Marsh and Pacey (1998) conducted an extensive literature search on the habitat and resource use of the native and non-native fish in the lower Colorado River. They concluded the native and non-native fishes in the river overlap broadly in their physical habitat and resource use. They stated:

> "No attribute of physical habitat or resource use can be identified that markedly or marginally favors one group of fishes over another, and we cannot envision habitat manipulations or features that could be made to accomplish such a goal. Rather, the evidence supports an hypothesis that presence of non-native fishes alone precludes successful life-cycle completion by components of the native fauna. This array of non-native fishes now present has feeding, behavioral, and reproductive attributes that allow it to displace, replace, or exclude native kinds."

Effect Analysis

Much of the lower Colorado River plus Lake Powell must be considered as occupied habitat for some life-stage of the razorback sucker, both wild and reintroduced fish. Therefore, it would not be remarkable to encounter a larval or adult fish anywhere in the mainstream river between Lake Powell and Yuma, Arizona. Because of the significant differences in their makeup, reservoirs and river reaches are each considered separately.

1) Mainstem Reservoirs:

Lake Mead has been occupied by razorback suckers since its formation. As the reservoir filled, razorback suckers must have initially been successful in recruiting fish to the adult life stage because the populations did initially expand. Lake Powell did not produce a large population after its filling. This may have been due to a scarcity of razorback sucker in the new reservoir either because the habitat was limiting to begin with, or razorback sucker in the area of the new reservoir were already on the decline due to the presence of non-native fish. The spawning process described earlier continues today on Lake Mohave. Biologists have captured over 100,000 razorback sucker larvae from the reservoir, indicating that both spawning and incubation of eggs has been successful over the wide range of reservoir operations during that period. However, despite these hundreds of thousands of spawning acts and production of hundreds of thousands of larvae, the reservoir population has not been able to replenish itself, and over 50 percent of the adult population has died of old age during the last 10 years. In Lake Mead, only remnant populations exist and without help; extirpation is only a matter of time.

In the future, adult populations of repatriated fish will be present in Lakes Mohave and Havasu as well as the lower river below Parker Dam. No decision has been made on augmenting the Lake Mead population. These populations, and designated critical habitat would continue to be protected under ESA. Efforts are currently being made to supplement adult breeding populations of razorback suckers by stocking lakes with young reared in predator free ponds. Operations at Lake Mohave are conducted in an effort to conserve and protect razorback sucker by controlling the amount of lake fluctuation during the spawning season. Spawning success has been limited by predation of eggs and larvae by non-native fish.

2) Riverine Reaches:

Limited observations of adult razorback suckers have been made in the river reach between Davis Dam and Lake Havasu, and between Parker Dam and Imperial Dam. Indirect evidence of spawning is provided in the periodic capture of young fish in canal systems and at structures which divert water from these reaches. Daily water level changes in these reaches expose gravel bars during the known spawning season for razorback sucker. A reduction of 0.05 (½ in.) to 0.66 feet (8 in.) in the river elevation resulting from a 400 kaf change in point of diversion will slightly increase the amount of exposed gravel bars. While the probability of this increase affecting incubating eggs of razorback sucker is remote, the possibility does exist, especially in light of recent repatriation of the species through various interagency rearing and stocking programs. Therefore, it must be concluded that the reduction of flows in the river reaches from Parker Dam to Imperial Dam may affect razorback sucker spawning potential.

Reasons for the statement that this possibility is remote are as follows. Historically, these reaches were mostly shifting sand bottom, which would be poor quality spawning habitat. Today, most of the entire reach has large areas of clean gravels available for spawning, and most of these are not exposed during daily flow changes. Adult razorback suckers spawn over an extended period and spawn both day and night (file data, USBR). Water level changes happen everyday in these reaches, and it is highly unlikely that these fish would be unaware that the river is moving up and down. The rate of change is greatest near the dams, and spawning gravels are available along most of the river's course, especially where desert washes enter the river and provide debris fans.

