GILA TOPMINNOW, *Poeciliopsis occidentalis occidentalis*,

REVISED RECOVERY PLAN

(Original Approval: March 15, 1984)

Prepared by

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for

Region 2

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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.

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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.

Projected Costs ($000's):							
Year	**Need 1**	**Need 2**	**Need 3**	**Need 4**	**Need 5**	**Need 6**	**Total**
1	45	25	49	7	5	1	132
2	25	20	51	7	5	1	109
3	25	20	54	7	5	1	112
4	15	22	56	7	0	1	101
5	19	22	59	7	0	1	108
6-20	430	886	1337	159	0	23	2,835
Total Cost	559	995	1,606	194	15	28	3,397

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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 mosquitofish, *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

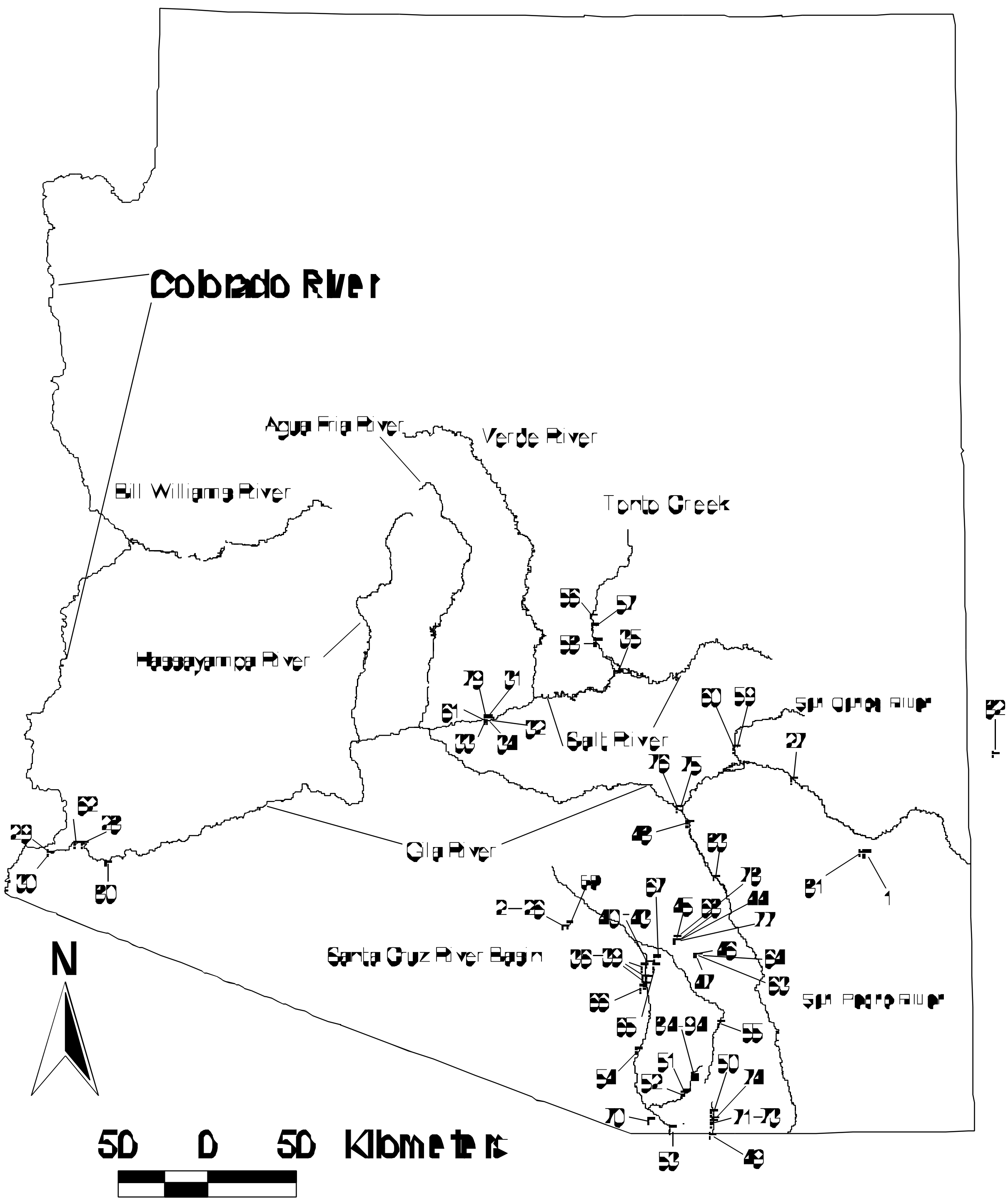
The Gila topminnow occupies the northernmost range of the tropical genus *Poeciliopsis*. The genus is distributed from the northern Andes in Colombia, along the Pacific coast of Central America and Mexico, to the Gila River. Two members of the genus also occur in some Atlantic streams of southern Mexico,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

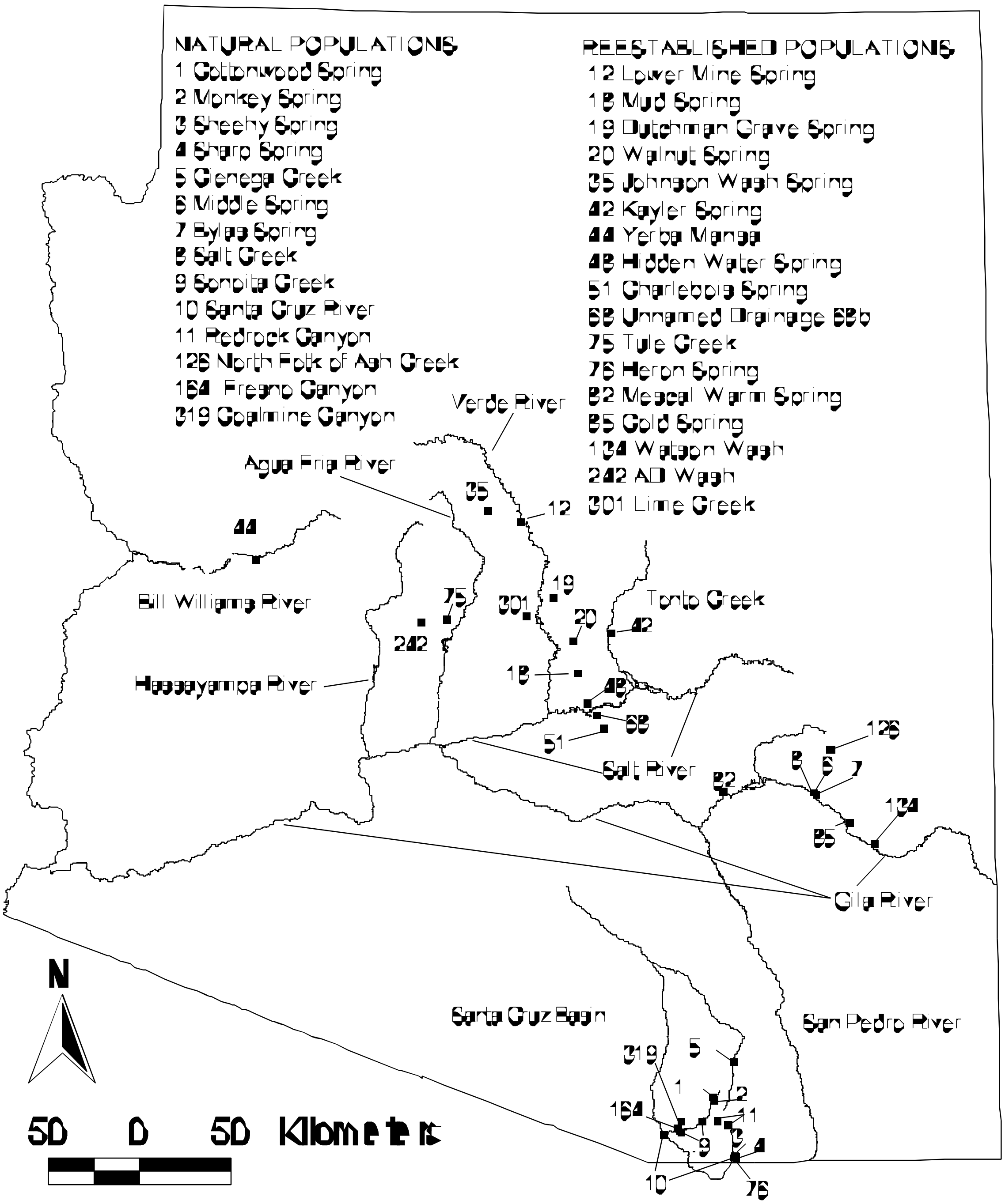


Since 1984, Gila topminnows have been discovered or rediscovered at four additional locations; North Fork of Ash Creek in 1985 (Jennings 1987), Fresno Canyon in 1992, Santa Cruz River north of Nogales in 1994, and Coal Mine Canyon in 1996 (Weedman and Young 1997). However, topminnow were last collected 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 (Meffe 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 37EC have been reported, with a maximum tolerance of 43EC 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 edgewaters 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 spermatophores (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:

I) 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).

Downlisting Criteria

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.

Task 3. Monitor natural and reestablished populations and their habitats.

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 <u>Maintain refugia populations of natural populations to ensure survival of the species.</u>

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, exhi-bit 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 <u>Designate critical habitat for Gila topminnow which will include, as a minimum, all natural populations.</u>

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

The geographic distribution of Gila topminnow should be accurately determined by watershed-wide surveys of aquatic habitats in Redrock Canyon, Cienega Creek, Sonoita 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 <u>Protect remaining natural and long-lived reestablished populations from invasion by detrimental nonnative aquatic species.</u>

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

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	Example2	Maximum allowed to replace Level 3 populations

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

Level 2 Pure replicates	4 from each of the 8 Level 1's=32	Assume 35 established	Assume 40 established	47
Level 2 mixed	20	assume 20 established	assume 27 established	35
Level 3 any combination of pure and mixed	60	only 54 required (2:1 replacement ratio)	only 30 required (replaced by 15 extra Level 2)	None required (replaced by extra level 2 populations)
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 <u>Identify habitats suitable for reintroduction of Gila topminnow.</u>

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).

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

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.

Site#	**Sitename**	**Stocked Before?**	**Land Owner(s)**	**Township and Range**	**Section**	**Date Stocked**	**Source of topminnow originally stocked**
328	A & A Gravel Pit	No	Tonto NF	02 N 08 E	35		
332	Alder Creek	No	Tonto NF	06 N 08 E	09		
312	Antelope Creek	No	BLM Phoenix & Private	11 N 02 E	28		
241	Arnett Creek	No	Tonto NF	02 S 12 E	06		
318	Ash Creek	No	BLM, Prescott NF & Private	11 N 03 E	08		
96B	Benson Spring	No	Tonto NF	01 S 11 E	36		
130	Bog Hole	No	AGFD-Coronado NF	22 S 17 E	32		
298	Buckhorn Spring #2	No	BLM Phoenix	08 N 02 W	28		
320	Carrizo Dam Tank	No	Buenos Aires NWR	22 S 08 E	07		
310	Chalky Spring	No	BLM Phoenix & Maricopa County	06 N 01 W	13		
326	Coal Mine Spring Tank	No	Private	Unsurveyed			
327	Coal Mine Unnamed Tank	No	Private	Unsurveyed			
311	Dripping Spring	No	BLM Phoenix & Private	11 N 02 E	30		
316	Dry Creek	No	BLM Phoenix & Private	11 N 03 E	05		
325	Fresno Tank 2	No	Private				
314	Garfias Wash Spring	No	BLM Phoenix	07 N 02 W	11		
240	Hess Canyon	No	Tonto NF	04 N 16 E	26		
309	Indian Creek	No	BLM Phoenix & Prescott NF	11 N 03 E	25		
307	Larry Creek	No	BLM Phoenix	09 N 03 E	09		
317	Little Ash Creek	No	BLM, Prescott NF & Private	11 N 03 E	05		
236	Long Gulch Artesian	No	Tonto NF	05 N 12 E	33		
306	Lousy Canyon	No	BLM Phoenix	09 N 03 E	05		
129	Mesquite Spring	No	BLM Phoenix	03 S 11 E	21		
305	Mexican Seep	No	Prescott NF	16 N 02 E	12		
315	Perry Tank Tinaja	No	BLM Phoenix	9.5 N 03 E	21		
207	Post Canyon	No	Audubon Society	21 S 18 E	28		
208	Reimer Spring	No	Prescott NF	12 N 04 E	06		

Table 3. List of known habitats available for reestablishment of Gila topminnow.

