RECLAMATION
Managing Water in the West

Draft Environmental Assessment

Native Fish Restoration Project
Redrock Canyon
Santa Cruz County, Arizona

U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office

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TABLE OF CONTENTS

FIGURES AND TABLES

CHAPTER 1 -- PURPOSE AND NEED

1.1 INTRODUCTION

The Bureau of Reclamation (Reclamation) and the cooperating agencies listed below have prepared this environmental assessment (EA) to analyze the potential effects of a proposed aquatic ecosystem restoration project on physical, biological, and cultural resources. The proposed project, which would be authorized for implementation on National Forest System (NFS) land, would include construction of a fish barrier, removal of nonnative fish and frogs, and restoration of the native fish and amphibian fauna in Redrock Canyon, Sierra Vista Ranger District, Coronado National Forest (CNF), Santa Cruz County, Arizona.

The EA was prepared in accordance with the National Environmental Policy Act (NEPA), Council on Environmental Quality (CEQ) regulations (40 CFR 1500-1508), Reclamation NEPA Handbook, and Forest Service NEPA Handbook 1909.15 (Environment Policy and Procedures). Reclamation is the lead Federal agency and the U.S. Forest Service, the U.S. Fish and Wildlife Service (FWS), and the Arizona Game and Fish Department (AGFD) are cooperating agencies, as defined in 40 CFR 1501.6.

This document is organized into six chapters and appendices:

- ***Chapter 1 – Purpose and Need****:* This chapter presents information on the history of the proposed action/project, the purpose of and need for the action, and the lead agency's proposal for achieving that purpose and need. This section also describes public involvement in the NEPA process.
- ***Chapter 2 – Comparison of Alternatives, including the Proposed Action****:* This chapter provides a detailed description of the lead agency's proposed action; cooperating agencies' proposed actions; alternative methods for satisfying the stated purpose and need; and key issues that are raised by the public, project proponents, and other agencies. The discussion also includes specific mitigation measures that are required to minimize potential adverse impacts. Finally, this chapter provides a summary table of the environmental consequences associated with each alternative.
- ***Chapter 3 – Affected Environment and Environmental Consequences****:* This chapter describes the environmental effects of implementing the proposed action and other alternatives, including no action. Within each section, the affected environment is described first, followed by a discussion of the potential effects of each alternative.
- ***Chapter 4 – Agencies and Persons Consulted****:* This chapter identifies persons who contributed to the preparation of this EA and lists agencies and persons consulted during the NEPA process.
- ***Chapter 5 – Environmental Laws and Directives****:* This chapter lists Federal environmental laws and directives that are relevant to the project.
- ***Chapter 6 – Literature Cited****:* This chapter lists documents used in preparation of this EA.

- ***Appendices****:* The appendices provide more detailed information to support the analysis presented in this EA.

1.2 BACKGROUND

1.2.1 The Redrock Canyon Watershed

The proposed project would be implemented in the watershed [1] of Redrock Canyon in the Canelo Hills of Santa Cruz County in southeastern Arizona (Figure 1). It is located on the CNF, with the exception of two small private inholdings, which are located at Redrock Ranch in the center of the basin and at Cott Tank in the uppermost portion of the basin. No state, tribal, or other lands are included in the project area. There are about 20,000 acres in the Redrock Canyon watershed, ranging in elevation from approximately 5,900 feet at the crest of the Canelo Hills to 4,075 feet near the mouth (Figure 2).

The primary stream course in Redrock Canyon is Redrock Canyon proper, which flows seasonally from upstream of Down Under Tank downstream to join with Harshaw Canyon and from there into Sonoita Creek in the town of Patagonia. Other named stream courses within the watershed include Oak Grove Spring Canyon, Lampshire Canyon, and the Cott Tank drainage. Areas of perennial or semi-perennial water are located throughout the watershed in streams, cienegas, springs, and stock tanks. Stock tanks may occupy sites of former natural springs. Primary areas of water that will be referred to in this EA are West Redrock Exclosure,[2] Falls and Falls Exclosure, Gate Spring and Gate Spring Exclosure, Cott Tank Exclosure (including Cott Tank drainage and Redrock Canyon proper below its confluence with Cott Tank drainage), and a developing semi-perennial area referred to as “above Redrock Ranch” (Figure 2). A number of named and unnamed springs exist. Stock tanks, small dams, watering troughs, wells, and trick tanks are scattered throughout the watershed. These are used primarily for livestock water, but a few were constructed for wildlife purposes. The location and status of all stock tanks and dams are described in Chapter 3.

Redrock Canyon is the largest of the Canelo Hills tributaries to Sonoita Creek. Sonoita Creek drains the east side of the Santa Rita Mountains, the north-central portion of the Patagonia Mountains, and the western side of the Canelo Hills before entering the Santa Cruz River near the town of Rio Rico. The Santa Cruz River is a north-flowing tributary of the Gila River and one of its major contributing systems. The Gila River basin is a complex watershed that is tributary to the Colorado River near the town of Yuma. It drains most of southern and central Arizona, southwestern New Mexico, and areas of northern Sonora, Mexico.

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[1] A watershed (also known as a basin or catchment) is the area above a specific point in a stream or stream system in which all water drains towards the stream. This includes all areas up to ridgelines, from where precipitation flows downhill to the stream.
[2] Exclosures are fenced areas intended to exclude livestock.

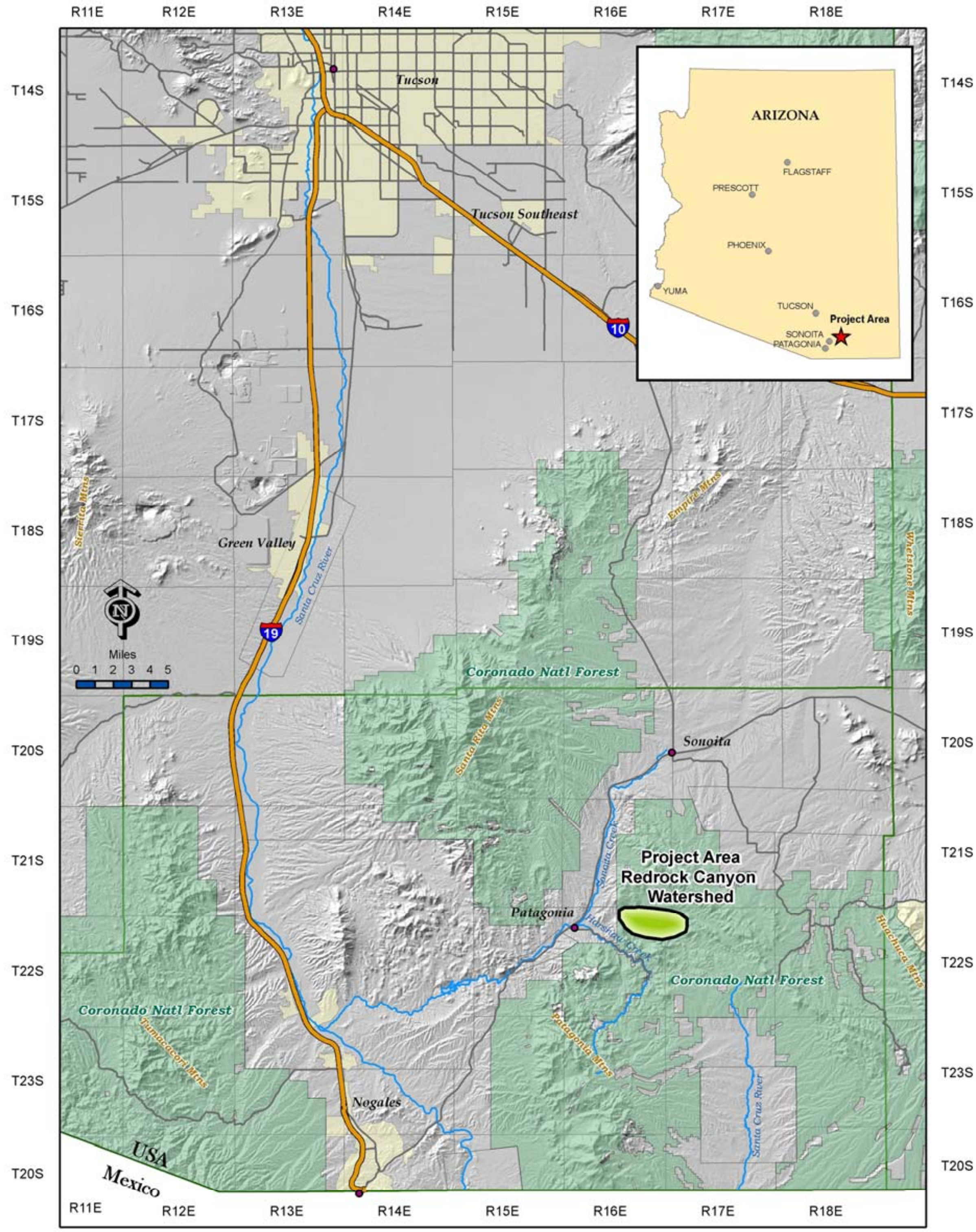

Figure 1. Project Area Map

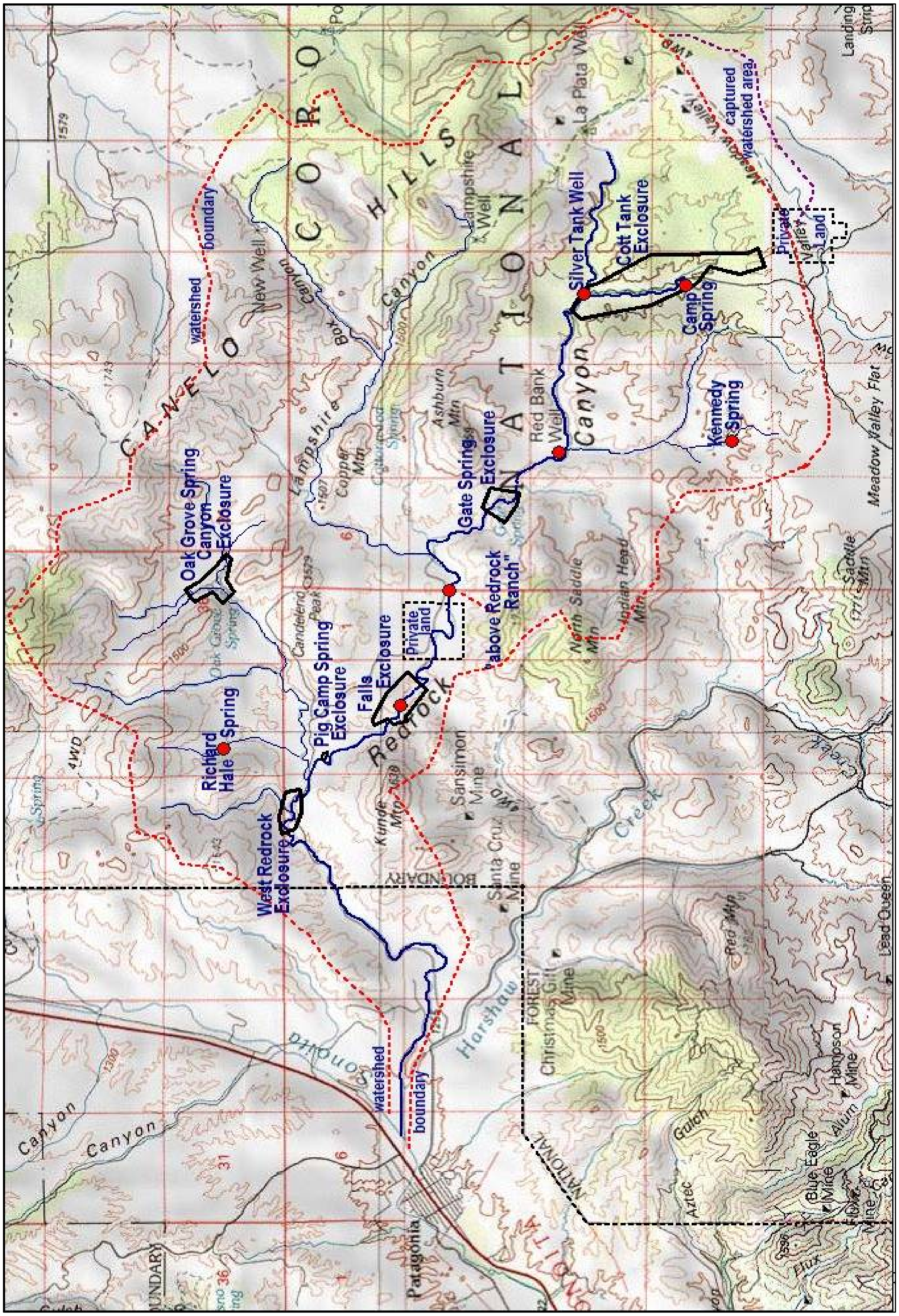

Figure 2. Locations and major features in Redrock Canyon watershed.

1.2.2 Aquatic Fauna in the Redrock Canyon Watershed and Gila River Basin

Redrock Canyon watershed supports a subset of the Gila River basin native[3] aquatic fauna (see Appendix A, Table A-1). Four species of native fish are known from the canyon, including longfin dace, speckled dace, desert sucker, and endangered Gila topminnow[4]. Several native amphibians are present in the watershed, most notably the federally listed threatened Chiricahua leopard frog and endangered Sonora tiger salamander. Three aquatic or semi-aquatic reptiles occupy Redrock Canyon watershed: Sonora mud turtle, black-necked gartersnake, and possibly Mexican gartersnake.

The aquatic ecosystems of the Gila River basin have been highly modified by humans, resulting in a significant decline in the native aquatic fauna (see Appendix B, Table B-1). Gila River basin native fishes are now among the most endangered species in the United States. Of the 21 species of fish native to the basin, one is extinct and six have been extirpated, although three have been repatriated with limited success. Eleven are federally listed as threatened or endangered, and one is formally recognized as warranted for Federal listing. The State of Arizona lists 14 as species of concern (AGFD 1996). Of the seven species not listed by the Federal or state government, all but two are identified as declining and in need of protection (Desert Fishes Team 2004).

Many of the Gila River basin native amphibian populations are also declining, particularly those tied to perennial surface water. Of the native amphibians of the Gila River basin, two are federally listed as endangered or threatened (Chiricahua leopard frog and Sonora tiger salamander), and one is managed through a conservation agreement in-lieu of listing. Seven are listed by the State of Arizona as species of concern (AGFD 1996). In addition, two Gila River basin native gartersnakes (narrow-headed gartersnake and Mexican gartersnake) are in serious decline (Holycross et al. 2006).

The decline in distribution and abundance of native aquatic species in the Gila River basin mirrors other declines throughout the Southwest; many of which have resulted from more than 150 years of habitat modification and destruction, as well as the introduction and spread of nonnative species by humans. Major portions of Arizona's surface waters have ceased flowing because of water diversion, draining, and ground-water pumping, while others have been converted from flowing streams and springs into impounded reservoirs, ponds, and stock tanks (Hendrickson and Minckley 1984; Rogge et al. 1995; Logan 2002; Mueller and Marsh 2003). These losses severed connectivity between streams and fragmented populations of fish and other aquatic species (Fagan et al. 2002). Water development and poor watershed practices dramatically altered riverine habitats, which also contributed to sharp declines in native fishes (Minckley et al. 1997). Accelerated erosion, sedimentation, channel downcutting, and other changes in channel

[3] "Native" (also indigenous, endemic, and aboriginal) refers to organisms that occur, or formerly occurred, in a particular region as a result of evolutionary or ecological processes. This is as opposed to organisms that have been intentionally or accidentally introduced outside their natural historic ranges by human activity. Organisms translocated outside their natural range by human activities are referred to as "nonnative" (also exotic, alien, introduced, nonindigenous, and invasive).
[4] For scientific names of all mentioned species, see Tables 1, 2, 6, and 7.

morphology commonly resulted from grazing, mining, timber harvest, roads, and other land use practices, caused loss or degradation of aquatic habitats (Cooke and Reeves 1976; Dobyns 1981; Bahre 1991). Physical and biological destabilization of riverine systems has led to a typical pattern in Arizona where native species tend to be restricted to the upper reaches of major drainage basins (FWS 2001b).

While initial declines in fish and amphibian populations resulted primarily from habitat destruction and modification, the effects of nonnative species are now the major contributing factor to declines and are a substantial impediment to successful restoration actions (Minckley 1991; Clarkson et al. 2005; Marsh and Pacey 2005). Approximately 40 nonnative fish species are established in the Gila River basin (see Appendix B, Table B-2). In addition, other nonnative aquatic species such as bullfrogs (*Rana catesbeiana*) and crayfish (primarily *Orconectes virilis)* have become major pests that seriously impact native fish, amphibians, and aquatic reptiles (Hayes and Jennings 1986; Rosen and Schwalbe 1995; Carpenter and McIvor 2000; Carpenter 2005).

Introduction and spread of nonnative aquatic species in the Gila River basin have occurred for a variety of reasons (see FWS 2001b for a review of mechanisms). Some are purposefully introduced to increase the diversity of, or food for, the sport fishery; for biological control; or for ornamental use. Others are accidentally released as bait or aquaculture species or introduced as a result of human transfers of water. Regardless of their mode of arrival, nonnative fishes have had a drastic detrimental effect on native aquatic species.

Direct impacts of nonnative fishes and other aquatic species to native forms include predation, competition, hybridization, habitat alteration, and parasite and pathogen transmission (Propst and Bestgen 1991; Minckley 1991; Douglas et al. 1994; Fernandez and Rosen 1996; Rosen and Schwalbe 2002; Bonar et al. 2004). Predation on early life stages (eggs, larvae, juveniles) is considered the primary avenue by which nonnative species depress and often eliminate what are considered predator-naive native species (Minckley 1991; Johnson et al. 1993; Kupferberg 1997; Snyder 2006). These effects are often exacerbated by habitat degradation. Yet, history shows that aquatic species as diverse as the "big river" razorback sucker, diminutive Gila topminnow, and Sonora tiger salamander can live and reproduce in degraded habitats as long as they are unaccompanied by nonnative fishes, but that they commonly wane or disappear when nonnatives become established (Minckley et al. 1977; Marsh et al. 1998; Pacey and Marsh 1998; Collins and Snyder 2002).

In Redrock Canyon, five nonnative species have invaded to date: western mosquitofish, largemouth bass, green sunfish, bluegill, and bullfrogs. The most recent date of their documented occurrence in Redrock Canyon is shown in Appendix A. All of these nonnatives have been present since the late 1970s; however, while largemouth bass, green sunfish, and bluegill have declined and may be gone, mosquitofish and bullfrogs have multiplied and spread throughout the basin.

All of the nonnative fishes appear to have originated as stockings into grazing stock tanks within the basin. These apparently were not authorized or recorded stockings, but by the late 1970s and early 1980s, most of the records for largemouth bass and all of the records of green sunfish, bluegill, and mosquitofish were from stock tanks. By 1985, mosquitofish were documented in streams in the center of the basin; and, by 1987, largemouth bass and green sunfish were common in the upper stream reaches. Largemouth bass became so abundant throughout the Cott Tank drainage that a mechanical removal effort was undertaken in 1989 to reduce adverse impacts to Gila topminnow (Stefferud 1989).

The ongoing drought in the southwest exacerbates the nonnative impacts to native species of the Redrock Canyon basin. The declining amount of surface water available increases losses to predation as the prey loses the ability to avoid the predator. The Gila topminnow appears to be less tolerant of crowding than are mosquitofish, thus giving mosquitofish a competitive edge during drought conditions (Dean 1987).

1.2.3 Biological Opinion for the Central Arizona Project (CAP)

Congress passed the Colorado River Basin Project Act (Act) in 1968. This Act authorized the Secretary of the Interior, through Reclamation, to construct the CAP to deliver Colorado River water for agricultural, industrial, and municipal uses in central and southern Arizona. The CAP, which was declared "substantially complete" in 1993, conveys Colorado River water through a 336-mile-long system of pumping plants, aqueducts, dams, and reservoirs.

During the late 1980s, the issue of introduction and spread of nonnative aquatic species through the CAP began to receive serious consideration among fisheries biologists. Because the CAP is an interbasin water transfer system, concern was expressed by wildlife resource management agencies that the CAP could accelerate the rate at which nonnative species are spread across basins and invade habitats occupied by threatened or endangered native fishes. In 1991, Reclamation requested formal consultation with the FWS, pursuant to Section 7(a)(2) of the Endangered Species Act (ESA). In 1994 and 2001, the FWS issued biological opinions on the delivery of CAP water to the majority of the Gila River basin (FWS 1994, 2001b).

The FWS concluded that interbasin water transfer through the CAP seriously and adversely affects the endangered Gila topminnow and razorback sucker and the threatened spikedace, loach minnow, and bald eagle[5]. The FWS also determined that CAP operations adversely modify critical habitat of the razorback sucker, spikedace, and loach minnow. The potential for establishment of nonnative species within the CAP system, and their subsequent escape and invasion into habitats occupied by protected native fishes, were cited as reasons for these adverse effects. Canal systems using CAP-supplied water and associated irrigation releases to the rivers of the Gila River basin, were identified by the FWS as principal routes, among others, by which nonnative species could move from the CAP to the Gila River and its tributaries.

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[5] The bald eagle was delisted from the ESA on August 8, 2007.

The conservation measures developed for the 2001 biological opinion and modified in an ongoing reconsultation with FWS regarding the CAP require the construction of drop-type fish barriers for controlling spread into native fish habitats by nonnatives that could be introduced through the CAP. To date, four barriers have been completed on three streams in Arizona,[6] and several others are in planning and design. The proposed Redrock Canyon aquatic ecosystem restoration project (which includes a fish barrier) would partially satisfy these required conservation measures. The ongoing reconsultation considers CAP effects to the newly listed Sonora tiger salamander, Chiricahua leopard frog, and Gila chub. Fish barriers built pursuant to the FWS biological opinions are all subject to NEPA compliance. In addition, the barrier proposed for Redrock Canyon is not yet part of a final biological opinion and would require Section 7 consultation, along with other elements of the proposed project.

1.3 PURPOSE OF AND NEED FOR ACTION

The purpose of the proposed project is to restore and protect populations of native fishes and amphibians throughout all appropriate areas of the Redrock Canyon basin. In order to achieve this goal, all nonnative fishes must be removed, and the basin must be managed to prevent their reinvasion. In addition, populations of nonnative bullfrogs must be significantly reduced or eliminated. The purpose of the proposed action is to establish self-sustaining populations of five fish species (Gila topminnow, Gila chub, desert sucker, speckled dace, and longfin dace), Chiricahua leopard frog, Sonora tiger salamander, and possibly other aquatic and semi-aquatic native species.

Opportunities for restoration of native fishes and amphibians of the Gila River basin are limited because the physical changes that many rivers and streams have undergone make them unsuitable for native fish restoration (e.g., drying, damming). In addition, challenges to removing nonnatives and controlling their reinvasion and land ownership patterns preclude many areas from native fish and amphibian restoration.

Redrock Canyon is a rare and outstanding example of an area with the potential for successful restoration of imperiled species throughout a drainage basin. This project is needed for the following reasons.

- A decline of native fishes and amphibian populations in Redrock Canyon has continued despite habitat improvement, and it appears to be directly linked to the presence of nonnative fishes and bullfrogs.
- The Forest Service, over the past 15 years, has devoted considerable effort to protection and enhancement of Redrock Canyon and its aquatic fauna. This effort may be negated unless control and removal of nonnative species occurs.
- Present drought conditions concentrate nonnative fish and amphibians into small areas, which provide optimal conditions for their removal.

[6] Fish barriers have been constructed on Aravaipa Creek, Fossil Creek, and Sonoita Creek. Construction of a fifth barrier is underway on Bonita Creek.

- Nonnative fish originating from Sonoita Creek are capable of reinvading the Redrock Canyon watershed, and natural barriers to their reinvasion afford protection only to the upper watershed. A constructed drop-type fish barrier is needed in lower Redrock Canyon to prevent nonnative fish reinvasions from downstream.