Finally, if such an effect would occur, it would be inconsequential to the continued existence of these fish. The primary limiting factor for these populations is nonnative fish predation, and the annual production of even tens of thousands of eggs and larvae have not been sufficient to stem the predation losses in Lakes Mead and Mohave. Similarly, the stocking of tens of thousands of larvae and small juveniles into these reaches of river over the last decade have not resulted in increased abundance of the species.

A decrease of 24 acres (0.6%) of open water out of a total of 4,012 acres in backwaters would also occur as a result of the change in point of diversion of 400 kaf. Razorback suckers use backwaters in the Imperial Division in varying degrees. Also associated with the change in river surface elevation would be a decrease of 71 acres (0.5%) of open water out of a total of 10,305 acres of open water associated with the main river channel.

Effect Summary:

Through ongoing conservation measures described for the razorback sucker described previously, and those proposed as part of the project, the status and survival of this species in Lakes Mohave, Havasu and other reaches of the river will be substantially improved. The goal of this conservation effort is to have 50,000 new adults in Lake Mohave and 25,000 new adults in Lake Havasu by the Year 2003; Reclamation is committed to fund and assist in providing at least half of these numbers. It is anticipated the Lake Mohave goal will be reached by 2002. With such success, the baseline status of the species will be dramatically improved and the potential jeopardy status diminished. The completion of these efforts, along with the Lake Mohave program, will provide for maintenance of the genetic variability of the razorback sucker for at least one more generation. Imminent extinction will be avoided and survival and recovery opportunities provided.

In summary, the effect analysis for razorback sucker concludes that implementing ISC and the change in point of diversion of 400 kaf from Imperial Dam to Parker Dam as a result of the SIAs may affect razorback sucker.

Bonytail (Gila elegans)
Federally Endangered

Description and Life Requisites

In appearance bonytail are gray to gray-green on the dorsal, with silvery sides fading to a white ventral surface. The fish is elongated and somewhat laterally compressed with a narrow caudal peduncle. A smooth predorsal hump is present in the adult form. Breeding males can be distinguished by reddish marks on the paired fins and the presence of tubercles anterior on the body (Vanicek, 1967). Adults are from 11 to 13 inches in length, although larger individuals (up to 24 inches) are occasionally taken. Positive field identification between bonytail and other forms of Gila is quite difficult and often considered tentative. Further, the name bonytail was assigned in general to the genus Gila by many researchers; thus, its population status in historic times is far from certain in areas where a mix of Gila species occurs. However, this problem is associated more with upper Colorado River basin populations.

As a result of the rarity of this species, the biology of the bonytail is not well understood. Spawning of bonytail has not been observed in riverine habitats, but based on the appearance of ripe fish in the upper basin, spawning appears to occur during late June and early July. Spawning in the lower basin occurs from late spring to early summer (Wagner, 1954). In Lake Mohave, schools of bonytail were observed over gravel reefs (Jonez and Sumner, 1954) and along clean sandy bottoms. Bonytail have spawned in earthen ponds in captivity, including rearing ponds around Lake Mohave (USBR, file data) and on the La Paz County golf course near Parker, Arizona (C.O. Minckley, pers. comm.). Bonytail produce an average of about 50,000 eggs/per fish (Hammond, pers. comm.). Hatching success is greatest in water temperatures from 59° to 68°F (Marsh, 1985). In the Green River, Vanicek and Kramer (1969) estimated fish to reach approximately 2 inches during their first year of life, 4 inches by the end of the second season, and approximately 6 inches by the end of the third season. Growth rates from young bonytail stocked into backwaters of Lake Mohave indicate substantially higher growth rates are possible depending on habitat conditions. During 1995, 4-inch fish were stocked into lakeside ponds in March and grew to over 12 inches by November (USBR, file data). Fish appear to feed primarily on zooplankton and insects.