Site#	Sitename	Stocked Before?	Land Owner(s)	Township and Range	Section	Date Stocked	Source of topminnow originally stocked
295	Rock Creek	No	Tonto NF	05 N 08 E	36		
243	Rock Spring #3	No	Tonto NF	06 N 09 E	06		
321	Rock Tank	No	Buenos Aires NWR	21 S 09 E	19		
331	Secret Spring	No	Tucson BLM, Coronado NF, TNC Muleshoe CMA				
239	Sevenmile Wash	No	Tonto NF	03 N 16 E	36		
308	Silver Creek	No	BLM Phoenix &Tonto NF	10 N 03 E	10		
313	St. Anthony Spring	No	BLM Phoenix	07 N 02 W	03		
322	State Tank	No	Buenos Aires NWR	21 S 08 E	25		
286	Sycamore Creek (near Sunflower)	No	Tonto NF				
237	Sycamore Creek (Sheep Bridge)	No	Tonto NF	09 N 07 E	29		
273 A	T-4 Spring	No	Private				
323	Triangle Tank	No	Buenos Aires NWR	21 S 08 E	27		
238	West Fork Pinto Creek	No	Tonto NF	10 N 13 E	07		
59	Alambre Tank	Yes	Coronado NF	13 S 17 E	16	820614	Monkey Spring
177	Aravaipa Creek	Yes	BLM Safford & TNC	07 S 20 E		770000	Boyce Thompson
272	Arivaca Creek	Yes	Buenos Aries NWR			360000	Unknown
273	Babocomari River	Yes	Private			680000	Unknown
180	Badger Springs	Yes	Az. State Land Dept.	10 N 02 E	24	750815	Boyce Thompson
26	Bain Spring	Yes	Prescott NF	10 N 02 W	06	830602	Boyce Thompson
84	Big Spring	Yes	BLM Safford	06 S 25 E	05	850722	Monkey Spring
54	Bronco Canyon Spring Tank	Yes	Tonto NF	07 N 05 E	28	830824	Boyce Thompson
245	Buckhorn Spring	Yes	Tonto NF	04 N 11 E	27	820604	Boyce Thompson
133	Buehman Canyon	Yes	Az. State Land Dept.	12 S 18 E	05	820616	Boyce Thompson
160	Camp Creek	Yes	Tonto NF	06 N 05 E		750722	Boyce Thompson

Table 3. List of known habitats available for reestablishment of Gila topminnow.

Site#	Sitename	Stocked Before?	Land Owner(s)	Township and Range	Section	Date Stocked	Source of topminnow originally stocked
91	Campaign Creek	Yes	Tonto NF	02 N 12 E		830603	Boyce Thompson
25	Campbell Flat Spring	Yes	Prescott NF	10 N 02 W	30	830602	Boyce Thompson
274	Canelo Cienega	Yes	Coronado NF			740000	Monkey Spring
67B	Castle Creek	Yes	Prescott NF, Az. State Land	9.5 N 02 E	19	860814	Boyce Thompson
49B	Cave Creek	Yes	Tonto NF	07 N 05 E	08	890000	Boyce Thompson
87	Cherry Creek	Yes	Tonto NF	05 N 15 E	05	850926	Monkey Spring
77	Cottonwood Artesian	Yes	Tonto NF	05 N 13 E	34	820610	Boyce Thompson
55	Cottonwood Spring & Creek	Yes	Tonto NF	03 N 12 E	09	820603	Boyce Thompson
72	Cow Creek	Yes	BLM Phoenix & Private	07 N 01 E	06	810900	Boyce Thompson
189	Deep Spring	Yes	Coconino NF	11.5 N 07 E	20	820517	Boyce Thompson
278	East Verde River	Yes	Tonto NF			650000	Monkey Spring
279	Fish Creek	Yes	Tonto NF			650000	Monkey Spring
280	Fossil Creek	Yes	Tonto NF			690000	Unknown
33	Government Spring	Yes	Prescott NF	13 N 03 E	33	820517	Boyce Thompson
281	Granite Creek	Yes	AGFD, Prescott NF			730628	Monkey Spring
81	Green Tanks (Rattlesnake Spring)	Yes	BLM Safford & Az State Land Dept.	03 S 15 E	07	850722	Monkey Spring
90	Harshaw Creek	Yes	Coronado NF	22 S 16 E	23	820617	Boyce Thompson
195	Holly Spring	Yes	Coconino NF	16 N 04 E	27	820517	Boyce Thompson
46	Horse Creek	Yes	Tonto NF	09 N 06 E	36	820610	Boyce Thompson
83	Howard Well	Yes	BLM Safford	11 S 29 E	35	850722	Monkey Spring
95	Humbug Creek	Yes	BLM Phoenix & Private	07 N 01 E	06	870306	Boyce Thompson
24	Indian Spring #1	Yes	Tonto NF	03 N 10 E	24	820611	Boyce Thompson
248	Lime Cabin Spring	Yes	Tonto NF	08 N 05 E	24	820610	Boyce Thompson
125	Little Nogales Spring	Yes	BLM Tucson	18 S 18 E	11	880819	Cienega Creek
132	Martin Well	Yes	BLM Safford	11 S 29 E	36	890703	Unknown
68A	Mesquite Tank #2	Yes	Tonto NF	02 N 09 E	01	820603	Boyce Thompson

Table 3. List of known habitats available for reestablishment of Gila topminnow.

Site#	Sitename	Stocked Before?	Land Owner(s)	Township and Range	Section	Date Stocked	Source of topminnow originally stocked
124	Nogales Spring	Yes	BLM Tucson	18 S 18 E	11	880819	Cienega Creek
205	O'Donnell Creek	Yes	TNC, Coronado NF	21 S 18 E	28	740800	Monkey Spring
247	Packard Spring	Yes	Tonto NF	06 N 10 E	17	820608	Boyce Thompson
112	Red Creek	Yes	Tonto NF	9.5 N 05 E	24	870816	Boyce Thompson
211	Redfield Canyon	Yes	Coronado NF	11 S 19 E	35	770728	Boyce Thompson
122	Rincon	Yes	Saguaro NP East	14 S 16 E	14	870730	Unknown
212	Rock Creek, 3 Bar "C"	Yes	Tonto NF	04 N 11 E		750806	Boyce Thompson
60	Rock Springs #2	Yes	Tonto NF	03 N 16 E	12	830601	Boyce Thompson
250	Sabino Canyon	Yes	Coronado NF	12 S 15 E	35	820614	Boyce Thompson
49A	Seven Springs	Yes	Tonto NF	07 N 05 E	09	800229	Boyce Thompson
34	Sheep Spring	Yes	Prescott NF	13 N 03 E	28	820517	Boyce Thompson
63	Sheepshead Spring	Yes	Coconino NF	16 N 04 E	33	820517	Boyce Thompson
220	Squaw Peak Spring	Yes	Prescott NF	13 N 05 E	20	820518	Boyce Thompson
223	Sycamore Creek near Dugas	Yes	Prescott NF	11 N 04 E		750812	Boyce Thompson
121	The Lake	Yes	Coronado NF	13 S 17 E	08	820614	Monkey Spring
15	Thicket Spring	Yes	Tonto NF	10 N 05 E	35	830603	Boyce Thompson
78B	Tucker Box	Yes	Tonto NF	05 N 13 E	20	820610	Boyce Thompson
73	Tule Creek Seep (2E)	Yes	BLM Phoenix & Private	08 N 01 E	28	820000	Boyce Thompson
97	Turkey Creek	Yes	Coronado NF, Audubon	21 S 18 E	33	860000	Unknown
13	Two Mile Spring	Yes	Tonto NF	09 N 06 E	28	830603	Boyce Thompson
39	Unn. Spring Fed Tank #498	Yes	Tonto NF	05 N 10 E	02	820608	Boyce Thompson
17A	Unnamed Spring #0	Yes	Tonto NF	06 N 09 E	16	820604	Boyce Thompson
32	Upper Horrell Spring	Yes	Tonto NF	02 N 12 E	14	830603	Boyce Thompson
288	Verde River at Perkinsville	Yes	Prescott NF & Private			770000	Unknown
148	Zig Zag Spring	Yes	Tonto NF	9.5 N 05 E	25	830000	Boyce Thompson

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 4. Guidelines for determining source for reestablishing populations of Gila topminnow to areas of the Gila River Basin.

Geographic Area	Metapopulation to be stocked	Extant reestablished populations (source). BTA=Boyce Thompson Arboretum
GEOGRAPHIC AREAS SUPPORTING NATURAL POPULATIONS		
Rillito Creek drainage	Cienega Creek only	None
Santa Cruz River drainage in San Rafael Valley	Upper Santa Cruz River	Heron Spring (Sharp)
Redrock Canyon drainage	Redrock Canyon only	None
Sonoita Creek above Patagonia Lake (except Redrock Canyon)	Upper Sonoita Creek	None
Santa Cruz drainage north of Nogales, not including Sonoita Creek below Patagonia Lake	Middle Santa Cruz	None
Sonoita Creek below Patagonia Lake not including Santa Cruz River or other tributaries	Lower Sonoita Creek	None
Gila River drainage above Coolidge Dam (not including San Carlos drainage if Ash Creek is re-discovered)	Bylas Complex (Ash Creek if found in San Carlos drainage)	Cold Spring (Monkey), Watson Wash (unknown)
GEOGRAPHIC AREAS WITH NO EXISTING NATURAL POPULATIONS		
Salt River above Roosevelt Dam	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.	None
Tonto Creek drainage		Kayler Spring (BTA)
Salt River below Roosevelt Dam and Verde River below Horseshoe Dam to Granite Reef Diversion Dam		Charlebois Spring (BTA), Hidden Water Spring (BTA), Unn. Drainage #68b (BTA)
Gila River below Coolidge Dam and Salt River below Granite Reef dam		Mescal Warm Spring (Monkey)
San Pedro River drainage		None
Verde River above Horseshoe Dam		Dutchman Grave, Lower Mine, Walnut and Mud springs and Lime Creek (all BTA)
Agua Fria River		Tule Creek (BTA), Johnson Wash Spring (BTA) and AD Wash (Sharp)
Hassayampa River		None
Outside Gila River Basin	No Reintroductions	Yerba Mansa (BTA)

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 <u>Maintain a population and habitat database and generate annual reports.</u>

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 spe-cies and populations has become a necessary approach for many threatened and endangered species (Frankel and Soulé 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 <u>Facilitate genetic exchange among reestablished populations.</u>

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.

TASK 6. INFORM AND EDUCATE THE PUBLIC AND RESOURCE MANAGERS.

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.