- Nonnative fish also are present in stock tanks within the Redrock Canyon basin and are sources of reinvasion to other aquatic habitats in the watershed. Therefore, removal of nonnative fishes from stock tanks is also needed.

- The severe depletion or elimination of native fishes and amphibians from the Redrock Canyon basin will require transplantation from other populations in order to restore the full complement of native aquatic species originally present in the basin.

1.4 SUMMARY OF PROPOSED ACTION

The proposed action would be implemented by Reclamation, in cooperation with the Forest Service, the AGFD and the FWS, to meet the purpose and stated in Section 1.3. It would include construction of a fish barrier in Redrock Canyon; removal of nonnative fish and frogs using integrated methods, including application of a commercially available piscicide; and augmentation, transplant, or reintroduction of native fish and amphibians.

With the exception of the first item (fish barrier), all elements of the project described below are common to the two action alternatives discussed in this EA. Removal and restoration actions would be a collective effort among the Forest Service, Reclamation, AGFD, and FWS. The AGFD would consider approval of all activities associated with native species capture, holding, and transplant. Additional details about the proposed action and alternatives are presented in Chapter 2.

- ***Fish barrier*** – Reclamation would build a reinforced poured-concrete fish barrier in lower Redrock Canyon approximately 4.25 miles upstream of Sonoita Creek. The barrier is intended to create an effective impediment to upstream movement of fish. This would include fish from Sonoita Creek and Patagonia Lake, both now and in the future. It would also act as a control site for eradication of nonnative fishes upstream in the Redrock Canyon watershed, preventing their reinvasion after removal.

- ***Native species salvage*** – Prior to stream renovation, Reclamation, Forest Service, AGFD, and FWS personnel would salvage a portion of the native fish, amphibian, Mexican gartersnake, and turtle populations from Redrock Canyon. These would be held temporarily on site or at other appropriate locations and returned to the stream following removal of nonnative species.

- ***Nonnative fish and frog removal*** – Nonnative fish and bullfrogs would be removed from the Redrock Canyon watershed using an integrated control approach. All nonnative fish would be eradicated from the drainage using the piscicides rotenone and antimycin A. Various mechanical methods would be used to remove adult bullfrogs, including netting, gigging, shooting (firearms), and euthanization. Stock tanks and stream pools would be pumped to lower water levels to facilitate bullfrog removal.

- ***Restoration of native fishes and amphibians*** – A suite of five native fish species and two rare amphibians potentially would be restored in all appropriate locations with suitable habitat within the Redrock Canyon watershed. These include longfin dace, speckled dace, desert sucker, Chiricahua leopard frog, Gila chub, Gila topminnow, and Sonora tiger salamander. In addition, Sonora mud turtle would be salvaged and restocked during treatment. The project may also benefit native Mexican gartersnake, a rare species that may inhabit Redrock Canyon.

- ***Monitoring*** – Post-treatment monitoring would be conducted to assess the success of the nonnative removal and native species restoration. Monitoring would continue for a minimum of 5 years after the nonnative removal. Post-treatment monitoring would incorporate results of existing ongoing monitoring efforts in the Redrock Canyon watershed. Also, the Forest Service would assume responsibility for "first-line" inspection of the fish barrier following flood events. Long-term maintenance of the barrier would be performed by the Central Arizona Water Conservation District (CAWCD).

1.5 DECISIONS TO BE MADE

Reclamation must decide whether to implement the proposed action, another action alternative, or no action. The Forest Service (Coronado National Forest Supervisor) must decide whether or not to authorize the use of NFS lands for implementation of the project. If the Forest Service authorizes the proposed action, Reclamation would construct the fish barrier in Redrock Canyon on NFS land.

In addition to approving the barrier, the Forest Service must decide whether to approve the mechanical and/or chemical treatment of surface waters in the watershed by AGFD, which may include (1) the application of piscicide (antimycin A and/or rotenone) to cienega pools, stream sections, and stock tanks; and (2) seining, netting, gigging, pumping, or other mechanical methods to remove bullfrogs from cienega pools, stream sections, and stock tanks. Removal and restoration actions would be a joint effort involving the Forest Service, Reclamation, AGFD, and FWS. The AGFD would consider approval of all activities associated with native species capture, holding, and transplant.

1.6 CONSISTENCY WITH CORONADO NATIONAL FOREST PLAN

The Coronado manages NFS land in the Redrock Canyon watershed in accordance with the *Coronado National Forest Land and Resource Management Plan (LRMP)* (LRMP; USFS 1986, as amended) and other national policy and direction, including the ESA. The proposed action was determined to be consistent with the goals, objectives, standards, and guidelines in the LRMP. The LRMP provides direction for the Coronado to allow the construction of fish habitat improvement structures as needed to support populations of threatened and endangered species. It also guides the transplanting of protected species into suitable habitat following guidelines or species recovery plans and memoranda of understanding. No amendments to the LRMP would be necessary to allow the proposed action to be implemented on NFS land.

1.7 PUBLIC INVOLVEMENT

The Council on Environmental Quality defines scoping as "…an early and open process for determining the scope of issues to be addressed and for identifying significant issues related to a proposed action" (40 CFR 1501.7). Scoping is an important underpinning of the NEPA process that encourages public input and helps focus the environmental impact analysis on relevant issues. Distribution of scoping information typically heralds the beginning of the public component of the NEPA process.

The project was listed on the CNF web site (www.fs.fed.us/r3/coronado) in a Schedule of Proposed Actions on January 1, 2007. On January 18, 2007, Reclamation posted a scoping notice on its Phoenix Area Office web site (www.usbr.gov/lc/phoenix) and mailed scoping information on the proposal to 53 potentially interested individuals, organizations, and agencies. In addition, a scoping meeting was held in Sonoita on February 8, 2007, to discuss the project with grazing permittees who have allotments within the project area. Reclamation and CNF received 11 letters of comment (including electronic mail) during the 30-day scoping period which ended on February 16, 2007. Six commenters responded favorably, and four commenters expressed opposition to the project. One responder advised the agencies that the proposed fish barrier would require a Floodplain Use Permit prior to construction.

The interdisciplinary team evaluated the issues raised during public scoping and categorized each according to possible significance or lack thereof. Relevant issues were defined as those that form the basis for alternative development, increased analysis, or the implementation of mitigation. Nonrelevant issues are those that are: (1) not within the scope of the project; (2) already decided/required by law, regulation, or other previous decisions; (3) unrelated to the decision being made; and, (4) conjectural and not supported by scientific or public interest.

Based on comments received during public scoping, the Forest Service and Reclamation identified the following significant issues:

- Effects of the project on nontarget species
- Effects of the project on water quality and quantity
- Effects of the project on visual aesthetics and scenery
- Effects of the project on livestock grazing
- Effects of the project on soils

In accordance with Forest Service regulations codified at 36 CFR 215.6 and Reclamation guidelines, the public will be offered a 30-day period to review this pre-decisional EA. Persons who offer oral or written comments on the EA or who otherwise express an interest in the project during the period will have a right to appeal a subsequent decision on its implementation following legal notice of the decision, pursuant to 36 CFR 215.6.

CHAPTER 2 -- DESCRIPTION OF THE ALTERNATIVES

This chapter describes the alternatives considered for the restoration project in greater detail. These include two action alternatives and no action. Also described are three alternatives that were considered but eliminated from further evaluation.

2.1 NO ACTION

In accordance with CEQ regulations at 40 CFR 1502.14 (d), no action must be considered as an alternative in each NEPA review. No action provides the baseline for comparison of environmental effects of the action alternatives. If no action is taken, Reclamation would not construct the proposed fish barrier, there would be no stream renovation, and native fish and amphibian restoration would not occur.

2.2 PROPOSED ACTION

The proposed action consists of five elements: (1) construct a barrier to prevent upstream incursion by nonnative fish; (2) salvage native fish, amphibians, and aquatic reptiles from waters of Redrock Canyon; (3) apply the piscicides antimycin A and rotenone and use mechanical methods to eradicate all nonnative fish in the watershed above the constructed barrier and reduce or eliminate bullfrog; (4) restore populations of native fish, frogs, salamanders, and semi-aquatic reptiles to all appropriate waters in the watershed; and, (5) monitor the aquatic fauna of the watershed following treatment and restoration actions.

Prevention of nonnative fish reinvasion is critical to the long-term success of Redrock Canyon aquatic ecosystem restoration. The fish barrier is an important measure to secure the western end of the project area against nonnatives invading from downstream. Other potential routes of reinvasion, such as stock tanks, would be addressed by proposed piscicide and mechanical treatments and by the continuation of Forest Service land and water management practices, which incorporate the recommendations and requirements of several biological opinions and the CNF *Stockpond and Aquatic Habitat Management and Maintenance Guidelines for the Chiricahua Leopard Frog*.

2.2.1 Fish Barrier

Site Selection. Potential sites for a constructed barrier were identified during on-the-ground surveys by fishery biologists from Reclamation, the Forest Service, AGFD, FWS, and biologists knowledgeable of Redrock Canyon and its aquatic fauna. Only sites in the lower drainage were considered in order to maximize the length of stream protected and minimize fragmentation of the resident population of Gila topminnow. A site approximately 4.25 miles upstream of the confluence with Sonoita Creek and 1 mile upstream from the CNF boundary was determined by Reclamation to be geologically suitable for placement of a barrier (Figures 3 and 4).

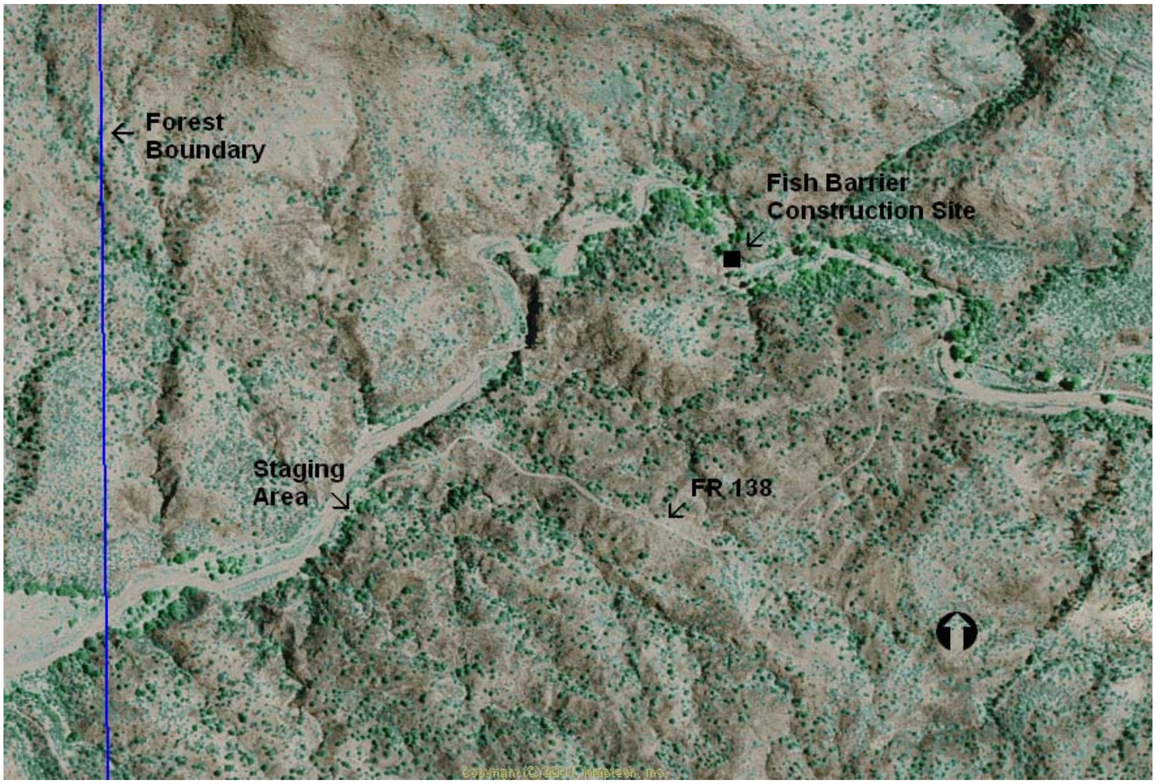

Figure 3. Proposed fish barrier construction site and staging area.

The proposed barrier would protect an estimated additional 7 miles of stream habitat from invasion by nonnatives compared to the area currently protected by natural barriers (see Alternative A). Approximately 1.5 miles of this additional habitat includes a near-perennial reach which historically has provided habitat for Gila topminnow and other native fishes (especially speckled dace and desert sucker). Protection of the more ephemeral stream reaches behind the barrier, which include short reaches of perennial water, would allow populations of Gila topminnow and other aquatic organisms to increase should a genetic bottleneck[7] occur, which is often the case during severe drought. Population expansion during favorable (wet) watershed conditions may prevent fixation of deleterious genetic variants that are often typical of small populations. Such "genetic rescue"[8] is an important element in the conservation of rare species (Hedrick 1995, Ingvarsson 2001). The additional stream length protected behind the constructed barrier will enhance metapopulation[9] dynamics for all species, thereby benefitting population genetics and population persistence.

Fish Barrier Construction. A reinforced poured-concrete drop structure would be constructed in a 10-foot-wide bedrock constriction of the channel located within the West Redrock Exclosure. The barrier would be anchored to abutment bedrock and keyed into

[7] When population numbers are temporarily reduced to a level insufficient to maintain the genetic diversity in the population
[8] An increase in population fitness owing to immigration of new alleles
[9] A set of local populations within some larger area, where typically migration from one local population to another is possible

the channel alluvium to ensure stability against water-transported debris and erosive forces typically associated with high magnitude flows. Placement of the keys and rock gabions would require excavation of a temporary 7-foot-deep trench in the channel alluvium between the bedrock abutments. Stream flow, if present, would be diverted around the trench during construction.

The proposed fish barrier would consist of five primary features (see Appendix C, Figure C-1 and C-2): (1) a 5-foot-high concrete drop structure to preclude upstream incursion of fishes; (2) secondary 1- to 3-foot-high concrete walls to fill low spots in bedrock along the left and right abutments; (3) a 10-foot-wide concrete apron spanning the length of the drop structure to prevent streambed scour and plunge pool development; (4) upstream and downstream keys to help anchor the barrier and prevent scour from undermining the structure; and, (5) gabion or riprap armoring across the entire width of the streambed along the upstream and downstream keys.

Placement of the keys and gabions or riprap would require excavation of a temporary 7-foot-deep trench in the channel alluvium between the bedrock abutments. Stream flows would be diverted around the trench, and one or two 10-foot-deep dewatering wells would be installed to keep the trench dry during construction. Construction would require minimal travel of small equipment, such as a backhoe and truck-mounted drill rig, over 0.7 miles of stream channel. A single vehicle would be parked at the barrier site during construction for emergency use in the event of injury, or for occasional transport of food, water, and construction supplies. Construction personnel would walk to the site from the existing road or staging area, and vehicles would not be used in the riparian corridor for routine transport of personnel. This area is presently used by vehicles only in its lower end on a sporadic basis. Earlier routes of Forest System Road (FSR) 138 through Redrock Canyon have used all or part of this section of stream channel. Concrete would be hauled from commercial off-site batch plants and transported to the site by helicopter. At the completion of barrier construction, the channel would be rehabilitated by obliterating vehicle tracks and recontouring of some areas, if necessary.

Primary staging of machinery and equipment would occur on one of two benches above the stream, adjacent to the FSR 138 low-water crossing (Figure 3). Staging activities would include unloading and storage of materials and supplies, equipment storage, and parking. The staging area would not exceed 1/2 acre in size. Temporary lay down of construction materials may occur on the terrace on the north side of the stream at the barrier site, but hazardous materials would not be stored there. Total disturbed area at the barrier site is expected to be approximately 0.12 acres. All reasonable efforts would be made to minimize removal of trees, and site rehabilitation would occur following project completion. The volume of construction traffic is expected to be low, and no disruption of public access is anticipated. Construction would require approximately 1.5 months.

Inspection and maintenance of the fish barrier would be necessary on a periodic basis, particularly following significant flooding. The Forest Service would be responsible for first-line inspection following flood events, and CAWCD would be responsible for maintenance.

2.2.2 Native Species Salvage

The AGFD has statutory authority to manage fish and wildlife resources of Arizona and ultimately would approve and oversee activities associated with native species salvage, bullfrog control, and native fish, amphibian, and aquatic reptile transplant. Native species salvage would begin several days prior to application of antimycin and/or rotenone.

Currently, there are three captive populations of Gila topminnow derived from individuals taken from the Cott Tank drainage and Falls area in 2002. Because of the strong resemblance between Gila topminnow and nonnative mosquitofish, any salvaged fish believed to be Gila topminnow would be quarantined in aquaria for absolute identification before being added to existing captive stocks. Identification of each individual Gila topminnow would be confirmed at both the salvage and release of quarantine stages by independent inspections by at least three biologists knowledgeable of, and with substantial experience in, discrimination of Gila topminnow from mosquitofish. Individuals would be released from quarantine only after they attain sufficient size for adequate identification (>40 mm). After the two-stage quarantine and identification process, salvaged Gila topminnow would be placed into captivity at a location(s) yet to be determined. Fish identifications would be confirmed by at least two biologists knowledgeable of, and experienced with, these species at the time of salvage and again before these fish are restocked into any natural habitat.

Chiricahua leopard frog is the only native ranid frog known from the Redrock Canyon watershed. Before application of piscicides, efforts would be made to locate and salvage Chiricahua leopard frogs. Any individuals salvaged, of any life stage, would be removed to a temporary holding facility, either on site or at an appropriate AGFD-approved facility elsewhere. Identification upon salvage and upon release from quarantine would be confirmed by at least two biologists knowledgeable of, and experienced with, identification of these species and their discrimination from bullfrogs.

Prior to application of piscicides, salamanders would be salvaged and placed into a temporary holding facility, either on site or at an appropriate location elsewhere. Any stock tank with water present would be sampled prior to piscicide application to test for salamander presence. Salamanders from each tank would be held separately because of the inability to make definitive identifications as to subspecies. No salamanders would be returned to the wild until their subspecific identification has been confirmed by genetic analysis.

Sonora mud turtles are common native occupants of waters of Redrock Canyon. There is some indication that rotenone is toxic to freshwater turtles (Fontenot et al. 1994; McCoid and Bettoli 1996). During salvage operations for fish, frogs, and salamanders in Redrock Canyon, Sonora mud turtles would be salvaged and held in temporary holding facilities, either on site or at an appropriate location elsewhere.

Mexican gartersnake is a possible, but unverified, inhabitant of the cienega-like habitats of upper Redrock Canyon and Cott Tank drainage. If individuals are found during project activities, they would be salvaged and placed into holding facility identified by AGFD.

Salvaged native species would be captured using a combination of dip nets, seines, hoop nets, minnow traps, electrofishing, and other appropriate techniques. Fish, tadpoles, and larval or branchiate adult salamanders would be transported from the site of capture to holding tanks via 2- or 5-gallon buckets containing stream water and battery-powered air stones. Adult frogs, turtles, gartersnakes, and metamorphosed salamanders would be transported in buckets or other containers. Location of salvage holding facilities for longfin dace, desert sucker, speckled dace, and native amphibians cannot be specifically identified at this time. Temporary holding in aerated tanks or soft-sided swimming pools may occur on site. Although detoxification of the stream would occur within a week, not all salvaged fish and amphibians may be returned immediately, depending on water conditions and continued presence of bullfrogs or other nonnative animals in Redrock Canyon. If longer-term holding is required, stocks may be transferred to appropriate holding facilities.

Water for temporary on-site holding facilities may be obtained from the stream, from water transported in from elsewhere, or from groundwater from an area well. All water placed into the holding facilities would be screened with fine mesh to ensure that no nonnative fish or amphibians are inadvertently introduced into the holding facilities. Any water transported from outside the basin would be from a source that is guaranteed free of nonnatives and pathogens, such as groundwater or treated water. All holding site facilities and equipment would be treated in accordance with protocols in the Chiricahua leopard frog recovery plan (FWS 2007) to prevent the spread of chytrid fungus and other diseases.

2.2.3 Nonnative Fish and Frog Removal

Nonnative fish and frogs would be eradicated from all surface waters in Redrock Canyon using an integrated approach (Dawson and Kolar 2003) that includes several removal techniques combined with invasion preventatives and management to reduce the risk of invasion. Two of the target nonnatives, mosquitofish and bullfrogs, have been known to move throughout the watershed using small, isolated, temporary waters; therefore, all surface waters, including stock tanks (Figure 4), located upstream of the constructed fish barrier would be subjected to nonnative removal efforts.

Nonnative removal would also occur in two earthen stock tanks in Meadow Valley and any surface waters in the Meadow Valley drainage upstream of those tanks. Although the natural drainage of these tanks is a south trending tributary of the Santa Cruz River, they presently drain to Cott Tank in upper Redrock Canyon watershed via a constructed ditch and are thus an artificial "captured" portion of the Redrock Canyon watershed. This part of Meadow Valley would be in the treated area. Interbasin diversions from Meadow Valley to other pipelines and troughs or tanks within the Redrock watershed would be inspected and a determination made as to whether or not they require treatment and nonnative removal. Other imports of water from outside the watershed (i.e. in upper Box Canyon and in Oak Grove Spring Canyon) would also be identified, inspected, and included in treatment, as necessary.

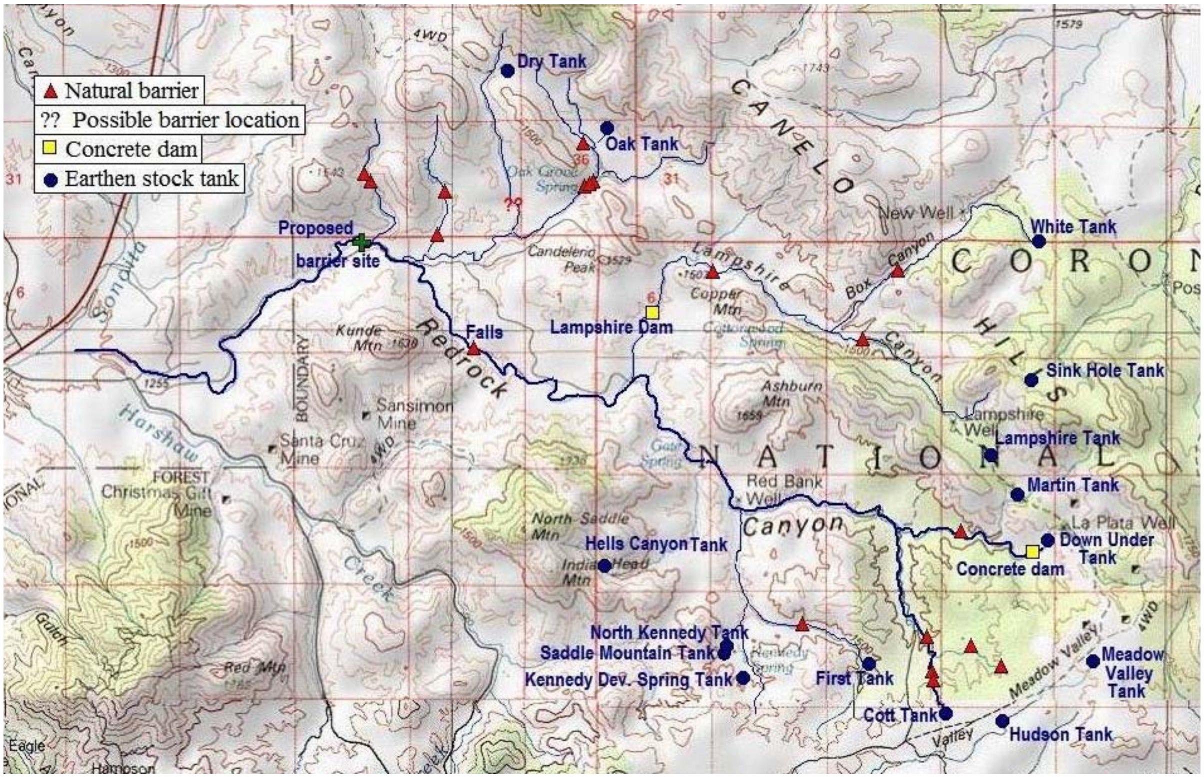

Figure 4. Stock tanks in the Redrock Canyon watershed.