Distribution and Abundance

The bonytail once ranged throughout the mainstem Colorado River and principal tributaries (Minckley, 1973). They were still abundant in Lake Mead after the completion of Hoover Dam (Moffett, 1943), however, by 1950 they were considered rare (Jonez and Sumner, 1954). By the time concern was raised for this fish, it had disappeared from much of its range. Consequently, the species was listed as endangered by FWS in April 1980. The most recent recovery plan for the bonytail summarizes the fish's distribution as:

> "The bonytail chub is very rare. In the Colorado River Basin, few individuals have been found in the last decade, and recruitment is apparently nonexistent or extremely low." (FWS, 1990)

Presently, bonytail are believed to be extirpated in the Colorado River from Glen Canyon Dam to Hoover Dam (McCall, 1979). Small populations may still exist in the upper basin, but as mentioned earlier, there is much confusion in fish identification due to the similarity in physical appearances with some of the roundtail chubs. Like the razorback, the largest remaining population of bonytail in the entire Colorado River basin resides in Lake Mohave. Unlike the razorback, however, population data from Lake Mohave are incomplete because too few fish have been captured to allow for a credible population estimate to be made.

Whether or not wild fish remain in Lake Mohave is not known, and most likely it cannot be determined. There were at least nine augmentation stockings of bonytail into Lake Mohave between 1981 and 1991 (USBR, file data). These stockings total over 150,000 fish and have ranged in size from less than 1 inch (fry) to 4-inch juveniles. These fish all originated at Dexter National Fish Hatchery, New Mexico, and were descendants of bonytail adults captured from Lake Mohave. (One group of 1,162 fish came from CFG's Niland Fish Hatchery, where they were being reared, but had originated as fry from Dexter National Fish Hatchery.) Only a small percentage of these fish was ever tagged or in some way marked. As part of the NFWG effort on Lake Mohave fingerling bonytail from Dexter National Fish Hatchery have been stocked into predator-free rearing ponds around the lake and later stocked into the reservoir after reaching 10-12 inches in length. All of these later fish have been PIT-tagged. A few of these fish have been recaptured (USBR, file data).

Fish were occasionally taken from Lake Havasu prior to 1970, but no up-to-date information or recent captures exist other than recaptures of fish released by the HAVFISH program during the past 2 years. The historical population has most likely been extirpated. Efforts are being undertaken to reintroduce bonytail back to Lake Havasu from lakeside coves using young obtained from Dexter National Fish Hatchery.

Like the razorback sucker, the primary limiting factor for bonytail appears to be non-native fish predation of the early life stages (egg to subadult). This conclusion is based on the fact that when reintroduced at a large size, the fish survive in the reservoir, and when stocked into predator-free environments the young fish grow to adulthood.

How and when the predation occurs is not certain, but Jonez and Sumner wrote the following report after observing spawning bonytail in Lake Mohave in May 1954:

> "In May 1954, with the aid of shallow-water diving gear, a large population of bonytail was observed spawning on a gravelly shelf about ten miles below Eldorado Fish Camp. It was estimated that there were about 500 bonytails spawning in the quarter-mile of gravel. It appeared that each female had three to five male escorts. Neither males nor females dug nests, and the eggs were broadcast on the gravel shelf. No effort was made to protect the eggs by covering them with gravel or by guarding them. However, the eggs adhered to the rocks, and that gave them some protection.... Large schools of adult carp were intermingling with the spawning bonytail. No young bonytails were observed in the spawning area, and it is presumed that the carp ate most of the eggs."

As mentioned earlier, juvenile razorback suckers tend to hide during the day in areas that are now occupied by predators, and when they emerge from these hiding areas, they fall prey to ambush predators such as largemouth bass. It is not known whether bonytail juveniles are nocturnal and subject to the same predation pressures. Bonytail juveniles placed in a large backwater pond connected to Lake Mohave by a barrier net (Davis Cove) were readily eaten by largemouth bass, an ambush predator that normally feeds during dawn and dusk when fish would be immerging and emerging from cover (USBR, file data).

<u>Effects Analysis</u>

Bonytail are presently found in Lakes Mohave and Havasu. Implementation of the ISC or change in point of diversion of 400,000 kaf between Imperial Dam and Parker Dam will not affect the operation of those lakes. Efforts are underway to re-introduce bonytail to the lower Colorado River below Parker Dam. The expected reduction in surface water elevation may affect the habitat for this potential recovery action.