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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

Priority #	Task #	Plan Task	Duration (yrs)	Responsible Agency		Cost Estimates ($000's)					Comments
				FWS Region 2	Other	FY 1	FY 2	FY 3	FY 4	FY 5	
1	1.1	Maintain refugia populations of natural populations to ensure survival of the species.	Ongoing	ES RE	AGFD FS BR BLM SCAIR ASPD TNC	3	3	3	3	3	
1	1.2	Designate critical habitat for Gila topminnow which will include, as a minimum, all natural populations.	5	ES		15	0	0	0	0	
1	1.3	Identify extent of geographic distribution of natural and long-lived reestablished populations including natural populations for which existence is in doubt.	10	ES FR	AGFD FS BLM SCAIR ASPD TNC	3	3	3	3	3	
1	1.4	Protect habitats occupied by natural and long-lived reestablished populations from detrimental land and water use practices.	20	ES FR RE	AGFD FS BLM SCAIR ASPD TNC	2	2	2	2	3	
1	1.5	Protect remaining natural and long-lived reestablished populations from invasion by detrimental nonnative aquatic species.	20	ES FR	AGFD FS BLM BR SCAIR ASPD TNC ASCHD	2	2	2	2	5	Large renovation projects may take additional money.
1	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	20	ES FR	AGFD NMDGF BR SCAIR ASPD ASCHD	5	0	0	0	0	

Priority #	Task #	Plan Task	Duration (yrs)	Responsible Agency		Cost Estimates ($000's)					Comments
				FWS Region 2	Other	FY 1	FY 2	FY 3	FY 4	FY 5	
1	1.7	Design and implement site specific management plans for natural and long-lived reestablished populations.	20	ES FR	AGFD FS BLM SCAIR TNC ASPD NMDGF	5	5	5	5	5	
1	1.8	Determine minimum viable population	3	ES		0	20	0	0	0	Population Viability Analysis
1	2.1	Identify habitats suitable for reintroduction of Gila topminnow.	5	ES	AGFD FS BR BLM TNC SCAIR ASPD	2	2	2	2	2	
1	2.2	Reestablish Gila topminnow in suitable habitats following geographic guidelines.	15	ES FR	AGFD FS BLM SC AIR ASPD TNC	5	5	5	5	5	
1	2.3	Protect habitats suitable for reestablishment from detrimental land and water use practices.	20	ES	AGFD FS BR BLM TNC SCAIR ASPD	4	4	4	5	5	
1	2.4	Protect habitats of reestablished or potential populations from detrimental nonnative aquatic species.	20	ES FR	AGFD FS BR BLM TNC SCAIR ASPD ASCHD	4	4	4	5	5	
1	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.	20	ES FR	AGFD FS BR BLM TNC SCAIR ASPD	5	0	0	0	0	

Priority #	Task #	Plan Task	Duration (yrs)	Responsible Agency		Cost Estimates ($000's)					Comments
				FWS Region 2	Other	FY 1	FY 2	FY 3	FY 4	FY 5	
1	2.6	Design and implement site specific management plans for all reestablished populations.	20	ES FR	AGFD FS BR BLM TNC SCAIR ASPD	5	5	5	5	5	
1	3.1	Develop standardized population and habitat monitoring protocols and implement them.	20	ES	BLM AGFD SCAIR TNC NMDGF FS BR	45	47	50	52	55	Monitoring
1	3.2	Maintain a population and habitat database and generate annual reports.	20	ES	AGFD NMDGF FS BLM BR	3	3	3	3	3	
1	3.3	Implement criteria for declaring reestablished populations as extirpated.	20	ES FR	AGFD FS BR BLM SCAIR ASPD TNC	1	1	1	1	1	
2	4.1	Facilitate genetic exchange among reestablished populations if needed.	20	ES FR	AGFD NMDGF FS BLM	2	2	2	2	2	
2	4.2	Conduct additional genetic studies of natural and reestablished populations.	20	ES	AGFD FS BLM SCAIR TNC	5	5	5	5	5	
2	5.0	Study life-history, genetics, ecology, and habitat of Gila topminnow and interactions with nonnative aquatic species.	4	ES FR	AGFD FS BLM	5	5	5	6		
3	6.0	Inform and educate the public and resource managers.	15-20 ongoing	ES EA	AGFD FS BR BLM SCAIR ASPD TNC	1	1	1	1	1	
					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.

LOCATION	COLLECTORS	YEAR	MAP #	SOURCE
Gila River				
Bylas Springs	Johnson, J. E.	1968	27	ASU 4472
Frisco Hot Springs	Koster, W. J.	1948	82	UofNM
Gila River - near Adonde Siding	Mearns, E. A.	1894	80	USNM 45436
Gila River - 2 mi. below Dome	Hubbs & Schultz	1926	62	UMMZ 094862
Gila River - near Gila	Mearns, E. A.	1894	28	USNM 45437
Gila River - just below Gillespie Dam	Kranzthor, G. M. Myers, G. S.	1929	N/A	USNM 94269
Gila River - 1 mi. below Winkleman	Simon, J. R.	1943	75	UMMZ 146667
Gila/Colorado River near Yuma		1890	29	Miller 1961
		1926	30	Miller 1961
Artesian spring fed ditch and reservoir 7 mi. SE of Safford	Miller, R. R. Winn, H. E.	1950	81	UMMZ 162703
Farm pond 6.5 mi. SE of Safford	Minckley, W. L. Koehn, R. K.	1964	1	ASU 635
Tributary of Gila River near Phoenix	Arizona Fish and Game Comm.	1934	N/A	UMMZ 102077
Salt River				
Salt River - between Phoenix and Tempe	Hubbs and Schultz	1926	61	UMMZ 094870 USNM 117590
At Tempe		1926	34	Hubbs 1926
Salt River near Tempe		1890	31	Miller 1961
	Gilbert, C. H. and Scofield	1890	33	USNM 048123
	Pilsbury, H.A.	1901	79	ANSP 38800
		1926	32	Miller 1961
Salt River - near Roosevelt	Chamberlain, F. M.	1904	35	USNM 129968
Tonto Creek - near Roosevelt	Chamberlain, F. M.	1904	N/A	USNM 130011

Appendix A. Continued.

LOCATION	COLLECTORS	YEAR	MAP #	SOURCE
Tonto Creek - midway between Roosevelt Dam and Payson	Hubbs and Schultz	1926	56	UMMZ 94883
Tonto Creek - 14 mi. above Roosevelt Lake	Gee, M. A.	1936	58	UMMZ 113524
Tonto Creek - 10 mi. above Roosevelt Lake	Hubbs, L. G.	1941	57	UMMZ 136185

San Carlos River

LOCATION	COLLECTORS	YEAR	MAP #	SOURCE
3 mi. above San Carlos Lake	Hubbs, L. G.	1941	59	UMMZ 136187
			60	UMMZ 136191

San Pedro River

LOCATION	COLLECTORS	YEAR	MAP #	SOURCE
San Pedro River - 4 mi. N of Feldman	Simon, J. R.	1943	76	UMMZ 146672
			48	UofA 95-83
Artesian Spring 13 km SE of Mammoth	McNatt, R.	1978	83	McNatt 1979

Santa Cruz River

LOCATION	COLLECTORS	YEAR	MAP #	SOURCE
Arivaca Creek, near Arivaca	Wright, A.H. and Wehrle, L.P.	1934	N/A	Cornell 6566
Binghampton Pond 3 mi. N of Tucson	Simon, J.R.	1943	67	UMMZ 146645
Cienega Creek	Various	1974	55	ASU
Cocio Wash	Hanks, K.	1969	69	UMMZ 190820
	McNatt, R. and Constantz, G.	1972	2	ASU 6271
	Constantz, G.	1973-1975	3 thru 26	ASU 10182 - 10205
Cottonwood Spring	Hubbs & Family	1938	N/A	UMMZ 125052
	Minckley, W. L.	1965	N/A	ASU
	Various	1967	N/A	ASU
Desert Shores Pond in Tucson	Simon, J.R. and Hendrickson, J.	1943	65	UMMZ 146644
Monkey Spring	Chamberlain, F. M.	1904	84	USNM 130003
	Hubbs & Family	1938	85	UMMZ 125051
	Follett, W.I. and Snyder, R.C.	1949	86	Cornell & UofA
	Heath, W.G.	1958	87	UofA
	Heath, W.G.	1959	88	UofA
	Minckley, W. L. & Koehn, R. K	1964	89	ASU
Monkey Spring	Minckley, W. L.	1965	90	ASU

Appendix A. Continued.

LOCATION	COLLECTORS	YEAR	MAP #	SOURCE
	Barber, W. E.	1966	91	ASU
	Constantz, G.	1973	92	ASU
	Constantz, G.	1974	93	ASU
	Constantz, G.	1975	94	ASU
Potrero Creek	Simon, J. R.	1943	70	UMMZ 146682
Rio Santa Cruz Mexico (TYPE SPECIMEN)	Clark, J.H.	1851	49	Baird and Girard 1853 Girard 1859
Sabino Canyon	Price, W.W.	1894	77	Rutter 1896
Sabino Canyon in Santa Catalina Mountains		1926	44	Hubbs 1926
Sabino Canyon 1 mile northeast Tucson	Tinkham E.R.	1947	78	ANSP 71814
Sabino Creek	Kranzthor, G. M. Myers, G. S.	1929	N/A	USNM 94273
	Wright, A.H. and Webole, L.P.	1934	45	Cornell 5618
	Simon, J. R.	1943	68	UMMZ 146650
Santa Cruz River - near Gage	Gorsuch & Ashburn	1939	73	UMMZ 131097
	Minckley, W. L.	1978	N/A	ASU
Santa Cruz River - ditch 30 mi. S of Tucson	J.A. Griswold	1935	54	Harvard
Santa Cruz River - 2 mi. NE of Lochiel	Ashburn, M. F.	1940	N/A	USNM 118419-118422
Santa Cruz River - 7 mi. NNE of Lochiel	Voorhies and others	1943	74	UMMZ 141728
	Frost, M. and Hendrickson, J.	1943	50	UofA 95-85
Santa Cruz River - 6 mi E Nogales at road to Washington Camp	Chamberlain, F. M.	1904	53	USNM 129996
Santa Cruz River 8 miles south of Tucson	Chamberlain, F. M.	1904	37	Miller 1961
Santa Cruz River - near San Xavier	Chamberlain, F. M.	1904	38	USNM 129988
Santa Cruz River - near Tucson	Brown, H.	1893	N/A	USNM 45444
	Chamberlain, F. M.	1904	36	USNM 129991 & USNM 12994
Santa Cruz River Tucson	Pilsbury, H.A.	1910	41	ANSP 38841
Santa Cruz River - 7 mi. S of Tucson at Midvale Farms Irrigation System	Simon, J. R.	1943	66 39	UMMZ 146671 & UofA 95-81
Sheehy Spring	Ashburn & Gorsuch	1939	71	UMMZ 131105
	Ashburn, M. F.	1940	72	UMMZ 132250

Appendix A. Continued.

LOCATION	COLLECTORS	YEAR	MAP #	SOURCE
Sonoita Creek - near Cottonwood Spring	Simon, J. R.	1943	N/A	UMMZ
	Minckley, W. L. & Rinne, J.	1967	N/A	ASU
Sonoita Creek - near Patagonia	Chamberlain, F. M.	1904	N/A	USNM 130000
	Minckley, W. L. & Rinne, J.	1967	N/A	ASU
Sonoita Creek, 1.2 mi SW of Patagonia on Hwy 82	Hinds, D.S.	1967	52	UofA 95-44
Sonoita Creek - 2.6 mi. SW of Patagonia, pool off creek	Minckley, W. L.	1967	N/A	ASU
Sonoita Creek - 3 mi. SW of Patagonia	Burt, C. E.	1928	51	UMMZ
	Minckley, W. L.	1967	N/A	ASU
	Johnson, J. E.			
Sonoita Creek - 3.5 mi. below Patagonia	Hubbs & Family	1938	N/A	UMMZ 125047
Sonoita Creek - below Patagonia Lake	Ginelly, H.	1973	N/A	ASU
	Frantz, B. and Silvey, B.	1976	N/A	ASU
	Ginelly, H. and others	1977	N/A	ASU
Sonoita River, 8 mi. N of Patagonia, also up small creek	Simon, J. R.	1943	N/A	UMMZ 141205
Spring 50 ft. W of Tanque Verde Creek	Simon, J. and others	1943	63	UMMZ 141725
Spring 200 ft. E of Tanque Verde Creek	Simon, J. and others	1943	64	UMMZ 141726
Tanque Verde Creek 3.5 mi east of Tanque Verde		1940	46-47	Nichols 1940; Hubbs and Miller 1941
Tuczon Sonora	A. Schott under Major Emory	1843	40	Girard 1859
at Tucson	A.L. Heerman under Lt. JG Parke	1848	42	Girard 1859
		1926	43	Hubbs 1926

Appendix B. Status of natural populations of Gila topminnow, *Poeciliopsis occidentalis occidentalis*, in the United States. Site number corresponds with Simons (1987) system. Information based on Bagley et al. (1991), Brown and Abarca (1992), and Weedman and Young (1997).

