GILA TOPMINNOW, *Poeciliopsis occidentalis occidentalis*,

REVISED RECOVERY PLAN

(Original Approval: March 15, 1984)

Prepared by

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for

Region 2

U.S. Fish and Wildlife Service
Albuquerque, New Mexico

December 1998

Approved: ___________________________

Regional Director, U.S. Fish and Wildlife Service

Date: _______________________________
DISCLAIMER

Recovery plans delineate reasonable actions required to recover and protect the species. The U.S. Fish and Wildlife Service (Service) prepares the plans, sometimes with the assistance of recovery teams, contractors, State and Federal Agencies, and others. Objectives are attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Time and costs provided for individual tasks are estimates only, and not to be taken as actual or budgeted expenditures. Recovery plans do not necessarily represent the views nor official positions or approval of any persons or agencies involved in the plan formulation, other than the Service. They represent the official position of the Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.
ACKNOWLEDGMENTS

Original preparation of the revised Gila topminnow Recovery Plan (1994) was done by Francisco J. Abarca, Brian E. Bagley, Dean A. Hendrickson and Jeffrey R. Simms. That document was modified to this current version and the work conducted by those individuals is greatly appreciated and now acknowledged. The 1994 revision and this current document benefitted from review and comments by the members of the Desert Fishes Recovery Team, and other individuals listed below. Special thanks to Peter Unmack and W.L. Minckley, Arizona State University, for some information used to construct the historic distribution map.

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Sally E. Stefferud, U.S. Fish and Wildlife Service
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Many other persons provided information for the preparation of this plan. The Service appreciates the help provided by team members (past and present), consultants, and other individuals who contributed to this effort.
EXECUTIVE SUMMARY

Current Species Status: The Sonoran topminnow, *Poeciliopsis occidentalis*, includes two subspecies, the Gila topminnow, *Poeciliopsis o. occidentalis*, and the Yaqui topminnow, *Poeciliopsis o. sonoriensis*. Both subspecies were listed as endangered within the U.S. portion of their range in 1967 with no critical habitat designation. The original recovery plan for the Sonoran topminnow was approved on March 15, 1984; this is a revision of that plan, but only includes the Gila topminnow within the U.S. A Yaqui Fishes Recovery Plan, which includes the Yaqui topminnow, was completed and approved by the U.S. Fish and Wildlife Service in 1995.

In the United States, the species currently occurs in the Gila River drainage, Arizona, particularly in the upper Santa Cruz River, Sonoita and Cienega creeks, and the middle Gila River. The Gila topminnow is restricted to 14 natural localities in Arizona. In Mexico, the species occurs in the Río Sonora, Río de la Concepción, and Santa Cruz River but are not listed under the Endangered Species Act.

Habitat Requirements and Limiting Factors: Gila topminnows occupy a variety of habitats: springs, cienegas, permanent and interrupted streams, and margins of large rivers. Habitat alteration and destruction, and introduction of predaceous nonnative fish, principally western mosquitofish, *Gambusia affinis*, is the main reason for decline of the Gila topminnow.

Recovery Objectives: Delisting of the subspecies is not considered feasible in the foreseeable future. The short-term goal of this plan is to prevent extirpation of the species from its natural localities in the U.S. and reintroduce it into suitable habitat within its former range. Downlisting of the Gila topminnow in the United States is possible. Recovery to a level of threatened is realistically estimated to take 20 years. The recovery category for this species is 9C.

Recovery Criteria: Downlisting of the Gila topminnow will be considered when: 1) Survival of the species in the U.S. is ensured by protecting existing natural populations and maintaining refugia stocks from each; 2) Populations are reestablished within the species’ historic range according to guidelines identified in this plan; 3) Protocols for population, habitat and genetic monitoring are developed, funded, and started. Natural (Level 1) populations and mixed populations will be established in Level 2 and Level 3 sites as described in the recovery section of this plan. Level 2 populations will be considered established only when they have persisted a minimum of 10 years.

Actions Needed:
1. Prevent extinction by protecting remaining natural and long-lived reestablished populations.
2. Reestablish and protect populations throughout historic range.
3. Monitor natural and reestablished populations and their habitats.
4. Develop and implement genetic protocol for managing populations.
5. Study life-history, genetics, ecology, and habitat of Gila topminnow and interactions with nonnative aquatic species.
6. Inform and educate the public and resource managers.

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I. INTRODUCTION

The genus *Poeciliopsis* is comprised of 19 known species (Meffe and Snelson 1989; Nelson 1994). The Sonoran topminnow, *Poeciliopsis occidentalis*, includes two subspecies, the Gila topminnow, *P. o. occidentalis*, and the Yaqui topminnow, *P. o. sonoriensis*. The Gila topminnow is native to the Gila River Basin of the United States and Mexico, and the Ríos de la Concepción and Sonora of northern Mexico (Minckley et al. 1991). It was considered one of the most common fishes in the southern part of the Colorado River basin prior to 1940 (Hubbs and Miller 1941). However, habitat loss and interaction with nonnative fishes, particularly western mosquito fish, *Gambusia affinis*, caused range-wide disappearances and decreases in abundance within the United States.

In 1967 the Gila (Sonoran) topminnow, including both subspecies, was listed as endangered within the United States, under the Endangered Species Protection Act of 1966 (USDI 1967). Following passage of the Endangered Species Act of 1969, the Gila (Sonoran) topminnow was included on Appendix D, the list of species endangered within the United States (USDI 1970). In 1973, the Endangered Species Act of 1973 was passed and separate lists of foreign and native endangered species were published in the Federal Register (USDI 1974). The Gila (Sonoran) topminnow was included in the native species listed as endangered in the United States, but was not included in the foreign species listed as endangered. The native and foreign species lists were later combined in the Code of Federal Regulations and the Gila (Sonoran) topminnow was erroneously entered as listed as endangered throughout its range, including Mexico. This error continued until 1989 and during that period the species was treated as protected under the Endangered Species Act in both the United States and Mexico, including preparation of the 1984 recovery plan, which covered the entire range. This error was discovered in 1988 for the Gila topminnow and several other species with ranges extending across the United States/Mexico border. The 1989 update of the Code of Federal Regulations list of endangered and threatened species (50 CFR 17.11) correctly indicated the Gila (Sonoran) topminnow as listed only in the United States portion of its range. No critical habitat has been designated. Listing and recovery priority guidelines for the U.S. Fish and Wildlife Service are available (USDI 1983). The Gila topminnow has a recovery category of 9C. It is still fairly widespread in Sonora (Vrijenhoek et al. 1985; Varela-Romero et al. 1990; Minckley et al. 1991; Campoy-Favela 1996); however, increases in nonnative fishes and human development also may be impacting the subspecies there (Hendrickson 1983; Meffe and Vrijenhoek 1988; Gómez-Alvarez et al. 1990).

Since being federally listed in 1967, the Gila topminnow has been reestablished into more locations than any native fish in the Southwest (Hendrickson and Brooks 1991). However, both naturally occurring and reestablished populations continue to decline. This recovery plan details the Gila topminnow recovery effort, acquaints the reader with the subspecies and its status, the threats it faces, and provides a revised plan for its survival and recovery in the United States.

Recovery planning for Gila and Yaqui topminnows were previously incorporated into a single recovery plan (U.S. Fish and Wildlife Service [USFWS], 1984). Recovery needs and actions for the
Yaqui topminnow parallel those required for other listed species from the Río Yaqui drainage and are treated in a separate recovery plan for the endangered and threatened fishes of the Río Yaqui (USFWS 1994). The following plan applies only to *Poeciliopsis occidentalis occidentalis*, the Gila subspecies. A glossary is included near the end of this document defining technical terms and their usage within this plan.

**Description**

The species was originally described by Baird and Girard (1853) as *Heterandria occidentalis* from a specimen collected in 1851 from the Santa Cruz River near Tucson. It was redescribed by Hubbs and Miller (1941) as *P. occidentalis*. As with all species in the family Poeciliidae, the Gila topminnow exhibits sexual dimorphism. Both males and females are tan to olive-bodied and usually white on the belly. Scales of the dorsum are darkly outlined and the fin rays contain melanophores, although lacking in dark spots. Dominant sexually mature males are often blackened, with some gold on the pre-dorsal midline, orange at the base of the gonopodium, and have bright yellow pelvic, pectoral, and caudal fins (Minckley 1973). Females remain drab in coloration upon reaching maturity and throughout their life. All male poeciliids have a modified anal fin called a gonopodium used to fertilize the female internally. Males seldom exceed 25 millimeters (mm) standard length (SL) and females average 30 to 45 mm SL.

Two forms of Sonoran topminnow, *P. o. occidentalis* and *P. o. sonoriensis*, have been recognized as subspecies by Minckley (1973), who listed their distinguishing features. The two subspecies can be distinguished by several characteristics. In *P. o. occidentalis* the snout is short, the mouth is subsuperior and the dark lateral band of the female extends from the opercle to the base of the caudal fin. In *P. o. sonoriensis* the snout is longer, the mouth superior and the lateral band of the female rarely begins before the base of the pelvic fins (Minckley 1973).

*P. o. occidentalis* is the only member of the family Poeciliidae that is native to the Gila River drainage. Mosquitofish, guppy (*Poecilia reticulata*), sailfin molly (*Poecilia latipinna*), Mexican molly (*Poecilia mexicana*), green swordtail (*Xiphophorus helleri*), and variable platyfish (*X. variatus*), are other members of the family introduced into waters within the Gila River basin purposefully to control mosquitos or surreptitiously through the tropical fish trade (Marsh and Minckley 1982; Clarkson 1998).

Mosquitofish have become ubiquitous and common throughout the Gila River drainage and closely resemble the Gila topminnow. They can be distinguished from Gila topminnows by the presence of a dark, sub-orbital bar (tear drop shaped) and black spots on the dorsal and caudal fin. Mosquitofish males do not become black as breeding male topminnows do. The gonopodium is longer in topminnows (relative to body length), reaching beyond the snout when in the copulatory position, whereas in mosquitofish it does not reach past the tip of the snout (Minckley 1973). Gila topminnows have weak spatulate teeth, whereas mosquitofish have strong, conical teeth reflecting their more carnivorous diet (Meffe et al. 1983).
Historic and Present Distribution

The Gila topminnow occupies the northernmost range of the tropical genus *Poeciliopsis*. The genus is distributed from the northern Andes in Colombia, along the Pacific coast of Central America and Mexico, to the Gila River. Two members of the genus also occur in some Atlantic streams of southern Mexico, Guatemala, and Honduras (Rosen and Bailey 1963).

Gila topminnows were historically widespread in the Gila River drainage below about 1500 meters (m) elevation (Minckley 1985; Appendix A; Figure 1). The subspecies was found in the San Francisco River at Frisco Hot Springs, New Mexico, west to the mainstem Gila River near Yuma, Arizona, and possibly even into the lower Colorado River (Koster 1957; Minckley and Deacon 1968; Appendix A). The fish thrived in the Salt River as far upstream as the present site of Roosevelt Lake and was also common in Tonto Creek (Miller 1961). Although there are no museum specimens from the Verde or San Simon rivers, Gila topminnows likely occurred there. Two collections are known from the San Pedro River. In 1943, J. R. Simon collected topminnows near Feldman, Arizona (University of Michigan Museum of Zoology), and in 1978 a population was discovered in a spring 13 kilometers (km) southeast of Mammoth (McNatt 1979). Records of Gila topminnow from the Santa Cruz River are abundant and include the headwaters above Lochiel, Arizona through Sonora, Mexico, and continuing to northwest of Tucson, Arizona (Baird and Girard 1854; Girard 1856; Evermann and Rutter 1894; Nichols 1940; Appendix A). Various tributary streams and springs, most notably Sonoita Creek, Cienega Creek, and Sabino Canyon, also historically supported Gila topminnows (Chamberlain 1904; Minckley 1969a). They are also found throughout the Ríos de la Concepción and Sonora in northern Sonora, Mexico (Vrijenhoek et al. 1985; Hendrickson and Juárez-Romero 1990; Minckley et al. 1991).

Gila topminnows must have formed an almost continuous population at low elevations throughout the Gila River before human settlement. During times of environmental extremes, such as droughts and floods, they may have disappeared from marginal habitats only to redistribute as conditions improved. This presumably led to widespread contact between otherwise geographically separated populations (Deacon and Minckley 1991).

The original recovery plan for Gila topminnow listed 10 extant natural populations; Monkey Spring, Cottonwood Spring, Sheehy Spring, Sharp Spring, Santa Cruz River near Lochiel, Redrock Canyon, Cienega Creek, Sonoita Creek (presumably including localities above and below Patagonia Lake), Salt Creek, and Bylas Springs (USFWS 1984). Gila topminnows were also known from Middle Spring (also known as SII or Second Spring) on the San Carlos Apache Indian Reservation (Meffe 1983). Middle Spring was considered part of the Bylas Springs complex in the earlier recovery plan.
Figure 1. Distribution of Gila topminnow based on records prior to 1980. Numbers are records as identified in Appendix A.
Since 1984, Gila topminnows have been discovered or rediscovered at four additional locations; North Fork of Ash Creek in 1985 (Jennings 1987), Fresno Canyon in 1992, Santa Cruz River north of Nogales in 1994, and Coal Mine Canyon in 1996 (Weedman and Young 1997). However, topminnows were last collected from the North Fork of Ash Creek in 1985 and from Sheehy Spring in 1987. They have also been very rare or absent during recent surveys (last five years) of Sonoita Creek above Patagonia Lake and Santa Cruz River near Lochiel. Mosquitofish are quite common in both areas. Topminnows were extirpated from one of the original 10 localities, Salt Creek by mosquitofish (Marsh and Minckley 1990) but the stream was renovated and restocked with Gila topminnows from Middle Spring. Subsequently, mosquitofish were found in the stream and it was again renovated and restocked, this time with topminnows from Bylas Spring. Thus, there are 14 naturally occurring localities (considering Sonoita Creek above and below Patagonia Lake as two separate localities) currently known to support Gila topminnows in the United States.

Eleven of the naturally occurring locations currently supporting Gila topminnows are in the Santa Cruz River system: Redrock Canyon, Cottonwood Spring, Monkey Spring, upper Sonoita Creek, Fresno Canyon, Coal Mine Canyon, lower Sonoita Creek, Santa Cruz River north of Nogales, Cienega Creek, Sharp Spring, and the upper Santa Cruz River. The other two remaining localities, Bylas Springs, Middle Spring, and Salt Creek, are next to the Gila River on the San Carlos Apache Indian Reservation. Bylas Springs has been unsuccessfully poisoned twice to remove mosquitofish (Meeffe 1983; Brooks 1985; Marsh and Minckley 1990). Another attempt at renovation of Bylas Springs was done by the Service's Arizona Fishery Resource Office and has so far been successful. The population at Middle Spring was eliminated by lack of water during the summer of 1989, but was recently reestablished (following construction of additional pool habitat) with Gila topminnows from the original Middle Spring population held at Roper Lake State Park. Salt Creek has also been renovated and restocked with topminnow originally from Bylas Spring (USFWS nd). The known localities currently supporting populations of Gila topminnow are depicted in Figure 2.

Gila topminnows are still widespread throughout northern Sonora, Mexico, in the Ríos de la Concepción and Sonora (Minckley et al. 1991). However, declines in those populations because of development and spread of nonnative fishes have also been noted (Hendrickson et al. 1980; Hendrickson 1983). These drainages also contain the unisexual hybrid *P. monacha-occidentalis* (Schultz 1961; Angus and Schultz 1979; Schultz 1989; Hendrickson and Juárez-Romero 1990). In the Río de la Concepción the unisexual hybrid comprised 0-3% of all poeciliids (Moore et al. 1970). In 1995 and 1996, populations of Gila topminnow were present in the Mexican portion of the Santa Cruz River, but were not collected from seven sites sampled in the San Pedro River in Mexico (Campoy-Favela 1996).
Figure 2. Current distribution of Gila topminnow in the United States.
As part of past recovery actions, more than 200 Gila topminnow reintroductions or natural dispersals from reintroductions have occurred at 175 wild locations (Appendix E). For this count, a wild location refers to an area that does not have a mailing address, in contrast with a captive population that does (follows Simons 1987). Eighteen wild populations remained in 1997, 17 of which are in historic range (Weedman and Young 1997; Appendix C). Seven of these populations are secure enough that they should persist into the foreseeable future. Minckley and Brooks (1985), Brooks (1985, 1986), Simons (1987), Bagley et al. (1991), Brown and Abarca (1992), and Weedman and Young (1997) describe, in detail, the plight of reestablished and captive populations of Gila topminnows.

Gila topminnows also have been stocked into many captive locations for propagation or conservation (Appendix E). Twelve captive populations were known to persist in 1997. The following publicly maintained populations are large enough to provide individuals for reintroductions, although one is known to be mixed with topminnows from more than one natural population: Arizona-Sonora Desert Museum, Boyce-Thompson Arboretum (mixed), Dexter National Fish Hatchery and Technology Center, Roper Lake State Park, Arizona State University, and Hassayampa River Preserve.

**Ecology and Life History**

**Habitat Use**

Habitat requirements of *P. o. occidentalis* are broad. They prefer shallow, warm, fairly quiet waters. However, they can become acclimated to a much wider range of conditions. Both lentic habitats and lotic habitats with moderate current are easily tolerated. Temperatures from near freezing under ice to 37°C have been reported, with a maximum tolerance of 43°C for brief periods (Heath 1962). Topminnows can live in a wide range of water chemistries, with recorded values of pH from 6.6 to 8.9, dissolved oxygen readings from 2.2 to 11 milligrams/liter (Meffe et al. 1983), and salinities from very dilute to sea water (Schoenherr 1974). The widespread historic distribution of Gila topminnows throughout rivers, streams, marshes, and springs of the Gila River Basin is evidence for their tolerance of these environmental extremes. One reestablished population, Mud Springs, survived for 16 years in a simple cement watering trough before being moved.

