Desert suckers are not known to move great distances within a river system, and resist downstream displacement during flood events (Sublette et al. 1990; AGFD 2003c; Lucas and Baras 2001). The species prefers flowing pools and rapids with a substrate comprised of gravel-rubble with interstitial silt (AGFD 2003c). Threats include reduced available habitat due to alteration of historical flow regimes, construction of reservoirs, and predation and competition by non-native fish.

Spawning occurs in late winter and early spring when adults gather in large numbers over riffle substrates where eggs are laid. The eggs adhere to gravel substrates within shallow depressions on the stream bottom (Sublette et al. 1990; AGFD 2003c).

Of the species that were observed during Bonar et al.'s (2004) research on the Verde River, desert suckers were the most abundant species observed (n = 10,022) at a ratio of 2.5:1 to the next most abundant native species, the Sonoran sucker (n = 4,444). The majority of desert suckers was observed during spring and summer, and were distributed throughout the entire length of the Verde River in both riffle and run habitats (Bonar et al. 2004).

3.2.4. Sonora Sucker – No Status

The Sonora sucker (*Catostomus insignis*) is a noticeably bi-colored species that can attain lengths of 31.5 inches and is described as having a fusiform, chubby body, a large head, and brownish coloration dorsally becoming yellow below (Minckley 1973).

Habitat preferred by the Sonora sucker seems to vary widely, from low elevation warm water streams (369 feet) to clear and cold higher elevation streams (2,663 feet) (AGFD 2003d). Minckley (1973) suggested that the species has a tendency to gravitate to gravelly or rocky pools or deep, quiet water. Similar to other members of its genus, the Sonora sucker is very sedentary and greatly resists downstream displacement, with very little seasonal movement observed (Sublette et al. 1990). Threats include reduced available habitat due to alteration of historical flow regimes, construction of reservoirs, and predation and competition by non-native fish.

Sonora suckers are considered omnivorous, feeding in early morning and late evening, and their diet appears to vary with availability of prey (Sublette et al. 1990; Minckley 1973). Food items taken by the species may include crustaceans, diatoms, algae, protozoans, and miscellaneous invertebrates. Young of the species are known to feed in large groups along the margins of streams (Sublette et al. 1990; AGFD 2003d; Minckley 1973). Spawning occurs from late winter through mid-summer (AGFD 2003d). The act of spawning is similar to that of other members of its genus and is characterized by the tendency of larger groups to move into shallower tributaries or onto riffles of larger streams with gravelly substrates where fertilized eggs are deposited, incubate, and develop (AGFD 2003d; Sublette et al. 1990; Minckley 1973).

The Sonora sucker was encountered by Bonar et al. (2004) in all reaches of the Verde River during their sampling effort from March 2002 through January 2003. Sonoran sucker was the second-most abundant native species observed (n = 4444).

3.2.5. Roundtail Chub - No Status

Roundtail chub (*Gila robusta*) is a cyprinid (minnow) fish with a thick, compressed, and moderately streamlined body shape and a darkened dorsum becoming lighter or silvery below (blotching or mottling present occasionally). The roundtail may obtain lengths of 20 inches in large river habitat (Minckley 1973; Sublette et al. 1990; AGFD 2003e; Voeltz 2002). The roundtail chub is considered a sportfish by the AGFD (Minckley 1973; AGFD 2005a).

Roundtail chub can be found in cool to warm water, mid-elevation streams (from 1,210 to 7,220 feet) and often prefer open areas of deeper pools and eddies of mid-sized to large streams (Voeltz 2002; AGFD 2003e). The species also can be found using relatively fast or turbulent water habitat just below rapids (Voeltz 2002). Habitat cover associated with roundtail chub includes the presence of boulders, undercut banks, overhanging cliffs, or organic matter but, in general, the species is less prone to require such cover as compared to other species in its genus (Voeltz 2002).

Roundtail chub spawning takes place during late winter and early summer when flow begins to taper after spring runoff (February through June) (Sublette et al. 1990; AGFD 2003e). Spawning activity is also often correlated with submerged cover (i.e., fallen trees, shrubs, etc.) (AGFD 2003e). Temperature is believed to be the most significant environmental factor triggering spawning in this species (Sublette et al. 1990). Roundtail deposit fertilized eggs on gravel substrates (AGFD 2003e). Both sexes of the species undergo considerable physical change during spawning season. Such changes include the growth of tubercles; the appearance of red and orange coloration, and in females, the abdomen becomes noticeably swollen with a distended vent (AGFD 2003e; Voeltz 2002).

Roundtail chub are primarily considered omnivorous and quite variable in their feeding habits, taking terrestrial and aquatic invertebrates, fish, lizards, detritus, and filamentous algae (AGFD 2003e; Sublette et al. 1990; Voeltz 2002).

Voeltz (2002) generally describes the species as “Unstable – Threatened” within the Verde River basin, which implies they are uncommon or rare with a limited distribution. According to data over the past 5 to 10 years, the roundtail chub shows a declining population with limited recruitment. The species is facing serious threats including, but not limited to, impacts from non-native fish species and habitat alteration and/or destruction. The species is thought to be extant in the following tributaries off the Verde River: Fossil Creek, Oak Creek, West Clear Creek, and Wet Beaver Creek. Roundtail chub were observed by Bonar et al. (2004) in all sections of the Verde River, all year long, and was the fourth-most common native species observed (n = 158).

The roundtail chub was petitioned to be listed by the Center for Biological Diversity (Center) on April 2, 2003. The petitioner requested the roundtail be listed as a distinct population segment in the Colorado River Basin, below Glen Canyon Dam. The Center cited habitat modification and destruction (livestock grazing, damming, dewatering, channelizing, etc.), predation by and competition with introduced non-native fish species, and the inadequacy of existing regulations to protect the species (Center for Biological Diversity 2003). The USFWS published a Federal Register notice on July 12, 2005 concluding that the petition may be warranted (70 FR 132).

3.2.6. Longfin Dace – No Status

The longfin dace (*Agosia chrysogaster*) is a small species, rarely exceeding 2.6 inches in length, found at elevations ranging from 1,360 to 6,740 feet (Sublette et al. 1990; AGFD 2003f). The physical appearance of the longfin dace was described by Minckley (1973) as "...dark gray above, white below; sides sometimes silvery or with a dark lateral band lying just below the lateral line." Considered by Minckley (1973) to be the "…most successful, highly adaptable, cyprinid fish native to the deserts of the American Southwest," the longfin dace occurs in a range of habitat from hot, low desert streams to cool clear brooks at higher elevations with a preference for gravely or sandy substrates (AGFD 2003f).

Longfin dace are opportunistic in their diet, taking aquatic invertebrates as well as feeding upon detritus, zooplankton, and algae (Minckley 1973; AGFD 2003f). Adults generally become sexually mature within 1 year of age and spawning occurs over a long, 6-month period beginning in December and continuing through July (and possibly September in low elevations) with a surge in spawning activity occurring in April (Minckley 1973; AGFD 2003f; Sublette et al. 1990).

The longfin dace is not currently listed by USFWS. Threats include human activities that alter the quality or flow of water, particularly flood control and irrigation, as well as predation from and competition with nonnative fishes (AGFD 2002f).

Bonar *et al.* (2004) counted 316 longfin dace in riffle habitat in the Verde River between Bartlett Dam and the confluence with the Salt River; observed consistently through all four seasons of the calendar year. No longfin dace were observed by Bonar *et al.* in any other reach within the Verde River mainstem.

3.2.7. Spikedace - Federally Listed as Threatened with proposed Critical Habitat

The spikedace (*Meda fulgida*) is a small (usually less than 3 inches total length) fish whose common name alludes to the well-developed spine in the dorsal fin. They feed primarily on aquatic and terrestrial insects (Schreiber 1978; Barber and Minckley 1983; Minckley 1973; Marsh et al. 1989). Spikedace are generally olive-gray to brown on the dorsal region, vibrantly silvery within the lateral portions, and have a white or yellowish-white belly (Minckley 1973; Sublette et al. 1990).

Spikedace prefer to live in clear, low to moderate gradient flowing water with slow to moderate velocities over sand, gravel, and cobble substrates at elevations ranging from 1,620 to 4,500 feet (AGFD 2003g; Propst et al. 1986; Rinne and Kroeger 1988). Specific habitat for this species consists of shear zones where rapid flow borders slower flow, areas of sheet flow at the upper ends of mid-channel sand/gravel bars, and eddies at downstream riffle edges (Propst et al. 1986). Young of the species will often reside in shallow, slow moving peripheral regions of a stream or in backwaters with silt and sand substrates (AGFD 2003g; Sublette et al. 1990).

Spikedace spawns from March through May with some yearly and geographic variation (Barber et al. 1970; Anderson 1978; Propst et al. 1986). Actual spawning has not been observed in the wild, but spawning behavior and captive studies indicate eggs are laid over gravel and cobble where they adhere to the substrate. Spikedace live about 2 years with reproduction occurring primarily in the 1-year old age class (Barber et al. 1970; Anderson 1978; Propst et al. 1986).

The spikedace was listed as a threatened species on July 1, 1986 (USFWS 1986). Critical habitat was designated on April 25, 2000 and included the Verde River from the confluence of Fossil Creek to the headwaters as well as several perennial tributaries within the drainage including Granite Creek, Oak Creek, Beaver/Wet Beaver Creeks, West Clear Creek, and Fossil Creek. However, in June 2004, in the matter of the New Mexico Cattle Growers and the Coalition of Arizona/New Mexico Counties for Stable

Economic Growth versus the USFWS, in the 10th Circuit Court, all critical habitat for the species was vacated and remanded back to USFWS for reconsideration and development due to the inadequacy of the economic analysis of the critical habitat designation. Critical habitat for this species has been re-proposed and includes portions of the Verde River basin.

The status of spikedace is declining rangewide. It is now restricted to approximately 289 miles of streams, and its present range is only 10 to 15% of its historical range. Within occupied areas, it ranges from common to very rare, but is presently common only in Aravaipa Creek and some parts of the upper Gila River in New Mexico (USFWS 2000). Although it is currently listed as threatened, the Service has found that a petition to uplist the species to endangered status is warranted. A reclassification proposal is pending; however, work on it is precluded due to work on other higher priority listing actions (USFWS 1994). Habitat destruction along with competition and predation from introduced non-native species are the primary causes of the species range-wide decline (Miller 1961; Williams et al. 1985; Douglas et al. 1994). However, within some reaches where the removal of permitted grazing has improved the habitat, the effect of the non-native fish population, specifically red shiner, is considered the most prominent factor in preventing the species' recovery (USFWS 2002a).

If critical habitat is redesignated, the primary constituent elements could be similar to those described in the earlier rule. The constituent elements included those habitat features required for the physiological, behavioral, and ecological needs of the species. For spikedace, these included permanent, flowing, unpolluted water; living areas for adult spikedace with slow to swift flow velocities in shallow water with shear zones where rapid flow borders slower flow, areas of sheet flow at the upper ends of mid-channel sand/gravel bars, and eddies at downstream riffle edges; abundant aquatic insect food base; living areas for juvenile spikedace with slow to moderate flow velocities in shallow water with moderate amounts of instream cover; living areas for larval spikedace with slow to moderate flow velocities in shallow water with abundant instream cover; sand, gravel, and cobble substrates with low to moderate amounts of fine sediment and substrate embeddedness; pool, riffle, run, and backwater components present in the aquatic habitat; low stream gradient; water temperatures in the approximate range of 35 to 65 degrees Fahrenheit; abundant aquatic insect food base; periodic natural flooding; a natural, unregulated hydrograph or, if the flows are modified or regulated, then a hydrograph that demonstrates an ability to support a native fish community; and habitat devoid of non-native aquatic species detrimental to spikedace or habitat in which detrimental non-native species are at levels that allow the persistence of spikedace.

Recent taxonomic and genetic work on spikedace indicates there are substantial differences in morphology and genetic makeup between remnant spikedace populations. Remnant populations occupy isolated fragments of the Gila basin and are isolated from each other. Anderson and Hendrickson (1994) found that spikedace from Aravaipa Creek are morphologically distinguishable from spikedace from the Verde River, while spikedace from the upper Gila River and Eagle Creek have intermediate measurements and partially overlap the Aravaipa and Verde populations. Mitochondrial DNA and allozyme analyses have found similar patterns of geographic variation within the species (Tibbets 1992, 1993).

Historically occurring throughout the mid-elevations of the Gila River drainage, the spikedace is currently extant in the middle upper Gila River, and Aravaipa and Eagle creeks (Barber and Minckley 1966; Minckley 1973; Anderson 1978; Marsh et al. 1989, Sublette et al. 1990; Jakle 1992; Knowles 1994; Rinne 1999). The population in the upper Verde River appears to be declining in numbers as recent surveys have failed to locate spikedace. Bonar et al. (2004) failed to observe any spikedace during field activities on the Verde River. The last known records are two fish found in 1999 by the AGFD in the Upper Verde River. The tributary streams to the Verde are believed to be unoccupied by the spikedace at this time and additional survey work is needed to determine its current status within the entire Verde River drainage.

3.2.8. Loach Minnow - Federally Listed as Threatened

Loach minnow (*Tiaroga cobitis*) is a small, slender, elongate fish with markedly upwardly directed eyes with an olivaceous background coloration that is highly blotched with darker pigment (Minckley 1973; AGFD 2003h). White spots on the base of the tail and dorsal fin distinguish loach minnow from the speckled dace (*Rhinichthys osculus*). Recent biochemical genetic work on loach minnow indicates that there are substantial differences in genetic makeup between remnant loach minnow populations (Tibbets 1993). Remnant populations occupy isolated fragments of the Gila River basin and are isolated from each other. Based upon her work, Tibbets (1992, 1993) recommended that the genetically distinctive units of loach minnow should be managed as separate units to preserve the existing genetic variation.

Loach minnow is a bottom-dwelling inhabitant of shallow, swift water over gravel, cobble, and rubble substrates at elevations ranging from 2,325 to 8,240 feet (Rinne 1989; Propst and Bestgen 1991; AGFD 2003h). Loach minnow uses the spaces between, and in the lee of, larger substrate for resting and spawning (Propst et al. 1988; Rinne 1989). It is rare or absent from habitats where fine sediments fill the interstitial spaces (Propst and Bestgen 1991). Some studies have indicated that the presence of filamentous algae may be an important component of loach minnow habitat (Barber and Minckley 1966). Loach minnow feeds exclusively on aquatic insects (Schrieber 1978; Abarca 1987). Loach minnow live between 2 and 3 years with reproduction occurring primarily in the second summer of life (Minckley 1973; Sublette et al. 1990). Spawning occurs in March through May (Britt 1982; Propst et al. 1988); however, loach minnow can spawn in the autumn under certain conditions (Vives and Minckley 1990). Loach minnow deposit their eggs on the downstream side of rocks in small cavities that form in the substrate under the rock. The eggs are attached to the underside of the rock. Limited data indicate that the male loach minnow may guard the nest during incubation (Propst et al. 1988; Vives and Minckley 1990).

Loach minnow was listed as a threatened species on October 28, 1986 (USFWS 1986). Critical habitat was designated on April 25, 2000 and included the Verde River from the confluence of Fossil Creek to the headwaters as well as several perennial tributaries within the drainage including Granite Creek, Oak Creek, Beaver/Wet Beaver Creeks, West Clear Creek, and Fossil Creek. However, the loach minnow is considered extirpated from the entire Verde River system, with the last confirmed observations occurring in 1938 above Camp Verde (USFS 2001).

In June 2004, in the matter of the New Mexico Cattle Growers and the Coalition of Arizona/New Mexico Counties for Stable Economic Growth versus the USFWS, in the 10th Circuit Court, all critical habitat for the species was vacated and remanded back to USFWS for reconsideration and development due to the inadequacy of the economic analysis of the critical habitat designation. Critical habitat for this species has been re-proposed, but does not include portions of the Verde River basin.

3.2.9. Gila Topminnow - Federally Listed as Endangered

Gila topminnow (*Poeciliopsis occidentalis*) belongs to a group of live-bearing fishes and are endemic to the Gila River basin. It occurs at elevations ranging from 1,320 to 7,510 feet but prefer elevation below 5,000 feet (AGFD 2003c). Males are smaller than females, rarely greater than 1 inch, while females are larger, reaching 2 inches. Body coloration is tan to olivaceous, darker above, lighter below and often white on the belly. Breeding males are usually blackened, with some golden coloration of the midline, and with orange or yellow at base of the dorsal fin.

Gila topminnow are live-bearers that give birth to 1 to 31 young per brood that mature a few months after birth depending on when they are born (Schoenherr 1974). They breed primarily from March to August, but a few females may become pregnant during other times of the year (Schoenherr 1974). Minckley (1973) and Constantz (1980) reported that Gila topminnow are opportunistic feeders that eat bottom debris, vegetation, amphipods, and insect larvae when available.

Gila topminnow and many other poeciliids can tolerate a variety of physical and chemical conditions. They are good colonizers in part because of this tolerance and in part because a single gravid female can start a population (Meffe and Snelson 1989). Minckley (1969, 1973) described their habitat as edges of shallow aquatic habitats, especially where abundant aquatic vegetation exists. Simms and Simms (1992) found the densities of Gila topminnow in Cienega Creek, Pima County, Arizona, to be greater in pool, glide, and backwater habitats and less dense in marsh, riffle, chute, cascade, and fall habitats. They found that occurrence was more frequent over sand substrates than over other categories of substrates. Gila topminnow are normally found in the upper one-third of the water column (Forrest 1992).

The Gila topminnow was listed as endangered in 1967 without critical habitat and remains protected under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.) as an endangered species (USFWS 1967). The Gila topminnow is highly vulnerable to adverse impacts from non-native aquatic species (Johnson and Hubbs 1989). Predation and competition from non-native fishes especially the mosquitofish (*Gambusia affinis*), have been major factors in its decline and continue to be a major threat to the remaining populations (Meffe 1983, 1985; Brooks 1986; Marsh and Minckley 1990; Stefferud and Stefferud 1994; Weedman and Young 1997; AGFD 2003i). A reproducing, stocked population in Lime Creek, an intermittent tributary to Horseshoe, persisted as recently as 2005 in the upper perennial reaches (Voeltz 2005).

There are no extant, naturally occurring populations of Gila topminnow in the Verde River basin. Although the AGFD has been actively stocking the species in selected areas within the drainage, these efforts have met with variable success. Four re-established, extant populations of Gila topminnow occur in the Verde River basin: Dutchmen Grave Spring, Lime Creek, Mud Springs, and Walnut Spring (Voeltz and Bettaso 2003).

3.2.10. Speckled Dace - Unlisted

The speckled dace (*Rhinichthys osculus*) is a relatively small minnow that rarely exceeds 3 inches in length and has a highly variable appearance ranging in background colors and patterns; even patternless individuals are observed (Minckley 1973; AGFD 2003j; Sublette et al. 1990). Minckley (1973) describes the body of this species as "…chunky, rounded, somewhat flattened ventrally…"

The speckled dace is generally rare below elevations of 4,900 feet but is considered in peak abundance at elevations between 6,500 and 9,800 feet, below riffles and eddies, in shallow water (<20 inches deep) (Minckley 1973). The species appears to prefer headwaters or small to medium rivers and are rarely found in lakes (AGFD 2003j). The species has relative intolerance for elevated temperatures and reduced oxygen, which explains the species' affinity for higher elevation systems throughout its distribution (Sublette et al. 1990).

The speckled dace is an omnivorous species that feeds along the bottom on algae, detrital material, insect larvae, small crustaceans, small snails, but "…sometimes rises to mid-water to inspect, and sometimes devour, floating materials" (Minckley 1973; AGFD 2003j). All feeding activity occurs during the evening hours of 9:00 pm and 1:00 am (Sublette et al. 1990).

Spawning activity in speckled dace has two defined periods; spring and late fall where the prior is dictated by photoperiod and water temperature and the latter is influenced by flow regimes (Sublette et al. 1990; Minckley 1973; AGFD 2003j). Swift water is sought by breeding adults where the female enters an area with gravelly substrate that has been cleared by courting males and releases her eggs into the substrate, which is then showered by sperm from several males (Sublette et al. 1990).

The speckled dace is the only native fish species that occupies all major drainages in western North America and is generally considered stable or abundant where it occurs (Minckley 1973). The speckled dace is found in Arizona in the Colorado, Bill Williams, and Gila River drainages (AGFD 2003j). The headwaters of the Verde River are located at approximately 3,800 feet in elevation, which is below the optimum elevation for the species. Bonar et al. (2004) did not observe any speckled dace during their work on the Verde River.

3.3. Non-native Fish Species

In order to assess the effect of reservoir operations on native fish, the Committee examined the life history and distribution of non-native species that could potentially benefit from reservoir operations within the 50-year term of the permit. The Committee focused much of the analysis of reservoir operations on the fisheries within Horseshoe rather than Bartlett because: 1) Horseshoe Dam acts as a barrier to upstream movement of non-native species that are produced in Bartlett Reservoir and a considerable amount of stream mileage (including tributaries), without barriers, resides upstream of Horseshoe; 2) critical habitat for razorback sucker includes Horseshoe and upstream segments of the

Verde River; 3) Bartlett operation will not significantly vary from historical operations; and 4) AGFD actively manages Bartlett Lake as a sport fishery, thus any change of operation would be in direct conflict with their and the Forest Service's ongoing recreation management priorities and direction. While much of the focus concerning specific reservoir operation alternatives were focused on Horseshoe Lake, the committee considered these factors above and analyzed the impacts of Bartlett Dam release/operations on the downstream native fish populations, and evaluated the potential for fish to be passed through the outlet works and over spillways during high flows into downstream habitats.

Generally, we assessed nonnative fish species were analyzed using their reproductive strategies or life history traits. We considered that future introductions of nonnative species could occur, and that these species would likely cause similar predation/competition impacts on native fish. We also expect that new species would likely have similar life history traits as those analyzed and that they would be affected by operations in comparable ways as those individual nonnative fishes we assessed. In the following section, we present life history data for individual Verde River nonnative fish species. We also discuss below and in Section 3.4 studies that have assessed how reservoir operations can impact these species of fish.

To compose the list of fishes for analysis we used the results of Robinson (2005), the most recent sample, as an indicator of the species likely to be present in large numbers within Horseshoe over time in addition to other species that were identified in the area historically and are anticipated to reoccur over the life of the permit. Many of these species were consistent with recent sampling by Bonar et al (2004) and AGFD historic sampling records in the reservoir. To determine the influence of various operation alternatives on non-native fish reproduction and survival, the committee summarized available spawning data for these species (Table 3-6 and 3-7, Figure 3-2). Many abiotic (lake substrates, water temperature) and biotic (interspecific competition, food resources, nest depths, egg incubation times) factors will influence spawning activity and success under the various reservoir operation scenarios considered. However, corresponding habitat or field data to analyze most factors are not available. Thus, the Committee assumed a worst-case scenario: that the entire reservoir was potential spawning habitat for all selected species (i.e., at all water elevations suitable spawning habitat would exist) and that seasonally terrestrial habitat would be inundated creating additional food and shelter for adults and developing fry; potentially resulting in increased reproduction and recruitment. Spawning periods (months) were then estimated for these species using published records/estimates and observations from nearby lakes with similar climate and environmental conditions (Bartlett Lake, Roosevelt Lake, and Lake Pleasant) with deference to the unique characteristics of Horseshoe such as its fluctuating water levels and shallow profile. To estimate the potential for non-native fish to move from the reservoir and prey on or compete with native fish, we searched for published data concerning likelihood of movement (i.e., territoriality) and known dispersal distances of future progeny of non-native fish species that originate or benefit from the reservoirs. The Committee also summarized literature concerning the influence of water management on species recruitment and survival.

The Committee acknowledged that the non-native fish, which could benefit from reservoir operations, were predators of or competitors with native fish adults, juveniles, and/or eggs. The evidence of direct predation is extensive (Pacey and Marsh 1998). Interspecific competition for resources (food, space), while confounded by myriad other abiotic and biotic factors, is likely to occur between native and non-native fish and has been implicated in the case of small non-native species such as red shiner and mosquitofish (Minckley 1973; Pacey and Marsh 1998), but it is difficult to measure in the field. In the Verde River, Bonar et al. (2004) found that largemouth bass had the highest percentage of fish in their diet and the highest consumption rate of native and total fish. Flathead catfish, channel catfish, smallmouth bass and yellow bullhead catfish were also reported as consuming fish, but at lower rates than largemouth bass.

Bonar et al. (2004) found that *Tilapia*, red shiners, and mosquitofish primarily fed on insects and plant material, with less than 1% of their diet consisting of fish. Bluegill, green sunfish and rainbow trout fed primarily on insects, with a small percentage of their diets consisting of native and non-native fish. Of these, common carp was highly abundant, and green sunfish, red shiner, and bluegill were present but in low numbers in the reservoir when it was high (Robinson, pers. comm. 2005). At low levels, when there was a minimal pool and most of the area in the conservation space was a river, common carp and goldfish continued to be the most abundant species, and red shiners were also abundant (Robinson, pers comm. 2005).

3.3.1. Largemouth Bass

Largemouth bass (*Micropterus salmoides*), also known as the largemouth blackbass, is a large member of the sunfish family (*Centrarchidae*) that can reach weights in excess of 25 pounds and lengths of over 36 inches in optimum conditions (LaRivers 1994). The native distribution of the largemouth bass is north central, southeastern, and south central United States, including tributaries of the Rio Grande in northeast Mexico (Sublette et al. 1990). However, this species has been widely and successfully introduced throughout North America and Europe because of its popularity as an excellent sport fish.

The largemouth bass is a habitat generalist and can live in a wide variety of habitats but prefers sluggish waters, particularly in larger, warmer streams and lakes with lower turbidity levels and beds of aquatic vegetation (Sublette et al. 1990; Moyle 1976; Bryan et al. 2000). It often centers around large rocks or logs or is found close to soft bottoms, stumps, and extensive growths of a variety of emergent and sub-emergent vegetation, especially water lilies, cattails, and other pondweeds in water depths generally less than 18 feet which may pertain to its ambush-style hunting tactics (Moyle 1976; Sublette et al. 1990).

The largemouth generally spawns from late spring to mid-summer. Spawning can occur in water temperatures of 58°F to 75°F in water depths of 0.5 to 23 feet. Incubation time for eggs can be as short as 2 days at a water temperature of 71.6˚F (Minckley 1973; Sublette et al. 1990; Moyle 2002). Nests constructed in shallow water or fluctuating reservoirs are negatively impacted by falling water levels. Falling water levels increase the effects of wave action and temperature fluctuations by reducing the depth of water over the nests; reducing cover for fry and fingerling bass, and reducing littoral zone productivity by stranding invertebrates and plants (Summerfelt and Shirley 1978). According to Sublette et al. (1990), nests are constructed by males preferably on firm substrate such as gravel or sand but also over soft, muddy bottoms or other substrata and are often located along the shallow margins of rivers and lakes. Fecundity of females varies greatly with size and location, ranging from 2,000 to more than 25,000 eggs in Arizona waters (Minckley 1973). After the eggs are deposited, the male will typically chase the female away and return to the nest to care for the eggs until they hatch and the young disperse, which takes approximately 13 to 20 days (Sublette et al. 1990; LaRivers 1994).

Largemouth bass are not known to move extensively within a drainage as most movements within an individual's home range are equal to or less than 8 miles in length possibly due to spawning behavior (Lucas and Baras 2001).

Juvenile largemouth bass begin feeding on zooplankton and macrobenthos until reaching the length of 1.5 to 2.0 inches where the diet becomes predominantly piscivorous (Sublette et al. 1990). The diet of adults varies and, in addition to fish, includes a variety of invertebrates, small mammals, reptiles, amphibians, and young waterfowl. Bonar et al. (2004) considered the largemouth bass to be the most significant piscivore in the Verde River with 16.8% fish in their diet (including Sonora sucker, desert sucker, and longfin dace) and was found in all reaches of the Verde River below Tavasci Marsh in pool and run environment types, year-round. Native fish were found in the diet of largemouth bass in the Verde River at all sampling locations downstream of Tavasci Marsh but the highest native fish predation occurred downstream of Bartlett Dam (Bonar et al. 2004).

3.3.2. Bluegill

Bluegill (*Lepomis macrochirus*) is a member of the sunfish family (*Centrarchidae*) that generally prefers static, clear water of ponds, reservoirs, and sluggish streams. Adult bluegills prefer warm waters with rooted aquatic vegetation and may benefit from rising reservoir levels that inundate shoreline vegetation. They tend to prefer structures such as weedbeds, fallen timber, etc. In Arizona, this species may be expected to occur in any waters below 8,200 feet elevation; most commonly in reservoirs and ponds (Minckley 1973). They are prone to stunting in smaller impoundments, and many smaller ranch ponds in the state support large populations of tiny, yet reproducing bluegill (Minckley 1973).

Spawning begins in late May and continues through August (Sublette et al. 1990), when water temperatures range from 64-80°F at depths of up to 9 feet (Minckley 1973; Sublette et al. 1990; Moyle 2002). Egg incubation periods may be as short as 2.5 days at water temperatures equal to or exceeding 70˚F (Minckley 1973; Sublette et al. 1990; Moyle 2002). No substrate preference is apparent for spawning behavior in this species; they have been reported using all substrates, including mud, for spawning (LaRivers 1994). Minckley (1973) cites egg spawn numbers of up to 49,000 per female in Arizona and the southwest. Eggs are guarded by the male. Males will continue to guard the newly hatched fry for another day, after which the male may begin to feed on the fry. No parental care is provided after hatching.

Bluegill feed mainly on aquatic insects and fish, but will attempt to eat almost anything that will fit in their mouths including fish eggs, snails, worms, and aquatic plants. Smaller invertebrates, zooplankton, and aquatic insects are all eaten (Minckley 1973). Young bluegills feed primarily on plankton, switching to insects, eggs, and fry of other species with adulthood. Bonar et al. (2004) considered bluegill a less significant piscivore in the Verde River with less than 4% fish in their diet. Bonar et al. (2004) confirmed bluegill distribution in the Verde River to include all reaches below Tavasci Marsh in the pool environment types and predominantly during the all seasons.

Bluegills tend to have small home ranges, but may exhibit seasonal movements between habitat types by aggregating in larger groups in deeper water in the winter and moving to shallower waters during the warmer seasons to spawn (Lucas and Baras 2001).

3.3.3. Channel Catfish

Channel catfish (*Ictalurus punctatus*) can achieve sizes up to 55 pounds and 51 inches in length (Sublette et al. 1990; LaRivers 1994). Channel catfish were originally found only in the Gulf States and Mississippi Valley but have since been widely introduced throughout the U.S. and much of northern Mexico (Sublette et al. 1990).

Channel catfish live in a wide array of habitats including swift flowing streams, large reservoirs, lakes, ponds, and some sluggish streams (Sublette et al. 1990; LaRivers 1994). Moyle and Nichols (1974) notes the ideal habitat for all sizes of this species is clear, rapidly flowing, warmwater streams with sand, gravel, or rubble bottoms. While channel catfish generally prefer clear water streams, they also do well in muddy waters.

Sexual maturity is generally reached at age 3 (Wellborn 1988). Channel catfish are cavity spawners and spawn only in secluded, semi-dark areas with temperatures generally ranging from 70°F and 85°F, at depths between 8 and 13 feet (Minckley 1973; Sublette et al. 1990; Moyle 2002). In natural waters, male catfish build nests in holes in the banks, undercut banks, hollow logs, logjams or rocks, or other similar areas the male can protect. The female lays a gelatinous egg mass that is protected and cared for by the male until eggs are hatched and fry leave the nest. Fecundity is correlated with body size; females lay 3,000 to 4,000 eggs per pound of body weight (Wellborn 1988). Eggs hatch in 5 to 10 days, depending on water temperature. Optimal growth of adult catfish occurs in warm waters of about 85° F.

Channel catfish are omnivorous and may feed during the day or night and take a variety of both plant and animal material including mollusks, and crustaceans (Moyle 1976). Young catfish feed primarily on aquatic insects. Adult diets include insects, snails, crawfish, green algae, aquatic plants, seeds, and small fish (LaRivers 1994). Adults that obtain lengths greater than 12 inches tend to become piscivorous (Moyle 1976). Growth rates of channel catfish seem closely related to population densities, with the most rapid increases in size associated with relatively low numbers of fish per unit area (Minckley 1973). In Arizona, channel catfish 20 inches long and weighing 10 pounds are not uncommon, especially from the larger reservoirs (Minckley 1973). Bonar et al. (2004) considered channel catfish a significant piscivore in the Verde River with greater than 4% fish in their diet (including Sonora and desert sucker) and found it in all reaches and all environment types of the Verde River, during all seasons of the year.

Additionally, according to Bonar et al. (2004), channel catfish were the second largest nonnative fish species encountered with a median length of 10.7 inches.

While, as a taxonomic group, the *Ictalurids* are widely considered sedentary, the channel catfish is considered a seasonally migratory species. Members of this species have recorded long distance movements of up to 78.3 miles in Midwestern drainages (Lucas and Baras 2001). According to Lucas and Baras (2001), this strategy allows them to exploit spawning and feeding habitats of smaller tributaries in the summer months and retreat to the safety of deeper water habitats during the winter months.

3.3.4. Flathead Catfish

The flathead catfish (*Pylodictis olivaris*) is a large (up to 55 inches and 100 pounds) catfish (Sublette et al. 1990). The native distribution of the flathead catfish in North America includes the Mississippi and Rio Grande river systems as well as other systems in northeastern Mexico (Sublette et al. 1990; Moyle 1976). Today, the species is widely found throughout the United States due to introductions. In Arizona, they were introduced sometime prior to 1950 into the Gila River system (Moyle 1976; Minckley 1973).

Adult flathead catfish may inhabit streams, lakes, and reservoirs preferring large quiet pools with logs and other debris. Within tributaries, flatheads will generally occupy only the larger pools close to the confluence with the mainstem water body (Sublette et al. 1990). Preferred habitat for the flathead catfish also includes areas under rocks, logs, or other rigid objects when found in faster flowing water (Moyle 1976). This species is also known to favor turbid waters and avoid streams with higher gradients or intermittent flows (Sublette et al. 1990).

Flatheads generally spawn in early spring and summer when water temperatures are between 72°F to 85°F at depths between 6 and 16 feet deep (Minckley 1973; Sublette et al. 1990; Moyle 2002). They build nests in dark secluded shelters such as natural cavities, undercut banks, or near large submerged objects. Gelatinous, adhesive eggs are laid in a compact golden-yellow mass, which is fanned continuously and guarded by the male (Sublette et al. 1990). The egg mass may contain between 4,000 and 59,000 eggs

(Sublette et al. 1990). After the incubation period that may range between 6-8 days, the hatched young remain near the nest for several days in a large compact school that is also guarded by the male.

Flathead catfish are mostly nocturnal feeders with young preferring invertebrates such as insect larvae, crayfish, mollusks, and worms. As they mature with age, they grow to a strict piscivorous, even cannibalistic, diet (Moyle 1976). Feeding behavior in this species has also been noted during daylight hours, particularly during higher turbid flows (Sublette et al. 1990). Adult flathead catfish are impressive predators, lying in wait and ambushing large-bodied fish with a sudden inhalation through their large mouth (Sublette et al. 1990; Moyle 1976). Adult flathead catfish can reach appreciable sizes and can prey upon most if not all species of adult native fish (Weedman, pers comm. 2005). There is little information concerning the migratory nature of the species but based on its foraging and breeding strategy is thought to be relatively sedentary, remaining in deep pools or eddies.

Bonar et al. (2004) considered flathead catfish a significant piscivore in the Verde River with greater than 4% fish in their diet (including Sonora and desert suckers) and were found all reaches of the Verde River in the riffle environment type year-round.

3.3.5. Carp

The common carp (*Cyprinus carpio*) is a member of the *Cyprinidae* (minnow or carp) family. The common carp is native to Asia and was one of the first species introduced outside of its native distribution (LaRivers 1994). Carp were introduced in Arizona prior to 1885 and were stocked into ponds, then into rivers, and have since spread to almost all waters of Arizona below an elevation of 6,500 feet (Minckley 1973). Carp appear to thrive in a wide variety of conditions, preferring warm lakes, streams, ponds, and sloughs with a lot of organic matter and proliferate in large, turbid rivers (Id.).

In Arizona, common carp begin spawning in late February and continue through June or July in water temperatures between 59°F and 73°F at depths of up to 6 feet deep. Vegetated areas in water depths between 1 and 4 feet are most often selected (Minckley 1973). Females lay between 100,000 up to as many as 2 million eggs depending on the body size of the female (Minckley 1973). Batches of eggs are laid over multiple areas and incubate for a period of 3 to 16 days at temperatures ranging between 59˚F and 73˚F (Minckley 1973; Sublette et al. 1990; Moyle 2002). The eggs are adhesive and stick to plants or detritus. Young carp remain in these vegetated areas until they are 3 to 4 inches in length and eat primarily small crustaceans.

Adults are omnivorous and eat insect larvae, crustaceans, annelids, mollusks, weed and tree seeds, wild rice, aquatic plants, and algae mainly by grubbing in sediments (Moyle 1976). Carp usually live between 9 and 15 years. Adults may uproot and destroy submerged aquatic vegetation and therefore may be detrimental to duck and native fish populations by increasing sedimentation and embeddedness of substrates (LaRivers 1994). They are extremely adaptable species with broad tolerances to chemical conditions, temperatures, currents, foods, and spawning condition, and therefore probably influence most species (directly or indirectly) with which they occur (Minckley 1973). Carp typically are a sedentary species with most recaptured within a few miles (kilometers) of tagging sites; however, a few individuals have been recorded moving great distances exceeding 500 miles (Becker 1983). Hladik and Kuecka (2003) noted very few movements of carp out of a temperate reservoir into tributary streams, and the few carp movements documented were in the downstream direction.

Bonar et al. (2004) considered the common carp as predominantly an insectivore and/or herbivore in the Verde River confirming that fish comprised less than 0.5% of their overall diet, and found them in all reaches of the Verde River, in pools, year-round.