Location	Site #	Ownership	Comments
Bylas Spring	7	San Carlos Indian Reservation	Discovered in 1968, invaded by mosquitofish in 1978-79. Renovated for mosquitofish in 1982 & 1984. 99% mosquitofish dominance in 1991 (Bagley et al. 1991; Brown & Abarca 1992). Topminnow were last collected in 1993.
Cienega Creek	5	BLM, Private, State Lands	Topminnows are found in over 13 km of creek, representing the largest natural topminnow habitat. No nonnative fish are present.
Cocio Wash	188	BLM	Discovered in 1967. Natural population lost to mining impacts. Restocked with mixed stocks in 1981. Topminnow last seen in 1982.
Coal Mine Canyon	301	State Parks and Private	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.
Cottonwood Spring	1	Private	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.
Fresno Canyon	164	Private	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.
Middle Spring	6	San Carlos Indian Reservation	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).
Monkey Spring	2	Private	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.

Appendix B. Continued.

Location	Site #	Ownership	Comments
North Fork Ash Creek	126	San Carlos Indian Reservation	Topminnows were found at "North Fork of Ash Creek approximately 3/4 mile south of Ash Creek Ranch" 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.
Redrock Canyon	11	USFS	Topminnow coexists with mosquitofish, longfin dace, desert sucker, and largemouth bass in several isolated reaches of this intermittent stream and its tributaries.
Salt Creek	8	1986	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.
Santa Cruz River, near Lochiel	10	Private	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 & black bullhead. Gila topminnow last collected in 1993 (J.A. Stefferud, pers. comm.).
Santa Cruz River, north of Nogales	10A	Private	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.
Sharp Spring	4	Private	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.).
Sheehy Spring	3	Private	Mosquitofish first recorded in 1979. No topminnows have been collected here since 1987.

Appendix B. Continued.

Location	Site #	Ownership	Comments
Sonoita Creek, above Patagonia Lake	9	Private	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.
Sonoita Creek, below Patagonia Lake	9A	State Parks and Private	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.

Appendix C. Summary of extant, long-lived reestablished populations of Gila topminnow, *Poeciliopsis occidentalis occidentalis*, in the United States, as of June 1998. Site number corresponds with Simons (1987) system.

Location	Site #	Year stocked	Comments
AD Wash	242	1993	Desert pupfish also stocked but not collected since 1993. Gila topminnow common and abundant in about ½ mile of intermittent stream flow.
Charlebois Spring	51	1983	Reported as extirpated by Brooks (1986), visited by Tonto National Forest biologists in 1991 and found to support a topminnow population. Present in 1993, 1996, and 1997.
Cold Springs	85	1985	Only one of the two pools has topminnow. Desert pupfish also present in the 6m by 6m pool. Red shiner discovered in 1998.
Dutchman Grave Spring	19	1983	Large topminnow population located in the Mazatzal Wilderness Area.
Heron Spring	76	1981, 1987	Small population of topminnow occupying a limited habitat.
Hidden Water Spring	48	1976, 1981	Topminnows persist with longfin dace and leopard frogs.
Johnson Wash Spring	35	1982	Small population limited by habitat size and encroaching vegetation.
Kayler Spring	42	1982	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.
Lime Creek	301	1982	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.
Lower Mine Spring	12	1983	Small population which may have suffered a genetic bottleneck (only one collected in 1995). Habitat subject to vegetation encroachment.
Mescal Warm Spring	82	1985	Small topminnow population. Habitat subject to vegetation encroachment. Only one collected in 1996.

Appendix C. Continued.

Location	Site #	Year stocked	Comments
Mud Spring	18	1982	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.
Tule Creek	75	1968, 1981	Topminnows had to be restocked following flooding in 1978 and continue to be present in large numbers.
Unnamed drainage	68b	1986	Topminnows washed down from Mesquite Tank #2. A small population has been present since 1987.
Walnut Spring	20	1982	Large population of topminnow is present in a small spring fed stock tank.
Watson Wash	134	`	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.
Yerba Mansa	44	1984, 1985, 1988	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.

Appendix D. Summary of Biological Opinions[1] issued by the U.S. Fish and Wildlife Service related to *Poeciliopsis occidentalis* or *Poeciliopsis o. occidentalis*.

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

Appendix D. Continued.

Number	Project	Agency	Sites	Incidental take terms and conditions	Conservation Recommendations	Implementation	Date of BO
89200	Habitat renovation, Tonto NF	FS	Sycamore Spring	Hold fish during renovation, monitoring	Control and monitor turbidity, limit vegetation removal, excavate to U-shape, exclude livestock, timing, close road, reporting	Project dropped; population lost due to flood damage	10-17-89
90018	Pupfish stocking and future management actions	BLM	Big and Cold Springs	Hold fish during renovation, monitoring	16 recommendations concerning stock size, timing, road closure, vegetation management, coordination, reporting	Implemented, some recommendations followed	12-1-89
90119[2]	Pima lateral feeder canal, Pinal County, CAP introduction of exotics	BR	Multiple	Implementation of RPA's: 2 barriers each on San Pedro and Aravaipa, continue 3 electric barriers on canals, monitor non-native fish, I&E, $500,000 for recovery actions annually for 25 years	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	Continuing	4-20-94, amended 5/98
90169	Watershed Action Plan, Coronado NF	FS	Redrock Canyon	Minimize disturbance, specialist involvement, habitat enhancement, notification, monitoring, reporting	Limit use of Pig Camp Spring, survey drainage for topminnow, involvement of fish biologist, use local stock for riparian planting	Project partially implemented; report requirements partly complied with.	11-29-90

Appendix D. Continued.

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

Appendix D. Continued.

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

Appendix D. Continued.

Number	Project	Agency	Sites	Incidental take terms and conditions	Conservation Recommendations	Implementation	Date of BO
92350	Arizona Trail, Canelo Pass to Patagonia, Sierra Vista RD, Coronado NF	FS	Redrock Canyon	12 measures to minimize disturbance, enforce no-camping restrictions, maintain exclosure, annual interagency review of cumulative impacts, reporting, monitoring	Choose Lampshire Canyon alternative instead	Trail constructed & in use, but not open to the public due to incomplete implementation Plan	12-23-92
92550[2]	Water quality criteria for Clean Water Act. All listed species & waterways in state.	EPA	Multiple	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	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	Implementation beginning	2-16-94
93263	Draft revised Black Canyon Habitat Mgt. Plan, Phoenix District & AGFD	BLM & AGFD	Tule, Cow, Humbug and Castle creeks, and AD Wash	Take will be addressed during section 7 on implementation of specific actions	None	All actions carried forward to Horseshoe Ranch CRMP	9-8-93
93348	Repair & construction of bank revetment, emergency flood repair, State Route 92 @ MP 15.45 & 17.10	FHA/ ADOT	Sonoita Creek	Minimize activity in wetted channel, pollution prevention, limit heavy equipment use, avoid riparian vegetation loss, monitoring, reporting	No trees >6" diameter should be removed	Implemented except for report	6-21-94, amended 9-26-95

Appendix D. Continued.

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

Appendix D. Continued.

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

[1] Pre-1988 records may be incomplete
[2] Jeopardy opinion
[3] 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.

SITE NAME AND LOCATION	SITE No.	DATE STOCK	POPULATION TYPE	N	SOURCE OF FISH STOCKED	ORIGIN OF FISH STOCKED	TOWN RANGE SECTION	LATITUDE LONGITUDE	EXTANT	AUTHORITY
AD WASH	242	930305	WILD	500	DEXTER	SHARP SPRING	8N 2W 36	335908 1122530	Y	STOCKING SLIP #3775
AGFD MESA	101	870202	CAPTIVE	19	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	AGFD SITE FILE
AGFD PHOENIX	151	900524	CAPTIVE	8	ENGEL-WILSON	MIDDLE SPRING			N	STOCKING SLIP
AGFD PHOENIX	151	91XXXX	CAPTIVE	2	AGFD PHOENIX	MIDDLE SPRING			N	AGFD FILES
AGFD PHOENIX	151	890710	CAPTIVE	50	ROPER LK ST PK	MIDDLE SPRING			N	STOCKING SLIP #7927
AGFD PHOENIX	151	800201	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	AGFD FILES
AGFD PONDS PHOENIX	198	6904XX	CAPTIVE	U	UNKNOWN	SAN BERNARDINO RANCH			N	SCHOENHERR 1974
AGFD PONDS PHOENIX	198	6904XX	CAPTIVE	U	UNKNOWN	BYLAS SPRING			N	SCHOENHERR 1974
AGFD PONDS PHOENIX	198	6904XX	CAPTIVE	U	UNKNOWN	COTTONWOOD SPRING			N	SCHOENHERR 1974
AGFD PONDS PHOENIX	198	6904XX	CAPTIVE	U	MONKEY SPRING	MONKEY SPRING			N	SCHOENHERR 1974 & MINCKLEY & BROOKS 1985
ALAMBRE TANK	59	820614	WILD	200	DEXTER	MONKEY SPRING	13S 17E 6	321808 1103620	N	BROOKS 1985
ANTELOPE POND WATER CATCHMENT	253	820521	WILD	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
APACHE CANYON EAST FORK	176	760114	WILD	200	VAUGHT POND	MONKEY COCIO BYLAS S	21S 11E 35	313318 1111139	N	AGFD 1976 MINCKLEY & BROOKS 1985 #4515
ARAVAIPA CREEK GRAHAM COUNTY	177	770809	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	AGFD 1977 MINCKLEY & BROOKS 1985
ARAVAIPA CREEK GRAHAM COUNTY	177	67XXXX	WILD	U	MONKEY SPRING	MONKEY SPRING			N	MINCKLEY 1969b & MINCKLEY & BROOKS 1985
ARAVAIPA CREEK PINAL COUNTY	177	67XXXX	WILD	U	MONKEY SPRING	MONKEY SPRING			N	MINCKLEY 1969B & MINCKLEY & BROOKS 1985
AREA 10 TANK RANGE SPRING	265	820421	WILD	50	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
AREA 10 TANK RANGE SPRING	265	820426	WILD	50	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
AREA 14 WATER CATCHMENT	267	720915	WILD	500	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
AREA 2 POND	257	720912	WILD	300	BOYCE- THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
AREA 2 WATER CATCHMENT	268	720915	WILD	250	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
AREA 8 WATER CATCHMENT	269	720915	WILD	1500	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
AREA 9 WATER CATCHMENT	284	720915	WILD	250	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
AREA R SPRING (AREA 5)	254	820416	WILD	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
AREA R SPRING (AREA 5)	254	82XXXX	WILD	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
AREA W WATER CATCHMENT	255	82XXXX	WILD	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
AREA Y WATER CATCHMENT	256	820511	WILD	250	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
ARIVACA CREEK	272	36XXXX	WILD	U	?			313422 1111930	N	MILLER 1961 MINCKLEY & BROOKS 1985
ARIZONA HISTORICAL SOCIETY TUCSON	138	870618	CAPTIVE	20	MARY GILBERT	MONKEY COCIO BYLAS S			N	AGFD SITE FILE
ARIZONA MUSEUM OF SCIENCE & TECHNOLOGY	152	890723	CAPTIVE	15	ROPER LK ST PK	MIDDLE SPRING			N	STOCKING SLIP #7928
ARIZONA-SONORA DESERT MUSEUM TUCSON	137	851112	CAPTIVE	U	YELLOWSTONE TK	MONKEY SPRING			Y	AGFD SITE FILE
ARIZONA STATE UNIVERSITY TEMPE	102	850802	CAPTIVE	50	SHARP SPRING	SHARP SPRING			N	BROOKS 1986 MINCKLEY PERS.COMM. 1998
ARIZONA STATE UNIVERSITY TEMPE	102	850602	CAPTIVE	150	TULE CREEK	MONKEY COCIO BYLAS S			N	BROOKS 1986 MINCKLEY PERS.COMM. 1998
ARIZONA STATE UNIVERSITY TEMPE	102	820327	CAPTIVE	157	BYLAS SPRING	BYLAS SPRING			N	MEFFE 1983 MINCKLEY PERS.COMM. 1998
ARIZONA STATE UNIVERSITY TEMPE	102	900422	CAPTIVE	60	BYLAS SPRING	BYLAS SPRING			N	STOCKING SLIP #7939 MINCKLEY PERS.COMM.
ARIZONA STATE UNIVERSITY TEMPE	102	8404XX	CAPTIVE	400	BYLAS SPRING	BYLAS SPRING			N	BROOKS 1986 MINCKLEY PERS.COMM. 1998
ARTESIAN WELL # 3	40	820608	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	6N 11E 8	335252 1111510	E	BROOKS 1985
ARTESIAN WELL # 4	70	820608	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	6N 11E 8	335250 1111505	E	BROOKS 1985