Meffe et al. (1983) reported that topminnows can tolerate almost total loss of water by burrowing into the mud for 1-2 days. Preferred habitats contain dense mats of algae and debris, usually along stream margins or below riffles, with sandy substrates sometimes covered with organic muds and debris (Minckley 1973). Topminnows are usually found in the upper 1/3 of the water column and young show a preference for the warmest and shallowest areas (Forrest 1992). Simms and Simms (1992) found topminnows occupying pools, glides, and backwaters more frequently than marshes or areas of fast flow. According to Schoenherr (1974), the spring-heads presently occupied by Gila topminnows are questionable as preferred habitat. Destruction of historically occupied habitats such as the marshes, sloughs, backwaters, and edgeworkers of larger rivers and presence of nonnative fishes in such habitats that remain has undoubtedly forced Gila topminnow out of their preferred historic
habitats and into the spring-heads and smaller erosive creeks we see them in today. Their tolerance of conditions in these habitats has allowed them to maintain populations with less impact from nonnative fishes.

**Reproduction**

Gila topminnows are viviparous fish, meaning embryos grow and mature within the female and are born living. Eggs are fertilized internally through deposition of spermatozoids (packets of sperm) into the female's genital pore by the male's gonopodium. Female Gila topminnow can store spermatozoa for several months, and may produce up to 10 broods after being isolated from males (Schultz 1961). Female Gila topminnows also exhibit superfetation in which two or more groups of embryos develop simultaneously at different stages. Females of the genus *Poeciliopsis* generally carry only two stages, although some *P. o. occidentalis* females have been shown to carry three for a few days when population densities are low. Mean intervals between broods is 21.5 days (Schoenherr 1974). Brood size ranges from 1-31 dependant upon female SL (Constantz 1974; Schoenherr 1974, 1977). Under optimum laboratory conditions, *Poeciliopsis* can produce 10 broods per year at intervals of 7-14 days (Schultz 1961).

Sexual maturity can be attained as early as two months or as late as 11 months following birth, dependant upon the season of birth (Schultz 1961; Constantz 1976, 1979; Schoenherr 1974). Females from Monkey Spring as small as 22 mm standard length, indicating an age of approximately four months, were sexually mature (Schoenherr 1974). Males begin gonopodial development at around 17 mm SL with most reaching maturity between 22-24 mm SL, at about four months.

Breeding occurs primarily during January through August, but in thermally constant springs young may be produced throughout the year (Heath 1962; Minckley 1973; Schoenherr 1974). During the peak of the breeding season up to 98% of mature females are pregnant (Minckley 1973). Dominant males (14-25 mm SL) turn black, defend territories, and court females. Smaller subordinate males do not turn black or defend territories. Instead, they take on a "sneaking" mating strategy where they attempt to mate with uncooperative females while the dominant male is busy elsewhere. Subordinate males have a longer gonopodium, which may have an adaptive benefit for this type of mating strategy (Constantz 1989). However, if the larger territorial males are removed, smaller males will become dominant, take on breeding coloration, and defend territories (Constantz 1975; Schoenherr 1977).

Brood size and the onset of breeding in topminnows can be influenced by several factors including food abundance, photoperiod, temperature, predation upon the population, and female size. Increased food supply and larger female size are believed to contribute to the greater fecundity seen in topminnows from Monkey Spring canal compared with topminnows from Monkey Spring headspring (Constantz 1974, 1979; Schoenherr 1974, 1977).

Sex ratios in stabilized populations nearly always favor females, varying from 1.5 to 6.3 per male (Schoenherr 1974). However, Schultz (1961) and Schoenherr (1974) both showed that ratios at birth
approximated 1.0. These different ratios can be explained two ways; by females living longer, or as indicated by Krumholz (1948), by males being less hardy than females. Mortality during transportation for reintroduction purposes has been observed to be higher for males than females, indicating sexual differences in ability to handle stress. Differences in sex ratios can be observed in populations depending on season of sampling, predation effects, or sampling technique biases.

An all female hybrid, *P. monacha-occidentalis*, occurs throughout the Gila topminnow range except in the Gila River drainage (Moore et al. 1970; Moore and McKay 1971; Lanza 1983). This form is a sexual parasite of *P. occidentalis*, and requires sperm of the parasitized sexual species to reproduce. Since territorial male topminnows have been shown to prefer to mate with conspecifics, it appears that subordinate males are responsible for proliferation of the hybrid form (Moore et al. 1970; Schoenherr 1974; Vrijenhoek et al. 1977; Keegan-Rogers and Schultz 1988; Schultz 1989). The male genome is incorporated in eggs, but discarded at oogenesis, resulting in clonal propagation of the genome of the all-female hybrid form. This process is known as hybridogenesis (Angus 1980; Schenck and Vrijenhoek 1986; Morizot et al. 1990).

**Growth**

Growth rate of Gila topminnows is variable, dependent on age, sexual maturity, habitat, and available resources (Constantz 1974; Schoenherr 1974). According to Schoenherr (1974), males stop growing after reaching sexual maturity, but females grow throughout their lives. However, other members of the Poeciliidae have been shown to continue growth after sexual maturity, although at a reduced rate (Snelson 1989). Males rarely exceed 25 mm SL; females can attain 50 mm SL. Females usually outlive males, which can live more than one year (Schoenherr 1974).

**Diet**

Gila topminnows are opportunistic omnivorous feeders, having a gut length 1.5 to 2 times SL of the individual (Schoenherr 1974). They have weakly spatulate dentition characteristic of an omnivorous diet. Primary food items include detritus, vegetation, amphipods, ostracods, and insect larvae; and rarely, other fishes (Schoenherr 1974; Gerking and Plantz 1980; Meffe et al. 1983; Meffe 1984). Gerking and Plantz (1980) noted that Gila topminnows prefer to eat large prey, but prey sizes are limited by mouth size. Schoenherr (1974) observed that individual fishes in complex habitats with several food resources present would select and focus on different items. He suggested that variation in feeding among individuals prevents over-utilization of a single resource, enhancing survival potential of the species by making it independent of that resource.

**Past and Future Threats to the Gila topminnow**

Habitat destruction and introduction of nonnative species have caused severe reductions of Gila topminnow populations, and are the main causes for its listing as an endangered species (USFWS 1984; Williams et al. 1985, 1989; Simons et al. 1989). These two factors are involved in the decline
of 98% of North American fishes listed as endangered, threatened or of special concern (Miller 1972; Deacon 1979; Deacon et al. 1979; Ono et al. 1983; Williams et al. 1989; Williams and Miller 1990).

**Habitat Destruction**

During the late 1800s and early 1900s, several factors caused widespread habitat changes throughout the Southwest. Heavy overgrazing and wood cutting combined with a drought during 1891-1893 caused extensive loss of vegetation resulting in 50-75% loss from cattle herds (Hastings and Turner 1965; Deacon and Minckley 1974; Hendrickson and Kubly 1984; Bahre and Hutchison 1985). This lack of vegetation made the area vulnerable to erosion when the drought ended. Floods, unbuffered by vegetation, scoured watercourses, deeply incised marshy cienega habitats, lowered water tables, desiccated watersheds, and turned permanent flowing waters into occasionally flooded arroyos. Marshes dried, springs failed, and streamside backwaters and inlets disappeared (Miller 1961; Fradkin 1981; Rea 1983; Hendrickson and Minckley 1985; Bahre 1991). In only 10 years the San Pedro River was "incised from its mouth for 125 miles upstream" (Bryan 1925). Groundwater pumping began around this time and caused additional lowering of the water table (Rogers 1980). Habitats were further impacted by construction of water diversions and dams, which dewatered downstream reaches and created artificial habitats favoring nonnative fish species (Minckley et al. 1991).

Historic events permanently altered much of the aquatic habitat in the arid southwest, but current and future activities also present a great risk. Land use practices such as livestock grazing, mining, timber cutting, road maintenance, and recreation pose threats through increased erosion, intensified flood events, and decreased groundwater storage to both existing populations and habitats proposed for reestablishment. In addition, continued urban and suburban development and population growth affects potential recovery of the species through increased groundwater pumping and diversions to supply the growing populations, stream and river channelization, and increased water pollution. Some populations are also at risk because they are supported in habitats constructed or modified by man and require periodic maintenance for support of the population. Performance of this maintenance may be limited by future budgetary restrictions within the various agencies responsible for management. In addition, habitats identified for recovery of Gila topminnow do not receive statutory protection and may be damaged or destroyed before Gila topminnow reestablishment, thus continuously reducing the likelihood of recovery of the species.

**Interactions with Nonnative Species**

Introduction of nonnative pathogens, parasites, plants, invertebrates, amphibians and fish may negatively affect the native fishes of the Southwest. At least one parasitic copepod, *Lernaea cyprinacea*, has been introduced to Arizona (James 1968) and other parasites and diseases are possible. Introduced plants such as salt cedar (*Tamarix ramosissima*), and white water cress (*Rorippa nasturtium-aquaticum*), alter aquatic habitats and displace native vegetation. The Asian clam (*Corbicula fluminea*) has probably or soon will be introduced into the Santa Cruz River basin via the Central Arizona Project canal. The impact to Gila topminnow by this invasive and prolific
filter feeder is unknown at this time, but is likely to affect nutrient cycling and food availability for Gila topminnow. Several species of crayfish have also become established in Arizona and investigations into their effects on native fishes have only recently begun. The nonnative and predatory bullfrog (*Rana catesbiana*), is also widespread and abundant throughout Gila topminnow historic range and is known to feed on fishes (Rosen and Schwalbe 1996). These are but a few examples of the variety of nonnative taxa that does or may affect Gila topminnow recovery. Negative impacts to Gila topminnow from nonnative predatory sport fishes such as largemouth bass (*Micropterus salmoides*) smallmouth bass (*Micropterus dolomieu*) and green sunfish, (*Lepomis cyanellus*) is also a problem. Degradation of habitats is a well recognized factor in establishment of nonnative species (Courtenay and Stauffer 1984, Arthington et al. 1990, Soule 1990, Aquatic Nuisance Species Task Force 1994).

Introduction of the western mosquitofish has caused the most problems for Gila topminnow. Mosquitofish tolerate similar environmental extremes and occupy similar habitats as Gila topminnow (Meffe et al. 1983). Schoenherr (1974) identified many areas that mosquitofish tends to avoid though they have access to them: thickly matted aquatic plants, swiftly flowing water, cold temperatures, and clear water springs high in carbonates. Simpson and Gunter (1956) found that mosquitofish had never been collected in salinities above 3%. Meffe (1984) noted that flooding events removed more mosquitofish than topminnow. In Sharp Spring, he found that before moderate flooding, mosquitofish comprised 11.5% of the fish fauna; after flooding they comprised only 0.7%. Controlled experiments using artificial streams showed that as flow increased, topminnows oriented to the flow and moved to the edge where current was reduced. In contrast, mosquitofish tried to maintain their midchannel position and were swept downstream. In areas not prone to flooding, coexistence rarely exceeded three years. However, in habitats that do flood, such as the Santa Cruz River, topminnows have survived in the presence of mosquitofish for more than 30 years. Not all flooding is beneficial for Gila topminnows, extreme flooding has removed several reestablished populations; Camp and Cave Creeks (Minckley 1969b), Tule Creek (Collins et al. 1981), and Seven Springs (USFWS 1984).

Mosquitofish can produce 3-4 broods per year in warm climates and, depending on individual size, females can produce from 1 to 315 embryos, they do not exhibit superfetation but still have greater reproductive potential than Gila topminnow, and they are smaller than topminnow at birth but have a faster growth rate (Moyle 1976). Female mosquitofish more than 50 mm SL are not uncommon and male mosquitofish rarely grow as large as Gila topminnow males. In contrast to Gila topminnow, mosquitofish exhibit morphological traits very characteristic of a carnivorous diet, possessing strong conical teeth and a short gut, and feed primarily on rotifers, snails, spiders, insect larvae, crustaceans, algae, detritus, and fish fry, including conspecifics (Minckley 1973; Meffe and Crump 1987).

The mechanism of replacement of topminnows by mosquitofish occurs at many levels. Direct predation and competition for space has been observed (Schoenherr 1974). Gila topminnow are considered naive in the ways of predation. Gila topminnows evolved with a naturally depauperate fish fauna that lacked many predators. The fish predators that were present, Colorado River squawfish (*Ptychocheilus lucius*) and fishes of the genus *Gila*, occupied different habitats and
probably had little impact on Gila topminnows (Miller 1961; Minckley et al. 1991). Mosquitofish prey directly on young topminnows and cause the death of adults due to infection following the shredding or removal of fins (Schoenherr 1974; Meffe 1985). Mosquitofish possess open cephalic canals that improve their ability to detect and find invertebrate and vertebrate prey, a trait lacking in topminnows (Rosen and Mendelson 1960). Competition for space, resulting in harassment of male and female topminnows by larger, dominant, more aggressive female mosquitofish also seemed instrumental in replacement of Gila topminnow by mosquitofish (Schoenherr 1974).

Large scale reductions of Gila topminnow correspond strongly with the spread of mosquitofish, which were first collected from Arizona in 1926 (Miller and Lowe 1964). Elimination of topminnows by mosquitofish can occur rapidly: <2 years for a reestablished topminnow population in Arivaca Creek (Miller 1961), and three years or less for a natural population from artesian ponds near Safford (Minckley and Deacon 1968). Schoenherr (1974, 1981), Minckley et al. (1977) and Meffe (1984) reported on over 20 populations that were severely reduced or eliminated by mosquitofish in less than three years. Long-term coexistence of topminnow and mosquitofish has been observed in several populations (Lower Sonoita Creek metapopulation, Sharp Spring, and Redrock Canyon) and may be related to habitat complexity, frequency and severity of flooding, which removes a larger percentage of mosquitofish, or continual dispersal from local uncontaminated populations of topminnow (Meffe 1984; Minckley and Meffe 1987; Weedman and Young 1997). Mosquitofish presently occupy much of the remaining habitats available for recovery of Gila topminnow (such as the San Pedro National Riparian Conservation Area), likely precluding successful recovery in those areas. Since mosquitofish have attained nearly a cosmopolitan distribution, it is unlikely that this threat can be removed from the historic range of the Gila topminnow.

**Genetic Considerations**

Some researchers have suggested that there are fitness related differences based on levels of genetic variability among natural Gila topminnow populations (Vrijenhoek et al. 1985). Based on these studies, Quattro and Vrijenhoek (1989) suggested that topminnows from Sharp Spring were more fit than those at Monkey Spring and thus more suitable for reintroduction. Based on that recommendation, the Dexter National Fish Hatchery and Technology Center population of Gila topminnows from Monkey Spring was replaced with stock from Sharp Spring in September of 1985. It was also recommended that Sharp Spring topminnow be used for all subsequent reintroduction purposes.

Molecular genetic data evidenced greater mitochondrial DNA (mtDNA) diversity in topminnows from the Rios Concepcion, Sonora, Matape, Mayo, and Yaqui, than that found in Gila topminnows of the Gila River drainage (Quattro et al. 1996). In fact, they found no detectable mtDNA diversity within any of the Gila basin populations examined (Middle Spring, Cienega Creek, Cottonwood Spring, Monkey Spring, Redrock Canyon, Sonoita Creek, Sharp Spring, and Sheehy Spring). This lack of diversity provides no evidence for historical isolation of any of these populations. Quattro
et al. (1996) pointed out that the conflicting information from the previous ecological and genetic studies and their current mtDNA data made it difficult to determine if these populations should be preserved in isolation or if gene flow among them should be reestablished.

More recent investigations into the fitness and genetic variability (represented by microsatellite loci and a major histocompatibility complex [MHC] locus) of Gila topminnow populations further examined these issues and contradicted some of the earlier results (Sheffer et al. 1997; Cardwell et al. 1998; Hedrick and Parker 1998; Parker et al. 1998; Parker et al. in press; Sheffer et al. 1998). Sheffer et al. (1997) were unable to replicate the results from Vrijenhoek et al. (1985) to verify that the population with the highest allozyme variation also had the highest fitness values (brood size, survivorship to 12 weeks, bilateral asymmetry). Furthermore, it is difficult to positively correlate genetic variability and fitness, and there are likely situations where negative or no correlation is possible (Hedrick and Miller 1992). Sheffer et al. (1997) concluded by suggesting that Cienega Creek stock be used in that drainage, Sharp Spring in the upper Santa Cruz River, Bylas Spring in the Gila River drainage and Monkey Spring not be used because it is already widely distributed. This approach limits the area (= habitat) available for each population. It also did not provide for replication of other populations not examined by them or identify suitable sources for reintroduction into other Gila River tributaries (Salt, Verde, San Pedro, Agua Fria, or Hassayampa rivers). In addition, pure Monkey Spring topminnow are not widely distributed but are present only in two localities (Cold Spring and Mescal Warm Spring), the others having been stocked with "mixed strains" from Boyce-Thompson Arboretum.

Recent investigations into the genetic variability of Gila topminnow populations led Parker et al. (in press) to conclude that Monkey Spring is strongly supported as a separate evolutionarily significant unit (ESU). From the perspective of molecular genetic variation, the other three localities (Sharp Spring, Bylas Spring, and Cienega Creek) may not qualify as separate evolutionarily significant units. However, they probably do qualify as management units as defined by Moritz (1994), i.e. populations that "have diverged in allele frequency and are significant for conservation in that they represent populations connected by such low levels of gene flow that they are functionally independent." Parker et al. (in press) concluded that these four populations exhibit microsatellite and MHC differences significant enough to suggest that they are on independent evolutionary trajectories.