3.3.6. Green Sunfish

A prominent member of the *Centrarchidae* family, the green sunfish (*Lepomis cyanellus*) is native to the eastern United States from the Great Lakes to Mexico (LaRivers 1994). Green sunfish were the earliest of the smaller sunfishes to be introduced into Arizona (Minckley 1973). They utilize lakes, reservoirs, and streams (particularly areas with little flow such as streams that become intermittent in the summer) and are tolerant of turbid water unlike most other sunfish species (Sublette et al. 1990). Interestingly, Moyle and Nichols (1974) points out that green sunfish are "generally rare" in habitats that contain four or more fish species and are frequently found in streams that have been heavily impacted by human activity where the native species have been lost. Moyle and Nichols (1974) also states that part of the success of this species as a non-native comes from its ability to withstand high water temperature (over 96° F), low oxygen levels (less than 3 ppm), and high alkalinity; conditions common in several tributaries to the Verde River (especially at lower elevations). Green sunfish appear to have no preference for a particular bottom type, but they are usually associated with some type of structure such as brush, vegetation, or rocks (LaRivers 1994).

Green sunfish are colonial breeders with males constructing nests in shallow water from mid-May to August (Sublette et al. 1990). Males build nests near protected coves, or at the lower end of the pool where the water depths range from 0.1 to 11.5 feet (Minckley 1973; Sublette et al. 1990; Moyle 2002). Several nests are often constructed in close proximity, although occasionally only a single nest is found. Males mate with numerous females in the same or different nests and continue to guard the nest for a short period after the eggs hatch which may take between 5 and 7 days at water temperatures ranging from 59˚F to 88˚F (Minckley 1973; Sublette et al. 1990; Moyle 2002).

Adult green sunfish tend to be solitary, secretive, and highly predaceous. Green sunfish have overly large mouths and eat primarily insects, crayfish, small fishes, and occasionally plant material, but is more of a fish eater than its relatives (LaRivers 1994; Moyle 1976; Sublette et al. 1990). This species is noted for its extremely aggressive nature and subsequent territoriality that is believed to be partly responsible for its success as a non-native species (Moyle 1976). Juvenile green sunfish feed on crustaceans, aquatic insects, larvae, and terrestrial insects. Bryan et al. (2000) observed the strongest negative correlation of juvenile fish species occurrence between the green sunfish and the desert sucker.

Bonar et al. (2004) considered green sunfish a less significant piscivore in the Verde River with less than 4% fish in their diet and found them in all reaches of the Verde River in pool and run environment types and predominantly during the spring and summer seasons. Lucas and Baras (2001) found that adult sunfish in general do not make long distance movements but display the tendency to make seasonal movements between habitat types (within local areas). Juveniles of the species show a pelagic behavior, drifting in surface waters for weeks, before finally moving to shallow water to claim a territory (Lucas and Baras 2001).

3.3.7. Red Shiner

Red shiner (*Notropis lutrensis*) is a small minnow that ranges from one-half to 3 inches in length (Sublette et al. 1990). The red shiner is native to the Rio Grande, Pecos, and Canadian drainages of New Mexico as well as the area ranging from South Dakota to the Gulf Coast states including Northeastern Mexico (Sublette et al. 1990; Moyle 1976). The species was introduced into Arizona and it spread to most waters at lower elevations (below about 500 feet), except where excluded by physical barriers such as dams or waterfalls (Minckley 1973). The present range of the red shiner in Arizona almost exactly complements the presently reduced ranges of the spikedace and loach minnow, essentially displacing these native minnows (Minckley 1973). Minckley (1973) concluded that there seems little doubt that the red shiner has contributed significantly to the decline in native Arizona fish populations, including those in the Verde River.

This ubiquitous species is well adapted to survive in high silt and turbidity streams with extreme flow variability, is tolerant of fluctuations in dissolved oxygen, pH, and salinity, and is often very successful in intermittent streams with high water temperatures (Sublette et al. 1990; Moyle 1976). The red shiner is a habitat generalist and occupies perennial rivers, ephemeral or intermittent streams, canals, and lakes. In the Colorado River drainage, which has been highly modified by anthropogenic activities, red shiner has become well established in several river systems. It often is the numerically dominant species, which could be the result of not only bait transfers or intentional stocking, but also from the species' aggressive colonizing nature (Minckley 1973).

Red shiner spawning occurs from April through September, usually peaking during June and July or when water temperatures range between 59˚F to 86˚F (Minckley 1973; Sublette et al. 1990; Moyle 2002). Red shiner nests may be found in riffles, sunfish nests, submerged roots, and crevices with substrata for nesting varying from gravel to silt (Sublette et al. 1990). This species is quite prolific as each clutch has an average of 585 eggs and upward of 19 clutches are laid per year (Sublette et al. 1990). The incubation time for red shiner eggs averages 4.4 days at a water temperature of 80˚F (Minckley 1973; Sublette et al. 1990; Moyle 2002).

Red shiner are largely omnivorous bottom browsers that feed on smaller fishes, insects, filamentous algae, diatoms, crustaceans, and a variety of microorganisms and plant material. Juvenile red shiner feed on small crustaceans, aquatic insects, larvae, and algae (Sublette et al. 1990; Moyle 1976). Minckley's (1973) assessment of the effect of the red shiner on the native fish community and the species' correlative effect on the current distributions of native fish (in particular loach minnow and spikedace) remain accurate with respect to the Verde River drainage. Bonar et al. (2004) considered red shiner as predominantly an insectivore and/or herbivore in the Verde River confirming that fish comprised less than 0.5% of their overall diet.

3.3.8. Smallmouth Bass

Smallmouth bass (*Micropterus dolomieu*) occupy mid-order streams and lakes that are cooler in temperature, relatively free of turbidity, and have boulder and broken rock substrata. They appear to prefer shady areas with submerged stumps, trees or crevices in clay banks for retreat (Sublette et al. 1990; Moyle 1976).

Spawning in this species occurs from March through May in Arizona, typically when water temperatures reach between 55°F to 74°F at depths ranging of up to 16 feet (Minckley 1973; Sublette et al. 1990; Moyle 2002). Males fan an oval depression in sand or gravel through violent, lateral movements of the body and caudal fin and defend their nest vigorously (Moyle 1976; Sublette et al. 1990). Female smallmouth bass produce between 2,000 and 20,825 eggs based on body weight (Sublette et al. 1990). The eggs may take between 2.25 days (at 75˚F) and 9.5 days (at 41˚F) to hatch (Minckley 1973; Sublette et al. 1990; Moyle 2002).

Young smallmouth bass generally possess a predominantly invertebrate diet consisting of chironomid pupae and larvae, and tiny crustaceans. However, when an individual smallmouth bass reaches a total length of about 8 inches, the diet shifts almost exclusively to piscivory when sufficient prey is available; otherwise, crayfish and amphibians will supplement the diet of the adult smallmouth (Sublette et al. 1990; Moyle 1976).

The native distribution of the smallmouth includes most of the Mississippi River basin and the Great Lakes system (Moyle 1976). Introduced smallmouth bass have been in Arizona since at least the early 1940s and are known from the mainstream of the lower Colorado River, the Verde River system, and throughout the Salt River basin below about 7,200 feet elevation (Minckley 1973). Minckley (1973) noted the species to be abundant in the Verde River, but rarely attained large sizes and seemed unusually susceptible to external parasitism by *Learnea cyprinacea*, a parasitic crustacean common in that area.

Bonar et al. (2004) considered smallmouth bass a significant piscivore in the Verde River with greater than 4% fish in their diet (including Sonora sucker). The species was found in all reaches of the Verde River above Horseshoe Dam in all environment types during the spring and summer (Bonar et al. 2000). Bryan et al. (2000) found one smallmouth bass below Bartlett Dam in the high gradient riffle environment type at the Bartlett Dam sampling location. Warnecke (1988) identified smallmouth bass as occurring in Horseshoe in limited numbers.

3.3.9. Black Crappie

Black crappie (*Pomoxis nigromaculatus*) is a member of the sunfish family (*Centrarchidae*) that inhabits warm sloughs, lakes, reservoirs and large, slow rivers. Black crappie are one of the most common, larger *Centrarchids* in Arizona impoundments that retain minimum pools and have unregulated inflow. The abundance of black crappie in Arizona impoundments may be attributed to fluctuating lake levels creating a large amount of submerged vegetation available for forage and cover, occasionally referred to as the new lake effect. Fluctuating water levels seem to have a detrimental effect on crappie populations, but they seem to be able to persist during low water and readily reproduce when water levels increase (Minckley 1973).

Black crappie do not tend to move long distances, but may exhibit seasonal movements between habitat types by aggregating in larger groups in deeper water in the winter and moving to shallower waters during the warmer seasons to spawn (Lucas and Baras 2001).

Spawning begins in May or June when water temperatures reach 57-68° F, in depths of 1 to 3 feet, and often at a very young age of 1 to 2 years (Minckley 1973; Sublette et al. 1990; LaRivers 1994; Moyle 2002). Crappie often spawn in large groups near submerged bushes or banks and are prolific egg layers as a typical 2-pound specimen can lay 150,000 eggs which take 2.4 days to incubate at a temperature of 65˚F (Minckley 1973; Sublette et al. 1990; LaRivers 1994; Moyle 2002). The black crappie is considered to be a guarder and nest spawner. Spawning takes place over mud, sand, or gravel bottoms (Minckley 1973). Without heavy cropping, populations tend to overpopulate and stunt.

Black crappie as adults are generally fish eaters (preferring minnows and small sunfish) but will use planktonic crustaceans and various larval and adult insects in juvenile life stages (Minckley 1973; Sublette et al 1990; Moyle 2002). In Arizona waters, as soon as the fish achieve a length of about 100 mm, they seemingly shift almost entirely to threadfin shad (Minckley 1973). Young feed on invertebrates and insect larvae.

Warnecke (1988) identified black crappie as one of three "primary species" found in Horseshoe when reservoir levels were relatively static (Warnecke 1988). Bonar et al. (2004) did not find black crappie in the Verde River. Bryan et al. (2000) found one black crappie below Bartlett Dam near Rio Verde Estates.

3.3.10. Rainbow Trout

Rainbow trout (*Oncorhynchus mykiss*) is a relatively long-lived and large (10 to 30 inches in length) member of the salmonid family (Sublette et al. 1990). Rainbow trout are native to the Pacific coastal streams from Alaska southward into Durango, Mexico but have been introduced globally to become the most widespread and abundant form within its genus (Sublette et al. 1990; Moyle 1976).

Rainbow trout can survive in a variety of habitats but prefer clear, cold streams and lakes with gravelly substrata free of silt and are often associated with overhanging vegetation, deep pools, submerged vegetation, log jams, boulders (Sublette et al. 1990). Temperatures from 54°F to 70°F in slightly alkaline conditions are considered optimum for this species (Sublette et al. 1990).

Rainbows will migrate upstream to spawn in colder streams over gravel or cobble substrate, typically in the spring (or in some cases the fall or early winter) in small tributaries of rivers, or in inlets or outlets of lakes (Sublette et al. 1990). However, within the Verde River mainstem, summer water temperatures greatly limit survival (Paradzick pers. comm. 2004). However, because of the rainbow trout's popularity as a sportfish, the species is annually stocked by the Arizona Game and Fish Department in the Camp Verde area of the Verde River and in Oak Creek and East Verde River (both tributaries to the Verde River). It also is stocked biennially by the Fort McDowell Indian Community in the Verde River below Bartlett Dam at much lower numbers, primarily to subsidize the bald eagle prey base. These stocked trout are precluded from surviving until reproducing by high summer water temperatures.

Rainbow trout are primarily insectivorous and, with increasing size, piscivorous (Sublette et al. 1990). The invertebrate prey base of this species seems to include drifting organisms in stream habitats but benthic invertebrates and zooplankton are the preferred prey item in lentic habitat (Sublette et al. 1990). Bryan et al. (2000) noted that rainbow trout can adversely affect native fish populations through aggressive displacement (interference competition), using resources more quickly and efficiently (exploitative competition), or by opportunistic piscivory.

Bonar et al. (2004) considered rainbow trout a less significant piscivore in the Verde River with less than 4% fish in their diet and found them in all reaches of the Verde River below Tavasci Marsh in relatively low concentrations in pool and run environment types year-round. Low numbers may be due in part to when sampling occurred as compared to stocking dates and the high mortality (80%) suffered by the species immediately after stocking (Bonar et al. 2004). Bonar et al. (2004) did state that continued stocking of rainbow trout has the "potential to impact native the abundance and distribution of native fish because their stocking overlaps with the peak of spawning activities by native fishes." Another potential threat posed by the rainbow trout is the genetic contamination of the native endangered Gila trout strain (the species will readily hybridize) if stocking continues in the East Verde River (Gila trout are still found in Dude Creek, a tributary to the upper East Verde River). Bryan et al. (2000) found rainbow trout (*n* = 11) below Bartlett Dam at the Sycamore Creek Confluence and Doka Ranch sampling locations.

3.3.11. Yellow Bullhead

Native to the eastern and central United States, the yellow bullhead (*Ameiurus natalis*) is a member of the family *Ictaluridae* that ranges in size from 6 to 18 inches in Arizona. Minckley (1973) describes them as most abundant in clear, rocky-bottomed, intermediate-sized streams but the species will also occur in clearer, shallow, warm and weedy bays of mainstream reservoirs of Arizona (Sublette et al. 1990; Minckley 1973; Moyle 1976).

Yellow bullhead spawn in the spring and early summer months and shape round nests under protective cover such as overhanging banks or large debris (Sublette et al. 1990). The eggs, numbering from 1,650 to 7,000, adhere together in a clump-like mass and are protected by the adult upon hatching (Sublette et al. 1990).

The yellow bullhead diet consists of plant material, crustaceans, mollusks, aquatic insects, and fish (Moyle 1976). Sublette et al. (1990) noted the species to be primarily piscivorous. Bonar et al. (2004) considered yellow bullhead a significant piscivore in the Verde River with greater than 4% fish in their diet (including longfin dace, Sonora sucker, and desert sucker) and found the species in all reaches of the Verde River in riffle and run environment types year-round. Bryan et al. (2000) found yellow bullhead (*n* = 41) below Bartlett Dam in low gradient riffle, glide, side channel – run, and backwater pool environment types at the Needle Rock, Box Bar Ranch, Rio Verde Estates, Sycamore Creek Confluence, Sycamore Creek, Doka Ranch, and Salt River Indian Community sampling locations.

3.3.12. Mosquitofish

A member of the Poeciliidae family, the mosquitofish (*Gambusia affinis*) is a small species, averaging 1 to 2.3 inches in length (Minckley 1973). The mosquitofish is native to the eastern and central United States, from southern Illinois and southern Indiana to Alabama and the mouth of the Rio Grande, Texas south to the 20th parallel in Mexico (La River 1994; Sublette et al. 1990). Mosquitofish have been stocked throughout the world for mosquito control, particularly to combat malaria (Moyle 1976). Minckley (1973) states that mosquitofish were introduced into Arizona in 1926 and have since spread to almost all suitable, warm water habitats in Arizona due to its adaptability to almost any conceivable habitat "ranging from clear, cool springs through turbid, hot, stock tanks." Mosquitofish inhabit lakes, rivers, creeks, ponds, springs, and ditches, with denser populations occurring in shallow water with thick vegetation (Sublette et al. 1990). Despite being capable of tolerating water temperatures from 40°F to over 100°F, the literature suggests this species is sensitive to temperature, particularly to colder temperatures, and will select thermally fluctuating sites in the summer and more thermally stable sites in the winter (LaRivers 1994; Sublette et al. 1990). Moyle and Nichols (1974) noted this species' tolerance for low dissolved oxygen levels, which might be expected in water temperatures approaching its upper limits.

Mosquitofish reproduce from March to October in water temperatures ranging from 77˚F to 86˚F using internal fertilization and ovovivipary, with females capable of giving birth to up to 226 young (brood size varies with size of female) (Sublette et al. 1990). Mosquitofish are principally carnivorous and will feed chiefly on insect larvae (its affinity for mosquito larvae led to the common name), crustaceans, algae and fish fry (Moyle 1976; Sublette et al. 1990). The species feeds opportunistically at the surface and invades water only a few inches deep, thereby permitting the fish to prey effectively on wriggling mosquito larvae, or whatever prey item is most abundant at the time (Moyle 1976).

Mosquitofish have been implicated in the extirpation or reductions in abundance, of native fishes in the southwest and elsewhere in the world (Minckley 1973). Minckley (1973) notes the adverse impacts of this non-native species are particularly evident to the distribution of Gila topminnow, the native, mosquito larvae-eating livebearer, which is predictably only found where the mosquitofish has not yet gained access or has been removed.

Bonar et al. (2004) considered the mosquito fish as predominantly an insectivore and/or herbivore in the Verde River confirming that fish comprised less than 0.5% of their overall diet. Mosquitofish were the second-most common non-native species observed by Bonar et al. (2004) in the Verde River and were observed in all reaches of the Verde River but principally in the headwaters above Sycamore Creek confluence and in the lower Verde River below Bartlett Dam in riffle and run habitats year-round. Bryan et al. (2000) found mosquito fish (n = 524) to be the most numerous non-native fish below Bartlett Dam and found them in low gradient riffle, glide, run, edgewater – glide, edgewater – main channel pool, side channel – run, backwater pool, and eddy pool environment types at the Bartlett campground, Needle Rock, Box Bar Ranch, Sycamore Creek Confluence, Doka Ranch, and Salt River Indian Community sampling locations.

3.3.13. Threadfin Shad

Threadfin shad (*Dorosoma petenense*) is a member of the family Clupeidae (herrings and shads), a group of generally small, fast-swimming, schooling fishes. Threadfin shad inhabit large lakes, reservoirs, or rivers with moderate currents, spending the daylight hours schooled-up feeding on plankton in deep water and moving to shoreline habitats during the evening hours to feed on organic detritus and encrusted organisms on sand (Sublette et al. 1990; Minckley 1973).

Spawning may occur in spring and/or summer months when water temperatures are between 57°F to 80°F (Minckley 1973; Sublette et al. 1990; Moyle 2002). Large schools of shad move along the shoreline, 6 to 10 feet from the bank in water about 3 feet deep when females detach from the main school and are followed closely by males (Minckley 1973). Threadfin eggs (800 to 9,000 per female) become adhesive soon after spawning, attaching themselves to grasses or other objects and hatch in 4 to 5 days.

Threadfin shad are native to the coastal waters of the Gulf of Mexico south to Guatemala and the interior drainages of the lower Mississippi River basin (Sublette et al.

1990). The species was introduced into Arizona's Colorado River reservoirs in 1953 and later in 1959 into reservoirs of the Salt and Verde rivers where they spread to inhabit all water of central Arizona below 3,280 feet elevation. The purpose of their introduction was to provide a relatively small, plankton-feeding species with a high reproductive rate as forage for game fishes (Minckley 1973). Bonar et al. (2004) detected only one individual shad in the Verde River below Bartlett Dam and Bryan et al. (2000) did not encounter any threadfin shad in the Verde River below Bartlett Dam. However, Warnecke (1988) did document the species in Horseshoe at 1% of the total catch per unit effort. Although threadfin shad breed in lentic water, the species was observed some 29 miles upstream of Horseshoe in the vicinity of Pete's Cabin Mesa which speaks to this species' ability for single-season movements (Broscheid, pers. comm. 2004).

3.3.14. Tilapia

The name "*Tilapia*" (*Tilapia* spp.) is loosely used to refer to fish that occupy the genus, *Tilapia*, which are within the family *Cichlidae* (Moyle 1976). The generic name for the fish is used due to the significant level of hybridization that has occurred post introduction into Arizona.

Widely grown in aquaculture as well as introduced to canals and reservoirs, *Tilapia* are a recognized commercial food fish that is an inexpensive source of protein worldwide. In the United States (and Arizona), *Tilapia* were introduced primarily for aquatic weed control in canal systems and reservoirs, and secondarily as a game fish (Moyle 1976).

All *Tilapia* species spawn in water temperatures that exceed 68˚F and are nest builders whose nests resemble those of sunfishes and are constructed in sand or mud bottoms. The nest building effort appears to be more for courtship purposes than for egg incubation, which may last between 11 to 12 days at temperatures equal to or above 68˚F (Minckley 1973; Sublette et al. 1990; Moyle 2002). Fertilized eggs are guarded and fanned in the nest by a brood parent until hatching, when the parent then transports the fry to a second, recently constructed nest in which the fry will be housed until their yolk sacs are absorbed (Moyle 1976).

Tilapia feed primarily on vegetation and algae, although at younger ages they will take insects, worms, plankton, larval fish, detritus and decomposing organic matter (Moyle 1976). Bonar et al. (2004) considered *Tilapia* as predominantly an insectivore and/or herbivore in the Verde River, confirming that fish comprised less than 0.5% of their overall diet. Bonar et al. (2004) found them only in the reach below Bartlett Dam in all environment types during the summer months.

Bryan et al. (2000) found *Tilapia* (n = 55) below Bartlett Dam in low gradient riffle, glide, and backwater pool environment types at the Box Bar Ranch, Sycamore Creek Confluence, Doka Ranch, Route 87 Bridge, and Salt River Indian Community sampling locations.

3.4. Reservoir Management Impacts on Fish Populations

Multiple uses of reservoirs often result in competing and conflicting demands on water management within impoundments, which can have great influence on the fishery. The fishery is a system of interacting, interdependent, and interrelated components. These components include the fishes, the environment or habitat, other biota, and the policies of resource managers (Summerfelt 1999). Of those components, water level fluctuations are widely recognized to have the most significant impacts on reservoir fishes and their success (Sammons and Bettoli 2000). Water temperatures are also recognized as influencing the spawning behavior of fishes. Water level fluctuation can alter available spawning habitat, trophic interactions and food webs, and water quality (e.g., temperature, oxygen levels, and turbidity), which in turn may impact the fish community composition, structure, reproduction, and recruitment (Irwin and Noble 1996; Annet et al. 1996; Summerfelt 1999; Hayes et al. 1999; Cowx 2002).

Non-native fish that occur in Horseshoe Reservoir and Bartlett Lake on any given year will attempt to reproduce, but an individual species' success depends on its specific timing of spawn, habitat preference, environmental conditions (e.g., available cover, lake and runoff temperature), and reservoir operation (i.e., drawdown rates, lake stability, storage carry-over). For example, those species that breed early (spring) would likely be impacted by reservoir drawdown during that time, but due to spawning variation among individuals and species (Figure 3-2), and inter and intra-annual variation of environmental conditions, success could vary widely in any one year. Similarly, the shallow reservoir profile of Horseshoe Lake may lead to warmer water temperatures in the upper end of the lake that could shorten incubation periods of deposited eggs, lessen the detrimental effects of water level fluctuation, and thus could increase egg survival and the amount of larvae successfully produced, particularly when the reservoir is maintained at higher levels for a longer duration in high runoff years (AGFD 2005c). Fluctuating water levels and portions of reservoirs that remain dry for extended periods can provide for growth of terrestrial vegetation and an increased level of submergent vegetation. The increased vegetation, when inundated in subsequent years, can provide additional cover and forage for many adult and larvae of native and non-native fish species, which could increase survivorship.

It is evident that successful reproduction can be high for some nonnative fish species during high water years or when storage is carried over between years (Warnecke 1988; AGFD 2005c), but even considering the factors above, in most years since the mid-1950s, water level fluctuations at Horseshoe have been identified as negatively impacting the reproduction and recruitment of sportfishes (Wagner 1954; Warnecke 1988). In 1954, Wagner (1954) described operations of Horseshoe as "not compatible to any degree with game fish production" and "[b]ecause of the nature of the paramount function of Horseshoe, nothing can be done with the reservoir itself to rehabilitate the fishery." Warnecke (1988), 30 years later, again noted that the undependable nature of the reservoir and complete dewatering results in borderline survivorship and recruitment of sportfish. The causes for the historically poor fish recruitment and survivorship in Horseshoe are likely driven by a number of factors. Rapid dewatering of the reservoir during spring (the historical operation) can negatively impact spawning success and recruitment; alter forage abundance and availability; and influence movement and foraging behavior of some fish species. For littoral-zone nest-building species (bass, sunfish), sharp reductions in water levels can expose nests, eggs, and larvae to drying, greatly reducing reproductive success (Stuber et al. 1982a, 1982b, 1982c; McMahon and Terrell 1982; Wright 1991; Summerfelt 1999; Hayes et al. 1999). However, a wide range in suitable nesting depths and suitable spawning temperatures, combined with short egg incubation periods, can temper the influence of lowering water levels in some species under certain conditions. Dewatering during spawning periods can also raise water temperatures, oxygen content, and turbidity, which also may affect recruitment success (Id.).

The low water levels typically maintained though the summer at Horseshoe may exacerbate the poor sportfish recruitment and survivorship. Sammons et al. (1999) and Sammons and Bettolio (2000) found that survival of young-of-year largemouth bass was positively correlated to summer reservoir levels. Mid-summer drawdown reduces the amount of habitat available for spawning. It also elevates water temperature at a critical time that not only accelerates egg and larval development; it can also suppress foraging, and reduce growth of species (McCauley and Kilgour 1990). These impacts to reproduction may be carried forward into the next year's breeding season as the abundance of some species of non-native fish will be reduced within the riverine portion of Horseshoe (Upper end of Reach 3) as it begins to fill and become a reservoir. Thus, multiple years of fluctuating reservoir levels and low summer pool levels can compound these detrimental effects on non-native fish recruitment and survival over time.

Under most reservoir management regimes in the United States, fisheries managers work with water operators to stabilize reservoir levels during critical spawning periods to enhance the fishery and improve recreational angling opportunities. Because of the unique operation and role Horseshoe plays in the water supply and delivery system for SRP (it stores then releases winter runoff to Bartlett and empties almost every year during the months of June through November to make room for the next year's flows), little effort has been put forth to manage the lake as a recreational fishery (Warnecke 1988). Since the mid-1950s, management has been passive, with erratic monitoring of the fish assemblage, attesting to poor production and unsuitability of the lake as a sportfishery. Conversely, Bartlett has been actively managed and publicized by AGFD as a sportfishery. Bartlett water levels fluctuate less and a minimum pool is maintained for recreation in cooperation with AGFD and the Tonto National Forest. In the early 1990s, AGFD installed artificial habitat within the lake to improve sportfish reproduction, increase fish abundance, and recreational angling opportunities. These data highlight the profound effect reservoir operations can have on populations of sportfish, both positively and negatively.

Table 3-6. Summary of life history information for non-native species on the Verde River.

Species	Prey (adult)	Spawning Habitat	Spawning Temp. (°F)	Spawning Season	Seasonal Movement
Largemouth bass	Fish, crayfish[13]; frogs, large insects, snakes, mice, small birds[14]; "most significant piscivore", 16.8% fish in diet[24]	Prefer lentic[1] with protective cover[13]; <20ft (6 inches to 25 ft); nest <5ft, often destroyed by wave action[22,23]	60[1]; most by 64, end spawn at 75[23]	Starts late April to early May; ends mid-late July[23] (total nesting period, 19d)	Movements 5 miles, related to spawning[25]
Bluegill	Aquatic insects and their larvae[8]; small crayfish, fish eggs, minnows, snails, worms; aquatic plants if necessary; <4%fish in diet[24]	Shallow water (6-12 inches[14]) with gravel substrate[8]; 3-9 ft[22]; Fine gravel, sand preferred but will use other[22]; nearly any substrate used[28]	70[8,]-75[1]; 63-88[22,23]; peak 67-80[22]	May[8] through August[1,23]; (total nesting period 7 d[22,23])	No long-distance movement; seasonal movements to deep water in winter[25]
Channel catfish	Omnivorous; insects, mollusks, crustaceans, fish, plant material[10,26,28]; "significant piscivore," >4% fish in diet[24]	Nest in dark, secluded areas such as drift piles[10]; 6-12 ft, in cavities[22,23]	75[10, 14];70-84[22,23]	Late Spring to early Summer[10,22]; mid-June to July @ Elephant Butte Res.[23]; (total nesting period 14 d)	Migrate up to 78.3 miles; migrate up tributaries in summer, winter in deep water[25]
Flathead catfish	Fish[11]; crayfish, mice and frogs if available[15]; "significant piscivore," >4% fish in diet[24]	Nest in shallow depression near shelter such as logs[11]; 6-15 ft; cavities s/as logs or other cover[22,23]	68-84[22]	June to July[22]; (total nesting period 8 d)	Sedentary[29]
Carp	Fry are planktivorous. Adults are primarily benthic, feeding on both plant and animal material[19]; <0.5% fish in diet[24]	Prefer <1.5 ft, up to 6 ft[22]; prefer inundated terrestrial or aquatic vegetation; pools[27]	64-73[22]	February to June[22]; late April to June @ Elephant Butte Res.[23]; (total nesting period 3-16 d[23])	Move great distances; not tied to season[26]
Green Sunfish	Insects, crayfish, mollusks, small fish; <4% fish in diet[24]	Colonial nesters in shallow water with rocky or gravel bottom[2,23]; 2 inches to 1 ft[22]; firm substrate, gravel or sand[22]; <20 inches[23]	70[2]; 66-88; optimal 68 – 80[22]	Late Spring through Summer[2]; Spring to late Summer[23]; (total nesting period 10-15 d)	Generally no long distance movement[25]
Red shiner	Small invertebrates[7]; small crustaceans, algae[21]; small fish,	Riffles, submerged objects, vegetation beds[7, 23]; thrive in	60-86[21]	April-September; peak in June-July[23,26]	unknown

Species	Prey (adult)	Spawning Habitat	Spawning Temp. (°F)	Spawning Season	Seasonal Movement
	algae, diatoms, crustaceans[23,26]; <0.5% fish[24]	unstable environments such as intermittent streams; spawn in quiet water with submerged debris such as aquatic plants, tree roots or logs. May also use gravel and sand bottoms[21]			

[1]UC Davis 2001
[2]AGFD 2004b
[3]Texas Parks and Wildlife 2004a
[5]AGFD 2004c
[6]Texas Parks and Wildlife 2004b
[7]Texas Parks and Wildlife 2004c
[8]Texas Parks and Wildlife 2004d
[10]Texas Parks and Wildlife 2004e
[11]Texas Parks and Wildlife 2004f
[12]AGFD 2004d
[13]Ohio River Fisheries Management Team 2000
[14]Washington Department of Fish and Wildlife 2000
[18]Wlosinski and Marecek 1996.
[19]Texas Parks and Wildlife 2004b
[20]PFBC 2003
[21]Moyle 1976
[22]USFWS HSI models
[23]Sublette et al. 1990—Fishes of New Mexico
[24]Bonar et al. 2004
[25]Lucas and Baras 2001
[26]Moyle 1976
[27]Minckley 1973
[28]LaRivers 1994
[29]Becker 1983

Table 3-7. Nonnative Fish Reproduction Temperatures, Depths, and Incubation Times

Species		Temperature	Depth	Incubation Time	
Common Name	**Scientific Name**	**˚F**	**Feet**	**Time (Days)**	**@ Temp (˚F)**
Largemouth Bass	*Micropterus salmoides*	57.9 - 75.2	4.9 - 23.0	2.0	72
				5.0	66
Smallmouth Bass	*Micropterus dolomieu*	54.5 - 74.3	< 16.4	9.5	55
				2.25	75
Bluegill	*Lepomis macrochirus*	64.4 - 80.1	< 9.0	2.5	≥70
Black Crappie	*Pomoxis nigromaculatus*	57.2 - 68.0	1.0 - 3.0	2.4	65
Channel Catfish	*Ictalurus punctatus*	69.8 - 84.2	8.2 - 13.1	5.0 - 10.0	70 - 84
Flathead Catfish	*Pylodictis olivaris*	71.6 - 84.2	6.6 - 16.4	6.0 - 8.0	72 - 84
Carp	*Cyprinus carpio*	59.0 - 73.4	< 6.0	3.0 - 16.0	59 – 73.5
Goldfish	*Carassius auratus*	60.8 - 78.8	NA	5.0 – 7.0	60 - 79
Green Sunfish	*Lepomis cyanellus*	59.0 - 87.8	0.13 - 11.5	5.0 - 7.0	59 - 88
Fathead Minnow	*Pimephales promelas*	59.0 - 86.0	1.0 - 3.0	5.0	73.5 - 86
Red shiner	*Notropis lutrensis*	59.0 - 86.0	NA	4.4	76
Yellow Bullhead	*Ameiurus natalis*	NA	NA	5.0 - 10.0	NA
Mosquitofish	*Gambusia affinis*	77.0 - 86.0	NA	Ovoviviparous	Ovoviviparous
Sailfin Molly	*Poecilia latipinna*	82.4 - 89.6	NA	Ovoviviparous	Ovoviviparous
Shortfin Molly	*Poecilia mexicana*	71.6 - 75.2	≤ 1.5	Ovoviviparous	Ovoviviparous
Threadfin shad	*Dorosoma petenense*	57.2 - 80.6	0.16 - 0.82	3.0	80
Tilapia	*Tilapia spp.*	≥ 68.0	2.8	11.0 - 12.0	≥ 680
Yellow bass	*Morone mississippiensis*	55.4 - 62.6	3.3 - 9.8	1.7 - 1.9	61 - 70.0

Source: Minckley (1973); Sublette et al. (1990); and Moyle (2002).
Temperature data collected on June 2, 2005 at Horseshoe Reservoir indicated a range from 58.2˚F at 64 feet below surface to 80˚F at the surface. NA = Information not available in references cited.

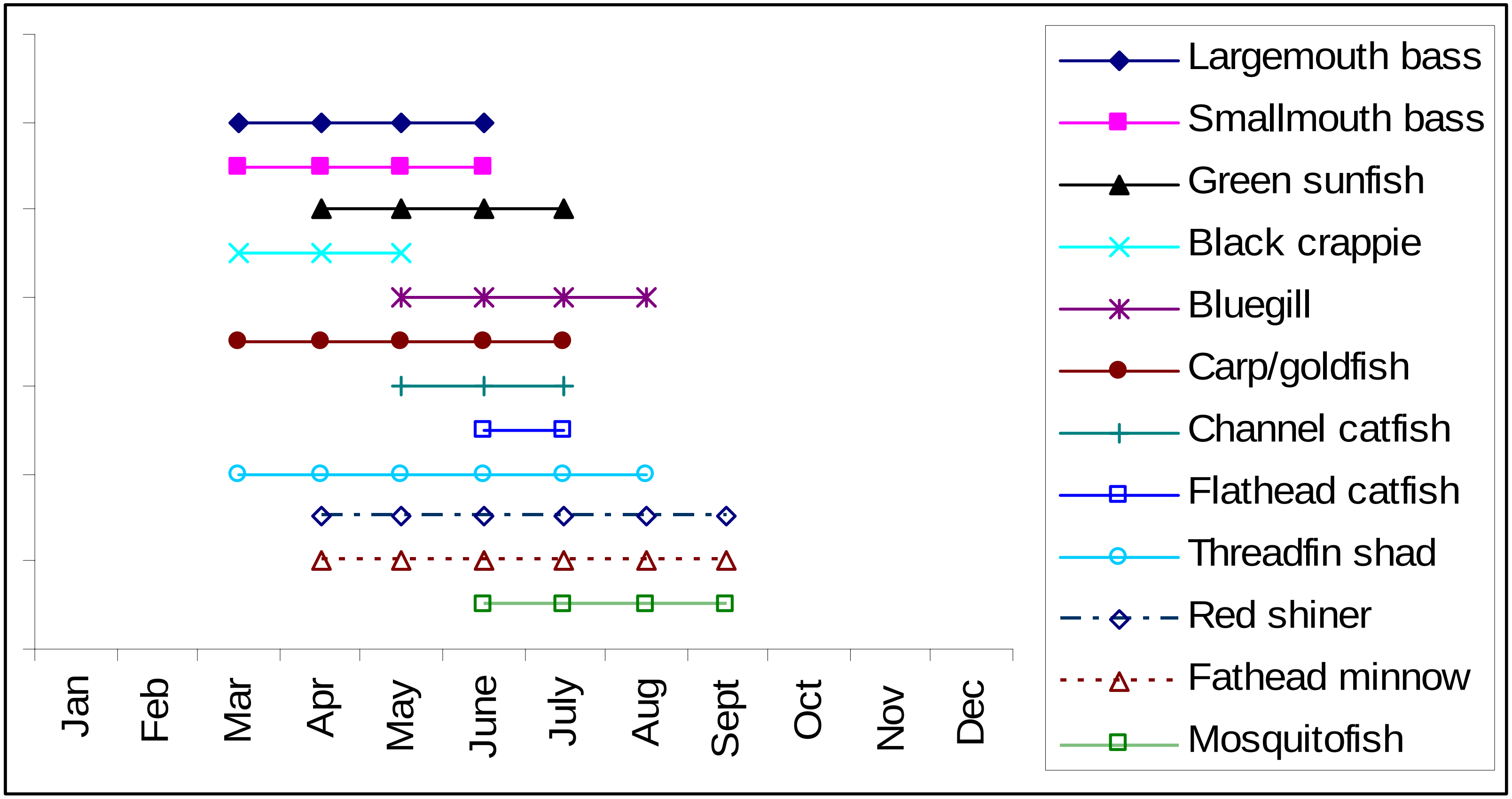


Figure 3-2. Estimated spawning periods of selected nonnative fish found in the action area (months based on Table 3-6).

3.5. Historical and Current Fish Stocking

3.5.1. Sportfish Stocking

Arizona Game and Fish Department's sportfish stocking program maintains and enhances recreational fishing opportunities at more than 150 locations within 10 watersheds in Arizona. These angling activities are governed by specific state wildlife statutes (ARS Title 17), and the rules that implement those laws. Specific plans that describe the objectives of recreational angling programs are outlined in Wildlife 2006 (AGFD 2001). These objectives met a cumulative demand of 5.3 million angler-use days in 2001 (Silberman 2003). Through responsible fisheries management with careful consideration of species composition and potential impacts to indigenous flora and fauna, AGFD works to provide sportfish opportunities that preclude the need for the public to illegally transport and haphazardly stock fish. Within the Action Area, AGFD has stocked sportfish since 1933. Most stockings were focused on the reaches above Horseshoe. The species stocked included warmwater, coldwater, and native fish (Table 3-8, 3-9, and Table 3-10). Currently, AGFD stocks seven locations upstream of Horseshoe with primary goals of providing coldwater (rainbow trout) recreational angling opportunities and enhanced habitat for native fish through unlimited harvest of smallmouth bass, largemouth bass, channel catfish, and flathead catfish. There have been recent tribal and private stocking of the Verde River with rainbow trout during winter months downstream of Bartlett Dam.