Appendix E. Continued.

ASU ANIMAL RESOURCE CENTER	102	9407XX	CAPTIVE	17	ROPER LAKE STATE PARK	MIDDLE SPRING S2			Y	SHEFFER PERS. COMM. 1998
ASU ANIMAL RESOURCE CENTER	102	9407XX	CAPTIVE	20	CIENEGA CREEK	CIENEGA CREEK			Y	SHEFFER PERS. COMM. 1998
ASU ANIMAL RESOURCE CENTER	102	9309XX	CAPTIVE	10	MONKEY SPRING	MONKEY SPRING			Y	SHEFFER PERS. COMM. 1998
ASU ANIMAL RESOURCE CENTER	102	9408XX	CAPTIVE	20	MONKEY SPRING	MONKEY SPRING			Y	SHEFFER PERS. COMM. 1998
ASU ANIMAL RESOURCE CENTER	102	9705XX	CAPTIVE	17	USFWS, SAN CARLOS FAO	BYLAS SPRING			Y	SHEFFER PERS. COMM. 1998
ASU ANIMAL RESOURCE CENTER	102	9408XX	CAPTIVE	20	SHARP SPRING	SHARP SPRING			Y	SHEFFER PERS. COMM. 1998
BABOCOMARI RIVER	273	68XXXX	WILD	U	?	?		313933 1103125	U	AGFD FILES
BADGER SPRINGS	180	750815	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	10N 2E 24		N	AGFD 1975 MINCKLEY & BROOKS 1985
BAIN SPRING	26	830602	WILD	500	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	10N 2W 6	341439 1123012	N	BROOKS 1985
BEAR CANYON	182	820617	WILD	2000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	23S 17E 36	312250 1102145	E	BROOKS 1985
BENCH WELL	67	830628	WILD	100	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	10N 1E 23	341114 1121323	E	BROOKS 1985
BIG SPRING	84	850722	WILD	500	DEXTER	MONKEY SPRING	6S 25E 5		N	BROOKS 1986
BLACKTAIL POND	293	820618	WILD	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
BLACKTAIL POND	293	820404	WILD	75	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
BLM KINGMAN	149	871104	CAPTIVE	105	DEXTER	SHARP SPRING			N	AGFD SITE FILE
BLM SAFFORD	150	831228	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	AGFD SITE FILE
BLUE MTN. SPRING	244	820610	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	6N 5E 19	335046 1114222	E	BROOKS 1985
BOSTON WATER CATCHMENT	266	820519	WILD	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
BOYCE-THOMPSON ARBORETUM	80	71XXXX	CAPTIVE	200	MONKEY SPRING	MONKEY SPRING	2S 12E 6		Y	AGFD SITE FILE
BOYCE-THOMPSON ARBORETUM	80	7106XX	CAPTIVE	4000	PAGE SPRINGS	ASSUMED MONKEY SPRIN	2S 12E 6	Y		MINCKLEY & BROOKS 1985
BOYCE-THOMPSON ARBORETUM	80	72OR73	CAPTIVE	U	COCIO WASH	COCIO WASH	2S 12E 6		Y	AGFD FILES J. JOHNSON PERS. COMM.
BOYCE-THOMPSON ARBORETUM	80	78 PRE	CAPTIVE	U	BYLAS SPRING	BYLAS SPRING	2S 12E 6		Y	AGFD SITE FILE
BOYCE-THOMPSON ARBORETUM	80	850601	CAPTIVE	300	TULE CREEK	MONKEY COCIO BYLAS S	2S 12E 6		Y	BROOKS 1986
BOYCE-THOMPSON ARBORETUM	80	850722	CAPTIVE	10000	DEXTER	MONKEY SPRING	2S 12E 6		Y	BROOKS 1986
BOYCE-THOMPSON ARBORETUM (POST RENOVAT)	80	8004XX	CAPTIVE	2000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	2S 12E 6		Y	AGFD SITE FILE
BRONCO CANYON SPRING TANK	54	830824	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	7N 5E 28	335545 1115115	N	BROOKS 1985
BUCKHORN SPRING	245	820604	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	4N 11E 27	333933 1111313	N	BROOKS 1985
BUEHMAN CANYON	133	820616	WILD	2000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	12S 17E 4	322505 1103200	N	BROOKS 1985
BUFFALO CORRAL POND SPRING	99	880412	WILD	285	DEXTER	SHARP SPRING			N	STOCKING SLIP #7891
BUFFALO CORRAL POND SPRING	99	840503	WILD	100	KINO SPRING	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
BUFFALO CORRAL POND SPRING	99	82XXXX	WILD	U	?				N	SIMONS 1987
BYLAS SPRING	7	820416	NATURAL	67	ASU	BYLAS			Y	MEFFE 1983
BYLAS SPRING	7	8407XX	NATURAL	200	ASU	BYLAS			Y	BROOKS 1986
CAMP CREEK	160	750722	WILD	100	BOYCE-THOMPSON	MONKEY COCIO BYLAS S		335500 1114900	U	AGFD 1975 STOCKING SLIP
CAMP CREEK	160	64XXXX	WILD	U	MONKEY SPRING	MONKEY SPRING			N	MINCKLEY 1969B & MINCKLEY & BROOKS 1985
CAMPBELLS FLAT SPRING	25	830602	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	10N 2W 30	341058 1123058	N	BROOKS 1985
CANADA DEL ORO	79	820615	WILD	2000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	11S 15E 2	323315 1104215	N	BROOKS 1985
CANELO CIENEGA	274	76XXXX	WILD	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	MINCKLEY & BROOKS 1985 GEHLBACH 1981
CARRIZO CREEK	275	69XXXX	WILD	U	?	?			U	AGFD FILES
CASTLE CREEK	67B	83TO84	WILD	U	BENCH WELL	MONKEY COCIO BYLAS S	9.5N 2E 19		N	SIMONS 1987
CAVE CREEK	49B	89 PRE	WILD	U	SEVEN SPRINGS	MONKEY COCIO BYLAS S	7N 5E 8		N	AGFD SITE FILE
CAVE CREEK	49B	65 PRE	WILD	U	MONKEY SPRING	MONKEY SPRING			N	MINCKLEY 1969B
CAVE SPRINGS	277	720915	WILD	300	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
CEDAR SPRING	185	820517	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	13N 3E 22	342945 1120015	N	BROOKS 1985
CENTRO ECOLOGICO DE SONORA		861005	CAPTIVE	30	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			U	STOCKING SLIP #7804
CHALK TANK	186	820518	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	12N 6E 34	342320 1114203	E	BROOKS 1985
CHALKY BUTTE WELL TANK	22	820603	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	3N 16E 35	333331 1103828	E	BROOKS 1985
CHARLEBOIS SPRING	51	830602	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	1N 10E 5	332705 1112032	Y	BROOKS 1985
CHERRY CREEK	87	850926	WILD	2500	DEXTER	MONKEY SPRING			U	BROOKS 1986
CIBIQUE CREEK	294	69XXXX	WILD	U	?				U	AGFD FILES
COLD SPRINGS	85	850722	WILD	500	DEXTER	MONKEY SPRING	5S 24E 17		Y	BROOKS 1986
COPPER CANYON	71	820518	WILD	2000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	13N 4E 10	343633 1115500	E	BROOKS 1985
COPPER CANYON	71	830601	WILD	100	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	13N 4E 10	343633 1115500	E	BROOKS 1985
CORNER ARTESIAN	41	820608	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	6N 11E 20	335055 1111527	E	BROOKS 1985
COTTONWOOD ARTESIAN	77	820610	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	5N 13E 34	334408 1110027	N	BROOKS 1985

Appendix E. Continued.