Similar genetic data on other natural populations of Gila topminnow in the U.S. is needed to decide their place in the overall recovery picture. Because of these previous studies and until additional genetic research dictates otherwise, it is recommended that each existing population of Gila topminnow remain separate. Until sufficient information is available indicating otherwise, each natural population will be replicated separately in geographically isolated habitats to prevent cross contamination of stocks.
Conservation Measures

Human movements of Gila topminnow began as early as 1936 for the purposes of mosquito control. Many reintroductions have occurred since then for the purposes of conservation of the species. Reintroductions have occurred into both man-made and naturally occurring habitats (Minckley and Brooks 1985). In September of 1981 a Memorandum of Understanding between the U.S. Fish and Wildlife Service, the U.S. Forest Service, and the Arizona Game and Fish Commission provided a catalyst for large-scale reintroductions of topminnows. This reintroduction program has had limited success (Brooks 1985, 1986; Simons 1987; Bagley et al. 1991; Brown and Abarca 1992; Weedman and Young 1997). Most of the populations established during these attempts disappeared almost immediately, while a few survived for 5-10 years. The reasons for failure of these populations was obvious in some cases (dredging, drying, flooding, bulldozing, replacement by mosquitofish), while others were only speculative. Most of the habitats stocked lacked contiguous habitats from which Gila topminnow could re-populate and were of such small size they lacked resiliency to natural and human induced factors. Currently, 17 reestablished populations persist in the wild within historic range.

A philosophical change in the approach to recovery of Gila topminnow occurred between the early 1980s and the present. Originally, it was thought that the Gila topminnow could be quickly and easily recovered through a quantity-driven approach by establishing many new populations (the “Johnny Applefish” approach). The limited success of this approach became apparent in the late 1980s and emphasis was switched to protection of natural and reestablished populations in conjunction with a quality-driven approach of reintroduction to better quality areas.

From 1985 through 1990, the downlisting criteria (as identified in the original recovery plan) of 20 populations surviving in the wild for three years were met. However, downlisting was not initiated since persistence of many populations appeared tenuous (Simons et al. 1989). In 1991, the number of successful reestablished populations fell below the 20 required for downlisting. Of the populations that failed since 1985, 51% of the losses are attributed to desiccation, 20% to flooding, 20% to unknown causes, 2% to mosquitofish, and the remaining 7% to miscellaneous factors such as cattle overuse, dredging, or low oxygen (Brown and Abarca 1992). Delisting criteria were included in the original recovery plan, but delisting is not considered feasible in the foreseeable future, therefore there are no delisting criteria in this plan.

The majority of reintroductions since 1981 used topminnows from Boyce-Thompson Arboretum. This captive population is believed to be made up of individuals from Bylas Springs, Cocio Wash, and Monkey Spring (Bagley et al. 1991; Johnson and Jensen 1991). However, some of the successful wild reintroductions do represent pure natural populations: topminnow from Monkey Spring are found in Cold Springs and Mescal Warm Spring, topminnow from Sharp Spring are present at Heron Spring and AD Wash. The remaining reestablished populations were established with fish from Boyce-Thompson Arboretum and are probably of a mixed origin.
Recovery efforts have included attempts to reclaim habitats by removing nonnative fish species (Meffe 1983). Physical and chemical renovations have taken place at Bylas Spring, Salt Creek, Hassayampa River Preserve, Roper Lake State Park, and Boyce-Thompson Arboretum. These efforts have had limited success (Meffe 1983; Bagley et al. 1991). Renovations were temporarily successful at Bylas Spring, Salt Creek, Roper Lake State Park, and Boyce-Thompson Arboretum. However, Bylas Spring, Hassayampa River Preserve, and Boyce-Thompson currently support topminnow populations coexisting with nonnatives. Salt Creek was recently renovated a second time and has been re-stocked with topminnow held at the ASU Animal Resources Center originally from Bylas Spring.

Recently, several management activities to protect Gila topminnow have taken place in habitats occupied by natural populations. At Cottonwood Spring, the Service and TNC have signed and implemented a Partners for Wildlife agreement with the landowner to build an exclosure around the spring and associated Sonoita Creek and exclude grazing within the riparian area. The Coronado National Forest has conducted formal consultation to close roads, construct exclosures, and modify Allotment Management Plans to improve conditions for the Gila topminnow in Redrock Canyon. They have also outlined plans to monitor riparian conditions, including aquatic systems and fish populations. Portions of lower Sonoita Creek, Fresno Canyon, and Coal Mine Canyon have been acquired by Arizona State Parks and are now part of the Sonoita Creek State Natural Area. Cienega Creek has been largely fenced to exclude cattle. There have also been other grazing management actions, reconstruction of a part of the stream, and headcut repair.

Additional conservation measures taken include establishment of populations at Dexter National Fish Hatchery and Technology Center and Arizona State University. Habitat protections such as road closures, livestock exclosures, recreation management, fish barrier construction, closure of areas to fishing, and habitat construction have also been done. The Arizona Game and Fish Department also continues a monitoring and reintroduction program partially funded through Section 6 of the Endangered Species Act. Section 7 consultations on Federal activities has also resulted in additional protections to populations present on Federal lands (Appendix D.).
II. RECOVERY

Objective and Criteria

The interim goal for recovery of Gila topminnow is ensuring their survival in the U.S. through protection of habitats currently occupied by natural populations and maintenance of refugia stocks of each natural population. Concurrent with these activities, recovery should be aggressively pursued through reestablishing populations on Federal and other lands wherever possible.

Delisting of the species is not considered feasible in the foreseeable future for several reasons. Most of the natural habitat for this species has been irrevocably lost or contaminated by mosquitofish. There are new and continuing threats to populations from habitat alteration and destruction and nonnative species introductions. And finally, existing mechanisms and resources for alleviating these threats are limited.

Downlisting from endangered to threatened can be achieved if recovery actions delineated below prove successful. Therefore, the objective of this plan is to downlist the species from endangered to threatened. It describes specific recovery actions determined necessary to secure the continued existence and recover the Gila topminnow. Activities such as protection of existing habitats, establishment of successful additional populations within historic range, and elimination of threats to all populations are included. In addition, the plan provides recommendations for life-history and genetic studies. The time frame for recovery of this species is estimated to be 20 years.

Successful recovery of the Gila topminnow will require substantial efforts from the following agencies and organizations: U.S. Fish and Wildlife Service, Region 2; U.S. Forest Service, Region 3; National Park Service; Bureau of Land Management; Arizona Game and Fish Department; Arizona State Land Department; Arizona State Parks Department; New Mexico Department of Game and Fish; The Nature Conservancy; San Carlos Apache Indian Tribe; and state and county vector control agencies.

Survival Criteria

Prior to considering the Gila topminnow, *Poeciliopsis o. occidentalis*, for downlisting, survival of the species in the United States must be ensured by:

1) Securing remaining natural populations and their habitats in the U.S. These include eight metapopulations at 14 locations:

   a) UPPER SANTA CRUZ (Sharp Spring and uppermost Santa Cruz River in US);
   b) MIDDLE SANTA CRUZ RIVER (north of Nogales)
   c) UPPER SONOITA CREEK (Cottonwood Spring and upper Sonoita Creek)
   d) REDROCK CANYON
e) MONKEY SPRING
f) LOWER SONOITA CREEK (Coal Mine and Fresno Canyons and Sonoita Creek below Patagonia Lake)
g) CIENEGA CREEK (single population on BLM and State property)
h) BYLAS SPRING COMPLEX (Bylas and Middle springs and Salt Creek)

II) Two populations of Gila topminnow have disappeared since the first recovery plan, Sheehy Spring and North Fork of Ash Creek. Continued searches for these populations should continue. If they are re-discovered, they should be included in Item i above as natural populations. Sheehy Spring would become a sub-population of the upper Santa Cruz River metapopulation and North Fork of Ash Creek would become a new metapopulation. In addition, any other new natural populations should be included.

III) The surviving reestablished populations within historic range (Appendix C) are also considered necessary for the survival of the species. They should receive the same protections as natural populations.

IV) Maintain refugia stocks for each of the eight natural metapopulations (changes may be made to this requirement in the future as new genetic information is developed).

V) Population monitoring plans as outlined below are devised and implemented.

A secured population is defined as one under the control of an agency or organization mandated or dedicated to legal protection against detrimental land and water practices which may threaten the continued existence of the Gila topminnow. Such agencies or organizations must possess adequate statutory authority to protect those populations, must have adequate regulations in place to enforce such authority, and have demonstrated over a period not less than 10 years adequate capability to protect and manage a viable population. If it is a non-Federal agency, they must provide formal protection of land and water (i.e. habitat acquisition or conservation easement) through an agreement with an agency or organization as described above for a period greater than 24 years. The efficacy of this agreement should be demonstrated over a period at least 10 years. Populations located on private land with a conservation agreement or easement that results in protection of the habitat or population as described above will also be considered secure. In addition, a reestablished population may only be considered secure in the absence of mosquitofish or any other nonnative aquatic species considered detrimental to Gila topminnow.

The metapopulations are delineated primarily on the basis of hydrologically connected drainages with a likelihood of natural gene flow between and among them, with some probability of gene flow within the unit, but isolated from other gene pools (i.e. other sub-basins). A natural population is defined as one which existed prior to fish transplantation by humans, and which exists today in its historic location free of known mixing with other populations by humans (Simons 1987).
The Gila topminnow will be considered for downlisting when:

1. Criteria detailed under Survival Criteria have been met to ensure survival;

2. Eight natural metapopulations (level 1 populations) are replicated, established, and viable within historic range in primary (level 2 populations) and secondary sites (level 3 populations) as described in Task 2 (below). In addition, mixed populations are established in Level 2 and Level 3 populations as identified in Task 2. Level 2 populations will not be considered established until they have persisted a minimum of 10 years;

3. Plans for monitoring populations and their habitats, and periodic assessment of genetic integrity, are developed and implemented; and,

4. The genetic protocol delineated in Task 4 (below) is implemented to allow exchange of genetic material among re-established populations.

A population viability analysis is needed to determine the size of a minimum viable population. Until such analysis shows otherwise, a viable population is defined as: (1) containing at least 500 overwintering adults; (2) possessing an adequate representation of all age classes and cohorts, and; (3) having evidence of reliable annual recruitment.

**Step-down Outline**

Task 1. Prevent extinction by protecting remaining natural and long-lived reestablished populations.

1.1 Maintain refugia populations of natural populations to ensure survival of the species.
1.2 Designate critical habitat for Gila topminnow which will include, as a minimum, all natural populations.
1.3 Identify extent of geographic distribution of natural and long-lived reestablished populations including natural populations for which existence is in doubt.
1.4 Protect habitats occupied by natural and long-lived reestablished populations from detrimental land and water use practices.
1.5 Protect remaining natural and long-lived reestablished populations from invasion by detrimental nonnative aquatic species.
1.6 Prohibit the introduction or release of nonnative aquatic species detrimental to Gila topminnow into areas occupied by natural or long-lived reestablished populations.
1.7 Design and implement site specific management plans for natural and long-lived reestablished populations.
1.8 Determine what a minimum viable population is.

Task 2. Reestablish and protect populations throughout historic range.

2.1 Identify habitats suitable for reestablishment of Gila topminnow.
2.2 Reestablish Gila topminnow in suitable habitats following geographic guidelines.
2.3 Protect habitats suitable for reestablishment from detrimental land and water use practices.
2.4 Protect habitats of reestablished or potential populations from detrimental nonnative aquatic species.
2.5 Prohibit the introduction and release of nonnative aquatic species into areas occupied by reestablished populations or identified as potential habitat for reestablished populations.
2.6 Design and implement site specific management plans for all reestablished populations.


3.1 Develop and implement standardized population and habitat monitoring protocols.
3.2 Maintain a population and habitat database and generate annual reports.
3.3 Implement criteria for declaring reestablished populations as extirpated.

Task 4. Develop and implement genetic protocol for managing populations.

4.1 Facilitate genetic exchange among reestablished populations if needed.
4.2 Conduct additional genetic studies of natural and reestablished populations.

Task 5. Study life-history, genetics, ecology, and habitat of Gila topminnow and interactions with nonnative aquatic species.

Task 6. Inform and educate the public and resource managers.
Narrative Outline

**TASK 1. PREVENT EXTINCTION BY PROTECTING REMAINING NATURAL AND LONG-LIVED REESTABLISHED POPULATIONS.**

Before the introduction of mosquitofish in the 1920's (Hubbs and Miller, 1941; Miller, 1961), the Gila topminnow was one of the most common fish in the Gila River Basin. Only eight naturally occurring metapopulations are known to persist in the United States. These populations should receive the highest priority for protection, since they represent the only known genetic material left for the survival of the species in the U.S. Currently, natural populations occupy headwaters and middle reaches of relatively small basins within a mosaic of private, state, and federal lands. A thorough history of monitoring and management actions for natural topminnow populations can be found in Minckley et al. (1977), Brooks (1985, 1986), Minckley and Brooks (1985), Simons (1987), Marsh and Minckley (1990), Bagley et al. (1991), Minckley et al. (1991), Brown and Abarca (1992) and Weedman and Young (1997).

Thirteen reestablished populations persist in the wild that were established from a mixed population being held at Boyce-Thompson Arboretum. These populations will contribute to down-listing requirements as described in this plan. They and all long-lived reestablished populations within historic range identified in Appendix C are considered essential to recovery by preventing extinction of the species. Future genetic research on these populations may provide results indicating they are suitable pure representatives of one or more natural populations and can contribute to down-listing requirements as pure replicates. Furthermore, future genetic research may also indicate that it is advantageous to conduct further mixing of these populations for experimental purposes, an approach for which these populations may prove extremely well suited.

1.1 Maintain refugia populations of natural populations to ensure survival of the species.

As part of the criteria for ensuring the survival of the species, each natural population should be replicated as a separate population in captivity. These refugia populations should be in a facility that can maintain the population for the long term, can maintain the genetic characteristics of the source population, and is secure. Specific details on holding facilities and numbers should be developed and provided to designated individuals for such activity. Refugia populations should be maintained in man-made habitats or aquaria as necessary. Artificial refugia are an important component of the effort to preserve several endangered or nearly endangered fish species, especially the highly endemic and severely threatened fish fauna of the North American deserts (Pister 1981; Johnson and Jensen 1991). These refugia should preserve a large fraction of the genetic variability originally present in their progenitors (Turner 1984).
Captive populations may be established at facilities managed by a variety of groups (schools, museums, public education displays, zoos etc.). These populations are expected to contribute to an awareness and understanding by the public of the status of this endangered fish and may also serve as additional Level 3 populations. Captive populations should contain a minimum of 500 overwintering individuals, possess an adequate representation of all age classes and cohorts, exhibit evidence of successful reproduction, and be established in semi-natural or man-made habitats.

Patterns of genetic variation in artificial populations may vary from those in natural populations (Templeton 1991). Each captive population should be assessed for genetic diversity and the genetic component of these populations managed according to genetic protocols to be developed as required in Task 4.

Dexter National Fish Hatchery and Technology Center has played a major role in the reintroduction program for the Gila topminnow. Literally thousands of topminnows (from Monkey and Sharp springs) have been produced by the hatchery and stocked into Arizona waters since 1981 (Johnson and Jensen 1991). Other captive populations are held at zoos, museums, and universities (Bagley et al. 1991; Brown and Abarca 1992). Since these populations may have high fluctuations in size and structure, periodic genetic reviews of currently maintained captive populations must also be implemented as described above.

Many additional man-made habitats are becoming available for the recovery of endangered fishes. Constructed wetlands for sewage treatment and outdoor educational ponds at schools are but a few examples. These habitats, if managed appropriately, provide an increased opportunity for the establishment of additional captive Level 3 populations that would meet propagation and educational objectives. Conversely, failure to use these habitats for that purpose may necessitate managers of those habitats seeking other species of fish for introduction, likely increasing the distribution of nonnative fishes within the Gila River basin.

1.2 Designate critical habitat for Gila topminnow which will include, as a minimum, all natural populations.

The Gila topminnow was listed as an Endangered Species in 1967 with no critical habitat designation. Critical habitat should be designated for the Gila topminnow. At a minimum, it should include all habitats currently occupied by the eight natural meta-populations. The Service will determine the full extent of critical habitat when the final critical habitat rule is made.

1.3 Identify extent of geographic distribution of natural and long-lived reestablished populations including natural populations for which existence is in doubt.

The geographic distribution of Gila topminnow should be accurately determined by watershed-wide surveys of aquatic habitats in Redrock Canyon, Cienega Creek, Sonoyta Creek, and the Santa Cruz
River in the San Rafael Valley and north of Nogales. Once accomplished, land ownership identification and habitat assessment should follow to determine protective measures.

Similarly, the San Pedro River and the San Carlos River, Arizona, should be surveyed for undiscovered populations. Habitats in the North Fork of Ash Creek and Sheehy Spring should be examined to determine if populations persist. Any new populations or range extensions discovered are subject to Survival Criteria and provisions of Task 1.

1.4 Protect habitats occupied by natural and long-lived reestablished populations from detrimental land and water use practices.

Identify land ownership of habitat essential for the survival of remaining natural and long-lived reestablished populations. This includes the recently occupied habitats at Sheehy Spring and North Fork of Ash Creek. Agencies and organizations that can supply legal protection from adverse land and water management practices need to acquire adequate amounts of land, including water rights, necessary to maintain and control habitat integrity for the near and distant future. In cases where a land owner is reluctant or unwilling to sell, attempts should be made to purchase conservation easements or other agreements for proactive management activities that favor topminnow habitat security. Compliance with Sections 7, 9, and 10 of the Endangered Species Act and applicable State laws are needed to protect all populations.

Eight of the 14 remaining natural topminnow populations are on private lands. Since the early 1980s, most private land owners have been extremely cooperative by allowing continuous monitoring of those locations. Appropriate mechanisms must be used to protect these populations. A legally-binding, long-term (>24 years) cooperative agreement with the land owner should be pursued for monitoring, habitat enhancement and protection, eradication of nonnatives, and relocation of fishes, if necessary.

Once sufficient land and water acquisitions or other protections have been attained, several tasks must be accomplished before topminnow populations can be considered secure. These include assurance of water quality and quantity, protection against habitat degradation, control and removal of detrimental nonnative plants, and modification of land management practices either directly or indirectly detrimental to aquatic habitats. Aquatic vegetation generally adds to habitat diversity. However, dense growths not checked by occasional disturbance (e.g. floods, herbivorous animals) can crowd surface water to the point that topminnow carrying capacity is severely diminished such as occurred at Bylas and Middle Springs (Marsh and Minckley 1990). Habitat features need to be monitored in order to recognize and avoid such subtle shifts in habitat quality. Following identification of vegetative overgrowth problems, manipulation of vegetation may be required to enhance habitat features for Gila topminnow survival.