1. Critical Habitat Description - Razorback Sucker and Bonytail

Critical habitat for the razorback sucker and bonytail was designated in March 1994. The critical habitat for the razorback sucker includes Lakes Mead and Mohave and the river reach between them. It also includes the Colorado River and its 100-year floodplain from Parker Dam to Imperial Dam including Imperial reservoir (Figure 11).

Critical habitat for bonytail includes the Colorado River from Hoover Dam to Davis Dam, including Lake Mohave. It also includes the Colorado River from the northern boundary of Havasu National Wildlife Refuge to Parker Dam, including Lake Havasu (Figure 11).

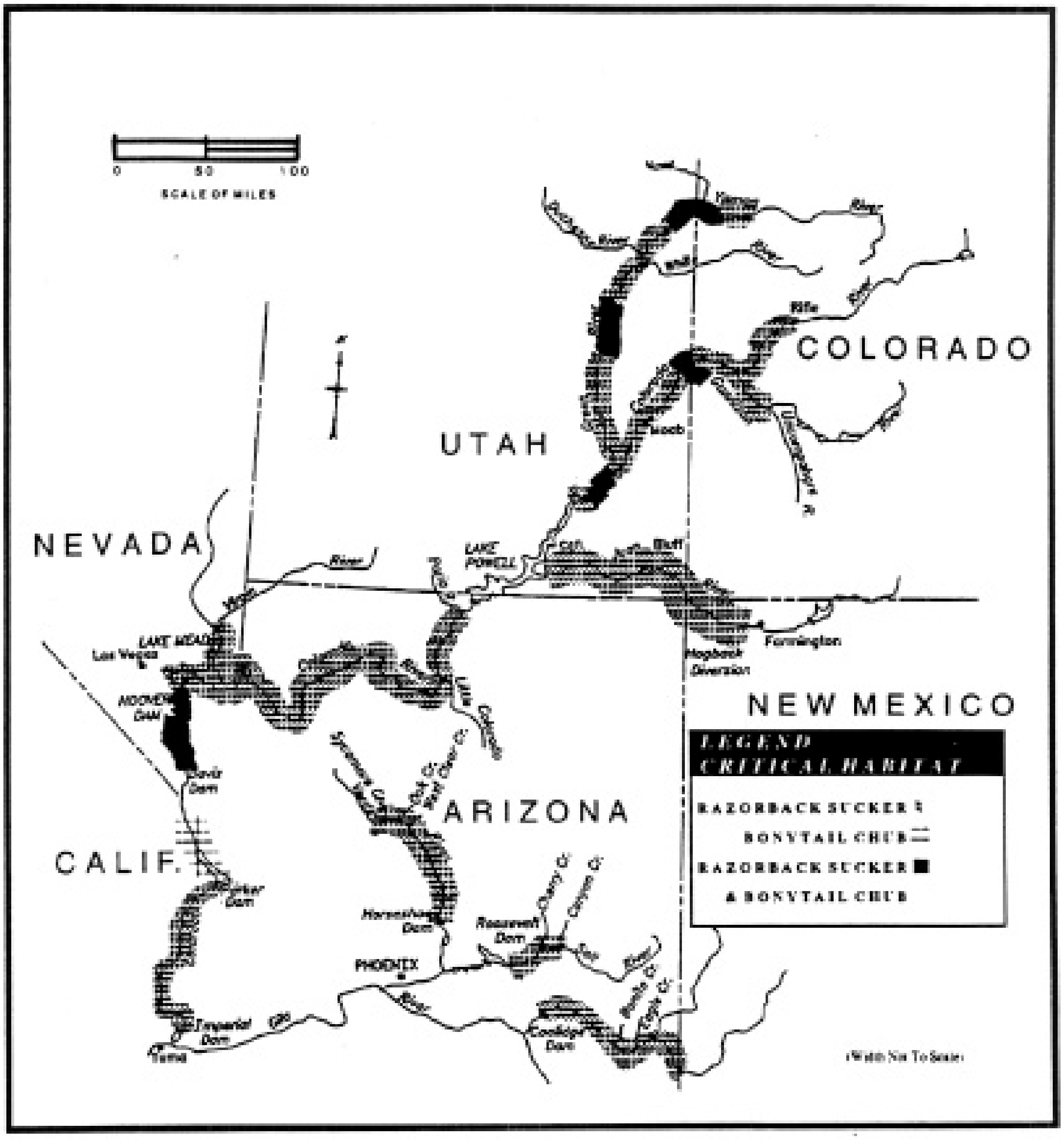

Figure 11. Location of Critical Habitat for Bonytail Chub and Razorback Sucker.

Critical habitat is a regulatory term used to describe requirements for certain species survival. It encompasses physical and biological features essential for survival and recovery of listed species. Within the context of this document, the components of critical habitat will be addressed jointly for each species. There are some differences in species requirements, but the system itself functions as a whole, so it should be addressed as a whole. For the endangered big-river fishes, critical habitat encompasses three major areas of consideration as follows :

> Water - A quantity of water of sufficient quality (i.e., temperature, dissolved oxygen, contaminants, nutrients, turbidity etc.) that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life-stage of each species.
>
> Physical Habitat - Areas of the Colorado River system that are inhabited or potentially habitable 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, secondary 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.
>
> Biological Environment - Food supply, predation, and competition are important elements of the biological environment. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation, although considered a normal component of this environment, may be out of balance due to introduced fish species in some areas.
>
> Each aspect of a critical habitat may, in and of itself, explain some changes in the population status of the big-river fishes, but the interactions between, and cumulative effects of, the combined elements are also of important concern.

Effects Analysis

Native fishes historically lived under more severe extremes of conditions than are currently found. The most visible changes that have occurred along the lower Colorado River have been those associated with the construction of facilities.

Water:

