Effects of Nonindigenous Aquatic Species to the Species Under Consultation

The effects of CAP to the six listed species is additive to the already highly deteriorated environmental baseline of the Gila River basin aquatic ecosystem. The status of the six species is poor and declining, with the long-term prospects for conservation problematic. Remaining occupied habitats are highly altered, making many of them conducive to colonization by nonindigenous species. Many of the former habitats of the six listed species are occupied by nonindigenous species to the exclusion of native species. Unless nonindigenous aquatic species can be controlled and further incursions prevented, recovery is not likely for any of these species, and their continued existence may be in peril.

Nonindigenous aquatic species include fishes, aquatic and semi-aquatic mammals, reptiles, amphibians, crustaceans, molluscs (snails and clams), insects, zoo- and phytoplankton, parasites, disease organisms, algae, and aquatic and riparian vascular plants. They may affect native fish and other aquatic fauna, including the species considered in this opinion, through predation (Meffe et al. 1983, Meffe 1985, Marsh and Brooks 1989, Propst et al. 1992, Rosen et al. 1995, Rosen and Schwalbe 2002, Rinne 1999), competition (Schoenherr 1974, Baltz and Moyle 1993, Lydeard and Belk 1993, Douglas et al. 1994), aggression (Meffe 1984, Dean 1987), habitat disruption (Hurlbert et al. 1972, Ross 1991, Fernandez and Rosen 1996a and b), introduction of diseases and parasites (Sinderman 1993, Clarkson et al. 1997, Robinson et al. 1998, Bradley et al. 2002), and hybridization (Dowling and Childs 1992, Echelle and Echelle 1997). Nonindigenous plants can reduce available habitat with abundant growth (e.g. water cress), potentially cause loss of surface water (e.g. salt cedar), or alter ecosystem dynamics (McKnight 1993, Stromberg and Chew 1997, Lovich and DeGouvenain 1998).

All of the six listed species are highly vulnerable to adverse effects from nonindigenous aquatic species. The Gila basin had a naturally depauperate aquatic fauna, and native aquatic species, including the five fish and one frog considered here, did not evolve with any significant predation or competition (Carlson and Muth 1989, Clarkson and Rorabaugh 1989). This evolutionary history makes them highly vulnerable to adverse effects from nonindigenous species.

All six species are expected to incur serious adverse effects by introduction and spread of nonindigenous aquatic species through the CAP. The degree of vulnerability of populations of these six species and presently unoccupied recovery areas to CAP mediated nonindigenous species is variable. Some, such as those in Aravaipa Creek and in the middle Gila River above Ashurst Hayden Dam are close to, and have direct routes from, the CAP aqueduct, though Aravaipa Creek now has some protection from the two fish barriers there. Others, such as those in the upper Salt River drainage, have a number of dams intervening between that area and the aqueduct and will be affected by CAP only indirectly through nonindigenous spread by bait bucket transport of species made more accessible by CAP, or by species that can move overland and use CAP as a staging area in their colonization efforts. The six species live primarily in medium-to-warmer temperature habitats that are likely to be successfully colonized by nonindigenous aquatic species moving along or being moved from the CAP aqueduct or its related facilities.

There is abundant evidence of the adverse effects of nonindigenous fish on spikedace, loach minnow, Gila topminnow, razorback sucker, Chiricahua leopard frog, and Gila chub. The listing of all of these species was based, in part, on adverse effects of nonindigenous species (USFWS 1984, Minckley and Deacon 1991, 51 FR 23769, 56 FR 54957, 67 FR 40790, 70 FR 66664). Native fishes and frogs of the Colorado River basin, including the Gila River basin, evolved in an aquatic species community that was largely free of predatory and competitive interactions (Carlson and Muth 1989, Minckley and Douglas 1991, Rosen et al. 1994). Many of the species, such as Gila topminnow and Chiricahua leopard frog inhabited areas of the streams in which they were the only aquatic vertebrates present (Minckley 1999, Rosen et al. 1994). Because of this evolutionary history, the native aquatic vertebrates of the Gila River basin are highly susceptible to adverse effects from nonindigenous fishes, most of which evolved in highly complex fish communities where predation and competition were substantial formative forces.

In addition, a recent analysis by Olden et al. (2006) suggests that the suite of ecological niches that nonindigenous fishes may use overlaps those of native fishes of the Colorado River basin. Native species declines are most associated with those nonindigenous species that exhibit the strongest overlaps in life-history strategies or where natives display a "periodic" life-history strategy (generally large-bodied fishes that reproduce in seasonal, periodically suitable environments) that is not well adapted to the altered environments in evidence today. Olden et al. (2006) found that nonindigenous species also tend to occupy vacant niches often provided by human-altered environments or with minimal overlap with native fish life-history strategies.

Spikedace, loach minnow, Gila topminnow, Chiricahua leopard frog, razorback sucker, and Gila chub may all experience adverse effects from amphibians and aquatic reptiles that may invade or spread through CAP. While the CAP aqueduct itself is not suitable habitat for many amphibians and reptiles, it may serve as a movement corridor, and together with various recharge and recreational waters created by CAP water, it may serve as a significant factor in spread of some species. Although bullfrogs are widely spread in the Gila basin, any mechanism that increases their spread is undesirable to native fishes and frogs. Bullfrogs are known to eat fish (Clarkson and DeVos 1986), and at the San Bernardino National Wildlife Refuge stomach samples from bullfrogs have shown that Yaqui topminnow are a common diet item. Gila topminnow are similarly vulnerable, and bullfrogs may be a contributing factor to the serious decline in some topminnow populations, such as Sharp Spring. Adult spikedace, loach minnow, razorback sucker, and Gila chub are less likely to be subject to bullfrog predation, but larvae, small juveniles, and smaller adults are highly vulnerable to bullfrogs, both because of size and because of their use of slower edge and backwaters. Bullfrogs are highly predaceous on Chiricahua leopard frogs, often causing their extirpation from occupied sites (Sredl and Howland 1994, Rosen et al. 1996).

Spiny softshell turtles and sliders are commonly found in the Gila basin and both are carnivores that consume fish on a regular basis (AGFD 2001). Spiny softshell turtles are established in the CAP canal (R. Clarkson, pers. comm., November 2002). Introduced painted turtles and snapping turtles are established in Phoenix area canals (Brennan and Holycross 2006). Use of the aqueduct and CAP created waters for spread of these two and other carnivorous nonindigenous turtles is likely. There are concerns regarding Tempe Town Lake and its potential to increase the

likelihood of escape and dispersal of the several varieties of nonindigenous turtles at the Phoenix Zoo (J. Howland, USFWS, pers. comm., 1999).

The Rio Grande leopard frog is another nonindigenous, predatory frog spreading through the Gila basin, and it is likely to use CAP waters and connections to access new areas. This is a large frog, which in New Mexico may actually be replacing bullfrogs in some situations (Degenhardt et al. 1996). It is known to eat other leopard frogs (Platz et al. 1990) and may be expected to consume small fish, such as Gila topminnow, and larval and juvenile spikedace, loach minnow, razorback sucker, and Gila chub.

Parasites and diseases of native fish and frogs may enter the Gila River basin along with nonindigenous frog and fish species. The nonindigenous Asian tapeworm, which recently invaded the Gila River basin, has caused declines of the woundfin in the Virgin River and in the Yaqui topminnow at San Bernardino National Wildlife Refuge (Heckmann et al.1986, USFWS 1997). Asian tapeworm can negatively affect fish through several mechanisms including intestinal disfunction, emaciation, anemia, reduced growth, reduced reproduction, and fatigue (Hoole and Nisan 1994, Mitchell 1994 in Clarkson et al. 1997, Scott and Grizzle 1979). The endangered fountain darter of Texas is being infested by a trematode (unnamed) from an exotic snail, the red-rim melania. The red-rim melania is also present in the Colorado River and has the potential to enter the Gila River system via the CAP aqueduct. Cysts of the trematode infect the gills of the darter. The effect of the cyst on the darter is unknown, but infection levels are very high (Fuller and Brandt 1997). Chytrid fungus is present in bullfrogs and tiger salamanders (Bradley et al. 2002), and is likely spread by them to new sites (Halliday 1998, Bradley et al. 2002, Collins et al. 2003).

The two species of crayfish that already exist in the Gila River basin have had negative impacts on aquatic habitats and on amphibians (Pister 1979, Deacon and Williams 1991, Fernandez and Rosen 1996a and b, Gamradt and Kats 1996, Inman et al. 1998). Many biologists feel that crayfish may have adverse impacts on spikedace and loach minnow, although no mechanism has been demonstrated. However, it is known that large crayfish will capture and eat darters, which are ecologically similar to loach minnow, and there may be food and habitat competition between darters and crayfish (Keller and Moore 2000). Conversely, crayfish make up a large portion of the diet of smallmouth bass and flathead catfish in the Verde River, perhaps benefiting native fishes (Parmley and Brouder 1998), but they may also help maintain those two piscivorous fish at higher populations. It is likely that both a predatory and competitive relationship exist between Gila topminnow and crayfish. In Cave Creek, Gila topminnow and native longfin dace populations crashed coincident with a dramatic upsurge in abundance of northern crayfish (Stefferud 1993, Young and Bettaso 1994). Chiricahua leopard frogs have disappeared from areas where crayfish have invaded (Fernandez and Rosen 1996a and b), and are one of the most serious threats to this frog (USFWS 2007). Enhanced movement throughout the Gila River basin due to the CAP interconnection of subbasins may enable spread of other species. Nonindigenous crayfish invasions have caused substantial concerns in other areas (Lodge et al. 2000). Several species, such as the rusty crayfish, may invade the Gila River basin in the future.