Piscicide would be applied to all surface waters in accordance with the specifications of a Pesticide Use Proposal approved by the CNF Supervisor prior to application. Rotenone and antimycin A would both be used. Rotenone would be used in pools and tanks where it is more effective than antimycin A because it is less susceptible to detoxification by sediment, organic matter, aquatic vegetation, and light. Antimycin A would be used for areas of flowing water or in areas where piscicide may need to be applied in areas distant from a road. Antimycin A and rotenone are Environmental Protection Agency (EPA)-registered piscicides that have been in widespread use in fisheries management (Meronek et al. 1996; Allen et al. 2006; also see Appendix D for annotated list of projects in Arizona that have used antimycin A).

Total eradication of all nonnative fish is the objective. Some death of bullfrog tadpoles and eggs is expected, although because of their resistance to the piscicides, total eradication is not likely. Bullfrog tadpoles and eggs would be manually removed during salvage, piscicide application, and monitoring, then euthanized. Adult bullfrogs are not likely to be significantly affected by piscicides. Some would be captured by netting or gigging, while others would be dispatched mechanically, using firearms or other means.

Both piscicides act at the cellular level to interrupt respiration in gill-breathing organisms and are nontoxic to humans and other non-gill-breathing organisms when applied at recommended concentrations. See Appendix E for detailed information on these piscicides. Rotenone would be used in the form of one of several commercially available powdered or liquid formulations. Antimycin would be used in the commercial formula Fintrol® concentrate (liquid form of antimycin A) and Fintrol® 15 (antimycin A-coated sand).

A certified pesticide applicator would be present during all piscicide applications. All product label requirements and safety precautions would be followed. Piscicides would be applied using a variety of methods depending on surface water conditions. If areas of continuous flow are present, drip station applications would be used (Stefferud and Propst 1996; Weedman et al. 2005). In isolated pools and tanks, piscicide would be applied by backpack or shore-mounted sprayers or by bucket. Mechanical agitation may be used to mix pooled water, where appropriate. Antimycin-coated sand would be spread over the water surface in deeper (>3 feet) areas. Concentrations of piscicide used would be within label directions, and application rates would be determined by estimates of pooled water volume or stream discharge in combination with bioassays that would determine the precise minimum dosages required to kill the target organisms. Application rates would be sufficient to maintain piscicide at toxic levels for a contact time of 8 hours for antimycin and 16 hours for rotenone (Gilderhus 1972). Effectiveness would be monitored by use of live cages containing locally captured mosquitofish (and any other nonnative fish present at the site) and bullfrog tadpoles in each pool, tank, or area of flow.

To ensure effectiveness of the treatment, a second piscicide application to all waters would occur within 2 weeks of the first treatment. Additional applications up to 4 years later may occur, depending on monitoring results.

Several stock tanks known to support high density of bullfrogs would be pumped down or dried completely, and all nonnative aquatic species found would be manually removed. These mechanical treatments to control bullfrogs would be repeated as necessary for up to 4 years.

The project area is lightly used by the public but would be signed in English and Spanish at key access points to notify users of considerations necessary to avoid exposure to treated waters. Reclamation and the Forest Service would work with permittees with livestock on the four allotments within the project area (Seibold-Crittendon, Kunde, Papago, and San Rafael) to avoid any impacts to cattle or disruption to grazing operations.

No disposal of dead fish and frogs is expected to be necessary. The volume of carcasses is anticipated to be small and would disappear within hours because of scavengers, desiccation, and decay. However, if necessary, disposal would be by on-site burial.

No neutralization is expected to be necessary, unless needed to expedite return of salvaged Sonora tiger salamanders and Chiricahua leopard frogs. Potassium and sodium permanganate, which are acceptable chemicals for detoxifying rotenone and antimycin-A (Marking and Bills 1975), would be available on site during all piscicide application in case it is needed. Unless during application, surface water is flowing from inside the treatment area into other areas (i.e., downstream of the CNF boundary), no neutralization would be used. Detoxification would be allowed to occur through natural oxidation. Detoxification, either natural or chemical, would be determined using sentinel cages containing native fish and/or amphibians.

2.2.4 Restoration of Native Fish and Amphibians

Following successful nonnative removal, native fishes, Chiricahua leopard frog, Sonora tiger salamander, Sonora mud turtle, and Mexican gartersnake would be repatriated into Redrock Canyon.

Gila topminnow. If any Gila topminnow are found during salvage they would be returned to the stream in the area of their capture following quarantine and a determination of treatment detoxification. Additional fish from captive populations of the species from Redrock Canyon would be restocked into Redrock Canyon watershed after the treatment area has been detoxified. If sufficient surface water to support Gila topminnow does not exist, the species would be stocked as soon as sufficient surface water becomes available. Population augmentation stocking would occur in all areas until a stable population has been established.

Restocking would follow standard procedures of the ongoing Gila topminnow recovery program.

Longfin dace. Longfin dace removed during salvage would be returned to the stream in the area of their capture following a determination of treatment detoxification. If less than 400 longfin dace are available from salvaged individuals, additional fish would be obtained from Harshaw Canyon, to which Redrock Canyon is confluent. Longfin dace taken from Harshaw Canyon would be quarantined and triple sorted by experienced individuals to ensure that no mosquitofish (which are present in Harshaw Canyon) are accidentally transported into Redrock Canyon. All transport water would be obtained from a guaranteed nonnative free source. Pathogen testing would not be necessary for Harshaw Canyon fish because they are from a source with frequent episodic connection with Redrock Canyon. Augmentation stockings may be repeated until a self-sustaining population is established

Desert sucker. Desert sucker removed during salvage would be returned to the stream in the area of their capture following a determination of treatment detoxification. It is unlikely that many desert sucker would be found during salvage; therefore, reintroduction would be made from stocks obtained from Sonoita Creek (either above or below Patagonia Dam). Fish taken from Sonoita Creek would be quarantined and triple sorted by experienced individuals to ensure that no nonnative fish (several are present in Sonoita

Creek) are accidentally transported into Redrock Canyon. All water used to transport fish would be from a guaranteed nonnative-free source. Pathogen testing would be conducted on desert sucker if obtained below Patagonia Dam; and, if necessary, appropriate treatment would be given to ensure that the possibility of disease transmission is minimized. Augmentation stocking may occur until a self-sustaining population is established.

Speckled dace. If any speckled dace are found during salvage, they would be returned to the stream in the area of capture following a determination of treatment detoxification. In addition, speckled dace would be restocked using fish obtained from Sonoita Creek above Patagonia Lake. Speckled dace taken from Sonoita Creek would be quarantined and triple sorted by experienced individuals to ensure that no nonnative fish (several are present in Sonoita Creek) are accidentally transported into Redrock Canyon. All water used in fish transport would be from a guaranteed nonnative-free source. Pathogen testing would not be necessary for Sonoita Creek fish obtained above Patagonia Lake, because they are from a source with frequent episodic connection with Redrock Canyon. Augmentation stocking may occur until a self-sustaining population is established.

Gila chub. Although there no records of Gila chub in Redrock Canyon, cienega habitats in Cott Tank drainage are similar to those in other occupied locations, such as Sheehy Spring where Gila chub thrive and historically coexisted with Gila topminnow. Given completion of other required regulatory processes and dependent upon assessment of habitat suitability and feasibility, establishment of Gila chub into locations within the Redrock Canyon watershed may occur as part of this project. Provided that sufficient surface waters are present, Gila chub would be introduced into appropriate waters of Redrock Canyon, particularly the cienega pools in the Cott Tank drainage, following removal of nonnatives. The source and quantity of Gila chub to be reintroduced into Redrock Canyon would be determined as part of the recovery program for the species, but would be from within the Santa Cruz River subbasin. Because the chub is a federally listed species, ESA Section 7 consultation must be completed, and any subsequent provisions of the biological opinion would be incorporated into the proposed project.

Chiricahua leopard frog. Chiricahua leopard frogs salvaged prior to treatment would be released back into the wild near the site of capture following a determination of detoxification and appropriate habitat conditions. Feasibility of augmentation of that population or restoration of Chiricahua leopard frog into other areas of the Redrock Canyon watershed has not yet been fully explored. Additional review is necessary to identify the highest priority sites and sources and mechanisms of transplant stock. Such efforts would be in accordance with the transportation and release protocols established in the recovery plan. Because the Chiricahua leopard frog is a federally listed species, ESA Section 7 consultation must be completed, and any subsequent provisions of the biological opinion would be incorporated into the proposed project.

Sonora tiger salamander. Sonora tiger salamander salvaged prior to treatment would be released back into the wild near the site of the capture following a determination of detoxification and appropriate habitat conditions. Redrock Canyon is outside what was formerly thought to be the limits of its historic range, and recent confirmation of salamanders discovered in Oak Tank as *Ambystoma tigrinum stebbinsi* has not yet been followed up with a thorough analysis of the potential for the species within the Redrock Canyon watershed. Expansion of Sonora tiger salamander into other areas of Redrock Canyon may occur as part of this project, depending upon assessment of habitat suitability and feasibility. These actions would be guided by the recovery plan. Because the Sonora tiger salamander is a federally listed species, ESA Section 7 consultation must be completed, and any subsequent provisions of the biological opinion would be incorporated into the proposed project.

Sonora mud turtle. Sonora mud turtles salvaged during pre-treatment work would be returned to the wild near the site of capture following a determination of detoxification.

Mexican gartersnake. Mexican gartersnakes that are salvaged during pre-treatment would either be returned to the wild near the site of capture or would be retained in captivity for breeding purposes. Upon attainment of sufficient captive stock, or using stock obtained from another appropriate source, Mexican gartersnake would be translocated into suitable habitats in Redrock Canyon watershed.

2.2.5 Monitoring

Following the initial treatment, an intensive monitoring effort would target all waters within Redrock Canyon and Meadow Valley watersheds to which piscicide or other removal methods were applied. Methods would include visual observation, dip nets, minnow traps, seines, and other nets, electrofishing, and any other appropriate techniques. Monitoring would be conducted in cooperation with AGFD and FWS. The primary purpose of the monitoring would be to detect the presence or absence of nonnative fish and bullfrogs, but also to document presence/absence, relative abundance, reproduction, and recruitment of native fish, Chiricahua leopard frog, and Sonora tiger salamander.

Following the initial 2 years' post-treatment, fish monitoring would continue as spring or early summer monitoring conducted by AGFD as part of the Gila topminnow recovery program monitoring. Supplementing these existing efforts, additional monitoring of other surface waters of the basin and those of Meadow Valley drainage included in the treatment would occur at least once every other year when resources and funding are available. Monitoring of stock tanks within Redrock Canyon watershed and those in Meadow Valley that are presently diverted into Redrock Canyon also would be conducted to detect nonnatives.

2.3 ALTERNATIVE A - NONNATIVE REMOVAL AND NATIVE RESTORATION WITHOUT BARRIER

Under this alternative, no artificial barrier would be constructed. This would leave areas downstream of the natural barrier at the Falls open to invasion of nonnative fish from downstream in Sonoita Creek (Figure 4). Therefore, under this alternative, nonnative aquatic species would be removed from the watershed only upstream of the existing natural barrier at the Falls and upstream of a set of natural barriers in upper Oak Grove Spring Canyon. The project area under Alternative A would differ from the Proposed Action in that about 1.6 miles of lower Redrock Canyon proper below the Falls, 2.2 miles of lower Oak Grove Spring Canyon, 1.8 miles of Oak Grove Spring Canyon tributaries, 1.4 miles of an unnamed tributary to lower Redrock Canyon, and one stock tank (Dry Tank) would be omitted. Other than this difference in area to be included in the project, the parameters would be the same as those outlined in Sections 2.2.2 to 2.2.5 of the Proposed Action.

Under Alternative A, native fish and amphibians would be restored into all suitable habitats in that portion of the watershed upstream of the Falls and in any suitable areas above the natural barriers in Oak Grove Spring Canyon. Restoration actions would follow the same parameters described in Section 2.2.4 of the Proposed Action, except that native species would not be restocked into any waters present in the 7 miles of Redrock Canyon and tributaries between the proposed artificial barrier site and existing natural barriers.

Monitoring under Alternative A would have the same parameters as under the Proposed Action but would not include the omitted area.

2.4 MITIGATION FOR ACTION ALTERNATIVES

Mitigation measures are prescribed to avoid, reduce, or compensate for adverse effects of an action. The following measures will be implemented for the action alternatives, as noted:

- Standard dust abatement best management practices (BMPs) will be used to minimize generation of airborne particulates during fish barrier construction (Proposed Action).

- Sediment and erosion controls will be established where appropriate to protect water quality and soils during and after fish barrier construction (Proposed Action).

- A Clean Water Act (CWA), Section 401, Water Quality Certification has been issued by the Arizona Department of Environmental Quality (ADEQ) for fish barrier construction. Terms and conditions of the certification will be integrated into the project (Proposed Action).

- Reclamation received a programmatic CWA, Section 404, permit from the U.S. Army Corps of Engineers (COE) to construct fish barriers required under the CAP biological opinion. Terms and conditions of the 404 permit will be implemented to reduce adverse effects to water quality during construction. Mitigation for impacts to vegetation was previously implemented by Reclamation for Redrock Canyon and all other Arizona fish barriers proposed under the 2001 CAP biological opinion. This mitigation consisted of acquisition of a Conservation Easement on 1,420 acres of land along the San Pedro River in southern Arizona, in cooperation with The Nature Conservancy.

- A CWA, Section 402, Stormwater Pollution Prevention Plan, which specifies pollution-control BMPs has been prepared for fish barrier construction. Coverage under the Arizona Pollutant Discharge Elimination System (AZDPES) general permit for storm water discharges associated with fish barrier construction will be obtained (Proposed Action).

- A Water Control Plan will be prepared with measures to protect water quality and care of the stream during fish barrier construction (Proposed Action).

- Concrete used in barrier construction will be visually compatible with the colors of surrounding substrates (Proposed Action).

- Signs of vehicle access to the barrier site will be obliterated following construction (Proposed Action).

- All reasonable effort will be made to avoid the removal of any trees along the access route to the barrier site and at the staging area (Proposed Action).

- Key public access points to Redrock Canyon will be posted in English and Spanish prior to application of the piscicide (both action alternatives).

- The Forest Service's Pesticide Use Proposal will clearly prescribe strict adherence to piscicide labels (both action alternatives).

- Piscicide applications will be conducted only during periods of low stream flow by certified applicators (both action alternatives).

- Stock pond treatments (pumping and piscicide applications) will be timed to avoid impacting livestock (both action alternatives).

- Alternative water sources will be provided, as appropriate, for livestock affected by pumping of stock tanks or pools or stock tank reconfiguration (both action alternatives).

- All construction equipment will be periodically inspected for leaks, which will be promptly corrected (Proposed Action).

- Hazardous substances and fuels will be stored outside the 100-year floodplain of Redrock Canyon (Proposed Action).

2.5 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS

Three alternatives were considered but eliminated from detailed analysis for various reasons.

- *Other fish barrier locations* -- To be effective, a fish barrier on Redrock Canyon must be located as far downstream as feasible to maximize the area protected and avoid leaving significant portions of Redrock Canyon available to harbor nonnatives, thus giving them a higher probability for successful reinvasion. Important native species habitat is located in the stream reach in the West Redrock Exclosure, the reach below Pig Camp Spring, and the central portion of Oak Grove Spring Canyon (see Figure 2). To protect those areas, the barrier must be located downstream near the CNF boundary. Failure to protect those areas of stream would not fully meet the purpose and need.

  Reconnaissance-level field investigations of possible barrier sites in Redrock Canyon were conducted by fishery biologists from Reclamation, the Forest Service, AGFD, FWS, and biologists knowledgeable of Redrock Canyon and its fishes. No technically suitable barrier sites occur downstream of where the canyon widens considerably near the CNF boundary. Selection criteria for barrier sites between that point and the existing natural barrier at the Falls were: (1) the presence of a narrow bedrock channel in which to solidly anchor the barrier and minimize site impacts, (2) access that minimizes adverse impacts to the stream, and (3) proximity to the lowermost end of known native fish habitat to provide the maximum benefit. No sites meeting those criteria were found other than the site in the Proposed Action.

- *Fish barrier without nonnative removal and native species restoration* -- This alternative would provide for construction of a fish barrier but would not remove the nonnative species present upstream from the barrier and would not restore populations of native fish and amphibians either through repatriation of extirpated species or expansion of existing populations of extant species. This alternative was not considered in detail because it fails to meet the purpose and need of this project. The continued presence of nonnative species within Redrock Canyon carries a high probability of complete extirpation of the only remaining native fish (Gila topminnow), Chiricahua leopard frog, and Sonora tiger salamander. Construction of a barrier without removing the existing nonnatives make the barrier essentially purposeless, as it would function only to prevent incursion of additional nonnative species and would do nothing to reverse negative impacts of nonnatives already present within the watershed.

  This alternative would not fulfill Reclamation's commitments under the 2001 revised and 1999 draft CAP biological opinions.

- *Stock tank breaching* -- Stock tanks are usually accessible by road and invite human use. They are an attractive nuisance[10] that provides the opportunity for people to stock nonnative fish or amphibians they find desirable or to dump unwanted pets or ornamental animals. Artificial waters such as these also provide stepping stones that enable nonnative species, such as bullfrogs, to move across an otherwise dry landscape between natural surface waters (FWS 2007). When stock tanks are deemed necessary for other management objectives, such as livestock grazing, they can be managed both to meet the needs of the livestock operator and concurrently provide useful habitat, albeit artificial, for some native aquatic species. Because the stock tanks in the Redrock Canyon watershed are currently managed to minimize the risk of reinvasion by nonnatives, breaching was considered unnecessary at this time and eliminated from further consideration as an element of the proposed project.

[10] "Attractive nuisance" is a legal term referring to a potential harmful situation that is sufficiently inviting or interesting; it attracts a person who does not understand the risk (usually referring to a child) into taking dangerous actions.

2.6 COMPARISON OF ALTERNATIVES

Table 4. Summary of environmental consequences by alternative.

RESOURCE	ALTERNATIVES		
	NO ACTION	PROPOSED ACTION	ALTERNATIVE A
Water Resources	No effect.	Short-term sediment increases during barrier construction. Short-term impact to surface waters scattered throughout about 30 miles of stream channel from piscicide application.	Short-term impact to surface waters scattered throughout about 23 miles of stream channel from piscicide application.
Vegetation	No effect.	Short-term, minimal effects to 0.02 acres of riparian vegetation at barrier site. Short-term effects to 0.1 acre of previously disturbed vegetation at staging area.	Long-term benefits to native vegetation at selected stock tanks.
Terrestrial Wildlife	No effect.	Short-term disturbance and possible incidental death at barrier and staging areas. Long-term improvement in riparian community at barrier site. Minor disturbance during other activities. Possible loss of public access to water at selected stock tanks.	Minor disturbance during other activities. Possible loss of public access to water at selected stock tanks.
Fish and Aquatic Wildlife	Continued negative impacts to all aquatic wildlife from nonnatives. Potential for future invasion of additional nonnative species. Probably extirpation of longfin dace, speckled dace, and desert sucker and preclusion of their recovery in project area. Continued high risk from introduction and spread of nonnatives through stock tanks.	Expansion of populations of five native fishes in scattered habitats throughout about 30 miles of stream channel. Stabilization or improvement of populations of canyon treefrog, black-necked gartersnake, Mexican gartersnake, and Sonora mud turtle. Mortality of some native fish, amphibians, and turtles from piscicide use. Protection of these populations against nonnative reinvasion.	Expansion of populations of five native fishes throughout about 23 miles of stream channel. Stabilization or improvement of populations of canyon treefrog, black-necked gartersnake, Mexican gartersnake, and Sonora mud turtle. Mortality of some native fish, amphibians, and turtles from piscicide use. Protection of these populations against nonnative reinvasion.
Special Status Species	Continued negative impacts to federally listed and sensitive aquatic wildlife from nonnatives. Potential for future invasion of additional nonnative species. Gila topminnow, Chiricahua leopard frog, and Sonora tiger salamander likely to be extirpated from Redrock Canyon.	Implementation of recovery plan recommendations for three species. Short-term adverse effects at barrier, including possible incidental take of Gila topminnow. Some mortality of all aquatic species because of piscicide use. Expansion of populations of Gila topminnow, Chiricahua leopard frog, and Sonora tiger salamander	Partial implementation of recovery plan recommendations for three species. Some mortality of all aquatic species from piscicide use. Expansion of populations of Gila topminnow, Chiricahua leopard frog, and Sonora tiger salamander populations in appropriate habitats throughout portion of the

	Gila chub is not restored to watershed.	populations in appropriate habitats throughout watershed. Protection of these populations against nonnative reinvasion. .	watershed. Protection of these populations against nonnative reinvasion.
Cultural Resources	No effect.	No effect.	No effect.
Livestock Grazing	No effect.	No effect.	No effect.
Recreation and Visual Resources	No effect.	With the proposed mitigation, the project would have minimal effects to recreation and would meet Visual Quality Objectives.	No effect.
Soils	No effect.	Approximately 0.12 acres of alluvial soils affected during construction of the fish barrier. Post construction sediment deposition on 1,475 feet of channel unpstream of the barrier. Low impact from foot traffic associated with stream renovation	Low impact from foot traffic associated with stream renovation
Air Quality	No effect.	Highly localized minor effect during construction resulting from fugitive dust and engine emissions.	No disturbance of air quality.

CHAPTER 3 – ENVIRONMENTAL CONSEQUENCES

This chapter presents the existing conditions in the project area and the environmental consequences that would result from no action and from implementation of either the proposed action or alternative A. The description of the affected environment and the impact analyses that follow are based on the best scientific information available.

3.1 WATER RESOURCES

3.1.1 Affected Environment

Average annual precipitation in the area of the project is 18 inches; however, daily precipitation is highly variable and can be greater than 4 inches (Sellers and Hill 1974). Precipitation is primarily rain, but some snow may occur at the higher elevations. The precipitation pattern is a bimodal monsoonal pattern, with winter storms originating in the northern Pacific Ocean and summer storms resulting from convective thunderstorms that form from moisture drawn into the region from the Gulf of Mexico and the Gulf of California.

Hydrology and Geomorphology. Redrock Canyon is a major tributary of Sonoita Creek, comprising approximately 15% of the drainage area above the Sonoita Creek gaging station (USGS gage #09481500), which is located 8 miles downstream of Patagonia. There is no discharge gage in Redrock Canyon. The collection of daily stream flow data at the Sonoita Creek gage was discontinued in 1972, although peak flows were recorded at this gage in 1977 and 1983. Peak flow for the period of record[11] was 16,000 cubic feet per second (cfs), recorded in October 1983. Mean annual discharge for the period of record was 8 cfs. Flood reoccurrence estimates are 3,130 cfs for a 2-year event, 7,190 cfs for a 10-year event, and 15,100 cfs for a 100-year event (Pope et al. 1998).

The Redrock Canyon watershed is approximately 8 miles long and 5 miles wide (Figure 2). It is bounded on the north and east by the Canelo Hills, on the south by the Patagonia Mountains, and the north edge of the San Rafael escarpment. The expansive interior supports a moderately complex network of drainages among moderate to steeply sloping ridges. The mainstem of Redrock Canyon proper is approximately 12 miles in length. There are two major tributaries inflowing from the south: Cott Tank drainage, which is about 1.75 miles long, and the unnamed tributary containing Kennedy Spring, which is approximately 3 miles long. Two major northern tributaries originate on the slope of the Canelo Hills, then run on a northwest/southeast axis behind a subsidiary ridge of the Canelo crest before turning abruptly to drop through short bedrock canyons into the main basin. The most upstream of these is Lampshire Canyon, with about 4.5 miles of mainstem and several tributaries, including Box Canyon, about 2.25 miles long. The second is Oak Grove Spring Canyon, with a mainstem of about 2.25 miles below the bedrock canyon and about 3 miles upstream in two main forks. Oak Grove Spring

[11] The period of record for gage #09481500 is 1930-1933, 1935-1972, 1977, and 1983.