Reach 1: Granite Reef – Bartlett Dam. AGFD does not currently stock sportfish in this reach; however, both rainbow trout and channel catfish were stocked in the past by USFWS and AGFD (USFWS 1980). A private fly fishing club stocked 400 to 700 rainbow trout annually near Rio Verde in 2001 to 2003 (Weedman, pers. comm. 2003). Stocking of both these species was on a catchable-size basis (8-inch fish) (Id.). From 1976 through 1979, 10,000 8-inch rainbow trout were stocked by FWS in this reach of the Verde River within the Fort McDowell Yavapai Nation (FMYN) boundaries each year from November through March (approximately 2,000 per month) (Id.). In 2002, approximately 4,500 rainbow trout were stocked in this reach to provide fishing opportunities and to supplement the diet of bald eagles (*Haliaeetus leucocephalus*) on

Table 3-8. Verde River watershed historical and current sportfish stocking locations.

Site	Historical Stocking (Warmwater[1], Coldwater[2], Native[3])	First Year Stocked	Last Year Stocked	Currently Stocking (Warm or Coldwater)
Reach 1: Granite Reef – Bartlett Lake				
Verde River	Coldwater	NA	2003	NA
Reach 2: Bartlett – Horseshoe				
Bartlett Lake	Warm/Cold	1939	1977	
Reach 3 – Horseshoe				
Horseshoe	Warmwater	1977	1977	
Reach 4: Horseshoe - Beasley Flat				
[Bonita Creek][4]	Coldwater	1935	1969	
[Dude Creek][4]	Coldwater	1935	1999	Coldwater (Native)
[Ellison Creek][4]	Coldwater	1933	1939	
[East Verde River][4]	Both, Native	1933		Coldwater
Fossil Creek	Coldwater, Native	1965		
Middle Verde River	Both, Native	1968	1994	
[Stehr Lake][4]	Both	1961	1980	
[Weber Creek][4]	Both	1933	1957	
Reach 5: Beasley Flat – Allen Diversion				
Camp Verde Reach	Warmwater, Coldwater, Native	1935		Coldwater, Native
[Deadhorse Lake][4]	Both	1977		Both
Lower West Clear Creek	Both, Native	1933		Coldwater
Lower Wet Beaver Creek	Both	1933		Coldwater
Middle Wet Beaver Creek	Coldwater	1933		Coldwater
[Montezuma][4]	Warmwater	1986	1995	
Oak Creek	Both, Native	1933		Coldwater
[Peck's Lake][4]	Warmwater	1935	1988	
[Willow Valley Lake][4]	Both	1936	1965	

[1] Generally included one or more of the following species: largemouth bass, redear sunfish, bluegill, channel catfish (but also see Table 3-8).

[2] Generally included one or more of the following salmonids: rainbow, brown, or brook trout (but also see Table 3.9).

[3] Mostly razorback sucker (but also see Table 3-8).

4 Reach outside of the Action Area but within the watershed.

Source: R. Sorenson pers. comm.

Table 3-9. Species stocked within the Action Area along the Verde River and tributaries between ~1930 – present; numbers and species stocked varied over time and stocking locations.

Warmwater	Coldwater	Native
Black crappie[1]	Artic grayling	Razorback sucker[4]
Bluegill[1]	Brook trout	Colorado pikeminnow[4]
Channel catfish[1,2]	Brown trout	Apache trout
Fathead minnow[1]	Cutthroat trout	
Flathead catfish	Rainbow trout[1,2,3]	
Largemouth bass[1]		
Northern pike		
Redear sunfish		
Smallmouth bass		
Striped bass		

[1] Currently stocked at Mingus Lake south of Cottonwood
[2] Currently stocked at Deadhorse State Park
[3] Currently stocked in coldwater locations
[4] Currently stocked in mainstem Verde River near Childs

Source: R... Sorenson pers comm.

Table 3-10. Numbers of rainbow trout stocked in select tributaries, 1999-2003.

Tributary	1999	2000	2001	2002	2003	5-year Total	Season
Oak Creek	60,967	63,626	67,051	54,643	64,202	310,489	Monthly, 12 months per year
Wet Beaver Creek	2,700	3,447	3,603	3,600	4,565	17,915	April to June, November
W. Clear Creek	3,600	3,600	2,700	3,600	3,639	17,139	April to June
E. Verde River*	20,739	8,300	18,300	4,050	5,562	56,951	April to June, later if there is stream flow

*Note: Numbers of fish stocked in E. Verde fluctuate; distribution of fish in this system is greatly influenced by water pumped into the river from the Blue Ridge Reservoir.

Source: R. Sorenson pers comm.

Native American reservation lands (Bonar et al. 2004). There may have been stocking efforts within the FMYN boundaries between 1979 and 2002, but the Committee was not able to locate that information. FWS had plans to stock brown trout in this reach beginning in 1981 (FWS 1980).

Reach 2: Bartlett Dam – Horseshoe Dam. AGFD first stocked Bartlett Lake in 1939 with largemouth bass and bluegill. Black crappie were stocked in 1962, and channel catfish and rainbow trout were stocked in 1977. The last year AGFD stocked fish into Bartlett Lake was 1979 (R. Sorenson pers comm.).

Reach 3: Horseshoe. AGFD stocked Horseshoe in 1977 with largemouth bass, flathead catfish, and black crappie. There have been no stockings since 1977 (R. Sorenson, AGFD, pers comm. 2004).

Reach 4: Horseshoe – Beasley Flat. Most stockings along this reach have included rainbow and brown trout in higher elevation tributaries (e.g., Bonita, Ellison, Weber, and Dude creeks, and East Verde River) outside of the Action Area. Stocking along the mainstem (middle Verde River) included pikeminnow and razorback during the late 1980s and early 1990s, and one stocking of northern pike in 1968. Currently, AGFD stocks the East Verde River (outside of the Action Area) with rainbow trout when water is available.

Reach 5: Beasley Flat – Allen Diversion. AGFD stocking activities began in this reach of the Verde River and its tributaries in 1933. Since then, numerous coldwater species (i.e., brown, cutthroat, rainbow, and brook trout, and arctic grayling), warmwater species (i.e., bluegill, channel catfish, flathead catfish, largemouth bass, northern pike, redear sunfish, small mouth bass, and striped bass), and native fish (i.e., razorback sucker, Colorado pikeminnow, and Apache trout) have been stocked. Currently, the Department's stocking program focuses on providing rainbow trout angling opportunities in the mainstem Verde River (near Camp Verde) and along main perennial tributaries (i.e., Oak, Wet Beaver, and West Clear creeks). In 2002, approximately 27,525 trout were stocked in the Camp Verde area (Bonar et al. 2004). Warmwater and coldwater species are stocked in lagoons at Deadhorse Ranch State Park. These lagoons have no hydrological connection to the Verde River but are located adjacent to the river in the 100-year floodplain.

3.5.2. Live Bait Fish Use and Transport

Possession, transportation, importation, and use of live baitfish for sportfishing are governed by Arizona Statute (R12-4-316). The fishing-related rules, in summary form, are published annually in the Fishing Regulations booklet, available free of charge at all AGFD Offices, authorized fishing licensed vendors, and often at stores or facilities near popular angling locations (e.g., marina stores). The rules and regulations are intended to reduce or eliminate potential impacts to threatened or endangered species caused by use and introduction of baitfish or other organisms. In the Action Area, the watershed above Horseshoe has special regulations that prohibit importation and use of live baitfish. The lower watershed regulations follow standard baitfish rules for the state. Transport of live crayfish is prohibited throughout the Verde River watershed. No live baitfish may be released into Arizona waters.

Reach 1: Granite Reef – Bartlett Dam. Fathead minnow, threadfin shad, red shiner, mosquitofish, carp, and sunfish may be used within this reach.

Reach 2: Bartlett Dam – Horseshoe Dam. Fathead minnow, threadfin shad, red shiner, mosquitofish, carp, and sunfish may be used within this reach.

Reach 3: Horseshoe. Live baitfish may not be transported to the Verde River upstream from Horseshoe Dam including Horseshoe Lake. Fathead minnow, mosquitofish, and red shiner are allowed at Horseshoe outside Maricopa County; these fish must be taken and used within the same water. Similarly, threadfin shad, sunfish, and carp are permitted at Horseshoe, but these fish must be taken and used at the lake.

Reach 4: Horseshoe – Beasley Flat. Live baitfish may not be transported to the Verde River upstream from Horseshoe Dam, including this river segment. Fathead minnow, mosquitofish, threadfin shad, sunfish, carp and red shiner are allowed as baitfish within the reach, but these fish must be taken and used within the same water.

Reach 5: Beasley Flat – Allen Diversion. Live baitfish may not be transported to the Verde River upstream from Horseshoe Dam, including this river segment. Fathead minnow, mosquitofish, threadfin shad, sunfish, carp and red shiner are allowed as baitfish within the reach, but these fish must be taken and used within the same water.

3.5.3. Fish Transport by the Public

All Reaches. Overland transfer of live fish by anglers or other persons from one location to another, while illegal, could occur but is difficult to predict or manage. However, AGFD has enacted regulations to prohibit such acts and, through law enforcement and education activities, works to reduce incidences of illegal transportation and introduction of all aquatic species. Sportfish species caught while fishing may be kept alive only on the waters where caught, and may not be transported alive from these waters (R12-4-316). Additionally, possession, transportation, and release of organisms deemed a potential threat to indigenous wildlife, fish, and habitat is prohibited by R12-4-401 through R12-4-407. These organisms are listed in R12-4-406; all sportfish species proposed for stocking are included on this list.

3.6. Hydrology, Geomorphology, and Dam Operations

3.6.1. Hydrological Data

Endemism is high among southwestern fish species, and many species show specialized adaptations to the unique environment of the desert streams (Rinne 2004). In larger low-elevation river systems, species evolved with high velocity and turbid flows during winter and spring runoff and localized flash floods during monsoon storms. Summer flows were often low and greatly reduced the abundance and distribution of available instream aquatic habitats. Specific fish life history traits, such as roundtail chub spawning activity, may be timed with hydrological events (Brouder 2001). Construction and operation of dams can alter the physical and chemical characteristics of a river system. Flow parameters such as magnitude, frequency, duration, timing, and rate of change may shift in response to dam presence and operation, and in turn influence native fish species recruitment and survival. However, the impacts of flow alteration occur within the context of the system and may be exacerbated by other environmental stressors (e.g., groundwater depletion, non-native fish interactions, livestock grazing) or mitigated by beneficial factors within the environment (e.g., higher summer base flows).

As discussed below, the flow changes created by these relatively small dams on the Verde River are not likely to have a significant impact on fish habitat within downstream reaches. Specifically, large flood events continue to occur below Bartlett and Horseshoe dams, which may be important to roundtail chub and other native species spawning activity (Bryan and Robinson 2000; Brouder 2001). The minimum flow instituted in the 1990s appears to be maintaining abundant sucker and chub populations. While there is some indication that roundtail populations below the Bartlett Dam have recently declined (Hyatt 2004), little information is known from other populations to determine if the trend was evident within other free-flowing river systems and may have been caused by lack of flood flows across the southwest due to drought conditions rather than local dam impacts. Bryan and Robinson (2000) and Brouder (2001) found similar age-class structure of roundtail chub in the upper and lower Verde River suggesting that flow alteration has not significantly reduced the frequency of recruitment events. Additionally, Bryan and Robinson (2000) found that roundtail chub growth rates were similar between the lower and upper Verde River, but that lower Verde fish attained larger sizes potentially due to warmer water temperature, food availability, or habitat. A reduction in the roundtail population below Bartlett has been noted in recent years. Although drought and other factors have been implicated, the actual causes are not known.

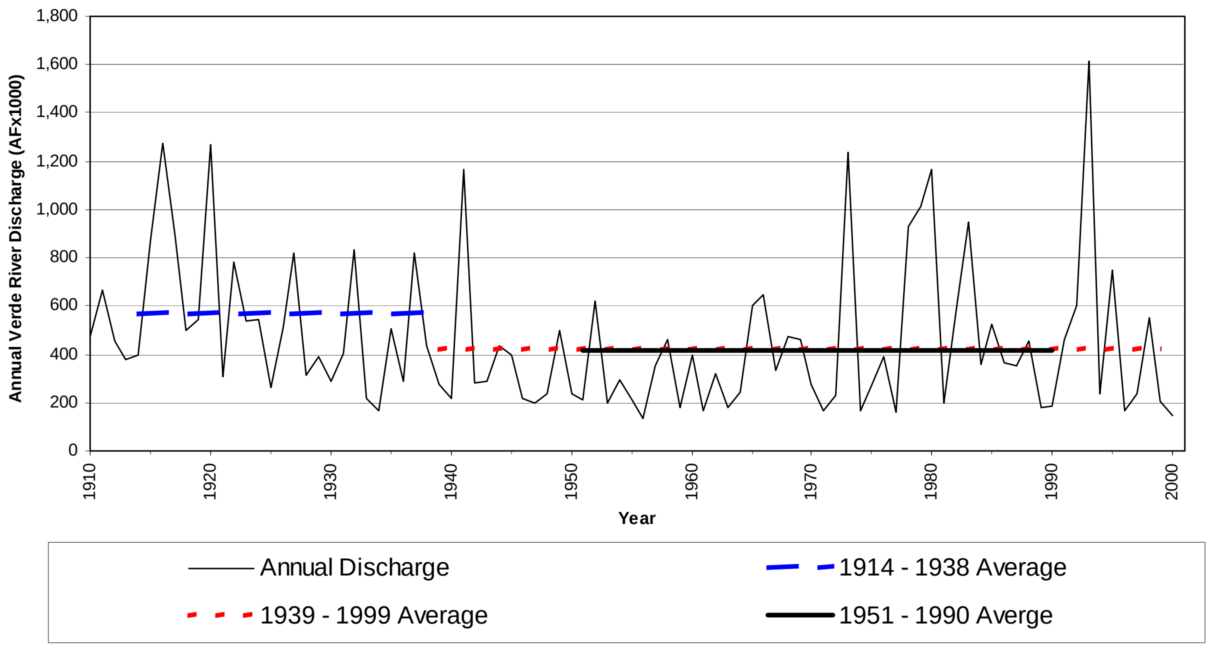
3.6.2. *Period of Record*

In the arid Southwest, the selection of the period of record for analysis of hydrologic statistics is important because long-term cycles of precipitation result in highly variable runoff between years and decades (Shepard et al. 2002; Jarrett 1991; Meko and Graybill 1995). A well-known example of the problem of using a limited period of record for drawing conclusions is the Colorado River Compact, which allocated one-half of the apparent runoff at Lees Ferry to the Lower Basin States. The compact is based on the period of record of 1896 through 1930, when the average annual discharge of the river was 17 million acre-feet (MAF) (Jarrett 1991). However, during the following 35 years, the average annual discharge of the river was only about 13 MAF, slightly less than the estimated long-term average flow of 13.5 MAF (Id.).

As in the Colorado River basin, the early decades of the 1900s were relatively wet in the Verde River watershed. The 1904-1938 “pre-dam” period of record has average annual flows that are 30% larger than the 1939-1999 “post-dam” period (Figure 3-3). Thus, comparison of the pre-dam data to post-dam data would attribute some of the hydrologic changes to the construction of dams that are actually differences in the period of record. For this reason, caution should be used in relying on Graf's analysis (1999) of Verde River flow changes because several of his conclusions rely on the 1904-1938 "pre-dam" period of record. Comparison of flows above and below the dams for the same period of record eliminates this problem of significant differences in the period of record. In the *Changes in Flows* section below, the effect of the dams on the magnitude and frequency of flows is summarized using a consistent period of record.

Even when using the post-dam data for hydrologic analysis, the period of record is not necessarily representative of long-term hydrological conditions, and portions of the record can be skewed due to unusually wet or dry decades. Stockton (1996) determined that the period 1951-1990 is representative of the average runoff during the past four centuries (1580-1995) for the Salt and Verde watershed. As shown in Figure 3-3, the 1951-1990 period and the 1939-1999 post-Bartlett Dam period have similar average annual flow. Thus, either period can be used to assess the long-term hydrology above and below the dams. Although Stockton's work has not been updated to reflect the period of record since 1995, which includes the extended drought of the past 8 years, the periods of 1951-1990 or 1939-1999 would still be expected to representative of long-term runoff conditions (extremely dry recent years would be at least partially offset by the very wet years of 1993 and 1995).

Figure 3-3. Unregulated annual flow of the Verde River near Bartlett and Horseshoe Dams.



Source: Stockton 1996 (1910-1995); Reigle, pers. comm. 2002 (1996-2000).

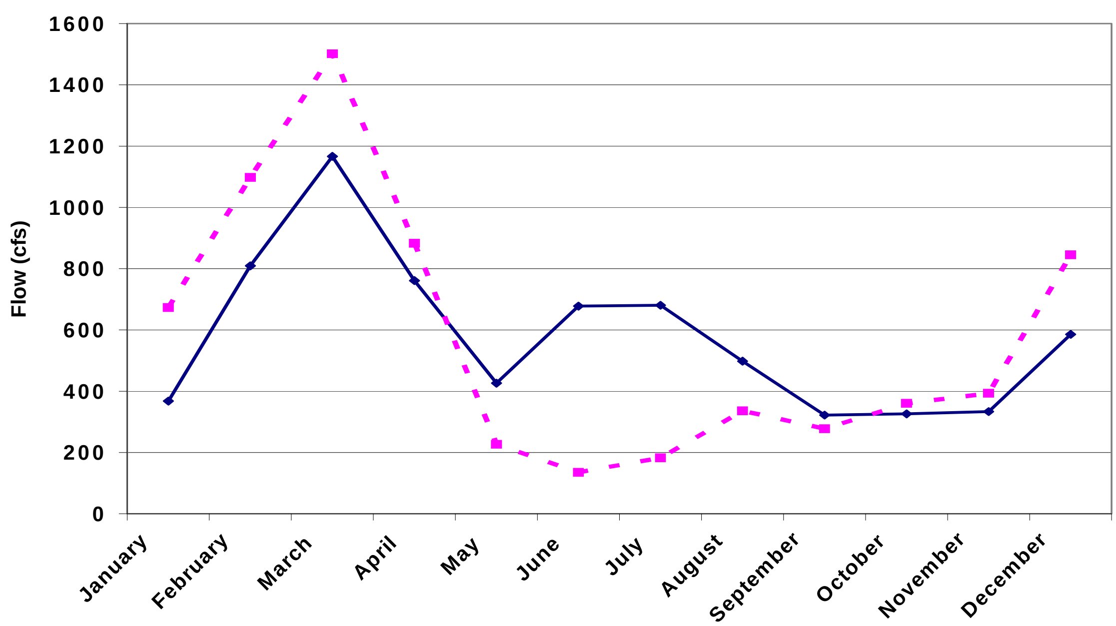
3.6.3. Minimum Flow

Following closure of Bartlett (1939) and Horseshoe (1945) dams, the minimum flow of the Verde River below Bartlett Dam was reduced — "most years experienced low flows below 50 cfs, with many years recording some days with zero flow" (Graf 1999). However, in 1993, SRP and the Fort McDowell Indian Community (now known as the Fort McDowell Yavapai Nation) entered into a permanent agreement that stipulates that a 100 cfs flow will be released from Bartlett Dam year-round except in extreme drought or an emergency. The minimum flow releases became effective on February 7, 1994 and have been continuous since that time except for brief interruptions in 1994 and early 1995 due to dam construction and maintenance activities. The 100 cfs minimum flow is in addition to reservoir releases to meet water orders along the Verde River and is part of the diversion at Granite Reef Dam. This minimum flow is to help maintain fish habitat and riparian vegetation along the Verde River. A minimum flow of 100 cfs is greater than the minimum inflow above Horseshoe. Above Horseshoe, the minimum flow drops below 100 cfs for up to 10 consecutive days in about one-half of the years (USGS 1991, p. 515; reporting flow statistics for the USGS gage on the Verde River below Tangle Creek, 1947-1989).

3.6.4. Changes in Flows

Figure 3-4 shows that the average monthly flow downstream of Bartlett is reduced in winter and increased in summer, a pattern typical of reservoirs in the western United States.

Figure 3-4. Mean monthly flow above and below Verde reservoirs, 1951-1990 (dashed line above Horseshoe, solid line below Bartlett).



Source: SRP[

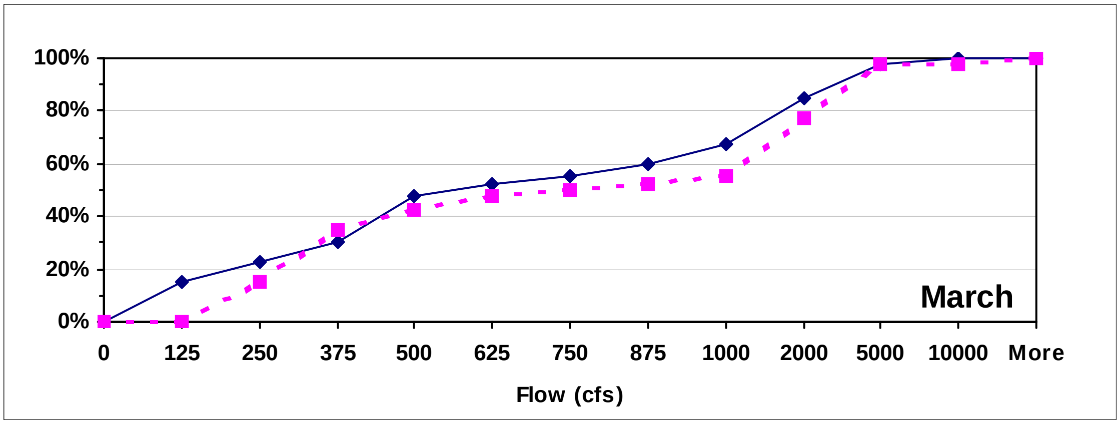
Horseshoe and Bartlett dams also change other flow patterns downstream of the reservoirs (Graf 1999):

- Mean annual peak flow is decreased
- Annual peaks flows are more variable
- Mean annual low flows are increased
- Mid-level floods are reduced in frequency and/or attenuated

However, because these dams have small storage volumes relative to the runoff of the Verde River, their effect on the overall magnitude and frequency of downstream flows is relatively small. In order to evaluate the significance of these changes in flow distribution, graphs of the cumulative frequency of flow for each month were developed showing the flow above and below the reservoirs. Below, the cumulative frequency of flows for March and July are discussed. A complete set of monthly cumulative frequency graphs is provided in Appendix 1.

Spring runoff provides the highest average monthly flow during the year (Figure 3-4). Figure 3-5 shows that the cumulative frequency distribution of flows above and below the Verde reservoirs is very similar in March. Also, the minimum releases from Bartlett that have been instituted since 1993 will largely eliminate the historical difference in

Figure 3-5. March cumulative frequency diagram of Verde River flow above and below SRP's dams, 1951-1990.

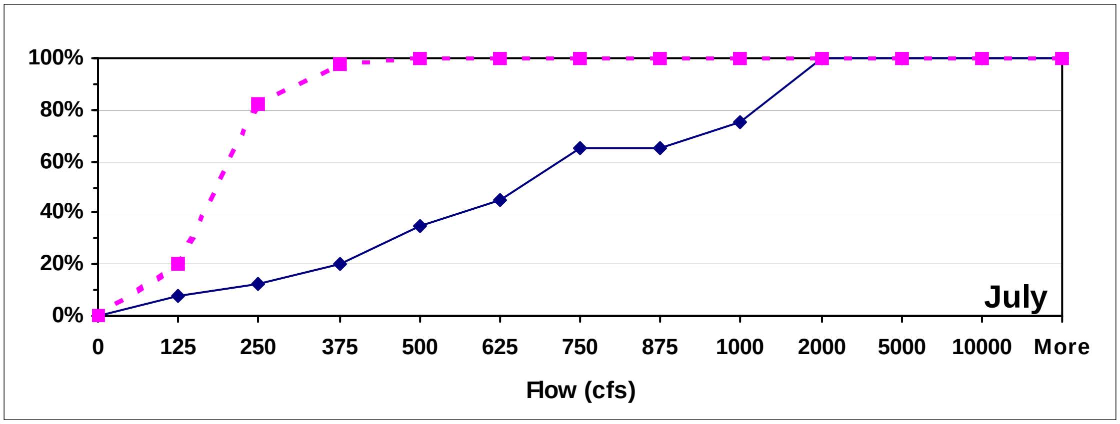


Dashed line = above Horseshoe, solid line = below Bartlett; shown as frequency (%) of flows less than or equal to the flow value on the x-axis.
Source: USGS gage data on file at SRP.

frequency of flow values below 100 cfs. Similarly, the cumulative frequency distribution of flows above and below the reservoirs is roughly the same during the period from September through April (Appendix 2).

Above the Verde reservoirs, June and July have the lowest average monthly flow. In July, releases of water to meet downstream diversion demands create a divergence in the frequency of flows over the range of about 100 to 1,000 cfs (Figure 3-6). On average, the flows are substantially greater downstream of Bartlett Dam in comparison to inflow to Horseshoe. A similar pattern occurs in May, June and August (Appendix 2).

Figure 3-6. July cumulative frequency diagram of Verde River flow above and below SRP's dams, 1951-1990.



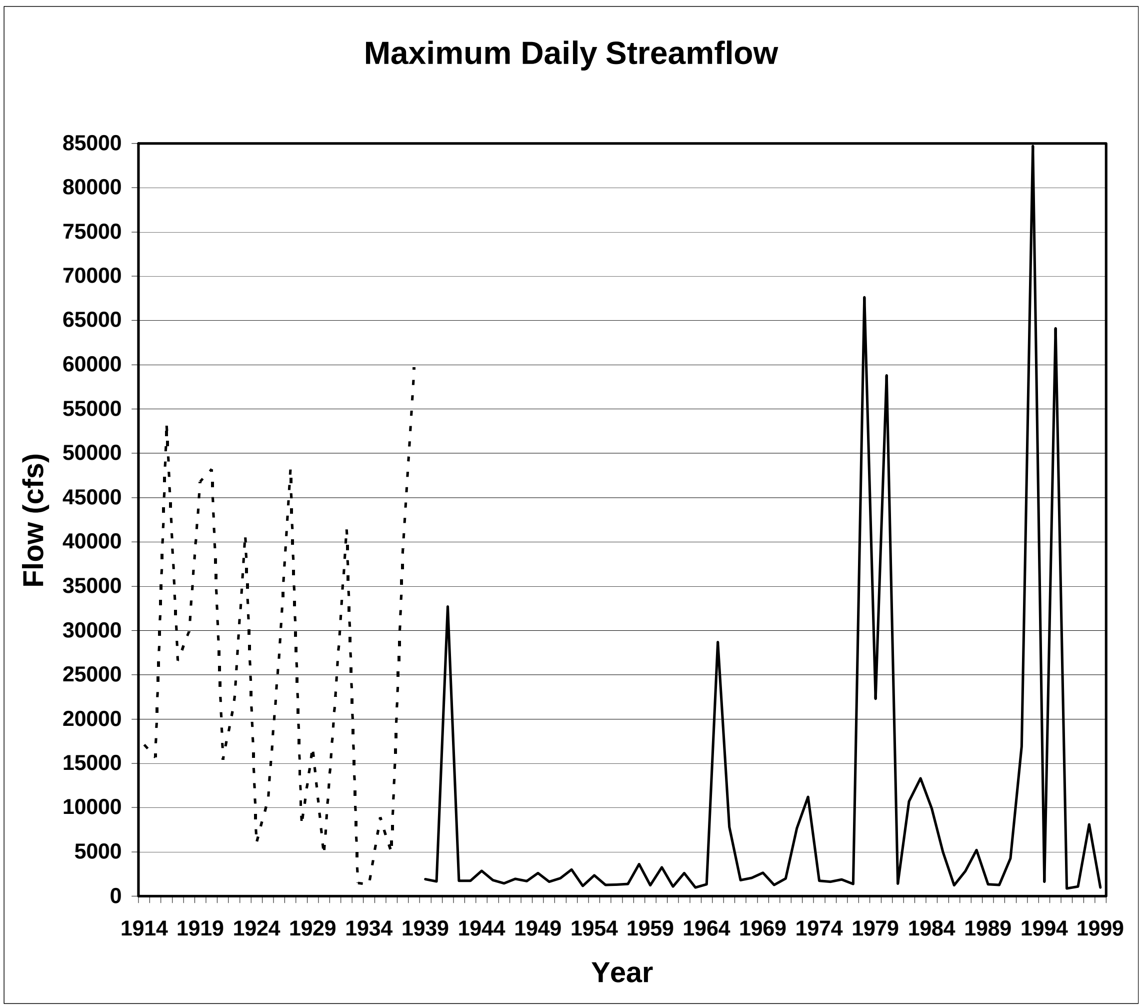
Dashed line = above Horseshoe, solid line = below Bartlett); shown as frequency (%) of flows less than or equal to the flow value on the x-axis.
Source: USGS gage data on file at SRP.

3.6.5. Flood Flows

One of the most significant flow patterns affecting the river channel and floodplain along the Verde River are periodic large flood flows. Figure 3-7 shows the maximum daily flow at the gage below Bartlett Dam for the period 1914-2000. Figure 3-78) shows the return period and exceedance probability for flows above and below the reservoirs. Except for the extended drought from the mid-1940s through the 1960s (Figure 3-78), peak flows exceeding 30,000 cfs occur regularly, even though the dams attenuate flood peaks.

Figure 3-7. Maximum annual daily flow, Verde River below Bartlett Dam, 1914-2000

(dashed line pre-Bartlett, solid line post-Bartlett).



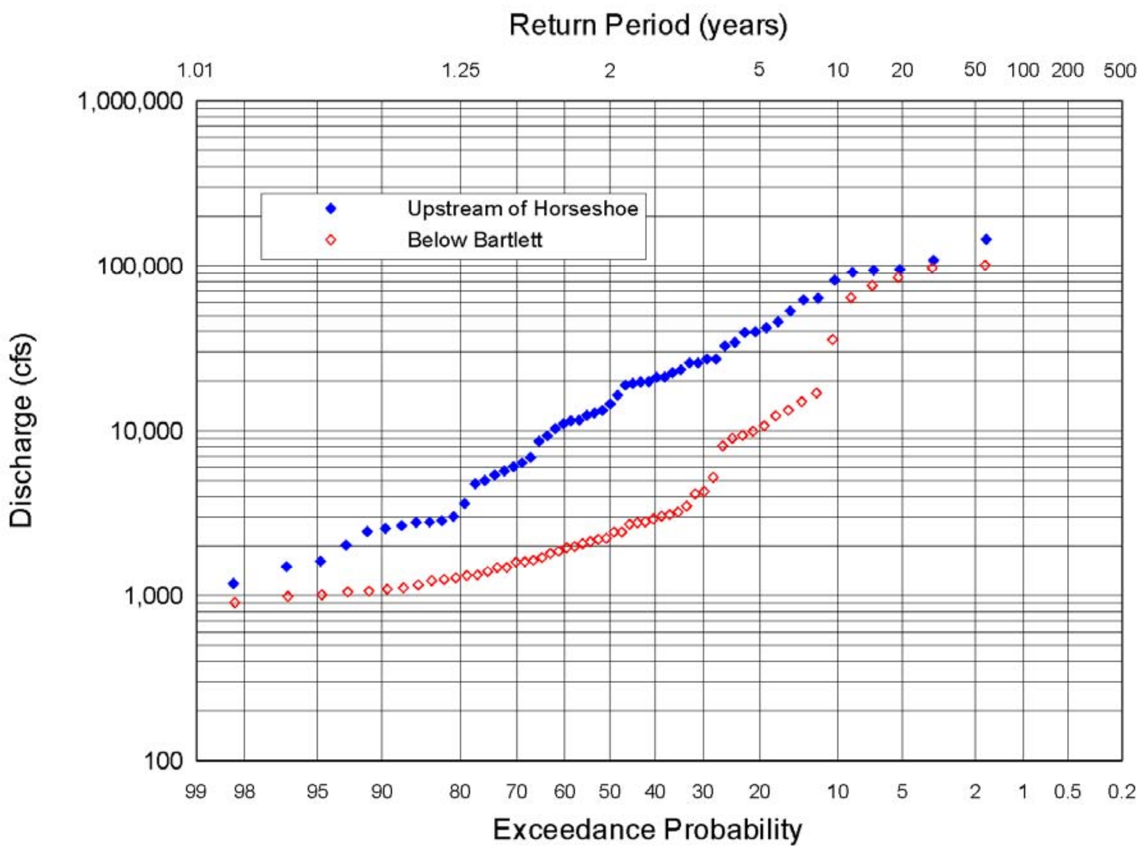
Source: SRP

3.6.6. Fluvial Geomorphology

The gradient of the Verde River above and below SRP's reservoirs is relatively steep (Figure 3-9). In this reach, the Verde River occupies a braided channel on the valley bottom, with the valley bottom ranging in width from 600 to 4,000 feet (MEI 2004). Bedrock and older resistant deposits of alluvium, which limit the lateral migration of the river channel, confine the valley bottom (MEI 2004).

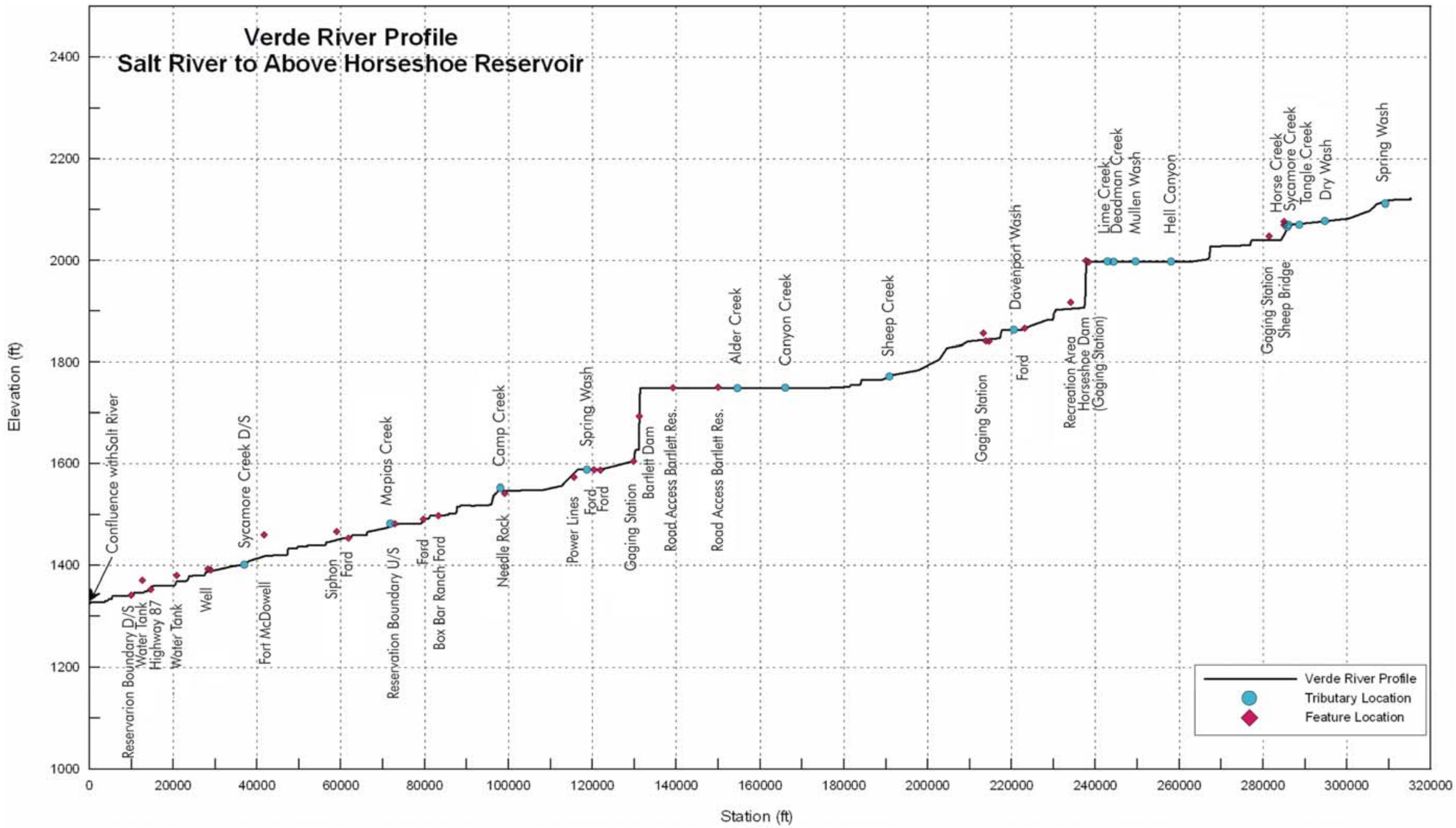
Horseshoe Dam captures an average of about 620 AF of sediment per year (SRP 2003). However, the relatively steep slope of the channel results in limited potential sediment deposition along the channel below the reservoirs (FWS 2002a).

Figure 3-8. Comparison of flood-frequency curves for upstream of Horseshoe and below Bartlett.



Source: MEI 2004.

Figure 3-9. Longitudinal profile of Verde River from Salt River confluence to Tangle Creek gage.



Source: MEI 2004.

The morphological characteristics of the river channel and active floodplain primarily reflect large, relatively infrequent floods having a recurrence interval of about 10 years or more (MEI 2004). Relatively coarse cobbles and gravels dominate the bed of the channel and adjacent floodplain (Id.). The main channel along the lower Verde has a capacity ranging from about 16,000 to 20,000 cfs, with significant sediment mobilization in the channel occurring when the flow is near channel capacity (Id.). As the main channel approaches capacity, flow begins to occur in secondary chute channels (Id.). Low elevation cobble-gravel bars adjacent to the main channel are inundated at flows of 10,000 to 20,000 cfs and significant sediment mobilization on these surfaces begins to occur above flows of 20,000 to 30,000 cfs (Id.). Sediment mobilization on the higher elevation bars on the floodplain requires flows in excess of 170,000 to 200,000 cfs (Id.).

3.6.7. Reservoir Operations

Operation of Horseshoe and Bartlett has resulted in fluctuating lake levels and stream flows in the Verde River below the dams. Lake levels have fluctuated seasonally with stored winter runoff being gradually used in spring and summer, and from year-to-year depending on the amount of runoff entering the lake from precipitation on the watershed and reservoir releases to meet water demands. Lake levels depend on the rate of inflow and the amount of water released through the dam outlets and spillways. Stream flows below the reservoirs are primarily the result of dam operations; however, flood flows periodically spill downstream due to the limited capacity of these reservoirs. These fluctuations of lake levels and stream flows are expected to continue in the future.

Modified operation of Horseshoe and Bartlett (such as pulse releases) has been suggested as a possible method for improving fish and wildlife habitat below the dams. As discussed above, such modified operations would be unlikely to significantly change habitat conditions in and along the river channel. In addition, the physical constraints summarized below limit the magnitude and duration of reservoir releases.