Effects of nonindigenous plants on native aquatic species are more difficult to document than animals because the effects are more indirect. Watercress, which has been spread throughout the entire Gila basin, has significantly modified backwater habitats occupied by Gila topminnow, and larvae and juveniles of other species. However, no data exist that demonstrate negative effects, and potential effects may be obscured by the many other substantial changes to the habitat. Giant salvinia, recently discovered in the Colorado River, has the potential for serious adverse effects to all native aquatic species, but is probably limited by winter cold to lower and warmer sites (Whiteman and Room 1991). It cannot tolerate ice on the water surface, so will not spread to higher sites with cold winters. This plant could easily extirpate Gila topminnow from certain sites by shading out native vegetation and depleting dissolved oxygen in the water (Thomas and Room 1986). Its ability to completely and rapidly cover pooled or low-velocity water in dense mats suggests it would be highly detrimental to Gila topminnow, which feed at the water surface in low-velocity areas, as do larvae and juvenile of native fishes. A plant similar to giant salvinia, the European frog-bit, has been introduced into the northeastern United States and is gradually spreading westward through the Great Lakes (USGS 2001). Like giant salvinia, European frog-bit forms dense floating mats on the surface of quiet waters (Upwellings 2000). Other invasive nonindigenous aquatic plants that have the potential to cover most or the entire water surface, such as water hyacinth and water lettuce (Schmitz et al. 1993), would also likely adversely affect Gila topminnow and larval native fish through interference with feeding patterns and reduction of dissolved oxygen.

Spikedace and loach minnow

Negative impacts to loach minnow and spikedace from nonindigenous species introductions have been and will be significant due to these species' proclivities for and current range in larger, connected stream systems. Adverse effects from a variety of nonindigenous species threaten spikedace and loach minnow. Many of the nonindigenous fish already present (mosquitofish, red shiner, carp, fathead minnow, yellow bullhead, black bullhead, channel catfish, flathead catfish, green sunfish, bluegill, smallmouth bass, and largemouth bass) in spikedace and loach minnow habitats have been implicated in adverse effects to other fish species (Minckley 1973, Moyle and Nichols 1974, Moyle 1976, Karp and Tyus 1990, Lydeard and Belk 1993, Ruppert et al 1993, Tyus and Saunders 2000). These species are all common in various parts of the Gila basin still occupied by spikedace and loach minnow, and their effects may vary from population to population (Propst et al. 1986, Propst et al. 1988, Marsh et al. 1990, Rinne 1991, Douglas et al. 1994, Rinne and Stefferud 1996, Medina and Rinne 1999). While the abundance and distribution of these existing nonindigenous fishes are not expected to be significantly affected by the CAP system, their already existing adverse impacts are great enough that any additions of nonindigenous species could result in serious declines or extirpation of spikedace and loach minnow populations.

For spikedace and loach minnow, the most vulnerable habitats are in the middle Gila River, Aravaipa Creek, and the San Pedro River. These areas are within direct access of potential CAP-derived nonindigenous species moving up the Gila River via its connection with the Florence-Casa Grande Canal, which directly receives CAP water. The electrical barrier on the Florence-Casa Grande Canal was installed to prevent escapes of nonindigenous species from the canal to the Gila River, but its effectiveness is not 100 percent (Clarkson 2004). The Gila River, being

close to the CAP aqueduct, is also vulnerable to bait bucket or accidental transport of species from the aqueduct. Because of the 1994 biological opinion, a paired set of fish barriers was constructed on lower Aravaipa Creek, thus substantially reducing the risk to that habitat. The middle Gila River is designated critical habitat for spikedace and loach minnow, and is poorly protected. The electrical barrier on the Florence-Casa Grande Canal and Ashurst-Hayden Diversion Dam are the only preventative measures between areas of CAP introduction and the listed species' habitats. Neither of those measures are entirely effective. The San Pedro River basin is considered a very important recovery area for those species and is equally vulnerable to CAP mediated nonindigenous fish invasions.

Spikedace and loach minnow habitats above Coolidge Dam are less vulnerable due to the major obstacle to upstream aquatic species movement posed by the dam. However, if nonindigenous species are introduced into the middle Gila River below Coolidge Dam, the likelihood of their being moved above the dam via bait bucket or accidental transport (human, equipment, or animal) becomes substantially greater. Once above Coolidge Dam, there is little to prevent a nonindigenous aquatic species from moving as far upstream as their physiological tolerances permit into the Gila, San Francisco, and Blue rivers, and Bonita Creek. A small dam on lower Eagle Creek, for diversion of water to the Phelps Dodge mine at Morenci, would help inhibit movement up Eagle Creek. Several low-head diversion dams on the Gila are not believed to present any significant long-term obstacle to upstream movement of nonindigenous aquatic species. Any new introductions of nonindigenous species into the Gila River system above Coolidge Dam carry significant potential for serious adverse effects to spikedace and loach minnow. A fish barrier is being constructed on Bonita Creek.

Loach minnow populations in the upper Black and White rivers and critical habitat for both spikedace and loach minnow in the Tonto Creek basin, while highly vulnerable to extirpation or adverse modification from new nonindigenous aquatic species, have a very low likelihood of being affected by nonindigenous aquatic species introduced or spread from CAP. This is due to the presence of two electrical barriers and four major dams on the Salt River between the CAP and those populations. However, heavy recreational use of the Salt River reservoirs has resulted in a number of bait bucket introductions and can be expected to play a part in gradual upstream movement of any nonindigenous species introduced into the lower Salt River by CAP. Heavy boat traffic into Roosevelt Lake, the uppermost of the reservoirs, creates a major risk of movement of species such as zebra mussel and giant salvinia that are likely to be accidentally carried or attached to boats.

The spikedace population and designated critical habitat in the Verde River and several of its tributaries would have only a moderate likelihood of introduction or spread of nonindigenous aquatic species from CAP. The presence of Bartlett and Horseshoe dams between the populations and CAP provides a high level of protection to direct upstream movement of nonindigenous species. However, as the upstream movement of tilapia past Bartlett Dam demonstrates, the recreational use of the two reservoirs creates a moderate to high likelihood that nonindigenous species that access the lower river from a CAP introduction will be moved over the dams by bait bucket transport or by accidental transport.

Gila topminnow

Reestablished Gila topminnow populations tend to be in small and isolated habitats. However, nonindigenous fishes continue to affect wild populations in places like the upper SCR in San Rafael Valley, Sonoita Creek, Sharp Spring, and Redrock Canyon. Introductions of new species over the life of the CAP will degrade existing and recovery habitats for this species. However, renovated streams upstream of constructed fish barriers and in other locations will provide recovery habitat for Gila topminnow.

Many nonindigenous fishes that might enter the Gila River basin through introduction and spread via CAP could have devastating impacts to Gila topminnow, at least in those habitats with connectivity to the rivers and streams of the basin. The pike killifish has been known to extirpate mosquitofish from habitats into which it is introduced (Courtenay and Meffe 1989) and would most certainly do the same to Gila topminnow. Oriental weatherfish may alter habitats and ecosystems and could thrive in soft substrate areas favored by Gila topminnow and desert pupfish (Dill and Cordone 1997).

Gila topminnow have been extirpated from substantial portions of their historical range by nonindigenous fishes. Mosquitofish have been implicated in many losses of Gila topminnow (Schoenherr 1974, Meffe 1984 and 1985, Marsh and Minckley 1990, Minckley 1999). Tilapia and mollies have been implicated in substantial population declines in desert pupfish (Matsui 1981, Schoenherr 1988). Largemouth bass have had adverse effects to Gila topminnow (Stefferud and Stefferud 1994) and caused the extinction of another endemic Gila basin pupfish, the Santa Cruz (= Monkey Springs) pupfish (Minckley 1973).