Canyon has two main tributaries downstream of the bedrock canyon, both unnamed, one about 2 miles in length and the other about 1.25 miles.

Most of the stream channels within the Redrock watershed are of low to moderate gradient. In the reach of Redrock Canyon that includes the barrier, the gradient is approximately 0.6%. The stream channel in that location is a bedrock sill with a braided channel through coarse sediment (gravel, cobble, boulder) upstream (Figure 5). A few streamside terraces with deposited soils exist in this reach of Redrock Canyon, but most of the channel is spatially unstable and reestablishes a new channel with each significant flood event.

Figure 5. Downstream view of proposed fish barrier site (photo courtesy of S.E. Stefferud).

Water Quantity and Quality. Anecdotal information from local ranchers indicates that Redrock Canyon historically supported more surface water and perennial streamflow than at present. Draining of the large cienega at the confluence of Harshaw, Redrock, and Sonoita creeks in the mid-1800s likely contributed to depletion of surface water in Redrock Canyon and downcutting of the channel (Hendrickson and Minckley 1984; Davis 1986). Agricultural activity may have played a role in destabilization of the terraces, removal of riparian vegetation, channel erosion, and subsequent reduction of perennial flow. Perennial surface water is now restricted to a few isolated areas. The size of these areas has constricted considerably since the mid-1990s because of extended drought in the area.

Over the past 15 years, perennial water has been found at Falls, Gate Spring, Cott Tank drainage, and Pig Camp Spring. As a result of increased bank storage in Cott Tank drainage following exclosure from livestock grazing in 1992, water is now perennially present in Redrock Canyon below its confluence with Cott Tank drainage. Surface water has usually also been present in the West Redrock Exclosure and in the springs/bedrock canyon area of Oak Grove Spring Canyon. After livestock were removed from the Kunde allotment in 1997, riparian vegetation developed along some reaches, and a new area of semi-perennial flow arose about 0.25 miles upstream of Redrock Ranch on the border of Sections 7 and 12 (Figure 2). By June 2001, there was 850 feet of surface flow, gradually diminishing to only 150 feet in October 2005 and disappearing by October 2006. Surface water is also usually found at several springs within the watershed.

The drought that began in the Southwest about 1995 has substantially reduced the amount of surface water in Redrock Canyon watershed. Some areas that had water year-round in the early 1990s may now occasionally be dry; and, where surface water persists, it is significantly reduced in extent. Despite good precipitation in 2000-2001, which prompted long periods of continuous flow through the mainstem, accumulating effects of the drought have resulted in loss of most of the water that supported native fish during the late 1970s to early 1990s when the majority of existing fish data were being gathered. The presence of native fish above barriers in Redrock Canyon and Cott Tank drainage indicates these areas have always retained enough surface water to support aquatic life even during earlier extended droughts, such as the late 1800s or the 1950s.

In June 2006, significant surface water existed in Redrock Canyon only in a few stock tanks, in Cott Tank drainage, and in Redrock Canyon within the Cott Tank exclosure downstream of the confluence with Cott Tank drainage. Table 2 depicts water conditions in the stream in June 2006. Strong summer rains in July through September 2006 likely increased the presence of surface water to some extent; but, in general, summer precipitation does not result in long-term enhancement of base flows.

Complex water systems have been constructed within the Redrock Canyon watershed to transport water long distances to service livestock. In addition to the 17 stock tanks, approximately 20 wells exist, although some may no longer be in use. Approximately 15 miles of pipeline feed water to many troughs throughout the drainage. About half a dozen trick tanks capture water in various locations. Some water is imported into the Redrock Canyon watershed from wells in the Meadow Valley, Cienega Creek, and Babocomari watersheds to serve livestock troughs in upper Redrock Canyon, portions of Oak Grove Spring Canyon, and upper Box Canyons. The Forest Service reports that imported water all originates from groundwater with no contact with surface water outside of Redrock Canyon, thus eliminating any potential for transport of nonnative aquatic vertebrates (pers. comm., Bill Edwards, Coronado National Forest, Sierra Vista Ranger District, September 2006).

Although the present scarcity of surface water is a major detriment to native fish and amphibians, it provides optimum conditions for removal of nonnative fishes. Reduced volume of water and elimination of marshy areas substantially reduces the complexity of application of piscicides and other control methods.

Table 2. Water conditions in Redrock Canyon stream and springs (excluding stock tanks), June 2006 (All data from unpub. data of J.A. & S.E. Stefferud, except as noted).

AREA	WATER PRESENT 2006	TYPE/EXTENT OF WATER
West Redrock Exclosure	No	Damp ground at barrier site
Pig Camp Spring	Yes	18-inches diameter <2-inches deep
Redrock Canyon between West Redrock Exclosure and Falls Exclosure (inc. USFS named Redrock Spring	No	
Falls Exclosure	Yes	At base of falls 12 x 15 feet, 4-feet deep
Redrock Canyon between Falls Exclosure and Gate Spring Exclosure	No	
Gate Spring Exclosure	Yes	Only in salt spring perched on channel side near lower end of exclosure
Redrock Canyon between Gate Spring Exclosure and Cott Tank Exclosure	No	
Redrock Canyon in Cott Tank Exclosure	Yes	Two pools 5x2 feet, 1-foot deep 4x3 feet, 0.5-feet deep
Redrock Canyon above junction with Cott Tank drainage	No	
Cott Tank drainage below barrier	Yes	Five pools 15x4 feet, 2-feet deep 5x3 feet, 0.8-feet deep 13x40 feet, 2.5-feet deep 55x4 feet, 2-feet deep 20x6 feet, 2.5-feet deep
"Camp" Spring in side tributary to Cott Tank drainage (Sec. 21)	Yes	Wet marsh 40 x 3 feet
Cott Tank drainage above barrier	Yes	Two pools 2x3 feet, 0.5-feet deep 15x10 feet, 1-foot deep plus 20 feet of marsh flow above and 34 feet of shallow open flow over bedrock below
Unnamed tributary to Cott Tank drainage in Sec. 22	Not surveyed	June 2003 – flow 15-feet long, shallow
Unnamed tributary to Redrock west of Oak Grove Spring Canyon (including USFS-named G&F Horizontal Well/Spring)	Not surveyed	June 2002 – pools <1% of area surveyed, ave. width 5 feet, ave. length 8.3 feet, ave depth, 5 inches (Mitchell 2002)
Oak Grove Spring Canyon springs (including North and Southeast Forks and USFS-named Oak Spring)	No	
Unnamed tributary to Oak Grove Spring Canyon in east ½ Sec. 35	No	Surveyed only up to bedrock and trough in lower end

Table 2 – Continued.

AREA	WATER PRESENT 2006	TYPE/EXTENT OF WATER
Unnamed tributary to Oak Grove Spring Canyon in west ½ Sec. 35 (including three springs – USFS-named North and Richard Hale Springs and an unnamed spring)	Not surveyed	June 2003 --slight seepage at upper spring, pool 3x4 feet, 2-inches deep. Below barrier near mouth, 30 feet of orange water 2-4-inches deep
Lampshire Canyon (including Cottonwood Spring)	No	
Rock and Turtle Springs	Not surveyed	
Spring in unnamed tributary to Redrock just east of Lampshire Canyon	Not surveyed	
Box Canyon	Not surveyed	June 2003 – stagnant pool 4-feet diameter at small bedrock drop at about 4,900-foot elevation
Kennedy Spring drainage (including Kennedy Spring)	Not surveyed	October 2002 – downstream about ½ mile from unnamed tank in Sec. 21 short areas of water up to 10 x 5 feet and 2-3-inches deep. At Kennedy Spring, flow 20-feet long up to 5-inches deep.

The ADEQ sets narrative and numeric standards for water quality based on the uses people and wildlife make of the water. For Redrock Canyon, uses are classified as live aquatic life, warm water, full body contact, and fish consumption. The 2004 Integrated 305(b) Water Quality Assessment and 303(d) Listing Report indicated that surface water in Redrock Canyon was in attainment of water quality standards for all designated uses.

There are no streams in the project area that are either Congressionally designated as or eligible for Wild and Scenic River status (http://www.rivers.gov/wildriverslist.html#az).

3.1.2 Environmental Consequences

No Action

Hydrology, geomorphology, and surface water quantity and quality would not change if no action is taken.

Proposed Action

Direct and indirect impacts to water resources in the project area may result during barrier construction, barrier presence, and mechanical and chemical treatments to remove nonnative species.

Waters of the U.S. The COE regulates discharges of fill material to waters of the U.S., pursuant to Section 404 of the CWA, and issues permits for actions proposed within such waters. Jurisdictional, non-tidal waters of the U.S. regulated by the COE are defined in 33 CFR 328.4 (c) as those that comprise the area of a water course that extends up to the ordinary high-water mark (OHWM), in the absence of wetlands. Based on Reclamation's delineation of the OHWM, less than 0.01 acre of jurisdictional waters would be affected by the discharge of 55 cubic yards of fill material during construction of the concrete barrier. The fill material would consist of structural concrete, gabions or riprap, and excavated channel alluvium redeposited as backfill at the barrier. A COE 404 permit has been issued for barrier construction (see Chapter 5 for additional CWA information).

Removal of nonnative species would have no impact on those attributes of jurisdictional waters of the U.S. regulated by the COE.

Hydrology and Geomorphology. Shortly after completion, the constructed barrier would trap bedload material behind it, causing a zone of sediment deposition upstream (Figure 6). Aggradation of the streambed from sediment deposition would slightly flatten the channel gradient and permanently raise the water surface profile along a 1,475-foot segment of stream, affecting 1.4 acres of channel. The higher stream profile would be most noticeable where water overtops the barrier (i.e., where there is a 5-foot elevation change) and would disappear altogether upstream at the point where the aggraded zone converges with the normal level of the streambed.

No long-term impact on sediment transport, siltation, or deposition patterns within the stream would occur. The raised water profile is expected to have a minimal erosive effect on the integrity of the channel banks, because they are armored with bedrock, boulders, and cobbles. Pool development on the upstream side of the barrier would be minimized to the maximum extent practicable by backfilling the area with surplus alluvium excavated to accommodate the barrier foundation and gabion trench. Bedload sediment that would be deposited during flooding and high seasonal flow is expected to displace any remaining pools within 2 to 3 years.

Changes in channel morphology in the construction area would have minimal effects on flow and erosion patterns at the downstream toe of the barrier, because gabion or riprap bedding would be placed along the apron.

Removal of nonnative species by chemical and mechanical treatments would have no impact on hydrology or geomorphology.

Figure 6. Post-construction sediment deposition upstream of the barrier.

Water Quantity and Quality. Construction of the barrier would have a negligible effect on surface and subsurface flows. The reach of stream encompassing the barrier site is on a shallow bedrock sill that forces groundwater to the surface, so any subsurface flow that might be cut off by the barrier foundation would become surface flow that spills over the top of the structure. In addition, the barrier foundation would be situated on an alluvial base above this sill, allowing a portion of the subsurface flow to pass under the structure.

At the barrier site, a greater quantity of subsurface water is likely to be retained in the stored sediments behind the barrier than at present. However, once this sediment is saturated, the volume of surface and subsurface water conveyed downstream beyond the barrier would approximate pre-construction conditions.

Barrier construction is planned to occur during the dry season. If atypical heavy precipitation should occur, there is a potential for runoff to transport fine sediment into the stream and increase its turbidity. In this location, however, the amount of fine sediment is minimal because of the coarse substrate of the floodplain (Figure 5). Further, floodwaters in this reach tend to be quite turbid anyway because of upstream channel instability. Therefore, no substantial change in the stream's turbidity is anticipated if runoff were to occur during barrier construction.

Pumping of stock tanks and possibly cienega pools to facilitate nonnative removal may affect surface water availability in the short term. Water removed from tanks and pools would be spread onto adjacent terraces and hillsides and would not be placed into the stream channel due to the risk of spreading nonnative species. Water availability for livestock would be affected if livestock are present during or shortly after pumping. In that case, effects would be mitigated by providing alternative sources of water for livestock use. Water availability for terrestrial wildlife would be adversely affected for the short-term. Current below-normal precipitation patterns provide insufficient runoff and base flow to keep most tanks and in-channel pools filled. Water removed by pumping may not be replaced for weeks or months depending on weather conditions. This could impact native fish restoration following nonnative removal. To avoid this, stock tanks and in-channel pools would not be pumped dry unless it is the only means available to ensure total eradication of nonnative fish and/or bullfrogs.

Effects to water quality from application of piscicides and neutralization compounds would be short term and restricted to the project area (see Appendix E). Piscicides would not be applied during periods of precipitation and runoff to avoid downstream water quality impacts. If, however, unexpected heavy precipitation and runoff occur after application has begun, piscicide in the downstream flow from the project area would detoxify rapidly because of dilution in floodwaters and the effects of turbulence, sediment, and organic material (Schnick 1974; Dawson et al. 1991; Lee et al. 1971). In the event of any potential movement of toxic amounts of piscicides downstream of the project area, detoxification with potassium or sodium permanganate would be undertaken at the constructed barrier site.

Alternative A

If Alternative A is implemented, the impacts to hydrology, geomorphology, groundwater, and water quality and quantity reported for the Proposed Action would not occur. Impacts to water quality from nonnative species removal (chemical and mechanical treatments) would occur over a smaller project area, because the area that would be treated under Alternative A comprises approximately 23 miles of stream channel in the mainstem and major tributaries, which is about 7 miles less than the area that would be treated under the Proposed Action.

Cumulative Effects – Water Resources

Sources of cumulative effects to water resources in the project area include historic human activities such as road construction, use of the area by undocumented immigrants, wildland fire, and livestock grazing.

Erosion remains a concern within the watershed, and the Forest Service has undertaken several projects to control specific sites of channel erosion. Neither action alternative includes plans for construction of additional roads nor would either be expected to substantially increase erosion or sediment production within the Redrock Canyon watershed.

Transitory use of the Redrock Canyon watershed by undocumented immigrants has created many user-built trails, where foot-traffic contributes to erosion and increases the probability of wildand fire occurrence because of unextinguished or uncontrolled campfires and signal fires. Wildland fire increases erosion, and subsequent runoff carries sediment and toxic ash into surface waters. The duration and extent of these effects are dependent on the size of the fire and the quantity and type of vegetation that burns.

Historic use of the watershed for grazing has reduced cover and destabilized soils, which contributed to sedimentation and adverse water quality effects. Current grazing management practices (see Section 3.4) have improved range conditions and reduced impacts to water quality.

Neither of the action alternatives would contribute cumulative, long-term effects to water resources.

3.2 BIOLOGICAL RESOURCES

3.2.1 Affected Environment -- Vegetation

Following is a general discussion of vegetation in the project area. Vegetation that comprises Forest Service-designated sensitive plant species in the Redrock Canyon watershed is addressed in Sections 3.2.7 and 3.2.9.

Redrock Canyon lies in the upper Sonoran life zone (Lowe 1964). Dominant vegetation types are broadleaf woodland (evergreen), with an overstory of Madrean oaks, predominantly Emory, Mexican blue, and Arizona white (*Quercus emoryi, Q. oblongifolia,* and *Q. arizonica*), and alligator juniper (*Juniperus deppeana*). Semi-desert grassland (Brown 1994) is also present in the watershed, with mesquite (*Prosopis velutina*) and catclaw acacia (*Acacia greggii*) the predominant overstory species and curly mesquite (*Hilaria belangeri*), gramma grasses (*Bouteloua* spp.), and lovegrass (*Eragrostis* spp.) the common understory species (USFS 2003).

Riparian vegetation is found discontinuously along Redrock Canyon proper and many of its tributaries (Danzer et al. 2001; Stefferud and Stefferud 2004). Well-developed riparian areas are found primarily within livestock exclosures, although they have also developed in the central portion on the Kunde allotment, which has not been grazed under permit since 1996. Fremont cottonwood (*Populus fremontii*) and Goodding and yew-leaf willow (*Salix gooddingii* and *S. taxifolia*) are a major component of these riparian areas, with an understory of deergrass (*Muhlenbergia rigens*), seepwillow (*Baccharis salicifolia*), and a variety of sedges (*Carex* spp.) and rushes (*Juncus* spp.). Outside of these areas, Arizona ash (*Fraxinus velutina*), Arizona walnut (*Juglans major*), and Arizona sycamore (*Plantanus wrightii*) are the primary tree species, with an understory of seepwillow, deergrass, and upland grasses. Small areas of mesquite bosque and sacaton (*Sporobolus wrightii*) are present on terraces.

In the stream channel, submergent and emergent vegetation in areas of surface flow includes a variety of algae, duckweed (*Lemna minor*), cattails (*Typha latifolia*), and spike-rushes (*Eleocharis* spp.). Nonnative vegetation in the riparian area includes tree of heaven (*Ailanthus altissima*), tamarisk (*Tamarix pentandra*), Johnson grass (*Sorghum* *halepense*), rabbit-foot grass (*Polypogon monseliensis*), Bermuda grass (*Cynodon dactylon*), and watercress (*Rorippa nasturtium-aquaticum*).

3.2.2 Environmental Consequences -- Vegetation

No Action

If no action is taken, vegetation would not be impacted.

Proposed Action

Sources of potential impact to vegetation include clearing of areas for a staging area and for fish barrier construction and introduction of nonnative plant seeds on vehicles and heavy equipment.

A staging area less than 0.1 acre in size would be located alongside FSR 138. Ground cover is sparse except during late summer, when annual grasses and forbs appear after monsoon precipitation. Vegetation that would be cleared or otherwise disturbed includes shrubs and herbaceous plants. The staging site has been disturbed repeatedly over many years by road maintenance, dispersed recreational camping, livestock grazing, and off-road vehicle travel. Impacts to vegetation from clearing during barrier construction are considered minimal because of the small area that would be disturbed, the type of vegetation present in that area (i.e., mostly seepwillow and scattered mesquite), and the high probability for regrowth of the area in a short period of time after the barrier is constructed.

Most of the proposed barrier construction site is unvegetated sand, gravel, and cobble (Figure 5). Vehicle trips into the construction area would be infrequent, and off-road travel would mostly be limited to the usually dry streambed between the FSR 138 low-water crossing and the barrier site. An estimated 0.02 acres of vegetation would be disturbed along a pre-existing vehicle corridor from FSR 138 upstream to the barrier site. Removal or trimming of seepwillow and deergrass may be required to allow construction vehicle access. These riparian species are both adapted to periodic disturbance and grow back rapidly from the ground level.

Vehicles and heavy equipment would be powersprayed before entering the construction site to lower the risk of nonnative plant spread.

No disturbance of riparian or upland vegetation would occur during removal of nonnative fauna and native species restoration. Effects to aquatic vegetation would be localized and minimal. Aquatic vegetation may be removed during salvage and piscicide treatment to allow for adequate distribution of the chemicals. Emergent vegetation, such as cattails, may be cut off below the water line but would grow back quickly after treatment. Duckweed may be scraped from the ponds and watercress from streams and springs to allow access to the water but would quickly recover following treatment.

Alternative A

Effects to vegetation under Alternative A would be similar to those described for the Proposed Action but without effects of barrier construction. Localized and ephemeral effects would occur to aquatic vegetation during salvage and piscicide application.

Cumulative Effects - Vegetation

Effects to vegetation are ongoing from other human activities in the area. Impacts to vegetation from livestock grazing in the watershed have been fully explored in the EA completed by the Forest Service on livestock management (USFS 2003).

Incremental effects on vegetation from either action alternative would be discountable. Vehicle use inside the West Redrock Exclosure at the proposed barrier site has the potential to cause a short-term interruption in the recovery of the riparian area that has developed since the exclosure was created in 2002.

3.2.3 Affected Environment -- Terrestrial Wildlife

Redrock Canyon provides a corridor for wildlife movement between Sonoita Creek and Canelo Hills. A wide variety of wildlife occupies the watershed. Habitat diversity is provided by high-elevation oak woodlands to low-elevation desert grasslands. The presence of surface water and riparian vegetation support a diversity and abundance of species that would not otherwise be found in these arid lands.

This section discusses terrestrial wildlife in the Redrock Canyon watershed. Ten federally listed species are considered in Section 3.2.7. Twenty-one animal species on the Forest Service's Region 3 sensitive species list and 13 on the CNF list of Management Indicator Species (MIS) are considered in Section 3.2.9.

3.2.4 Environmental Consequences -- Terrestrial Wildlife

No Action

If no action is taken, terrestrial wildlife would not be impacted.

Proposed Action

Terrestrial wildlife in the immediate vicinity of the barrier and staging area would be disturbed in the short-term by vehicle and equipment activity and human presence. Direct injury or mortality of slow-moving animals may occur during vehicle or equipment operation. Losses are expected to be minimal, as most species would be temporarily displaced from the area shortly after the onset of construction.

Temporary noise and habitat disturbance would occur in both areas. In the long-term, the barrier is expected to locally improve the quality of riparian habitat by creating a small area of fine-sediment deposition and water retention upstream, which would encourage a denser growth of riparian vegetation. The fish barrier is not expected to prevent movement of terrestrial species. Side slopes in the area are sufficient to allow terrestrial wildlife to easily move around the barrier.

Removal and restocking of native aquatic wildlife would not affect terrestrial wildlife. Movement of project personnel throughout the canyon could result in a few days of disturbance of wildlife.

During piscicide application, terrestrial wildlife may drink or have body contact with waters containing rotenone or antimycin A and may consume fish killed by the piscicide. Terrestrial vertebrates do not uptake either of the piscicides through body contact, and neither piscicide is toxic to vertebrate animals when applied at levels and formulations in accordance with the labels. The effects of rotenone and antimycin A on terrestrial vertebrates are reported in detail in Appendix E.

Cattle, which may be in the watershed during the project, are not expected to be affected by either piscicide. Rotenone was used as a control for grub on dairy and beef cattle for many years with no adverse effects, and the EPA has reported that there is no need to restrict livestock consumption of treated waters (Finlayson et al. 2000). However, alternative water sources for livestock would be provided, as necessary, to prevent disruption of cattle access to water or to draw cattle away from areas where their presence may disrupt project implementation.

Alternative A

Implementation of Alternative A would have minimal effects on terrestrial wildlife, which would be similar to those of the Proposed Action. Effects at the barrier site from construction and vehicle traffic would not occur. Minor, temporary, and localized disturbance of terrestrial species may result from nonnative removal and native restocking operations. No effect from piscicide application would result (see Proposed Action).

Cumulative Effects – Terrestrial Wildlife

Historical and ongoing livestock operations within the Redrock Canyon watershed have previously impacted terrestrial wildlife as a result of changes in vegetation and forage availability, roads, and water development. Recreation in the watershed is light, with some hunting and minimal effects to terrestrial wildlife. Activities associated with undocumented migration and efforts at its control have increased human activity within the watershed. Neither of the two action alternatives would incrementally contribute to these cumulative effects.

3.2.5 Affected Environment -- Fish and Aquatic Wildlife

Redrock Canyon historically supported a diverse aquatic vertebrate fauna, including the five species of fish proposed for restoration[12], Chiricahua leopard frog, canyon treefrog, Sonora tiger salamander, Sonora mud turtle, black-necked gartersnake, and possibly Mexican gartersnake (Appendix A). Two federally listed fish (Gila topminnow and Gila chub), the leopard frog, and the salamander are discussed in Section 3.2.7. The desert sucker is a Forest Service-sensitive species (FSS), but is discussed here because of the similarity of effects with longfin and speckled dace. The other species to be discussed in this section include longfin dace, speckled dace, canyon tree frog, Sonora mud turtle, and black-necked and Mexican gartersnakes. Aquatic invertebrate fauna exist in Redrock Canyon surface waters; however, little is known about the individual species of that assemblage. No rare aquatic invertebrates are known from the Redrock Canyon watershed (see discussion of Huachuca springsnail in Section 3.2.7).