The relatively small size of Horseshoe and Bartlett means that the volume of water available for release is limited. In addition, the outlet valves at the dams have low capacities. The maximum capacity of the Horseshoe Dam outlet valve is 1,800 cfs at full reservoir levels. The maximum release at full reservoir levels through Bartlett Dam's two outlet valves is 2,400 cfs.

Higher releases of water are possible through the spillway gates when the reservoirs are relatively full. However, storage facilities are not available downstream of Bartlett Dam to capture releases that exceed water demand. Thus, the range of flow variation downstream of Bartlett Dam without losing water over the Granite Reef diversion dam is limited to a few hundred cfs in the winter when demand is low to about 3,000 cfs in the summer when demand is high. Some flow manipulation between Horseshoe and Bartlett would be possible with capture of the peak flows in Bartlett but the range, amount, and duration of flow modifications are limited by the outlet capacity and the relatively small storage capacity of Horseshoe and Bartlett. Large releases of water would result in a number of adverse impacts to water users including recreation use at Bartlett and water supply reductions to SRP, Phoenix, the Salt River Pima-Maricopa Indian Community, and the Fort McDowell Yavapai Nation, which each have water rights in the Verde reservoirs, as well as water users that receive water under contracts with SRP.

3.7. Other Factors Impacting Species/Critical Habitat within the Action Area

A number of activities, other than the operation of Horseshoe and Bartlett Dams, directly or indirectly impact the aquatic ecosystem of the Verde River, including the presence of dams and other stream barriers, surface water diversions, changes in land use including urbanization and development, population growth, recreation, agricultural run-off, sand and gravel mining, other mining activities, roads and trails, livestock grazing, and wildfire. For this analysis, the Committee evaluated the potential of activities other than dam operations to impact the quality of the stream habitat in each of the five reaches. These activities have resulted in modification of water quantity, water quality, watershed condition, hydrology, stream channel characteristics, riparian and aquatic vegetation, bank stability, and other aquatic habitat characteristics. A general discussion of the other factors impacting the aquatic ecosystem is provided below, followed by specific discussions of these factors within each reach in Section 3.6.3.

The aquatic ecosystem can be impacted by activities that occur not only in the river channel, but within the watershed. The Arizona Department of Environmental Quality (ADEQ) identified a number of non-point source activities that contribute to water pollution, alterations in river flow characteristics, and changes in vegetation and wildlife populations (ADEQ 1988). These activities include agricultural diversions and water impoundments, grazing, urbanization/development, roads, bridge construction, in-stream recreational activities (e.g., ATVs), resource extraction, agricultural return flows, leaking septic tanks, riparian alteration, streambank modification/destabilization, and dam construction (ADEQ 1988; Cook et al. 1991).

Impacts to the river from human activities are expected to continue as the human population grows along the river corridor and within the watershed. In the past 50 years, the human population within the Verde River watershed has grown substantially, with ranches and farms being converted into residential and commercial areas (Yavapai County Water Advisory Committee and U.S. Bureau of Reclamation 2003). The population in the Verde Valley (Reach 5) has doubled in each of the past two decades (Id.). These changes have had, and will continue to have, a significant effect on the river system, including increased demand for water, increased run-off, shortened return intervals for flood events, water quality impacts, and increased recreation impacts (YCWAC and BOR 2003; Barnett and Hawkins 2002; ADEQ 2004; PNF 2001; USDA 2004).

Growth in the Verde River Basin, both within the Action Area and beyond the boundaries of the Action Area, will place added pressure on limited water resources. Increased ground water pumping along the river (within the Holocene alluvium) and at source locations (springs, aquifers) may ultimately affect the amount of base flow available in the river (Owen-Joyce and Bell 1983). Although these impacts have not been directly measured yet, SRP, in cooperation with the Verde Watershed Association, AGFD, and the U.S. Forest Service, recently installed two stream gages on the Verde River to measure base flows and to assist in identifying future impacts to base flows from upstream water use. The Verde Falls low-flow gage is located approximately 4 miles downstream from Camp Verde and was installed in 2000, and the gage at Perkinsville was installed in 2004.

In addition to dewatering, diversions for irrigation ditches have a number of impacts on the stream channel including: a reduction in the quantity and quality of aquatic resources for native fish; changes in stream channel morphology; changes in water temperature, chemistry and flow pattern; and, reduction in riparian area width and vegetation type (USFWS 1989). Return flows from agricultural fields have the potential to introduce pesticides and fertilizers back into the river (Id.). Unused water or “tail water” eventually returns to the river; however, the majority of the ditches are unlined so that large amounts are lost to seepage, resulting in redistribution of surface water to generally shallow ground water.

During flood events, diversions can create major erosion and sediment problems in the river or stream channel (Alam 1997). Washout of rock and earth diversion dams is reported to occur with some regularity during periods of high runoff. Each time the diversions are washed out, front-end loaders and dozers are used in the stream channel to re-build the structures. Rapidly rising floodwaters in ditches may quickly exceed ditch capacity and overtop the ditch causing extensive erosion of stream banks between the ditch and the stream channel (Id.).

Sullivan and Richardson (1993) observed that areas immediately downstream from diversion structures have a decreased potential to support a diverse and abundant aquatic community due to reduced water levels. They reported that water flows became negligible at these points and that anaerobic conditions prevailed and aquatic productivity was reduced in the little water that remained in the channel below these points.

3.7.1. Grazing

Historical and current grazing of livestock along the river and within the watershed has also played an indirect role in the degradation of the aquatic and riparian habitat along the river. Although impacts have lessened in recent years, grazing has historically had significant adverse impacts to stream bank vegetation along the Verde River. Some sections of the river are severely grazed and livestock use in some areas has been a long-term chronic problem (USDA 2004). Analysis of the impacts of livestock grazing on fish and fish habitat requires examination of subtle, long-term, incremental changes in watershed functions, riparian and aquatic communities, and stream channel morphology; however, extrapolations of general hydrologic and biologic principles and site-specific research data provide a large body of evidence linking degradation of watersheds, stream channels, aquatic and riparian communities, and fish habitat and populations in western North America to grazing and grazing management (Leopold 1924, 1951; York and Dick-Peddie 1969; Hastings and Turner 1980; Dobyns 1981; Kauffman and Krueger 1984; Skovlin 1986; Kinch 1989; Chaney et al. 1990; Platts 1990; Armour et al. 1991; Bahre 1991; Meehan 1991; Fleischner 1994).

The impacts of livestock grazing on native fish survival and recovery, as well as on their critical habitat, occur through seven components: 1) water quality (e.g., nutrient concentrations, water temperature); 2) stream channel morphology (e.g., channel depth and width, substrates); 3) hydrology (e.g., overland runoff, peak flow, flood velocity); 4) riparian zone soils (e.g., compaction, infiltration); 5) instream vegetation (e.g., algae and emergent vegetation abundance); 6) stream bank vegetation (e.g., herbaceous cover, overhanging vegetation, species composition); and 7) trophic level or food web changes (e.g., aquatic insect or amphibian composition/abundance) (Armour et al .1991; Belsky et al. 1999). Alteration to these riparian components can have varying impacts on native fish communities and their habitat. Changes in the upland or watershed can include removal of vegetation, alteration of species composition of vegetation communities, decreased soil stability and porosity, decreased water infiltration, and increased soil erosion and compaction. Grazing can reduce the roughness coefficient of watersheds, which in turn results in more surface runoff, soil erosion, and flooding, which have impacts on the river, as discussed below. Resulting changes to watercourses can include changes in the hydrograph such as decreased base flows, increased flood flows, and increased sediment (Gifford and Hawkins 1978; Kauffman and Krueger 1984; Chaney et al. 1990; Platts 1990; Fleischner 1994).

Livestock grazing is the most pervasive activity on National Forest land and has had the greatest effect on soil conditions. Allotment files, historical documents, and research indicate that resource conditions have been affected. Data indicate severe soil erosion and loss of perennial plant species diversity due to livestock grazing in the watershed. Reduced livestock numbers, changes in timing and duration of grazing, and other management improvements are slowly improving ecological conditions on the river, but trespass and uncontrolled livestock grazing still present a problem in a number of locations along the river (PNF 2001; Ross Unpublished).

3.7.2. Water Quality

Water quality parameters in the Action Area also were evaluated using the Arizona Department of Environmental Quality's (ADEQ) biennial report, termed the 305(b) report, which provides the results of 2 years of compiling and assessing large amounts of data consisting of analytical results from water quality samples collected by multiple agencies, academic institutions, and private entities (from 1998-2003) to determine, within a designated waterbody or reach, if any or all designated uses of those waterbodies are attaining their representative water quality standards. Bioassessments by ADEQ provide an indication of water quality and also provide an index to the availability of prey resources for native and non-native fish species. Several designated uses were identified by ADEQ, but the Committee focused on the Aquatic & Wildlife (cold water) (A&Wc) or Aquatic and Wildlife (warm water) (A&Ww) designated uses, as these are the sole uses that address whether the quality of the water is supporting aquatic biota as an element of habitat.

In many instances, a given reach was assessed by ADEQ as "Inconclusive." This term indicates that a potential water quality issue was observed, but some facet of the data set was deemed insufficient according to ADEQ policy, which prevented ADEQ from determining whether the designated use was being attained. With respect to exceedances in turbidity levels, the turbidity standard was repealed in rule by ADEQ in 2002, with the understanding that samples would still be analyzed for turbidity but waterbodies would not be designated as "Impaired" due to this parameter alone, until such time that an adequate standard is adopted in rule to address suspended sediment (unless the U.S. Environmental Protection Agency does so by citing a violation of the narrative water quality standard). A reach that has any designated use assessed as "Inconclusive" is automatically added the ADEQ's "Planning List" where it will receive additional sampling effort until the designated uses for the reach can be confirmed as "Attaining." Because of the timeliness of the data, all following discussion on water quality in this section of the report is based on ADEQ's (2004) "The Status of Water Quality in Arizona – 2004 Arizona's Integrated 305(b) Assessment and 303(d) Listing Report," unless otherwise referenced.

3.7.3. Summary of Factors Impacting Aquatic Species and Habitat by Reach

Reach 1: Granite Reef Dam to Bartlett Dam. Discharge of the Verde River in this reach is controlled by discharge at Bartlett Dam, except for very high flows. Below the dam, the river channel tends to be constrained by bedrock outcrops. As the Verde River flows from upstream reaches to downstream reaches, the valley broadens. Vegetation along this reach is dominated by a Fremont cottonwood-Goodding's willow riparian community.

Land Use. The lower 19 miles of this reach (63%) are within the boundaries of the Fort McDowell Yavapai Nation (FMYN) and the Salt River Pima Maricopa Indian Community lands. The remaining 11 miles from FMYN to Bartlett Dam are managed by the TNF, except for two small parcels of private land.

Water Use. For over 50 years, the City of Phoenix extracted ground water from the alluvial aquifer in the lower reaches of the Verde River below Bartlett Dam. The City maintained a maximum of 14 wells in this reach. A 1945 USGS study indicated that the principal source of water for this well field was recharge from the surface flow and subsurface flow of the Verde River (McDonald and Padgett 1945). This USGS study also indicated that the ground water table was being lowered as a result of pumping at these wells, based on water yield from the well field and estimated recharge rates from river flows. Ground water depletion along this reach is likely to have affected instream flows, riparian vegetation and aquatic habitat during that period (Id.; FWS 1980). The

City of Phoenix has since abandoned this well field, but some of the wells are being operated by the Fort McDowell Yavapai Nation (FMYN) for water supply.

Diversion Structures. One surface water diversion occurs in this reach. An earthen diversion dam has been constructed within the river channel on the northern end of the FMYN. This structure diverts water into 17 miles of irrigation ditches that supply water to orchards and croplands on 1,463 acres on the FMYN (Appendix 3). In more recent years, the FMYN has increased its water use from this diversion in the river and from the underlying alluvial aquifer. This water use is expected to continue to grow as the human population, commercial enterprise and agricultural operations (Appendix 4) expand on the FMYN (Hoffman and O'Day 2001).

Based on annual accounting statements submitted to the Maricopa County Superior Court pursuant to the Fort McDowell Water Settlement, Table 3-11 shows the annual surface water diversions that have occurred in recent years.

Table 3-11. Annual amount of water diverted from the Verde River by FMYN (Units).

1998	1999	2000	2001	2002	2003	2004
6,652	12,018	9,556	11,390	16,067	15,349	17,133

The Fort McDowell Water Settlement entitles the FMYN to divert up to 36,350 AF per year from the Verde. In the future, the FMYN expects to divert all but 4,526 AF of that amount (31,824 AF diverted). That water has been leased to the City of Phoenix for 99 years.

Recreation. This reach of the Verde River experiences intense recreation pressure year-round, with the most popular Forest Service areas suffering from excessive litter, soil compaction, off-road vehicle use, and contamination with feces (USDA 2004). Areas to the west of the river in Scottsdale, Rio Verde, and unincorporated areas of the County have experienced extensive residential and commercial development in the last 5 years. Because of the close proximity of the Phoenix urban area, recreation pressures along this reach of the river are expected to continue to increase.

Urbanization, Development, Roads. There is little new development occurring along the Verde River in both the northern and southern portions of this reach. Lands adjacent to the southern portion of this reach are under the control of the FMYN. The northern portion is under the control of the TNF. Areas between the FMYN and TNF are experiencing rapid residential development. Unpaved roads and unauthorized off-road vehicle use on both the forest and FMYN are heavily used for recreation

Water Quality. Within Reach 1, approximately 93 water quality samples were collected between 1998 and 2002 by AGFD, U.S. Geological Survey (USGS), SRP, University of Arizona (UofA), or ADEQ. Samples were collected in Camp Creek, Colony Wash, Grande Wash, and the Verde River. Grande Wash is "Not Attaining" the full-body contact designated use due to exceedances in two of two samples for *Escherichia coli*. However, *E. coli* is not a parameter that directly affects the suitability of the aquatic habitat for fish and therefore is not of particular concern for this analysis. The Verde River from Bartlett Dam downstream to the confluence with Camp Creek was assessed as "Impaired" for the A&Ww designated use due to exceedances of the chronic copper standards in four of 80 samples as well as exceedances of the total and chronic selenium standards.

The remaining downstream portion is largely within the FMYN and therefore, not in the jurisdiction of ADEQ. Hoffman and O'Day (2001) collected six samples within the area of the northern boundary of the Fort McDowell Indian Community between 1998 and 1999. Sample results indicated that parameters (major ions and nutrients, organic compounds, metals and suspended sediment), were all generally within acceptable limits, according to state and federal water quality standards (Hoffman and O'Day 2001).

Ground Water Pumping. There are 662 ground water production wells in the vicinity of Reach 1, according to the ADWR Wells 55 Database. This number includes wells along Sycamore Creek, which drains into this reach (Appendix 5).

Livestock Grazing. Unrestricted livestock grazing occurs on FMYN lands. Both cattle and wild horses graze along the river year-round. The Bartlett Allotment lies adjacent to the Verde River on Forest Service lands but grazing is not currently permitted.

Water Management. Under the Fort McDowell Water Settlement, SRP is required to release a minimum flow of 100 cfs year-round from Bartlett Dam plus water orders on the Verde River except in situations of emergency, drought, or water quality problems, as specified in the Settlement Agreement. Drought is defined as any time that 1) total SRP storage is less than 50% of normal for the month; and 2) SRP Verde storage is less than 80,000 AF from March through November, or 60,000 AF from December through February. Although the drought criteria have been triggered in recent years, SRP has not reduced the minimum flow (see Section 3.6 for stream flow data below Bartlett Dam).

Sand and Gravel Mining. FMYN operates a large sand and gravel mine in the floodplain adjacent to the active river channel. These mining facilities remove unconsolidated stream deposits to produce materials for construction. In addition to the actual physical disturbance to the floodplain, these operations require water for washing aggregates and equipment, for dust control, and other activities.

Fire. Recently, catastrophic fires have occurred in Sonoran Desert vegetation within the watershed. Changes in plant species composition and soil condition as a result of those fires will have long-term consequences on the watershed in the form of reduced infiltration, rapid runoff and sedimentation and increased presence of fire-resistant exotic vegetation, such as red brome and buffel grass. However, data are lacking to quantify the extent of impact on this reach due to these wildfires. Impacts of recent fires that occurred further upstream would be partially mitigated by the dams that would capture any toxic ash flows from higher in the watershed.

Reach 2: Bartlett Dam to Horseshoe Dam. This reach of the Verde River is bounded by Horseshoe Dam at the upstream end and Bartlett Dam on the downstream end. It encompasses all of Bartlett Lake and 20 miles of river.

Water Use. One surface water diversion is located at Johnson Ranch.

Land Use. The TNF manages this reach of the river, except for a privately owned parcel (less than 1 mile of river frontage) just downstream from Horseshoe Dam.

Diversion Structures. One diversion structure associated with the private land is located in this reach a few miles downstream from Horseshoe Dam. This diversion structure is used to shunt water to irrigated pasturelands and fields on the east side of the river. The diversion is an earthen structure that typically gets washed out during high flow events and is reconstructed using earth-moving equipment.

Urbanization, Development, Roads. Because most of the lands adjacent to this reach of the river are under the control and management of the TNF, the area is largely undeveloped. Unpaved Forest Service roads lead to recreational sites along the river and a paved road leads to recreational amenities at Bartlett.

Recreation. This reach receives heavy recreational pressures at Bartlett Lake and along the western side of the river corridor. The primary activities at Bartlett Lake are related to the use of watercraft, such as boating, fishing, water-skiing, jet-skiing, and access to camping and picnicking sites.

A number of developed Forest Service campsites are located along the western bank of the river upstream from Bartlett Lake. These campsites receive heavy use from both foot and vehicular traffic. Campsite areas tend to be denuded, and noxious weeds, such as yellow starthistle, are present.

Water Quality. Bank erosion is a problem in the riverine portion of this reach. It is unclear whether the erosion is caused by dam releases or recreation (or a combination of both), but the resulting instability may be contributing to sediment influxes into the stream channel.

The ADEQ 305(b) report states that, within Reach 2, approximately 66 samples were collected by AGFD, UofA, or ADEQ in predominantly the Verde River and Bartlett. The results for samples collected in the Verde River between Horseshoe Dam and the confluence with Alder Creek were assessed as “Inconclusive” by ADEQ because the minimum number of samples required for conclusive assessment was not collected and several core parameters were missing from the analysis (i.e., *E. coli*, total metals [boron and mercury], and dissolved metals [copper, cadmium, and zinc]).

Over 60 water quality samples were collected from Bartlett between 1998 and 2002. With respect to the A&Ww designated use, one sample result out of sixty exceeded the standard for pH and another (out of seven samples analyzed for turbidity) exceeded the former standard for turbidity. Additionally, analytical parameters such as dissolved copper, cadmium and zinc were missing from the analysis. For these reasons, ADEQ assessed Bartlett as "Inconclusive" for the A&Ww designated use.

Ground Water Pumping. There are eight domestic wells pumping ground water adjacent to the river in this reach. These wells are associated with activities at Bartlett Lake and at the private ranch that is located just downstream from Horseshoe Dam (Appendix 5).

Livestock Grazing. The Bartlett, Sears Club-Chalk Mountain and St. Clair Forest Service Grazing Allotments lie adjacent to or near the river in this reach.

Water Management. See Section 3.6 on the historical operation of Bartlett Lake and Dam.

Gravel Mining. There are no gravel mines in this reach.

Fire. Impacts of catastrophic fire could be high in the near future due to recent wildfires in adjacent uplands. However, data is lacking to quantify the extent of impact on this reach due to recent burns. Impacts of fires further upstream would be partially mitigated by Horseshoe dam that would capture any toxic ash flows from higher in the watershed.

Reach 3: Horseshoe Dam to the top elevation of Horseshoe. This reach encompasses the entire length of Horseshoe to its full capacity.

Land Use. The area surrounding this reach is managed by the TNF. There are no private lands in this reach.

Diversion Structures. There are no diversion structures in this reach.

Urbanization, Development, Roads. The adjacent uplands are undeveloped grasslands and desert scrub. Except for roads that lead to the dam and lake, the area is largely inaccessible with few Forest Service roads leading directly to the upper end of the lake.

Recreation. Recreational activities are primarily associated with Horseshoe, and include boating, fishing, camping, and picnicking. Recreational impacts appear to be low to moderate.

Water Quality. The ADEQ 319(b) report states that the AGFD and the University of Arizona collected a total of 19 water quality samples at four sites within Horseshoe between 1999 and 2000. In one sample, the pH standard for the A&Ww designated use was exceeded at a pH of 9.3. Additionally, the former A&Ww turbidity standard, 25 Nephelometric Turbidity Units (NTU), was exceeded in four of eight samples with results ranging from 0.8 to 90 NTU. Lastly, core parameters such as total boron, mercury, manganese, copper and lead, and dissolved copper, cadmium and zinc were missing from the analyses for Horseshoe. For these reasons, ADEQ assessed the A&Ww designated use for this reach as "Inconclusive."

Ground Water Pumping. There are no ground water wells in the vicinity of this reach, except for a domestic well near Horseshoe Dam.

Livestock Grazing. The Sears Club-Chalk Mountain Forest Service Grazing Allotment lies adjacent to Horseshoe.

Water Management. See reservoir operations in Section 3.6 and the impact of reservoir operations on fisheries (Section 3.3).

Fire. Recent fires during the summer of 2005 forced temporary closure of public access by the Tonto National Forest to Horseshoe and the Verde River, which eliminated removal of non-native sportfish by anglers in a year when reservoir levels were maintained high for a longer than normal period. However, an increase in the size and number of predators in Horseshoe following this closure was not observed during the fall 2005 sampling (Robinson pers. comm. 2005)

Recent wildfires (June to July 2004 and 2005) in the watershed above Horseshoe Dam resulted in flushes of ash and sediment into the area upstream from the lake, and caused a fish kill in tributaries and Verde River. Although they did not cause fish kills in the lake, the potential for this type of impact exists in the future. Flushes of ash and sediment may cause adverse impacts on aquatic biota. A long-term watershed danger from these wildfires is the potential for soil damage through removal of organic matter, loss of surface layer, and changes to surface soil structure that result in reduced infiltration, rapid runoff, and increased sedimentation and peak flows in the stream channel (Warnecke, pers. comm. 2004; Barnett and Hawkins 2002). For example, AGFD, USFS, and USFWS personnel salvaged Gila topminnow from Lime Creek in July 2005 during the Cave Creek Complex fire due to the concern that late summer monsoon storms would wash resulting ash into the creek and cause a catastrophic fish kill.

Reach 4: Top elevation of Horseshoe to Beasley Flats. The gradient of the river increases at the upstream end of this reach as the river flows out of the Verde Valley and crosses a landscape dominated by basalt cliffs. Floodplain width narrows, water velocity increases, riffles become larger and more frequent, and low velocity pools are present between riffles. Several large rapids are present in this reach, including the Class 4 rapids at Verde Falls, approximately 2 miles downstream from Beasley Flat. The extent of riparian and emergent vegetation is influenced by the geomorphology of the reach, narrowing where the river flows through steep-walled canyons. Annual base flow at the upper end of this reach (Camp Verde gage) averages 159 cfs (4.5 cms) (USGS website). Major perennial tributaries along this reach are Fossil Creek and East Verde River.

This reach of the Verde River is characterized as having long pools separated by short riffles. Habitat mapping of the Wild and Scenic reach identified 29% pools, 13% riffles and less than 1% side channels in the Scenic Section and 37% pools, 14% riffles and 6% side channels in the Wild section (Sillas, pers. comm. 2004).

Land Use. This reach is under National Forest management and is split among the Prescott, Coconino, and the Tonto National Forests. The northern boundary of the TNF is approximately 3 miles upstream of the confluence with Fossil Creek.

Special Management/Regulation. In 1984, 39.5 miles of the Verde River were designated as Wild and Scenic under the authority of the 1968 Wild and Scenic Rivers Act, as amended. The boundaries of this designation extend from Beasley Flat to Red Creek. The Scenic River area extends 14.5 miles through this reach from Beasley Flat to below Childs. This portion of the river is managed to preserve naturally occurring flora and fauna, river-oriented recreational activities, scenic qualities, and archaeological and historic resources (USDA 2004).

Diversion Structures. There are no diversion structures or surface water diversions in this reach. There is one small earthen agricultural diversion at Doll Baby Ranch on the East Verde River located upstream of the Action Area.

Urbanization, Development, Roads. Lands adjacent to the mainstem are largely undeveloped. However, a great deal of residential development associated with the community of Payson has occurred on private lands along the East Verde River in unincorporated areas.

Population. The primary area of population growth is along the East Verde River (outside of the Action Area). With this growth, demand for water resources has also increased. In terms of surface flows, the impact of this growth on the East Verde and mainstem Verde rivers is unknown; however, water supplies in this region are limited, and future growth could result in the diversion of surface flows in the East Verde.

Recreation. Road access is limited and dispersed camping and impacts associated with road and trail access are not extensive (USFS 2002a). Vehicular access to the river within this reach includes the Beasley Flat Road (FS 334), the Falls-Sycamore Canyon Road (FS 500), Brown Springs Road (FS 574), Childs Access Road (FS 502), Powerline Road (FS 16), and FS 7. Trails can be accessed from FS 500, 574 and 57. In areas where road access is provided, primarily at Beasley Flats and Childs, impacts are moderate to severe.

Recreational activities include camping, hiking, fishing, swimming and boating. It is a popular reach for kayaks and canoes because of the white water conditions in some areas. The most popular times for floating the river are March and April. River use is very light on the Wild section and light to moderate on the Scenic section with both day and overnight usage. Boating use fluctuates with water level.

The Beasley Flat site is the beginning of the Verde Wild and Scenic River and the demarcation point for whitewater boating. This site is popular with users, being the only access point between Camp Verde and Brown Springs, and receives consistent heavy day use and fishing use. The Beasley Flat site provides parking, restrooms, and paths to the river (PNF 2001).

The popular recreational site located at the Verde Hot Springs, located just upstream from Childs, receives heavy recreation pressure, especially during summer months. A dispersed camping area at Childs also receives heavy recreational use.

Most recreational fishing takes place at easily accessible sites, such as Beasley Flat, Verde Falls, Gap Creek, and Childs. The AGFD changed its fishing regulations in 1998 permitting unlimited harvest of channel catfish, flathead catfish, smallmouth bass, and largemouth bass.

Numerous river campsites occur within the Wild and Scenic section of the Verde River and a total of 97 campsites were evaluated by the Forest Service (USFS 2002b) with more than half the campsites having moderate to widespread litter, feces, excessive fire rings, and other damage.

Recreation and river use are expected to increase reflecting the strong population growth trends in the Verde Valley, Phoenix metropolitan area, and other surrounding communities (USDA 2004).

Water Quality. Bioassessments conducted in the Verde River from West Clear Creek to Fossil Creek and from Tangle Creek to Ister Flat found good and exceptional macroinvertebrate communities (ADEQ 2000). The A&Ww designated use was assessed as “Not Attaining” due to exceedances of the former turbidity standard (6 of 17 samples) and the chronic selenium standard (1 of 1 samples). Fish macroinvertebrate communities and habitat were found to be poor at Childs due to organic sediment enrichment, recreational use and vehicle disturbance (USDA 2004). The A&Ww designated use in the lower reach (confluence of Tangle Creek to Ister Flat) was assessed as "Inconclusive" due to exceedances of the former turbidity standard (5 of 24 samples).

The ADEQ 305(b) report stated that within Reach 4, approximately 155 water quality samples were collected by USGS, ADEQ, UofA, and SRP in the East Verde River, Fossil Creek, Round Tree Canyon Creek, Sycamore Creek, and the Verde River.

The East Verde River was determined to exceed A&Ww standards for former turbidity (2 of 2 samples), chronic selenium (2 of 2 samples), boron (4 of 20 samples), and arsenic (7 of 23 samples); the latter is thought to be due to naturally high levels in native soils. The East Verde River was divided by ADEQ into three reaches for assessment purposes: 1) the upper reach from the headwaters to the Ellison Creek confluence (A&Wc designated use)(outside the Action Area); 2) the middle reach from the Ellison Creek confluence to the American Gulch confluence (outside the Action Area); and 3) the lower reach from American Gulch to the confluence with the Verde River. With respect to the A&Wc and A&Ww designated uses, the upper reach assessed as "Inconclusive" (only two sampling events) and the lower reach assessed as "Attaining." The middle reach assessed as "Impaired" due to the aforementioned exceedances in chronic selenium.

The A&Ww designated use was assessed as "Inconclusive" for Fossil Creek (only two samples collected).

Ground Water Pumping. The ADWR Wells 55 database has 1,411 ground water wells listed in the vicinity of this reach. The majority of ground water pumping is associated with the communities of Payson, Pine and Strawberry, and surrounding developments. These communities are associated with the East Verde River and Fossil Creek watersheds. Impacts from pumping would mainly impact the East Verde River (Appendix 5).

Livestock Grazing. Six Forest Service grazing allotments are associated with this reach. They include the Brown Springs Allotment on the Prescott National Forest (PNF) and Skeleton Ridge, Red Creek, Cedar Bench, Payson/Cross V, and Deadman Mesa Allotments on the Tonto National Forest. Cattle graze the river portion of the Brown Springs Allotment for a portion of the year, but the Forest Service is proposing to fence the river in that area to exclude grazing. Most livestock have been excluded from Forest Service lands along the river. However, grazing impacts on the TNF portion of the reach are variable. Reports prepared by Mike Ross (Ross unpublished) indicate that trespass livestock grazing occurs frequently in many locations and that grazing is still having a negative impact in a number of locations along this reach.

Other Factors. Recent large, very hot wildfires in the upper watershed (i.e. Willow Fire) resulted in negative impacts to water quality in the East Verde River and in the mainstem Verde below the confluence with the East Verde and above Horseshoe Lake. During large precipitation events in the summer of 2004 and 2005, flushes of ash and sediment were washed into the stream channel causing adverse impacts to aquatic biota. Fish kills were reported in the East Verde and the mainstem Verde down to Sheep's Bridge in 2004 and above Horseshoe Lake in 2005. The extent of impacts to the fish community are unknown at this time. Another long-term consequence from these wildfires is reduced infiltration, rapid runoff and sedimentation that results from soil damage through removal of organic matter, loss of surface layer and changes to surface soil structure (Barnett and Hawkins 2002).

Reach 5: Upper end of Wild and Scenic Reach to Allen Diversion. Reach 5 generally encompasses the area from Clarkdale to below Camp Verde, an area that is referred to as the Verde Valley. Historically, this area has been more densely populated than other areas on the Verde River. The major tributaries that contribute to the river in this reach are Oak Creek, Wet Beaver Creek, and West Clear Creek. These tributaries originate on the Coconino Plateau or Mogollon Rim.

This reach tends to have low flow velocities and low channel gradient, which would likely contribute to greater fish species diversity by allowing the accumulation of detritus and nutrients important to aquatic life (Adamus et al. 1991). However, Sullivan and

Richardson (1993) report that disturbances within the reach have reduced the quality of habitat for native species relative to upper reaches of the Verde River. Sullivan and Richardson (1993) cited a number of factors that contributed to degradation of aquatic habitat in this reach, including agricultural operations, urban development, bridge construction, road-building, agricultural diversions, extensive recreational use, sand and gravel operations, and historical and current removal of riparian vegetation. The increase in impervious surfaces that results from urban development and road building results in increased surface runoff, which may contain fertilizers, pesticides and other contaminants. Increased surface runoff also affects the timing and magnitude of peak flood flows (Barnett and Hawkins 2002).

A number of highly erosive areas occur in this reach because of vegetation removal, sand and gravel operations, and extensive recreational activities. Sullivan and Richardson (1993) attributed a decline in aquatic diversity in the vicinity of these erosive areas to an increase in suspended solids.

Land Use. More than 30 miles of this reach are privately owned, 1.4 miles are tribal lands, and 0.35 mile is owned by the State of Arizona, Arizona State Parks Board.

Water Use. Increasing demands for water to support rapid population growth in this reach and in the upper Verde watershed may be the greatest threat to maintaining instream flows in this reach of the river. Ground water pumping from both domestic and commercial wells is expected to have an increasing impact on surface water flows (ADWR 2000; Appendix 4). Another threat comes from the potential for water exchanges that would allow increased diversions of surface water from the river channel (USDA 2004).

Diversion Structures. Stream flows in this reach are highly modified due to the presence of 47 diversions (Alam 1997). Twelve active diversions are located on the mainstem of the Verde in this reach, 23 diversions are on Oak Creek, nine diversions are on Wet/Beaver Creek, and three diversions are on West Clear Creek (Id.). The Arizona Department of Water Resources Verde River Watershed Study (2000) and Alam (1997) include a detailed inventory of these ditch systems. A summary table and maps of diversion locations are provided in Appendix 3.

Irrigation ditches range in size from over 50 cfs and 17 miles long to less than 1 cfs and less than 1 mile long (Alam 1997). An estimated 15,000 acre-feet are diverted for irrigation of 4,770 acres (Appendix 3). Although farming is mainly reliant on surface water, approximately 1,200 irrigation wells provide water during shortfalls in surface water availability (ADWR 2000).

Use of surface water for agricultural and landscape irrigation and other domestic uses impacts the integrity of the river by diverting significant amounts of water from the stream channel into ditch systems. Some of these diversions can remove the entire surface flow of the river or tributary during portions of the year (Alam 1997; Owen-Joyce and Bell 1983). The magnitude of diversions is such that the flow in the Verde River is reduced by two-thirds or more downstream from the Cottonwood Ditch (and is nearly dry in years of extreme drought).

Urbanization, Development, Roads. Increased urbanization within this reach will continue to place a greater demand on water resources for municipal, agricultural, industrial and recreational uses. This river segment, including perennial tributaries, runs through the communities of Clarkdale, Cottonwood, Verde Village, Rimrock, Lake Montezuma, McGuireville, Cornville, Page Springs, Sedona, West Sedona, Village of Oak Creek, and surrounding unincorporated areas of private and state trust lands.

Barnett and Hawkins (2002) identified urbanization as being a contributor to changes in the hydrology of the river and its major tributaries, especially Oak Creek, Beaver Creek and West Clear Creek. Depending on the type and character of development and the amount and configuration of impervious surfaces, urbanization can increase the timing and amount of storm water runoff from the watershed. Impervious areas reduce infiltration of precipitation and produce runoff from rainstorms in larger amounts and more rapidly, resulting in higher peak flood flows and more frequent flows of a given magnitude (e.g., a flood magnitude that would occur on a 5-year frequency interval may be occurring on a 2-year interval) (Barnett and Hawkins 2002). Storm runoff from urbanized areas has the potential to increase sediment and turbidity in the river channel. In addition, there are impacts of storm runoff flushing contaminants from streets, parking lots, and commercial and industrial areas (Id.).

Population. The population in this reach has been doubling each decade for the past two decades (Yavapai County Water Advisory Committee and U.S. Bureau of Reclamation 2003). In recent years, all towns within the Verde Valley have experienced rapid increases in their populations. The population of the Verde River basin doubled between 1980 and 1994. During that same time period, the Towns of Camp Verde, Clarkdale, and the City of Cottonwood experienced population increases of 89%, 63% and 38% respectively (ADWR 2000). This trend in rapid growth is projected to continue with some forecasts estimating a 128% increase in population between 1994 and 2040 for the Verde Valley.

Yavapai County as a whole also has experienced tremendous growth in recent years. Between 1980 and 1990, Yavapai County's population increased 58% from 68,145 to 107,714. By July 1997, Yavapai County's population had increased from 107,714 to 142,075; a 32% increase (ADWR 2000). Census data indicates a steady growth for major populated centers within the watershed. The population in Yavapai County is estimated to exceed 305,000 people by the year 2040 (ADWR 1997) and 325,000 people by the year 2050 (ADWR 2000).

Recreation. Mixed land ownership makes access to the river and most of its tributaries difficult to regulate. Existing public and private access points exist along the entire corridor. The Verde Village Homeowner's Association owns a 2-mile stretch of the river, which provides recreational access for local homeowners. The PNF has installed seven developed access points in the Verde Valley and many undeveloped access points exist by way of ephemeral washes that drain into the river from the west side of the valley.

Recreational use of the river and its banks tends to be high. Activities include fishing, camping, picnicking, horseback riding, swimming, rock throwing and skipping, boating, hiking, and all terrain vehicle use. Motorized off-road vehicle use, illegal unregulated camping, partying, illegal dumping of trash, and removal and trampling of vegetation have all been mentioned as problems in the area (ASPB 1990; Macphee, pers. comm. 2004). Although driving into and in the river is unauthorized on both the PNF and CNF, and a number of roads to the river have been closed, vehicles driving in the river and floodplain remain a problem. Impacts and violations are greatest between Cottonwood and Camp Verde where there are often several roads within a segment of floodplain (PNF 2001). A heavily traveled road that crosses the river exists upstream from the I-17 bridge on the Camp Verde Yavapai tribal land. Trucks traveling from a sand and gravel operation regularly drive across the river at this location. Vehicle use within the active channel and floodplain results in reduced vegetative cover, compacted soils, increased turbidity and increased surface runoff.

Water Quality. The USGS, ADEQ, and SRP previously evaluated the bacteriological quality of surface flows under the single sample category. Samples taken in Oak Creek and the Verde River periodically exceed the maximum allowable limits. These data indicate that, for at least short periods, fecal pollution at some sites may be a potential hazard to swimmers during the summer months when streamside recreation and tourism is at its peak. High fecal coliform counts also may be attributed to livestock and other wild animals defecating in or close to streams (Owen-Joyce et al. 1983).

Much of the Verde River was listed as water quality limited in past 305(b) reports due to turbidity (ADEQ 1998). The most recent 305(b) Report listed the portion of the Verde River in this assessment meets surface water quality criteria except one station near Camp Verde, which is in partial support of full body contact due to *E. coli* (ADEQ 2000). Much of the river corridor in the Verde Valley is in private ownership and not managed by the Forest Service. Many residents of Camp Verde use septic systems and poor water quality may be due to septic leakage or from livestock on private land. Because no livestock are permitted on the river within National Forest lands in the Verde Valley, this impairment is not attributed to livestock grazing on public lands (PNF 2001). In its 1998 report, ADEQ listed the Verde River as impaired due to turbidity. The Verde River is a permanent, flowing stream that meets ADEQ (2000) water quality standards.