For Gila topminnow, the most vulnerable reestablished populations are those in the Agua Fria drainage. Extant populations include AD Wash, Larry Creek, Tule Creek, and Lousy Canyon. Populations at Badger Springs, Castle Creek, Cedar Spring, Cow/Humbug Creek, Sheep Spring, Sycamore Creek, and Tule Creek seep, are extirpated and have been identified for augmentation stocking. Most of these habitats are in isolated springs that are very unlikely to be invaded by nonindigenous aquatic species introduced by CAP. However, Tule Creek, Lousy Canyon, Cow/Humbug Creek, and Sycamore Creek all have some level of connectivity to the Agua Fria proper. A fish barrier was built by Reclamation on Tule Creek to inhibit upstream movement by nonindigenous fish moving out of Lake Pleasant. Except at the maximum water level in Lake Pleasant, the barrier should protect this population from direct upstream movement. The barrier is not easily visible or accessible and is not likely to experience bait bucket transport at the barrier site. However, human use in the area is increasing due to heavy recreational development at the lake, thus increasing the potential for bait bucket and accidental transport. Tule Creek is also vulnerable to invasion by semi-aquatic CAP introduced species such as various invertebrates (crayfish, crabs, etc.) and amphibians and reptiles (frogs, turtles, etc.), which may not be stopped by the barrier. Lousy Canyon has a high natural barrier, although some Gila topminnow are present below the barrier and are accessible to upstream movement of CAP introduced species out of Lake Pleasant. The Cow and Humbug Creek complex has no barrier and already is heavily impacted by nonindigenous species. Additional nonindigenous species that might be introduced by CAP into Lake Pleasant are likely to move upstream into Cow and Humbug Creek

and preclude use of this habitat by Gila topminnow, barring a barrier and renovation. There are no plans for additional barriers in the Agua Fria drainage.

Two habitats identified for augmentation stocking are also located in the Hassayampa subbasin at Bain Spring and Campbell Flat Spring. The level of risk from CAP introduced nonindigenous species at these sites is low.

Gila topminnow populations are present in the Cave Creek drainage, tributary to the Salt River. Gila topminnow have not been detected at Cave Creek and Seven Springs for several years, but is identified for augmentation stocking. Movement of introduced species into Cave Creek directly from the CAP aqueduct is unlikely. However, the presence of the CAP aqueduct in the area presents some potential for bait bucket or accidental transport into Cave Creek and upstream into the Gila topminnow habitat. In addition, the proximity of the CAP aqueduct to perennial water in Cave Creek increases the likelihood that species, such as frogs and turtles, may use the aqueduct as a staging area in overland movement that may eventually result in their successful colonization of Cave Creek.

The Verde River basin has a number of Gila topminnow populations and recovery habitats. Most of these are isolated springs and have a very low probability of effect from CAP introduced or spread nonindigenous species. However, Lime Creek, which enters Horseshoe Reservoir, and Horse and Red creeks, which enter the river above the reservoir, are periodically connected to the Verde River. The potential for CAP introduced nonindigenous species to reach Horseshoe Reservoir is moderate, and any species reaching there would have open access to Lime Creek and the Gila topminnow population. This could result in loss of this population. The draft Horseshoe-Bartlett Salt River Project Habitat Conservation Plan proposes the construction of a barrier on Lime Creek. The likelihood of such effects to Horse and Red creeks is much less, but there is still some potential for loss of these habitats to nonindigenous species introduced or spread by the CAP. Fossil Creek and the East Verde River, both of which were stocked with Gila topminnow at one time, have been identified for augmentation stocking. Fossil Creek now has a barrier and has been renovated (Weedman et al. 2005, Overby and Overby 2005). The East Verde is normally connected to the Verde River and would be highly vulnerable to any nonindigenous species from CAP that successfully passed both Bartlett and Horseshoe dams.

There are a number of Gila topminnow populations in the Salt River subbasin, particularly the Tonto Creek drainage. Most of these populations are in isolated habitats that are not at risk from nonindigenous species introduced or spread by the CAP. In addition, the presence of the four mainstem dams on the Salt River reduces the risk to Gila topminnow in this subbasin to a low level.

Gila topminnow sites along the middle Gila River (Mescal Warm Springs) and the San Pedro River (Buehman Canyon, Babocomari River, O'Donnell/Canelo Cienega) are at risk from CAP introduced and spread nonindigenous species. Mescal Warm Springs may presently support a population, and it is isolated from the Gila River by a natural barrier. Portions of Buehman Canyon are above a natural barrier and O'Donnell/Canelo Cienega (occupied) and the Babocomari River have several small diversion dams between them and invading species from the CAP that would substantially lower the likelihood of species reaching those sites. There is

one desert pupfish population at the Boyce-Thompson Arboretum in an impoundment just off Queen Creek. The distance from the Gila River and the impoundment dam make the risk to this population from CAP mediated nonindigenous species low. The controlled situation at the admission-required Arboretum should help prevent bait bucket transfers, however bait bucket releases have occurred several times, including fathead minnow that are presently in the pond.

Above Coolidge Dam on the Gila River, there are several occupied, or formerly occupied and identified for augmentation, Gila topminnow habitats at Cold Springs Seep, Big Spring, Green Tanks, Howard Well, Martin Well, and Redrock Wildlife Area. Of these, only Redrock Wildlife Area has sufficient connection to the Gila River to present a significant risk from nonindigenous aquatic species that may move up the river from the CAP. However, the three small spring sites at the Bylas Springs complex are natural remnant populations of Gila topminnow and are the only known remaining stock from the entire Gila basin outside of the Santa Cruz subbasin. As such, their survival is critical. The three springs in the Bylas complex are all located on the edge of the Gila River floodplain just shortly upstream of San Carlos Reservoir. They are highly vulnerable to invasion by nonindigenous species from the river. Although there are small fish barriers on these systems, those barriers are intended to exclude primarily mosquitofish and may not be high enough to exclude other fish. They will also not protect Bylas Springs against CAP mediated nonindigenous species such as crayfish, frogs, turtles, and other species that can move overland, or species such as giant salvinia that might be moved overland by other species. Any additional nonindigenous species introduced into the Gila River in this area, whether through CAP or other means, represent a serious risk of extirpation for the Bylas Springs topminnow populations. Bylas Springs has been invaded multiple times by mosquitofish (Marsh and Minckley 1990, Voeltz and Bettaso 2003).

Except for the Bylas Springs complex, all remaining natural populations of Gila topminnow are in the SCR subbasin and are subject to threat from the introduction and spread of nonindigenous aquatic species via CAP. Predation by many nonindigenous species already occurs, and new predatory species are expected to increase adverse effects to Gila topminnow. It is also highly vulnerable to competition from nonindigenous species. Remaining habitats are generally very small and moderately to highly modified. Competition by introduced species for very limited resources is a substantial threat. Parasites and diseases will enter Gila topminnow habitats along with nonindigenous animals, and some, such as Asian tapeworm, have already infected Yaqui topminnow to the detriment of that subspecies. Human modifications of many Gila topminnow habitats have rendered them only moderately suitable for Gila topminnow. Already under stress because of adverse habitat conditions, any additional stresses to Gila topminnow, such as increased predation, competition, harassment, diseases, or habitat alteration by nonindigenous species is highly significant.

Gila topminnow habitats in the SCR mainstem and Sonoita Creek are the most likely to experience direct water-to-water connections with CAP or CAP in-lieu waters. Therefore, topminnow populations in those areas are the most likely to be impacted by CAP associated transfers of nonindigenous aquatic species. Depending on yearly precipitation and time of year, the 25 to 30 mi (45-50 km) of the river is often dry between Tucson and the most downstream SCR population of Gila topminnow above Tubac. Several in-channel recharge projects may occur in the SCR downstream of this reach, including one in the Green Valley area, and the Gila

topminnow population in the SCR downstream from Nogales is the closest population to those projects. This reach of the SCR is readily accessible to people and is parallel to Interstate 19 and other roads, has several crossings, and several adjacent communities and other dwellings. Thus, the potential for bait-bucket transfer is relatively high, and even with a management program against nonindigenous species, there is still a significant likelihood of CAP-mediated nonindigenous aquatic species invasion. The protection of Santa Cruz tributaries will partially offset the inability to protect the mainstem Santa Cruz upstream of the CAP with a barrier.

The probably extirpated population of Gila topminnow in the upper SCR near Lochiel is the upstream end of the population that occupies the loop of the river in Mexico. Information on river conditions in Mexico is incomplete, but we are unaware of any significant barrier to upstream movement of nonindigenous aquatic species from the Tucson area into the upper Santa Cruz. Because it is on privately owned land, the San Rafael population is accessible to most people only at one crossing. This was the most upstream of the riverine populations, is already severely stressed by nonindigenous species impacts, and has a high potential for upstream invasion from nonindigenous species. Longfin dace were found in the river at the US-Mexico border in 2007, for the first time in four years (AGFD and Service files). It is possible these longfin dace came from a population in the river five miles downstream in Mexico.

Alongside the upper SCR lie the Gila topminnow populations of Sharp and Heron springs. The only barrier to nonindigenous aquatic species movement out of the river into Sharp Spring is a short stretch that is dry except during floods. Nonindigenous species moving upstream along the SCR would eventually reach Sharp Spring. The spring is very vulnerable to additional nonindigenous species incursion. Until recently it was privately owned and did not receive much use from people. However, it now belongs to Arizona State Parks Department, and because it is only a short walk from the road, human use and therefore the probability of bait bucket introductions, is expected to increase. As the only remaining Gila topminnow population in a true cienega, as a relatively isolated and pristine habitat, and given its existing threat from mosquitofish and bullfrogs, the level of risk from CAP to Sharp Spring is considered high. Gila topminnow have not been found there since 2002 (Service files), and may have been extirpated by the interconnected effects of mosquitofish and drought. Heron Spring is upstream from a substantial earthen dam impounding a stock tank. Only those nonindigenous aquatics capable of overland or air movement could access the site. Probability of bait-bucket transfer is low because there is limited vehicle access and the spring is not visible from any road. Heron Spring is one of the oldest surviving reestablishment sites, has no mosquitofish, and is considered highly valuable to Gila topminnow survival.