Longfin dace. Until the mid-1990s, longfin dace were common throughout the mainstem of Redrock Canyon from above Camp Spring downstream to below the Forest Service boundary, and in Lampshire Canyon below Lampshire Dam and in the lower half of Oak Grove Spring Canyon and its two main tributaries (Stefferud unpub. data). Their abundance and distribution expanded and contracted according to seasonal and annual water conditions. They were the only fish regularly occupying open areas of temporally intermittent flow (Figure 7). By 1994, they had disappeared from the watershed upstream of Gate Spring, by 2001 they disappeared from the reach between the Falls and Gate Spring, and the last longfin dace below the Falls was recorded in 2003 (Appendix A). The reason for their disappearance is unsubstantiated but is likely related to the adverse effects of nonnatives and to the gradual drying of the stream channels in the watershed.

By 2003, the drought had dried major areas that had supported longfin dace. Although water was still present most of the time at Gate Spring, there are now periods of no water. In the Cott Tank exclosure, while water still exists, it is isolated in pools, which are not preferred habitat for longfin dace and are occupied by mosquitofish. Stream areas between pools that existed prior to 1996 are now totally dry. Mosquitofish are thought to have little effect on longfin dace under normal conditions. Longfin dace are usually found in relatively fast, shallow water on riffles and runs, whereas mosquitofish cannot maintain in fast current and prefer pools, stream margins, and backwaters. However, when pushed by drought into the remaining pools, mosquitofish may have a substantial negative effect on longfin dace survival. Longfin dace are still common in Sonoita Creek downstream of Patagonia (Foster and Mitchell 2005; Killeen 2005) and in Harshaw Creek (Stefferud and Stefferud 2004).

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[12] Gila topminnow, longfin dace, speckled dace, desert sucker, and Gila chub

Figure 7. Longfin dace habitat in temporally intermittent flows, June 2001 (photo courtesy of J.A. Stefferud).

Speckled dace. Speckled dace have occurred for decades in Sonoita Creek near its junction with Redrock Canyon (Minckley 1969). Although it was once a common species throughout the Gila River basin and remains relatively widespread in the northern part of the basin, only this small speckled dace population remains in the southern part of the basin (Desert Fishes Team 2004).

Speckled dace prefer fast water and coarse substrates and are most often found in riffles. No early records of speckled dace exist in Redrock Canyon; the first record did not occur until the 1970s. By that time, substantial anthropogenic changes had occurred in the Redrock Canyon watershed, and the availability of water and suitable habitat had likely changed dramatically. In November 2001, following good summer rains, speckled dace was found occupying Redrock Canyon in the vicinity of the proposed barrier site (Stefferud and Stefferud 2004). Despite sampling, no additional sightings of speckled dace have occurred in Redrock Canyon. It is presumed speckled dace move upstream from adjacent Sonoita Creek during periods of strong flow, such as in 2001.

Desert sucker. Desert sucker are periodically found in Redrock Canyon below the Falls. They apparently move upstream from Sonoita Creek during times of good surface water flow but, despite the presence of suitable water upstream, cannot move beyond the barrier presented by the Falls. Records are from 1987, 2001, and 2002, but this lower reach was seldom sampled prior to 1999 (Simons 1987a; AGFD files; Stefferud unpub. data). Desert sucker is one of the most persistent native fish species in the Gila River basin, but populations are declining throughout its range (Desert Fishes Team 2004). They are able to use small waters and a rather wide range of habitat types but require at least some riffle or run habitat in which to reproduce (Minckley 1973).

Canyon tree frog. Based on incidental sightings during fish sampling, canyon tree frog is common in the lower portion of Redrock Canyon, including Oak Grove Spring Canyon (Stefferud unpub. data). However, given its nocturnal nature and the presence of suitable habitat, it is likely that the species is found at water sources throughout the watershed. Tadpoles are aquatic herbivores, while adults feed on small invertebrates, both aquatic and terrestrial.

Sonora mud turtle. The Sonora mud turtle is an opportunistic predator that prefers pools and slow-moving waters. It is found throughout Redrock Canyon. It is common within the Cott Tank exclosure and has been seen at Gate Spring, Falls, several miles upstream in Lampshire Canyon, in tributaries of Oak Grove Spring Canyon above the springs, and in Down Under and Martin Tanks (Stefferud unpub. data; Mitchell 2002). Given that most surveys have been by biologists looking for fish, only a small proportion of mud turtles observations are likely recorded.

Black-necked gartersnake. The black-necked gartersnake has been observed at Gate Spring, near Red Bank Well, and there was a probable sighting in upper Lampshire Canyon (Stefferud unpub. data). These records were taken during fish surveys, and other records of the species in the watershed may exist. Black-necked gartersnakes feed primarily on frogs.

Mexican gartersnake. In September 2006, in response to a petition requesting Federal listing of the northern subspecies of Mexican gartersnake (*T. e. megalops*), the FWS concluded that listing was not warranted because of uncertainty regarding its status in Mexico. The finding concluded that the subspecies has been extirpated in 85-90% of its historical range in the United States.

The Mexican gartersnake is a riparian obligate species and uses cienegas, stock tanks, rivers, streams, and springs. It preys on frogs (both tadpoles and adults), native fish, and occasionally lizards, mice, and invertebrates (Rosen and Schwalbe 1988). The presence of native anurans and fish appears to be necessary to support Mexican gartersnake. Many nonnative fish in Arizona have spines in their fin rays, making them unsuitable prey for Mexican gartersnakes (Holycross et al. 2006). Predation by nonnative fish, bullfrogs, and crayfish is a major cause of the substantial declines that have occurred in the distribution and abundance of Mexican gartersnake (Fernandez and Rosen 1996; Degenhardt et al. 1996; Rosen et al. 2001; Holycross et al. 2006).

There are no verified records of Mexican gartersnake in the Redrock Canyon watershed. Mexican garter snakes are extant in O'Donnell Creek and the San Rafael Valley and were formerly in Bog Hole, only 2 miles from Cott Tank drainage. Habitat appears to exist for Mexican gartersnake in Redrock Canyon. While much of the drainage is drier and rockier than preferred by Mexican gartersnake, the cienega habitat in the Cott Tank exclosure appears to offer suitable habitat. Developing herbaceous cover within the Gate Spring exclosure may also provide suitable habitat, but the failure of perennial surface water and consequent loss of fish and frog prey in recent years may prevent its use by gartersnakes.

Nonnative Species. Five nonnative aquatic species are known to have invaded Redrock Canyon: largemouth bass, green sunfish, bluegill, mosquitofish, and bullfrogs. The adverse effects of these species have already been discussed in Section 1.2, and the date of their most recent occurrence in areas of Redrock Canyon and their distribution are shown in Appendix A (Table A-1 and Figures A-1 to A-3). Removal of these species has long been discussed among biologists and agencies with interest in Redrock Canyon. A mechanical removal of largemouth bass in Cott Tank drainage was carried out in 1989 but did not succeed in eradicating that species from the area.

Stefferud and Stefferud (1994) discussed the potential to use piscicides for mosquitofish removal. They cited Desert Fishes Recovery Team deliberations concluding that mosquitofish removal attempts should not be made as long as survey data showed Gila topminnow continuing to be more predominant than mosquitofish, but that if data showed mosquitofish gaining dominance, then steps should be taken to immediately remove the mosquitofish. Data from the Stefferud autumn surveys show mosquitofish gaining dominance in 2002 (Figure 8). In 2000 and 2001, mosquitofish made up only three and 13% of fish sampled. In 2002, they comprised 66%, rising to 97% by 2005.

The largemouth bass is an aggressive predator; adults feed almost exclusively on fish, tadpoles, and crayfish (Moyle 2002). It has been shown to prey on native Gila basin fishes with adverse impacts to their populations and may completely extirpate some natives in small habitats (Minckley 1969; Minckley et al. 2002; Bonar et al. 2004). Largemouth bass is primarily a species of ponds and slower waters, which limits its potential distribution within Redrock Canyon (Appendix 3, Figure A-3). Cienega pool systems present in the Cott Tank drainage provide suitable habitat for largemouth bass. In addition to populations in stock tanks, largemouth bass established a reproducing population within the Cott Tank drainage during the late 1980s and early 1990s, declining only as the pools shrank with the onset of drought.

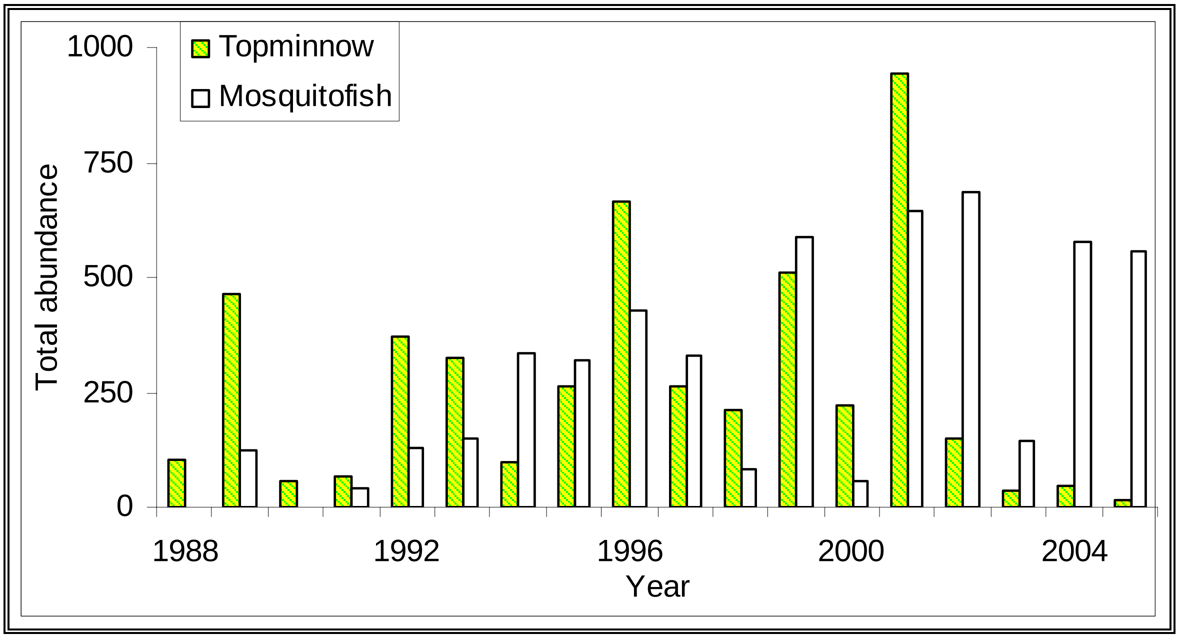

Figure 8. Gila topminnow and mosquitofish relative abundance in Redrock Canyon 1988-2005 (Stefferud and Stefferud 1994 and unpub. data).

Green sunfish and bluegill records are limited to Redrock Canyon and Cott Tank drainage from Down Under and Cott tanks downstream to just beyond the confluence of the two channels (Appendix A, Table A-1 and Figure A-3). These two species are aggressive invaders in the Gila River basin and are well adapted to small waters. They easily establish reproducing populations, even in spatially intermittent streams such as Redrock Canyon (Capone and Kushlan 1991). Green sunfish and bluegill are opportunistic predators, consuming eggs, larvae, and small adult fish, as well as frog eggs and tadpoles and salamander eggs and young, with adverse effects to native fish, frog, and salamander populations (Lemly 1985; Rosen et al. 1995; Dudley and Matter 2000). The presence of these two sunfishes may have contributed to establishment of the nonnative bullfrog population. Bullfrog invasion has been shown to be facilitated by the presence of bluegill, through the reduction of predation on bullfrog tadpoles by predatory macroinvertebrates (Adams et al. 2003). Because of the substantial similarities between bluegill and sunfish food habits, it likely that green sunfish may play the same role in bullfrog invasion. Green sunfish and bluegill have been recorded in Redrock Canyon only in the upper end, including both the Redrock Canyon proper and Cott Tank drainages.

Although a small-bodied species, mosquitofish has been implicated in declines of many native fish and amphibians (Grubb 1972; Casterlin and Reynolds 1977; Courtenay and Meffe 1989). They are highly aggressive, preying on fish eggs and larvae in addition to invertebrate foods. They are effective predators even in heavily vegetated and shallow areas that otherwise act as safe harbors from larger predators (Baber and Babbitt 2004). Mosquitofish also harass and nip individuals larger than themselves, leading to damage, disease, exhaustion, and death (Hurlbert et al. 1972; Fuller et al. 1999; Lawler et al. 1999). This behavior may also result in non-lethal interactions that have signficant long-term adverse consequences to the harassed individuals and populations (Lima 1998). In Redrock Canyon, Gila topminnows show a high incidence of fin damage when mosquitofish are present (Dean 1987). Snyder (2006) found that although Sonora tiger salamander can persist in the presence of mosquitofish, they cannot establish a population where mosquitofish are present. Mosquitofish may also present substantial competition to native species, particularly during times of severe habitat constriction (Meffe 1983) such as the present drought. Mosquitofish are abundant in the Cott Tank livestock exclosure and readily colonize other areas of the canyon when surface waters are present. They have been recorded widely throughout the watershed (Appendix A, Table A-1 and Figure A-2).

Bullfrogs are predatory in both tadpole and adult stages and reach high densities in southwestern waters (Kane et al. 1992; Rosen and Schwalbe 1995; Mueller et al. 2006). Bullfrog tadpoles are also known to produce chemicals that inhibit growth in tadpoles of other species and inhibit reproduction in guppies (*Poecilia reticulata)*, a live-bearer similar to Gila topminnow (Boyd 1975; Kupferberg 1997). They have been implicated in the decline of several native fish and amphibian species (Lawler et al. 1999; Rosen and Schwalbe 2002; Bradford et al. 2004). Bullfrogs need permanent water but can migrate long distances over dry land to find a new water source, and it is not unusual to find them occupying small areas of isolated water. They have been present in Redrock Canyon since at least 1988 but did not become abundant until mid-1990s. Their spread appears to be associated with stock tanks in the drainage, and at least five tanks in the drainage have been recorded to support bullfrogs (Appendix A, Table A-1 and Figure A-1). Bullfrogs are common to abundant in Cott Tank drainage and at some of the stock tanks. Records from elsewhere in the basin are sporadic.

3.2.6 Environmental Consequences -- Fish and Aquatic Wildlife

<u>No Action</u>

If no action is taken, nonnative aquatic species in the Redrock Canyon watershed would likely continue to expand in distribution and quantity, which may result in the extirpation of most native aquatic species. Although persistent drought will cause populations of all aquatic species to remain low until it subsides, it is not expected to eliminate mosquitofish or bullfrogs. Green sunfish and bluegill, if still present in the basin, may survive extended drought. Only largemouth bass, if still present, could likely to be eliminated by drought conditions because of its requirement for relatively large pools.

Neither adult longfin nor speckled dace are believed to be particularly susceptible to mosquitofish predation and harassment or adverse impacts from bullfrogs because of differences in preferred habitat use. Adult desert suckers are often found in pools where sunfishes, largemouth bass, mosquitofish, and bullfrogs congregate. While predation by sunfishes and bullfrogs may be limited to eggs, larvae, and juvenile suckers, even large adults may be harassed and killed by relentless biting by mosquitofish (Baber and Babbitt 2004). Larval stages of both daces and desert sucker use backwater and vegetated stream edge habitats extensively where they are preyed upon by mosquitofish, sunfish, and perhaps bullfrogs.

A significant portion of the habitat for these three fish species is located downstream of the natural barrier at the Falls. Without a constructed barrier, there is no mechanism to prevent future invasion of lower Redrock Canyon (including Oak Grove Spring Canyon) by additional nonnative aquatic species.

Without human intervention, longfin and speckled dace and desert sucker cannot move into the large portion of the Redrock Canyon watershed above the Falls nor to areas of Oak Grove Spring Canyon above its natural barriers. If no action is taken, these species would be limited to that portion of Redrock Canyon below the Falls and lower Oak Grove Spring Canyon. This limited range increases their vulnerability to predation, drought, fire, and other negative factors.

Under the no action alternative, longfin dace will continue to decline and perhaps become extirpated in Redrock Canyon as a self-sustaining population. Below the Falls, longfin dace, speckled dace, and desert sucker may be able to retain a periodic colonization pattern from Sonoita Creek but will not be able to expand their occupation of Redrock Canyon nor establish self-sustaining populations there.

With no action, ongoing predation of canyon tree frog, black-necked gartersnake, and Sonora mud turtle by nonnative fish and bullfrogs would continue. However, adult populations of the Sonora mud turtle should not be impacted to a great extent because of its size and shell (van Loben Sels et al. 1994). Bullfrogs, as well as nonnative fishes, may compete for food resources of all three native herptiles (reptiles or amphibians). With the limited amount of surface water in the Redrock Canyon watershed, the prey base of fish, frogs, and aquatic invertebrates is limited. A large predator like largemouth bass or a small but abundant predator like mosquitofish may usurp food resources of other organisms. Bullfrog tadpoles are unpalatable to many fish, giving them a competitive advantage over native leopard frog tadpoles (Kruse and Francis 1977).

Proposed Action

The Proposed Action would be beneficial to longfin and speckled dace, desert sucker, canyon treefrog, black-necked and Mexican gartersnake, and Sonora mud turtle. The three fish species would be restored into Redrock Canyon, and, with removal of predation by mosquitofish and reduced predation from bullfrogs, the three repatriated species could be expected to expand into all suitable areas and establish self-sustaining populations. The tree frog, gartersnake, and mud turtle would be released from predation and competition by nonnative aquatic species, allowing their populations to potentially expand in numbers and distribution within the watershed. Mexican gartersnake would also be restored to the watershed through salvage and/or stocking.

The fish barrier particularly would benefit longfin and speckled daces and desert sucker. Longfin dace is now restricted to the 1.5-mile reach below the natural barrier at the Falls and about 2.5 miles of the lower portion of Oak Grove Spring Canyon below the barriers on its mainstem and tributaries. The only records of speckled dace and desert sucker from Redrock canyon are in this lower reach of mainstem Redrock. Confinement to this small, intermittently flowing area makes both species vulnerable to any incursion by additional species of nonnatives, such as yellow bullhead (*Ameiurus natalis)* which are found downstream in Sonoita Creek (Killeen 2005). The construction of the proposed fish barrier would prevent such future invasions and would permit the removal of existing nonnatives in the area. The Proposed Action would assist in re-establishing longfin and speckled daces and desert sucker upstream of the Falls, providing them with the opportunity to establish larger, more widely distributed populations, thus making them less vulnerable to threats from all sources.

The constructed fish barrier would work in conjunction with existing natural barriers within the canyon to achieve the benefits of a multiple-barrier system. Multiple-barrier systems confer advantages in controlling possible future nonnative incursions and are recommended (Carpenter and Terrell 2006). Only one natural barrier, the Falls, exists in the central portion of Redrock Canyon (Figure 4), approximately 1.5 miles upstream of the barrier site in the Proposed Action. Other natural barriers exist in the upper reaches of most of the tributaries but, because of their headwater locations, only a few are useful as parts of a multi-barrier system for the watershed as a whole. Constructed barriers also exist in at least two locations: Lampshire Dam and an old cement dam downstream of Down Under Tank. All stock tanks form barriers, but none have known habitat upstream for aquatic fauna.

Placing a fish barrier in lower Redrock Canyon also has the potential to adversely impact native fish and other aquatic species. Loss of gene flow, inbreeding, and fragmentation are all possible adverse effects of barriers to fish movement (Sloat 1999). However, the species that occupy Redrock Canyon have already undergone substantial fragmentation and blockage of genetic exchange, and the addition of a constructed barrier would not add substantially to this blockage.

Although it may not have existed as a barrier prior to downcutting in the late 1800s or early 1900s, the present barrier at the Falls effectively prevents any upstream gene flow in fish populations in Redrock Canyon. Genetic information indicates that Gila topminnow in Redrock Canyon are a part of the larger Sonoita Creek management unit but show small variations that indicate some degree of fragmentation, both between Redrock Canyon and Sonoita Creek and between Falls and Cott Tank drainage (Hedrick et al. 2001). If at a future time, enhanced genetic interchange is deemed desirable, it can be accomplished by periodically moving individuals from the five native fish species from the downstream segment of Redrock Canyon into upper segments (Waite et al. 2005).

Another potential adverse effect of a constructed barrier is the possible loss of larvae of native fishes through downstream drift over the barrier. Any larvae that did drift over the barrier would be unable to return upstream and would likely die as the reach of stream below the barrier regularly becomes dry. It is unlikely that downstream drift of larvae below the barrier site has played any significant role in survival of the native fish of Redrock Canyon since the loss of the cienega at Patagonia in the late 1890s. The portion of the stream downstream of the proposed barrier site is dry most of the year; and, rather than moving back upstream, it appears that fish in that stretch tend to become isolated in pools which eventually dry resulting in their loss.

Removal of nonnatives and prevention of downstream reinvasion and new invasions would benefit all aquatic wildlife. Nonnative predation effects to canyon tree frog, black-necked and Mexican gartersnakes, and Sonora mud turtle were discussed earlier. While that discussion refers to the adverse effects of continuation of nonnative predation, under the Proposed Action, the effects would be reversed. Release from nonnative predation would benefit all three species, likely allowing them to expand their numbers and distribution within Redrock Canyon watershed.

Some loss of gill-breathing nonnative aquatic wildlife would occur as a result of the use of piscicides in the surface waters of the Redrock Canyon watershed. All fish not salvaged would be killed by the piscicide. However, the restocking of salvaged fish following nonnative removal, with possible augmentation stocking from captive or nearest-neighbor stocks, is expected to result in increased abundance and distribution of longfin and speckled dace and desert sucker, for a long-term gain for both species.

Little data exists on effects of the piscicides to amphibians. Lesser (1970) found that antimycin was not toxic to northern leopard frog tadpoles in fish-killing concentrations. Rotenone, however, is toxic to northern and southern leopard frog tadpoles at piscicide application levels (Hamilton 1941, as reported in Fontenot et al. 1994; Chandler and Marking 1982, as reported in Fontenot et al. 1994; Burress 1982). Adult leopard frogs were much less sensitive. It is likely that the proposed application of rotenone may result in some mortality of canyon tree frog tadpoles. Adults should not be affected because they primarily are air-breathers and because they detect and avoid rotenone by leaving the water (Fontenot et al. 1994). The effects of rotenone are reversible if the animal is removed from exposure soon enough (Finlayson et al. 2000). The common tree frog (*Hyla arborea)* not only survived treatment of a pond with rotenone, but established a reproducing population (Bronmark and Edenhamn 1994). Mortality of canyon tree frog during treatment may be limited by the higher likelihood of their presence in the areas to be treated with antimycin and lower likelihood in areas to be treated with rotenone, because of differences in habitat. Nonnative bullfrog tadpoles may be affected by the piscicide, but mortality of all larval bullfrogs is unlikely. Adult bullfrogs would not likely be affected. Mechanical methods would be used to capture and kill adult bullfrogs, including netting, gigging, firearms, and euthanization.

No studies of effects of either antimycin A or rotenone on reptiles have been done. Black-necked and Mexican gartersnakes are not expected to be affected by either antimycin A or rotenone because they are air-breathers (Fontenot et al. 1994). Sonora mud turtles could be affected by both piscicides because of their use of aquatic respiration (absorption of oxygen through the buccopharyngea, skin, and/or cloaca) (Fontenot et al. 1994). Use of rotenone in Lake Conroe in Texas resulted in mortality of many mud turtle (*Kinosternon subrubrum*) at levels within rotenone label levels for piscicide use (McCoid and Bettoli 1996). No data is available regarding antimycin A toxicity, but in Fossil Creek where an extensive nonnative removal project using high concentrations of antimycin A occurred in 2004 (with no turtle salvage), Sonora mud turtles were commonly found during post-treatment monitoring in 2005 (Marsh et al. 2006). To prevent mortalities, Sonora mud turtles would be salvaged prior to piscicide application and returned after detoxification. However, not all turtles would be salvaged, and some of those remaining in the stream may fail to leave the water before receiving a potentially lethal dose of piscicide.