Within the watershed of Reach 5, over 3,500 water quality samples were collected by USGS, ADEQ, Phelps Dodge, and Slide Rock State Park in Beaver Creek, Munds Creek, Oak Creek, West Fork Oak Creek, Pumphouse Wash, Spring Creek, the Verde River, West Clear Creek, and Wet Beaver Creek (ADEQ 2004). The vast majority of these samples (n = 3,408) were collected outside the Action Area in Slide Rock State Park on Oak Creek to monitor *E. coli* levels.

ADEQ collected 29 water quality samples in Beaver Creek; the A&Ww designated use was assessed as "Inconclusive" because several core parameters were missing from the analysis [i.e. *E. coli*, total metals (lead, copper, and mercury), and dissolved metals (copper, cadmium, and zinc)] and due to exceedances of the former turbidity standard in five of 26 samples collected. Between Slide Rock State Park to the confluence of Dry Creek on Oak Creek, the A&Ww designated use was assessed as "Attaining." Other sections of Oak Creek in the Action Area were not sampled enough to make an assessment.

Within Reach 5 on the mainstem Verde River, the segment between the confluence of Oak Creek to the confluence of Beaver Creek with A&Ww designated use was assessed as "Not Attaining" due to a history of exceedances of the former turbidity standard. Ongoing data collection and a total maximum daily load analysis to address the potential sources of turbidity substantiates this designation. Between the confluence of Beaver Creek to the confluence of West Clear Creek, the A&Ww designated use was assessed as "Inconclusive" due to missing analysis of dissolved metals (copper, cadmium, and zinc).

Livestock Grazing. The PNF administers the Squaw Peak, Verde and Brown Springs grazing allotments along this reach. River frontage on the Squaw Peak allotment was fenced to exclude livestock grazing in the early 1980s and the Verde allotment frontage was fenced in 1995 (PNF 2001). Cattle access the river at several watering points on the Brown Springs allotment (Id.). However, the PNF recently received a grant from the Arizona Water Protection Fund to fence river frontage on the Brown Springs allotment, except for an area of about 50 to 100 yards where livestock access is controlled (PNF 2001; Doug Macphee pers. comm. 2006).

Mining. Copper mining played a significant role in the early years in Yavapai County and the Verde Valley and was once one of the largest employers. Today, however, mining employs less than 2% of the labor force in Arizona. The copper mines in the Verde Valley were phased out of operation by the end of the 1960s. There are still a few tailings piles in the vicinity of Clarkdale adjacent to the river, which may contribute minerals and metals to the Verde River (AWDR 2000).

Historically, sand and gravel operations were found throughout Reach 5 within the active channel of the Verde River. However, only three major locations remain. One is along the mainstem upstream from the I-17 bridge on lands owned by the Yavapai Apache. The other two operations occur near the mouth of tributaries along West Clear Creek and Beaver Creek.

Sand and gravel facilities mine unconsolidated stream deposits to produce materials for construction. Washing aggregate accounts for the bulk of water use by sand and gravel facilities. Dust control, equipment washing, and other activities are secondary water uses. Sand and gravel facilities demands vary from year to year based on the demand for aggregate material. The estimated total demand for water in 1997 was 1,540 acre-feet. Approximately 1,400 acre-feet of this number was ground water and 140 acre-feet was effluent (Sullivan and Richardson 1993)

Fire. In recent years, wildfires burned large acreages within the watershed associated with this reach. However, there have been no recent reports of fish kills in this reach due to flushing of ash and sediment off the burned areas into the river.

4.0 Descriptions of Reservoir Operation Alternatives and Impact Analysis Methods

As stated in Section 1, the purpose of this report is to determine the impacts of future operations of Horseshoe and Bartlett on native fish populations over the 50-year permit period covered in the HCP. The impacts analysis presented in this chapter focuses on two issues: 1) direct impacts to native fishes caused by reservoir operations; and 2) considering the baseline, the incremental effect of non-native fish produced due to reservoir operations and their future impact (predation, competition for space and resources) on native fish located within the Action Area, over the life of the permit. The impacts of reservoir operations were initially evaluated under three alternatives; 1) No Permit; 2) Historical Operation; and 3) Modified Full Operation. Due to concerns that the Modified Full Operation Alternative did not adequately address impacts on native fish populations, a new alternative—Rapid Drawdown—was developed and analyzed.

The Rapid Drawdown alternative was designed to minimize non-native fish recruitment to the maximum extent practicable, which would benefit covered fish species. Extensive literature on fish reproduction (primarily bass and sunfish) in reservoirs describes the negative impacts of fluctuating water levels on spawning and recruitment (Willis 1986; Wright 1991; Maceina and Bettoli 1998; Sammons et al. 1999; Sammons and Bettoli 2000). Under the Rapid Drawdown Alternative, the reservoir would be evacuated as fast and as early in the spring as possible to disrupt spawning of non-native species found in Horseshoe.

However, early in the review of this alternative, the Committee identified potential conflicts in meeting the conservation needs of the southwestern willow flycatcher and yellow-billed cuckoo, despite the benefits the alternative offered for covered fish species. For example, altering the timing and rate of reservoir drawdown could impact recruitment and survival of willow trees. Similarly, early drawdown would dewater habitat early in the breeding season, which could impact the breeding habitat quality of riparian forest for the flycatcher and cuckoo. Thus, to balance conservation of both native fishes and birds, the Committee further evaluated and modified several drawdown alternatives and scenarios and developed a fourth alternative—Optimum Operation (Proposed Alternative) with the assistance of Service fisheries biologist, Jeff Whitney. This alternative combined aspects of the Modified Full Operation and the Rapid Drawdown concept to minimize the production and survival of non-native fish species, while maintaining habitat for southwestern willow flycatcher and yellow-billed cuckoo within the conservation space of Horseshoe. The four alternatives analyzed are described below.

4.1. No Permit Alternative

Under the No Permit Alternative, USFWS would not issue an ITP to SRP for continued operation of Horseshoe and Bartlett. Without an ITP, SRP would be expected to do everything within its control to avoid take of federally listed species associated with the continued operation of the reservoirs. To avoid the risk of potential take of flycatchers, Horseshoe would be operated to reduce the water level below the elevation at which flycatchers nested in the previous year before commencement of the current nesting season. Unless a large runoff event occurred that could not be passed through the reservoir immediately, the reservoir elevation would be lowered by May 1 to expose vegetation used by flycatchers for nesting.

To minimize the risk of future impacts to currently listed native fish (razorback sucker, and Colorado pikeminnow), SRP would empty Horseshoe for as long as possible each year to minimize the production of non-native fish species.[2] Horseshoe would be completely drained each year unless inflow exceeded outlet capacity and the reservoir could not physically be completely drained. Based on reservoir operation modeling using historical inflows, the probability of not being able to completely drain Horseshoe in any given year is less than 1% (1 in 113 years). Additionally, SRP would work with AGFD and USFWS concerning native fish stocking in the Verde River to help prevent take of listed fish from future reservoir operations.

In the future, currently unlisted native fish that occur upstream from Horseshoe or downstream from Bartlett may become federally listed and reservoir operations might result in adverse impacts. In that event, SRP's options would include seeking an incidental take permit, modifying reservoir operations, or implementing other measures such as blocking movement or removing non-native fish from the reservoirs. SRP's decision on which option to pursue would depend on the circumstances present at the time, e.g., the certainty of the relationship between impacts and reservoir operations, technological options for preventing dispersal of non-native fish from the reservoirs, the

[2] Horseshoe would typically be drained by June and the Verde River continues to flow through the reservoir bed during periods when Horseshoe is drained.

then-existing laws and regulations pertaining to federally listed species, legal liabilities to the water users that SRP serves, and the ability to obtain permits for removal of sport fish.

4.2. Historical Operation Alternative

The Historical Operation Alternative would involve issuance of an ITP by the USFWS for the continued full operation of Horseshoe and Bartlett consistent with the historical operating objectives set forth below, along with implementation of minimization and mitigation measures. The intent of this alternative would be to minimize the biological, environmental, and socioeconomic impacts from future reservoir operations, to continue full water storage at these two reservoirs, and to satisfy the criteria of Section 10(a) of the ESA.

Under the Historical Operation Alternative, Horseshoe and Bartlett would continue to be operated with the same objectives that SRP has used in the past. SRP operates the reservoir system to minimize spills of water past Granite Reef Dam with the following objectives:

- "Maintain the safety and integrity of the dams.
- Maintain sufficient storage to meet water delivery obligations.
- Optimize reservoir storage within the reservoir system.
- Maintain adequate carryover storage in case of low runoff.
- Conjunctively manage ground water pumping given reservoir storage and projected runoff and demand.
- Maximize hydrogeneration.
- Permit necessary facility maintenance."[3]

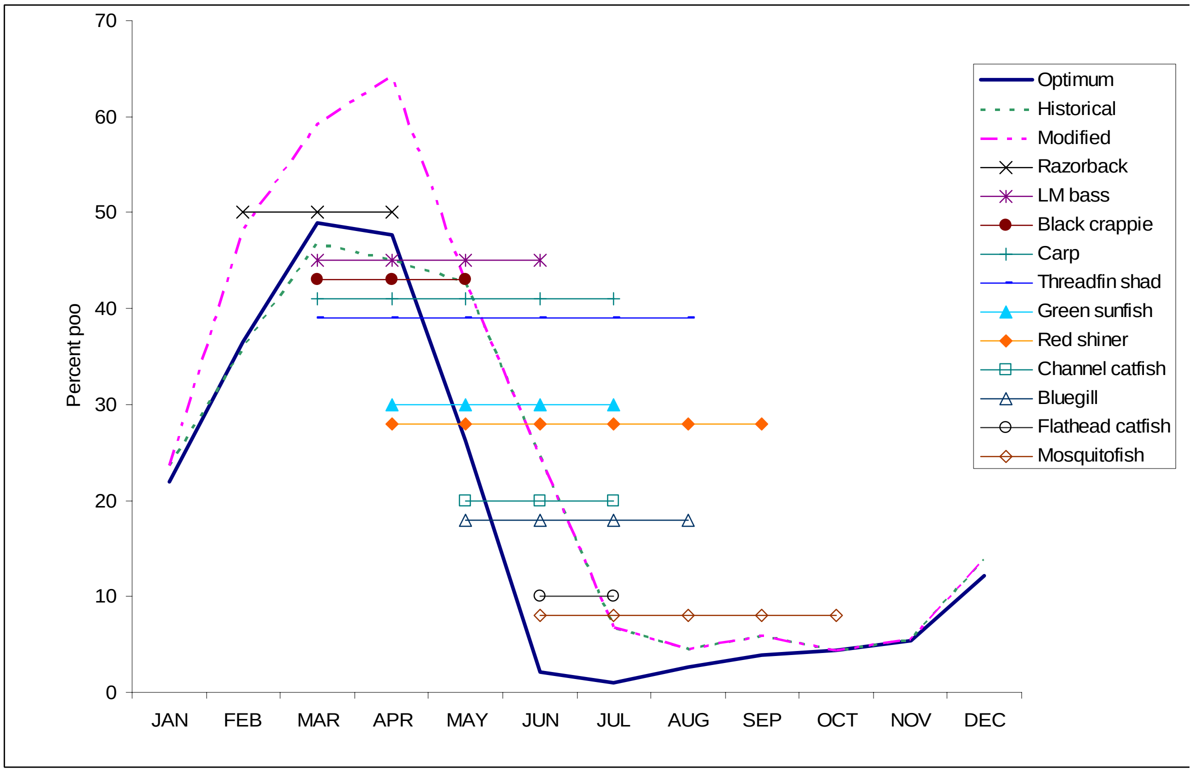
A graph of the generalized operation scenario (i.e., average annual reservoir drawdown rate and timing) relative to fish spawning periods is provided in Figure 4-1. While, the general pattern of storage is similar among alternatives (Figure 4-2), the frequency of higher water levels occurs more often in May and June under Historical Operations than the Optimum alternative. Horseshoe would be completely drained each year unless: 1) inflow exceeds outlet capacity and the reservoir could not physically be

[3]Modified Roosevelt Operating Agreement, see Appendix 1.

completely drained; or 2) lack of storage space in Bartlett means that water released from Horseshoe would be spilled. Based on reservoir operation modeling using historical inflows, the probability of not being able to completely drain Horseshoe in any given year is less than 1% (1 in 113 years).

Although not an objective of operations, historical operations have negatively impacted non-native fish production and survival based on fisheries monitoring by AGFD (Warnecke 1988), and allowed willow trees to colonize, persist within the pool, and be used for nesting by flycatcher and cuckoo.

Figure 4-1. Average annual Horseshoe elevation levels (month time-step) for three operational alternatives.



Graph also shows probable spawning periods of selected non-native fish species found within Horseshoe, and the razorback sucker spawning period. Fluctuating reservoir levels can disrupt non-native species spawning activities, thus where declining or rising water levels and spawning periods occur at the same time, operations minimize non-native fish production. Maintaining a minimum pool (June-November) reduces the survivorship of larvae, young-of-year, and adult fish and decreases the carry-over of fish into the following year's spawning season.

Note: spawning periods are not related to Y-axis (% pool), only X-Axis (month) because all inundated habitat in the reservoir was assumed suitable.

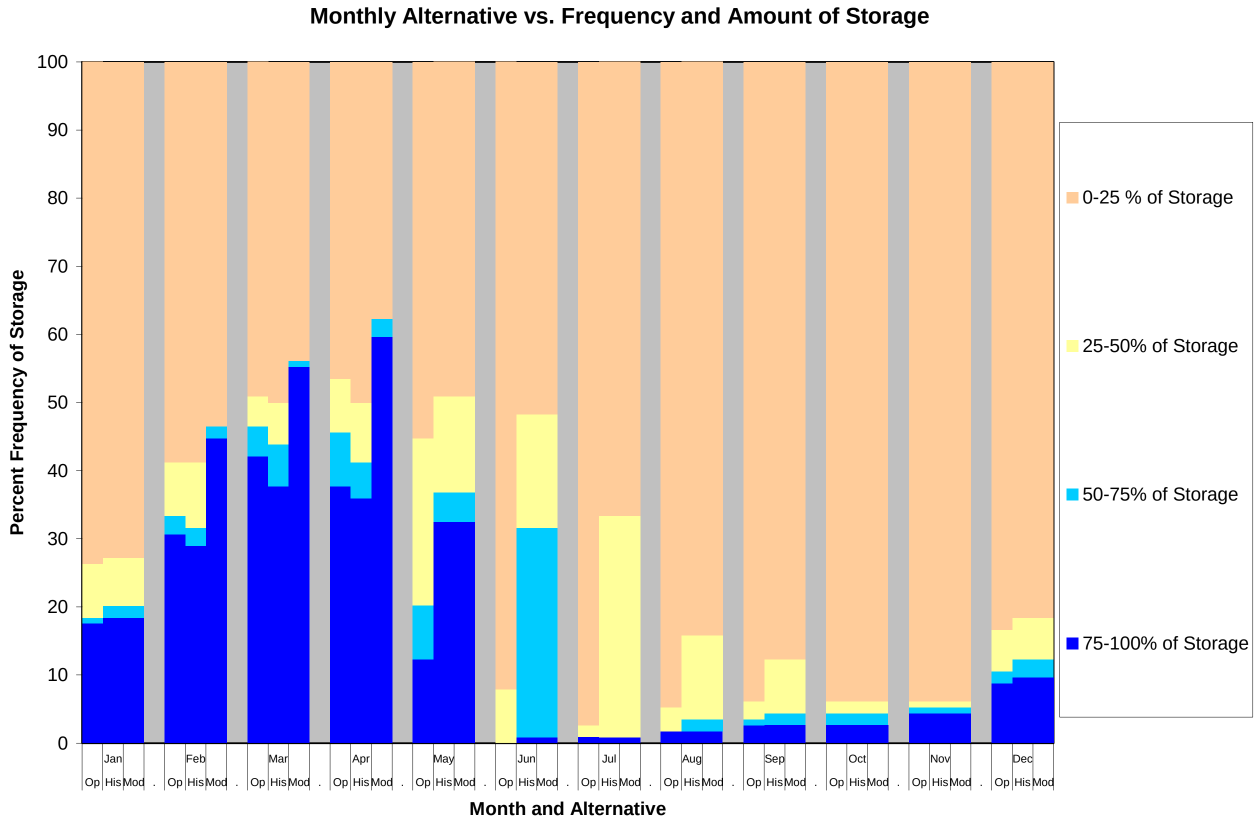


Figure 4-2. Graph showing the percent frequency of the amount of storage for each alternative by month.

For example, under the optimal operation alternative during March, the reservoir would be low (near empty, <25% storage) approximately 45% of the time, be high (>75% storage), 38% of the time, and partially (25-75%) full the remaining time.

4.3. Modified Full Operation Alternative

The Modified Full Operation Alternative would involve issuance of an ITP by the USFWS for the continued full operation of Horseshoe and Bartlett with the addition of reservoir operating goals to establish tall dense riparian vegetation at the upper end of Horseshoe and to manage Horseshoe water levels to minimize impacts to covered native fish species, and to benefit the razorback sucker.

The reservoirs would be operated consistent with the objectives set forth below. The intent of this alternative is to minimize the biological, environmental, and socioeconomic impacts from future reservoir operations, continue water storage at these two reservoirs, and satisfy the criteria of section 10(a) of the ESA.

Under the Modified Full Operation, Horseshoe and Bartlett would continue to be operated by SRP as part of its reservoir system in a manner consistent with their purpose as water storage facilities. However, two objectives would be added to the reservoir management objectives: 1) maximize establishment of tall dense vegetation above elevation 2,010 feet in Horseshoe; and 2) manage Horseshoe water levels to minimize impacts to covered native fish species and to benefit the razorback sucker. The addition of those two objectives would result in the following set of management objectives for Horseshoe and Bartlett:

- Maintain the safety and integrity of the dams
- Maintain sufficient storage to meet water delivery obligations
- Optimize reservoir storage within the reservoir system
- Maintain adequate carryover storage in case of low runoff
- Conjunctively manage ground water pumping given reservoir storage and projected runoff and demand
- Maximize hydrogeneration
- Permit necessary facility maintenance
- Maximize establishment of tall dense vegetation above elevation 2,010 feet in Horseshoe (1 in 3 year inundation event)
- Manage Horseshoe water levels to minimize impacts to covered native fish species and to benefit the razorback sucker

One of the minimization measures is the additional reservoir operation objective to establish tall dense vegetation at the upper end of Horseshoe. Under the Modified Full Operation Alternative, Horseshoe levels would be maintained at or above an elevation of 2,010 feet in March, April, and early May to encourage germination and establishment of primarily willow and tamarisk, and secondarily cottonwood (based on seed set). Maintaining these water levels would be contingent on when water supply is available, consistent with the other reservoir operation objectives. To the extent practicable, the rate of Horseshoe draw down above an elevation of 2,010 feet would be slowed to support the recruitment of willow and cottonwood (slower rate of drawdown is not shown on Figure 4-1 due to averaging over the monthly time-step). The opportunity to manage Horseshoe levels for the benefit of tall dense vegetation would occur 1 in 3 years on average.

Maintaining high reservoir levels periodically in early to mid-spring to encourage recruitment of willow and cottonwood would provide favorable conditions for grow-out of stocked or naturally reproducing razorback suckers. Studies conducted in Lake Mead for the Southern Nevada Water Authority indicate that reservoirs can provide grow-out habitat and possible breeding habitat for razorbacks (Bio-West 2005). While Modified Operations could benefit razorback sucker, it could also benefit non-native fish species that co-occur in the reservoir.

Rapid drawdown would typically begin in April-May to reduce available spawning habitat and interrupt spawning activity and subsequent production for non-native fish (Figure 4-1). While, the general pattern of storage is similar among alternatives, the reservoir would be held higher more frequently in February-April than the Historical or Optimum alternatives (Figure 4-2). The reservoir would likely be higher in June than the Optimum alternative but at similar levels as the Historical Operation. As part of the Modified Full Operation Alternative, Horseshoe would be completely drained for a period during each year, typically by June or July, to adversely impact the production and recruitment of non-native species unless: 1) inflow exceeds outlet capacity and the reservoir could not physically be completely drained; or 2) lack of storage space in

Bartlett means that water released from Horseshoe would be spilled. Based on reservoir operation modeling using historical inflows, the probability of not being able to completely drain Horseshoe in any given year is less than 1% (1 in 113 years).

4.4. Optimum Operation Alternative (Proposed Action)

This alternative would involve issuance of an ITP by the USFWS for the continued full operation of Horseshoe and Bartlett with the addition of reservoir operating objectives to maintain (but not maximize) tall dense vegetation in Horseshoe and to manage Horseshoe water levels to minimize impacts to covered native fish species and to benefit the razorback sucker (i.e., balance the reservoir management for both fish and birds, while meeting operational objectives).

The reservoirs would be operated consistent with the objectives set forth below. The intent of this alternative is to minimize adverse biological, environmental, and socioeconomic impacts from future reservoir operations, continue water storage at these two reservoirs, and satisfy the criteria of section 10(a) of the ESA. The Committee believes that this alternative best minimizes adverse biological, environmental, and socioeconomic impacts from future reservoir operations and best meets the priorities identified for the evaluation of alternatives.

Under the Proposed Action, SRP would continue to operate Horseshoe and Bartlett as part of its reservoir system in a manner consistent with its purpose as water storage facilities. However, two objectives would be added: 1) support tall dense vegetation in Horseshoe; and 2) manage Horseshoe water levels and rate of drawdown to reduce impacts to covered native fish species and to benefit the razorback sucker. The addition of those two objectives would result in the following set of objectives for Horseshoe and Bartlett:

- Maintain the safety and integrity of the dams
- Maintain sufficient storage to meet water delivery obligations
- Optimize reservoir storage within the reservoir system
- Maintain adequate carryover storage in case of low runoff
- Conjunctively manage ground water pumping given reservoir storage and projected runoff and demand

- Maximize hydrogeneration
- Permit necessary facility maintenance
- Maintain tall dense vegetation in Horseshoe (drought mitigation – inundate dry habitat 1 in every 13 years on average)
- Manage Horseshoe water levels and rate of drawdown to minimize impacts to covered native fish species and to benefit the razorback sucker

The Optimum Operation Alternative (the Proposed Action) is similar to the Historical Operations with the additional incorporation of an earlier, more rapid drawdown resulting in a complete evacuation of the lake occurring approximately 4 to 6 weeks earlier in most years than other alternatives (Figure 4-1 and Figure 4-2). The primary assumptions of this concept are that: 1) non-native fish reproduction is adversely impacted by fluctuating reservoir levels that reduce recruitment due to disruption of egg incubation (guarding) by adults, desiccation of eggs, and concentration or forced movement of larvae and young fish out of near-shore cover (increase predation rate); thus early and more rapid drawdown is more effective at reducing successful recruitment; and 2) the area of the pool (i.e., stable water levels) behind Horseshoe Dam is minimized, which in turn reduces the amount of habitat available for spawning and also minimizes successful survival of any young produced.

Under the Optimum Alternative, SRP would work to rapidly draw down the reservoir beginning in March and continue high dam release rates through June (Figure 4-1). SRP would store water in Bartlett first, and then Horseshoe after Bartlett fills. Additionally, beginning as early as March and lasting through June, SRP could take additional water to meet water demands from the Verde, which would normally be released from the Salt River. This would result in Horseshoe being emptied earlier (usually about 4 to 6 weeks) than the historical operation (Figure 4-1). Due to typically high spring flows into Horseshoe, drawdown rates during March are expected to be similar to historic rates and April drawdown is expected to be slightly faster and start earlier compared to the Historical Alternative (under the Modified Operation lake levels would be increasing during this period).

Slower drawdown rates in March will continue to disrupt non-native fish spawning activity and will also allow for potential recruitment and maintenance of primarily cottonwood and tamarisk forest (based on seed-set) at lower reservoir elevations compared to the Modified Operation Alternative, and at higher reservoir elevations compared to Historical Operation Alternative. In April, drawdown rate would be maximized to negatively impact non-native fish reproduction. The change in timing (i.e., one month earlier compared to Historical Operations) could have an impact on willow recruitment and survival of young trees/saplings because drawdown rates may not be timed with seed production and ground water levels may recede faster than tree root growth. To offset these potential impacts, existing suitable willow flycatcher and cuckoo breeding habitat will be periodically inundated to maintain habitat and provide moisture following periods of drought when water is available. Off-site habitat also will be acquired to provide suitable flycatcher and cuckoo breeding habitat to compensate for reservoir habitat that may be unavailable in any one year.

Under the Optimum Operation Alternative, after 2 successive years without storage above elevation 1,990 feet, the objective would be to fill Horseshoe, at the earliest opportunity, in order to relieve the drought stress on cottonwood and willow. Filling Horseshoe after 2 dry years would depend on whether adequate water supply is available, consistency with the other reservoir operation objectives, and maintenance of a minimum pool of 50,000 AF in Bartlett to minimize impacts on recreation use at that reservoir. The need to manage Horseshoe levels to maintain tall dense vegetation would occur 1 in 13 years on average based on historical runoff patterns (see Appendix 5). In order to minimize impacts to native fish, following inundation of flycatcher and cuckoo habitat, Horseshoe would be emptied as early, rapidly, and completely as feasible to adversely impact non-native fish reproduction and recruitment. During these storage events, the reservoir fluctuations would follow the Optimum Operation storage and drawdown pattern shown on Figure 4-1. As a secondary benefit of periodically maintaining high reservoir levels to maintain cottonwood and willow, razorback suckers would benefit from extending the duration for grow-out of stocked fish or larvae fish from naturally reproducing individuals. However, this would occur less frequently (1 in 13 years), and larvae or young-of-year suckers would be drawn out of near-shore cover sooner compared to the Modified Operation Alternative (i.e., 1 in 3 years high water levels, and delayed drawdown). As stated previously, while Modified Operations could benefit razorback sucker, it could also benefit non-native fish species that co-occur in the reservoir.

Based on historical runoff, early and rapid drawdown would be delayed in about 1 in 3 years on average when additional water is accrued in New Conservation Storage in Roosevelt (NCS), thereby reducing SRP shareholder and contractor water supplies.[4] However, rapid drawdown would commence as soon as possible and the pattern of storage and water level fluctuation would be similar to the Historical Operations (Figure 4-1). Considering the various operational needs (i.e., normal conditions, drought mitigation, and delay for NCS), the frequency and amount of storage would be similar to Historical Operations in between January-April (Figure 4-2), but the reservoir would be lower much more frequently in March-June than either the Historical or Modified operations. Appendix 5 shows the difference in storage and drawdown between the Historical and Optimum Operations using the 113 years of runoff data into Horseshoe Lake. The graphs show that under Optimum operations, reservoir drawdown occurs a few weeks earlier than Historical Operations, and that the reservoir empties annually in early June-July each year. Also, during periods of storage to mitigate for drought conditions (1:13 years) and when water release is delayed due to runoff in the Salt River watershed, reservoir drawdown is rapid, water levels do not stabilize for long periods, and the lake is emptied by early summer (June/July).[5] Overall, the reservoir under this alternative is expected to be empty >45% of the time during the critical spring and summer spawning period for non-native fish (Figure 4-3), and be empty by June 92% of the time. Based on reservoir operation modeling using historical inflows, the probability of not being able to

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[4] At times when water is accruing to NCS, SRP must release the full amount of water demand from the Salt River reservoirs to satisfy water rights that are senior to NCS. Early and rapid draw down would require that water be released from Horseshoe and Bartlett to meet demand, which would be in direct conflict with the obligation to release the full amount of demand from the Salt River.

[5]Modified Roosevelt Operating Agreement, see Appendix 1.

completely drain Horseshoe in any given year is less than 1% (1 in 113 years) due to 1), inflow exceeds outlet capacity and the reservoir could not physically be completely drained; or 2) lack of storage space in Bartlett means that water released from Horseshoe would be spilled.

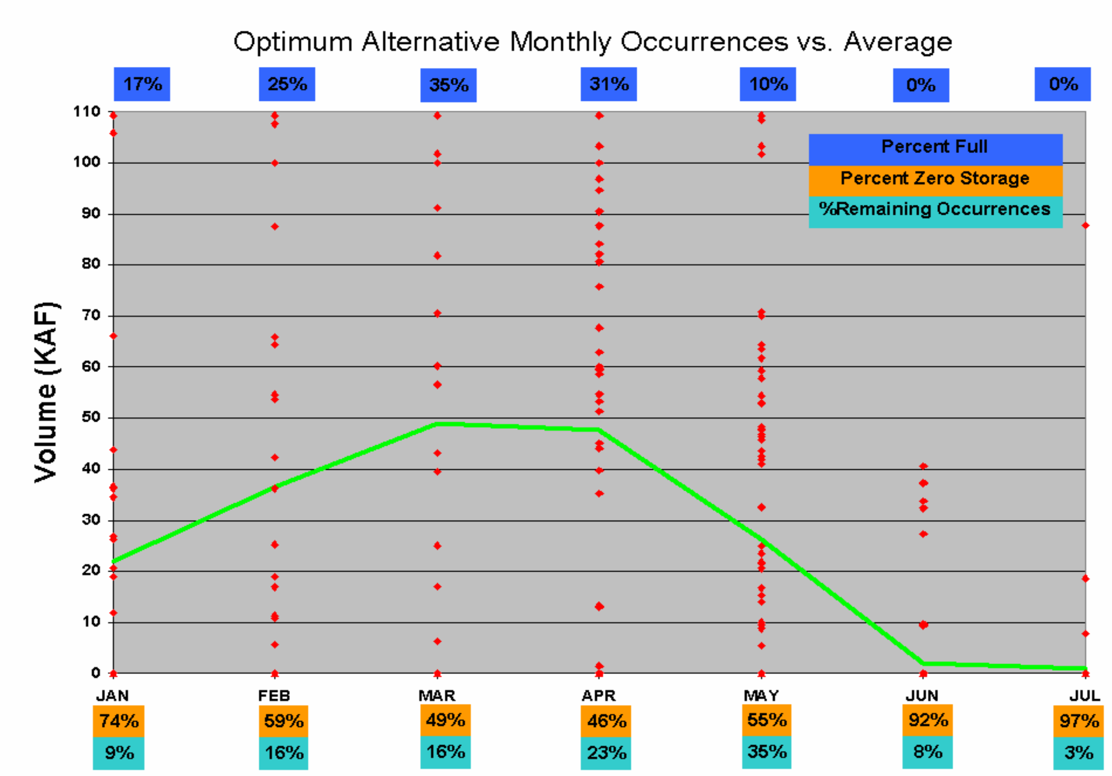

Figure 4-3. Plot of the frequency of storage volumes (y-axis) in Horseshoe Reservoir. A summary of those frequencies per month for the Optimum Alternative is noted in boxes (percent full). Red dots show individual occurrences from model runs using 113 years of data (some points are hidden/stacked), and green line shows mean storage level.

In conjunction with the Optimum Operation of Horseshoe and Bartlett, SRP would implement additional measures to minimize and mitigate the future take of federally listed bird species including acquisition and management of riparian habitat in the Verde Valley and in the Safford Valley, or elsewhere in central Arizona. The minimization and mitigation measures for covered bird species are described in more detail in the HCP. Other minimization and mitigation measures for impacts to native fish would include construction of a fish barrier on Lime Creek, assistance with stocking of razorback suckers in Horseshoe and other native fish in the Action Area, contributions to Bubbling Ponds Native Fish Hatchery, and watershed management efforts as described in Section 7 of this document.

4.5. Method of Impact Analysis

4.5.1. Native Fish Impacts Approach

Although there are currently no known self-sustaining populations of listed fish species in Horseshoe or Bartlett, or elsewhere in the Action Area at some time during the 50-year permit term, populations of listed fish may occupy the reservoirs or other parts of the Action Area (defined previously). State and federal agencies are attempting to re-establish some currently listed species in the Verde River mainstem (razorback sucker, pikeminnow); renovation of a tributary has recently been completed (i.e., Fossil Creek is proposed for stocking of spikedace, loach minnow, Gila topminnow and other species); and species that may be listed in the future could have populations in or near the reservoirs or could be reintroduced to the Action Area.

Future operation of Horseshoe and Bartlett by SRP under any of the four alternatives involves the periodic modification of habitat occupied by native and non-native fish species in the Verde River. For example, all alternatives involve wide fluctuations in water levels to meet the goals and objectives of the reservoir operations plan. The difference in the alternatives is primarily the amount of water stored in Horseshoe, the duration of water storage, and the rate and timing of drawdown impacting the duration of stable water levels (Table 4-1). The Committee determined that the impacts of non-native fish (i.e., predation, competition) would be similar among all covered native fish species based on life history information (Section 3.2); thus the Committee lumped all native species together to determine the impacts of reservoir operations.

Assessment of impacts on native fish from the continued operation of Horseshoe and Bartlett differs from a typical biological impact analysis. In this case, impacts do not occur as a single, permanent event and the amount of effect cannot be precisely predicted or measured for any specific future event. The quantity of adverse impacts of individual

Table 4-1. Summary of key hydrological variables influencing non-native fish production for each operational alternative and collective estimate of relative impact based on these variables.

Reservoir Measures		Operation Alternatives		
		Historical	Modified	Optimum
No. stable spring months		0	0	0
No. rapid drawdown months		2	3	2
No. slow drawdown months		2	0	1
Month rapid drawdown expected to begin		May	Mid-May	April
Months with empty (<10% full) reservoir		4	4	5
Frequency (percent time) of zero storage	March	50%	44%	49%
	April	50%	37%	46%
	May	49%	49%	55%
	June	54%	54%	92%
	July	66%	66%	97%

native fish from future Horseshoe and Bartlett operations is difficult to estimate and measure for several reasons:

- Physical loss of adult native fish is unlikely because the species are mobile; future adverse impacts could occur by direct loss of native fish within the reservoirs (e.g., by stranding in isolated pools or passage through outlet works).
- Indirect impacts to native fish primarily would be a result of impacts on habitat conditions (stable water levels), which might benefit non-native fish reproduction, and therefore cause a small incremental increase of direct predation on native fish and larvae and competition for space and resources above the baseline conditions.

Because of the unique situation described above, the Committee agreed that the method used to assess impacts to the razorbacks and other native fish needs to be scientifically based, objective, and correlated to the species likely to benefit from reservoir operations. Predation and competition with non-native species are the primary indirect impacts that could eventually result in the anticipated incidental take of native fish in the Verde River from operations at Horseshoe and Bartlett, and the precise quantity of that take is difficult to estimate and measure, the consensus was to use the accepted alternative of quantifying incidental take in terms of impacts to river miles of occupied habitat (USFWS 1996, p. 3-14).

4.6. Habitat Equivalency Analysis Approach

The Committee's approach to estimate adverse impacts to native fish species followed the conceptual framework of Habitat Equivalency Analysis (NOAA 2000). This approach evaluates the natural and anthropogenic influences (impacts) that contribute to the existing and future condition of native fish habitat. The approach is based on two assumptions: 1) all contributing impacts or "factors" on native fish habitat can total no more than 100 %; and 2) estimates of the severity, spatial extent, and duration of the impacts are developed by consensus of technical experts. Application of this approach in the Impacts Analyses involves the following steps:

1. Comprehensively reviewing available baseline information.
2. Reaching consensus for evaluating each contributing factor by reach.
3. Evaluating the impact of each factor on native fish within each mainstem reach and connected tributaries of the Verde River in the Action Area.
4. Assigning a relative percent contribution of future reservoir operations on the impacts to native fish by reach.
5. Multiplying the percent contribution within each reach by the total river miles within the reach to calculate the river miles impacted by reservoir operations.

The Committee identified early in the process that impacts to native fish species were related to a set of biological and management assumptions based on best available science. These assumptions provide the context to evaluate the alternatives. The primary biological and management assumptions concerning non-native and native fish in the Verde River to provide the context to analyze the impacts of each alternative were:

1. Non-native fish species of primary concern are those that are reasonably certain to occur in Horseshoe over the life of the permit and those that breed early and in mid-spring when reservoir water temperatures may be colder and/or levels may be stable due to dam operations (Figure 3-2). Non-native species of secondary concern are those that breed later in the season or at higher water temperatures, but may benefit in some years when water levels remain stable later in the breeding season.

2. Stable water level during breeding periods benefits non-native fish because it allows uninterrupted spawning; conversely, fluctuating reservoir levels negatively impact non-native fish that use nests to spawn (e.g., bass, sunfish) because of impacts on environmental conditions (oxygen, temperature), desiccation of eggs may occur, and/or adults may be unable to guard the nest against predators. Eggs that are laid and adhere to substrates/vegetation but may not be guarded (e.g., carp and red shiner), may be desiccated by falling water levels, as well (Section 3.3).
3. Timing of non-native fish spawning may vary annually due to local weather conditions, lake water temperature and stratification, conditions in the watershed (rain on snow events) that affect stream and lake water temperatures, local aquatic habitat conditions and substrates, and/or other environmental factors (Section 3.3). Because data were lacking to quantify many of the existing variables (i.e., temperature, substrates), and some variations in environmental conditions (e.g., temperature) cannot be reliably predicted in the future, the Committee assumed that the entire reservoir area was potential spawning habitat (i.e., worst-case scenario), and used conservative spawning periods for each non-native fish species based on published records and expert observations for similar habitat conditions (Figure 3-2).
4. The majority of non-native fish produced in the reservoir are not expected to disperse long distances from the reservoirs (Section 3.3) and the magnitude of impacts would be greatest near the reservoirs. Individual long distance movements, and dispersal and subsequent fitness of non-native progeny were also considered at a lesser magnitude (Section 3.3).
5. There are large self-sustaining populations of non-native fish in the Action Area, which confound managers' ability to discriminate between fish spawned in Horseshoe and Bartlett Lakes, and those individuals spawned or present in the mainstem river or tributaries that are presently impacting native fish (Sections 3.1 and 3.3).
6. Future stocking of razorback sucker and Colorado pikeminnow adults in the Verde River mainstem will continue independent of the HCP, based on past 20 years of efforts and current AGFD management plans.
7. State and federal fisheries managers expect that within the next 50 years reasonably foreseeable native fish conservation efforts (i.e., barriers, renovations, and restocking of native fishes for conservation and recovery) will likely be focused on Verde River tributaries (e.g., Fossil Creek, West Clear Creek, Wet Beaver Creek) and the Upper Verde River, before addressing non-native fish in the Verde River mainstem downstream of the Tapco diversion (Weedman, pers. comm. 2005). Such rationale is based on past and present conservation efforts, past, present, and expected future AGFD fisheries management policy, and the need to successfully manage or

control non-native species in the tributaries prior to initiating removal efforts in the mainstem (also see discussion of resolving native fish and sportfish management conflicts in Clarkson et al. 2005);

8. Based on past and currently planned statewide fish conservation efforts (e.g., Fossil, Aravaipa, and Bonita creeks), large scale conservation efforts (i.e., chemical renovations) on Verde River tributaries will likely include barriers to preclude non-native fish (either individuals from existing self-sustaining populations or those produced in Horseshoe) from immigrating into conservation areas and causing harm to covered species.
9. Reservoir operations and fisheries management of Bartlett are not expected to change appreciably from historic or current conditions; therefore, there is little, if any, expected modification from baseline of fish habitat or populations between Bartlett and Horseshoe under any alternative.
10. Bartlett operations that benefit non-native fish, which pass through or over the dam, will have the greatest impact near the dam and will gradually decrease downstream with increased distance from the dam and as the fish community shifts from a more native composition near the outflow to primarily non-native near the downstream terminus of the Action Area.