COTTONWOOD SPRING	55	820603	WILD	800	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	3N 12E 5	333750 1110815	N	BROOKS 1985
COW CREEK	72	8109XX	WILD	U	TULE CREEK	MONKEY COCIO BYLAS S	8N 1W 25		N	AGFD SITE FILE
DEEP SPRING	189	820517	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	11.5N 7E 2	342210 1113955	N	BROOKS 1985
DEMO AIRFIELD	263	720915	WILD	300	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
DESERT BOTANICAL GARDEN	114	871104	CAPTIVE	450	DEXTER	SHARP SPRING			N	AGFD SITE FILE
DEXTER	153	860421	CAPTIVE	116	HERON SPRING	SHARP SPRING			Y	AGFD SITE FILE DEXTER FILES
DEXTER	153	850923	CAPTIVE	284	SHARP SPRING	SHARP SPRING			Y	BROOKS 1986
DEXTER	153	761008	CAPTIVE	200	MONKEY SPRING	MONKEY SPRING			N	MINCKLEY & BROOKS 1985 DEXTER FILES AGFD
DEXTER	153	840723	CAPTIVE	100	YELLOWSTONE TK	MONKEY SPRING			N	AGFD SITE FILE DEXTER FILES
DEXTER	153	840724	CAPTIVE	535	ALAMBRE TANK	MONKEY SPRING			N	AGFD SITE FILE DEXTER FILES
DEXTER RENOVATED	153	850722	RENOVA	5000	RENOVATION	MONKEY SPRING			N	AGFD FILES DEXTER FILES
DUTCHMAN GRAVE SPRING	19	830603	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	9N 7E 16	340656 1113832	Y	BROOKS 1985
EAST VERDE PONDS	285	68XXXX	CAPTIVE	U	?				U	AGFD FILES
EAST VERDE RIVER	278	65XXXX	WILD	U	MONKEY SPRING	MONKEY SPRING			N	MINCKLEY 1969B & MINCKLEY & BROOKS 1985
EL PILAR	251	820617	WILD	2000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	20S 15E 24	314036 1104550	E	BROOKS 1985
FIG SPRING	246	820610	WILD	400	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	7N 7E 28	335520 1113810	N	BROOKS 1985
FISH CREEK	279	65XXXX	WILD	U	MONKEY SPRING	MONKEY SPRING			N	MINCKLEY 1969B & MINCKLEY & BROOKS 1985
FORT HUACHUCA LAKE	191	720912	WILD	12000	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD 1972 MINCKLEY & BROOKS 1985
FOSSIL CREEK	280	69XXXX	WILD	U	?				U	AGFD FILES
FOSSIL CREEK	280	67XXXX	WILD	U	MONKEY SPRING	MONKEY SPRING			N	MINCKLEY 1969B & MINCKLEY & BROOKS 1985
FROG SPRING	47	820609	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	9N 6E 7	340828 1114650	E	BROOKS 1985
FULLERTON COLLEGE FULLERTON CA.		74 PRE	CAPTIVE	U	UNKNOWN	UNKNOWN			U	SCHOENHERR 1974
GARDEN CANYON	259	720915	WILD	500	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
GEORGE WASHINGTON UNIVERSITY	168	830921	CAPTIVE	200	DEXTER	MONKEY SPRING			U	DEXTER FILES
GOVERNMENT SPRING	33	820517	WILD	500	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	13N 3E 33	342740 1120145	N	MINCKLEY & BROOKS 1985 AGFD FILES
GOVERNMENT TANK	193	8206XX	WILD	200	?	?	13S 17E 4		E	AGFD SITE FILE USFS FILES.
GRANITE CREEK	281	730628	WILD	400	AGFD PONDS	MONKEY SPRING			N	AGFD 1973 MINCKLEY & BROOKS 1985
GRANITE CREEK	281	700626	WILD	250	PAGE SPRINGS	ASSUMED MONKEY SPRIN		N		AGFD 1970 MINCKLEY & BROOKS 1985
GRAPEVINE SPRING	94	820603	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S		333715 1104630	E	BROOKS 1985
GREEN TANKS	81	850722	WILD	500	DEXTER	MONKEY SPRING	3S 15E 7		N	BROOKS 1986
HAPPY CAMP SPRING	92	820603	WILD	400	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	1S 12E 28	331834 1110824	E	BROOKS 1985
HARSHAW CREEK	90	820617	WILD	500	?		22S 16E 23		N	AGFD SITE FILE
HASSAYAMPA RIVER PRESERVE	140	890819	CAPTIVE	650	ROPER LK ST PK	MIDDLE SPRING			Y	STOCKING SLIP #7935
HASSAYAMPA RIVER PRESERVE AQUARIUM	140	890819	CAPTIVE	50	ROPER LK ST PK	MIDDLE SPRING			N	STOCKING SLIP #7929
HASSAYAMPA RIVER PRESERVE WICKENBURG	140	880523	CAPTIVE	40	MIDDLE SPRING	MIDDLE SPRING			N	STOCKING SLIP #7906
HERON SPRING	76	870818	WILD	U	HERON SPRING	SHARP SPRING	24S 17E 13		Y	AGFD SITE FILE
HERON SPRING	76	810708	WILD	150	SHARP SPRING	SHARP SPRING	24S 17E 13		Y	AGFD SITE FILE
HIDDEN WATER SPRING	48	810519	WILD	200	HIDDEN WATER	MONKEY COCIO BYLAS S	3N 9E 21	333538 1112615	Y	AGFD SITE FILE
HIDDEN WATER SPRING	48	760603	WILD	350	MONKEY SPRING	MONKEY SPRING	3N 9E 21	333538 1112614	Y	AGFD 1976 MINCKLEY & BROOKS 1985
HOLLY SPRING	195	820517	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	16N 4E 27	344535 1115000	N	BROOKS 1985
HORSE CREEK	46	820610	WILD	400	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	8N 6E 1	340335 1114045	N	BROOKS 1985
HORSE PASTURE SPRING	258	720915	WILD	250	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
HOWARD WELL	83	850722	WILD	500	DEXTER	MONKEY SPRING	11S 29E 36	322620 1092046	N	BROOKS 1986
HUACHUCA CANYON SPRING	260	720915	WILD	500	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
HULL SPRING	30	820518	WILD	500	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	14N 4E 19	343525 1115742	N	BROOKS 1985
HUMBUG CREEK	95	81TO87	WILD	U	COW CREEK	MONKEY COCIO BYLAS S	7N 1E 6		N	SIMONS 1987 AGFD FILES.
INDIAN RESERVATION		721025	CAPTIVE	2000	AGFD PONDS	MONKEY SPRING			U	AGFD 1972
INDIAN RESERVATION		720930	CAPTIVE	1000	AGFD PONDS	MONKEY SPRING			U	AGFD 1972
INDIAN SPRING	24	820611	WILD	500	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	3N 10E 24	333517 1111645	N	BROOKS 1985
INDIAN SPRINGS #2	57	830602	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	10N 2W 3	341400 1122750	E	BROOKS 1985
JOHNSON WASH SPRING	35	820518	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	14N 3E 33	343258 1120225	Y	BROOKS 1985
JOSEPHINE CANYON	197	771109	WILD	125	MONKEY SPRING	MONKEY SPRING	20S 14E 35		E	MINCKLEY & BROOKS 1985
JOSEPHINE CREEK	197	820617	WILD	500	?				E	AGFD FILES
JUBILEE SPRING	27	830601	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	11N 1E 2	341911 1121341	E	WEEDMAN & YOUNG 1997
KAYLER SPRING	42	820604	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	7N 10E 14	335635 1111805	Y	BROOKS 1985

Appendix E. Continued.

KINO SPRING	98	820317	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
KINO SPRING	98	720914	WILD	300	?	?			N	AGFD HUACHUCA FILES
LAUNDRY RIDGE	262	720915	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
LIME CABIN SPRING	248	820610	WILD	400	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	8N 5E 24	340110 1114750	N	BROOKS 1985
LIME CREEK	301	96PRE	WILD	U	LIME CABIN SPRING	MONKEY COCIO BYLAS S	8N 5E 24	340020 1114705	Y	WEEDMAN & YOUNG 1997
LITTLE NOB WELL	61	820603	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	3N 16E 35	333324 1103853	E	BROOKS 1985
LITTLE NOGALES SPRING	125	880819	WILD	172	CIENEGA CREEK	CIENEGA CREEK	18S 18E 11		N	STOCKING SLIP #7912
LITTLE OUTFIT	199	82XXXX	WILD	U	?	?	22S 17E 25	312928 1103352	E	AGFD FILES
LOWER MINE SPRING	12	830601	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	13N 5E 29	342903 1115107	Y	BROOKS 1985
MANSFIELD	93	820617	WILD	2000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	21S 15E 8	313710 1104953	E	BROOKS 1985
MARTIN WELL	132	89 PRE	WILD	U	?	?	11S 29E 36		N	AGFD SITE FILE
MC CLURE SPRING	261	720915	WILD	300	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
MC CLURE SPRING	261	820511	WILD	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
MCCANN SPRING TANK	53	820609	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	5N 7E 26	334447 1113549	E	BROOKS 1985
MESCAL WARM SPRING	82	850722	WILD	500	DEXTER	MONKEY SPRING	3S 17E 20	330903 1103814	Y	BROOKS 1986
MESQUITE FLAT TROUGH	38	820608	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	6N 10E 34	334903 1111903	E	BROOKS 1985
MESQUITE SPRING TANK (UNNAMED STREAM)	45	820609	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	5N 8E 31	334413 1113433	E	BROOKS 1985
MESQUITE TANK #1	62	830601	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	1N 11E 26	332430 1111145	E	BROOKS 1985
MESQUITE TANK #2	68	820603	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	2N 9E 1	333231 1112250	N	BROOKS 1985
MIDDLE MESA TANK	58	830601	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	11N 1E 1	341934 1121221	E	BROOKS 1985
MONKEY TANK	201	820518	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	12N 5E 12	342610 1114740	E	BROOKS 1985
MONTEZUMA TANK	202	820518	WILD	2000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	14.5N 3E 3	343805 1120120	E	BROOKS 1985
MUD SPRING TANK	16	830602	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	9.5N 5E 20	341113 1115148	N	BROOKS 1985
MUD SPRINGS	18	820609	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	5N 8E 26	334455 1112950	Y	BROOKS 1985
MUD SPRINGS	18	970805	WILD	130	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	5N 8E 26	334455 1112950	Y	AGFD FILES
NEW ENGLAND AQUARIUM	170	880831	CAPTIVE	50	DEXTER	SHARP SPRING			U	AGFD FILES DEXTER FILES
NOGALES SPRING	124	880819	WILD	258	CIENEGA CREEK	CIENEGA CREEK	18S 18E 11		N	STOCKING SLIP #7913
O'DONNELL CREEK	205	7408XX	WILD	U	MONKEY SPRING	MONKEY SPRING			U	GEHLBACK AGFD SITE FILE
OXBOW SPRING	56	820518	WILD	500	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	15N 3E 18	344210 1120350	N	BROOKS 1985
PACKARD SPRING	247	820608	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	6N 10E 17	335130 1112100	N	BROOKS 1985
PAGE SPRINGS HATCHERY	158	69TO70	CAPTIVE	U	MONKEY SPRING	MONKEY SPRING			N	SCHOENHERR 1974 & MINCKLEY & BROOKS 1985
PAGE SPRINGS HATCHERY	158	67XXXX	CAPTIVE	U	MONKEY SPRING	MONKEY SPRING			N	MINCKLEY & BROOKS 1985
PAGE SPRINGS HATCHERY	158	69TO70	CAPTIVE	U	UNKNOWN	BYLAS SPRING			N	SCHOENHERR 1974
PAGE SPRINGS HATCHERY	158	69TO70	CAPTIVE	U	UNKNOWN	SAN BERNARDINO RANCH			N	SCHOENHERR 1974
PAGE SPRINGS HATCHERY	158	69TO70	CAPTIVE	U	UNKNOWN	COTTONWOOD SPRING			N	SCHOENHERR 1974
PAPAGO GOLF COURSE POND		65XXXX	CAPTIVE	U	MONKEY SPRING	MONKEY SPRING			N	MINCKLEY 1969B
PAPAGO INDIAN RESERVATION		72XXXX	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO SPRING			U	MINCKLEY & BROOKS 1985
PAPAGO PARK POND		65XXXX	CAPTIVE	U	MONKEY SPRING	MONKEY SPRING			N	MINCKLEY 1969B
PASTURE WELL	31	860618	WILD	30	UNN SPR #2	MONKEY COCIO BYLAS S	15N 3E 16		E	AGFD SITE FILE
PASTURE WELL	31	83TO85	WILD	U	UNN SPR #2	MONKEY COCIO BYLAS S	15N 3E 16		E	BROOKS 1986
PEOPLES CANYON	28	840713	WILD	800	TULE CREEK	MONKEY COCIO BYLAS S	12N 10W 14		E	BROOKS 1986
PHOENIX ZOO	119B	860811	CAPTIVE	300	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	AGFD SITE FILE
PHOENIX ZOO	119B	860715	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	AGFD SITE FILE
PHOENIX ZOO	119A	751007	CAPTIVE	750	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	AGFD 1975 STOCKING SLIP
PHOENIX ZOO VELDT POND	119	96XXXX	CAPTIVE	1200	ASU ANIMAL RESOURCE CEN	SHARP SPRING			Y	AGFD SITE FILE
PILOT TANK	96	830601	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	1S 11E 36	331825 1111053	E	BROOKS 1985
PINAL COUNTY HEALTH DEPARTMENT		7208XX	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS			U	MINCKLEY & BROOKS 1985
PINE SHADOWS LAKE SHOWLOW	210	750728	CAPTIVE	300	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	AGFD 1975 MINCKLEY & BROOKS 1985
PRESCOTT COLLEGE		700626	CAPTIVE	100	PAGE SPRINGS	ASSUMED MONKEY SPRIN			U	AGFD 1970
PRIVATE AQUARIUM (MARY GILBERT)		870318	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	AGFD SITE FILE
PRIVATE AQUARIUM PHOENIX		890105	CAPTIVE	15	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	STOCKING SLIP #7922
PRIVATE AQUARIUM PHOENIX		890105	CAPTIVE	35	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			U	STOCKING SLIP #7921
PRIVATE AQUARIUM TEMPE		8903XX	CAPTIVE	2	TONY VELASCO	MONKEY COCIO BYLAS S			N	STOCKING SLIP #7927
PRIVATE AQUARIUM TEMPE		890105	CAPTIVE	4	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	STOCKING SLIP #7923
PRIVATE LAKE		730526	CAPTIVE	50	AGFD PONDS	MONKEY SPRING			U	AGFD 1973

Appendix E. Continued.