Macroinvertebrates could suffer some adverse effects from use of piscicides, and those effects could differ in areas treated with antimycin A versus rotenone. Effects of antimycin A on aquatic invertebrates are variable. Any effects on aquatic insect populations are usually short-term, as mortality is incomplete (Minckley and Mihalick 1981) and recolonization is rapid (Gray 1981; Gray and Fisher 1981). Stefferud (1977) found short-term increases in invertebrate drift in high-elevation streams but no change in species composition following treatment. Kiner et al. (2000) found no signficant differences in species abundance for pre- and post-treatment sites but found significant differences in relative abundances of some invertebrate groups. In Arizona, Minckley and Mihalik (1981) concluded that long-term changes in the aquatic invertebrate fauna resulting from antimycin A treatment of Ord Creek were minimal but that a few taxa may have been locally eliminated. Others (Walker et al. 1964; Vezina 1967; Gilderhus et al. 1969; Lennon and Berger 1970; Snow 1974; Houf and Campbell 1977; Morrison 1979) failed to discern adverse effects of antimycin A on invertebrates in general.

Rotenone is commonly sold in different formulations for use as an insecticide and so has a higher potential for adverse effects to the invertebrate community than antimycin. Burress (1982) found that piscicide level applications of rotenone caused reductions in benthic pond invertebrates and zooplankton but that the populations rebounded rapidly. They also found substantial increases in phytoplankton because of released nutrients and reduction of plankton-feeding animals. No effects of species diversity, emergence, seasonal dynamics, abundance, or relative numbers of taxa were found by Houf and Campbell (1977).

Adverse effects to black-necked and Mexican gartersnake could occur as a result of temporary removal of the fish and frog food source. While the major prey of the Mexican gartersnake is native fish and frogs, it is known to eat mosquitofish and bullfrog tadpoles (Holycross et al. 2006). During the period between the time fish are totally removed from the system and the time they are restocked, the prey base of both garter snakes would be substantially reduced. However, some frogs would remain, as adult frogs would not be killed by the piscicide, and some tadpoles are also expected to survive.

Alternative A

The area of effect from implementation of Alternative A is smaller than that of the Proposed Action. Because of this, aquatic species and their habitat in approximately 7 miles of stream would not receive the benefits of nonnative removal and native species restoration. Potential adverse effects of a barrier through loss of gene flow, fragmentation, and larval drift (discussed under the Proposed Action) would not occur if Alternative A is implemented.

Without a constructed barrier, this alternative may result in the long-term loss of all native fish populations from the reach of Redrock Canyon below the natural barrier of the Falls. This would include Oak Grove Spring Canyon and its tributaries below the natural barriers on those streams (Figure 4). Other native aquatic species would also likely be excluded from this reach over time, as existing nonnatives and others moving upstream from Sonoita Creek (e.g., yellow bullhead, green sunfish) become dominant.

Benefits to the native aquatic wildlife would be similar in nature to those discussed for the Proposed Action, but to a lesser extent. Removal of nonnatives without blocking their route of reinvasion (i.e., a barrier) has little long-term value. Therefore, portions of the watershed that lie downstream from the natural barrier at the Falls would not be included in the project area. Nonnative removal and native fish restoration would be implemented only in those areas upstream of the Falls and upstream of the natural barriers on upper Oak Grove Spring Canyon, Redrock Canyon proper below the Falls, and in Oak Grove Spring Canyon and its tributaries below their natural barriers.

Mortality of aquatic species during piscicide application would be slightly less than that resulting from implementation of the Proposed Action because of the reduced area to which treatment would be applied.

Cumulative Effects – Fish and Aquatic Wildlife

Effects to aquatic wildlife from either of the two action alternatives are cumulative to the ongoing impacts from livestock grazing, roads, and other human uses in the watershed. See the cumulative effects discussion in Section 3.1.2 for more detail on cumulative effects to water quantity, quality, and channel geomorphology. Either of the two action alternatives would reduce stress on native aquatic species populations from nonnative species. This would make the native species able to better withstand the stresses resulting from livestock grazing.

3.2.7 Affected Environment -- Federally listed Species

The FWS identifies nine species with potential to occur in the project vicinity (Table 3). Four of them would not be affected by the project because either they are not known to occur in the Redrock Canyon watershed, and/or there is no suitable habitat for them in the project area: Huachuca water umbel, Canelo Hills ladies tresses, Mexican spotted owl, and jaguar. Effects to the remaining five listed species in Table 3 were reported in a

Biological Assessment prepared for this project (USFS and Reclamation 2007). A discussion of these species follows below.

Table 3. Federally listed or candidate species addressed in this EA.

COMMON NAME	SCIENTIFIC NAME	STATUS	OCCURRENCE
Plants			
Huachuca water umbel	*Lilaeopsis schaffneriana* var. *recurva*	Endangered	Not recorded in project area
Canelo Hills ladies tresses	*Spiranthes delitescens*	Endangered	Closest known population is at O'Donnell Creek
Amphibians			
Sonora tiger salamander	*Ambystoma tigrinum stebbinsi*	Endangered	Recorded in project area
Chiricahua leopard frog	*Rana chiricahuensis*	Threatened	Recorded in project area
Fish			
Gila topminnow	*Poeciliopsis occidentalis*	Endangered	Recorded in project area
Gila chub	*Gila intermedia*	Endangered	Suitable habitat but no records
Birds			
Mexican spotted owl	*Strix occidentalis lucida*	Threatened	Nearest Protected Activity Center is 1 mile south
Mammals			
Lesser long-nosed bat	*Leptonycteris curasoae yerbabuenae*	Endangered	Foraging habitat in project area
Jaguar	*Panthera onca*	Endangered	Nearest recent record is in the Huachuca Mountains

Source: FWS web site at "www.fws.gov/southwest/es/arizona/documents/countylists/santacruz.pdf""

Sonora tiger salamander. Listed as endangered in 1997, the salamander was only recently discovered in the Redrock Canyon watershed. In February 2003, Sonora tiger salamanders were found in Oak Tank in the east fork of the north fork of Oak Grove Spring Canyon (AGFD records – the record is referred to Kunde Tank, as synonym for Oak Tank). Earlier reports of salamanders in Sink Hole Tank in the upper reaches of an unnamed tributary to Lampshire Canyon have not been verified. Eggs and larvae of this salamander are completely aquatic. Adults may remain gilled (branchiate) or may metamorphose to an air-breathing form. As larvae or branchiate adults, they feed on zooplankton and macroinvertebrates; and, as terrestrial adults, they eat terrestrial and aquatic macroinvertebrates (Collins and Snyder 2002). They prefer soft substrates and perennial water. The 2002 Recovery Plan for Sonora tiger salamander does not specifically mention Redrock Canyon, because that population was unknown at the time the plan was completed. However, it calls for removal of nonnatives from any ponds that contain Sonora tiger salamander (Collins and Snyder 2002).

Chiricahua leopard frog. This species was listed as endangered in 2002. It is known from the Oak Grove Spring Canyon tributary of Redrock Canyon since 1995 (Scott 1995). There are earlier anecdotal records of probable leopard frogs in Redrock Canyon, but the identity of those individuals cannot be confirmed. In 2003, Chiricahua leopard frogs were found inhabiting Oak Tank, the same stock tank in Oak Grove Spring Canyon where Sonora tiger salamanders were found. Chiricahua leopard frog has experienced severe declines throughout its range due, in part, to predation and competition by nonnative fishes, bullfrogs, tiger salamanders, and crayfish (FWS 2007). It is likely the species historically occupied much of the surface water within the Redrock Canyon watershed but was reduced by loss of surface water due to human activities, the arrival of nonnative fishes by the 1970s, and the 1980s' invasion of bullfrog. Chiricahua leopard frog tadpoles are primarily herbivorous and occupy still to moderately flowing waters in springs, streams, and ponds. Adult frogs are opportunistic and eat terrestrial and aquatic invertebrates, fish, frogs, toads, and other animals. The Recovery Plan for Chiricahua leopard frog calls for elimination of nonnative predators at or near Chiricahua leopard frog populations, measures to prevent their reinvasion, and establishment of new or reestablishment of former populations (FWS 2007).

Gila topminnow. This species has been recognized as an endangered species since 1967. Although the population in Redrock Canyon was not known until 1978, it was known from Sonoita Creek, and there were earlier unverified reports of it from Redrock Canyon (Rinne et al. 1980). At the time of its discovery, it was one of only two natural populations on Federal lands. Since that time, the other natural population (Cocio Wash on Bureau of Land Management (BLM) lands) has been extirpated, but an additional natural population (Cienega Creek) has been acquired by BLM. Although Gila topminnow was probably historically widespread on Forest Service lands in the Gila River basin, Redrock Canyon contains the only natural Gila topminnow population surviving on any National Forest (FWS 1998).

The Cienega Creek population of Gila topminnow on BLM lands is vulnerable to adverse effects from upstream water and land uses because a large part of the upper watershed is in private ownership and supports significant urban, suburban, and rural growth. An important advantage Redrock Canyon possesses as a recovery area for Gila topminnow and four other native fishes is Federal ownership of >99% of the watershed above the National Forest boundary, thus eliminating many potential threats from upstream land and water use. Only two small private inholdings exist in Redrock Canyon (Figure 2). One, of approximately 60 acres, is located in upper Cott Tank drainage and is the site of Cott Tank. At present, it is used only for livestock grazing. The other is a 160-acre parcel located in the heart of Redrock Canyon just upstream from the Falls. It was originally a homestead and the headquarters of a livestock ranch but is currently unoccupied.

Despite efforts for recovery of Gila topminnow through introduction of new populations, its status continues to be poor (Desert Fishes Team 2003). Natural populations continue to decline and disappear, and introductions meet with limited success. Loss of natural populations within the past 20 years is almost exclusively associated with establishment or expansion of populations of nonnative species, particularly mosquitofish (Minckley 1999).

The Revised Recovery Plan for Gila topminnow calls for building and maintaining barriers against nonnative fishes, removal of nonnatives present in Gila topminnow occupied habitats, and protection and enhancement of existing populations (FWS 1998).

The 2000 draft revision of the Recovery Plan specifically calls for a barrier and nonnative fish removal at Redrock Canyon (Weedman 2000). Repatriation into historic habitats is a major element of the recovery program. However, the recent dramatic decline of Gila topminnow in Redrock Canyon was not foreseen in the plan, and it does not address restocking of the Redrock population.

Gila chub. This fish was listed in 2005 and does not yet have a recovery plan. It has never been recorded from Redrock Canyon but was known from Monkey Spring to the northwest (Minckley 1969) of Redrock Canyon and still exists in O'Donnell Canyon and Sheehy Spring to the northeast and south (Weedman et al. 1996). Cienega habitat, such as is present in Cott Tank drainage and may once have been present in other portions of the canyon, provides suitable habitat for Gila chub. Downcutting and other changes to channel geomorphology, human use of the water, nonnative predation, and earlier droughts may have alone or in combination extirpated Gila chub from Redrock Canyon before fish sampling began in the early 1970s. Gila chub and Gila topminnow were both historically found in Monkey Spring, O'Donnell Creek, and Sheehy Spring, indicating that they are co-evolved species capable of long-term coexistence. Gila chub are opportunistic carnivores and feed on macroinvertebrates, small fish, and tadpoles (Weedman et al. 1996).

Lesser long-nosed bat. The lesser long-nosed bat was listed in 1988. This species overwinters in Mexico and moves north in the spring to maternity colonies and lower elevations near blooming columnar cacti. Three known post-maternity bat roosts of greater than 250 bats occur in the vicinity of the proposed project (USFS 2003). The closest roost is at Patagonia Bat Cave, which is typically occupied from mid-July through mid-September (Fleming 1997). Lesser long-nosed bats from these roosts likely forage in the Redrock Canyon watershed. The two cacti used by the bats are not present in Redrock Canyon, but both paniculate agaves are present. The extent to which lesser long-nosed bats use the most common agave in Redrock Canyon, Scott agave, or amole (*Agave schottii*) is unknown (FWS 2002).

3.2.8 Environmental Consequences -- Federally listed Species

<u>No Action</u>

With no action, nonnative species would continue to pose a threat to federally listed aquatic species in the Redrock Canyon watershed, and future invasions, via upstream migration and through upstream stock tanks, are likely. Because of natural barriers, extirpated federally listed fish are not likely to recolonize Redrock Canyon without human intervention.

If no action is taken, populations of Gila topminnow, Chiricahua leopard frog, and Sonora tiger salamander would likely continue to decline in the Redrock Canyon watershed. Restoration of Gila chub into Redrock Canyon would not occur.

Declining water availability in the presence of mosquitofish and bullfrogs is likely to result in extirpation of the native fish and frogs but is unlikely to completely exterminate nonnatives. Once areas become rewatered, mosquitofish will move out to recolonize available water. Bullfrogs would likely be more vulnerable than mosquitofish to the effects of drought; Snyder (2006) found that bullfrogs are eliminated from stock tanks that dry completely.

Proposed Action

The Proposed Action is intended to have an overall benefit on federally listed amphibians and fish. The project would assist in the attainment of the objectives of the Gila topminnow, Sonora tiger salamander, and Chiricahua leopard frog recovery plans. It would also implement recommendations for conservation of Gila chub. The constructed barrier would provide a reinvasion-prevention mechanism to allow successful removal of nonnatives in the reach of Redrock Canyon below the Falls and in lower Oak Grove Spring Canyon. Other benefits to listed species would be similar to those described for non-listed amphibians and fish in Section 3.2.6.

Barrier construction would not likely adversely affect federally listed fish species in the short-term, because few are likely to be at or near the barrier site during construction. Gila topminnows have been found near the construction site in years of good surface water (Stefferud unpub. data). If topminnows are observed during construction, every attempt would be made to salvage individuals and move them to existing captive populations using the quarantine procedure described in Section 2.3. Nevertheless, there is a very low probability that a few individuals may be injured and/or killed by construction activities or by vehicle traffic in the stream corridor below the barrier. This possible negative effect would be minor in comparison with the substantial benefit to Gila topminnow from exclusion of nonnative species moving upstream. No federally listed amphibian species, or suitable habitat, exist at or near the site of the proposed barrier or at the staging area.

Beneficial effects to listed fish and amphibian species from removal of nonnatives would be long-term. Release of existing populations from the pressure of nonnative predation would allow them to reoccupy all available habitats, subject to the constraints of precipitation and surface water availability. Removal of nonnatives will allow a good likelihood for successful restoration of the three federally listed fish and amphibians through restocking, an activity with a very low probability of success in the presence of mosquitofish and bullfrogs (Lydeard and Belk 1993).

Piscicide application to remove nonnative species has the potential to concurrently kill individuals of federally listed native species not removed during salvage activities. Revival of natives affected by rotentone has been reported (Finlayson et al. 2000). This technique was effective for recent rotenone treatments in Sonora tiger salamander-occupied tanks in the San Rafael Valley (J. Rorabaugh, FWS, pers. com, August 2006). It may also be effective for Chiricahua leopard frog adults, if any are affected by the rotenone. However, the close physical resemblance of Chiricahua leopard frog tadpoles and Gila topminnow to similar nonnatives make this type of rescue operation difficult and risky. The loss of a few individuals of these two species would be acceptable when compared with the substantial improvement in the long-term status of their populations in the Redrock Canyon watershed that would be afforded by the Proposed Action.

Restoration of native listed species in the Redrock Canyon watershed through restocking of salvaged and captive-bred, or translocated individuals would increase the abundance and distribution of Gila topminnow, Chiricahua leopard frog, and Sonora tiger salamander in this watershed. This, in turn, would contribute substantially toward recovery of these species. The ultimate goal of the Proposed Action is the removal of nonnatives, prevention of their reinvasion, and restocking of native aquatic species, including the entire suite of native fishes, which would result in a self-sustaining aquatic species assemblage in Redrock Canyon.

No adverse effect on lesser long-nosed bat is anticipated because implementation activities (construction and piscicide application) would not affect any appreciable numbers of agave potentially used for foraging, nor would these activities occur during the period when lesser long-nosed bat is expected to use nearby roosts.

Alternative A

With implementation of Alternative A, renovation would occur, but an important mechanism for preventing reinvasion would be omitted. Further, a portion of the watershed would be omitted from restoration actions if this alternative is implemented.

Without a downstream barrier, the restocking of native fish or amphibians into the lower reach where nonnatives still exist offers little probability of successful enhancement or even survival of the native species. Stocking fish is a well-used method to increase their abundance and distribution and is commonly used in recovery activities. However, Minckley (1995) pointed out that unless the reason for extirpation is removed, the likelihood of success is low. In Redrock Canyon, considerable effort has been made to remove some of the reasons for decline of native aquatic species, including exclusion of livestock grazing from certain areas, road closures, and localized erosion control. Despite this, the effect of nonnative presence has been sufficient to preclude reversal of native population declines. When past water flow has been good, some natives, such as the Gila topminnow, have been able to maintain the status quo, but the recent addition of drought has caused Gila topminnow populations to decline significantly despite these inititatives.

Given the smaller project area, the benefits of Alternative A realized by nonnative removal would be commensurately smaller than those to be realized by implementation of the Proposed Action. The type and mechanism of benefits from nonnative removal are similar to those already discussed for the proposed action. For the same reason, mortality to individuals of federally listed species missed during salvage operations would be less.

<u>Cumulative Effects – Federally listed Species</u>

Livestock grazing and management, including development of stock tanks, ground-water pumping, and transport of water from streams, springs, and aquifers have cumulatively caused adverse impacts on Gila topminnow, Chiricahua leopard frog, and Sonora tiger salamander in the Redrock Canyon watershed. Although distribution of waters to the uplands through creation of stock tanks serves to reduce impacts of cattle on riparian areas by providing better forage-use distribution throughout the watershed, negative effects of livestock grazing to fish and their habitats include: (1) increases in summer stream temperatures resulting from loss of overhanging vegetation that are less suited to fish physiologies; (2) increased sedimentation from bank and upland erosion that traps and suffocates eggs and fry; (3) increased channel width because of hoof-induced bank sloughing and consequent erosion that reduces stream cover and decreases winter stream temperatures; (4) stream channel trenching or braiding that degrades instream habitats and increases the streams' susceptibility to catastrophic floods; and, (5) plant community alteration and vegetation loss that reduce bank cohesiveness, cover attributes, and terrestrial food inputs (Kauffman and Krueger 1984, Platts and Raleigh 1984, Armour et al. 1991, Platts 1991, Belsky et al. 1999). Substantial effort has been made to alleviate direct effects of livestock on the perennial waters of Redrock Canyon through exclusion of cattle from the riparian areas and an upland buffer.

Taking no action would not contribute to these cumulative adverse effects to federally listed species but would also not have a beneficial effect on the decline of their respective populations. Both of the action alternatives may contribute to the loss of a few individuals of federally listed species, but the degree of this loss would be discountable relative to the much greater impacts on these species from livestock grazing and management in the watershed.

3.2.9 Affected Environment -- Forest Service Special Status Species (FSS)

FSS and MIS that may occur in the project area are identified in Tables 4 and 5, along with species protected by Arizona Native Plant Law (NPL).

Forest Service Sensitive (FSS) Species. These species are unique to each Region of the Forest Service; the Forest Service Region 3 FSS list United States Department of Agriculture (USDA) (USDA 1999) applies to the CNF. FSS are listed by the Regional Forester as "sensitive" because there is concern for population viability across their range, and all occurrences contribute significantly to the conservation of the species. Forest Service Manual (FSM) 2670.32 directs that a biological evaluation be prepared to determine potential effects on species designated as "sensitive" by the Regional Forester. USDA Regulation 9500-4 directs the Forest Service to avoid actions that may cause a sensitive species to become threatened or endangered (FSM 2670.12). Populations of all FSS wildlife, fish, and plants must be maintained at viable levels in habitats distributed throughout their geographic range on NFS lands (FSM 2670.22). The population viability of FSS species becomes a concern when downward trends in or habitat capability are predicted. Whenever the Forest Service undertakes or approves an activity on NFS lands, the agency seeks to avoid or minimize impacts to FSS.

Table 4. FSS on the Coronado National Forest.

COMMON NAME	SCIENTIFIC NAME
Mammals	
Arizona shrew	*Sorex arizonae*
Huachuca Mountains pocket gopher	*Thomomys umbrinus intermedius*
Birds	
Gould's turkey	*Meleagris gallopavo mexicana*
Apache goshawk	*Accipiter gentilis apache*
Northern gray hawk	*Asturina nitida maxima*
Baird's sparrow	*Ammodramus bairdii*
Chihuahua savannah sparrow	*Passerculus sandwichensis*
Amphibians	
Western barking frog	*Eleutherodactylus augusti cactorum*
Reptiles	
Mexican gartersnake	*Thamnophis eques megalops*
Fish	
Desert sucker	*Pantosteus clarki*
Sonora sucker	*Catostomus insignis*
Invertebrates	
Giant aryxna skipper	*Agathymus aryxna*
Brigadier skipper	*Agathymus evansii*
Poling's giant skipper	*Agathymus polingi*
Pima orange tip	*Anthocharis pima*
Crescent metalmark	*Apodemia phyciodoides*
Arizona metalmark	*Calephelis arizonenesis*
Obsolete viceroy butterfly	*Limenitis archippus obsoleta*
Ursine giant skipper	*Megathymus ursus*
Spotted skipperling	*Piruna polingii*
Mexican meadowfly	*Sympetrum signiferum*
Plants	
Santa Cruz agave*	*Agave parviflora* var. *parviflora*
Saiya*	*Amoreuxia gonazlezii*
Large-flowered blue star	*Amsonia grandiflora*
Lemmon milkweed	*Asclepias lemmonii*
Greene milkweed	*Asclepias uncialis*
Huachuca milk vetch*	*Astragalus hypoxylus*
No common name	*Browallia eludens*
Chiltepin	*Capsicum annuum*
Sedge	*Carex chihuahensis*
Sedge	*Carex ultra*
Santa Cruz beehive cactus*	*Coryphantha recurvata*
No common name	*Coursetia glabella*
No common name	*Erigeron arsolius*
Bartram's stonecrop*	*Graptopetalum bartramii*
Mock pennyroyal	*Hedoma dentatum*
Huachuca golden aster	*Heterotheca rutteri*
Arizona alum root	*Heuchera glomerulata*
No common name	*Hexalectris revoluta*

Table 4. Continued.

COMMON NAME	SCIENTIFIC NAME
Texas purple spike*	*Hexalectris warnockii*
Huachuca morning glory	*Ipomoea plummerae* var. *cuneifolia*
Lemmon's morning glory	*Ipomoea tenuiloba* var. *lemmonii*
Thurbers's morning glory	*Ipomoea thurberi*
Wooly fleabane	*Laennecia eriophylla*
Supine bean*	*Macroptilum supinum*
Escoba	*Marina diffusa*
Wiggins milkweed vine	*Metastelma mexicanum*
Box Canyon muhly	*Muhlenbergia dubioides*
Beardless chinch weed	*Pectis imberbis*
Superb beardtongue	*Penstemon superbus*
Chiricahua brookweed	*Samolus vagans*
Nodding blue-eyed grass	*Sisyrinchium cernuum*
Lumholtz nightshade	*Solanum lumholtzianum*
Lemmon's stevia	*Stevia lemmonii*
Pinos Altos flame flower*	*Talinum humile*
Tepic flame flower*	*Talinum marginatum*
Thurber hoary pea	*Tephrosia thurberi*
Sonora noseburn	*Tragia laciniata*

* Protected under Arizona Native Plant Law.
Source: Forest Service, Southwestern Region Sensitive Species List, Regional Forester memorandum to Forest Supervisors, July 21, 1999.

Management Indicator Species (MIS). MIS are selected as representative of many other species. As such, they provide a basis for overall Forest management based, in part, on the effects on these species and their habitats. National Forest Management Act (NFMA) implementing regulations (36 CFR 219.19) and FSM 2600 guidelines require that Forest Plans identify certain vertebrate and/or invertebrate species as MIS, and that these species be monitored "in order to assess the effects of management activities on their populations and the populations of other species with similar habitat needs which they represent (FSM 2620.5).