Monkey Spring has long been recognized as an extremely unique habitat. It was historically occupied by an undescribed species of pupfish (Cyprinodon spp.), and a morphologically distinct form of Gila
chub (*Gila intermedia*). The Gila topminnows currently present also exhibit unique genetic characteristics. The spring system is located on privately owned land currently lacking adequate protection measures. Monkey Spring is recognized as habitat that is seriously threatened by future local development, especially groundwater pumping by nearby expanding residential developments.

1.5 **Protect remaining natural and long-lived reestablished populations from invasion by detrimental nonnative aquatic species.**

Removal of nonnative aquatic species should be conducted from all natural populations where technically possible, following construction of appropriate barriers to reinvasion (e.g. Bylas, Sharp and Sheehy springs, Coal Mine, Fresno and Redrock canyons, and Upper Santa Cruz River). In those sites where nonnatives have not yet invaded (e.g. Cottonwood Spring), improved barriers to invasion should be erected. Periodic thorough surveys of habitats adjacent to natural populations must be conducted to locate and remove nonnative aquatic species. Renovation and reintroductions have recently occurred at Middle Spring and Salt Creek. Development and application of methods to manage against nonnative species in habitats where successful removal is unlikely (e.g. Sharp Spring) are also needed.

Topminnow habitat at risk of contamination by nonnative plants and animals will require preventative measures. One measure needed to reduce the risk of contamination is an inventory of watersheds and elimination of all sources of nonnative aquatic species having a potential for dispersal, either through immigration during flood or transport by people.

When habitat renovation is considered, several factors should be taken into account including population origin (natural vs. reestablished), immediacy of threat, status of replicate populations of the same lineage, and probability of short and long-term success. Some factors negatively affecting success include poor organization and execution of renovation, potential recontamination by the public or from nearby populations in the watershed, habitat complexity and size, and lack of barriers to fish migration (Marsh and Minckley 1990; Rinne and Turner 1991).

1.6 **Prohibit the introduction or release of nonnative aquatic species detrimental to Gila topminnow into areas occupied by natural or long-lived reestablished populations.**

Nonnative aquatic species are a major threat to the continued existence of the Gila topminnow. Declines and extirpations of several reestablished Gila topminnow populations are attributable to negative impacts by mosquitofish. It is imperative that invasion of nonnative aquatic species into topminnow habitats and connected waters be prevented. All relevant agencies should make a concerted effort to prohibit introduction or restocking of nonnative aquatic species, especially mosquitofish. Stricter regulations on use and movement of mosquitofish are needed. Mosquitofish are now prohibited as baitfish in the Verde River above Horseshoe Dam and in the Salt River above the Roosevelt Diversion Dam upstream of Roosevelt Lake by the Arizona Game and Fish Commission. Mosquitofish are commonly used for control of mosquitos throughout Arizona.
Research into the ability of native fish to meet this need is beginning. If they prove successful in controlling mosquito larvae, such use should be encouraged.

1.7 Design and implement site specific management plans for natural and long-lived reestablished populations.

Management plans that cover single or multiple populations must be prepared and properly implemented before a topminnow population will be considered secure. Cooperative planning involving all major stakeholders within the watershed where a natural population(s) occurs or where recovery related activities are needed should be established. Relevant actions in this recovery plan need to be incorporated into management decisions as they are made. Government (federal, state, local) and private entities should be encouraged to participate in "ecosystem level" planning. This type of planning, and subsequent full implementation of such plans, is crucial to long-term survival of the Gila topminnow. This level of planning is especially necessary for natural populations affected by multiple land owners. Impacts of activities such as livestock grazing, mining, timber harvest, vegetation management, mosquito control, recreation, and agricultural, residential, or other development, must be assessed and factored into each plan.

1.8 Determine what constitutes a minimum viable population for wild and refugia populations.

Populations that are less than the minimum viable size suffer negative impacts from stochastic events and genetic bottlenecks than larger populations. Ensuring that wild and refugia populations are a viable size will reduce the management needed to maintain specific populations and make it easier to recover the species.

**TASK 2. REESTABLISH AND PROTECT POPULATIONS THROUGHOUT HISTORIC RANGE.**

Stocking of topminnows started in 1936 (Minckley 1969b) and was intensified in 1982 under a 1981 Memorandum of Understanding (MOU) between the Service, U. S. Forest Service, and the Arizona Game and Fish Department. Since then, one of the most aggressive reintroduction efforts for an endangered species has been implemented, with more than 350 documented stockings of Gila topminnow to wild and captive localities. Among short-lived fishes in North American deserts, no other fish has been transplanted as many times as the Gila topminnow (Hendrickson and Brooks 1991). Prior to 1982, Gila topminnows were stocked into 62 wild sites (Minckley and Brooks 1985). In 1982, 88 wild sites were stocked, followed by 27 in 1983 (Brooks 1985, 1986). An additional 29 wild sites have been stocked or populated by dispersal from stocked populations since 1983. A total of 206 documented Gila topminnow reintroductions have been conducted at 178 wild locations (Minckley and Brooks 1985; Simons 1987; Bagley et al. 1991; Brown and Abarca 1992). Reintroductions also have occurred into 141 captive sites. Appendix E provides a summary of all known Gila topminnow stockings.
Despite this large-scale reintroduction effort, the percentage of successfully reestablished populations remains low (~8%) (Weedman and Young 1997). Attributed reasons for failure are dessication, negative interactions with mosquitofish, floods, low dissolved oxygen, and habitat destruction by cattle. Bagley et al. (1991) identified several sites that received Gila topminnows from more than one population, resulting in mixed populations. As an example, Boyce-Thompson Arboretum received Gila topminnows in 1971 from Page Springs Hatchery (Minckley and Brooks 1985). These fish originally came from Monkey Spring. However, around 1973 fish from Cocio Wash, now an extirpated natural population, were also stocked into the Arboretum (AGFD files). AGFD files also report Gila topminnows from Bylas Spring being stocked into the Arboretum prior to 1978. With a few exceptions, most of the reintroductions in 1982 and 1983 used fish from Boyce-Thompson Arboretum. These populations of mixed origin will be maintained and their genetic characteristics periodically assessed before significant management actions are undertaken (e.g., renovations, further stocking, population mixing, etc.).

A three-level approach to re-establishing Gila topminnow populations, similar to that used in the Desert Pupfish Recovery Plan (USFWS 1993), is recommended (Table 1.). Natural populations in the Gila River Basin (currently eight metapopulations at 14 localities) represent the only genomes available for recovery of this species in the U.S. These populations are designated as Level 1 and should receive the highest priority for protection.

Populations reestablished in wild sites with natural habitats capable of sustaining a viable population with minor human intervention and persisting a minimum of 10 years will be considered Level 2 populations. These Level 2 populations may inhabit naturally occurring sites enhanced by man, but can’t require routine maintenance for their survival. Captive populations will not be considered as Level 2 populations. The existing eight metapopulations identified above (as well as any new populations discovered) will be replicated in at least four Level 2 sites for each metapopulation. In addition, at least 20 Level 2 populations of mixed origin will be reestablished. These Level 2 populations will be reestablished at localities with the least possible likelihood of being contaminated by topminnows from other populations and according to the geographic guidelines provided in Task 2.2. These populations should receive a high degree of protection and will be expected to persist at minimum of 10 years, but preferably indefinitely, with little to no human intervention. The level of a population may be designated at stocking or at any time up until 10 years later. Levels may be changed based on changed conditions or new information.

| Table 1. Downlisting criteria for reestablished populations of Gila topminnow, *Poeciliopsis occidentalis occidentalis*, in the United States. |
|-------------------|----------------|----------------|----------------|--------------------------|
| Population Level | Number required | Example 1 | Example 2 | Maximum allowed to replace Level 3 populations |

25
Table 1. Downlisting criteria for reestablished populations of Gila topminnow, *Poeciliopsis occidentalis occidentalis*, in the United States.

<table>
<thead>
<tr>
<th>Level 2 Pure replicates</th>
<th>Assume 35 established</th>
<th>Assume 40 established</th>
<th>47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 2 mixed</td>
<td>20</td>
<td>assume 20 established</td>
<td>35</td>
</tr>
<tr>
<td>Level 3 any combination of pure and mixed</td>
<td>60 only 54 required (2:1 replacement ratio)</td>
<td>only 30 required (replaced by 15 extra Level 2)</td>
<td>None required (replaced by extra level 2 populations)</td>
</tr>
</tbody>
</table>

| Total | 112 | 109 | 97 | 82 |

Populations reestablished in wild or captive natural, semi-natural, or man-made habitats that aren’t capable of sustaining a viable population for at least 10 years without human intervention will be designated as Level 3 populations. Level 3 populations may require extensive human intervention and are permitted to be lost during the course of recovery actions as long as additional populations are reestablished, either in the same locale or elsewhere. If planned management activities are expected to eliminate a Level 3 population, there must be a replacement population established for at least 6 months prior to implementing the activity expected to result in the loss of that population. If the disappearance is the result of an unplanned activity or natural event, a new population must be immediately reestablished. The natural history of the Gila topminnow included frequent disappearance of populations followed by reestablishment through natural dispersal. These Level 3 populations are intended as an attempt to mimic these events; however, because of current habitat fragmentation, natural dispersal is no longer possible. Therefore, Level 3 populations that occasionally disappear due to natural events such as drying or flooding will be reestablished by man as needed.

Philosophically, Level 3 populations are intended to provide managing agencies with some degree of flexibility in the implementation of this recovery plan. Level 3 populations are perceived to be half as valuable as Level 2 populations to the recovery of Gila topminnow. Therefore, extra Level 2 pure populations established above the minimum 32 required (up to a maximum of 47) will result in a corresponding two-fold decrease in the number of Level 3 populations required to meet the downlisting requirements. Establishment of Level 2 mixed populations above the minimum 20 required (up to a maximum of 35) will result in an additional two-fold decrease in the number of Level 3 populations required to meet the downlisting requirements. Possible reestablishment scenarios are provided as examples in Table 1 and further discussed below. An appropriate number of Level 3 populations must be established and maintained relative to the number of Level 2 populations in existence according to the criteria in Table 1 to meet the downlisting requirements for reestablished populations. Additional populations, beyond those needed for downlisting, shall also be maintained. This would insure that the minimum number of population needed for downlisting would always be maintained.
For the first example in Table 1, if 35 pure and 20 mixed populations are established that meet Level 2 requirements, only 54 Level 3 populations must be maintained to meet downlisting requirements for reestablished populations. For the second example in Table 1, if 40 pure and 30 mixed populations are established that meet Level 2 requirements, only 24 Level 3 populations must be maintained. Under either example, if a Level 2 population is lost, two Level 3 populations must immediately be established to maintain the minimum number of overall populations required to meet downlisting requirements. Restocking of the locality (if it is still suitable habitat) previously supporting the lost Level 2 population may provide one of the needed Level 3 populations.

Stocks of Gila topminnow for replicating Sharp Spring should be obtained from Dexter National Fish Hatchery and Technology Center. Refugia populations, as identified in Task 1.1 should be established for each natural population and, as they become available, provide progeny for future introductions. Direct use of wild progeny should be discouraged from natural populations that:

1) contain mosquitofish, as the probability of contamination is considered high, or;

2) are small populations from which removal of suitable numbers for stocking purposes would constitute a threat to the source population.

2.1 Identify habitats suitable for reintroduction of Gila topminnow.

Populations should be reestablished in a variety of available habitats (springheads, cienegas, streams, margins of rivers). These habitats should reflect, as much as is possible, historic conditions prior to anthropogenic modifications. Large numbers of topminnows should not be concentrated into a single habitat type, but should be distributed among suitable habitats within a locality. A concerted effort by resource management agencies and organizations should be carried out to identify additional areas suitable for the recovery of Gila topminnows.

Detailed habitat assessment must be conducted prior to any reintroduction, as recommended by Williams et al. (1988), and be sanctioned by the pertinent agencies. Potential high quality reintroduction sites will have permanent water, no mosquitofish or other predatory nonnative species, high level of habitat complexity, and a minimum of detrimental human activities. Some general reestablishment site criteria are recommended (Table 2).
Table 2. General criteria for determining reintroduction site suitability (modified from Brooks 1985).

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage area</td>
<td>~ 1.0 km²</td>
</tr>
<tr>
<td>Elevation</td>
<td>&lt; 1,600 m</td>
</tr>
<tr>
<td>Stream flow</td>
<td>Perennial, lotic, sheltered areas with &lt; 0.1 m³/sec flow.</td>
</tr>
<tr>
<td>Stream gradient</td>
<td>&lt; 3%</td>
</tr>
<tr>
<td>Stream geomorphology</td>
<td>Stream channel classification of B,C,D or E (Rosgen 1994).</td>
</tr>
<tr>
<td>Pond surface area</td>
<td>&lt; 2 ha</td>
</tr>
<tr>
<td>Pond depth</td>
<td>&lt; 2 m</td>
</tr>
<tr>
<td>Channelization</td>
<td>Little or none.</td>
</tr>
<tr>
<td>Habitat composition</td>
<td>Complex, heterogeneous, protected from major reoccurring flash flooding.</td>
</tr>
<tr>
<td>Cover</td>
<td>Moderate to abundant aquatic vegetation</td>
</tr>
<tr>
<td>Other species</td>
<td>Only native fishes and a variety of insect life.</td>
</tr>
<tr>
<td>Water quality</td>
<td>General guidelines - ADEQ Aquatic Wildlife Water Quality Standards (ADEQ 1992)</td>
</tr>
<tr>
<td>Development potential</td>
<td>Low or none</td>
</tr>
</tbody>
</table>

A proposed locality does not necessarily have to meet all criteria in Table 2. Those values should be used as guidelines during the evaluation of proposed reestablishment localities. Further information on habitat preferences and quantitative analyses on failure and success of reestablished populations should prompt revision of this protocol. Efforts should be made to survey continuously for potential reestablishment sites within each sub-basin, and within the historic range of Gila topminnow. Many localities have already been identified for potential reestablishment of Gila topminnow. Some have been previously stocked and since failed, while others have not yet been stocked. Many of the areas previously stocked with Gila topminnow that failed are still considered suitable for continued attempts at reestablishment and will likely provide habitat to support at least Level 3 populations. Table 3 provides a list of localities that have been identified, evaluated, and found to be suitable for reestablishment of Gila topminnow.
Table 3. List of known habitats available for reestablishment of Gila topminnow.

<table>
<thead>
<tr>
<th>Site#</th>
<th>Sitename</th>
<th>Stocked Before?</th>
<th>Land Owner(s)</th>
<th>Township and Range</th>
<th>Section</th>
<th>Date Stocked</th>
<th>Source of topminnow originally stocked</th>
</tr>
</thead>
<tbody>
<tr>
<td>328</td>
<td>A &amp; A Gravel Pit</td>
<td>No</td>
<td>Tonto NF</td>
<td>02 N 08 E</td>
<td>35</td>
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<td></td>
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<td>332</td>
<td>Alder Creek</td>
<td>No</td>
<td>Tonto NF</td>
<td>06 N 08 E</td>
<td>09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>312</td>
<td>Antelope Creek</td>
<td>No</td>
<td>BLM Phoenix &amp; Private</td>
<td>11 N 02 E</td>
<td>28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>241</td>
<td>Arnett Creek</td>
<td>No</td>
<td>Tonto NF</td>
<td>02 S 12 E</td>
<td>06</td>
<td></td>
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</tr>
<tr>
<td>318</td>
<td>Ash Creek</td>
<td>No</td>
<td>BLM, Prescott NF &amp; Private</td>
<td>11 N 03 E</td>
<td>08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>96B</td>
<td>Benson Spring</td>
<td>No</td>
<td>Tonto NF</td>
<td>01 S 11 E</td>
<td>36</td>
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<tr>
<td>130</td>
<td>Bog Hole</td>
<td>No</td>
<td>AGFD-Coronado NF</td>
<td>22 S 17 E</td>
<td>32</td>
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<td>298</td>
<td>Buckhorn Spring #2</td>
<td>No</td>
<td>BLM Phoenix</td>
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<td>320</td>
<td>Carrizo Dam Tank</td>
<td>No</td>
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<td>07</td>
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<tr>
<td>310</td>
<td>Chalky Spring</td>
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<td>BLM Phoenix &amp; Maricopa County</td>
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<tr>
<td>326</td>
<td>Coal Mine Spring Tank</td>
<td>No</td>
<td>Private</td>
<td>Unsurveyed</td>
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<tr>
<td>325</td>
<td>Fresno Tank 2</td>
<td>No</td>
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<td></td>
<td></td>
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<tr>
<td>314</td>
<td>Garfias Wash Spring</td>
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<td>11</td>
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<tr>
<td>240</td>
<td>Hess Canyon</td>
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<td>309</td>
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<td>307</td>
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<td>Little Ash Creek</td>
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<td>BLM, Prescott NF &amp; Private</td>
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<td>236</td>
<td>Long Gulch Artesian</td>
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<td>05 N 12 E</td>
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<td>315</td>
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<td>207</td>
<td>Post Canyon</td>
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<td>208</td>
<td>Reimer Spring</td>
<td>No</td>
<td>Prescott NF</td>
<td>12 N 04 E</td>
<td>06</td>
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</tr>
</tbody>
</table>
Table 3. List of known habitats available for reestablishment of Gila topminnow.