The Committee came to consensus on the magnitude of the various other contributing factors impacting native fish species within each reach of the Action Area. The magnitude of the impacts from contributing factors was rated 0 to 5. The next step in the evaluation was to view the cumulative magnitude of all contributing factors within each reach and to assign a relative percent contribution (or percent responsibility) of future reservoir operations on native fish populations and habitat. For example, the relative percent of impact on native fish in the Verde Valley (Reach 5) from reservoir operation was agreed to be very low, less than 5% based on the fact that it is more than 50 miles upstream of Horseshoe, most riparian land in the Verde Valley is privately owned and heavily populated, the stream is impacted by numerous water diversions, extensive grazing, and mining, the river has self-sustaining populations of non-native fish, and AGFD seasonally stocks the area with rainbow trout. This process was completed for each reach of the mainstem Verde River and the six tributaries determined to be within the Action Area as described in Section 2.0.

The final step in the analysis was to multiply the percent contribution within each reach by total reach length to calculate the number of river miles impacted by reservoir operations. This process was repeated for each of the four alternatives (see Table 5-1). River miles impacted within the tributaries were assumed to be similar among all alternatives, and the percent relative impact was calculated using a process that averaged the continuum of decreasing impacts as described below:

Oak Creek

- Estimated reservoir impact at the confluence is 5%
- Reach extends to the first instream low-water road crossing located 3 miles upstream (near Oak Creek Estates)
- There are >6 water diversions upstream of this point to Page Springs hatchery (Jim Cooper, SRP Water Rights, pers comm.).
- The midpoint of 0 to 5% = 2.5% impact over the reach (which reflects the continuum impacts steadily decreasing above the confluence)
- 2.5% of 3 miles = 0.08 miles of relative impact.

Wet Beaver

- Estimated reservoir impact at the confluence is 5%
- Stream reach at the confluence is intermittent during the growing season, thus the impact was reduced by 1/3. (0.666 * 5% = 3.33%)
- Reach extends to first instream diversion located 12 miles upstream from the confluence near Montezuma's Castle.
- There are at least 6 water diversions in that area, at which point the impact goes to zero.
  The midpoint of 0 to 3.33% = 1.67 %
- 1.67% of 12 miles = 0.2 miles of relative impact.

W. Clear

- Estimated reservoir impact at the confluence is 5%
- Stream reach at the confluence is intermittent during the growing season, thus the impact was reduced by 1/3. (0.666*5% = 3.33%)
- An infiltration basin captures subflow of the river at 1.3 miles above the confluence where the stream dries up during the growing season,
- At 1.96 miles there is the first of 3 water diversions; we extended the reach to this first surface flow diversion.
- The midpoint of 0 to 3.33% = 1.67%
- 1.67% of 2 miles = 0.03 miles of relative impact

Similarly, because Bartlett Lake operations did not vary among alternatives, the Committee determined that considering baseline conditions, operation of Bartlett Dam accounted for 20% of the impact to native fishes in the reach below the dam (Reach 1), and 5% to the reach between the reservoirs.

5.0 Estimate of Adverse Impacts

Estimates of future adverse impacts were identified and discussed by the Committee as described in the previous section. Potential loss occurs in two forms: direct and indirect. Direct loss may result from: 1) individual native fish that are killed or injured as they pass through the outlet works of either Horseshoe or Bartlett dam; or 2) stranding in isolated pools of Horseshoe as water levels are drawn down (the conservation pool of Horseshoe retains water throughout the year). There will be no direct loss of riverine habitat because there will be no increase in maximum reservoir levels under any alternative. Indirect impacts consist of improved lake habitat created by reservoir operations benefiting non-native fish, which contribute to the existing self-sustaining populations of non-native fish that are predators and competitors of listed and other covered native fish species.

The incremental impact of reservoir operations varied greatly among reaches (2 to 80%), but overall impacts were less variable (17 to 22%) among alternatives (Table 5-1). Lack of high variation among alternatives was due to the incorporation of rapid drawdown and minimization of the frequency of carry-over storage among all alternatives, and the high impact of baseline conditions on native fishes in the action area (approximately 80%). The impact analysis for each alternative is described in detail below.

Table 5-1. Estimate of relative reservoir impacts by alternative on native fish communities.

	Mainstem Verde						Tributary Creeks					
	1	**2**	**3**	**4a**	**4b**	**5**	**Lime**	**E. Verde**	**Fossil**	**W. Clear**	**Wet Beaver**	**Oak**
Historical Operations												
River Miles (estimated)	28	21	10	8	44	38	6	8	3	2	12	3
% Reservoir Impact	20%	5%	80%	70%	25%	5%	80%	8%	18%	1.7%	1.7%	2.5%
River Miles Affected	5.60	1.05	8.00	5.60	11.00	1.90	4.80	0.66	0.54	0.03	0.20	0.08
Total River Miles Impacted	**39.46**											
No Permit Alternative												
River Miles (estimated)	28	21	10	8	44	38	6	8	3	2	12	3
% Reservoir Impact	20%	5%	70%	50%	15%	5%	70%	8%	18%	1.7%	1.7%	2.5%
River Miles Affected	5.60	1.05	7.00	4.00	6.60	1.90	4.20	0.66	0.54	0.03	0.20	0.08
Total River Miles Impacted	**31.86**											
Optimal Operation (Preferred)												
River Miles (estimated)	28	21	10	8	44	38	6	8	3	2	12	3
% Reservoir Impact	20%	5%	72%	55%	18%	5%	72%	8%	18%	1.7%	1.7%	2.5%
River Miles Affected	5.60	1.05	7.20	4.40	7.92	1.90	4.32	0.66	0.54	0.03	0.20	0.08
Total River Miles Impacted	**33.90**											
Modified Operation												
River Miles (estimated)	28	21	10	8	44	38	6	8	3	2	12	3
% Reservoir Impact	20%	5%	75%	60%	20%	5%	75%	8%	18%	1.7%	1.7%	2.5%
River Miles Affected	5.60	1.05	7.50	4.80	8.80	1.90	4.50	0.66	0.54	0.03	0.20	0.08
Total River Miles Impacted	**35.66**											

5.1. Impacts of the No Permit Alternative

Under the No Permit Alternative, water would be drawn down rapidly to expose vegetation used for flycatcher nesting at Horseshoe Lake. SRP would coordinate with AGFD and USFWS to prevent future take of individual razorback sucker and pikeminnow that could be stocked in the future in the Verde River. A fish barrier would be built in Lime Creek to prevent impacts to the Gila topminnow populations. There would be no need for coverage for impacts to non-listed fish in the Action Area unless they are listed in the future. However, Horseshoe would be drained for as long as possible each year and would typically be completely drained by June, which would minimize the quantity of spawning habitat for non-native fish. Reservoir levels would be rapidly drawn down to disrupt spawning during early spring and avoid take of flycatchers. However, there would be short periods of relatively stable water levels depending on demand and inflow. The No Permit Alternative does not include reservoir or fisheries management (i.e., stocking) to benefit razorback sucker. Razorbacks would not benefit from maintaining high water levels and this alternative would not support or provide suitable spawning/grow-out habitat for a sustainable razorback population.

Considering baseline conditions and the effects of operations on nonnative fish production and recruitment, the Fish and Watershed Committee determined that the No Permit Alternative would impact covered native fish species within the equivalent of approximately 31.9 river miles in the Action Area (Table 4-1. As stated above, SRP would work with AGFD and USFWS to prevent harm to razorback sucker and Colorado pikeminnow due to reservoir operations, and a fish barrier would be constructed in Lime Creek to prevent harm to Gila topminnow.

5.2. Impacts of the Historical Operation Alternative

Under this alternative, water would be drawn down at historical rates based on demand and reservoir management constraints (Figure 4-1). Horseshoe would be empty typically by mid summer in average and below average water years (Figure 4-1 and Figure 4-2). Historical operation would provide two months of slow and two months of rapid drawdown rates (Table 4-1). Time of rapid drawdown would begin in May, which intersects (interrupts) the greater part of the spawning period for most nonnative species (Figure 4-1), and intersects the midpoint of the spawn (i.e., may have less impact) for bass, black crappie, carp, and threadfin shad. This drawdown timing could allow more non-native fish to reproduce in mid-late spring relative to other alternatives. The reservoir, on average, would be emptied by July, and held at a minimum level for 4 months. Approximately 50% of the time of the time the reservoir would be empty during the spawn for early season breeders: bass, carp, threadfin shad, and there would be no storage approximately 33% to 50% during the spawn for the other species, which would reduce the frequency habitat is available for reproduction. The reservoir would be drained every year except during extreme events that were estimated to occur 1:113 years, which would minimize survivorship of larvae and adults. The Fish and Watershed Committee determined, based on these parameters and baseline conditions, that the Historical Operation alternative would impact the equivalent of approximately 39.5 river miles in the Action Area (Table 4-1).

5.3. Impacts of Modified Full Reservoir Operation

The Modified Full Operation Alternative would store water in Horseshoe whenever possible to promote riparian vegetation in the upper end of the reservoir. Under this alternative, spawning and nursery habitat for razorback sucker (and other species) would also be provided during the key months of January and February in average and above-average years to encourage grow-out and recruitment in the juvenile age classes so that dispersal could take place while the reservoir is subsequently drawn down and survival may be improved. Rapid drawdown is a component of this operational alternative. While rapid drawdown begins within the same month as the Optimum Alternative (but is slightly delayed) and a month earlier than Historical Operation, the reservoir levels are higher in April than other alternatives and three months are required to drain the lake to a minimum pool (Figure 4-1, Table 4-1). Timing of rapid drawdown would intersect (interrupt) the midpoint of the spawning period for most nonnative species (Figure 4-1), thus having less detrimental affects to non-native fish than Optimum Operations. Approximately 40% to 45% of the time the reservoir would be empty during the spawn for early season breeders: bass, carp, threadfin shad, and there would be no storage approximately 33% to 50% of the time during the spawning periods for the other species (Figure 4-1 and Figure 4-3; Table 4-1, which would reduce the frequency habitat is available for reproduction. The reservoir would be drained every year except during extreme events (estimated to occur 1 in 113 years) to minimize carry-over storage, which would reduce available spawning habitat and decrease survivorship of larvae and adults (Section 3.3). The Committee believed that the additional storage of high water, which could benefit non-native fish reproduction, was not offset by the rapid drawdown impacts, grow-out benefit to razorback sucker, and maintenance of willow flycatcher at higher reservoir elevations. The Fish and Watershed Committee determined that, based on these parameters and baseline conditions, Modified Full Operation of the reservoirs would impact the equivalent of approximately 35.7 river miles in the Action Area (Table 5-1).

5.4. Impacts of Optimum Operation Alternative

The Optimum Operation Alternative is intended to best balance: 1) the need to provide suitable flycatcher and cuckoo habitat for longer durations over the term of the permit at the upper end of Horseshoe; and 2) the need to address impacts of Horseshoe operations on covered fish species and critical habitat, while meeting SRP's other stated operational goals and delivery objectives. To the maximum extent practicable, adverse impacts of the proposed action not mitigated by reservoir operations would be addressed through additional mitigation and minimization activities.

On average, the Optimum Reservoir operation would initiate rapid drawdown 4 to 6 weeks earlier than the Historical Operation Alternative when feasible (Figure 4-1). Lowering water levels earlier in the spring (beginning March-April) would maintain availability of flycatcher and cuckoo habitat, and reduce the likelihood of successful non-native spawning and subsequent carryover of non-native larval and young-of-year fish (Figure 4-1; Table 5-1). On average, timing of rapid drawdown would intersect (interrupt) early and middle portions of bass, black crappie, carp, threadfin shad spawning periods, and interrupt much of the spawning periods for the remaining species (Figure 4-1). During years when water release is delayed (i.e., NCS, or vegetation mitigation) the drawdown and concomitant impacts to non-native fish would parallel the

Historical Operations (see above). Approximately 45% to 55% of the time the reservoir would be empty during the spawn for early season breeders: bass, carp, threadfin shad, and there would be no storage approximately 55% to 97% of the time during the spawn for the other species (May – September), which would reduce the frequency habitat is available for reproduction. The reservoir would be drained every year except during extreme events (estimated to occur 1 in 113 years) to minimize carry-over storage, which would reduce available spawning habitat and decrease survivorship of larvae and adults (Section 3.3). Reducing the reproduction and recruitment of non-native fish also might benefit the recruitment and survival of razorback sucker within the reservoir. However, less floodplain/inundated lake bottom, both in area and duration, would be available during the spring for razorback sucker spawning, grow-out, and cover from predators compared to Modified Full or Historical Operations.

The Fish and Watershed Committee determined, based on parameters described above and baseline conditions, that the Optimal Operation Alternative would impact the equivalent of approximately 33.9 river miles in the Action Area (Table 5-1). Impacts would be offset by mitigation actions (Section 6), including stocking adult or sub-adult razorback in the lake, which are expected to grow, and then disperse when water levels fall. As noted above, stocked razorbacks would benefit from increased habitat and forage, and lower predator densities during high reservoir levels (i.e., the lake will have been empty for two years limiting non-native fish survival and carry-over), however, the frequency of habitat available for razorbacks would occur less often (1 in 13 years) compared to Modified Operations (1 to 3 years).

6.0 Recommended Mitigation Strategies and Adaptive Management

6.1. Purpose

To present the approach to address incidental loss and adverse impacts of critical habitat with respect covered species in the Horseshoe and Bartlett HCP.

Overall Goal: Minimize and mitigate the impacts of the action to the maximum extent practicable and avoid adverse impacts to critical habitat. The primary means to achieve this goal will be:

1. Minimizing or reducing non-native fish reproduction, recruitment, and movement;
2. Increasing native fish recruitment, distribution and relative abundance; and
3. Maintaining water flows in the Verde River above Horseshoe

6.2. Introduction

Future loss described in Sections 5 and 6 is anticipated to occur from an incremental increase in predation/competition by non-native fish produced in the reservoirs, or by direct loss of individuals within the reservoirs (e.g., by stranding or passage through outlet works). This is the take that would be addressed by the Horseshoe and Bartlett HCP. Based on fish community movement and dispersal behaviors and scientific literature, the estimate of the portion of the Verde in which native fish could be impacted by future reservoir operations is between Granite Reef dam and upstream reaches of the Verde River and tributaries not restricted by physical or other barriers as described in Section 2.

6.3. Methods

Many possible mitigation and minimization activities (collectively, “mitigation actions”) were suggested by SRP, AGFD, USFWS, and others. Because of the difficulty to convert mitigation actions into river miles of native fish habitat benefited, the following approach was developed by the Committee. Like the evaluation of impacts, the Committee’s approach to calculating mitigation credits followed the conceptual framework of Habitat Equivalency Analysis (NOAA 2000). This process involved developing a Mitigation Credit Matrix by working through the following steps:

1. Evaluating the technical feasibility of each proposed mitigation action – actions that were considered to have a low technical feasibility were eliminated from further analysis.
2. Establishing a set of four criteria to evaluate mitigation actions.
3. Reaching consensus on the degree each mitigation action satisfied the criteria (expressed as a percentage).
4. Calculating the total river miles potentially suitable and feasibly available for the mitigation action, based on baseline presented in Section 3.
5. Assigning the percentage contribution from SRP to the mitigation actions for shared projects.

6. Calculating the total possible river miles available for mitigation by each action (total river miles available multiplied by the percent contribution from SRP).
7. Calculating the relative mitigation credit as described below.

Mitigation credit = the total possible river miles available for mitigation multiplied by the overall degree of criteria satisfaction (described in more detail below).

This approach provided a process for estimating the various proposed mitigation actions that is consistent and equivalent to the estimate of relative impacts presented in Section 5. Note that the total of mitigation credits available exceeds the determination of impacts because implementing all the available mitigation actions would greatly exceed the level of estimated loss from reservoir operations.

7.0 Mitigation Actions and Credits

A list of 20 potential mitigation actions was compiled from earlier proposals by SRP and Phoenix, a proposed State Conservation Strategy for native fish (AGFD 2005d), and input and comments from AGFD and the USFWS. These 20 mitigation actions fall into nine general categories, including:

- Operations (level of fill, timing and rate of releases)
- Fish barriers
- Non-native fish removal (angler pressure, chemical/physical removal)
- Native fish stocking (hatchery improvements; numbers, species and locations of stocking, salvage and relocation)
- Habitat enhancement (refugia ponds, gravel washing)
- Statewide conservation (SCA)
- Education
- Research and surveys
- Watershed efforts

The list of specific proposed mitigation actions and associated relative mitigation credits is provided in the Mitigation Credit Matrix (Table 7-1).

7.1. Mitigation Credit Matrix

One of the first tasks in developing the Mitigation Credit Matrix was to establish a set of criteria for evaluating each individual mitigation action. Mitigation Criteria (in no special order):

1. Directly mitigates/minimizes the adverse impacts to listed species or potential adverse modification of critical habitat resulting from the proposed action (e.g., stocking razorbacks into Horseshoe mitigates adverse impacts from stranding/internment of native fish caused by reservoir operations, whereas actions that primarily benefit headwater species have a lower value).
2. Geographical relationship to impacted areas (areas close to highly impacted areas (reservoirs) are valued higher than more distant locations).
3. Number of native species benefited (mitigation actions that benefit more species of native fish are valued higher than actions that benefit a single species).
4. Effectiveness (proposed mitigation actions that effectively accomplish the stated objective, including actions that potentially lead to self-sustaining populations are valued higher than actions dependant on perpetual management).

The Committee held several workshops/conference calls to work each proposed mitigation action through the Mitigation Credit Matrix until consensus was reached on river miles available for each mitigation action and the degree (%) each action satisfied the evaluation criteria. Total mitigation credit for each action was calculated by multiplying available river miles by the overall criteria satisfaction (an average of the satisfaction rating for each of the four criteria). The cumulative total of mitigation credits available from all possible mitigation actions was 93.2 river miles. The 20 mitigation actions were compared side-by-side and the most cost-effective and biologically effective mitigation were selected for implementation. Final mitigation/minimization efforts consist of a combination of actions selected by SRP/Phoenix, in consultation with USFWS, to offset the total level of impacts. The proposed SRP mitigation package results in 81.2 river miles of credit to offset approximately 34 river miles of relative impacts from the Optimal Operation. Thus the available credits greatly exceed the level of impacts.

7.2. Proposed Minimization/Mitigation Measures

The following minimization and mitigation measures would be employed as initial components of the HCP:

a) **Rapid Drawdown** — The rapid drawdown component of Optimum Operation would minimize adverse impacts on native fish, which reduces the need for mitigation by 5.4 river miles downstream and 16 river miles upstream of Horseshoe.

b) **Stocking of Small (Fingerling) or Adult Razorback Sucker Into Horseshoe** — SRP would provide funding support for AGFD to stock razorback sucker during Horseshoe fills as conditions permit (every 3 to 4 years on average during high water years (e.g., 2005) and years when flycatcher habitat maintenance goal is in effect). The mitigation credit for this component is 16.4 river miles.

c) **Install Fish Barrier on Lime Creek** — SRP would pay 100% of the cost of construction of a fish barrier on Lime Creek to benefit the Gila topminnow and longfin dace. The mitigation credit for this component is 3.4 river miles.

d) **Bubbling Ponds Native Fish Hatchery Improvements and Support** — SRP would provide $500,000 in contributions and in-kind support for planning, design, engineering, and fund-raising to improve and expand the Bubbling Ponds Native Fish Hatchery to benefit all mainstem species. The mitigation credit for this component is 20.5 river miles.

e) **Stocking of Native Fish in the Verde Watershed** — SRP would provide funding support for AGFD to stock native fish annually into the Verde watershed, including the Action Area, to benefit covered and other native fish species. The mitigation credit for this component is 11.4 river miles.

f) **Watershed Management Efforts** — SRP would continue, and expand where feasible, their substantial watershed management efforts to maintain or improve stream flows to benefit all mainstem species. These efforts include: 1) funding of stream gages and scientific studies; 2) funding and in-kind support for watershed improvements; and 3) administrative and legal efforts to curtail stream flow reductions from illegal surface water diversions and ground water pumping. As examples, the following is a partial list of Verde River water management activities over the past 5 years. Similar types of efforts and expenditures are expected for the foreseeable future. However, without a 10(a)(1)(B) permit for operation of Bartlett and Horseshoe Reservoirs, most water management activities would be curtailed because water management is primarily useful if SRP has the ability to store water in the reservoirs. While these activities do not directly address the anticipated impacts of reservoir operations on native fish, these water conservation activities do provide ancillary benefit to the fish community by helping ensure perennial flow in the Action Area in the face of increasing demands. The minimization and mitigation credit for this measure is estimated to be 8.0 **river miles**.

- **Aerial Photos.** Aerial photos of the Verde watershed are flown approximately every 5 years. These photos are used for various management and monitoring purposes. For example, photos were recently made available to Scott Bonar and his graduate students for their study of native and non-native fish and their habitats. Estimated cost = $30,000/set.
- **GIS Data.** GIS coverages and data files are developed and updated for land and water uses in the Verde watershed, which are used for management and monitoring. Estimated cost = $100,000/year.
- **Staff Time and Expenses.** SRP Water Group staff, consultants, and attorneys participate in a wide variety of studies, meetings, forums, groups, legal proceedings, and other activities involving Verde River water management. Estimated cost = $220,000/year.
- **Standard Stream Gages.** SRP helps fund 9 gages in the Verde watershed, including satellite telemetry and technical support. Estimated cost = $75,000/year.
- **Low Flow Stream Gages.** SRP has helped to install 3 low flow gages (Campbell Ranch below Paulden, Black Bridge at Camp Verde, and Verde Falls below Camp Verde) to monitor potential depletions of base flow from ground water pumping. Initial cost = $200,000, plus on-going O&M expenses. Reclamation helped fund the gages near Camp Verde.
- **NAU Verde Watershed Research and Education Program.** SRP has contributed to this program for the past 5 years. Total cost = $250,000.
- **Geologic and Ground Water Studies.** SRP has provided recent funding to the USGS and NAU in support of data collection, geologic map production, and studies of springs to evaluate ground water resources and pumping impacts. Estimated cost = $50,000.
- **Prescott National Forest.** SRP funded a test site for juniper clearing. Cost = $20,000.
- **Funding of Watershed Initiatives.** Contributions to watershed groups for education and clean-up efforts, including: the Verde River Monitoring Program, Verde Canyon Railroad trip on watershed issues, Master Watershed Steward Program through Yavapai County Cooperative Extension, Arizona Watershed Alliance, Verde Watershed Association, and Oak Creek Canyon Task Force. Estimated cost = $25,000.

The overall mitigation credits assigned to the proposed SRP Mitigation Package totals **81** river miles. Because of the uncertainties inherent in assigning both an estimate of relative reservoir impacts and relative mitigation credits (expressed in surrogate terms of river miles), SRP has proposed to implement a suite of mitigation actions where the cumulative credits exceed the estimated level of impacts. The 81 river miles of credits are more than double the 34 river miles of relative impacts from the Optimum Operation Alternative, which more than offsets any uncertainty in their effectiveness.

7.2.1. Monitoring and Adaptive Management

Monitoring of native fish populations and effectiveness of the minimization and mitigation measures would require periodic surveys in Horseshoe and at several locations on the Verde above and below Horseshoe and Bartlett. To the extent feasible, native and non-native fish would be marked to provide data on survivorship and movement patterns to help assess the effectiveness of the minimization and mitigation measures.

SRP would conduct or provide funding for 3 surveys a year on a rotating basis, such that each location is surveyed every other year. Locations of fish surveys would be as follows:

- In Horseshoe
- Above Horseshoe (2 locations to be determined)
- Lime Creek
- At or below Bartlett (2 locations to be determined)

The HCP and Permit would address potential changes of circumstances as follows:

a. If planning and fund-raising efforts to improve and expand the Bubbling Ponds Native Fish Hatchery are unsuccessful, SRP would provide remaining funds and their fund-raising support for improvements and operation of another native fish hatchery, or such other measures designated by USFWS in consultation with AGFD as adaptive management.

b. If the minimization and mitigation actions prove to be ineffective in achieving the desired result of mitigating for native fish, SRP would provide remaining funds for mechanical non-native fish removal efforts in select mainstem reaches or tributaries in the Verde watershed or such other measures designated by USFWS in consultation with AGFD.

c. If monitoring efforts find non-native fish Lime Creek above the barrier, SRP would fund rehabilitation of Lime Creek.

d. If monitoring associated with this permit or unrelated fish sampling conducted by AGFD or another entity indicate a reservoir influence on tributaries (e.g., tagged fish migrating upstream of Horseshoe) sampling locations above Horseshoe can be moved/modified as appropriate.

e. If tagged fish are found near Wet Beaver or West Clear confluences we would include sampling sites in those tributaries. Additional funds would be made available to the existing conservation actions (hatchery improvements, stocking efforts), or if state and federal agencies have native fish projects (e.g., renovations) scheduled at that time (or foreseeable future) in the Verde basin, SRP could contribute to those efforts.

7.3. Management and Maintenance of Minimization and Mitigation Measures

SRP would fund annual management and mitigation measures for native fish for the duration of the permit as follows:

- All costs of Horseshoe drawdown and operations.
- All costs for the actual stocking of Horseshoe with razorback suckers and actual stocking of native fish in the Verde watershed as provided by the HCP.
- All costs for the maintenance of the Lime Creek fish barrier, and rehabilitation, if necessary.
- $25,000/year for operation and maintenance costs of the Bubbling Ponds Native Fish Hatchery.
- All costs for SRP watershed management efforts.

Table 7-1. Mitigation Credits (in River miles)

Proposed Action	A	B	C (AxB)	D	E	F	G	H	C x H	Comments
	Total River Miles Available for Credit	% Contribution from SRP	Net River Miles	Degree of criteria satisfaction (expressed as %)				Overall Criteria Satisfaction (Avg. D-G)	Total Credit	
				Directly Mitigates Take	Geographic Relationship	Number of Native Species	Effectiveness of Action			
Horseshoe rapid drawdown	7.2	100%	7.2	60%	100%	80%	60%	75%	5.4	Reservoir completely drawn down every year. Drawdown would be initiated and completed earlier in the year and the rate of drawdown would be faster to disrupt non-native fish production
Horseshoe rapid drawdown (upstream)	20.1	100%	20.1	60%	100%	100%	60%	80%	16.0	
Provide for stocking (labor, transport, etc.) of razorback into or above Horseshoe (Sheep Bridge).	27.4	100%	27.4	100%	100%	10%	30%	60%	16.4	Provides a direct benefit to razorback sucker and the PCEs of designated critical habitat. Conducted as conditions permits. Stocking in addition to AGFD effort.
Removal of catch limits (provide incentives) on non-native fish below Bartlett	5.6	10%	0.6	10%	100%	30%	10%	38%	0.2	Most effective in 20 miles below Bartlett dam, however, this action is beyond SRP control
Increase angler access to Horseshoe Lake	7.2	50%	3.6	10%	100%	80%	10%	50%	1.8	Any physical improvements need approval from USFS
Fish barrier installed on Lime Creek	4.3	100%	4.3	100%	100%	20%	95%	79%	3.4	Assumes that future impact to the tributary will be directly connected to reservoir operations. Barrier provides direct and most sustainable mitigation. Renovation of creek as needed as adaptive management.

Proposed Action	A	B	C (AxB)	D	E	F	G	H	C x H	Comments
	Total River Miles Available for Credit	% Contribution from SRP	Net River Miles	Degree of criteria satisfaction (expressed as %)				Overall Criteria Satisfaction (Avg. D-G)	Total Credit	
				Directly Mitigates Take	Geographic Relationship	Number of Native Species	Effectiveness of Action			
Physical removal of non-native fish in tributaries	1.5	50%	0.8	90%	30%	70%	75%	66%	0.5	Best implemented when used in conjunction with barrier and/or possibly prior to stocking natives, dependent on status of native community in the tributary
Chemical removal of non-native fish in tributaries	1.5	50%	0.8	90%	30%	70%	95%	71%	0.5	
Physical removal of non-native fish in mainstem	4.4	0%	0.0	90%	100%	90%	15%	74%	0.0	Chemical and physical removal in mainstem needs documentation of effectiveness - SRP participation would require full AGFD cooperation (socially and politically unpopular).
Chemical removal of non-native fish in mainstem	17.9	0%	0.0	90%	90%	90%	30%	75%	0.0	
Capital improvements to Bubbling Ponds Hatchery and production support to increase capacity and flexibility (incl. brood stock and genetics programs)	32.9	100%	32.9	0%	100%	100%	50%	63%	20.5	SRP is making 100% of it's proposed contribution, capped at $500,000, upfront. SRP will also provide support for federal and state grant money to expand the hatchery (estimated at $7 M, less the $500,000 = $6.5 M), plus annual funding of $25,000/year. Directly mitigates impacts to native fish by addressing the threat of reduced reproduction.

	A	B	C (AxB)	D	E	F	G	H	C x H	
				Degree of criteria satisfaction (expressed as %)						
Proposed Action	**Total River Miles Available for Credit**	**% Contribution from SRP**	**Net River Miles**	**Directly Mitigates Take**	**Geographic Relationship**	**Number of Native Species**	**Effectiveness of Action**	**Overall Criteria Satisfaction (Avg. D-G)**	**Total Credit**	**Comments**
Assist AGFD with stocking native fish (possibly pikeminnow) in Verde watershed where appropriate at various times and size classes depending on fish availability, water (habitat) conditions and stocking strategy	28.5	50%	14.3	100%	80%	90%	50%	80%	11.4	This mitigation has an implied adaptive management as strategies can change as knowledge is gained. Stocking would be guided by location priorities: 1) below Bartlett 2) above Horseshoe 3) tributaries, and species priorities; 1) razorback, 2) chub, 3) native suckers, 4) small stream species.
Assist AGFD with research in Horseshoe and upstream for successful implementation of future activities to reduce threats to Introduced natives (non-native removal)	7.2	20%	1.4	0%	100%	20%	20%	35%	0.5	Research on stocking strategies, movement patterns and fish community interactions. Stocking programs for razorback and pikeminnow have been implemented on the Verde River since 1981
Participate and support State Conservation Agreement (SCA) development (incl. fund AGFD Fish Biologist position)	32.9	20%	6.6	10%	50%	100%	50%	53%	3.4	A state-wide coordinated effort provides potential for long-term sustainable solutions for native fish. Initial efforts of SCA would be focused on the Verde. Uncertainty in completion of SCA
Develop refugia ponds- Upper Verde	14.2	20%	2.8	10%	10%	100%	20%	35%	1.0	Lack of suitable locations on Lower Verde, some potential on Upper Verde, unproven effectiveness
Develop quarantine facility	32.9	50%	16.4	10%	10%	50%	10%	20%	3.3	More suitable for native fish transplant activities

	A	B	C (AxB)	D	E	F	G	H	C x H	
Proposed Action	**Total River Miles Available for Credit**	**% Contribution from SRP**	**Net River Miles**	**Degree of criteria satisfaction (expressed as %)**				**Overall Criteria Satisfaction (Avg. D-G)**	**Total Credit**	**Comments**
				Directly Mitigates Take	**Geographic Relationship**	**Number of Native Species**	**Effectiveness of Action**			
Spikedace/Loach minnow survey	1.5	100%	1.5	0%	10%	20%	10%	10%	0.2	
Fund gravel washing research	0.5	100%	0.5	0%	100%	10%	10%	30%	0.2	Research over small area (0.5 miles) in Reach 1 that may not benefit entire reach.
Fund Information and Education Program	34.0	5%	1.7	0%	1%	100%	1%	26%	0.4	Important component to conservation but difficult to quantify mitigation value
SRP watershed management efforts	20.1	100%	20.1	0%	30%	100%	30%	40%	8.0	No permit would result in less management from SRP: No water = no fish
Total									93.2	
Total of 10 native species covered: razorback, dessert, and Sonoran suckers, pikeminnow, roundtail chub, loach minnow, spikedace, Gila topminnow, speckled dace, longfin dace.										
SRP Mitigation Package Credits									81.2	

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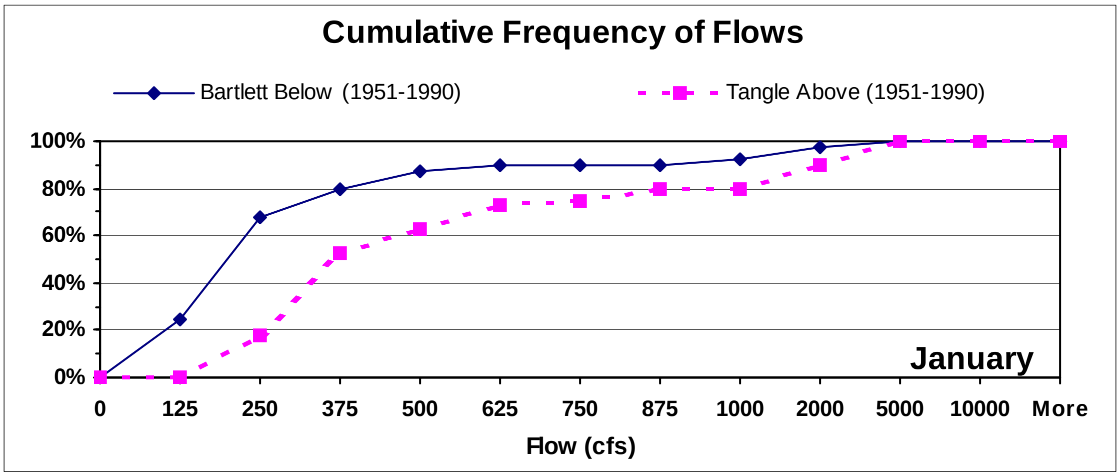
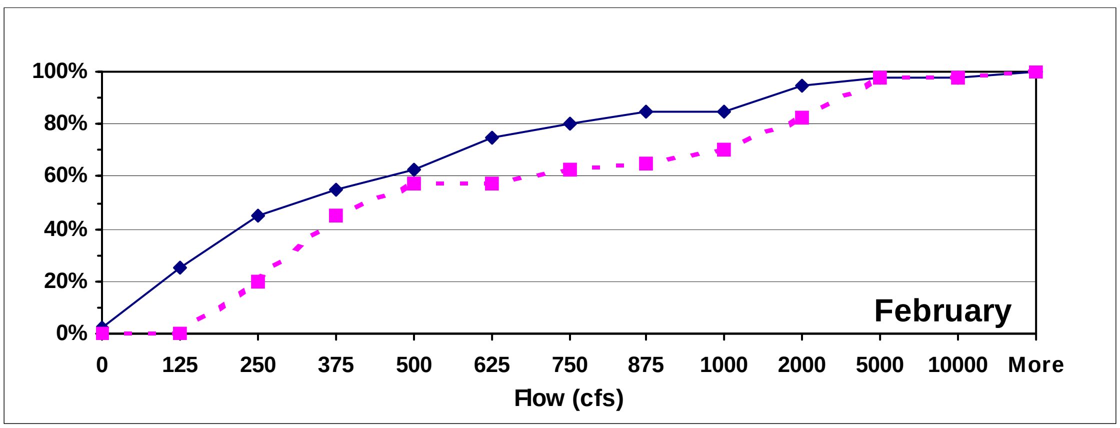
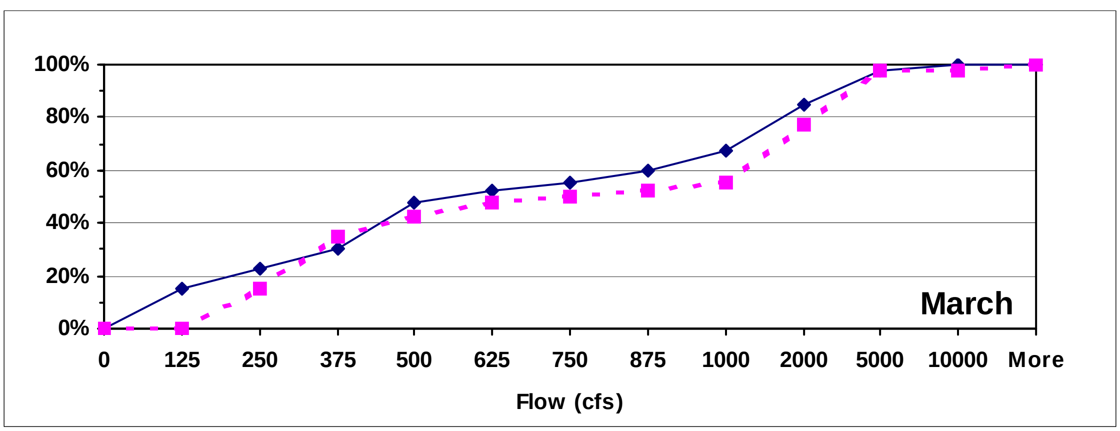
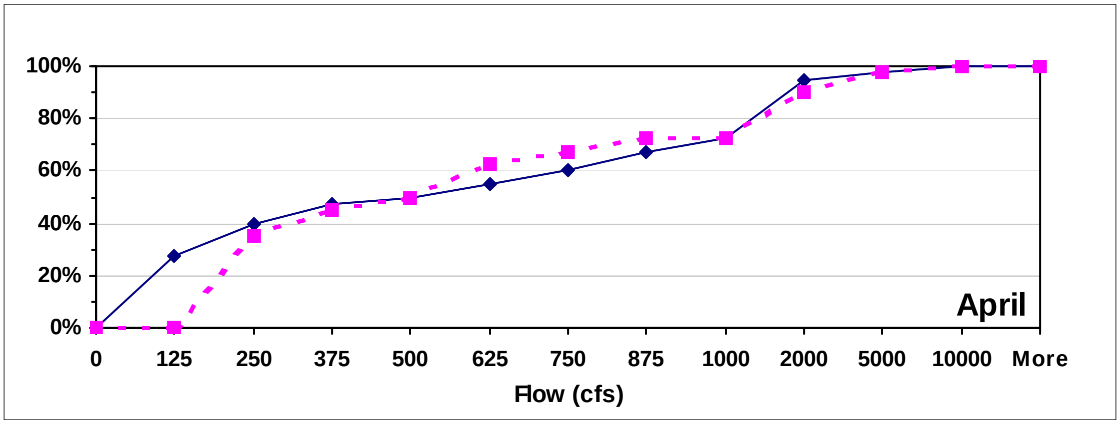
Appendix 1:
Monthly Cumulative Frequency Chart of Verde River Flow Above and Below SRP's Dams 1951-1990