As a habitat that was formerly naturally occupied by Gila topminnow, Sheehy Spring is considered a reestablishment site of extremely high value. The small dam on the spring is not a barrier and did not exclude mosquitofish. Sheehy Spring is vulnerable to invasion by any nonindigenous aquatic species moving up the SCR. Sheehy Spring is also a potential barrier site. Until that barrier is built, impacts from nonindigenous species could occur.

The Sonoita Creek basin contains five Gila topminnow populations. There is perennial flow in Sonoita Creek about 4 mi (7 km) upstream of the Santa Cruz confluence. Gila topminnow are found from the confluence upstream to the Town of Patagonia, except for Patagonia Lake, a

recreational fishing reservoir about a third of the way up the drainage. There is no barrier in the lower section of Sonoita Creek to upstream invasion of nonindigenous species from the SCR. This population is already impacted by predation and competition from nonindigenous species, including mosquitofish, whose source is mainly from Patagonia Lake. It is a large population of topminnow and is under stress from a variety of human activities. Human access is moderate and expected to increase. Nonindigenous species invasions from the CAP via the SCR would have a high likelihood of causing extirpation of this Gila topminnow population.

Fresno Canyon is a tributary of lower Sonoita Creek, and it is part of the lower Sonoita Creek complex of natural topminnow populations. A rockfall that is probably a barrier exists in the canyon, and the lower reaches of the canyon flow only during floods. The site is further protected by an ephemeral channel above the barrier. The habitat has been highly impacted by livestock grazing, and there have been several nonindigenous species recorded there. Fencing of the surrounding State Natural Area should greatly reduce grazing. Any new nonindigenous species introductions could extirpate this population. A renovation of Fresno Canyon to remove green sunfish was done in 2007, which should significantly enhance the security of this population, and its tributary population in Coal Mine Canyon.

Coal Mine Canyon, a tributary of Fresno Canyon, also has a natural population of Gila topminnow that was discovered in the 1990s. Coal Mine Canyon empties into Fresno Canyon above the natural barrier on Fresno Canyon. Thus, it would have the same low potential for impacts from nonindigenous species. There is a rough 4-wheel drive road that goes to Coal Mine Spring, where the topminnow mainly reside. However, it is on land owned by AGFD, and behind a locked gate.

Above Patagonia Dam, the risk of upstream invasion from nonindigenous aquatic species decreases. However, as a highly popular recreation area, Patagonia Lake is a prime place for bait-bucket transfers. The population of Gila topminnow in Sonoita Creek above the lake is small and appears to be only barely clinging to existence. The smallness of the creek and the lack of complex habitat keep many of the nonindigenous species in Patagonia Lake from moving upstream into the Gila topminnow habitat, but despite that the species, abundance, and distribution of nonindigenous species above the lake is steadily increasing (H. Blasius, AGFD, pers. comm. November 2001). If this trend continues or if new nonindigenous species more adapted to smaller, flowing habitats are introduced, then this Gila topminnow population could easily be extirpated. The construction of a barrier above Patagonia Lake would restrict nonindigenous species in the lake (both existing and those arriving via the CAP and bait-bucket routes) from moving upstream into upper Sonoita Creek. It would also allow for possible removal of existing nonindigenous species in upper Sonoita Creek as a recovery action. This reach of Sonoita Creek is readily accessible to humans.

Cottonwood Spring is located next to and drains into the floodplain of Sonoita Creek upstream of the Town of Patagonia. There is perennial flow in Sonoita Creek in this area. A barrier to nonindigenous species movement was constructed by Reclamation downstream of this population. The Service, AGFD, The Nature Conservancy, and the private landowner have carried out substantial efforts in the last few years to improve the habitat and population of Gila topminnow at Cottonwood Spring. No mosquitofish or other nonindigenous fish are found here,.

and it is considered very important to survival of the species to ensure the spring remains free of nonindigenous aquatic species.

Monkey Spring is also a tributary of upper Sonoita Creek, but it is located up a steep drainage and is not in the floodplain. Although it is protected from upstream invasion of nonindigenous species that must swim, Monkey Spring has proved highly vulnerable to nonindigenous predators and has already lost at least one species through that mechanism.

Redrock Canyon, another tributary of the upper Sonoita Creek, until recently supported Gila topminnow in three semi-isolated areas of perennial flow. They are protected from nonindigenous aquatic species invasions by a lower reach that flows only during floods and a natural falls that should be an effective barrier at most flows to fish movement upstream. Two of the core areas of topminnow occupation are above the falls, a third straddles the falls with most of the topminnow being downstream from the falls, and a fourth is located downstream of the falls. Redrock Canyon is one of only two natural populations of Gila topminnow on Federal land and the only one where the watershed is almost entirely under Federal management, and as such has a higher prospect for long-term protection. Nonindigenous fish have been recorded from all areas of the canyon, but only the uppermost area consistently has nonindigenous species in significant numbers. A popular hiking trail in the canyon crosses the creek near the falls and increases the risk of bait-bucket transfer of any species that is moving upstream. The topminnow areas downstream of the falls are at high risk from additional nonindigenous aquatic species moving upstream from Sonoita Creek. Both the planned barrier on Sonoita Creek above Patagonia Lake and the barrier proposed in lower Redrock Canyon would directly restrict upstream fish movement into Redrock Canyon.

Lower Cienega Creek at the Cienega Creek Preserve is above a diversion dam that probably serves as a barrier. This site would have no additional protection by the barriers proposed as part of the CAP project. Movement up the Pantano Wash/Cienega Creek complex in the Tucson metropolitan area would be inhibited by channelization and lack of flow except during floods, but some nonindigenous species movement is likely. The Preserve is readily accessible to humans, but requires a permit from Pima County, and could be used as a transfer point or source for release of nonindigenous species into the upper portion of Cienega Creek. A small natural barrier occurs between the two areas of perennial water, but it would not be 100% effective at stopping all species. Because of upper and lower Cienega Creek's popularity and accessibility, it is a likely candidate for bait-bucket release of nonindigenous aquatic species (Although it is closed to fishing). As the largest Gila topminnow population in existence in the United States and one of only four natural populations free of nonindigenous species, any threat of nonindigenous species incursion is considered of grave threat to the survival of the species in the United States. There is a moderate probability that nonindigenous aquatic species introduced by CAP will spread into the lower reaches of Cienega Creek and then be moved by recreationists over the falls into the Gila topminnow habitat. However, the management against nonindigenous species conservation measure will ameliorate this effect.

In addition to occupied Gila topminnow sites, several previously identified potential reestablishment sites in the Santa Cruz subbasin may be adversely affected by invasion and spread of nonindigenous aquatic species via CAP. These include, but are not limited to, Alambre

Tank, Bog Hole, Cinco Ponds, Little Nogales Spring, Nogales Spring, and other sites in the Tucson basin. No comprehensive inventories have been conducted of potential reestablishment sites in the Santa Cruz subbasin. However, many are expected to be stocked with Gila topminnow during the 100-year project life, and may also be adversely affected by nonindigenous species from CAP. Because of scanty information on these sites, it is difficult to assess the vulnerability of specific sites to nonindigenous species from CAP, however, in general the larger and lower-gradient sites are more vulnerable to nonindigenous species invasion. Unfortunately, those characteristics are associated with higher quality Gila topminnow reestablishment sites. As has been discussed, successful reestablishment is considered essential to long-term survival of Gila topminnow.

Over the 100-year life of the CAP, the probability is high that one or more nonindigenous aquatic species will use the CAP as an avenue to colonize habitats now occupied by Gila topminnow and either alone, or in concert with other nonindigenous species or habitat degradation, have major adverse consequences to Gila topminnow. In addition, the probability is also high that one or more nonindigenous aquatic species will be placed via CAP into areas adjacent to Gila topminnow habitat, thereby significantly increasing the probability that people, animals, or other mechanisms will transport it the remaining distance. Together, these direct and indirect effects from CAP carry a substantial likelihood of seriously decreasing the probability of the survival and recovery of Gila topminnow, unless actions are taken to ameliorate the threat.

Razorback sucker

Although razorback sucker repatriations have been attempted with millions of fish and a variety of waters, none have resulted in establishment of sustaining populations (Hendrickson 1993, Marsh et al. 2003, Hyatt 2004, Schooley and Marsh 2007). This species' greatest potential recovery habitat in the basin is in the largest mainstem rivers that also exhibit the highest level of contamination by nonindigenous fishes. Although a planned Verde River fish barrier and renovation could assist recovery efforts for this species in the Gila River basin, a significant change in management direction is needed if recovery is to succeed (Hyatt 2004, Clarkson et al. 2005, Desert Fishes Team 2006).