PRIVATE POND		721101	CAPTIVE	1000	AGFD PONDS	MONKEY SPRING	U	AGFD 1972
PRIVATE POND		720711	CAPTIVE	1000	AGFD PONDS	MONKEY SPRING	U	AGFD 1972
PRIVATE POND		720418	CAPTIVE	500	AGFD PONDS	MONKEY SPRING	U	AGFD 1972
PRIVATE POND		730526	CAPTIVE	25	AGFD PONDS	MONKEY SPRING	U	AGFD 1973
PRIVATE POND		721101	CAPTIVE	200	AGFD PONDS	MONKEY SPRING	U	AGFD 1972
PRIVATE POND		720929	CAPTIVE	150	AGFD PONDS	MONKEY SPRING	U	AGFD 1972
PRIVATE POND		720930	CAPTIVE	100	AGFD PONDS	MONKEY SPRING	U	AGFD 1972
PRIVATE POND (CLARK TANKS) DEER VALLEY		730628	CAPTIVE	400	AGFD PONDS	MONKEY SPRING	U	AGFD 1973
PRIVATE POND (SPONCEL'S)		710909	CAPTIVE	2500	AGFD PONDS	MONKEY SPRING	U	AGFD 1971
PRIVATE POND (VERDE LAKES)	287	730503	CAPTIVE	600	AGFD PONDS	MONKEY SPRING	U	AGFD 1973
PRIVATE POND APACHE JUNCTION		73XXXX	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO SPRINGS	U	MINCKLEY & BROOKS 1985
PRIVATE POND ARIVACA	127	880528	CAPTIVE	500	CIENEGA CRK.	CIENEGA CRK.	U	STOCKING SLIP #7911 AGFD SITE FILE
PRIVATE POND CAMP VERDE		73XXXX	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO SPRINGS	U	MINCKLEY & BROOKS 1985
PRIVATE POND CAREFREE		75XXXX	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	U	MINCKLEY & BROOKS 1985
PRIVATE POND CAREFREE		72XXXX	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO SPRINGS	U	MINCKLEY & BROOKS 1985
PRIVATE POND CAREFREE		720711	CAPTIVE	1000	AGFD PONDS	MONKEY SPRING	U	STOCKING SLIP #4536
PRIVATE POND CAVE CREEK		730503	CAPTIVE	500	AGFD PONDS	MONKEY SPRING	U	AGFD 1973
PRIVATE POND CAVE CREEK		740812	CAPTIVE	200	AGFD PONDS	MONKEY SPRING	U	AGFD 1974 STOCKING SLIP
PRIVATE POND CORNVILLE		7107XX	CAPTIVE	300	?		U	AGFD FILES
PRIVATE POND CORNVILLE	276	71XXXX	CAPTIVE	U	PAGE SPRINGS	ASSUMED MONKEY SPRIN	N	MINCKLEY & BROOKS 1985
PRIVATE POND ENGLE-WILSON		890823	CAPTIVE	20	AGFD NONGAME	MIDDLE SPRING	Y	STOCKING SLIP #7914
PRIVATE POND GLENDALE		740604	CAPTIVE	25	AGFD PONDS	MONKEY SPRING	U	STOCKING SLIP #4742
PRIVATE POND GLENDALE		720710	CAPTIVE	500	AGFD PONDS	MONKEY SPRING	U	AGFD 1972 STOCKING SLIP #4535
PRIVATE POND GLENDALE		740604	CAPTIVE	25	AGFD PONDS	MONKEY SPRING	U	STOCKING SLIP
PRIVATE POND GLENDALE		720426	CAPTIVE	12	AGFD PONDS	MONKEY SPRING	U	AGFD 1972 STOCKING SLIP #4532
PRIVATE POND GLENDALE		730615	CAPTIVE	50	AGFD PONDS	MONKEY SPRING	U	AGFD 1973 STOCKING SLIP #4734
PRIVATE POND GLENDALE (2)		72-73	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO SPRINGS	U	MINCKLEY & BROOKS 1985
PRIVATE POND LOCATION UNKNOWN (3)		72XXXX	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO SPRINGS	U	MINCKLEY & BROOKS 1985
PRIVATE POND MESA		740625	CAPTIVE	100	AGFD PONDS	MONKEY SPRING	U	AGFD 1974
PRIVATE POND MESA (ROSSMOOR LAKES)		740506	CAPTIVE	600	AGFD PONDS	MONKEY SPRING	U	AGFD 1974 STOCKING SLIP #4579
PRIVATE POND PALO VERDE		730502	CAPTIVE	500	AGFD PONDS	MONKEY SPRING	U	AGFD 1973
PRIVATE POND PARADISE VALLEY		720814	CAPTIVE	1800	AGFD PONDS	MONKEY SPRING	U	AGFD 1972 STOCKING SLIP #4539
PRIVATE POND PATAGONIA		820617	CAPTIVE	100	?		U	AGFD FILES
PRIVATE POND PAYSON		740802	CAPTIVE	36	AGFD PONDS	MONKEY SPRING	U	AGFD 1974 STOCKING SLIP #4743
PRIVATE POND PEORIA		730526	CAPTIVE	100	AGFD PONDS	MONKEY SPRING	U	AGFD 1973
PRIVATE POND PHOENIX		730406	CAPTIVE	100	AGFD PONDS	MONKEY SPRING	U	AGFD 1973
PRIVATE POND PHOENIX		721001	CAPTIVE	100	AGFD PONDS	MONKEY SPRING	U	AGFD 1972
PRIVATE POND PHOENIX		740812	CAPTIVE	18	AGFD PONDS	MONKEY SPRING	U	AGFD 1974 STOCKING SLIP #4542
PRIVATE POND PHOENIX		730611	CAPTIVE	50	AGFD PONDS	MONKEY SPRING	U	AGFD 1973 STOCKING SLIP #4733
PRIVATE POND PHOENIX		720704	CAPTIVE	500	AGFD PONDS	MONKEY SPRING	U	STOCKING SLIP
PRIVATE POND PHOENIX		720424	CAPTIVE	1000	?	?	U	STOCKING SLIP
PRIVATE POND PHOENIX		740926	CAPTIVE	40	AGFD PONDS	MONKEY SPRING	U	AGFD 1974
PRIVATE POND PHOENIX		740615	CAPTIVE	75	AGFD PONDS	MONKEY SPRING	U	AGFD 1974
PRIVATE POND PHOENIX		720929	CAPTIVE	150	?		U	AGFD FILES
PRIVATE POND PHOENIX		720710	CAPTIVE	500	AGFD PONDS	MONKEY SPRING	U	STOCKING SLIP
PRIVATE POND PHOENIX		730501	CAPTIVE	500	AGFD PONDS	MONKEY SPRING	U	AGFD 1973
PRIVATE POND PHOENIX		720704	CAPTIVE	500	AGFD PONDS	MONKEY SPRING	U	AGFD 1972 STOCKING SLIP #4537
PRIVATE POND PHOENIX		730607	CAPTIVE	50	AGFD PONDS	MONKEY SPRING	U	AGFD 1973
PRIVATE POND PHOENIX		720930	CAPTIVE	100	?		U	AGFD FILES
PRIVATE POND PHOENIX		740812	CAPTIVE	36	AGFD PONDS	MONKEY SPRING	U	AGFD 1974 STOCKING SLIP #4541
PRIVATE POND PHOENIX		720424	CAPTIVE	1000	AGFD PONDS	MONKEY SPRING	U	AGFD 1972 STOCKING SLIP #4531
PRIVATE POND PHOENIX		730417	CAPTIVE	75	AGFD PONDS	MONKEY SPRING	U	AGFD 1973
PRIVATE POND PHOENIX		730527	CAPTIVE	100	AGFD PONDS	MONKEY SPRING	U	AGFD 1973
PRIVATE POND PHOENIX		730503	CAPTIVE	50	AGFD PONDS	MONKEY SPRING	U	AGFD 1973
PRIVATE POND PHOENIX		730526	CAPTIVE	35	AGFD PONDS	MONKEY SPRING	U	AGFD 1973

Appendix E. Continued.