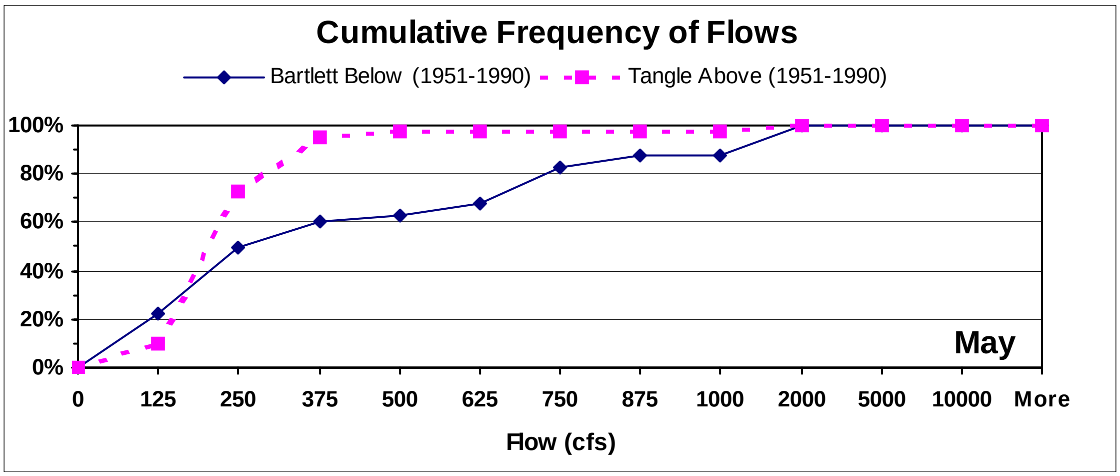
(USGS gage data shown as frequency (%) of flows less than or equal to the flow value on the x-axis)

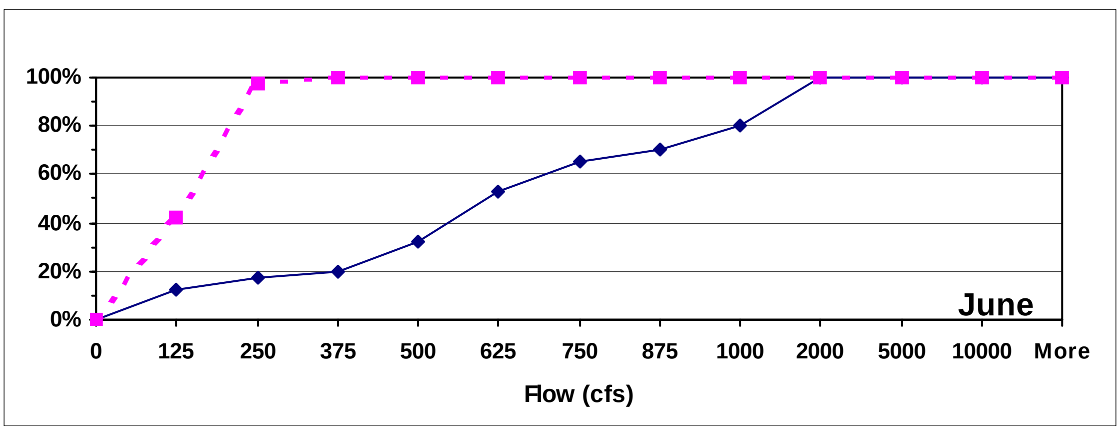


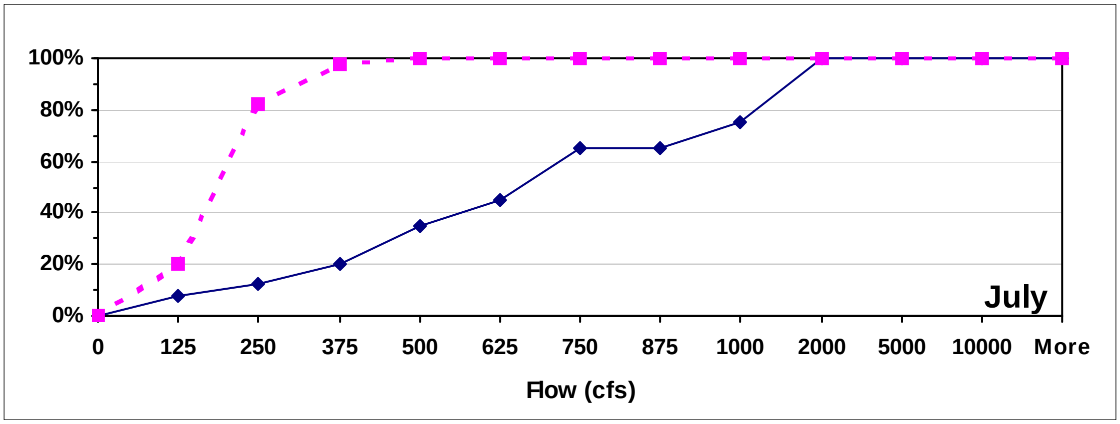


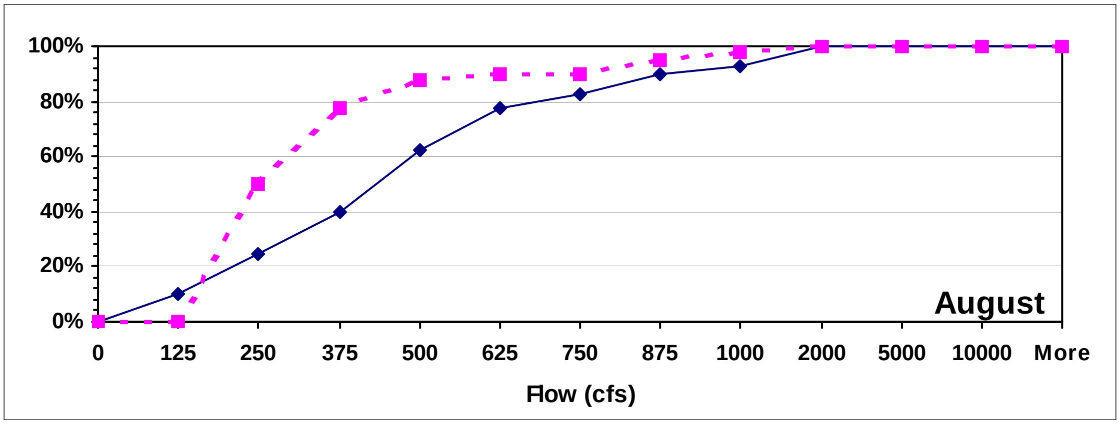


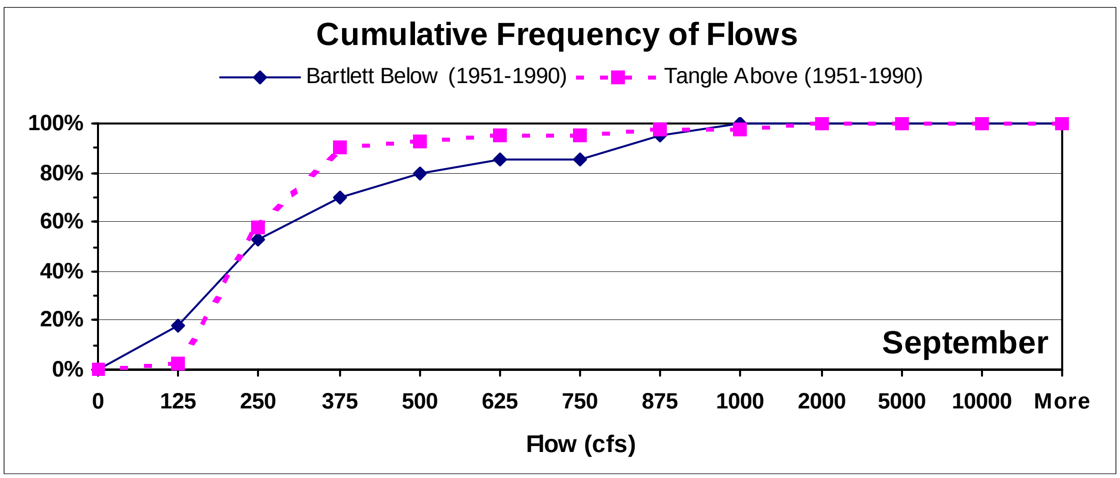

100%
80%
60%
40%
20%
0%
0 125 250 375 500 625 750 875 1000 2000 5000 10000 More
Flow (cfs)
April

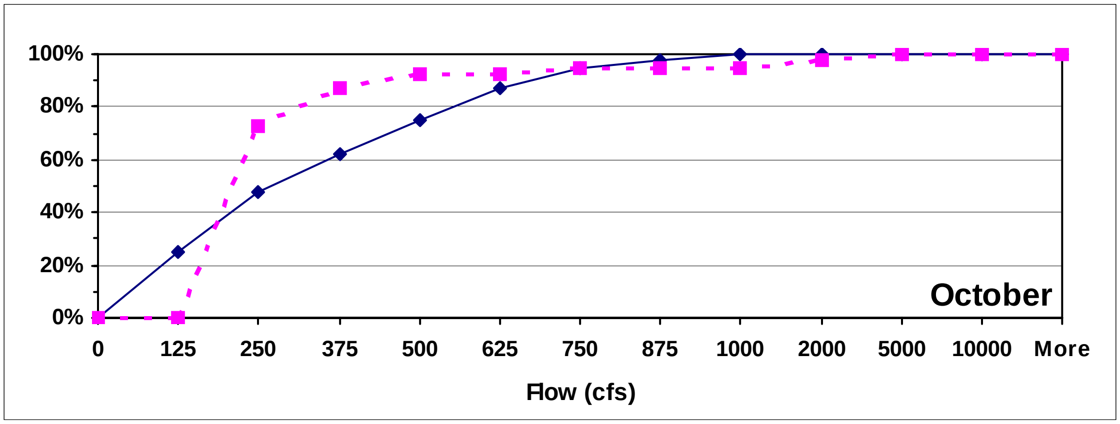

Cumulative Frequency of Flows
Bartlett Below (1951-1990)
Tangle Above (1951-1990)
100%
80%
60%
40%
20%
0%
0 125 250 375 500 625 750 875 1000 2000 5000 10000 More
Flow (cfs)
May

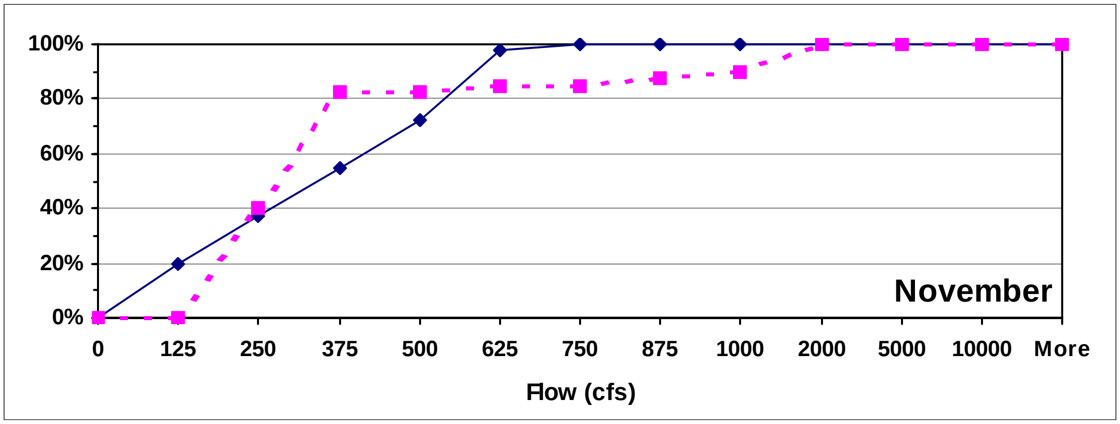

100%
80%
60%
40%
20%
0%
0 125 250 375 500 625 750 875 1000 2000 5000 10000 More
Flow (cfs)
June

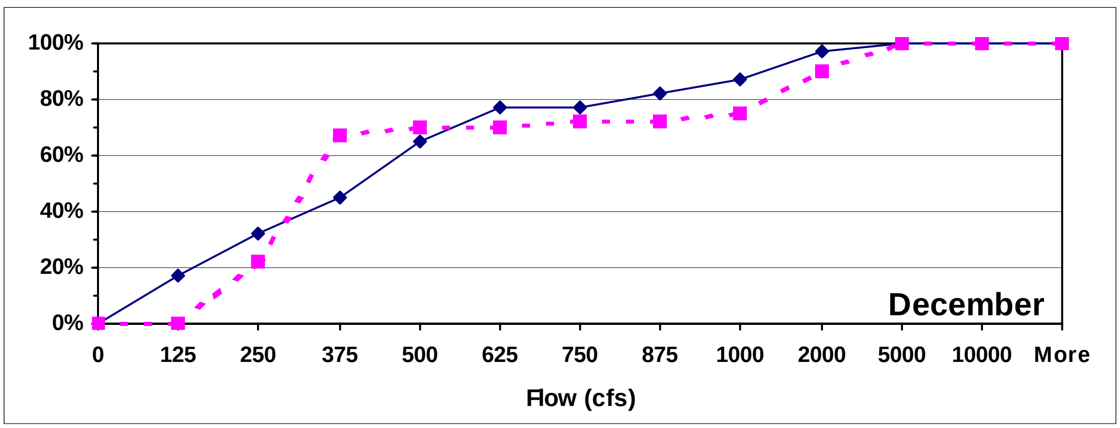

100%
80%
60%
40%
20%
0%
July
0
125
250
375
500
625
750
875
1000
2000
5000
10000
More
Flow (cfs)


100%
80%
60%
40%
20%
0%
August
0
125
250
375
500
625
750
875
1000
2000
5000
10000
More
Flow (cfs)

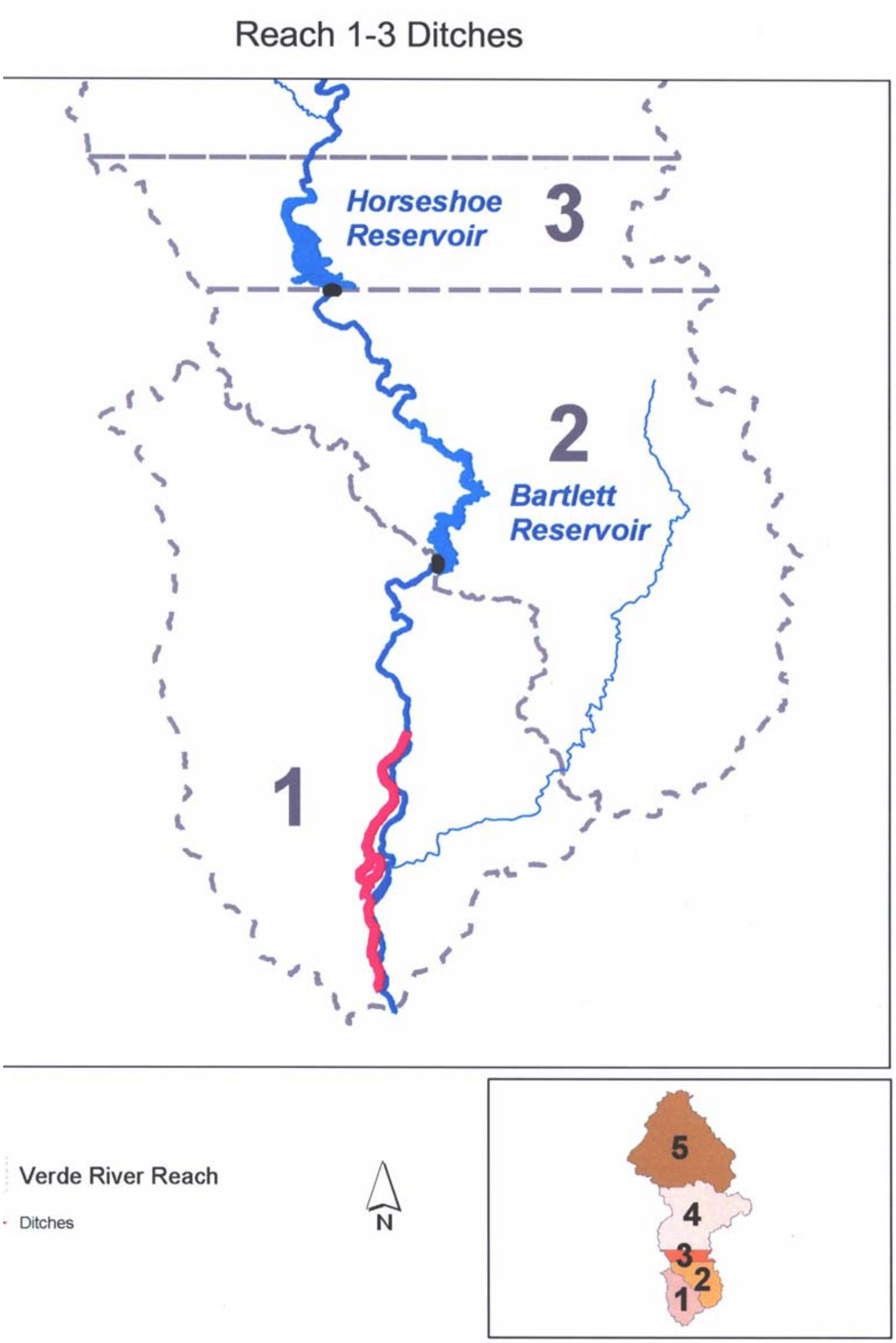

Cumulative Frequency of Flows
Bartlett Below (1951-1990)
Tangle Above (1951-1990)
100%
80%
60%
40%
20%
0%
September
0
125
250
375
500
625
750
875
1000
2000
5000
10000
More
Flow (cfs)

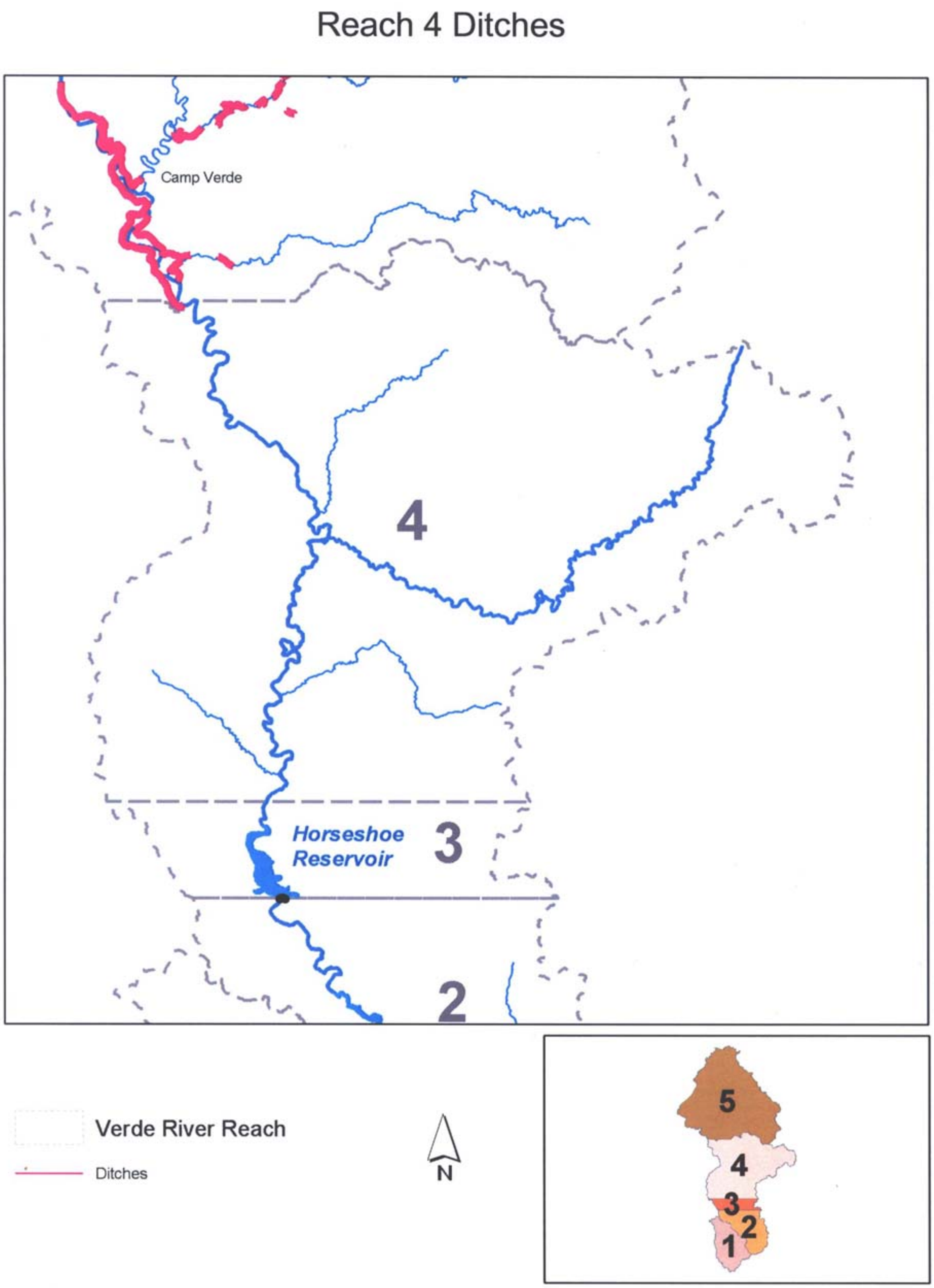

100%
80%
60%
40%
20%
0%
October
0
125
250
375
500
625
750
875
1000
2000
5000
10000
More
Flow (cfs)

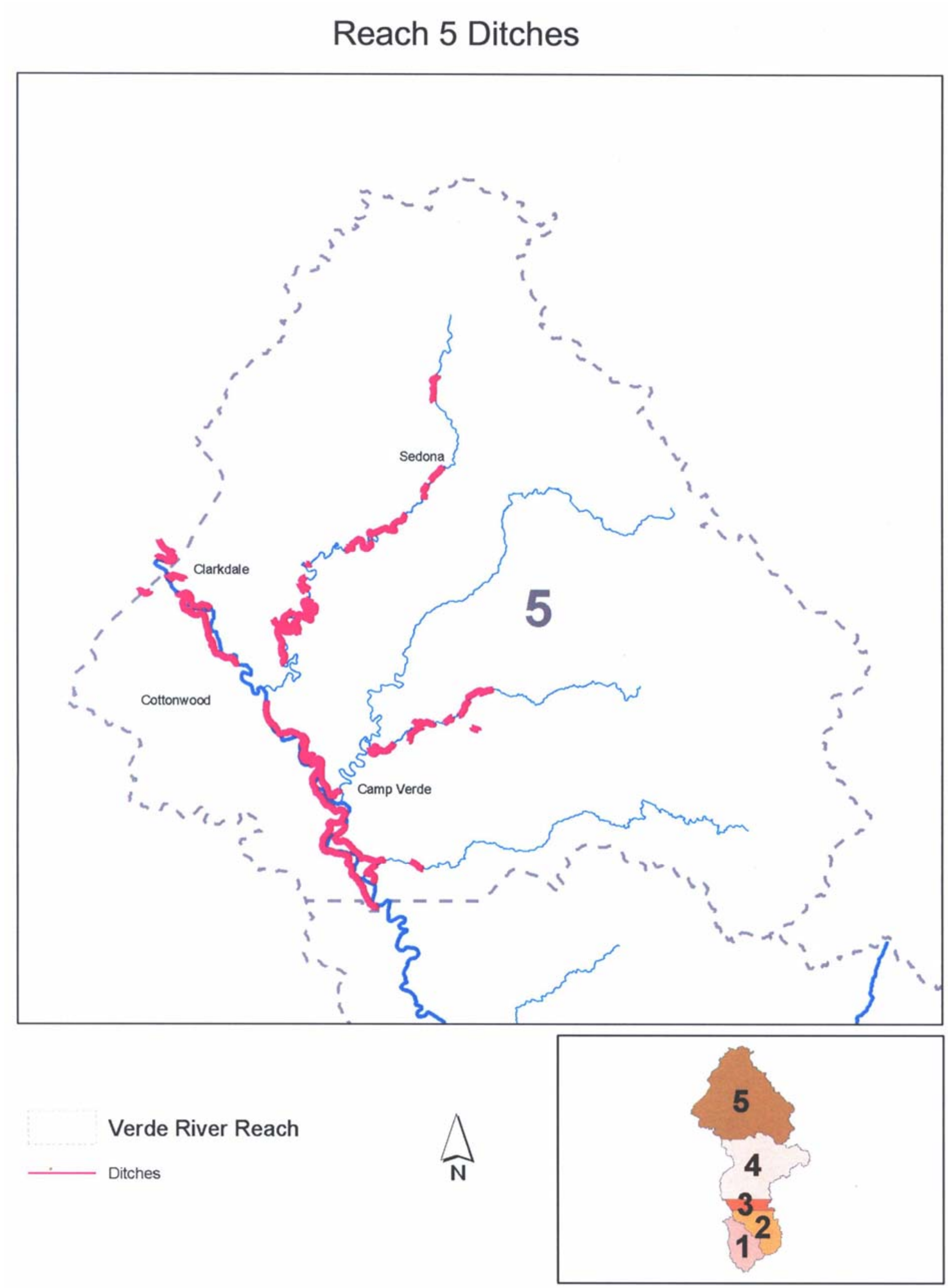

100%
80%
60%
40%
20%
0%
November
0
125
250
375
500
625
750
875
1000
2000
5000
10000
More
Flow (cfs)


100%
80%
60%
40%
20%
0%
December
0
125
250
375
500
625
750
875
1000
2000
5000
10000
More
Flow (cfs)

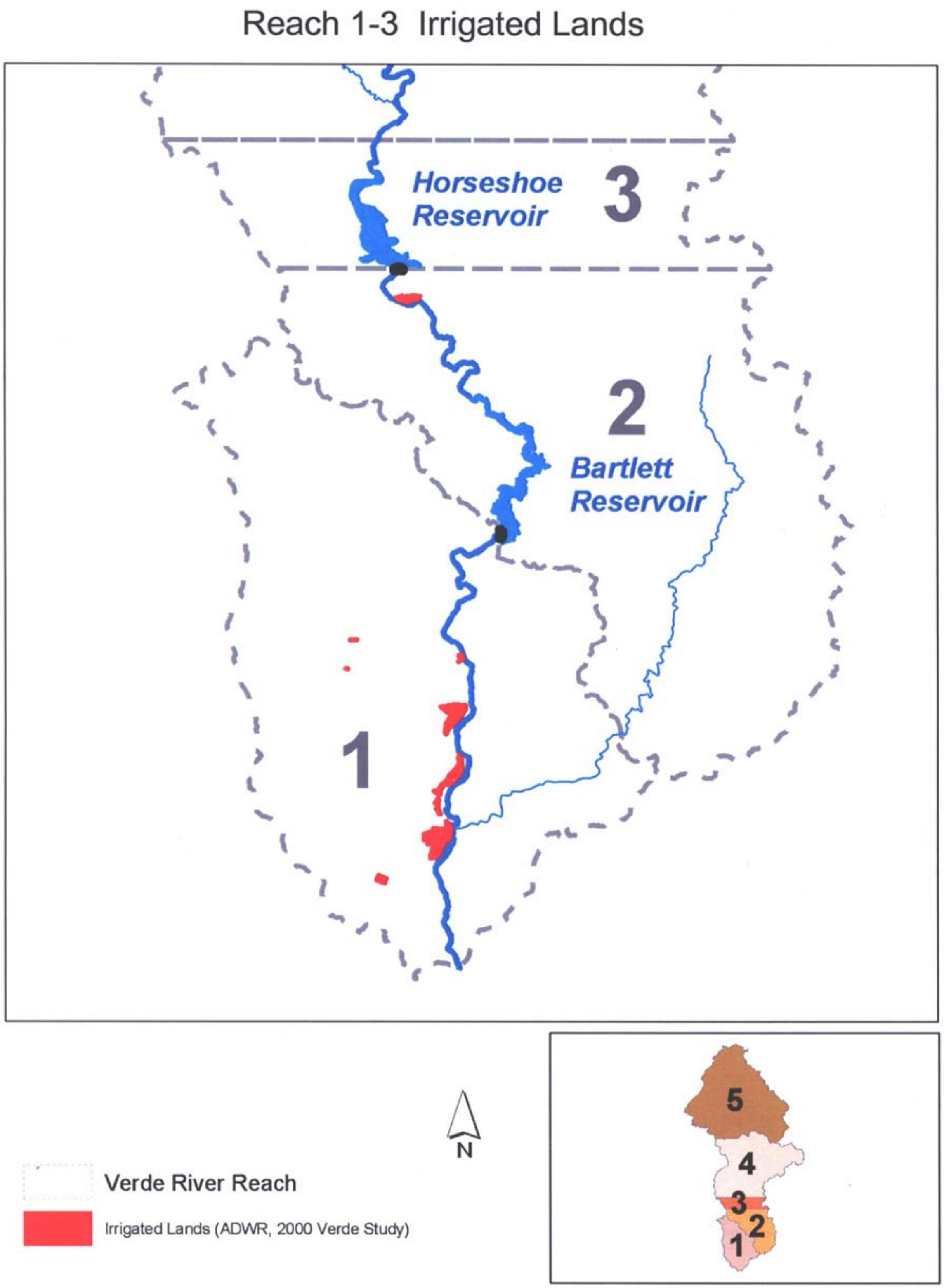
Appendix 2:
Locations of Irrigation Ditches Within the Action Area



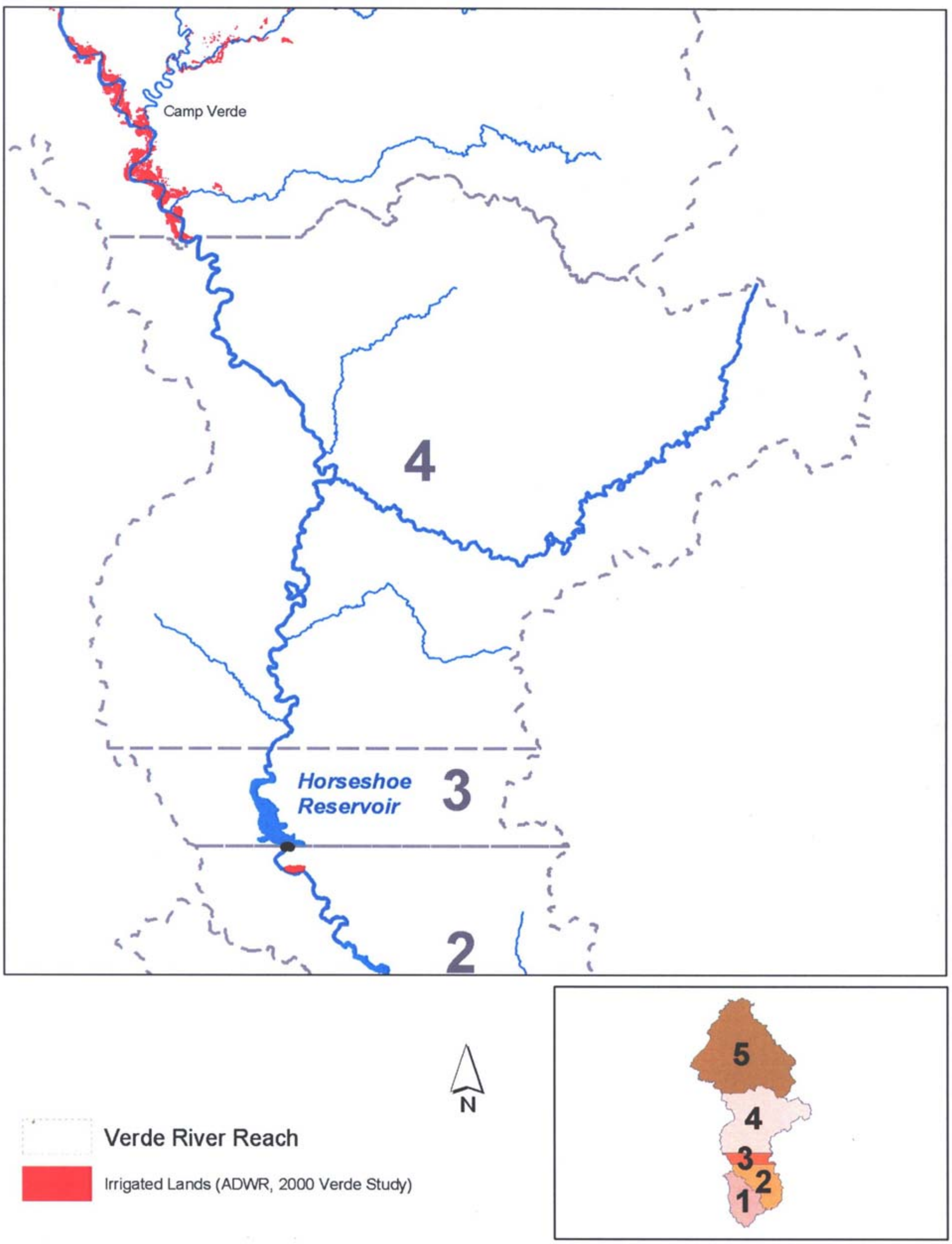

Reach 4 Ditches
Camp Verde
4
Horseshoe
Reservoir
3
2
Verde River Reach
Ditches
N
5
4
3
2
1


Reach 5 Ditches
Sedona
Clarkdale
Cottonwood
Camp Verde
5
Verde River Reach
Ditches
N
5
4
3
2
1

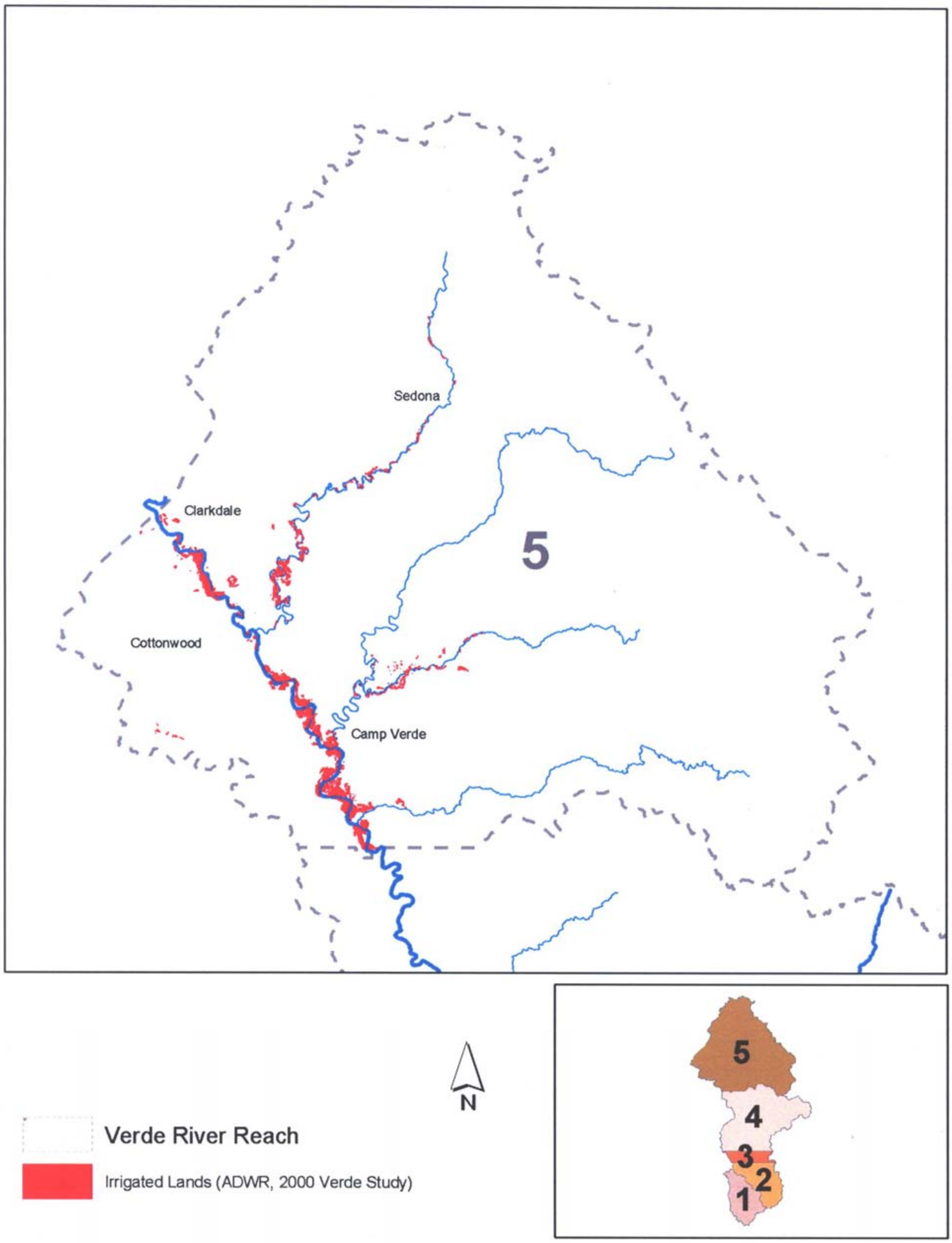
Appendix 3:
Locations of Irrigated Lands Within the Action Area