Razorback sucker exists in the Gila basin only as repatriated, and apparently not yet sustaining, populations. The middle and upper Verde River, the upper Salt River, and the Gila River above Coolidge Dam are designated critical habitat for razorback sucker. The most important of the repatriated populations are in the upper Salt and Verde rivers. As discussed for spikedace and loach minnow, the major dams on both of these rivers reduce the likelihood of invaders from CAP to a low to moderate risk. However, the heavy recreation on the reservoirs is a significant factor in that risk and may be a mechanism that allows a species from CAP to reach the upper Salt or Verde rivers. Razorback sucker were stocked in the Gila River above San Carlos Reservoir, Bonita Creek, and the San Francisco and Blue rivers, and possible recovery habitat exists in the San Pedro River. The status of the populations in these areas is unknown, as no fish have been found in years, and repatriation efforts do not appear successful. The relative accessibility of these areas to CAP introduced or spread nonindigenous species is the same as discussed earlier for spikedace and loach minnow.

In addition to the substantial adverse effects nonindigenous fish have had on remnant natural populations of razorback sucker (Pacey and Marsh 1998, Tyus and Saunders 2000), the repatriation of razorback sucker into the Gila River basin has met with limited success, to a large degree due to nonindigenous fish (Marsh and Brooks 1989, AGFD 1998). Stocking efforts on the upper Salt River have been largely unsuccessful due to heavy predation and dominance of flathead and channel catfishes. Predation on larvae by red shiner has been documented for Colorado squawfish and similar predation by other small nonindigenous species could be expected (Ruppert et al. 1993, Dunsmoor 1995). Nonindigenous species introductions via CAP that might significantly affect razorback sucker would most likely be predatory species or species that alter habitats or carry pathogens. If the incipient spread of white and striped basses via CAP reaches Horseshoe Reservoir, the razorback sucker that use that reservoir could be impacted by predation. Predation on larval and juvenile razorback sucker is a major factor in the decline of reservoir populations on the Colorado River (Minckley et al. 1991, Marsh et al. 2003, Schooley and Marsh 2007), and striped bass are a major part of that predation. Novel species, such as swamp eel, which has invaded Florida, Georgia, and Hawaii, could move through irrigation systems connected to CAP and eventually find its way into backwater habitats used by razorback sucker. Swamp eel is highly predacious and can also move overland and survive drought by burying in wet mud. Several tilapia species have substantial potential for habitat alterations that could adversely affect razorback sucker, particularly in larval and juvenile habitats (Shireman 1984, Dill and Cordone 1997).

Chiricahua leopard frog

Although the Chiricahua leopard frog frequently occupies fishless habitats, we expect it will be negatively impacted by introductions and establishment of nonindigenous organisms, including nonindigenous fishes, American bullfrogs, crayfish, spiny softshell turtle, pond slider, and potentially Rio Grande leopard frogs (*Rana berlandieri*). The swift water, concrete-lined CAP canals are poor habitat for nonindigenous frog species such as bullfrog or Rio Grande leopard frog. No ranid frogs have ever been detected in the CAP since monitoring began in 1986; however, Rio Grande leopard frogs have occasionally been found in concrete-lined canals in southwestern Arizona, southeastern California, and Sonora (Rorabaugh et al. 2002, Rorabaugh and Servoss 2006). But other features of the CAP such as constructed recharge basins are likely to provide better dispersal habitats for nonindigenous amphibians. These habitats may provide stepping stone habitats for the Rio Grande leopard frog and bullfrogs to invade portions of the range of the Chiricahua leopard frog. Also of concern, American bullfrogs and Rio Grande leopard frogs can contract chytridomycosis (Bradley et al. 2002, Rorabaugh 2005) and could carry the disease to Chiricahua leopard frog populations via recharge basins or other CAP aquatic features. Renovated streams upstream of constructed fish barriers within the historical range of the Chiricahua leopard frog should provide recovery habitat for the species, and the conservation fund will provide much needed funds for headstarting and implementation of other recovery actions in the Gila Basin.

Northern populations of the Chiricahua leopard frog along the Mogollon Rim and in the mountains of west-central New Mexico are disjunct from those in southeastern Arizona, southwestern New Mexico, and Mexico. Because these populations are much farther from the

CAP and urban population centers, and also above the dams on the Salt and Verde rivers, it is unlikely that they will be seriously impacted by CAP-mediated nonindigenous species. However, many of the populations below the rim do not enjoy the same protections from nonindigenous species that may be moved by the CAP. These southern populations are more likely to be impacted by nonindigenous species moved by the CAP.

Gila chub

Gila chub occupies a variety of aquatic habitats in the basin, some small and relatively isolated, that are less likely to be reached by nonindigenous aquatic species. Other habitats are in larger streams with better connectivity that will increase probabilities of nonindigenous species invasions and their impacts. However, several planned fish barrier projects and stream renovations will directly benefit Gila chub (O'Donnell, Redfield, and Hot Springs canyons, Bonita Creek).

The Gila chub populations in the upper Gila River basin (Turkey Creek [New Mexico], San Carlos River, Blue River [San Carlos drainage], Cienega Creek, Dix Creek, Eagle Creek, and Bonita Creek) would have the same potential for impacts from nonindigenous species as those discussed for the spikedace, Gila topminnow, and loach minnow populations in the upper Gila River basin. The same is also true for the Verde River populations (Walker Creek, Spring Creek, Williamson Valley Wash), as discussed in the razorback sucker, Gila topminnow, and spikedace sections above.

The SCR has four tributaries with extant populations of Gila chub: Sabino Canyon, Romero Canyon, Sheehy Spring, and Cienega Creek. Other locations are being considered for reestablishment. Sabino, Romero, and Cienega are all upstream of the effluent reach of the SCR and the Tucson basin. All three streams have natural or human-constructed barriers, or both, in addition to long stretches of dry stream between the chub-occupied reaches and the SCR. However, all three streams are readily accessible to humans, and thus are susceptible to baitbucket transfer of nonindigenous aquatic species.

The San Pedro River basin has four extant populations in Redfield Canyon, O'Donnell Creek, Hotsprings Canyon/Bass Canyon and near the Babocomari River at T4 Spring. All three streams have natural or human-constructed barriers, or both, in addition to long stretches of dry stream between the chub-occupied reaches and the San Pedro River. However, all locations are readily accessible to humans, and thus are susceptible to baitbucket transfer of nonindigenous aquatic species. The Natural Resource Conservation Service plans barriers at T4 Spring, and existing erosion plugs on O'Donnell Creek will be enhanced.

The Agua Fria River has chub populations at Silver Creek, Little Sycamore Creek, Larry Creek, Lousy Canyon, Indian Creek, and Sycamore Creek. The potential for impacts from nonindigenous aquatic species to Gila chub in the Agua Fria basin are very similar to those described for the Gila topminnow.

Critical Habitat

The PCEs for the razorback sucker, loach minnow, Gila chub, and spikedace are very similar. All four species have PCEs that define critical habitat as having water of sufficient quality and quantity, which includes lack of contaminants; proper levels of dissolved oxygen, nutrients, turbidity, pH, and conductivity; and with a hydrologic regime that meets the needs of each species. Because some of the nonindigenous aquatic species (common carp, tilapia, crayfish, certain plants) are known to affect these elements, nonindigenous species could negatively affect those PCEs dealing with water.

Another PCE common to the four species are provisions for physical habitat. These PCEs cover specific habitat requirements such as pools and riffles, amount of sediment, food supply, sufficient cover, and a healthy, intact riparian vegetation community. Nonindigenous species that alter these habitat characteristics would be problematic for these PCEs. Nonindigenous riparian and aquatic plants can certainly alter intact riparian vegetation, as is evidenced by the widespread impacts of salt cedar (Kerpez and Smith 1987, Stromberg and Chew 1997, Lovich and DeGouvenain 1998). Nonindigenous plants may present more of a problem, since the conservation measures proposed by Reclamation focus more on nonindigenous aquatic vertebrates. The conservation of native fishes funding will address some of the impacts by improving the conservation status of mainly the four listed fish.

Most importantly, areas free of nonindigenous fish are a common component of the PCEs for loach minnow, Gila chub, spikedace, and razorback sucker. Because it is likely that the CAP will move, directly or indirectly, a nonindigenous aquatic species into designated critical habitat, we believe impacts will occur to this PCE component for all four species. It's important to note that some of the areas designated as critical habitat already have multiple nonindigenous species present. Since many of these areas occur in larger aquatic systems, it is unlikely that they feasibly can be treated to remove the existing nonindigenous species, let alone any new ones. In addition, the areas of designated critical habitat that are free, or mostly free, of nonindigenous species, are more likely to stay that way because of their tendency to be further away from the CAP. Because of these existing circumstances and the proposed conservation measures, we do not believe that the effects from the CAP to this PCE rise to a level that significantly adversely affects designated critical habitat for the four species. In addition, the proposed barriers, funding to manage nonindigenous species, and information and education program will ameliorate the likelihood that CAP-mediated nonindigenous species significantly impact critical habitat beyond the degree to which it has already been affected by nonindigenous species.