PRIVATE POND PHOENIX		730511	CAPTIVE	50	AGFD PONDS	MONKEY SPRING			U	AGFD 1973
PRIVATE POND PHOENIX		8908XX	CAPTIVE	10	COTTONWOOD ARTESIAN	MONKEY COCIO BYLAS S			U	AGFD FILES
PRIVATE POND PHOENIX (34)		72-74	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			U	MINCKLEY & BROOKS 1985
PRIVATE POND PRESCOTT		7107XX	CAPTIVE	4000	?	?			U	AGFD FILES
PRIVATE POND PRESCOTT		700626	CAPTIVE	150	PAGE SPRINGS	ASSUMED MONKEY SPRIN			U	AGFD 1970
PRIVATE POND SCOTTSDALE		7107XX	CAPTIVE	4000	?				U	AGFD FILES
PRIVATE POND SCOTTSDALE		730802	CAPTIVE	200	AGFD PONDS	MONKEY SPRING			U	AGFD 1973 STOCKING SLIP #4736
PRIVATE POND SCOTTSDALE		730619	CAPTIVE	20	AGFD PONDS	MONKEY SPRING			U	AGFD 1973 STOCKING SLIP #4735
PRIVATE POND SCOTTSDALE		730521	CAPTIVE	100	AGFD PONDS	MONKEY SPRING			U	AGFD 1973
PRIVATE POND TEMPE		880220	CAPTIVE	70	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			U	STOCKING SLIP #2427
PRIVATE POND TEMPE		740826	CAPTIVE	250	AGFD PONDS	MONKEY SPRING			U	AGFD 1974
PRIVATE POND TEMPE (3)		65XXXX	CAPTIVE	U	MONKEY SPRING	MONKEY SPRING			N	MINCKLEY & BROOKS 1985
PRIVATE POND TOLLESON		740819	CAPTIVE	150	?	?			U	STOCKING SLIP #4744
PRIVATE POND WICKIEUP		730407	CAPTIVE	50	AGFD PONDS	MONKEY SPRING			U	AGFD 1973 MINCKLEY & BROOKS 1985
QUEEN CREEK	162	77 PRE	WILD	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	9S 2E		U	AGFD SITE FILE
RED CREEK	112	82T087	WILD	U	THICKET SPRING	MONKEY COCIO BYLAS S	9.5N 5E 24		N	SIMONS 1987
REDFIELD CANYON	211	770728	WILD	500	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	AGFD 1977 MINCKLEY & BROOKS 1985
REDROCK WILDLIFE AREA	139	890519	WILD	149	DEXTER	SHARP SPRING			U	AGFD FILES
REDROCK WILDLIFE AREA	139	890629	WILD	100	DEXTER	SHARP SPRING			U	DEXTER FILES
REED SPRING	43	820604	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	8N 10E 34	335920 1111942	N	BROOKS 1985
RINCON	122	87 PRE	WILD	U	?	?	14S 16E 14		N	SIMONS 1987
ROCK CREEK 3-BAR WATERSHED "C"	212	750806	WILD	150	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	AGFD 1975 MINCKLEY & BROOKS 1985
ROCK SPRING #1	52	820609	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	5N 7E 23	334552 1113605	E	BROOKS 1985
ROCK SPRINGS	282	69XXXX	WILD	U	?				U	AGFD FILES
ROCK SPRINGS #2	60	830601	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	3N 16E 12	333650 1103630	N	BROOKS 1985
ROCK TANK SPRING	64	830602	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	7N 4E 35	335445 1115445	N	BROOKS 1985
ROMERO CANYON	252	820615	WILD	2000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	12S 15E 7	322400 1105100	U	BROOKS 1985
ROPER LAKE STATE PARK AQUARIUM	123	890819	CAPTIVE	U	ROPER LK ST PK	MIDDLE SPRING			U	STOCKING SLIP #7905
ROPER LAKE STATE PARK	123B	871103	CAPTIVE	300	MIDDLE SPRING	MIDDLE SPRING			N	STOCKING SLIP #7881
ROPER LAKE STATE PARK	123B	880926	CAPTIVE	300	MIDDLE SPRING	MIDDLE SPRING			Y	STOCKING SLIP #7902
RUTGERS UNIVERSITY	172	890912	CAPTIVE	40	SHARP SPRING	SHARP SPRING			N	STOCKING SLIP #7958
RUTGERS UNIVERSITY	172	860917	CAPTIVE	45	THICKET SPRING	MONKEY COCIO BYLAS S			U	STOCKING SLIP #7802
RUTGERS UNIVERSITY	172	890912	CAPTIVE	40	MONKEY SPRING	MONKEY SPRING			N	STOCKING SLIP #7959
SABINO CANYON	250	820613	WILD	2000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	12S 15E 23	322030 1104650	N	BROOKS 1985
SALT CREEK	8	860926	WILD	300	MIDDLE SPRING	MIDDLE SPRING			Y	SIMONS 1987 AGFD FILES
SALT RIVER HORSESHOE BEND	86	850926	WILD	2500	DEXTER	MONKEY SPRING			N	BROOKS 1986
SALT RIVER TEMPE	214	66XXXX	WILD	U	MONKEY SPRING	MONKEY SPRING			N	MINCKLEY 1969B & MINCKLEY & BROOKS 1985
SEVEN SPRINGS	49A	64XXXX	WILD	U	MONKEY SPRING	MONKEY SPRING	7N 5E 9	335744 1115053	N	MINCKLEY 1969B & MINCKLEY & BROOKS 1985
SEVEN SPRINGS	49A	800229	WILD	200	AGFD AQUARIA	MONKEY COCIO BYLAS S	7N 5E 9	335744 1115053	N	MINCKLEY & BROOKS 1985 STOCKING SLIP
SEVEN SPRINGS	49A	750722	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	7N 5E 9	335744 1115053	N	AGFD 1975 MINCKLEY & BROOKS 1985
SHEEP SPRING	34	820517	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	13N 3E 28	342835 1120205	N	BROOKS 1985
SHEEPSHEAD SPRING	63	820517	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	16N 4E 33	344427 1115540	N	BROOKS 1985
SHUTE SPRING	163	760804	WILD	250	MONKEY SPRING	MONKEY SPRING			E	AGFD 1976 MINCKLEY & BROOKS 1985
SPRING FED TANK # 078	78A	820610	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	5N 13E 31	334403 1110349	E	BROOKS 1985
SQUAWPEAK SPRING	220	820518	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	13N 5E 20	343030 1115035	N	BROOKS 1985
SYCAMORE CREEK (MIDDLE VERDE)	237	76XXXX	WILD	U			9N 6E 25		N	AGFD FILES
SYCAMORE CREEK (MIDDLE VERDE)	237	75XXXX	WILD	U			9N 7E 29		N	AGFD FILES
SYCAMORE CREEK 611.03201	286	75XXXX	WILD		MONKEY SPRING	MONKEY SPRING				MINCKLEY & BROOKS 1985
SYCAMORE CREEK NEAR DUGAS	223	750812	WILD	150	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	11N 4E	342115 1115815	N	AGFD 1975 STOCKING SLIP
SYCAMORE CREEK NEAR SUNFLOWER	286	68XXXX	WILD	U	?				U	AGFD FILES
SYCAMORE II TURNOFF TANK	264	820511	WILD	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	COLEMAN FIELD NOTES AGFD FILES
SYCAMORE SPRING	21	820603	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	3N 15E 24	333527 1104707	E	BROOKS 1986
T.T. SPRING	14A	820609	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	9.5N 5E 25	341054 1114725	N	BROOKS 1985
THE LAKE	121	820614	WILD	200	DEXTER	MONKEY SPRING	13S 17E 8	321935 1103715	N	BROOKS 1985
THICKET SPRING	15	830603	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	10N 5E 35	341146 1114820	N	BROOKS 1985

Appendix E. Continued.

TOHONO CHUL PARK TUCSON	136	870721	CAPTIVE	U	AZ-SON DES MUS	MONKEY SPRING			U	AGFD SITE FILE
TRES ALAMOS	36	840719	WILD	1000	TULE CREEK	MONKEY COCIO BYLAS S	10N 9W 13		E	BROOKS 1986
TUCKER BOX	78	820610	WILD	600	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	5N 13E 20	334605 1110235	N	BROOKS 1985
TULE CREEK	75	68XXXX	WILD	1000	MONKEY & BOYCE-THOMPSON	ASSUMED MONKEY	8N 1E 28	340020 1121616	N	MINCKLEY & BROOKS 1985
TULE CREEK	75	810930	WILD	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	8N 1E 28	340020 1121616	Y	AGFD SITE FILE
TULE CREEK SEEP (2E)	73	82XXXX	WILD	U	TULE CREEK	MONKEY COCIO BYLAS S	8N 1E 28	340009 1121546	N	BROOKS 1986
TULE CREEK UNN. SPRING (1E)	74	82XXXX	WILD	U	TULE CREEK	MONKEY COCIO BYLAS S	8N 1E 28	340013 1121555	N	BROOKS 1986
TURKEY CREEK	97	86XXXX	WILD	U	?	?	21S 18E 33		U	AGFD SITE FILE
TWO MILE SPRING	13	830603	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	9N 6E 28	340517 1114413	N	BROOKS 1985
UNIVERSITY OF ARIZONA TUCSON	174	820613	CAPTIVE	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			N	AGFD SITE FILE
UNIVERSITY OF ARIZONA TUCSON	174	910622	CAPTIVE	U	CIENEGA CREEK	CIENEGA CREEK			U	AGFD FILES
UNNAMED (T.T.) SPRING	14B	820609	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	9.5N 5E 24	341125 1114730	E	BROOKS 1985
UNNAMED (T.T.) SPRING	14B	83XXXX	WILD	U	T.T. SPRING	MONKEY COCIO BYLAS S	9.5N 5E 24	341125 1114730	E	BROOKS 1985
UNNAMED DRAINAGE #68	68B	82TO85	WILD	U	MESQUITE TANK #2	MONKEY COCIO BYLAS S	2N 9E 1		Y	BROOKS 1986
UNNAMED SPRING (11N 1E SEC. 2) JUBILEE	146	830601	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	11N 1E 12	341851 1121253	N	BROOKS 1985
UNNAMED SPRING #0	17A	820604	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	6N 9E 21	335120 1112658	N	BROOKS 1985
UNNAMED SPRING #1	17B	820604	WILD	600	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	6N 9E 21	335120 1112645	E	BROOKS 1985
UNNAMED SPRING #2	29	830601	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	15N 3E 16	344122 1120209	E	BROOKS 1985
UNNAMED SPRING #3	37	820603	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	4N 11E 2	334249 1111223	N	BROOKS 1985
UNNAMED SPRING #4	50	820609	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	5N 7E 24	334605 1113520	E	BROOKS 1985
UNNAMED SPRING #5	65	830602	WILD	500	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	9.5N 5E 32	340945 1115215	N	BROOKS 1985
UNNAMED SPRING #6	66	820609	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	10N 5E 34	341150 1114845	E	BROOKS 1985
UNNAMED SPRING #7	100	830603	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	7N 10E 4	335900 1112045	E	BROOKS 1985
UNNAMED SPRING FED TANK # 408	17C	820604	WILD	300	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	6N 9E 21	335120 1112635	E	BROOKS 1985
UNNAMED SPRING TANK # 498	39	820608	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	5N 10E 2	334840 1111830	N	BROOKS 1985
UPPER HORRELL SPRING	32	830603	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	2N 12E 12	333127 1110515	N	BROOKS 1985
USFWS OFFICE ALBUQUERQUE	144	880808	CAPTIVE	100	DEXTER	SHARP SPRING			N	AGFD FILES DEXTER FILES
USFWS OFFICE SAN CARLOS		9109XX	CAPTIVE	13	SALT CREEK	MIDDLE SPRING			N	AGFD FILES
VAUGHT POND #1	166	750811	CAPTIVE	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S			U	AGFD 1975 STOCKING SLIP #4512
VERDE RIVER NEAR PERKINSVILLE	288	77 PRE	WILD	U	?				N	AGFD FILES
WALNUT SPRING	20	820604	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	6N 8E 3	335351 1113118	Y	BROOKS 1985
WARM SPRINGS LITTLE BLUE RIVER	289	68XXXX	WILD	U	?				U	AGFD FILES
WARM SPRINGS SAN CARLOS RIVER	290	68XXXX	WILD	U	?				U	AGFD FILES
WATSON LAKE	291	700626	WILD	1360	PAGE SPRINGS	ASSUMED MONKEY SPRIN			N	AGFD 1970 MINCKLEY & BROOKS 1985
WATSON WASH	134	84TO89	WILD	U	?	?	6S 25E 23		Y	AGFD SITE FILE
WAYNE STATE UNIVERSITY DETROIT		76 PRE	CAPTIVE	U	UNKNOWN	UNKNOWN			U	AGFD FILES
WHITE ROCK SPRING	249	820609	WILD	200	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	9N 5E 12	340755 1114720	E	BROOKS 1985
WHITE TANK #1	69	830601	WILD	1000	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	11N 1E 11	341821 1121303	E	BROOKS 1985
WHITE TANK #2	230	820614	WILD	200	DEXTER	MONKEY SPRING	13S 17E 14	321802 1103435	E	BROOKS 1985
WILLOW CREEK RESERVOIR	292	700626	WILD	3090	PAGE SPRINGS	ASSUMED MONKEY SPRIN			N	AGFD 1970 MINCKLEY & BROOKS 1985
WINDMILL POND #1	270	720915	WILD	600	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
WINDMILL POND #2	271	720915	WILD	600	BOYCE-THOMPSON	MONKEY COCIO SPRINGS			N	AGFD HUACHUCA FILES
YELLOWSTONE TANK	23	820614	WILD	200	DEXTER	MONKEY SPRING	13S 17E 20	321722 1103800	E	BROOKS 1985
YERBA MANSA	44	841220	WILD	250	TULE CREEK	MONKEY COCIO BYLAS S	11N 11W 21		Y	BROOKS 1986
YERBA MANSA	44	850529	WILD	600	TULE CREEK	MONKEY COCIO BYLAS S	11N 11W 21		Y	BROOKS 1986
YERBA MANSA	44	880809	WILD	250	DEXTER	SHARP SPRING	11N 11W 21		Y	AGFD SITE FILE
ZIG ZAG SPRING	148	83 PRE	WILD	U	BOYCE-THOMPSON	MONKEY COCIO BYLAS S	9.5N 5E 25	341041 1114731	N	AGFD SITE FILE