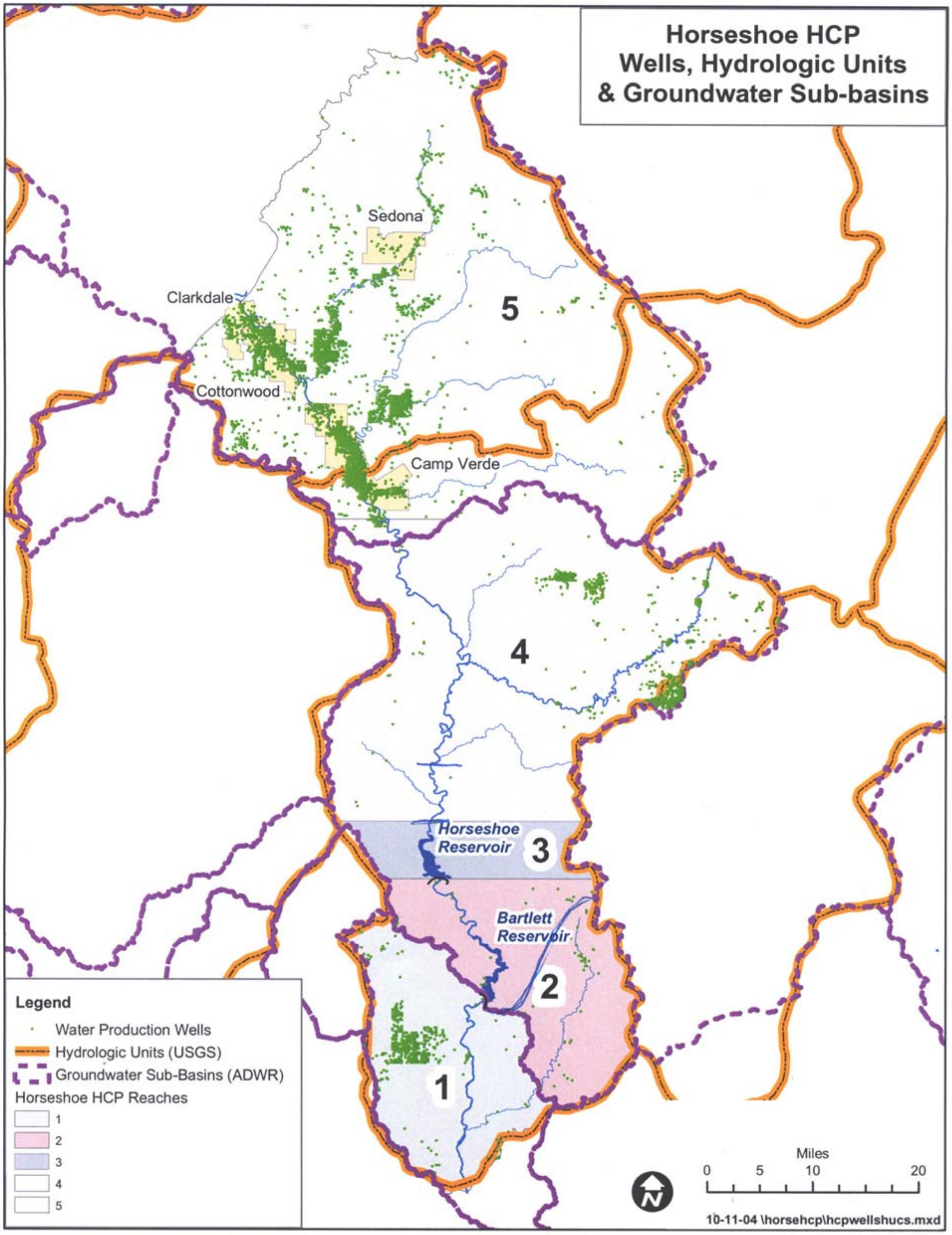
Reach 4 Irrigated Lands

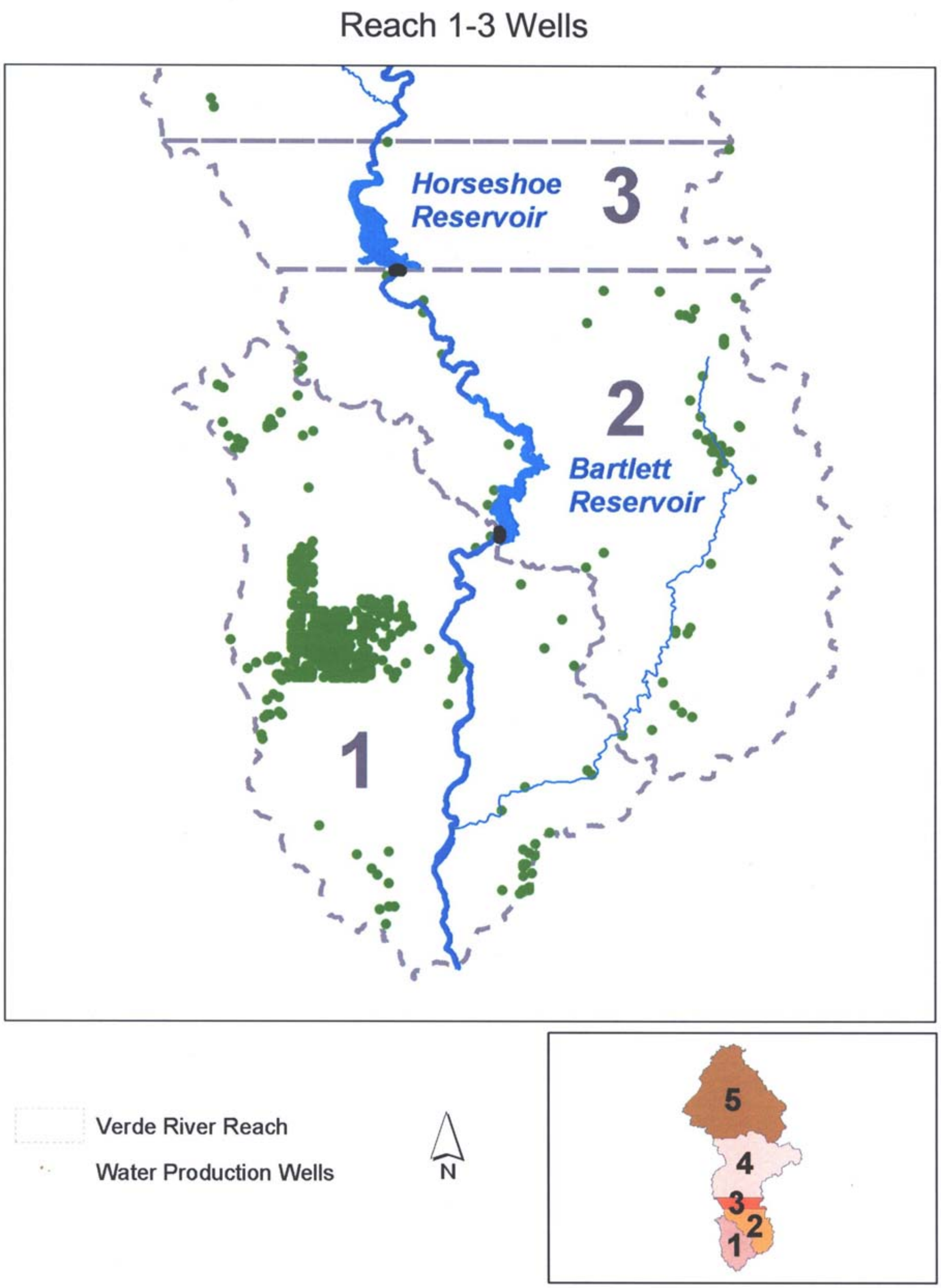


Reach 5 Irrigated Lands

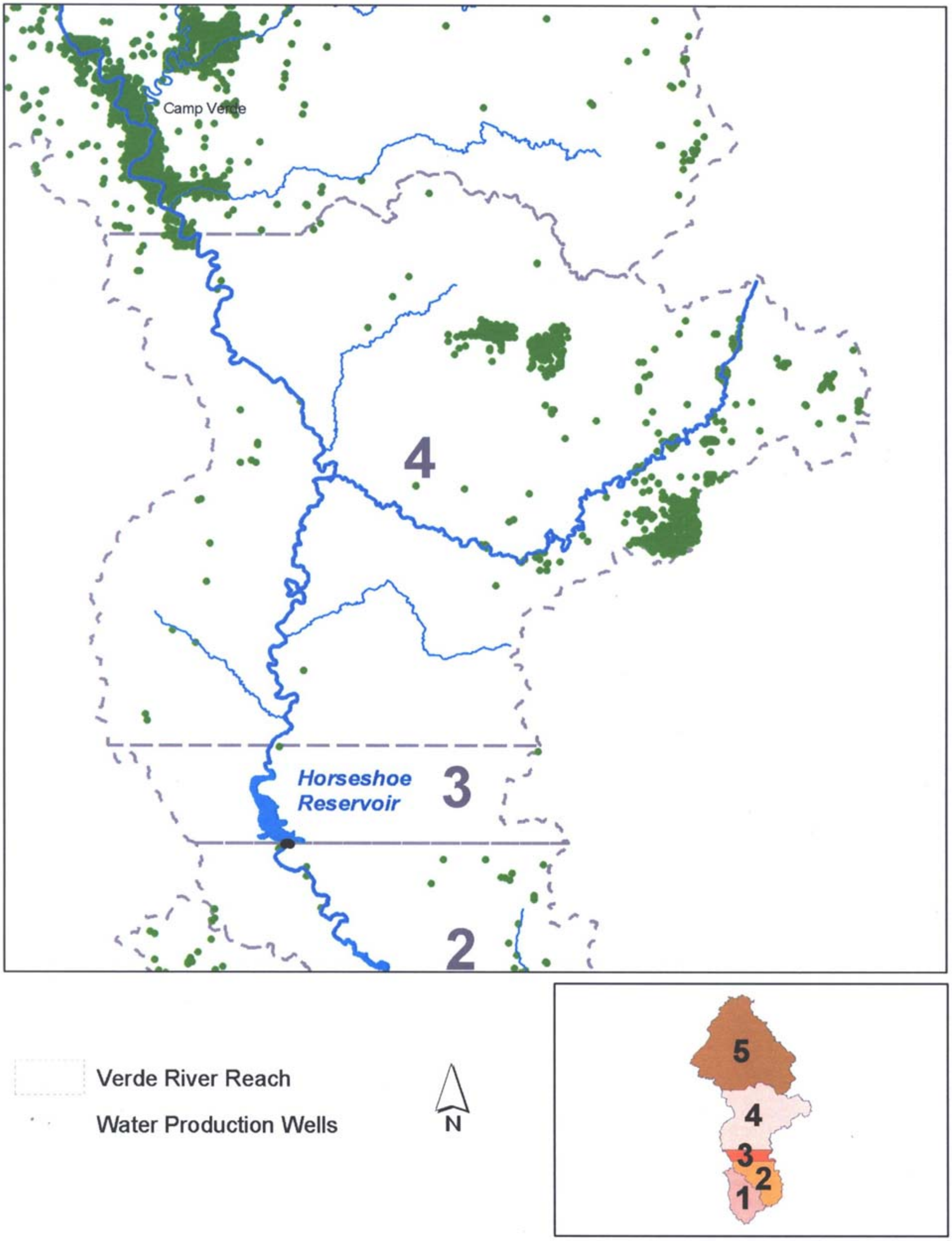


Appendix 4:
Locations of Ground Water Wells Within the Action Area

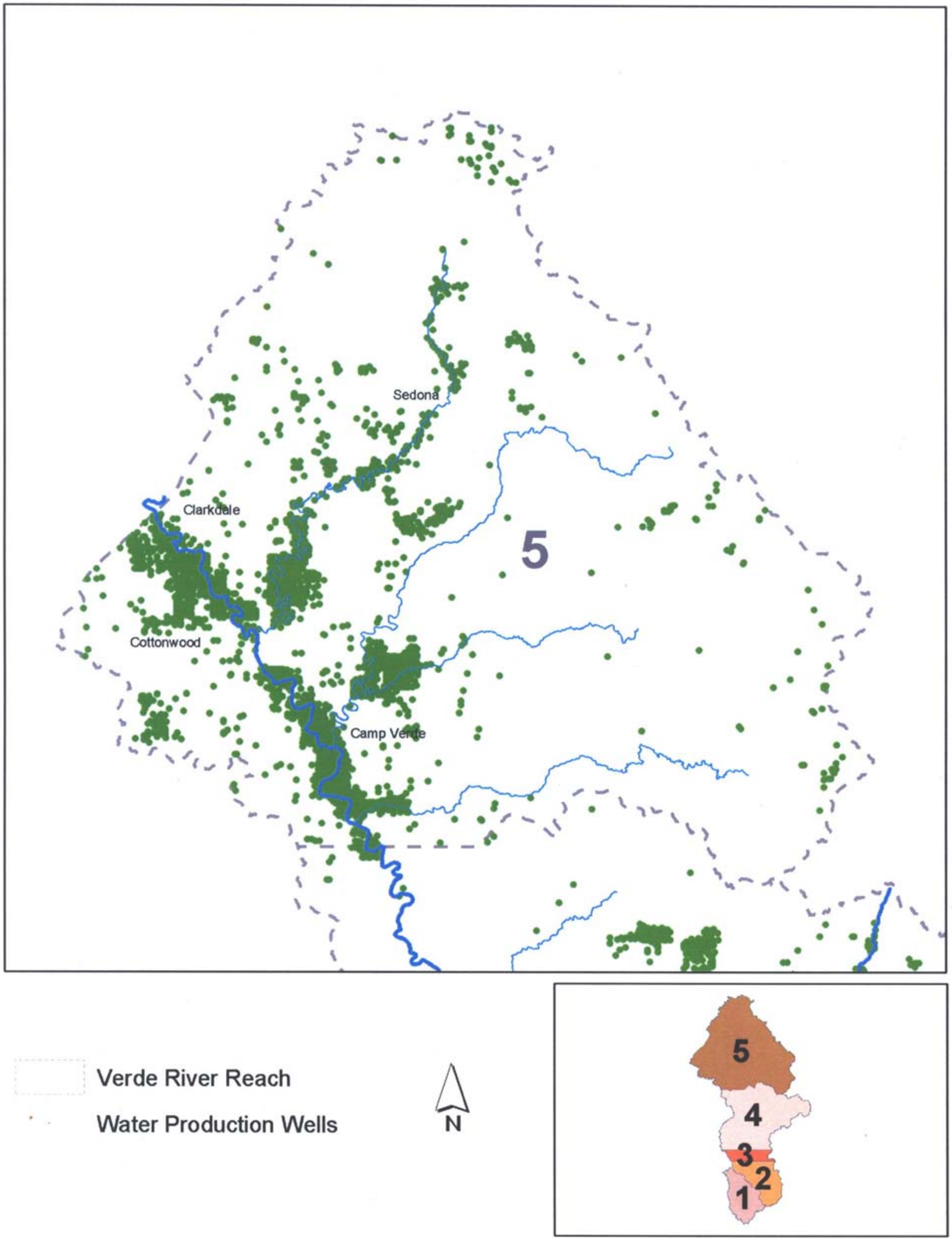



Reach 1-3 Wells
Horseshoe Reservoir
3
2
Bartlett Reservoir
1
Verde River Reach
Water Production Wells
N
5
4
3
2
1

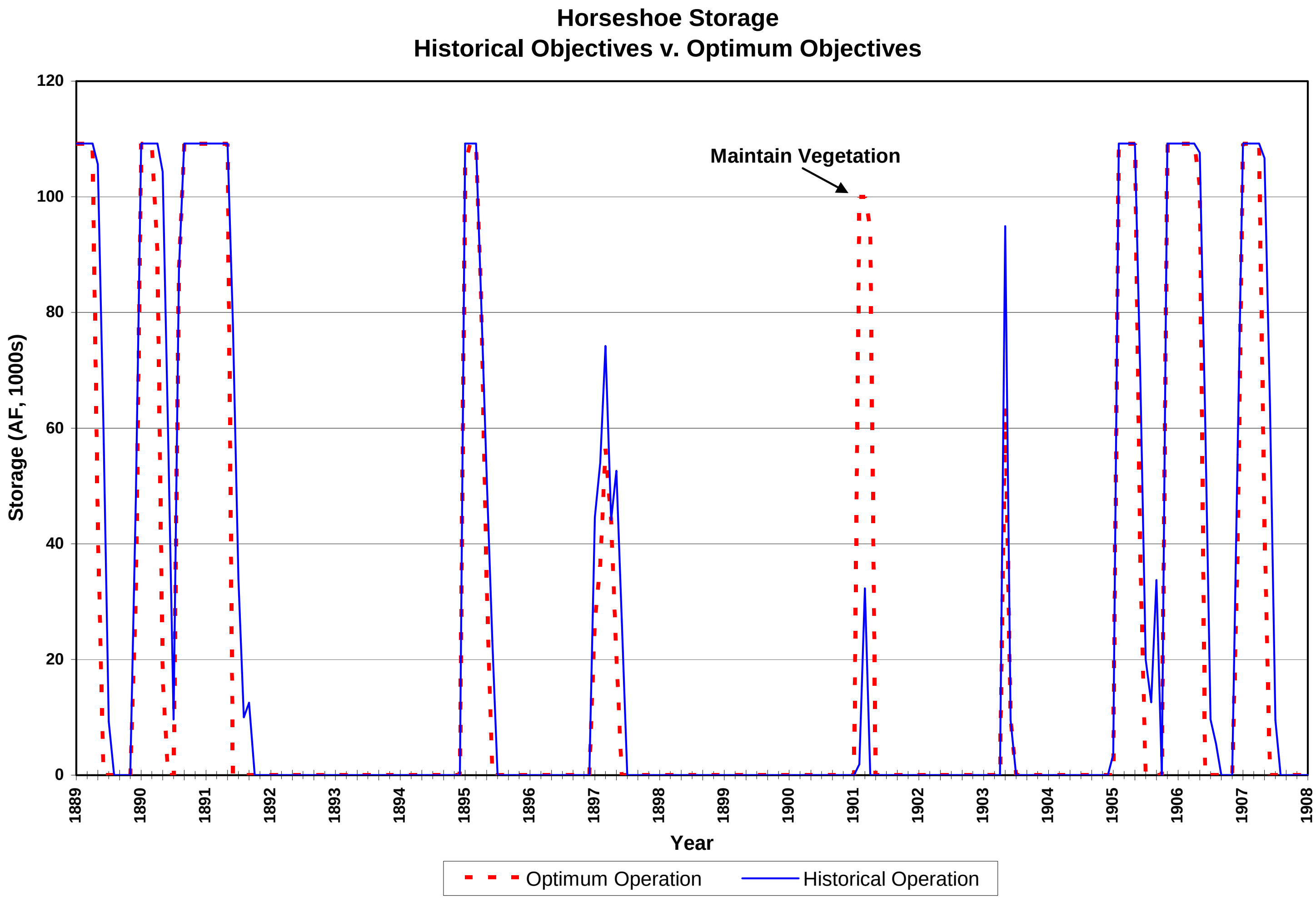
Reach 4 Wells

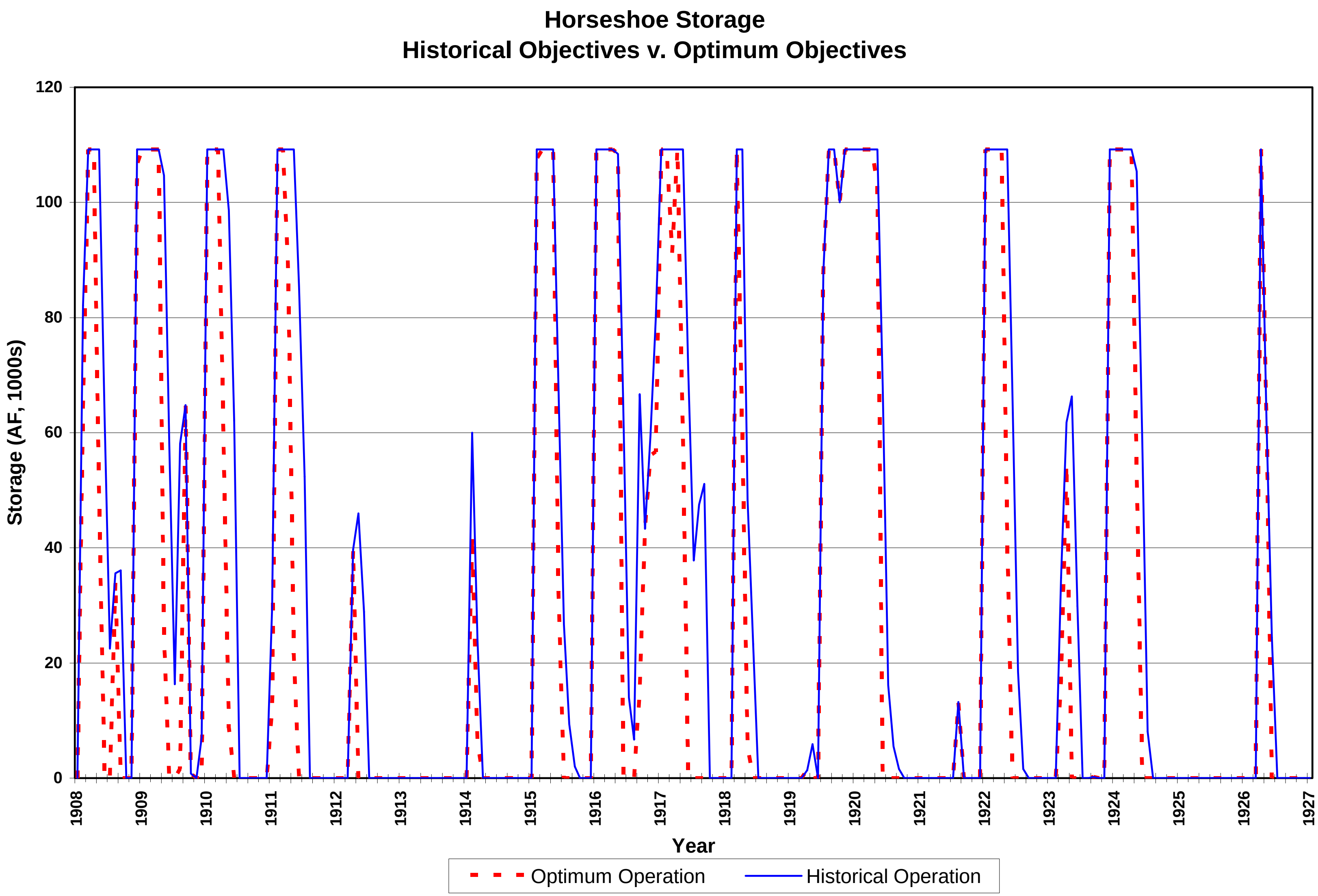


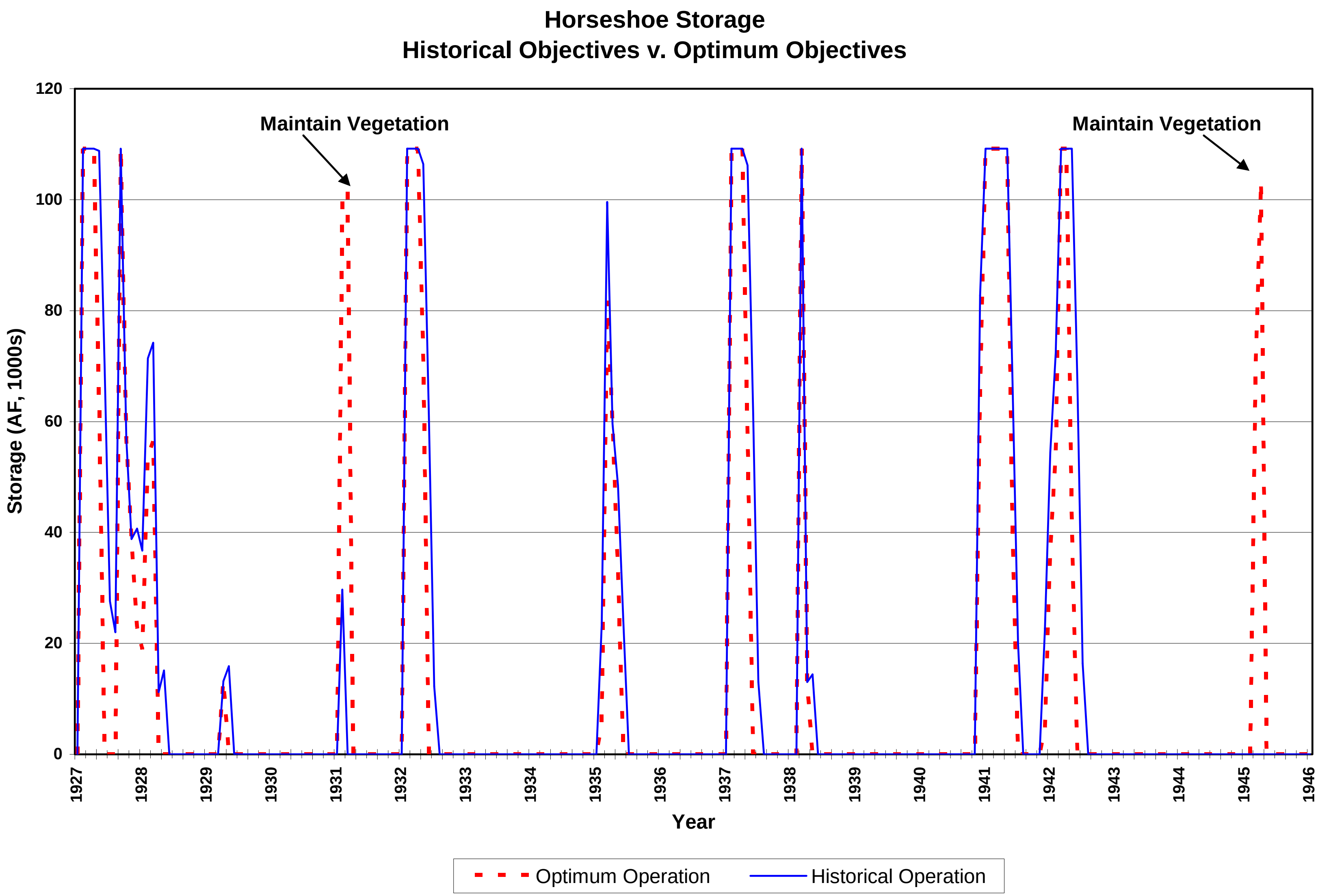
Reach 5 Wells

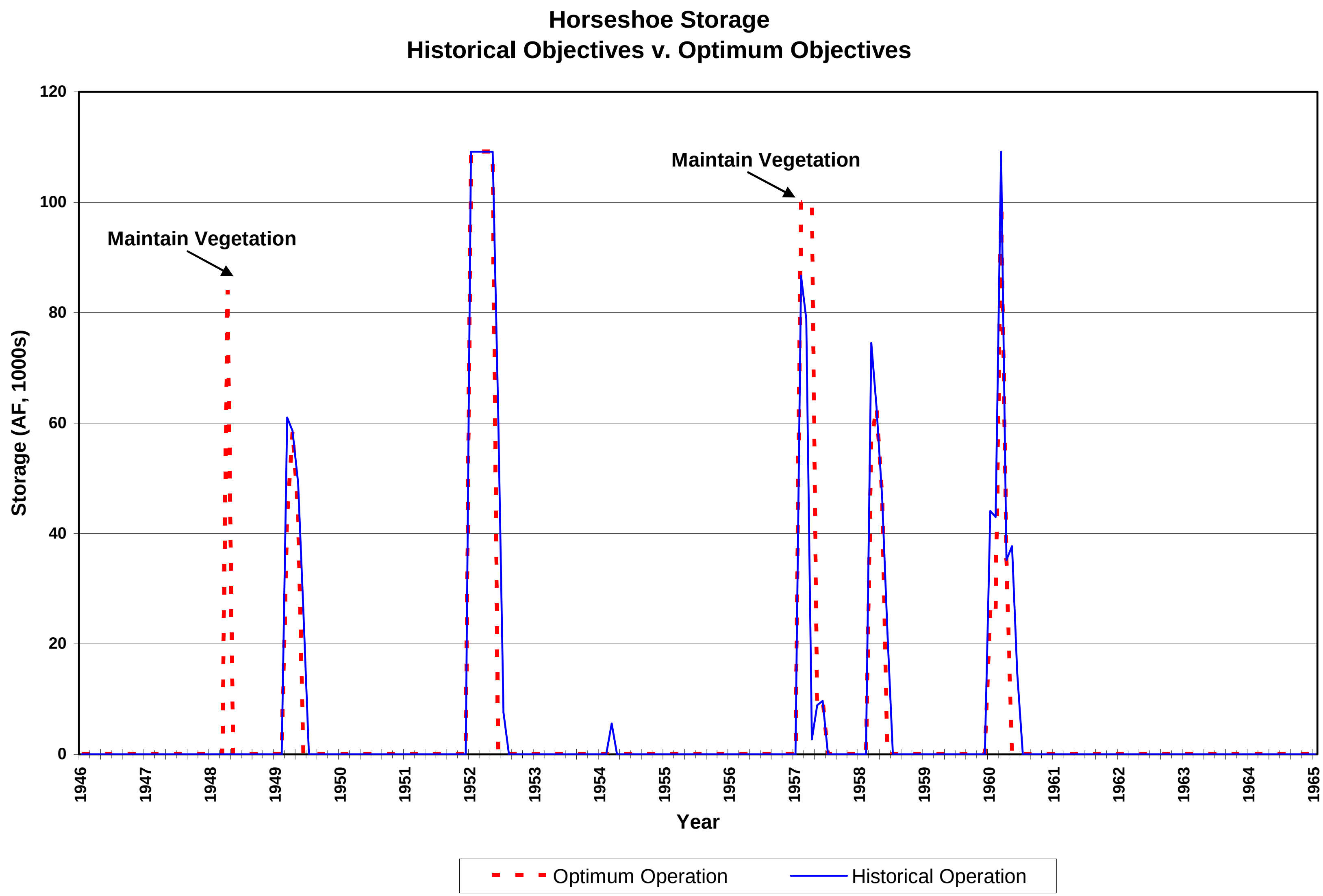


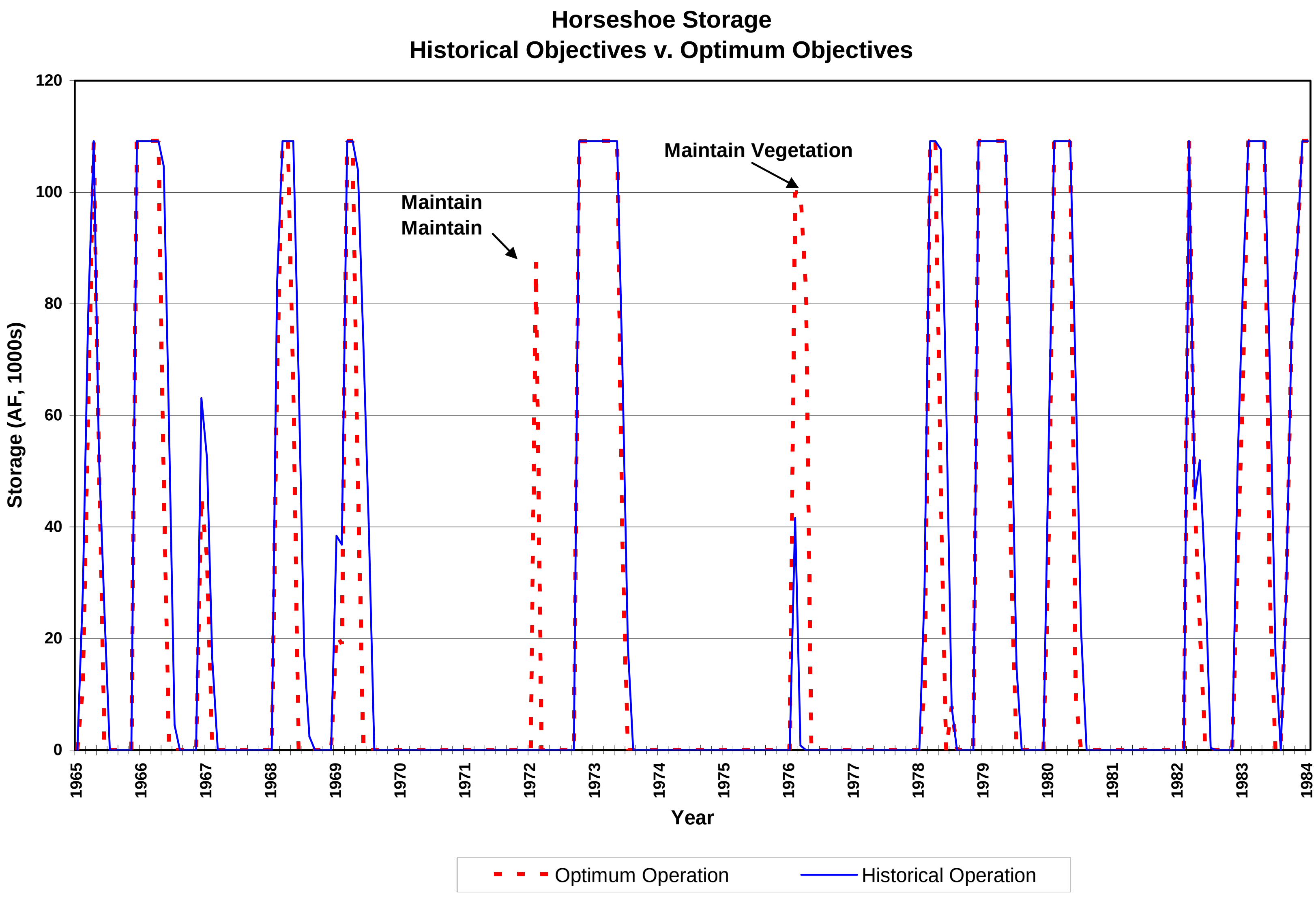
Appendix 5. Modeling results (using 113 years of runoff data) showing projected annual differences in storage in Horseshoe Lake between the Historical and Optimum Operation Alternatives.

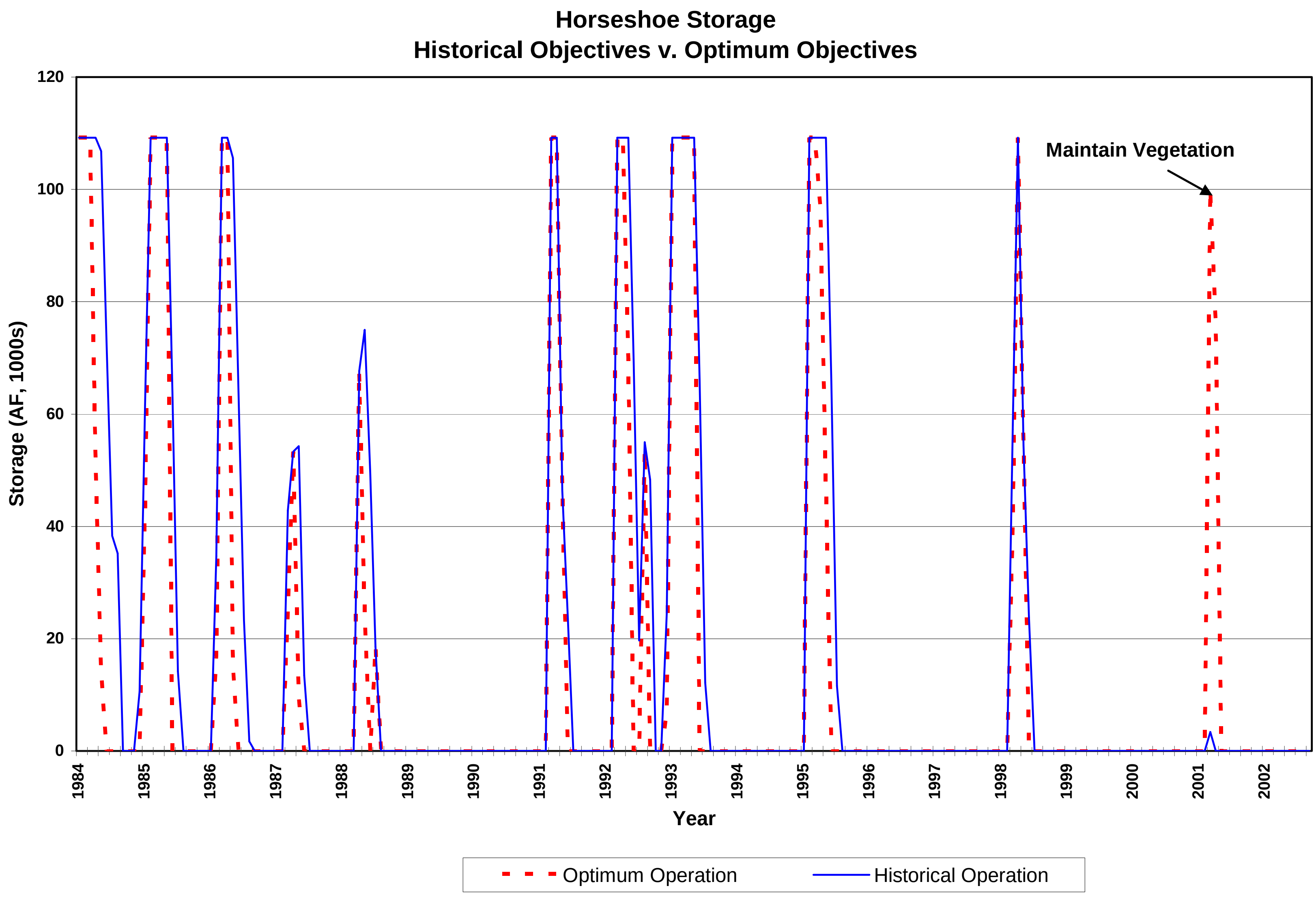



Horseshoe Storage
Historical Objectives v. Optimum Objectives
Storage (AF, 1000s)
120
100
80
60
40
20
0
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
Year
Optimum Operation
Historical Operation


Horseshoe Storage
Historical Objectives v. Optimum Objectives
Maintain Vegetation
Maintain Vegetation
Storage (AF, 1000s)
0
20
40
60
80
100
120
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
Year
Optimum Operation
Historical Operation


Horseshoe Storage
Historical Objectives v. Optimum Objectives
Maintain Vegetation
Maintain Vegetation
Storage (AF, 1000s)
0
20
40
60
80
100
120
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
Year
Optimum Operation
Historical Operation


Horseshoe Storage
Historical Objectives v. Optimum Objectives
Storage (AF, 1000s)
120
100
80
60
40
20
0
Maintain
Maintain
Maintain Vegetation
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
Year
Optimum Operation
Historical Operation


Horseshoe Storage
Historical Objectives v. Optimum Objectives
Storage (AF, 1000s)
120
100
80
60
40
20
0
Maintain Vegetation
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Year
Optimum Operation
Historical Operation