Several proposed barriers are in designated critical habitat (stream/species):

- O'Donnell Creek – Gila chub;
- Blue River – loach minnow;
- Verde River – spikedace;
- Redfield Canyon – Gila chub;

- Hot Springs Canyon – Gila chub.

If the barriers are constructed in designated critical habitat, there will be effects to the PCEs. Reclamation builds the barriers to minimize impacts to the stream and its hydrology. The barriers should actually enhance the PCE common to all four species, by reducing threats from nonindigenous aquatic species.

Conservation Measures

The conservation measures that Reclamation has included with the proposed action for CAP in the Gila River basin will substantially alleviate threats from introduction and spread of nonindigenous aquatic species via CAP, both directly to the species and to the primary constituent elements of designated critical habitat. The funding of recovery actions will improve the status of the six listed species. Direct threat removal will occur through construction of barriers plus monitoring and management against nonindigenous species, and the information and education program will help alleviate the indirect threat from "bait-bucket" transfers associated with CAP waters and CAP introduced species. However, not all threats can, or will be removed. Significant areas where threats are not ameliorated by the conservation measures include the SCR from Tucson upstream and lower Sonoita Creek. The middle Gila River above Ashurst-Hayden Dam, which is directly connected to the CAP aqueduct through the Florence-Casa Grande Canal, is mostly protected from direct connection by the electrical barriers. The conservation measures also do not effectively ameliorate impacts from nonindigenous aquatic species that may be introduced and spread through CAP that are not fish (i.e. invertebrates, amphibians, turtles, plants, pathogens). Monitoring under the conservation measures is exclusively focused on fish, and the barriers are designed to prevent fish movement, but not necessarily that of other taxa.

Because of this inability to alleviate a portion of the threats from CAP, the conservation measures also include actions for recovery "in-lieu of threat removal." This approach was first used in the 1994 reasonable and prudent alternative to deal with threats from CAP for which there is no known feasible method to remove or ameliorate adverse affects. Recovery in-lieu of threat removal will provide for actions to improve the status of the listed species so that remaining threats are of less consequence to the survival and recovery of those species.

These conservation measures are the result of years of discussion and negotiation to address the impacts of the CAP to listed fish. Each conservation measure was designed to address one part of the nonindigenous aquatic species problem or to enhance the conservation status of native fish. Because each conservation measure is part of an overall strategy designed to address nonindigenous aquatic species, all conservation measures need to be implemented for the strategy to be effective. The jeopardy opinion and the reasonable and prudent alternatives from the 1994 BO have withstood challenges in court.

It must be recognized that although the barriers to upstream fish movement are a major part of the benefits of the conservation measures, if those barriers are not accompanied by appropriate management action, there is the potential that the barriers may result in adverse effects. Barriers

fragment populations and prevent upstream emigration (Sloat 1999). Barriers may also have direct and indirect effects, depending on where they are built. Proposed barriers will be placed below or near the downstream end of perennial flow. On streams where nonindigenous species already exist upstream, barriers can, under some circumstances, enhance the likelihood of the nonindigenous species becoming predominant. To ensure benefits from the barriers, in most circumstances they must be accompanied by control of nonindigenous species upstream. Because the nonindigenous species removal and repatriation of native species is outside the authority of Reclamation, the success of the barriers depends heavily on implementation of those management actions by the Service and other entities. The Service is committed to ensuring expeditious and successful completion of those actions, which are necessary to implement the recovery plans for the listed fish considered in this biological opinion. However, the conclusions of this consultation regarding CAP and the extent of Reclamation's responsibility under this consultation are mostly independent of any delays or impediments to implementation or effectiveness of those actions. We assume that all barriers included in the conservation measures will be built within 15 years, regardless of the schedule proposed by Reclamation in the conservation measures.

Barriers

The proposed Redrock Canyon barrier is in the planning stages, in combination with a renovation and fish reestablishment. This barrier will help protect what may still be an existing Gila topminnow population, which is the only natural population on National Forest System land. Chiricahua leopard frogs may also benefit, although the barrier will not be effective against bullfrogs or crayfish that are present nearby. The barrier may also facilitate replication of the Sheehy Spring population of Gila chub. Redrock has mosquitofish, which in combination with drought, likely led to the demise of the topminnow population. Largemouth bass were last observed there in 1995 (Weedman and Young 1997).

The primary purpose of the proposed barrier at Sheehy Spring is to protect existing populations of Gila chub and facilitate replication of one of the SCR subbasin populations of Gila topminnow. It will also facilitate the removal of mosquitofish, which led to the loss of the natural Gila topminnow population there.

The proposed middle Sonoita Creek barrier is intended to protect an existing natural population of Gila topminnow and facilitate replication of one of the SCR subbasin populations of Gila chub. Many nonindigenous fish, in addition to crayfish and bullfrogs, have been found in this reach of Sonoita Creek. The barrier should minimize the movement of nonindigenous fish from Patagonia Lake.

The existing paired barriers on Aravaipa Creek protect existing populations of loach minnow and spikedace, and potentially the Gila topminnow and desert pupfish that have been reestablished on the Aravaipa south rim. Numerous nonindigenous fish have been found in Aravaipa Canyon (Barber and Minckley 1966), including red shiner, which are problematic for spikedace and likely other native fishes.

The primary purpose of the proposed Blue River barrier is to protect existing populations of loach minnow and Chiricahua leopard frogs, and to facilitate replication of the Eagle Creek or New Mexico Gila River populations of spikedace. Numerous nonindigenous fish have been found in the Blue River drainage, and the barrier should minimize further invasions, and allow management against nonindigenous species.

The Bonita Creek proposed barrier is intended to protect an existing population of Gila chub and to facilitate replication of Eagle Creek populations of spikedace and loach minnow. Environmental compliance has been completed for the Bonita Creek barrier and a construction contract has been awarded. This barrier will help protect Bonita Creek from the numerous nonindigenous species in the Gila River.

The existing Cottonwood Spring barrier should protect an existing natural population of Gila topminnow. Mosquitofish have been observed in Sonoita Creek, downstream of Cottonwood Spring.

The purpose of the potential Hot Springs Canyon barrier is to protect an existing population of Gila chub and to facilitate replication of Aravaipa Creek populations of spikedace and loach minnow (completed). Gila topminnow were recently stocked in Hot Springs Canyon, but it is too soon to know if they have established a reproducing population.

The purpose of the proposed O'Donnell Canyon barrier is to protect existing populations of Gila chub, Gila topminnow, and Chiricahua leopard frog. The section of creek above the existing grade control structures was renovated a few years ago, to remove green sunfish and largemouth bass. This stream harbors one of the last populations of Sonora sucker (*Catostomus insignis*) in southeastern Arizona. Green sunfish have recently been found below the grade control structures (Rob Clarkson, Reclamation, pers. comm., March 24, 2008), which will eventually fail unless stabilized.

The primary purpose of the potential Redfield Canyon barrier is to protect an existing populations of Gila chub and facilitate replication of Aravaipa Creek populations of spikedace and loach minnow (completed). Gila topminnow has been reestablished in the Redfield Canyon drainage, but it is too soon to know if they have established a reproducing population. Many nonindigenous species are known downstream in the San Pedro River.

The potential barrier in the Tonto Creek drainage has not yet been definitively identified, but Spring Creek and Rock Creek have been investigated. The primary purpose of the barrier is to protect an existing population of headwater chub and facilitate replication of the East Fork White River population of loach minnow and an undetermined population of spikedace.

The upper Verde River barrier is proposed to protect existing populations of spikedace and facilitate replication of the Aravaipa Creek population of loach minnow. Razorback sucker and other native fishes will also benefit. Renovation is also likely to occur above the barrier.

There will be direct impacts to aquatic organisms during barrier construction, if water and listed species are present during construction. Barrier construction can be a major undertaking, with

major impacts at the project site. However, the construction site is only a very small portion of a stream. Indirect effects could include severing populations of listed species, changing local habitat types, and short-term and long-term changes in sediment regimes. Barriers can actually segment fish populations if the barrier has perennial flow below it that can be occupied by the native fish. Movement of fish and genetic material from below the barrier to above the barrier can no longer occur. The impacts of this segmentation should be minor for these reasons:

- Most barriers will be below habitat that is suitable to the six listed species;
- The effects of a segmented population are minor unless the upstream population is small;
- Active management can ameliorate impacts from population segmentation if negative impacts to the population are documented.
- The benefits of protecting the population above the barrier from invasion by nonindigenous species will likely outweigh the negative impacts of segmenting the population of a listed species.

Delays in meeting the stipulated schedule of a minimum of three barriers constructed in each consecutive five-year period may result in small increases in the risk to listed species via nonindigenous species impacts and a lag in the implementation of conservation actions. However, we believe the delay will not significantly change the capability of the conservation measures to remove the threat of jeopardy and adverse modification of critical habitat. Although potential harm to listed species caused by this delay cannot be erased, continued implementation of conservation measures should compensate through application of enhanced recovery actions for the species.