MIS species and habitat are monitored to observe trends in resources, evaluate management actions, and provide a timely warning of problems or undesirable conditions affecting the resource. MIS were designated during the development of each Forest Plan based on the following criteria: threatened or endangered, requiring of special habitat needs, or in high public demand. The analysis of impacts to MIS as part of the NEPA process contributes to the identification of trends, which may necessitate development of mitigation or new alternatives when a proposed action is under consideration.

Table 5. MIS on the Coronado National Forest.

COMMON NAME	SCIENTIFIC NAME
Cavity-nesting birds*	
Northern gray hawk	***Asturina nitida maxima***
Arizona tree frog	***Hyla eximia***
Peregrine falcon	***Falco peregrinus***
Mearn's quail	***Crytonyx montezumae mearnsi***
White-tailed deer	***Odocoileus virginianus***

Table 5. Continued.

COMMON NAME	SCIENTIFIC NAME
Black bear	***Ursus americanus***
Rose-throated becard	***Pachyramphus aglaiae***
Thick-billed kingbird	***Tyrannus crassirostris***
Sulphur-bellied flycatcher	***Myiodynastes luteiventris***
Northern beardless tyrannulet	***Camptostoma imberbe***
Bell's vireo	***Vireo bellii***
Five-striped sparrow	***Amphispiza quinquestriata***

**Primary cavity nesters*: ladder-backed, Arizona, Gila, acorn, and hairy woodpeckers, northern flicker
**Secondary cavity-nesters*: American kestrel; elf, flammulated, whiskered screech, western screech, and northern pygmy owls; brown-crested, ash-throated, dusky, and Cordilleran flycatchers; violet green swallow, juniper and bridled titmice, white-breasted nuthatch, house and Bewick's wren, eastern bluebird, European starling, and Lucy's warbler.

3.2.10 Environmental Consequences -- Forest Service Special Status Species

There would be no net loss of habitat for the species listed in Tables 4 and 5 as a result of this action. The two action alternatives would have no effect on populations or trends toward Federal listing of most FSS and MIS (USFS and Reclamation 2007). The exceptions are the desert sucker, Sonora sucker, western barking frog, Mexican gartersnake, and the two sedges because of their proximity to stream bottoms where the activities of the two action alternatives would occur. But, Sonora sucker has never been recorded from Redrock Canyon and is not presently found in Sonoita Creek upstream of Patagonia Lake (Rodgeveller 2000; Foster and Mitchell 2005; Killeen 2005). Western barking frog has been found in mountains both to the east (Huachuca Mountains) and west (Santa Rita Mountains) but has never been recorded from the Redrock Canyon watershed. Potential effects to Mexican gartersnake and desert sucker are discussed in Section 3.2.6 because of the similarity of issues and effects to other non-listed fish and aquatic wildlife. Several species birds on the FSS and MIS lists use riparian vegetation and are discussed below.

<u>No Action</u>

The No Action alternative would affect only those species that would benefit from a barrier, aquatic nonnative removal, native fish restoration, and management changes to minimize risks of aquatic nonnative reinvasions. The effect would be negative because of a loss of the conservation that would accrue as a result of those actions. In the list of FSS and MIS, only desert sucker meets those criteria. Effects to this species were discussed in Section 3.2.6.

<u>Proposed Action</u>

The population of northern gray hawk is apparently stable (Csargo 2002). It uses riparian woodland with large trees, usually near mesquite forests, and forages on lizards and small mammals. It is only present in the area from mid-March to mid-autumn. Although gray hawk may be present in areas where Proposed Action activities occur, the only activity that has a potential to disturb the hawk is barrier construction. Because no large riparian trees would be removed, no adverse effects on the gray hawk are expected from the Proposed Action.

The blue-throated hummingbird, rose-throated becard, sulphur-bellied flycatcher, thick-billed kingbird, northern beardless tyrannulet, and Bell's vireo are birds recorded in or near the Redrock Canyon watershed and that use riparian or mesquite bosque habitats. Primary threats to these species are from destruction of riparian areas. No riparian loss would occur as a result of the Proposed Action, and no other effects are expected to the vegetation used as habitat for these birds or to the insects that comprise their food.

The closest known population of the sedge *Carex ultra* is in the Huachuca Mountains, and the closest known population of *Carex chihuahensis* is in the Santa Rita Mountains. There is a potential for either of the two species to exist in Redrock Canyon. Because they are associated with wetted areas, if present in Redrock Canyon, they could potentially occur in areas affected by the action alternatives. The barrier site is not typical habitat for most *Carex,* and it is unlikely either species is present. Nonnative removal and native species restoration activities are unlikely to affect either species, if present. Although there would be foot traffic along areas of surface water, it would not be of sufficient volume or intensity to destroy sedges. Temporary dewatering of stock tanks has the greatest potential for effects to the two sedges. However, the immediate vicinity of stock tanks tends to be largely unvegetated because of heavy livestock use and periodic use of heavy equipment to dredge and repair the tanks. Vegetation that occurs tends toward disturbance and weedy species, not species more associated with stable riparian areas, such as sedges. Prior to any dewatering of stock tanks, surveys for these sedges would be conducted.

Alternative A

The alternative of renovating and restoring native species without barrier construction would have a lesser effect on FSS and MIS than the proposed action. Without barrier construction, the slight possibility of injury or mortality during construction would be eliminated. Otherwise the effects of this alternative would be the same as those described for the Proposed Action.

Cumulative Effects - Forest Service Special Status Species

The primary activity affecting habitat for FSS and MIS in the Redrock Canyon watershed is livestock grazing. Roads, water developments associated with livestock grazing, and immigration and border control activities also have adverse effects. Careless use of backcountry fires by immigrants are an important cause of wildfire. Neither of the two action alternatives is expected to add to the cumulative impacts of these activities.

3.3 CULTURAL RESOURCES

3.3.1 Affected Environment

Southern Arizona was occupied by small mobile bands of hunter-gathers from the beginning of the Paleoindian period about 11,000 B.C. to the end of the Archaic period around 1200 B.C. By the end of the Archaic, pithouse villages were established near agricultural fields along the larger streams, while procurement and camp sites continued to be located away from major river valleys. Probable Archaic sites are represented by lithic scatters and possible camp sites on ridge tops and near water sources in and around the Patagonia Mountains.

An agricultural economy, combined with hunting and wild plant collecting, continued to be followed throughout the rest of the Early Agricultural and Ceramic period (ending ca. AD 1450) in southern Arizona. Ceramic period occupation in the Redrock Canyon area is indicated by scattered habitation sites along major drainages as well as smaller, probable special use sites. Ceramics and other artifacts from identified sites suggest interaction with the Trincheras Culture to the south as well as the Hohokam to the north.

The O'odham occupied the area around Redrock Canyon and nearby Sonoita Creek when the Spanish first visited the area in the 1690s. After settling in the Santa Cruz Valley, Spanish settlers also used the area for limited mining, charcoal production, and grazing until increased Apache hostilities forced its abandonment in the mid to late 1700s. The Patagonia area was used intermittently by the O'odham, Mexicans, and Americans after the Gadsden Purchase (1854) when southern Arizona became a territory of the United States. Mining and grazing became better established after Apache hostilities declined in the 1880s, and grazing continues to be the major land use in the area today.

Most archaeological surveys in the project area have been conducted by the Forest Service in association with a number of range management projects, including fencelines, riparian exclosures, and stock tanks. Four previously identified archaeological sites are located within a mile of the project area, but none are close enough to be affected by the fish barrier construction or related activities. All four represent prehistoric ceramic period occupations. The closest site is situated on the north bank of Redrock Creek less than ¼ of a mile above the fish barrier. This habitation site's location on a high terrace above the stream precludes any impact from possible sedimentation behind the barrier.

The project scoping letter was sent to 12 Native American tribes with traditional ties to southeastern Arizona; no comments were received. Archaeologists from Reclamation and CNF conducted a Class III Survey of the areas that would undergo ground-disturbing activities, including the access route, fish barrier locale, temporary laydown area, and staging area. No cultural resources were identified within the footprint of the proposed construction area. A finding of "no historic properties affected" was made by Reclamation following the survey. The CNF concurred with this finding in an Inventory Standards and Accounting form, signed by Forest Archaeologist Mary Farrell and Forest

Supervisor Jeanine Derby on December 8, 2006. The State Historic Preservation Office concurred with this determination on January 11, 2007.

3.3.2 Environmental Consequences

No Action

There would be no change in existing conditions. Environmental factors, including surface and channel erosion as well as cattle grazing, would continue to affect any resources in the area. It is assumed that current land use and management practices would continue, as would Federal protections to cultural properties now in place. Minimal impact to cultural resources would be anticipated as the result of not implementing the Redrock Canyon fish restoration project.

Proposed Action

For the most part, ground-disturbing activities would be limited to fish barrier construction and related tasks. The proposed fish restoration activities (native salvage, nonnative removal, native restoration, monitoring) would have minimal to no impact to any potential cultural resources in the area.

Construction of the fish barrier, including temporary access up the streambed, a laydown area, and staging area along the road would not impact any known cultural resources or archaeological sites within the project area. While the addition of a barrier may result in upstream sediment buildup within the channel, the closest archaeological site is located on a high terrace over 1,000 feet upstream and would not be affected by increased sedimentation.

Nonnative species removal and native fish restoration would not involve any ground-disturbing activities and would largely take place in the immediate vicinity of water resources with margins previously disturbed by flooding or tank construction. These activities would have no effect on cultural resources within the fish restoration area.

Alternative A

This alternative would have no potential to affect cultural resources. With Alternative A, there would be no ground-disturbing activities from the fish barrier construction. The impact of the activities related to the fish restoration would be minimal.

Cumulative Effects – Cultural Resources

Livestock grazing is the major ongoing use of the project area, with human impacts introduced by ranchers, recreational enthusiasts, and other foot and vehicle traffic through the area. Because cultural resources would not be affected by either no action or the action alternatives, cumulative impacts would not occur.

3.4 SOCIOECONOMIC EFFECTS - LIVESTOCK GRAZING

3.4.1 Affected Environment

The Redrock Canyon watershed encompasses all or portions of four livestock grazing allotments administered by the Forest Service. These allotments are Seibold-Crittenden, Kunde, Papago, and San Rafael. Livestock management on each of these allotments is guided by an allotment management plan (AMP). Implementation of the AMP is documented in the Annual Operating Instructions (AOI). The AOI sets forth the maximum permissible grazing use authorized for the upcoming grazing season, the planned sequence of grazing, improvements to be constructed, reconstructed or maintained; allowable use or other standards to be followed by the permittee; and required monitoring for the grazing season. Management of the four allotments is described below.

Seibold-Crittenden Allotment. The allotment was created by combination of the Crittenden and Seibold Allotments in 2005. The allotment contains ten pastures, of which the following six occur within the Redrock Canyon watershed: Corral Canyon (small part), Red Bear, Oak Grove, Moonshine, and East Redrock and West Redrock Pastures. The first four are grazed by the main herd as part of a six-pasture rotation. The East and West Red Rock Pastures are grazed with 30 head of heifers and/or cows for up to 90 days (90 Animal Unit Months (AUMs)[13]) during the winter (November-April), except that once every 3 to 5 years the entire herd may graze these two pastures for 1 month (130 AUMs) in the winter.

Livestock exclosures were constructed around Pig Camp Spring (0.1 mile) and Gate Spring (0.3 mile) in the 1990s on behalf of Gila Topminnow. Oak Grove Spring was fenced in 2001 with the expectation that excluding livestock grazing would develop habitat for Gila topminnow; however, the habitat did not develop in the last 6 years. The stream in the West Redrock pasture was fenced to exclude livestock in 2002. All of these exclosures are maintained and monitored by the grazing permittee and/or Forest personel at least once a year to ensure the fences are functional.

Kunde Allotment. The Kunde Allotment occupies the middle portion of the drainage and consists of four pastures: Holding, Lower Lampshire, Upper Lampshire, and Redrock. Redrock Canyon passes through the Redrock Pasture. Historically, one of the greatest challenges to successful management of the Kunde Allotment has been poor water availability in the rougher pastures and adherence to the grazing rotation schedule. This would often result in overuse of the lower pasture where reliable water was available. Livestock management was changed in 1991 to require winter use only in pastures along Redrock Creek. Permitted numbers were reduced from 100 Cattle Yearlong (CYL)[14] to 53 CYL. The Falls exclosure (0.5 mile) and Gate Springs exclosure (0.3 mile) were constructed to protect two of the wettest sections of the creek. Further reductions occurred in 2004 when the Forest issued a decision to exclude grazing from the Redrock

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[13] One AUM is equivalent to enough forage to support one adult cow without a calf for 1 month's time.
[14] CYL represents the number of adult cattle that are being raised year-round.

Pasture to reduce grazing impacts to the Gila topminnow and to improve riparian and watershed condition. Permitted numbers of cattle were reduced to 31 CYL to reflect the reduction in available capable acres. The AMP established a three-pasture rotational grazing schedule using Upper Lampshire, Lower Lampshire, and Holding pastures to allow growing season rest in all pastures, at least every other year. The permit was waived to a new permittee and has been in non-use for resource protection purposes since then.

Papago Allotment. The allotment consists of a 14-pasture deferred rotation grazing system, of which Lampshire pasture is the only one within the Redrock Canyon watershed. Lampshire Pasture is grazed annually during December-January or February-March. The main feature in this pasture is Box Canyon, a tributary to Lampshire Canyon which flows into Redrock Canyon. Riparian vegetation is limited in Box Canyon, and there is no potential for fisheries or amphibians.

San Rafael Allotment. The upper part of the drainage is included in the San Rafael allotment, which is part of the Vaca Ranch headquartered in the San Rafael Valley. There are 23 pastures on the Vaca Ranch but only two are within the Redrock Canyon watershed: North Redrock and South Redrock. These two pastures are grazed in rotation during winter from October through March. Cott Tank (1.9 miles) exclosure was constructed in the mid-1990s and extended downstream into Redrock Canyon about ¼ mile in the early 2000s.

3.4.2 Environmental Consequences

No Action

There would be no effect to livestock grazing under this alternative.

Proposed Action

Barrier Construction and Maintenance. The fish barrier would be constructed in the West Redrock pasture on the Seibold-Crittenden Allotment. This pasture is grazed during winter once every 3 to 5 years. The proposed barrier site is located within the West Redrock Exclosure. This site consists mostly of exposed bedrock and provides little if any forage used by livestock. All reasonable efforts would be made to minimize removal of trees, and site rehabilitation would occur following project completion. The volume of construction traffic is expected to be low and would not disrupt access for the livestock grazing permittee. Similarly, periodic operation and maintenance of the fish barrier are not anticipated to impact the grazing operation.

Nonnative Species Removal. Nonnative removal from stock tanks and surface waters would occur on all four of the allotments within the project area. Reclamation and the Forest Service would cooperate with permittees to avoid disruption of grazing operations. Pumping of stock tanks and possibly cienega pools to facilitate nonnative removal may affect surface water availability in the short term for livestock if livestock are present during or shortly after pumping. If cattle are in the pastures where the tanks are located during treatment, sufficient water would be made available for cattle, including refilling tanks or providing an alternative water source if necessary until the stock tanks refill with the summer rains.

Piscicides would be applied in accordance with a Forest Supervisor-approved Pesticide Use Proposal during periods of low stream flow. There are approximately 13 stock tanks in the watershed, although most are not perennial. Three reaches of Redrock Canyon have perennial surface water: Falls, Gate Spring, and Cott Tank drainage. Surface water has usually also been present in the West Redrock pasture, at Pig Spring, and Oak Grove Spring, and approximately 0.25 miles upstream of Redrock Ranch on the border of Sections 7 and 12. Livestock are excluded from these areas and would not have access to the water during treatment with piscicides.

Piscicides would also be applied to surface water outside of livestock exclosures, such as stock ponds. Cattle are not expected to be affected by either rotenone or antimycin A. Rotenone has been used as a control for grub on dairy and beef cattle for many years with no adverse effects, and the EPA has reported that there is no need to restrict livestock consumption of treated waters (Finlayson et al. 2000). However, alternative water sources for livestock would be provided as appropriate during the project, to prevent disruption of cattle access to water or to draw cattle away from areas of project activity where their presence may disrupt project implementation.

Native Species Transplants

Gila topminnow. Gila topminnow has been documented in Redrock Canyon since at least 1979 (Rinne et al. 1980). The importance of Redrock Canyon to recovery of Gila topminnow is well-established (Recovery Plan). Consultation with FWS since 1990 has resulted in four biological opinions that specifically address management in Redrock Canyon: the Redrock Canyon Action Plan (2-21-90-F-169b), the Canelo Pass to Patagonia Segment of the Arizona Trail (2-21-92-F-350), and the 1998 and 2002 supplemental Biological Assessment of Ongoing and Long-term Grazing on the Coronado National Forest (AESO/SE 2-21-98-F-399 and 2-21-98-F-399-R1). The terms and conditions of the biological opinion include several actions necessary to minimize the take of Gila topminnow in Redrock Canyon under current management. These actions include the construction and maintenance of livestock exclosures, continued monitoring of fish and aquatic habitats, and reporting data to the FWS. As a result, about 2.8 miles of the Redrock Creek and Cott Tank drainage valley bottom are fenced to exclude domestic livestock; livestock are permitted on the unprotected reaches of Redrock Creek during winter only; and water tanks, drinkers, and salting areas are on the uplands to draw livestock away from the stream and gain better distribution patterns.

As documented by photo points and data, projects completed during the past decade are improving riparian conditions in Redrock Canyon. A series of photos taken at 1,000-foot intervals through Redrock Canyon in 1989 and repeated in 1996 and 2001 generally show the channel becoming narrower with increased definition of channel banks, substrate particle size increasing (as fine sediments are either captured by streambanks vegetation or passed through the system), and recruitment and growth of woody and herbaceous riparian plants (Stefferud 2001). In the exclosures, aquatic habitats dramatically improved with increases in overhanging vegetation, establishment of defined streambanks, and a trend towards enhanced channel stability and higher diversity of aquatic habitats. The extent of surface water in time and space and the length of the "green line" vegetation have expanded a considerable distance beyond the exclosures. In some reaches, herbaceous vegetation is beginning to catch and retain fine sediments during over bank flows.

The proposed augmentation of Gila topminnow, ultimately to establish a self-sustaining population, is not anticipated to cause any additional limitations or restrictions for livestock grazing. Permittees would continue to be required to adhere to Forest standards and guidelines for grazing and the approved AMP, and the Forest Service must ensure all terms and conditions for incidental take statements are followed.

Gila chub. Gila chub has not been recorded in Redrock Canyon. Apparently suitable habitat exists in few locations, most notably in Cott Tank drainage. Given completion of other required regulatory processes, Gila chub would be reintroduced into this area following removal of nonnatives, providing that sufficient surface waters are present. Because Gila chub would occupy the same areas as Gila topminnow, management for Gila chub is not anticipated to be substantially different than that for Gila topminnow.

It is anticipated that transplant of Gila chub would not necessitate any additional requirements or restrictions for livestock grazing than are already in place for Gila topminnow. Specifically, the permittee would be required to inspect and maintain livestock exclosure fences and ensure livestock use remains within allowable levels, as specified in the AMP. The Forest would be required to monitor the fisheries and stream habitat in cooperation with AGFD.

Chiricahua leopard frog. All four allotments contain potential habitat for Chiricahua leopard frogs, but the most likely site for a transplant is historically occupied habitat on the Seibold-Crittenden allotment. Grazing occurs in or near most habitats occupied by the frogs, and maintenance of viable populations appears to be compatible with well-managed livestock grazing. The 2002 biological opinion specifies terms and conditions for livestock management activities on the Seibold allotment that are necessary to minimize the take of Chiricahua leopard frog. These measures include requirements to survey for and salvage frogs during stock pond cleaning activities; measures designed to minimize the introduction of nonnative species or chytrid contamination into occupied sites; measures to reduce direct mortality and damage to aquatic cover as a result of livestock impacts; and the requirement to monitor and report incidental take. In 2005, the Forest developed aquatic habitat guidelines for Chiricahua leopard frogs that are intended to implement the terms and conditions of the biological opinion. Permittees are notified of these terms and conditions in their AOIs.

It is anticipated that transplant of Chiricahua leopard frog would not trigger any additional limitations or restrictions for livestock grazing than are currently in place.

Sonora tiger salamander. In an effort to minimize the take of Sonora tiger salamanders as a result of routine stockpond maintenance, the Forest has adopted stockpond management and maintenance guidelines that are in effect on allotments in the San Rafael Valley and surrounding areas. The Forest Service anticipates no additional restrictions or changes in livestock management as a result of transplanting Sonora tiger salamanders. If management is adequate to maintain stock tanks as they are, the populations of Sonora tiger salamander would persist and expand as a result of the removal of nonnative species. Cattle ranching and Sonora tiger salamanders have coexisted for many decades in Arizona. There is no reason to believe they could not continue to coexist.

Cumulative Effects – Livestock Grazing

Neither action alternative is expected to alter existing livestock grazing practices within the watershed. Therefore, the proposed project would not have incremental or additive socioeconomic effects on grazing operations.

3.5 RECREATION AND VISUAL QUALITY

3.5.1 Affected Environment

Visual Quality. Landscape character in the project area is comprised of rolling topography covered with a mosaic of vegetation that includes semi-desert grassland, evergreen oak woodland, and mesquite-prickly pear. Along the creek through Redrock Canyon is riparian vegetation comprising of cottonwood, willow, and lush grasses. Existing condition of visual quality in the area is generally good.

Visual Quality Objectives (VQOs) established for National Forest lands provide standards that govern proposed alteration of the landscape. The CNF Plan designates the project area with a VQO of "Modification," which means that while management activities may visually dominate the characteristic landscape, they must utilize naturally established form, line, color, and texture. According to the VQO inventory, the nearest visually sensitive travel ways in the project area include Highway 82 (Sensitivity Level 1: High) and FSR 58 (Sensitivity Level 2: Average). In addition, a project-level review reveals that the Arizona Trail passes through the project area, and this route would qualify as a Sensitivity Level 1 travel way.

Recreation. There are no developed recreation sites in the project area. Dispersed uses throughout this part of the forest include scenic driving, hiking, birdwatching, camping, and hunting. In the project area, Arizona Trail use (including hiking, horseback riding, and mountain biking) and exploration of backroads on off-highway vehicles are popular recreation activities. However, there is poor access and rugged terrain in the Redrock Canyon watershed, so most recreational use occurs on existing roads and trails. The Arizona Trail bisects the upper watershed, but avoids the proposed barrier site. Access for high clearance four-wheel drive vehicles is provided by Forest roads.

3.5.2 Environmental Consequences

No Action

There would be no effect to visual quality or recreational use under this alternative.

Proposed Action

Visual Quality. Many of the proposed activities have little or no impact to visual quality, including removal of fish/amphibians/turtles, application of piscicide, reintroduction of native fish and amphibians, and monitoring. Construction of a permanent, concrete fish barrier impacts visual quality, but when mitigated, the barrier will meet the area's VQO. Mitigation would include: (1) using colored concrete to match adjacent natural rock colors for the entire fish barrier (all exposed surfaces including walls and apron); (2) minimizing removal of trees and damage to other vegetation; (3) restoring the stream channel, staging areas, and vehicle tracks as needed following construction; and (4) selecting riprap rock type and color to match native rock.

Recreation. Most of the proposed activities would have little impact on recreation, and construction of the fish barrier is not expected to affect recreational use. Because the barrier includes a 5-foot-high, concrete drop structure, there is a potential risk of injury to visitors. However, because there are no recreation trails or roads that access the barrier site, this risk is minimal. There may be a slight disturbance to recreational users in areas where piscicide applications and bullfrog eradication activities are being conducted. Mitigation would include: (1) posting cautionary signage (construction and piscicide treatment areas) in both English and Spanish, and (2) restoring all disturbed ground created by this project, especially tracks or trails that might encourage visitors to access the fish barrier, and other areas that might encourage heavier dispersed uses (parking, camping, etc.).