<table>
<thead>
<tr>
<th>Site#</th>
<th>Sitename</th>
<th>Stocked Before?</th>
<th>Land Owner(s)</th>
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<th>Section</th>
<th>Date Stocked</th>
<th>Source of topminnow originally stocked</th>
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<tr>
<td>295</td>
<td>Rock Creek</td>
<td>No</td>
<td>Tonto NF</td>
<td>05 N 08 E 36</td>
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<td>243</td>
<td>Rock Spring #3</td>
<td>No</td>
<td>Tonto NF</td>
<td>06 N 09 E 06</td>
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<td>331</td>
<td>Secret Spring</td>
<td>No</td>
<td>Tucson BLM, Coronado NF, TNC Muleshoe CMA</td>
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<td>Sevenmile Wash</td>
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<td>Tonto NF</td>
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<td>308</td>
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<td>Sycamore Creek (near Sunflower)</td>
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<td>03 N 16 E 36</td>
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<td>Sycamore Creek (Sheep Bridge)</td>
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<td>273</td>
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<td>177</td>
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<td>750815</td>
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<td>26</td>
<td>Bain Spring</td>
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<td>84</td>
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<td>133</td>
<td>Buehman Canyon</td>
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<td>12 S 18 E 05</td>
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<td>Camp Creek</td>
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<td>Township and Range</td>
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<td>77</td>
<td>Cottonwood Artesian</td>
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<td>Tonto NF</td>
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<td>278</td>
<td>East Verde River</td>
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<td>33</td>
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<td>281</td>
<td>Granite Creek</td>
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<td>81</td>
<td>Green Tanks (Rattlesnake Spring)</td>
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<td>83</td>
<td>Howard Well</td>
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<td>248</td>
<td>Lime Cabin Spring</td>
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<td>125</td>
<td>Little Nogales Spring</td>
<td>Yes</td>
<td>BLM Tucson</td>
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<td>132</td>
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<td>68A</td>
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<td>02 N 09 E</td>
<td>01</td>
<td>820603</td>
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Table 3. List of known habitats available for reestablishment of Gila topminnow.

<table>
<thead>
<tr>
<th>Site#</th>
<th>Sitename</th>
<th>Stocked Before?</th>
<th>Land Owner(s)</th>
<th>Township and Range</th>
<th>Section</th>
<th>Date Stocked</th>
<th>Source of topminnow originally stocked</th>
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<tr>
<td>124</td>
<td>Nogales Spring</td>
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<td>BLM, Tucson</td>
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<td>205</td>
<td>O’Donnell Creek</td>
<td>Yes</td>
<td>TNC, Coronado NF</td>
<td>21 S 18 E</td>
<td>28</td>
<td>740800</td>
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<td>247</td>
<td>Packard Spring</td>
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<td>Red Creek</td>
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<td>211</td>
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<td>Saguaro NP East</td>
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<td>Sycamore Creek near Dugas</td>
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<td>73</td>
<td>Tule Creek Seep (2E)</td>
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<td>97</td>
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<td>Upper Horrell Spring</td>
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<td>288</td>
<td>Verde River at Perkinsville</td>
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<td></td>
<td>770000</td>
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</table>
2.2 **Reestablish Gila topminnow in suitable habitats following geographic guidelines.**

To ensure that reestablishment activities do not adversely impact natural populations, Gila topminnow are to be reestablished in accordance with the geographic guidelines (Table 4). Estimates of probability of gene flow between any population should be made. If there is a probability of topminnow from two pure reestablished populations of different sources establishing and mixing downstream, there should be no chance for mixed offspring of those fishes to get back into their pure source populations and converting them into mixed populations.

Gila topminnow for reestablishment may come from a variety of sources, including natural, refugia, captive, or reestablished populations. Initially, topminnows will need to be taken from those natural populations that are not yet replicated anywhere and placed into suitable refugia. After a refugia population is established for a natural population, it should be used as the source for subsequent stocking into wild or captive sites. Reestablishment of large numbers of fish is extremely important, since small populations of short-lived species, such as the topminnow, are more prone to extinction than are similar-sized populations of long-lived species (Hendrickson and Brooks 1991). In addition, stocking large numbers of fish may also prevent genetic bottlenecks, which reduce genetic diversity (Echelle 1991). It may also be necessary to conduct several stockings over the course of several years to reestablish a new population.

In addition, the reestablishment program should consider the following recommendations:

A) Supplemental stockings in a single location must be evaluated on a case-by-case basis and should be done if available data show that such action would be advantageous, such as the population dropping below 500 individuals due to extremely stochastic natural events or controllable human induced factors.

B) Many reestablishment efforts require habitat restoration or improvement prior to stockings.

C) Gila topminnow stockings should be coordinated and documented with records centrally filed. To avoid duplication of efforts and records, the proposing agency should coordinate all activities with the Service and AGFD (or New Mexico Department of Game and Fish [NMDGF] if located in New Mexico). All stocking records should be stored at AGFD (or NMDGF in New Mexico) for proper distribution to pertinent agencies and individuals.

D) Reestablishment sites that have maintained populations for extended periods of time, and are thus of proven stability, should be given as much protection as possible, and should not receive new stockings unless future genetic studies clearly demonstrate that such action would be advantageous.
<table>
<thead>
<tr>
<th>Geographic Area</th>
<th>Metapopulation to be stocked</th>
<th>Extant reestablished populations (source). BTA=Boyce Thompson Arboretum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rillito Creek drainage</td>
<td>Cienega Creek only</td>
<td>None</td>
</tr>
<tr>
<td>Santa Cruz River drainage in San Rafael Valley</td>
<td>Upper Santa Cruz River</td>
<td>Heron Spring (Sharp)</td>
</tr>
<tr>
<td>Redrock Canyon drainage</td>
<td>Redrock Canyon only</td>
<td>None</td>
</tr>
<tr>
<td>Sonoita Creek above Patagonia Lake (except Redrock Canyon)</td>
<td>Upper Sonoita Creek</td>
<td>None</td>
</tr>
<tr>
<td>Santa Cruz drainage north of Nogales, not including Sonoita Creek below Patagonia Lake</td>
<td>Middle Santa Cruz</td>
<td>None</td>
</tr>
<tr>
<td>Sonoita Creek below Patagonia Lake not including Santa Cruz River or other tributaries</td>
<td>Lower Sonoita Creek</td>
<td>None</td>
</tr>
<tr>
<td>Gila River drainage above Coolidge Dam (not including San Carlos drainage if Ash Creek is re-discovered)</td>
<td>Bylas Complex (Ash Creek if found in San Carlos drainage)</td>
<td>Cold Spring (Monkey), Watson Wash (unknown)</td>
</tr>
</tbody>
</table>

**GEOGRAPHIC AREAS WITH NO EXISTING NATURAL POPULATIONS**

<table>
<thead>
<tr>
<th>Geographic Area</th>
<th>Metapopulation to be stocked</th>
<th>Extant reestablished populations (source). BTA=Boyce Thompson Arboretum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt River above Roosevelt Dam</td>
<td>Pure replicates of the eight natural meta-populations, or any combination of mixed populations, as long as no chance of contamination of pure populations can occur from upstream or downstream dispersal from populations of mixed or pure replicates of different natural populations.</td>
<td>None</td>
</tr>
<tr>
<td>Tonto Creek drainage</td>
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<td>Kayler Spring (BTA)</td>
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<tr>
<td>Salt River below Roosevelt Dam and Verde River below Horseshoe Dam to Granite Reef Diversion Dam</td>
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<td>Charlebois Spring (BTA), Hidden Water Spring (BTA), Unn. Drainage #68b (BTA)</td>
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<tr>
<td>Gila River below Coolidge Dam and Salt River below Granite Reef dam</td>
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<td>Mescal Warm Spring (Monkey)</td>
</tr>
<tr>
<td>San Pedro River drainage</td>
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<td>None</td>
</tr>
<tr>
<td>Verde River above Horseshoe Dam</td>
<td></td>
<td>Dutchman Grave, Lower Mine, Walnut and Mud springs and Lime Creek (all BTA)</td>
</tr>
<tr>
<td>Agua Fria River</td>
<td></td>
<td>Tule Creek (BTA), Johnson Wash Spring (BTA) and AD Wash (Sharp)</td>
</tr>
<tr>
<td>Hassayampa River</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Outside Gila River Basin</td>
<td>No Reintroductions</td>
<td>Yerba Mansa (BTA)</td>
</tr>
</tbody>
</table>
E) All permits, Section 7 consultations, NEPA documents, and other environmental compliance documents must be completed prior stocking of fish.

2.3 Protect habitats suitable for reestablishment from detrimental land and water use practices.

Protection of areas identified under Task 2.1 is necessary for the recovery of Gila topminnow. Identification of land ownership of habitat essential for the recovery of Gila topminnow is also necessary. Agencies and organizations that can supply legal protection from adverse land and water management practices need to acquire adequate amounts of land including water rights necessary to maintain and control habitat integrity for the near and distant future. Attempts should be made to purchase conservation easements or other agreements for proactive management activities that favor topminnow habitat security on other private lands. Compliance with Sections 7 and 9 of the Endangered Species Act and State laws are needed to protect all populations. Critical habitat should be designated for identified reintroduction sites that do, or are expected to support level 2 populations.

Once sufficient land and water acquisitions or other protections have been attained, several actions must be taken before reestablished topminnow populations can be considered secure. These include assurance of water quality and quantity, protection against habitat degradation, control and removal of detrimental nonnative plants, and modification of land management practices either directly or indirectly detrimental to aquatic habitats.

2.4 Protect habitats of reestablished or potential populations from detrimental nonnative aquatic species.

Where possible, removal of nonnative aquatic species should be conducted. Construction of appropriate barriers to reinvasion should also be considered. Development and application of methods to manage against nonnative species in habitats where successful removal is unlikely are also needed.

Topminnow habitat at risk of contamination by nonnative plants and animals will require an inventory of watersheds and elimination of all sources of nonnative aquatic species having a potential for dispersal, either through immigration during flood or transport by people. When habitat renovation is considered, several factors should be taken into account including immediacy of threat, status of replicate populations of the same lineage, and probability of success.

2.5 Prohibit the introduction or release of nonnative aquatic species into areas occupied by reestablished populations or identified as potential habitat for reestablished populations.

Nonnative aquatic species are a major threat to the continued existence of the Gila topminnow. Declines and extirpations of several reestablished Gila topminnow populations are attributable to negative impacts by mosquitofish. It is imperative that invasion of nonnative aquatic species into
topminnow habitats and connected waters be prevented. All relevant agencies should make a concerted effort to prohibit introduction or restocking of mosquitofish. Stricter regulations on use and movement of mosquitofish are needed. Mosquitofish are also commonly used for control of mosquitos throughout Arizona. Research into the ability of topminnow to meet this need is beginning. If they prove successful in controlling mosquito larvae, use consistent with this plan should be encouraged.

2.6 **Design and implement site specific management plans for all reestablished populations.**

Management plans that cover single or multiple populations must be drafted as needed and properly implemented before a topminnow population will be considered secure. Cooperative planning that involves all major entities within the watershed where a reestablished population(s) occurs or where recovery related activities are needed should be established. Relative portions of this recovery plan need to be incorporated into management plans as they are developed. Government (federal, state, local) and private entities should be encouraged to participate in such "ecosystem level" planning. This type of planning, and subsequent full implementation of such plans, is crucial to recovery of the Gila topminnow. Impacts of activities such as livestock grazing or watering, mining, timber harvest, vegetation management, mosquito control, recreation, and agricultural, residential, or other development, must be assessed and factored into each plan. Such plans for Level 2 populations are a higher priority than for Level 3 populations.

### TASK 3. MONITOR NATURAL AND REESTABLISHED POPULATIONS AND THEIR HABITATS.

3.1 **Develop and implement standardized population and habitat monitoring protocols.**

Success in meeting and measuring progress toward goals and objectives of this recovery plan will depend on reliable data accumulated in a systematic way to assess population and habitat changes over time. Frequent monitoring of natural populations will allow early detection of destructive nonnative organisms and habitat degradation. Monitoring of natural populations should be done at least once a year between March and September. Preferably, natural populations will be monitored twice a year to document overwintering population minima and late summer population maxima (needed to evaluate limiting factors and genetic bottlenecks). Semiannual sampling should be conducted once during February or March and once during September or October.

Because regular, well structured monitoring is the only reliable means for evaluating the health of populations and evaluating and updating reintroduction methods, it is imperative to develop a comprehensive population and habitat monitoring protocol. This protocol must be sufficient to detect changes in population size and habitat quality, and to explain reasons for success and failure of natural and reestablished populations. Any protocol used should fit with a well planned reestablishment study design aimed at determining habitat and population requirements for survival (see also Task 6).
Several natural resource agencies are involved in Gila topminnow monitoring. Therefore, a standardized monitoring protocol must be developed and implemented by the agencies. Comparable methodology (sampling gear, effort, season, location, etc.) should be used every year in order to provide an accurate assessment of population characteristics. Each visit to a particular site should occur at approximately the same time of year in order to minimize seasonal variation. Voucher specimens of fish should accompany any collection where doubt concerning identification exists. It is particularly important to obtain ratios over time of numbers of nonnatives and topminnows to provide insight into the co-occurrence or extirpation of topminnows in each site (Minckley et al. 1977; Meffe et al. 1982). Monitoring data tailored to identifying population trends should include the following categories at a minimum: date, time, location, recent weather events, sampling technique, number of fish captured, capture per unit of effort, and size class distribution (adult vs. juveniles). Surface fish counts need verification of species identity, since mosquitofish and topminnow are difficult to distinguish at a distance.

Habitat data should be collected along with population data. After a broad inventory data set has been gathered on associated aquatic biota, physical habitat, water quality and quantity, watershed condition, etc., monitoring should be tailored to identify habitat trends. Other site specific data may be necessary. Permanent habitat photopoints and stream cross-sections will aid in interpretation of habitat data collected.

3.2 Maintain a population and habitat database and generate annual reports.

AGFD is designated as the repository agency for habitat and population monitoring data. Annual reports should be generated and distributed to other interested parties involved in the management of the Gila topminnow. Data stored at AGFD is available to cooperators. Once standardized population and habitat monitoring protocols are established, a consistent report format should be adopted to allow rapid analysis of comparable data from reports over time.

**TASK 4.DEVELOP AND IMPLEMENT GENETIC PROTOCOL FOR MANAGING POPULATIONS.**

A successful recovery program for an endangered species such as the Gila topminnow must take into account an evolutionary perspective that addresses the need for continued adaptive change in all populations (Meffe and Vrijenhoek 1988; Leberg 1990; Meffe 1990; Hendrickson and Brooks 1991). The optimal strategy for preserving both management options and evolutionary flexibility of taxa is to maintain as many populations as possible while retaining natural patterns of genetic flow within and among populations (Echelle 1991). Maintenance of genetic diversity within species and populations has become a necessary approach for many threatened and endangered species (Frankel and Soule 1981; Templeton 1991; Templeton et al. 1991; Hedrick and Miller 1992).
Comprehensive genetic analyses for the Gila topminnow began after massive reintroduction efforts were undertaken (Meffe and Vrijenhoek 1988). Initial studies on genetic geographic allozyme variation indicated the existence of three distinctive groups of natural populations from the U.S. and Sonora (Vrijenhoek et al. 1985). The first group included all populations from the Gila River basin, Río Sonora, and Río de la Concepción, Sonora. The second group was formed by the entire Río Yaqui, the Río Matape, and the lower Río Mayo. A third distinctive group occupies the upper Río Mayo.

For reasons previously discussed, and until further genetic analysis indicates otherwise, each natural population will be replicated separately in geographically isolated habitats to prevent cross-contamination of stocks. Where conditions allow, populations of topminnow will be mixed and stocked into areas with limitations previously identified. Genetic data on other natural populations of Gila topminnow in the U.S. similar to that available in Parker et al. (in press) is needed to determine the place of these populations in the overall recovery picture. Future protective actions against invasion by mosquitofish will certainly include fish barriers in those sub-basins currently occupied by the Gila topminnow. Close population and genetic monitoring will be necessary to document effects of this additional "fragmentation."

4.1 Facilitate genetic exchange among reestablished populations.

Recovery actions proposed in this plan are somewhat complex and special attention will need to be paid to sources used for stocking Level 2 and Level 3 populations and detailed records on the transfer if fish will need to be kept. Decisions based on surface hydrology will need to be made to determine areas where mixed and pure populations are established. The results of genetic exchange should be monitored in accordance with genetic studies to be developed under Task 4.2. Genetic exchange between populations should be carried out carefully, after coordinating with the U.S. Fish and Wildlife Service and appropriate state game and fish agency, according to the following recommendations:

1. Gene flow may be from any Level 1 metapopulation or its established refugia directly to its pure Level 2 or Level 3 population or to any Level 2 or 3 mixed population, but never from the Level 2 or 3 population back to its Level 1 source.

2. Gene flow may be from any population in existence to any Level 2 or 3 mixed population.

3. Gene flow may be between any pure Level 2 or Level 3 population derived from the same Level 1 population, but not from Level 2 or 3 populations back to Level 1 populations.
4.2 **Conduct additional genetic studies on natural and reestablished populations.**

Since remnant natural Gila topminnow populations in the U.S. present genetic differences from those southern populations in Mexico, it is imperative to expand our knowledge by conducting additional genetic analyses of the U.S. populations.

Genetic studies utilizing mitochondrial DNA support the notion that the Gila basin historically harbored what was a single, essentially basin wide, pan-mictic population, and that geographic differences between Gila basin and Sonoran populations may be the result of recent bottlenecks probably caused by human actions (Quattro et al. 1996). It has also been suggested that those differences might be just a geographic trend with the northern (Gila River basin) populations having low heterozygosity levels and southern (Mexico) populations having higher levels of genetic diversity (Vrijenhoek et al. 1985). However, divergent frequencies of five polymorphic microsatellite loci identified from four populations in separate drainages, geographic isolation and habitat differences within the four drainages led Hedrick and Parker (1998) to recommend separate conservation and management units for the four watersheds.

The conservative approach to recovery would require keeping remaining natural populations separate. Natural populations will be protected and replicated, and future management actions will include mixing gene pools from the natural populations to establish mixed populations in the wild. Experimental mixing of topminnows under a laboratory or controlled setting might also include stocks from the Río de la Concepción and (perhaps) Río Sonora, and progeny from crosses of these Sonoran stocks with U.S. stocks.