The conservation measures proposed will provide significant assistance in the recovery programs for spikedace and loach minnow, although localized, short-term adverse effects may occur during barrier construction in occupied streams. The benefits will be slightly less for razorback sucker and Gila topminnow, although important recovery actions for both species will occur through the recovery and nonindigenous species management funds, as evidenced by the history of the first years of implementing those funds (Appendix 4). All listed and unlisted native fish in the Gila River basin, especially the desert fishes, will benefit from some recovery actions through these funds.

Even though barriers will afford a major benefit to native fish and frogs, barrier construction and maintenance will adversely affect the six listed species if they were to occur near the barrier. The proposed barrier locations may change, but several of the completed and proposed barriers could have listed species at the site during the life of the barriers or during construction. It is reasonably certain that the construction and maintenance of some of the barriers will occur when one of the six listed species covered by this BO is present. The table below lists the completed and proposed barriers and which of the listed species may be present at that site.

Table 10. Completed and proposed barriers and which of the six listed species may be present at that site or repatriated to the site following barrier construction and stream renovation.

Barrier	Razorback sucker	Gila topminnow	Chiricahua leopard frog	Gila chub	Loach minnow	spikedace
Completed Barriers						
Aravaipa Creek					XXXXX	XXXXX
Cottonwood Spring/Sonoita Creek		XXXXX				
Fossil Creek	XXXXX				XXXXX	XXXXX
Potential Barriers						
Sonoita Creek		XXXXX				
Verde River						XXXXX
Tonto Creek drainage						
Redfield Canyon			XXXXX	XXXXX		
O'Donnell Canyon		XXXXX	XXXXX	XXXXX		
Hot Springs Canyon				XXXXX		
Bonita Creek				XXXXX		
Blue River				XXXXX	XXXXX	XXXXX
Sheehy Spring		XXXXX		XXXXX		
Redrock Canyon		XXXXX	XXXXX			

Funds

The impacts not fully offset by the barriers will be ameliorated by management against nonindigenous species, information and education, conservation of native fishes, and the Chiricahua leopard frog recovery actions. All of these conservation measures will be funded by the Bureau of Reclamation. These conservation measures should ensure that there is not a significant decrease in the numbers, distribution, or reproduction of the six listed species. The conservation measures are expected to provide for the recovery of the species by enabling management actions against nonindigenous species, which should protect important existing populations and provide for the expansion and replication of populations. This funding will also allow control and research activities to occur that should offset most negative effects from CAP facilitated nonindigenous species. The funding provided for recovery actions for both the fish and the Chiricahua leopard frog will not only mitigate for those effects not addressed by the other conservation actions, but it should also enable us to improve the status of all six species. The funding provided for education will create more public support for native aquatic species management and inform the public about issues with nonindigenous species.

The Service is concerned that funding for the conservation measures will largely be spent on spikedace and loach minnow, and larger habitats, to the near exclusion of smaller sites and Gila

topminnow. The numbers in Appendix 4 show that, to date, 12 percent of the conservation funds have been spent on Gila topminnow, with eight percent of the recovery funds spent on topminnow. The Gila chub, which was listed in late 2005, has benefited from more spending than the Gila topminnow. Also, loach minnow and spikedace combined account for 57 percent of the funds expended so far. Impacts from CAP-mediated transfer of nonindigenous aquatic species will be problematic in the SCR subbasin. In addition, since most Gila topminnow natural sites are in the Santa Cruz basin and are the cornerstone of Gila topminnow recovery, implementation of the conservation measures must address this issue. The Service believes a minimum of funding for the Gila topminnow and SCR basin is necessary. Of the funding to date that can be directly attributed by basin, two percent of RPA 3 funding and 11 percent of RPA 4 funding have gone to the SCR. Reclamation initially proposed $50,000 annually for recovery actions in the SCR, about 18 percent of the current proposal of $275,000. We requested that $50,000 be funded under RPA 4 for the SCR, also 18 percent of $275,000. Thus, our belief that 10 percent of RPA 3 and RPA 4 be spent on Gila topminnow and the SCR is less than the original proposals by us and Reclamation. While we expect that the funding provided by the two conservation measures will address Gila topminnow in the SCR, we want to ensure that it does. The SCR subbasin is also important for the conservation and recovery of the Chiricahua leopard frog and Gila chub, which also demonstrates the necessity for actions occurring in the Santa Cruz basin to be funded.

Fish Monitoring

The purpose of the monitoring program is to establish baseline data on the presence and distribution of nonindigenous and native fish in the target reaches. Experience from the CAP Gila opinion has shown that it is not possible to detect small to moderate changes in abundance of various species within the fish community. Therefore, the primary goal of this monitoring is to determine presence or absence of nonindigenous species and distribution within the Gila River basin of those present, detect substantial changes in distribution, and detect major changes in the fish community over time. Because of limitations of knowledge and technology and because the largest threat is expected to come from nonindigenous fish, this monitoring is targeted at fish. However, it is expected that limited information will also be gathered on distribution of some of the more obvious new nonindigenous amphibians, plants, reptiles, or invertebrates, including when new species appear. Monitoring is a necessary component of the conservation measures, as it must be done in addition to construction of barriers to identify when management actions against nonindigenous species should be taken.

Information and Education

The purpose of the information and education conservation measure is to increase public awareness of human-aided bait bucket transfers, pet-dumping, and other private avenues of nonnative aquatic species introductions and translocations and to increase awareness of, and support for, conservation of native fishes and their habitats, with emphasis on the problems nonnative aquatic species create for those species. Without an attempt to address the source of many nonindigenous species introductions, people, the other conservation measures are likely to fail. We do not expect this information and education will be able to fix the problem. But this

program, in concert with similar programs conducted by other agencies, may help reduce the movement of nonindigenous species.

Conclusion to Effects Analysis

Novel and existing nonindigenous fishes and other aquatic organisms that enter, are transported through, moved by people into or out of, or escape from the CAP canal and enter Gila River basin surface waters via its interconnection points, have potential to move upstream into surface waters occupied by the federally listed species considered here. Nonindigenous species that escape the CAP have the potential to establish populations in surface waters where they further are subject to human-mediated transport to waters inhabited by federally listed species via bait bucket or unintentional transfer. Negative impacts to federally listed species can accrue via predation, competition, or hybridization or through modification of habitat. Nonindigenous species can also harbor exotic parasites and disease that could be transferred to populations of federally listed aquatic organisms.

In summary, the six species addressed here are all highly vulnerable to adverse impacts from nonindigenous aquatic species and already exist under some degree of pressure from nonindigenous predation, competition, disease transmission, or other threats. The habitats of all six species are degraded and are threatened by a wide variety of ongoing or future impacts. The status of the species is poor and declining. The CAP is an interbasin water transfer and will, like most other such transfers, introduce and spread nonindigenous aquatic species. Except for the species already introduced through CAP (striped bass, white bass, Asian clam, quagga mussel), the identity of the species which will invade is not entirely predictable but may include a wide variety of invertebrates, vertebrates, and plants. Sufficient facilities and mechanisms for movement from the CAP into Gila basin surface waters exist to ensure that some nonindigenous species are likely to make that move, either by themselves or with human assistance. Bait bucket transfers of nonindigenous species made more available through CAP are likely to occur. Water bodies created using CAP water will provide increased habitat and colonization staging areas for nonindigenous aquatic species. Some existing populations of spikedace, loach minnow, Gila topminnow, Gila chub, razorback sucker, and Chiricahua leopard frog may be affected up to the level of extirpation, while others may experience little or no effects. Recovery potential for these species may be completely precluded in some areas, including designated critical habitat. These adverse effects mostly are ameliorated by the conservation measures, although there are significant areas where threats cannot be feasibly removed. Recovery in-lieu of threat removal provisions of the conservation measures assist in counteracting those remaining threats.

We believe that the conservation measures will limit or address the impacts from nonindigenous species that may be transported by CAP-mediated avenues to the listed species and their designated critical habitat. Any impacts not limited or addressed by the barriers, management against nonindigenous species fund, and information and education, will be ameliorated by the conservation of native fishes funding, and the funding for Chiricahua leopard frog recovery actions. These conservation measures should, therefore, ensure that there is not a significant decrease in the numbers, distribution, or reproduction of the six listed species. The conservation measures are expected to provide for the recovery of the species by enabling management

actions against nonindigenous species, which should protect important existing populations and provide for the expansion and replication of populations.

Cumulative Effects

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation following section 7 of the Act.

There are many actions associated with the CAP, including those of CAWCD that are often interrelated or interdependent. Other actions are cumulative. Please refer to Table 2 for a listing of the responsible parties for actions related to the CAP.
Private actions using CAP water are also cumulative to the Federal action involved in CAP. The use of CAP water for agricultural, municipal and industrial, Indian, and recharge purposes may change significantly over the course of the 100-year project life, but is not expected to cease or decrease. Therefore it is a reasonably foreseeable action, the effects of which must be considered in the analysis conducted in this biological opinion. It is also likely that the CAP, in its current or modified form, will continue past the 100-year project life. As with some CAWCD cumulative actions, the private actions directly using CAP water are described as part of the earlier overall project description section of this biological opinion.