Implementing the SIA or Surplus Criteria will not destroy or adversely modify the quality of water, a constituent element needed for the critical habitat of these fishes.

Water temperature is known to impact the ability of fish to spawn. However, this effect in the lower basin impacts only a localized area and does not account for why the species has declined across its entire range (Minckley et al., 1991). Hoover Dam, for example, releases cold, hypolimnetic water, which may impair the ability of some stage of the life-cycle to survive, but Mueller (1989b) documented spawning and presence of larvae in this reach of the river. There have been numerous accounts of razorback suckers and bonytail spawning downstream in Lake Mohave where water temperatures approach 80° F, yet the population still does not recruit.

Historically, water quality exhibited wide ranges for common physico-chemical parameters deemed important for fish (e.g. temperature, dissolved oxygen, pH, salinity). Water quality in reservoirs is more stable than it was historically due to the buffering capacity of large masses of water. Reservoir temperatures are relatively stable on a daily basis. Oxygen levels are within tolerable ranges, as are a host of other basic limnological characteristics such as pH and conductivity.

Mainstem dams desilt the water. Reduced turbidity downstream of dams is a factor related to initial construction, and it's impact is conjectural: less suspended sediment means less physical stress to fish, but clear water may accelerate predation. Lower turbidity means greater light penetration and more primary production, and removal of fines means cleaner spawning gravels and more attachment sites for benthic and sessile animals (secondary production).

Increasing salinity has been a major water quality concern on the lower river. Much of the increase in salt load is a result of agricultural drainage. Diversions result in less water in the river channel to dilute saline return flows. Increases in salinity along the mainstem Colorado River have not yet attained a level that would impact native fishes. The proposed changes in point of diversion would not be expected to cause a salinity increase significant enough to impact native fishes.

The potential exists for the concentration of other chemicals and toxic compounds besides salt. Selenium and several pesticides have been identified, but there are no data yet that demonstrate levels are high enough in the lower river to affect reproduction of native fishes. A discussion of selenium in the lower Colorado River can be found in Appendix G.