**TASK 5. STUDY LIFE-HISTORY, GENETICS, ECOLOGY, & HABITAT OF GILA TOPMINNOW AND INTERACTIONS WITH NONNATIVE AQUATIC SPECIES.**

Because of the large number of survey sites, most of the natural and reestablished populations have only been evaluated for the presence and abundance of topminnows and habitat type and quality. A more quantitative and rigorous approach needs to be explored to further our understanding of topminnow biology and habitat.

Further studies on Gila topminnow might include, but not be limited to, minimum temperature thresholds, temperature preference and preference breadth; minimum oxygen requirements; emergent plant density as a limiting factor; resistance to flooding under different channel configurations and temperatures; holding and transportation stress and associated mortality; niche partitioning and shift in carrying capacity when syntopic with historic native fishes, especially desert pupfish (*Cyprinodon macularius*); differences in water quality; interactions between topminnows and nonnative aquatic species at various life stages; cause and incidence of diseases at existing populations; and movement patterns of adult and juvenile topminnow.
As part of the recovery actions for the Gila topminnow, a public information and education program should be developed to inform the public of the objectives and needs of this recovery program. An informed and caring public will provide strong support for the conservation of endangered species, particularly the Gila topminnow. The desert pupfish has gained popularity among students and science teachers at the high school and grade school level thanks to a successful education and display program. Outdoor environmental education areas are being established at schools across Arizona, many of which have ponds suitable for supporting large populations of topminnow and pupfish. These habitats, if managed appropriately with suitable security, provide increased opportunity for public outreach and education and should serve as refugia for other recovery purposes. Endangered Species Act permits are required for these sites.

Information and education materials must be developed in formats that are appropriate for the target audience. Materials may take the form of brochures, newspaper and magazine articles, videotape or slide presentations, displays of live topminnows, television presentations, seminars, and workshops. When possible, the media and environmental groups should be encouraged to disseminate information.

All involved agencies and groups should participate in periodic meetings to update and exchange information pertinent to the recovery program of the Gila topminnow. Training seminars, particularly on proper sampling methodology and identification of the Gila topminnow and mosquitofish, should be implemented as needed, especially when new resource managers start to participate in management activities.
References Cited


-----, G. Kobetich, J. D. Williams, and S. Contreras-Balderas. 1979. Fishes of North America endangered, threatened, or of special concern. Fisheries 4:29-44.


Girard, C. 1856. Researches upon the cyprinoid fishes inhabiting the fresh waters of the United States of America, west of the Mississippi Valley, from specimens in the museum of the Smithsonian Institution. Proceedings of the Academy of Natural Sciences Philadelphia 8:165-213.


Rogers, J. A. 1980. The geographic and historic importance of cienega environments in the Upper Santa Cruz River Basin. Presented at Arizona Nevada Academy of Sciences and Southwest and Rocky Mountain Regional Annual Meeting of ANAS.


III. IMPLEMENTATION SCHEDULE

Definition of Priorities

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to meet the recovery objective.

Abbreviations Used

AGFD = Arizona Game and Fish Department
ASPD = Arizona State Parks Department
ASCHD = Arizona State and County Health Departments
BLM = Bureau of Land Management
BR = Bureau of Reclamation
FS = Forest Service
FWS = Fish and Wildlife Service
NMDGF = New Mexico Department of Game and Fish
SCAIR = San Carlos Apache Indian Reservation
TNC = The Nature Conservancy

FR = Fish and Wildlife Service, Fisheries Resources Program
ES = Fish and Wildlife Service, Ecological Services
EA = Fish and Wildlife Service, External Affairs
RE = Fish and Wildlife Service, Realty
### PART III - IMPLEMENTATION SCHEDULE

<table>
<thead>
<tr>
<th>Priority #</th>
<th>Task #</th>
<th>Plan Task</th>
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<th>Responsible Agency</th>
<th>Cost Estimates ($000's)</th>
<th>Comments</th>
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<td>Designate critical habitat for Gila topminnow which will include, as a minimum, all natural populations.</td>
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<td>1.3</td>
<td>Identify extent of geographic distribution of natural and long-lived reestablished populations including natural populations for which existence is in doubt.</td>
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<td>AGFD FS BLM SCAIR ASPD TNC</td>
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<td>Protect remaining natural and long-lived reestablished populations from invasion by detrimental nonnative aquatic species.</td>
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<td>Prohibit the introduction or release of nonnative aquatic species detrimental to Gila topminnow into areas occupied by natural or long-lived reestablished populations</td>
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<td>1.7</td>
<td>Design and implement site specific management plans for natural and long-lived reestablished populations.</td>
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<td>Determine minimum viable population</td>
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<td>Population Viability Analysis</td>
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<td>Identify habitats suitable for reintroduction of Gila topminnow.</td>
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<td>Reestablish Gila topminnow in suitable habitats following geographic guidelines.</td>
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<td>Protect habitats suitable for reestablishment from detrimental land and water use practices.</td>
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<td>Prohibit the introduction and release of nonnative aquatic species into areas occupied by reestablished populations or identified as potential habitat for reestablished populations.</td>
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<tr>
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<td>Design and implement site specific management plans for all reestablished populations.</td>
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<td>Develop standardized population and habitat monitoring protocols and implement them.</td>
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<td>Maintain a population and habitat database and generate annual reports.</td>
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<td>Implement criteria for declaring reestablished populations as extirpated.</td>
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<td>Facilitate genetic exchange among reestablished populations if needed.</td>
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<td>Conduct additional genetic studies of natural and reestablished populations.</td>
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<td>6.0</td>
<td>Inform and educate the public and resource managers.</td>
<td>15-20 ongoing</td>
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Total: 122 119 102 107 108
IV. GLOSSARY OF TERMINOLOGY

**Captive population**: populations established outside of or within historic range in aquaria, pools, or ponds at a location that has a mailing address.

**Cienega**: mid-elevation (1,000-2,000 m) wetlands characterized by permanently saturated, highly organic, reducing soils, and a depauperate flora dominated by low sedges highly adapted to such soils (Hendrickson and Minckley 1985).

**Evolutionarily significant unit**: populations or units which have diverged in allele frequency and are significant for conservation in that they represent populations connected by such low levels of gene flow that they are functionally independent.

**Extant**: describes a geographic area or population where topminnow are still considered to be present.

**Extirpated**: describes a geographic area formerly occupied by topminnow which has gone through the extirpation procedures and is no longer considered to have topminnow present, geographic areas may be as large as a watershed or as small as a spring.

**Failed**: describes a geographic area where the most recent survey did not document the presence of topminnow.

**Historic range**: A broad geographic area, usually watershed based, where the best available information indicates a species occurred before the factors causing the species' decline began; for the Gila topminnow, historic range includes the entire Gila River basin.

**Level 1 Populations**: same as natural population

**Level 2 Populations**: reestablished wild populations of pure or mixed origin which have survived a minimum of 10 years in natural or enhanced natural sites with little to no human intervention.

**Level 3 Population**: reestablished wild or captive populations in natural, semi-natural, or man-made habitats that aren’t capable of sustaining a viable population for at least 10 years without human intervention.

**Metapopulation**: all individuals occurring within a hydrologic sub-basin, or other definable geographic unit, with some probability of gene flow within the unit, but isolated from other gene pools (other sub-basins). Usually refers to a group of geographically distinct populations that are likely to experience periodic genetic exchange.

**Native**: a species within its historic range.
Natural site: relatively free of human or human-induced impact; in a condition approximating that which existed before manipulation during historic human occupation.

Natural population: a population which existed prior to fish transplants by humans, which exists today in its historic location free of known mixing with other populations by humans (Simons 1987).

Nonnative (exotic): a species outside of its historic range.

Population: all individuals which occur in a specified area, have a common ancestry or are potentially able to interbreed (Pianka 1978).

Semi-natural: a man-made habitat designed to mimic naturally occurring aquatic habitats and not needing infusion of supplemental food resources to maintain the population.

Reestablished: Level 2 or Level 3 populations stocked within historic range of the species where documentation of earlier, natural presence at that specific site may or may not exist, these were formerly referred to as reintroduced populations.

Refugia Population: Populations established for the primary purpose of preventing extinction of the species from the U.S. They must be in a facility that can maintain them for the long-term, can maintain genetic characteristics of the source population, and is secure.

Secure Population: One under the control of an agency or organization mandated or dedicated to legal protection against detrimental land and water practices which may threaten the continued existence of the Gila topminnow. Such agencies or organizations must possess adequate statutory authority to protect those populations, must have adequate regulations in place to enforce such authority, and have demonstrated over a period not less than 10 years adequate capability to protect and manage a viable population. If it is a non-Federal entity, they must provide formal protection of land and water (i.e. habitat acquisition or conservation easement) through an agreement with an agency as described above for a period greater than 24 years. The efficacy of this agreement should be demonstrated over a period at least 10 years. Populations located on private land with a conservation agreement or easement that results in protection of the habitat or population as described above will also be considered secure. In addition, a reestablished population may only be considered secure in the absence of mosquitofish and any other nonnative aquatic species considered detrimental to Gila topminnow.

Stock: refers to the origin of a reestablished population and identifies the natural population from which it was established and may be the same as metapopulation depending on additional genetic research.
**Viable population**: a population containing at least 500 over-wintering adults, possessing an adequate representation of all age classes and cohorts, and having evidence of reliable annual recruitment.

**Wild population**: a population established within historic range in a natural habitat at a location that does not have a mailing address (follows methodology began in Simons 1987).
V. APPENDICES
Appendix A. Gila topminnow historic records from the United States prior to 1980. Records were obtained from the following museums and were not personally verified by the author; Arizona State University (ASU), Academy of Natural Sciences Philadelphia (ANSP), United States National Museum (USNM), University of New Mexico (UofNM), University of Michigan (UMMZ), University of Arizona (UofA) as identified by S.M. Norris and W.L. Minckley, and Cornell (Cornell) and Harvard (Harvard) universities from internet search. Other records are included from references as cited. Map numbers correspond to Figure 1 of the Gila Topminnow Recovery Plan.

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<tr>
<th>LOCATION</th>
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<td>Koster, W. J.</td>
<td>1948</td>
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<td>80</td>
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<td>Gila River - 2 mi. below Dome</td>
<td>Hubbs &amp; Schultz</td>
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<td>62</td>
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<td>80</td>
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<td>Gila River - just below Gillespie Dam</td>
<td>Kranzthor, G. M. Myers, G. S.</td>
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<td>Gila/Colorado River near Yuma</td>
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<td>1890</td>
<td>29</td>
<td>Miller 1961</td>
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<td></td>
<td></td>
<td>1926</td>
<td>30</td>
<td>Miller 1961</td>
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<td>Artesian spring fed ditch and reservoir 7 mi. SE of Safford</td>
<td>Miller, R. R. Winn, H. E.</td>
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<td>Farm pond 6.5 mi. SE of Safford</td>
<td>Minckley, W. L. Koehn, R. K.</td>
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<td>Tributary of Gila River near Phoenix</td>
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<td></td>
<td>1926</td>
<td>34</td>
<td>Hubbs 1926</td>
</tr>
<tr>
<td>Salt River near Tempe</td>
<td></td>
<td>1890</td>
<td>31</td>
<td>Miller 1961</td>
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<td></td>
<td>Gilbert, C. H. and Scofield</td>
<td>1890</td>
<td>33</td>
<td>USNM 048123</td>
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<td></td>
<td>Pilsbury, H.A.</td>
<td>1901</td>
<td>79</td>
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<td>1926</td>
<td>32</td>
<td>Miller 1961</td>
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<tr>
<td>Salt River - near Roosevelt</td>
<td>Chamberlain, F. M.</td>
<td>1904</td>
<td>35</td>
<td>USNM 129968</td>
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<tr>
<td>Tonto Creek - near Roosevelt</td>
<td>Chamberlain, F. M.</td>
<td>1904</td>
<td>N/A</td>
<td>USNM 130011</td>
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## Appendix A. Continued.

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<th>LOCATION</th>
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<tr>
<td>Tonto Creek - midway between Roosevelt Dam and Payson</td>
<td>Hubbs and Schultz</td>
<td>1926</td>
<td>56</td>
<td>UMMZ 94883</td>
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<tr>
<td>Tonto Creek - 14 mi. above Roosevelt Lake</td>
<td>Gee, M. A.</td>
<td>1936</td>
<td>58</td>
<td>UMMZ 113524</td>
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<tr>
<td>Tonto Creek - 10 mi. above Roosevelt Lake</td>
<td>Hubbs, L. G.</td>
<td>1941</td>
<td>57</td>
<td>UMMZ 136185</td>
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<tr>
<td><strong>San Carlos River</strong></td>
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<td></td>
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<tr>
<td>3 mi. above San Carlos Lake</td>
<td>Hubbs, L. G.</td>
<td>1941</td>
<td>59</td>
<td>UMMZ 136187</td>
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<td></td>
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<td>60</td>
<td>UMMZ 136191</td>
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<tr>
<td><strong>San Pedro River</strong></td>
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<tr>
<td>San Pedro River - 4 mi. N of Feldman</td>
<td>Simon, J. R.</td>
<td>1943</td>
<td>76</td>
<td>UMMZ 146672</td>
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<td>48</td>
<td>UofA 95-83</td>
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<tr>
<td>Artesian Spring 13 km SE of Mammoth</td>
<td>McNatt, R.</td>
<td>1978</td>
<td>83</td>
<td>McNatt 1979</td>
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<tr>
<td><strong>Santa Cruz River</strong></td>
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<td>Arivaca Creek, near Arivaca</td>
<td>Wright, A.H. and Wehrle, L.P.</td>
<td>1934</td>
<td>N/A</td>
<td>Cornell 6566</td>
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<tr>
<td>Binghampton Pond 3 mi. N of Tucson</td>
<td>Simon, J.R.</td>
<td>1943</td>
<td>67</td>
<td>UMMZ 146645</td>
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<tr>
<td>Cienega Creek</td>
<td>Various</td>
<td>1974</td>
<td>55</td>
<td>ASU</td>
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<td>Cocio Wash</td>
<td>Hanks, K.</td>
<td>1969</td>
<td>69</td>
<td>UMMZ 190820</td>
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<td></td>
<td>McNatt, R. and Constantz, G.</td>
<td>1972</td>
<td>2</td>
<td>ASU 6271</td>
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<tr>
<td></td>
<td>Constantz, G.</td>
<td>1973-</td>
<td>3 thru</td>
<td>ASU 10182 - 10205</td>
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<td></td>
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<td>1975</td>
<td>26</td>
<td></td>
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<tr>
<td>Cottonwood Spring</td>
<td>Hubbs &amp; Family</td>
<td>1938</td>
<td>N/A</td>
<td>UMMZ 125052</td>
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<tr>
<td></td>
<td>Minickley, W. L.</td>
<td>1965</td>
<td>N/A</td>
<td>ASU</td>
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<td></td>
<td>Various</td>
<td>1967</td>
<td>N/A</td>
<td>ASU</td>
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<tr>
<td>Desert Shores Pond in Tucson</td>
<td>Simon, J.R. and Hendrickson, J.</td>
<td>1943</td>
<td>65</td>
<td>UMMZ 146644</td>
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<td>Monkey Spring</td>
<td>Chamberlain, F. M.</td>
<td>1904</td>
<td>84</td>
<td>USNM 130003</td>
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<tr>
<td></td>
<td>Hubbs &amp; Family</td>
<td>1938</td>
<td>85</td>
<td>UMMZ 125051</td>
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<td></td>
<td>Follett, W.I. and Snyder, R.C.</td>
<td>1949</td>
<td>86</td>
<td>Cornell &amp; UofA</td>
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<td></td>
<td>Heath, W.G.</td>
<td>1958</td>
<td>87</td>
<td>UofA</td>
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<td>Heath, W.G.</td>
<td>1959</td>
<td>88</td>
<td>UofA</td>
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<td>Minckley, W. L.</td>
<td>1964</td>
<td>89</td>
<td>ASU</td>
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<td></td>
<td>&amp; Koehn, R. K</td>
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<td>Monkey Spring</td>
<td>Minckley, W. L.</td>
<td>1965</td>
<td>90</td>
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## Appendix A. Continued.