Various non-Federal actions in addition to those from direct use of CAP water are also cumulative to the CAP impacts to six listed species. Human population growth in the Gila River basin, particularly in Phoenix and other urban areas, is predicted to occur into the future (Arizona Department of Economic Security 2001) and will place ever greater demands on all natural resources in the basin, especially water. Growth and development will continue to result in changes in watershed condition and watershed function affecting water quality and quantity, riparian vegetation, channel morphology, and flood characteristics. Groundwater pumping in areas such as the upper San Pedro Valley and the Prescott and Chino Valley area threaten the water supply of streams important to spikedace, loach minnow, Gila topminnow, and razorback sucker. As more people live and recreate in the area, opportunities will also increase for nonindigenous aquatic species to enter the basin. Illegal releases of nonindigenous organisms will continue and increase (Aquatic Nuisance Species Task Force 1994, Rosen et al. 1995) as will the demand for stocking of nonindigenous sport fish by the AGFD (65 FR 24328). Use of nonindigenous organisms as pets may also increase, as will illegal release of those organisms (Moore et al. 1976, Shelton and Smitherman 1984, Welcomme 1988).

There are many conservation actions being considered by the AGFD for native fish and frogs. Two important conservation actions are the approved Safe Harbor Agreements for the Chiricahua leopard frog and the topminnow and pupfish. While these two agreements and any other conservation actions taken by AGFD are likely to be federally funded or approved, at least some of them will have no Federal nexus.

That southeastern Arizona and much of the American southwest have experienced serious drought recently is well known. What is known with far less certainty is how long droughts last.

State-of-the-art climate science does not yet support multi-year or decade-scale drought predictions. However, instrumental and paleoclimate records from the Southwest indicate that the region has a history of multi-year and multi-decade drought (Hereford et al. 2002, Sheppard et al. 2002, Jacobs et al. 2005). Multi-decade drought in the Southwest is controlled primarily by persistent Pacific Ocean-atmosphere interactions, which have a strong effect on winter precipitation (Brown and Comrie 2004, Schneider and Cornuelle 2005); persistent Atlantic Ocean circulation is theorized to have a role in multi-decadal drought in the Southwest, particularly with respect to summer precipitation (Gray et al. 2003, McCabe et al. 2004). Given these multi-decade "regimes" of ocean circulation, and the severity and persistence of the present multi-year drought, there is a fair likelihood that the current drought will persist for many more years (Stine 1994, Seager et al. 2007), albeit with periods of high year-to-year precipitation variability characteristic of Southwest climate.

The information on how climate change might impact southeastern Arizona is less certain than current drought predictions. However, virtually all climate change scenarios predict that the American southwest will get warmer during the 21st century (IPCC 2001, 2007). Precipitation predictions show a greater range of possibilities, depending on the model and emissions scenario, though precipitation is likely to be less (USGCRP 2001, Seager et al. 2007). To maintain the present water balance with warmer temperatures and all other biotic and abiotic factors constant, precipitation will need to increase to keep pace with the increased evaporation and transpiration caused by warmer temperatures.
Key projections to keep in mind include:

- decreased snowpack — an increasing fraction of winter precipitation could fall as rain instead of snow, periods of snowpack accumulation could be shorter, and snowpacks could be smaller; ironically, due to changes in snow-precipitation characteristics, runoff may decrease even if total precipitation increases (Garfin 2005, Seager et al. 2007);

- earlier snowmelt — increased minimum winter and spring temperatures could melt snowpacks sooner, causing peak water flows to occur much sooner than the historical spring and summer peak flows (Stewart et al. 2004);

- enhanced hydrologic cycle—in a warmer world an enhanced hydrologic cycle is expected; flood extremes could be more common causing more large floods; droughts may be more intense, frequent, and longer-lasting (Seager et al. 2007).

Continuing drought and climate change, when added to the historical and continuing threats, will make native aquatic species conservation in the Gila River Basin even more difficult. The impact of site desiccation to fish is obvious. Frogs may be able to move to another site. Many less obvious effects could occur with drought and a warmer climate. A site with reduced streamflow, or a pond or pool with low water levels could become fishless due to reduced dissolved oxygen. We have seen this occur at three important natural Gila topminnow sites (i.e. Sharp Spring, Redrock Canyon, Cienega Creek). Nonindigenous aquatic species may become more restricted in distribution as well; however, both native and nonindigenous species will be

competing for remaining aquatic habitats, and extensive case history suggests that nonindigenous species will win.

Drought and climate change will also impact watersheds and subsequently the water bodies in those watersheds. Drought, and especially long-term climate change will affect how ecosystems and watersheds function. These changes will cause a cascade of ecosystem changes, which may be hard to predict and are likely to occur non-linearly (Seager et al. 2007).

As an example, drought and climate change will cause changes in fire regimes in all southeastern Arizona vegetation communities. The timing, frequency, extent, and destructiveness of wildfires are likely to increase and may facilitate the invasion and increase of nonindigenous plants. These changed fire regimes will change vegetation communities, the hydrological cycle, and nutrient cycling in affected watersheds (Brown et al. 2004). Some regional analyses conservatively predict that acreage burned annually will double with climate change (MacKenzie et al. 2004). Such watershed impacts could cause enhanced scouring and sediment deposition, more extreme flooding (quicker and higher peak flows), and changes to water quality due to increases in ash and sediment within stream channels. Severe watershed impacts such as these, when added to reductions in extant aquatic habitats, will severely restrict sites available for the conservation of native fish and other aquatic vertebrates and make management of extant sites more difficult.

Many of the predictions about the impacts of climate change are based on modeling, but many predictions have already occurred. The tree die-offs and fires that have occurred in the south-west early in this century show the impacts of the current drought. Because of drought, climate change, and human population growth, negative effects to aquatic habitat in the Gila basin continue to occur. The basin's rivers, streams, and springs continue to be degraded, or lost entirely.

CONCLUSION

After reviewing the current status of each species, the environmental baseline for the action area, the effects of the proposed action and the interrelated and interdependent actions, and the cumulative effects, it is the Service's biological opinion that the delivery of CAP water in the Gila River basin, with the implementation of the proposed conservation measures, is neither likely to jeopardize the continued existence of spikedace, loach minnow, Gila topminnow, razorback sucker, Gila chub, or Chiricahua leopard frog nor likely to destroy or adversely modify the critical habitats of spikedace, loach minnow, Gila chub, or razorback sucker. Our rationale for these conclusions is summarized below.

1) The Chiricahua leopard frog occurs at many sites at high elevation that are much less likely to be impacted by nonindigenous species whose movement might be facilitated by the CAP.

2) The proposed barriers will reduce the movement of deleterious nonindigenous species and allow management for the recovery of native species to occur on protected streams.

3) The monitoring program should detect invasions of known or novel nonindigenous species and allow quick action to manage against them.

4) Funding provided for management against nonindigenous species will allow control and research activities to occur that should offset most negative effects from CAP facilitated nonindigenous species.

5) Funding provided for recovery actions for both the fish and the Chiricahua leopard frog will not only mitigate for those effects not addressed by the other conservation actions, but should also improve the status of all six species.

6) The Funding provided for education will create more public support for native aquatic species management and inform the public about issues with nonindigenous species.

7) Though some Gila chub populations are readily accessible to people and are close to CAP related facilities, several other populations are not. Several existing Gila chub populations are or will be protected by existing barriers. Gila chub will also benefit from the two conservation measure funds, through reduction of nonindigenous species and by reestablishment of new populations and other recovery actions.

8) Most spikedace populations are not readily accessible to people or close to CAP related facilities. The populations in the Verde River are above the major dams on both of these rivers. Several existing spikedace populations are, or will be, protected by existing barriers. Spikedace will also benefit from the two conservation measure funds, through reduction of nonindigenous species and by reestablishment of new populations and other recovery actions. There are multiple actions that have been completed and are being planned that will help recover the spikedace (Appendix 4).

9) Razorback sucker populations exist in the Gila basin only as repatriated, non- reproducing, populations. The repatriated populations are in the upper Salt and Verde Rivers, above the major dams on both of these rivers. Therefore, the likelihood of invaders from CAP is a low to moderate risk. The razorback sucker will also benefit from barriers and the two conservation measure funds, through reduction of nonindigenous species, and by reestablishment of new populations and other recovery actions (Appendix 4).

10) Though some Gila topminnow populations are readily accessible to people and close to CAP related facilities, several other populations are not. Several existing Gila topminnow populations are, or will be, protected by existing barriers. Gila topminnow will also benefit from the two funds, through reduction of nonindigenous species and by reestablishment of new populations and other recovery actions. There are multiple actions being planned that will help recover the Gila topminnow (Appendix 4).

11) Most loach minnow populations are not readily accessible to people or close to CAP related facilities. The populations in the upper Salt and Verde Rivers, are above the major dams on both of these rivers. Several existing loach minnow populations are, or will be, protected by existing barriers. Loach minnow will also benefit from the two conservation measure funds,.