As far as actual quantity of water, consistent low or high flows really do not differ from each other, because in either case the habitat stabilizes around the flow. Average seasonal patterns of water release, although not nearly of historical magnitude, follow the same general pattern, with the highest flows occurring in the spring and early summer. Potential adverse effects may occur due to the slightly lower minimum daily flows expected from changing points of diversion from Imperial Dam to Parker Dam.

Physical Habitat:

Historically, the stream bed through most of the lower Colorado River was shifting sand. Initial blockage of sediment by dam building caused armoring of the stream bed. The increases in potential spawning sites for native fishes has never been quantified, but intuitively they are very great. For example, there is about 44 miles of river channel between Headgate Rock Dam near Parker, Arizona, and Palo Verde Diversion Dam near Blythe, California. Historically this 44-mile reach was predominately shifting sand substrate. Placement of Headgate Rock Dam in 1941 caused channel cutting and armoring over this entire reach. Placement of Palo Verde Diversion Dam in 1957 caused some backing up of the river reach above it, and fine materials again were deposited. Today, coarse materials (gravels, cobbles, boulders) now comprise over 50 percent of the stream bed substrate for the first 32 miles below Headgate Rock Dam (Minckley, 1979).

Routine operation causes fluctuations in the river which may expose gravel bars and desiccate incubating eggs. Slightly lower minimum daily flows may expose more gravel bars than are currently exposed. This may adversely modify critical habitat for these fishes.

Changes in water levels drain backwater habitats, making these habitats unavailable for use by fishes. Slightly lower minimum daily flows may result in more shallow backwaters. Artificial measures have been used to physically recreate backwaters in several reaches of the river. Some of these are potentially useful to fish, while many are separated from the river and require manual introduction and removal. On some backwater habitats left open to the river, maintenance dredging assures these habitats maintain enough water to be viable over the full range of water fluctuations.

Short-term fluctuations in reservoir can destroy eggs of native fishes by exposing them to wave action or desiccation. In the three mainstem Colorado River reservoirs, it is unlikely Reclamation will lower the water level more than 2 feet in any 10-day period, thus preventing such an impact from occurring during the spawning period.

Desert pupfish (Cyprinodon macularius)
Federally Endangered

Description and Life Requisites

The desert pupfish is a small killifish with a smoothly rounded body shape. Adults generally range from 2-3 inches in length. Males are smaller than females and during spawning the males are blue on the head and sides and have yellow edged fins. Most adults have narrow, dark, vertical bars on their sides. The species was described in 1853 from specimens collected in San Pedro River, Arizona. There are two recognized species and possibly a third form (yet to be described). The species, Cyprinodon macularius, occurs in both the Salton Sea area of southern California and the Colorado River delta area in Mexico and is the species of concern, herein. The other species is C. eremus and is endemic to Quitobaquito Spring, Arizona.

The desert pupfish was listed as an endangered species on March 31, 1986. Critical habitat for the species was designated at the time of listing and included the Quitobaquito Spring which is in Organ Pipe Cactus National Monument, and San Felipe Creek along with its two tributaries Carrizo Wash and Fish Creek Wash in southern California. All of the former and parts of the latter were in Federal ownership at the time of listing. Reclamation purchased the remaining private holdings along San Felipe Creek and its tributary washes and turned them over to CFG in 1991. All of the designated critical habitat is now under State or Federal ownership.

Desert pupfish are adapted to harsh desert environments and are extremely hardy. They routinely occupy water of too poor quality for other fishes, most notably too warm and too salty. They can tolerate temperatures in excess of 110° F; oxygen levels as low as 0.1 ppm; and salinity nearly twice that of sea water (over 70 parts per thousand [ppt]). In addition to their absolute tolerance of these parameters, they are able to adjust and tolerate rapid, extreme changes to these same parameters (Marsh and Sada, 1993). Pupfish have a short life span, usually only 2 years, but they mature rapidly and can reproduce as many as three times during the year.