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<thead>
<tr>
<th>LOCATION</th>
<th>COLLECTORS</th>
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<tr>
<td>Potrero Creek</td>
<td>Simon, J. R.</td>
<td>1943</td>
<td>70</td>
<td>UMMZ 146682</td>
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<tr>
<td>Rio Santa Cruz Mexico</td>
<td>Clark, J.H.</td>
<td>1851</td>
<td>49</td>
<td>Baird and Girard 1853</td>
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<td>(TYPE SPECIMEN)</td>
<td></td>
<td></td>
<td></td>
<td>Girard 1859</td>
</tr>
<tr>
<td>Sabino Canyon</td>
<td>Price, W.W.</td>
<td>1894</td>
<td>77</td>
<td>Rutter 1896</td>
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<tr>
<td>Sabino Canyon in</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Santa Catalina Mountains</td>
<td>Tinkham E.R.</td>
<td>1947</td>
<td>78</td>
<td>ANSP 71814</td>
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<td>Sabino Creek</td>
<td>Kranzthor, G. M. Myers, G. S.</td>
<td>1929</td>
<td>N/A</td>
<td>USNM 94273</td>
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<tr>
<td>Wright, A.H. and Webole, L.P.</td>
<td></td>
<td>1934</td>
<td>45</td>
<td>Cornell 5618</td>
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<td>Simon, J. R.</td>
<td></td>
<td>1943</td>
<td>68</td>
<td>UMMZ 146650</td>
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<tr>
<td>Santa Cruz River - near Gage</td>
<td>Gorsuch &amp; Ashburn</td>
<td>1939</td>
<td>73</td>
<td>UMMZ 131097</td>
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<td>Minckley, W. L.</td>
<td>1978</td>
<td>N/A</td>
<td>ASU</td>
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<tr>
<td>Santa Cruz River - ditch 30 mi. S of Tucson</td>
<td></td>
<td>1935</td>
<td>54</td>
<td>Harvard</td>
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<tr>
<td>Santa Cruz River - 2 mi. NE of Lochiel</td>
<td>Ashburn, M. F.</td>
<td>1940</td>
<td>N/A</td>
<td>USNM 118419-118422</td>
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<td>Santa Cruz River - 7 mi. NNE of Lochiel</td>
<td>Voorhies and others</td>
<td>1943</td>
<td>74</td>
<td>UMMZ 141728</td>
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<td></td>
<td>Frost, M. and Hendrickson, J.</td>
<td>1943</td>
<td>50</td>
<td>UofA 95-85</td>
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<tr>
<td>Santa Cruz River - 6 mi E Nogales at road to Washington Camp</td>
<td>Chamberlain, F. M.</td>
<td>1904</td>
<td>53</td>
<td>USNM 129996</td>
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<tr>
<td>Santa Cruz River 8 miles south of Tucson</td>
<td>Chamberlain, F. M.</td>
<td>1904</td>
<td>37</td>
<td>Miller 1961</td>
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<td>Santa Cruz River - near San Xavier</td>
<td>Chamberlain, F. M.</td>
<td>1904</td>
<td>38</td>
<td>USNM 129988</td>
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<td>Santa Cruz River - near Tucson</td>
<td>Brown, H.</td>
<td>1893</td>
<td>N/A</td>
<td>USNM 45444</td>
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<td></td>
<td>Chamberlain, F. M.</td>
<td>1904</td>
<td>36</td>
<td>USNM 129991 &amp; USNM 12994</td>
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<tr>
<td>Santa Cruz River Tucson</td>
<td>Pilsbury, H.A.</td>
<td>1910</td>
<td>41</td>
<td>ANSP 38841</td>
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<tr>
<td>Santa Cruz River - 7 mi. S of Tucson at Midvale Farms Irrigation System</td>
<td>Simon, J. R.</td>
<td>1943</td>
<td>66</td>
<td>UMMZ 146671 &amp; UofA 95-81</td>
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<tr>
<td>Sheehy Spring</td>
<td>Ashburn &amp; Gorsuch</td>
<td>1939</td>
<td>71</td>
<td>UMMZ 131105</td>
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<td></td>
<td>Ashburn, M. F.</td>
<td>1940</td>
<td>72</td>
<td>UMMZ 132250</td>
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### Appendix A. Continued.

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<tr>
<th>LOCATION</th>
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<tr>
<td>Sonoita Creek - near Cottonwood Spring</td>
<td>Simon, J. R.</td>
<td>1943</td>
<td>N/A</td>
<td>UMMZ</td>
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<tr>
<td></td>
<td>Minckley, W. L. &amp; Rinne, J.</td>
<td>1967</td>
<td>N/A</td>
<td>ASU</td>
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<td>Sonoita Creek - near Patagonia</td>
<td>Chamberlain, F. M.</td>
<td>1904</td>
<td>N/A</td>
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<td>Minckley, W. L. &amp; Rinne, J.</td>
<td>1967</td>
<td>N/A</td>
<td>ASU</td>
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<td>Sonoita Creek, 1.2 mi SW of Patagonia on Hwy 82</td>
<td>Hinds, D.S.</td>
<td>1967</td>
<td>52</td>
<td>UofA 95-44</td>
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<td>Sonoita Creek - 2.6 mi. SW of Patagonia, pool off creek</td>
<td>Minckley, W. L.</td>
<td>1967</td>
<td>N/A</td>
<td>ASU</td>
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<td>Sonoita Creek - 3 mi. SW of Patagonia</td>
<td>Burt, C. E.</td>
<td>1928</td>
<td>51</td>
<td>UMMZ</td>
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<td>Minckley, W. L.</td>
<td>1967</td>
<td>N/A</td>
<td>ASU</td>
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<td></td>
<td>Johnson, J. E.</td>
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<tr>
<td>Sonoita Creek - 3.5 mi. below Patagonia</td>
<td>Hubbs &amp; Family</td>
<td>1938</td>
<td>N/A</td>
<td>UMMZ 125047</td>
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<tr>
<td>Sonoita Creek - below Patagonia Lake</td>
<td>Ginelly, H.</td>
<td>1973</td>
<td>N/A</td>
<td>ASU</td>
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<td></td>
<td>Frantz, B. and Silvey, B.</td>
<td>1976</td>
<td>N/A</td>
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<td>Ginelly, H. and others</td>
<td>1977</td>
<td>N/A</td>
<td>ASU</td>
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<td>Sonoita River, 8 mi. N of Patagonia, also up small creek</td>
<td>Simon, J. R.</td>
<td>1943</td>
<td>N/A</td>
<td>UMMZ 141205</td>
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<tr>
<td>Spring 50 ft. W of Tanque Verde Creek</td>
<td>Simon, J. and others</td>
<td>1943</td>
<td>63</td>
<td>UMMZ 141725</td>
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<tr>
<td>Spring 200 ft. E of Tanque Verde Creek</td>
<td>Simon, J. and others</td>
<td>1943</td>
<td>64</td>
<td>UMMZ 141726</td>
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<tr>
<td>Tanque Verde Creek 3.5 mi east of Tanque Verde</td>
<td></td>
<td>1940</td>
<td>46-47</td>
<td></td>
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<td></td>
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<td>Nichols 1940; Hubbs and Miller 1941</td>
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<tr>
<td>Tucson Sonora</td>
<td>A. Schott under Major Emory</td>
<td>1843</td>
<td>40</td>
<td>Girard 1859</td>
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<tr>
<td>at Tucson</td>
<td>A.L. Heerman under Lt. JG Parke</td>
<td>1848</td>
<td>42</td>
<td>Girard 1859</td>
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<td></td>
<td></td>
<td>1926</td>
<td>43</td>
<td>Hubbs 1926</td>
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<tr>
<th>Location</th>
<th>Site #</th>
<th>Ownership</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cienega Creek</td>
<td>5</td>
<td>BLM, Private, State Lands</td>
<td>Topminnows are found in over 13 km of creek, representing the largest natural topminnow habitat. No nonnative fish are present.</td>
</tr>
<tr>
<td>Coal Mine Canyon</td>
<td>301</td>
<td>State Parks and Private</td>
<td>Topminnows discovered on State Park lands in 1996. Also discovered on private land upstream in 1997. Green sunfish and longfin dace also present in lower reaches, no sunfish in upper.</td>
</tr>
<tr>
<td>Cottonwood Spring</td>
<td>1</td>
<td>Private</td>
<td>Small but stable population of topminnows contained in 40 m long spring-fed stream, which flows near Sonoita Creek. Topminnows also present in pools of Sonoita Creek. No nonnative fish. Under Cooperative Management Agreement with landowner, Service, AGFD, and TNC.</td>
</tr>
<tr>
<td>Fresno Canyon</td>
<td>164</td>
<td>Private</td>
<td>Discovered in 1992, is an intermittent tributary to Sonoita Creek, entering below Patagonia Lake. Topminnow dominance 80-100%. Longfin dace, green sunfish, largemouth bass, red shiner, fathead minnow, and desert sucker also present in past.</td>
</tr>
<tr>
<td>Middle Spring</td>
<td>6</td>
<td>San Carlos Indian Reservation</td>
<td>Middle Spring was renovated and topminnow were reestablished in 1996 from Roper Lake State Park (Stuart Leon, U.S. Fish and Wildlife Service, 1996, personal communication).</td>
</tr>
<tr>
<td>Monkey Spring</td>
<td>2</td>
<td>Private</td>
<td>Topminnows found in springhead, 30 m stream flowing into normally dry impoundment and a cement canal diverted from the stream. Large population, no nonnative fish.</td>
</tr>
</tbody>
</table>
Appendix B. Continued.

<table>
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<th>Location</th>
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<tr>
<td>North Fork Ash Creek</td>
<td>126</td>
<td>San Carlos Indian Reservation</td>
<td>Topminnows were found at &quot;North Fork of Ash Creek approximately 3/4 mile south of Ash Creek Ranch&quot; in July of 1985 (Jennings 1987). No topminnow collected since. Mosquitofish, fathead minnow, green sunfish, and rainbow trout have been found. Until complete surveys of the Ash Creek Drainage can be conducted, this population is considered extant.</td>
</tr>
<tr>
<td>Redrock Canyon</td>
<td>11</td>
<td>USFS</td>
<td>Topminnow coexists with mosquitofish, longfin dace, desert sucker, and largemouth bass in several isolated reaches of this intermittent stream and its tributaries.</td>
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<tr>
<td>Salt Creek</td>
<td>8</td>
<td>1986</td>
<td>Supported a natural topminnow population until elimination by mosquitofish. Salt Creek was renovated in 1997 and restocked with topminnow from ASU, originally from Bylas Spring.</td>
</tr>
<tr>
<td>Santa Cruz River, near Lochiel</td>
<td>10</td>
<td>Private</td>
<td>Intermittent stream near the gaging station NE of Lochiel contains topminnow, mosquitofish, green sunfish, fathead minnow, largemouth bass, longfin dace, Sonora sucker, desert sucker, bluegill, yellow &amp; black bullhead. Gila topminnow last collected in 1993 (J.A. Stefferud, pers. comm.).</td>
</tr>
<tr>
<td>Santa Cruz River, north of Nogales</td>
<td>10A</td>
<td>Private</td>
<td>Gila topminnows have been collected from several localities north of the Nogales wastewater treatment plant over the past several years. Longfin dace, desert sucker, Sonora sucker and mosquitofish have also been collected. Gila topminnow were also collected from Peck Canyon near the confluence with the Santa Cruz River in 1998.</td>
</tr>
<tr>
<td>Sharp Spring</td>
<td>4</td>
<td>Private</td>
<td>Topminnow population has coexisted with mosquitofish in various pools since discovered in 1979 (Meffe et al. 1982). Mosquitofish dominance ranged from 76-99% in 1990 (Brown and Abarca 1992) and averaged 90% (range 74-98%) during fall sampling during 1988-97(S.E. Stefferud, pers. comm.).</td>
</tr>
<tr>
<td>Sheehy Spring</td>
<td>3</td>
<td>Private</td>
<td>Mosquitofish first recorded in 1979. No topminnows have been collected here since 1987.</td>
</tr>
</tbody>
</table>
Topminnows are found in two locations: 1) Near Cottonwood Spring is a small population, mosquitofish were found 200 m downstream in 1991; 2) Near Patagonia- small population, one individual found in 1986, 1987, 1990, 1994, 1995 (Simons 1987; Brown & Abarca 1992; USFWS unpublished data). Nonnatives recorded from Sonoita Creek or Patagonia Lake are longfin dace, desert sucker, largemouth bass, green sunfish, red shiner, brook trout, speckled dace, Sonora sucker, flathead catfish, yellow bullhead, and fathead minnow.

Below Patagonia Lake, downstream to Santa Cruz River -topminnows have coexisted with mosquitofish since 1969. Also collected from Sonoita Creek were longfin dace, desert sucker, largemouth bass, green sunfish, red shiner, brook trout, speckled dace, Sonora sucker, flathead catfish, yellow bullhead, and fathead minnow.

<table>
<thead>
<tr>
<th>Location</th>
<th>Site #</th>
<th>Year stocked</th>
<th>Comments</th>
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<tr>
<td>AD Wash</td>
<td>242</td>
<td>1993</td>
<td>Desert pupfish also stocked but not collected since 1993. Gila topminnow common and abundant in about ½ mile of intermittent stream flow.</td>
</tr>
<tr>
<td>Cold Springs</td>
<td>85</td>
<td>1985</td>
<td>Only one of the two pools has topminnow. Desert pupfish also present in the 6m by 6m pool. Red shiner discovered in 1998.</td>
</tr>
<tr>
<td>Dutchman Grave Spring</td>
<td>19</td>
<td>1983</td>
<td>Large topminnow population located in the Mazatzal Wilderness Area.</td>
</tr>
<tr>
<td>Heron Spring</td>
<td>76</td>
<td>1981, 1987</td>
<td>Small population of topminnow occupying a limited habitat.</td>
</tr>
<tr>
<td>Johnson Wash Spring</td>
<td>35</td>
<td>1982</td>
<td>Small population limited by habitat size and encroaching vegetation.</td>
</tr>
<tr>
<td>Kayler Spring</td>
<td>42</td>
<td>1982</td>
<td>Small population existed with longfin dace, red shiner, green sunfish, and crayfish in a large pool near the confluence with Tonto Creek, which was removed by flooding January of 1993. Topminnow and longfin dace continue to persist in the spring drainage and at confluence with Tonto Creek.</td>
</tr>
<tr>
<td>Lime Creek</td>
<td>301</td>
<td>1982</td>
<td>Dispersed from Lime Cabin Spring, stocked in 1982 and reported as extirpated (Brooks 1985). Topminnow were discovered in 1996 (Weedman and Young 1997). Green sunfish and longfin dace also present.</td>
</tr>
<tr>
<td>Lower Mine Spring</td>
<td>12</td>
<td>1983</td>
<td>Small population which may have suffered a genetic bottleneck (only one collected in 1995). Habitat subject to vegetation encroachment.</td>
</tr>
<tr>
<td>Mescal Warm Spring</td>
<td>82</td>
<td>1985</td>
<td>Small topminnow population. Habitat subject to vegetation encroachment. Only one collected in 1996.</td>
</tr>
</tbody>
</table>
### Appendix C. Continued.

<table>
<thead>
<tr>
<th>Location</th>
<th>Site #</th>
<th>Year stocked</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mud Spring</td>
<td>18</td>
<td>1982</td>
<td>Population survived in cement water trough through 1997. Four pools were dug during summer 1997 and two were supplementally stocked from Boyce Thompson Arboretum in September 1997. Now no topminnow in trough, but the two pools both support them.</td>
</tr>
<tr>
<td>Tule Creek</td>
<td>75</td>
<td>1968, 1981</td>
<td>Topminnows had to be restocked following flooding in 1978 and continue to be present in large numbers.</td>
</tr>
<tr>
<td>Unnamed drainage</td>
<td>68b</td>
<td>1986</td>
<td>Topminnows washed down from Mesquite Tank #2. A small population has been present since 1987.</td>
</tr>
<tr>
<td>Walnut Spring</td>
<td>20</td>
<td>1982</td>
<td>Large population of topminnow is present in a small spring fed stock tank.</td>
</tr>
<tr>
<td>Watson Wash</td>
<td>134</td>
<td>`</td>
<td>Undocumented stocking resulted in this population, discovered in 1989. Coexisted with red shiner and guppies in a thermal well outflow. In 1998 mosquitofish were discovered, topminnows now extremely rare.</td>
</tr>
<tr>
<td>Yerba Mansa</td>
<td>44</td>
<td>1984, 1985, 1988</td>
<td>Gila topminnow are present in a spring fed pond. Desert pupfish have also been stocked, although not recently collected. This site does not count towards recovery because it is outside of the historic range of the species.</td>
</tr>
</tbody>
</table>
**Appendix D.** Summary of Biological Opinions\(^1\) issued by the U.S. Fish and Wildlife Service related to *Poeciliopsis occidentalis* or *Poeciliopsis o. occidentalis*.

<table>
<thead>
<tr>
<th>Number</th>
<th>Project</th>
<th>Agency</th>
<th>Sites</th>
<th>Incidental take terms and conditions</th>
<th>Conservation Recommendations</th>
<th>Implementation</th>
<th>Date of BO</th>
</tr>
</thead>
<tbody>
<tr>
<td>82189</td>
<td>Gila topminnow MOU and reintroduction, Prescott, Coronado, &amp; Tonto NF's</td>
<td>FS</td>
<td>Multiple</td>
<td>None</td>
<td>None</td>
<td>Multiple sites stocked</td>
<td>5-13-82, amended 7-16-82, 1-7-83, 5-20-83</td>
</tr>
<tr>
<td>83010</td>
<td>Central Arizona Project control study (Plan 6, Cliff, New Waddell, Roosevelt Dams)</td>
<td>BR</td>
<td>Multiple</td>
<td>None</td>
<td>Construct fish barrier on Tule Creek</td>
<td>Barrier constructed</td>
<td>3-8-83, amended 4-7-83</td>
</tr>
<tr>
<td>83012</td>
<td>Coronado National Forest Plan</td>
<td>FS</td>
<td>Multiple</td>
<td>None</td>
<td>None</td>
<td>Unknown</td>
<td>12-6-85</td>
</tr>
<tr>
<td>83013</td>
<td>Tonto National Forest Plan</td>
<td>FS</td>
<td>Multiple</td>
<td>None</td>
<td>None</td>
<td>Unknown</td>
<td>7-26-85</td>
</tr>
<tr>
<td>86008</td>
<td>Acquisition of wildlife habitat, San Pedro River</td>
<td>FWS</td>
<td>NA</td>
<td>NA</td>
<td>Project dropped</td>
<td></td>
<td>12-9-85</td>
</tr>
<tr>
<td>88114</td>
<td>Safford District RMP, Cochise, Graham, Gila, Pima Counties</td>
<td>BLM</td>
<td>Multiple</td>
<td>None</td>
<td>Acquire water rights and others</td>
<td>Unknown</td>
<td>4/5/90, amended 3/18/94</td>
</tr>
<tr>
<td>88167</td>
<td>Phoenix Resource Management Plan, Apache, Navajo, Pima, Pinal, Santa Cruz, Maricopa, Yavapai Counties</td>
<td>BLM</td>
<td>Multiple</td>
<td>None</td>
<td>Reintroduce topminnow into Larry Creek</td>
<td>Unknown</td>
<td>12-16-88</td>
</tr>
</tbody>
</table>
## Appendix D. Continued.

<table>
<thead>
<tr>
<th>Number</th>
<th>Project</th>
<th>Agency</th>
<th>Sites</th>
<th>Incidental take terms and conditions</th>
<th>Conservation Recommendations</th>
<th>Implementation</th>
<th>Date of BO</th>
</tr>
</thead>
<tbody>
<tr>
<td>89200</td>
<td>Habitat renovation, Tonto NF</td>
<td>FS</td>
<td>Sycamore Spring</td>
<td>Hold fish during renovation, monitoring</td>
<td>Control and monitor turbidity, limit vegetation removal, excavate to U-shape, exclude livestock, timing, close road, reporting</td>
<td>Project dropped; population lost due to flood damage</td>
<td>10-17-89</td>
</tr>
<tr>
<td>90018</td>
<td>Pupfish stocking and future management actions</td>
<td>BLM</td>
<td>Big and Cold Springs</td>
<td>Hold fish during renovation, monitoring</td>
<td>16 recommendations concerning stock size, timing, road closure, vegetation management, coordination, reporting</td>
<td>Implemented, some recommendations followed</td>
<td>12-1-89</td>
</tr>
<tr>
<td>90119²</td>
<td>Pima lateral feeder canal, Pinal County, CAP introduction of exotics</td>
<td>BR</td>
<td>Multiple</td>
<td>Implementation of RPA’s: 2 barriers each on San Pedro and Aravaipa, continue 3 electric barriers on canals, monitor non-native fish, I&amp;E, $500,000 for recovery actions annually for 25 years</td>
<td>4 barriers, canal dryups, facilitation of multi-agency effort to address sport fish and native fish conflicts, oppose introduction of non-native species in lower Colorado basin</td>
<td>Continuing</td>
<td>4-20-94, amended 5/98</td>
</tr>
<tr>
<td>90169</td>
<td>Watershed Action Plan, Coronado NF</td>
<td>FS</td>
<td>Redrock Canyon</td>
<td>Minimize disturbance, specialist involvement, habitat enhancement, notification, monitoring, reporting</td>
<td>Limit use of Pig Camp Spring, survey drainage for topminnow, involvement of fish biologist, use local stock for riparian planting</td>
<td>Project partially implemented; report requirements partly complied with</td>
<td>11-29-90</td>
</tr>
</tbody>
</table>
### Appendix D. Continued.

<table>
<thead>
<tr>
<th>Number</th>
<th>Project</th>
<th>Agency</th>
<th>Sites</th>
<th>Incidental take terms and conditions</th>
<th>Conservation Recommendations</th>
<th>Implementation</th>
<th>Date of BO</th>
</tr>
</thead>
<tbody>
<tr>
<td>90196</td>
<td>Diversion dam maintenance and repair, flood damage emergency section 7</td>
<td>BLM</td>
<td>Cienega Creek</td>
<td>Minimize disturbance, salvage topminnow in canal, reporting</td>
<td>Design and construct permanent structure</td>
<td>Implemented</td>
<td>1-2-91</td>
</tr>
<tr>
<td>90254</td>
<td>Gila topminnow reintroductions and site management, Prescott and Tonto NF</td>
<td>FS</td>
<td>8 sites</td>
<td>13 requirements concerning stock choice, holding of fish during work, vegetation management, notification of permittees, site maintenance, coordination, reporting.</td>
<td>9 site-specific and 6 general recommendations regarding site management and maintenance</td>
<td>No reintroductions made</td>
<td>11-9-90</td>
</tr>
<tr>
<td>91060</td>
<td>Riparian exclosure, Yavapai County</td>
<td>BLM</td>
<td>Tule Creek</td>
<td>Minimize disturbance, fence maintenance, reporting</td>
<td>Lock gate, pollution prevention, monitoring</td>
<td>Implemented, monitoring continuing</td>
<td>2-21-91, amended 3-28-91</td>
</tr>
<tr>
<td>91160</td>
<td>Permanent canal control structure</td>
<td>BLM</td>
<td>Cienega Creek</td>
<td></td>
<td></td>
<td>withdrawn</td>
<td></td>
</tr>
<tr>
<td>91200</td>
<td>Bar V Bar and Campaign AMP, Tonto NF</td>
<td>FS</td>
<td>Campaign Creek, Upper Horrell Spring</td>
<td>Enforce AMP as proposed, report violations or changes</td>
<td>Annual fish and riparian monitoring</td>
<td>No fish monitoring has occurred; unknown</td>
<td>8-7-91</td>
</tr>
</tbody>
</table>
Appendix D. Continued.

<table>
<thead>
<tr>
<th>Number</th>
<th>Project</th>
<th>Agency</th>
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</tr>
</thead>
<tbody>
<tr>
<td>91299</td>
<td>Quien Sabe prescribed burn, Cave Creek RD, Tonto NF</td>
<td>FS</td>
<td>Cave Creek</td>
<td>350' buffers, don't burn &gt;40% slopes near stream, no water use from stream, no motorized vehicles in stream, monitoring, reporting</td>
<td>Burn plan revision using interagency biologists, adjust burn perimeter, exclusion of &gt;60% slopes, burn before June 15, sediment, water quality, and fish studies, no grazing for 3 years</td>
<td>Burned with plan revision and perimeter changes, fish monitoring completed, no studies</td>
<td>10-3-91</td>
</tr>
<tr>
<td>91469</td>
<td>Pipeline</td>
<td>BLM</td>
<td>Tule Creek</td>
<td>Minimize disturbance, inspect and repair</td>
<td>Pollution prevention, leave pipeline and trough</td>
<td>Pipeline installed</td>
<td>9-3-91</td>
</tr>
<tr>
<td>92001</td>
<td>Asarco land exchange, Ray, Mission, and Silverbell Mines</td>
<td>BLM</td>
<td>Cocio Wash, Cienega Creek</td>
<td>None for fish</td>
<td>None for fish</td>
<td>Unknown</td>
<td>12-27-91</td>
</tr>
<tr>
<td>92213</td>
<td>Dos S Unit, Sunflower Allotment AMP, Mesa RD, Tonto NF</td>
<td>FS</td>
<td>Mud Spring</td>
<td>Improvement maintenance, habitat management, grazing change sequences; Service concurrence with Mud Springs work, biologist input, minimize disturbance, trough replacement supplemental topminnow stocking, monitoring, reporting</td>
<td>Fish barriers on Picadilla &amp; Rock Creeks, evaluate springs on Dos S for topminnow recovery potential</td>
<td>Unknown</td>
<td>2-11-94</td>
</tr>
</tbody>
</table>
## Appendix D. Continued.

<table>
<thead>
<tr>
<th>Number</th>
<th>Project</th>
<th>Agency</th>
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<th>Implementation</th>
<th>Date of BO</th>
</tr>
</thead>
<tbody>
<tr>
<td>92350</td>
<td>Arizona Trail, Canelo Pass to Patagonia, Sierra Vista RD, Coronado NF</td>
<td>FS</td>
<td>Redrock Canyon</td>
<td>12 measures to minimize disturbance, enforce no-camping restrictions, maintain exclosure, annual interagency review of cumulative impacts, reporting, monitoring</td>
<td>Choose Lampshire Canyon alternative instead</td>
<td>Trail constructed &amp; in use, but not open to the public due to incomplete implementation Plan</td>
<td>12-23-92</td>
</tr>
<tr>
<td>92550²</td>
<td>Water quality criteria for Clean Water Act. All listed species &amp; waterways in state.</td>
<td>EPA</td>
<td>Multiple</td>
<td>Adopt implementation standards for the anti-degradation rule and make available to FWS. RPA: stricter SE and HG criteria, new methodology for lipophilic compound evaluation, changes to criteria for several chemicals in Gila and Santa Cruz Rivers, more surrogate species toxicity testing, narrative biocriteria standards for 6 reference sites</td>
<td>Designate 13 waters as navigable and designate a use, evaluate numeric criteria for heavy metals in unique waters, clarify unique waters designation, evaluate turbidity criteria rule, consult FWS on NPDES permits</td>
<td>Implementation beginning</td>
<td>2-16-94</td>
</tr>
<tr>
<td>93263</td>
<td>Draft revised Black Canyon Habitat Mgt. Plan, Phoenix District &amp; AGFD</td>
<td>BLM &amp; AGFD</td>
<td>Tule, Cow, Humbug and Castle creeks, and AD Wash</td>
<td>Take will be addressed during section 7 on implementation of specific actions</td>
<td>None</td>
<td>All actions carried forward to Horseshoe Ranch CRMP</td>
<td>9-8-93</td>
</tr>
<tr>
<td>93348</td>
<td>Repair &amp; construction of bank revetment, emergency flood repair, State Route 92 @ MP 15.45 &amp; 17.10</td>
<td>FHA/ADOT</td>
<td>Sonoita Creek</td>
<td>Minimize activity in wetted channel, pollution prevention, limit heavy equipment use, avoid riparian vegetation loss, monitoring, reporting</td>
<td>No trees &gt;6” diameter should be removed</td>
<td>Implemented except for report</td>
<td>6-21-94, amended 9-26-95</td>
</tr>
</tbody>
</table>
### Appendix D. Continued.

<table>
<thead>
<tr>
<th>Number</th>
<th>Project</th>
<th>Agency</th>
<th>Sites</th>
<th>Incidental take terms and conditions</th>
<th>Conservation Recommendations</th>
<th>Implementation</th>
<th>Date of BO</th>
</tr>
</thead>
<tbody>
<tr>
<td>93405</td>
<td>Exclosure fence, Partners for Wildlife Project, Santa Cruz County</td>
<td>FWS</td>
<td>Cottonwood Spring, Sonoita Creek</td>
<td>Screen pipe entry, minimize trenching and resod, monitor habitat and fish, reporting</td>
<td>Maintain fence</td>
<td>Implemented, monitoring continuing</td>
<td>3-15-93</td>
</tr>
<tr>
<td>93430</td>
<td>Headcut repair &amp; fencing, Empire-Cienega Resource Conservation Area</td>
<td>BLM</td>
<td>Cienega Creek</td>
<td>Minimize disturbance, specialist involvement, monitoring, reporting</td>
<td>Monitor headcut for 1-2 years</td>
<td>Partially implemented</td>
<td>2-7-94, amended 9-25-95</td>
</tr>
<tr>
<td>94130</td>
<td>Emergency repairs to FR 449A, Tonto Basin RD, Tonto NF</td>
<td>FS</td>
<td>Campaign Creek</td>
<td>Minimize work in channel, pollution prevention, limit area of modification and heavy equipment use, augmentation stocking, monitoring, reporting</td>
<td>Discuss private unauthorized road repair with private land owner</td>
<td>Implemented except for augmentation</td>
<td>8-18-94</td>
</tr>
<tr>
<td>94205</td>
<td>Fifth MSO package, Beehive, Pumphouse, Government, Tonto Basin AMP &amp; grazing strategy</td>
<td>FS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>08-02-94</td>
</tr>
<tr>
<td>94210</td>
<td>Railroad abutment removal on Patagonia Preserve</td>
<td>FWS</td>
<td>Sonoita Creek</td>
<td>Minimize spread of material in channel, no heavy equipment in channel, reporting, monitoring</td>
<td>Survey habitat after major floods</td>
<td>Implemented</td>
<td>2-23-94</td>
</tr>
<tr>
<td>95177</td>
<td>Interim Grazing Plan on the Empire-Cienega Resource Conservation Area</td>
<td>BLM</td>
<td>Cienega Creek</td>
<td>22 measures: fully implement grazing plan, build and locate repressos to minimize habitat for &amp; spread of nonnatives, construct 5 riparian exclosures, monitoring, reporting</td>
<td>9 recommendations including identification of tompminnow reintroduction sites</td>
<td>Partially implemented</td>
<td>1-8-96</td>
</tr>
</tbody>
</table>
### Appendix D. Continued.

<table>
<thead>
<tr>
<th>Number</th>
<th>Project Description</th>
<th>Agency</th>
<th>Sites</th>
<th>Incidental take terms and conditions</th>
<th>Conservation Recommendations</th>
<th>Implementation</th>
<th>Date of BO</th>
</tr>
</thead>
<tbody>
<tr>
<td>95303</td>
<td>Cross F Grazing Allotment Permit, Tonto NF</td>
<td>FS</td>
<td>Walnut Springs</td>
<td>Implement permit as described, Alder Pasture (Walnut Spring) use is 6 months of 18, maintain fence, monitoring, reporting</td>
<td>Identification of topminnow reintroduction sites, consult on revised AMP</td>
<td>Partially implemented</td>
<td>12-9-95</td>
</tr>
<tr>
<td>95319</td>
<td>Cienega Grazing Allotment Permit, Verde RD, Prescott NF</td>
<td>FS</td>
<td>Johnson Wash Spring</td>
<td>NA</td>
<td>NA</td>
<td>Formal withdrawn, informal completed, fenced from grazing</td>
<td>7-17-95 concurrence</td>
</tr>
<tr>
<td>95508&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Extension, headcut repair, riparian exclosure, drinkers, Partners for Wildlife Project</td>
<td>FWS</td>
<td>Cottonwood Spring, Sonoita Creek</td>
<td>Screen pipeline intakes, keep heavy equipment out of active channel, project timing, reporting, monitoring</td>
<td>Monitor fence line integrity, implement Agreement and Wildlife Management Plan</td>
<td>Headcut structures built</td>
<td>9-12-95</td>
</tr>
<tr>
<td>96205</td>
<td>Livestock grazing on 13 allotments along the Gila River</td>
<td>BLM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>09-02-96</td>
</tr>
<tr>
<td>98373</td>
<td>Cienega Creek stream restoration project</td>
<td>BLM</td>
<td>Cienega Creek</td>
<td>8 measures; minimize project failure &amp; disturbance, riparian &amp; fish monitoring, revegetate</td>
<td>Consult on road maintenance, identify reintroduction sites, conduct riparian ecological site inventory</td>
<td>Mostly implemented</td>
<td>6-3-98</td>
</tr>
</tbody>
</table>

<sup>1</sup> Pre-1988 records may be incomplete  
<sup>2</sup> Jeopardy opinion  
<sup>3</sup> New Mexico Ecological Services Field Office number
### Appendix E

Summary of all known introductions of *Gila topminnow* (*Poeciliopsis occidentalis occidentalis*) in the U.S., as of April, 1994 (updated and modified from Bagley et al. 1991). This information is taken from the AGFD Native Fish Database and listed here in alphabetical order by site name. Fields are defined as follows: Site Name and Location = commonly accepted name which refers to a particular site. Site No. = an arbitrary number unique to each site (following Simons 1987, Bagley et al. 1991, and Brown and Abarca 1992). Date Stocked = date (in format of YR+MO+DY) site was stocked. N = number of fish stocked, U indicates an unreported number of fish. Source of Fish Stocked = place where the stocked fish came from. Origin of Fish Stocked = indicates which natural population the stocked fish originally came from. Township-Range-Section = legal description for a site. Latitude-Longitude = latitudinal and longitudinal coordinates for a site. Extant = indicates current status, if known, of the site: Y=yes, N=no, U=unknown, E=Officially declared Extirpated. Authority = source of the stocking information.

<table>
<thead>
<tr>
<th>Site Name and Location</th>
<th>Site No.</th>
<th>Date Stocked</th>
<th>Population Type</th>
<th>Population</th>
<th>Source of Fish Stocked</th>
<th>Origin of Fish Stocked</th>
<th>Town Range</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Extant</th>
<th>Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD WASH</td>
<td>242</td>
<td>930305</td>
<td>WILD</td>
<td>500</td>
<td>DEXTER</td>
<td>SHARP SPRING</td>
<td>8N 2W 36</td>
<td>335908</td>
<td>1122530</td>
<td>Y</td>
<td>STOCKING SLIP 43775</td>
</tr>
<tr>
<td>AGFD MESA</td>
<td>101</td>
<td>870202</td>
<td>CAPTIVE</td>
<td>19</td>
<td>BOYCE-THOMPSON</td>
<td>MONKEY COCCIO BYLAS S</td>
<td>N</td>
<td>AGFD SITE FILE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGFD PHOENIX</td>
<td>151</td>
<td>900524</td>
<td>CAPTIVE</td>
<td>80</td>
<td>ENGEL-WILSON</td>
<td>MIDDLE SPRING</td>
<td>N</td>
<td>STOCKING SLIP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGFD PHOENIX</td>
<td>151</td>
<td>91XXXXX</td>
<td>CAPTIVE</td>
<td>2</td>
<td>AGFD PHOENIX</td>
<td>MIDDLE SPRING</td>
<td>N</td>
<td>AGFD FILES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGFD PONDIX PHOENIX</td>
<td>151</td>
<td>890710</td>
<td>CAPTIVE</td>
<td>50</td>
<td>ROPER LK ST PK</td>
<td>MIDDLE SPRING</td>
<td>N</td>
<td>STOCKING SLIP 47927</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGFD PONDIX PHOENIX</td>
<td>151</td>
<td>800201</td>
<td>CAPTIVE</td>
<td>U</td>
<td>BOYCE-THOMPSON</td>
<td>MONKEY COCCIO BYLAS S</td>
<td>N</td>
<td>AGFD FILES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGFD PONDIX PHOENIX</td>
<td>198</td>
<td>6904XX</td>
<td>CAPTIVE</td>
<td>U</td>
<td>UNKNOWN</td>
<td>SAN BERNARDINO RANCH</td>
<td>N</td>
<td>SCHOENHERR 1974</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGFD PONDIX PHOENIX</td>
<td>198</td>
<td>6904XX</td>
<td>CAPTIVE</td>
<td>U</td>
<td>UNKNOWN</td>
<td>BYLAS SPRING</td>
<td>N</td>
<td>SCHOENHERR 1974</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGFD PONDIX PHOENIX</td>
<td>198</td>
<td>6904XX</td>
<td>CAPTIVE</td>
<td>U</td>
<td>UNKNOWN</td>
<td>COTTONWOOD SPRING</td>
<td>N</td>
<td>SCHOENHERR 1974</td>
<td></td>
<td></td>
<td></td>
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Gila Topminnow Revised Recovery Plan December 1998
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- AGFD FILES: Arizona Game and Fish Department Files
- COLEMAN FIELD NOTES AGFD FILES: Coleman Field Notes
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<td>VAUGHT POND #1</td>
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