Desert pupfish inhabit desert springs, small streams, creeks, marshes and margins of larger bodies of water. The fish usually inhabit very shallow water, often too shallow for other fishes. Present distribution of the subspecies C. macularius includes natural populations in at least 12 locations in the United States and Mexico, as well as over 20 transplanted populations.

Distribution and Abundance

Desert pupfish do not inhabit the project area. One of the natural populations in Mexico is in the Cienega de Santa Clara, a 100,000 acre bowl on the Colorado River Delta 60 miles south of the U.S./Mexico border. The area is about 90 percent unvegetated salt flats with a number of small marsh complexes along the eastern edge of the bowl where it abuts an escarpment. The area is disconnected from both the Colorado River and the Gulf (Sea of Cortez), however extreme high tides result in the lower half of the bowl becoming inundated to a level of one foot or less of salt water from the gulf. The marsh areas on the east side are small and are spring fed. The largest marsh complex is on the northeast side where two agricultural drains provide relatively fresh water inflows. The desert pupfish occur in a number of these marsh complexes.

Reclamation biologists discovered this population of desert pupfish in 1974 during preproject investigations for a feature of the Colorado River Basin Salinity Control Project. At that time, the Cienega was being fed by agricultural return flows from the Riito Drain in Mexico which provided about 35 cfs flow. The project feature being investigated was construction of a bypass canal for drain water from WMIDD.

Desert pupfish were found in the marsh along with mosquitofish, sailfin mollies, carp and red shiners. The bypass canal was completed in 1978 and provided a steady flow of over 150 cfs to the marsh. Based upon aerial surveys, the added inflow caused the marsh to grow from an estimated 300 acres of vegetated area in 1974 to roughly 10,000 acres in 1985. Recent aerial surveys show that while the inflows have continued, the marsh has not continued to grow in size. Desert pupfish continue to exist in the marsh. The fish tend to inhabit the shallow edges of the marsh in vegetated areas. Desert pupfish from the Cienega were transported to Dexter National Fish Hatchery during May 1983, and many of the transplanted populations in the United States are of this subspecies and stem from this initial transplant.

Effects Analysis

Desert pupfish will not be affected by the ISC.

D. Summary of Effects Analysis

Conservation measures will offset adverse effects associated with the proposed action. Approximately 124 acres of riparian restoration will have beneficial effects to the enhancement of southwestern willow flycatcher habitat. Creation and restoration of 62 acres of backwater are intended to offset the projected reduction of backwater habitat. Introduction of 20,000 razorback suckers into the system are expected to help offset impacts to the species as a result of water surface reduction. Continuation of Lake Mead razorback sucker study will help contribute to the understanding of why a population persists and may lead to techniques for establishing self-sustaining populations elsewhere. Life history studies to add to the very limited knowledge on bonytail will help contribute to the successful re-establishment of populations. Conservation measures will be accomplished in such a manner and timed as to minimize effects to breeding and maximize beneficial use.

The potential effects of the implementation of the ISC and SIA's on species under consideration are summarized in Table 17.

Table 17. Summary of Effect Analyses

Common Name	Scientific Name	Status[1]	Effect Analysis		
			Species		Critical Habitat
			No Effect	May Affect	May Adversely Modify
TERRESTRIAL					
Southwestern willow flycatcher	*Empidonax traillii extimus*	E		X	
Bald eagle	*Haliaeetus leucocephalus*	T	X		
Desert tortoise (Mohave population)	*Gopherus agassizzii*	T	X		
Yellow-billed cuckoo	*Coccyzus americanus*	S		X	
MARSH					
Brown pelican	*Pelecanus occidentalis*	E	X		
Yuma clapper rail	*Rallus longirostris yumanensis*	E		X	
California black rail	*Laterallus jamaicensis cotorniculus*	S		X	
AQUATIC					
Razorback sucker	*Xyrauchen texanus*	E		X	X
Bonytail	*Gila elegans*	E		X	
Desert pupfish	*Cyprinodon macularius*	E	X		

[1]E=Endangered, T=Threatened, PT=Proposed Threatened, S=Sensitive