Alternative A

There would be no effect to visual quality under this alternative. Effects to recreation would be similar to those described under the Proposed Action for piscicide applications.

Cumulative Effects -- Recreation and Visual Quality

Proposed project activities, including construction of a fish barrier, would have minor and highly localized impacts on the visual quality and recreation. The CNF's Schedule of Proposed Actions currently lists several other activities in or near the proposed project area, including grazing allotment management plans, mineral exploration, road maintenance, and fuels management. None of these projects will have major impacts to visual quality or recreation. Therefore, the cumulative effects from the proposed project would be minimal.

3.6 SOILS AND GEOLOGY

3.6.1 Affected Environment

Geologic units within the Redrock Canyon watershed include surficial alluvium, volcanics, metamorphic, and sedimentary rock. Nearly 85 percent of upland soils are grouped within the Lampshire-Graham-Rock Outcrop and Chiricahua-Lampshire associations (NRCS 2007). These soils consist of cobbly or heavy clay loam and very cobbly loam formed on hillsides. Alluvial deposits eroded from upland areas fill the canyon bottom and underlie stream terraces.

Moderately to steeply sloping canyon walls entrench the stream throughout the project area. The fish barrier would be located in a narrow cut in a low ridge of basalt that trends nearly perpendicular to the canyon walls. At the fish barrier site, the top of the rock abutments are approximately 6 feet above the surface of the alluvium. Channel width through this rock cut is approximately 10 feet at the surface of the alluvium.

The channel alluvium consists of fine sand, gravel, and cobbles. Boulders and bedrock are present along the channel and occur at various depths within the alluvium. An outcrop of basalt forms the channel bed approximately 40-feet upstream of the barrier site. At the rock cut, the alluvial deposits extend beyond 7 feet to an unknown depth.

3.6.2 Environmental Consequences

No Action

Existing conditions would prevail into the foreseeable future. Unnatural rates of erosion and sedimentation would continue as a result of human-induced disturbances within the watershed.

Proposed Action

Construction would directly affect less than 0.1 acre of channel and floodplain substrates at the barrier site. Excavation for the barrier foundation would displace an estimated 55 cubic yards of alluvium, which would be replaced by approximately 5 cubic yards of concrete, 8 cubic yards of gabions, and 42 cubic yards of backfill. Surplus material excavated from the foundation trench would used as backfill along the upstream side of the barrier to minimize temporary pool development following construction.

A backhoe, drill rig, and pickup truck needed for construction would be “walked” up the channel from FSR 138. This would result in a minor disturbance to alluvial soils on a 3,500-foot segment of normally dry streambed. All other equipment and imported material would be transported to the barrier site by helicopter.

Construction staging would affect approximately 0.1 acre of alluvial soils on a floodplain bence at the FSR 138 low-water crossing downstream of the barrier. Approximately 0.02

acre of alluvial soils would be affected by construction material lay down on a floodplain terrace adjacent to the barrier site. Appropriate post-construction stabilization of these areas would be required to minimize potential erosion.

In the short-term following construction, stream-transported coarse material would be immobilized by the barrier, forming a new layer of bedload deposits over existing channel substrates. Deposition of this material would be accelerated by seasonal high flows and floods. Localized effects include a reduction in gradient and aggradation of the active stream channel for approximately 1,475 feet (1.4 acres) upstream of the barrier (Figure 6).

Short-term capture of bedload sediment at the barrier is expected to have minimal impact on stream balance downstream. Redrock Canyon carries high coarse sediment loads during floods, and the amount of bedload that would be immobilized at the barrier relative to the total volume transported within the stream is small. Total sediment yield downstream would be consistent with pre-project conditions once streambed aggradation at the barrier has stabilized. No long-term impact on sediment transport within the stream would occur.

The proposed action would have a low impact on soils from pedestrian traffic associated with stream renovation and native fish and amphibian restoration.

Alternative A

This alternative would have minimal impact on soils from pedestrian traffic associated with stream renovation and native fish and amphibian restoration.

Cumulative Effects -- Soils and Geology

The effects of project activities on channel features and sedimentation would be incremental to historic and ongoing uses of the watershed. During the 20th century, livestock grazing, trails (both authorized and unauthorized), and roads were the primary human-induced sources of sedimentation. Recreational use was and is a minor contributor to sedimentation. Changes in grazing practices have reduced erosion in riparian areas and other portions of the watershed, although grazing continues to be a source of sedimentation. The proposed native fish restoration project would not add substantially to the cumulative impacts of other past, present, or reasonably foreseeable actions on soils because of the limited scope of the proposal (short duration and relatively small area impacted) and use of appropriate erosion control practices to mitigate soil impacts.

3.7 AIR QUALITY

3.7.1 Affected Environment

Air quality is determined by the ambient concentrations of pollutants that are known to have detrimental effects on human health. The U.S. Environmental Protection Agency (EPA) has promulgated National Ambient Air Quality Standards (NAAQS) for six criteria pollutants: carbon monoxide, nitrogen dioxide, particulate matter (PM_{10} and $PM_{2.5}$), ozone, sulfur dioxide, and lead. Areas with air quality that do not meet the standards are designated as "nonattainment areas." Designation of nonattainment submits an area to regulatory control of pollutant emissions so that attainment of the NAAQS can be achieved within a designated time period. The Redrock Canyon watershed is located in an attainment area for all regulated NAAQS (EPA 2007). Ambient air quality in the area is excellent.

The Clean Air Act (CAA) provides special protection for visibility and other air quality values in specially designated Class I areas where the cleanest and most stringent protection from air quality degradation is considered important. These areas include National Parks and Wilderness Areas which have been specifically designated Class I under Section 162(a) of the CAA. There are no Class I areas near Redrock Canyon.

The primary sources of air pollutants (PM_{10}) affecting the watershed include traffic on unpaved roads, fire (both wildland fire and prescribed burning), and natural events such as windstorms.

3.7.2 Environmental Consequences

No Action

No change in air quality would result from taking no action.

Proposed Action

Fugitive dust emissions could result from excavation and grading of alluvium within the stream channel at the barrier construction site. Dust emissions could be expected to vary depending on the level of activity, specific operation, and level of moisture encountered in floodplain soils. A direct effect to air quality would result from construction vehicles transporting employees and equipment over the unpaved FSR 138. Integration of ADEQ, Reclamation, and Forest Service BMPs for dust suppression would minimize the impact of particulate emissions on air quality.

In addition, the operation of construction vehicles and equipment would produce tailpipe combustion products such as nitrogen oxides, carbon monoxide, sulfur oxides, and reactive organic gases which would locally degrade ambient air quality for very short periods of time. These emissions would not result in measurable changes in ambient concentrations of regulated pollutants and a change in attainment status for the air quality region.

Alternative A

Implementation of this alternative would not result in the fugitive dust emissions associated with the proposed construction of a fish barrier. Vehicle traffic during nonnative species removal and restocking of native species would be negligible.

Cumulative Effects – Air Quality

Sources of atmospheric emissions from the action alternatives include vehicle traffic and equipment operation, both of which would release particulates and gaseous exhaust emissions to the atmosphere. The very small quantities of pollutants released would have negligible effect on local air quality for a very short period of time. Therefore, changes in ambient concentrations of regulated atmospheric pollutants would be unnoticeable, and cumulative impacts with other sources of pollutants in the airshed would not result.

CHAPTER 4 – AGENCIES AND PERSONS CONSULTED

List of Preparers

Rob Clarkson, Bureau of Reclamation, Biologist
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Tom Jones, Arizona Game and Fish Department, Biologist
Mike Sredl, Arizona Game and Fish Department, Biologist
Ross Timmons, Arizona Game and Fish Department, Biologist
Matt Killeen, The Nature Conservancy, Preserve Manager

List of Agencies and Persons Contacted

Libraries:

Patagonia Public Library

Chamber of Commerce:

Nogales/Santa Cruz County Chamber of Commerce

Indian Communities:

Ak-Chin Indian Community
Fort Sill Apache Tribe
Gila River Indian Community
Mescalero Apache Tribe
Salt River Pima-Maricopa Indian Community
San Carlos Apache Tribe
The Hopi Tribe
Tohono O'odham Nation
Pascua Yaqui Tribe
Pueblo of Zuni
White Mountain Apache Tribe
Yavapai Apache Nation

County Agencies:

Santa Cruz County Board of Supervisors
Santa Cruz County Health Services

State Agencies:

Arizona Department of Agriculture
Arizona Department of Environmental Quality
Arizona Department of Water Resources
Arizona Game and Fish Department
Arizona State Historic Preservation Office

Federal Agencies:

U.S. Fish and Wildlife Service
U.S. Army Corps of Engineers
U.S. Geological Survey

Conservation and Environmental Organizations:

American Rivers
Arizona Riparian Council
Center for Biological Diversity
Desert Fishes Council
Friends of Arizona Rivers
Forest Guardians
Sierra Club
Sky Island Alliance
The Nature Conservancy

Grazing Organizations:

Arizona Cattle Growers Association
Canelo Hills Coalition

Other Organizations

Arizona Cooperative Extension Service
Arizona People for the American Way

CHAPTER 5 - RELATED ENVIRONMENTAL LAWS/DIRECTIVES

The following is a list of Federal laws, Executive Orders, and other directives that apply to the action alternatives discussed in this EA:

The National Environmental Policy Act (NEPA) of 1969, as amended requires Federal agencies to evaluate the potential environmental consequences of major Federal actions. An action becomes "federalized" when it is implemented, wholly or partially funded, or requires authorization by a Federal agency. The intent of NEPA is to promote consideration of environmental impacts in the planning and decision-making process prior to project implementation. NEPA also encourages full public disclosure of the proposed action, accompanying alternatives, potential environmental effects, and mitigation.

Scoping information was distributed to more than 53 individuals, organizations, and agencies on January 18, 2007. In addition, information on the proposed project was posted on CNF's Schedule of Proposed Actions and Reclamation's Phoenix Area Office web site in January 2007.

The EA was prepared and distributed for 30-day public review in accordance with Reclamation guidelines and Forest Service regulations at 36 CFR 215.

The National Forest Management Act (NFMA) of 1976, as amended requires the Forest Service, acting on behalf of the Secretary of Agriculture, to assess Forest lands and develop management plans based on multiple-use, sustained-yield principles for each unit of the Forest Service. The statute also requires the Forest Service to provide for the biological diversity of National Forests consistent with overall multiple-use objectives of the planning area and to maintain viable populations in the planning area.

The Coronado Land and Resource Management Plan (LRMP) was adopted on August 4, 1986, and has been amended 11 times. Forest planning is guided by the Code of Federal Regulations (CFR) at 36 CFR 219, which states that projects implemented after the LRMP is in place must be "consistent with the plan" (36 CFR 219.8(e)). The project was designed in conformance with the Coronado LRMP long-term goals and objectives on public lands for maintainenance of viable populations of native fishes and amphibians and work toward recovery of federally listed species.

Forest Sensitive Species and Management Indicator Species (MIS) for the proposed project are identified in Section 3.2.9 of this document. Effects to these species are disclosed in this EA and in the Biological Evaluation and MIS Analysis prepared by the District Biologist. This analysis meets NFMA obligations for MIS under 36 CFR 219.14(f).

The Fish and Wildlife Coordination Act (FWCA) of 1958, as amended provides a procedural framework for the consideration of fish and wildlife conservation measures in

Federal water resource development projects. Coordination with the FWS and State wildlife management agencies are required on all Federal water development projects.

The barrier element of the proposed project is the result of ESA Section 7(a)(2) consultation between Reclamation and FWS. Coordination among Reclamation, FWS, and AGFD has been ongoing since the project's inception. The FWS concluded that the current level of coordination among the agencies is sufficient to meet any regulatory needs required by the FWCA.

The Endangered Species Act (ESA) of 1973, as amended provides protection for plants and animals that are currently in danger of extinction (endangered) and those that may become so in the foreseeable future (threatened). Section 7 of this law requires Federal agencies to ensure that their activities do not jeopardize the continued existence of threatened or endangered species or adversely modify designated critical habitat.

Construction of a fish barrier in Redrock Canyon is part of the conservation measures being considered in an in-progress formal Section 7 consultation between Reclamation and the FWS. Recovery actions are a part of Reclamation's fund transfer program under the 2001 biological opinion, and nonnative removal, native fish restoration, and stock tank management changes are, in part, terms and conditions of the incidental take statements of a 2002 biological opinion to the Forest Service. Possible effects to proposed and listed species and critical habitat resulting from project implementation were examined in a Biological Assessment prepared by Reclamation and the Forest Service and submitted to the FWS in August 2007. The Biological Assessment concluded the project may affect, and is likely to adversely affect, Gila topminnow, Gila chub, Sonora tiger salamander, and Chirichua leopard frog because some may be harmed by chemical and mechanical treatments of aquatic habitat, despite salvage efforts prior to the treatments. The proposed action may affect, but is unlikely to adversely affect, the lesser long-nosed bat. Despite possible adverse effects during implementation, the project is expected to have long-term, net benefits to native fish and amphibians by removing nonnative predatory fish and bullfrogs and preventing nonnative fish from reinvading stream habitat in Redrock Canyon.

The Migratory Bird Treaty Act (MBTA) of 1918, as amended implements various treaties and conventions between the United States and Canada, Japan, Mexico, and the former Soviet Union for the protection of migratory birds. The MBTA prohibits the take, possession, import, export, transport, selling or purchase of any migratory bird, their eggs, parts or nests.

Implementation of this project would not violate provisions of the MBTA.

The Clean Air Act (CAA) of 1963, as amended requires any Federal entity engaged in an activity that may result in the discharge of air pollutants must comply with all applicable air pollution control laws and regulations (Federal, State, or local). It also directs the attainment and maintenance of National Ambient Air Quality Standards (NAAQS) for six different criteria pollutants including carbon monoxide, ozone, particulate matter, sulfur oxides, oxides of nitrogen, and lead. Air quality in the project area is in attainment of NAAQS.

Short-term construction emissions (particulate matter) associated with the proposed project would have localized and minor effects on air quality in the Redrock Canyon watershed.

The Clean Water Act (CWA) of 1977, as amended strives to restore and maintain the chemical, physical, and biological integrity of the nation's waters by controlling discharge of pollutants. The basic means to achieve the goals of the CWA is through a system of water quality standards, discharge limitations, and permits. Section 404 of the CWA identifies conditions under which a permit is required for actions that result in placement of fill or dredged material into waters of the United States. In addition, a 401 water quality certification and 402 National Pollutant Discharge Elimination System (NDPES) permit are required for activities that discharge pollutants to waters of the U.S. The EPA has delegated responsibility to administer water quality certification and NPDES programs in Arizona to ADEQ.

The discharge of dredged and fill material resulting from construction of the barrier requires a CWA Section 404 permit from the COE. Reclamation submitted an application to the COE for 404 permit coverage of all barriers that would be constructed pursuant to the 2001 CAP biological opinion. Reclamation received a conditional 401 water quality certification and a 404 permit for these barriers on June 24 and October 30, 2003, respectively. All special conditions of the 401 certification and 404 permit would be implemented. Coverage under the Section 402 Arizona Pollutant Discharge Elimination System General Permit for construction activities would be obtained prior to construction.

The National Historic Preservation Act (NHPA) of 1966, as amended mandates all federally funded undertakings that have the potential to affect historic properties are subject to Section 106 of the NHPA. Federal agencies are responsible for the identification, management, and nomination to the National Register of Historic Places of cultural resources that could be affected by Federal actions. Consultation with the Advisory Council on Historic Preservation and the State Historic Preservation Office (SHPO) (or Tribal Historic Preservation Office) is required when a Federal action may affect cultural resources on, or eligible for inclusion on, the National Register.

Archaeologists from Reclamation and CNF conducted a Class III Survey of the areas that would undergo ground-disturbing activities, including the access route, fish barrier locale, temporary laydown area, and staging area. No cultural resources were identified within the footprint of the proposed construction area. A finding of no historic properties affected was determined by Reclamation following the survey. Coronado National Forest indicated concurrence with the finding in an Inventory Standards and Accounting form, signed by Forest Archaeologist Mary Farrell and Forest Supervisor Jeanine Derby on December 8, 2006. The SHPO concurred with this determination on January 11, 2007.

The Resource Conservation and Recovery Act (RCRA), as amended establishes thresholds and protocols for managing and disposing of solid waste. Solid wastes that exhibit the characteristic of hazardous waste, or are listed by regulation as hazardous waste, are subject to strict accumulation, treatment, storage, and disposal controls.

The proposed project is not expected to generate hazardous waste as defined and regulated under RCRA. To minimize the possible impact of hazardous materials (petroleum, oil, and lubricants) used during construction, all equipment would be periodically inspected for leaks. Any significant leaks would be promptly corrected. Nonhazardous solid waste would be disposed of in accordance with State and Federal regulations at an approved landfill. Spills and disposal of contaminated media would be managed in accordance with State and Federal requirements.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended requires all persons who apply pesticides classified as restricted use be certified, or that they work under the direct supervision of a certified applicator. Aquatic applicators must demonstrate a practical knowledge of the secondary effects that can be caused by improper application rates, incorrect formulations, and faulty application of restricted pesticides. Applicators must have a practical knowledge concerning potential effects on plants, birds, beneficial insects, and other organisms that may be present in aquatic environments.

Piscicides have been used by fisheries managers in National Forests for stream and lake renovation projects since the 1930s. The U.S. Department of Agriculture Policy Regulation 9500-4 provides broad policy direction for fish and wildlife management in National Forests, including use of piscicides. Antimycin A is registered under the product name Fintrol. Antimycin A and rotenone are approved for use on Forest Service lands. Application of Antimycin A and rotenone in Redrock Canyon would be under the direction of a certified applicator in accordance with a Forest Service approved Safety Plan. The applicator would be charged with ensuring that all label and safety requirements are met. Piscicide applications would be consistent with relevant requirements of FIFRA.

Executive Order 11988 (Floodplain Management) requires Federal agencies to avoid, where practicable alternatives exist, the short- and long-term adverse impacts associated with floodplain development. Federal agencies are required to reduce the risk of flood loss; minimize the impacts of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values served by floodplains in carrying out agency responsibility.

The proposed project is necessary for the protection of the existing native fish community and potential recovery of listed species. Because the nature of the project requires minor construction in an active channel, no practicable alternative exists. Floodplain effects would be highly localized and minor.

Executive Order 11990 (Wetlands) requires Federal agencies, in carrying out their land management responsibilities, to take action that would minimize the destruction, loss, or degradation of wetlands and take action to preserve and enhance the natural and beneficial values of wetlands.

The proposed project would not adversely affect wetland functions or values. No physical loss of wetland habitat would occur.

Executive Order 12898 (Environmental Justice) requires Federal agencies to identify and address, as appropriate, disproportionately high and adverse human health and environmental effects of their programs, policies, and activities on minority and low-income populations.

The proposed project area encompasses uninhabited National Forest land and potentially a minor portion of two private inholdings. No impact on low income or minority populations as defined by Executive Order 12898 would result.

Secretarial Order 3175 (incorporated into Departmental Manual at 512 DM 2) requires that if any Department of the Interior agency actions might impact Indian trust assets, the agency must explicitly address those impacts in planning and decision documents, and the agency must consult with the tribal government whose trust resources are potentially affected by the Federal action.

The proposed project would affect CNF land and potentially two private (non-Indian) inholdings. No Indian trust assets would be affected.

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APPENDIX A

Location Records for Native and Nonnative Aquatic Vertebrates in the Redrock Canyon Watershed and Vicinity

Table A-1. Location records for native and nonnative species.

SPECIES	LOCATION	IN PROJECT AREA?	LATEST RECORD	SOURCE
Chiricahua leopard frog *Rana chiricahuensis*	Unnamed tributary from north to Oak Grove Spring Canyon in west 1/2 Sec. 35	yes	1997	Scott 1995
	Unnamed tank in north fork Oak Grove Spring Canyon (Oak Tank)	yes	2003	M. Sredl, AGFD, pers. com. 2006
	Meadow Valley Tank & unnamed tank downstream (Hudson Tank)	yes	1982	FWS 2006a
	Harshaw Creek near Harshaw town site	no	1998	FWS 2006a
	Sonoita Creek near Patagonia	no	1945	FWS 2006a
	Monkey Spring	no	2000	FWS 2006a
	Flower Tank in Western Canyon	no	1979	FWS 2006a
	O'Donnell Canyon	no	2000	FWS 2006a
	San Rafael Valley tanks	no	1999	FWS 2006a
Sonora tiger salamander *Ambystoma tigrinum stebbinsi*	Unnamed tank in unnamed tributary to Lampshire Canyon (Sink Hole Tank)	yes	possible record in 2002	Mitchell 2002
	Unnamed tank in north fork Oak Grove Spring Canyon (Oak Tank)	yes	2003	M. Sredl, AGFD, pers. com. 2006
	Meadow Valley Tank & unnamed tank downstream (Hudson Tank)	yes	1996	ASU museum
	Bog Hole	no	1996	ASU museum
	San Rafael Valley	no	2006	FWS 2006b
Sonora mud turtle *Kinosternon sonoriense*	Lampshire	yes	2001	Stefferud unpub. data
	Oak Grove Spring Canyon	yes	2002	Mitchell 2002
	Redrock Canyon Lampshire to Red Bank Well (inc. Gate Spring)	yes	2001	Stefferud unpub. data
	Redrock Canyon in Cott Tank Exclosure	yes	2003	Stefferud unpub. data
	Cott Tank drainage below barriers	yes	2005	Stefferud unpub. data
	Cott Tank drainage above barriers			
	Martin Tank	yes	2002	Mitchell 2002
	Down Under Tank	yes	2002	Mitchell 2002
	Santa Cruz River in San Rafael Valley (US only)	no	2005	Stefferud unpub. data
	Sheehy Spring	no	2005	Stefferud unpub. data

SPECIES	LOCATION	IN PROJECT AREA?	LATEST RECORD	SOURCE
Black-necked gartersnake *Thamnophis cyrtopsis*	Gate Spring	yes	1989	Stefferud unpub. data
	Red Bank Well	yes	1990	Stefferud unpub. data
	Lampshire Canyon	yes	2001	Stefferud unpub. data
Mexican gartersnake *Thamnophis eques*	Redrock Canyon – Cott Tank drainage	Yes	Questionable records 1989, 2006	Stefferud unpub. data A. Karam, ASU, pers. com. 2006
	O'Donnell Creek at Finley Tank	no	2000	Rosen et al. 2001
	Bog Hole	No	1986	Rosen & Schwalbe 1988
	Sheehy Spring	no	2000	Rosen et al. 2001
	Santa Cruz River in San Rafael Valley	no	2000	Rosen et al. 2001
Desert sucker *Pantosteus clark*	Redrock Canyon below Falls	yes	2002	AGFD unpub. data
	Sonoita Creek near Patagonia	no	2005	Foster and Mitchell 2005
	Santa Cruz River in the San Rafael Valley	no	1995	Stefferud unpub. data
Gila topminnow *Poeciliopsis occidentalis*	Redrock Canyon below Falls	yes	2003	Stefferud unpub. data
	Pig Camp Spring	yes	2001	Stefferud unpub. data
	Oak Grove Spring Canyon	yes	1987	Stefferud unpub. data
	Unnamed tributary from north to Oak Grove Spring Canyon in (west side Sec. 35)	yes	1987	Stefferud unpub. data
	Lampshire Canyon	yes	2001	Stefferud unpub. data
	Redrock Canyon, Falls to Lampshire Canyon	yes	2001	Stefferud unpub. data
	Redrock Canyon Lampshire to Red Bank Well (inc. Gate Spring)	yes	2001	Stefferud unpub. data
	Redrock Canyon in Cott Tank Exclosure	yes	2002	Stefferud unpub. data
	Cott Tank drainage below barriers	yes	2005	Stefferud unpub. data
	Cott Tank drainage above barriers	yes	1995	Stefferud unpub. data
	Santa Cruz River in San Rafael Valley (US only)	no	1993	Weedman and Young 1997
	Sheehy Spring	no	1987	Bagley et al. 1991
	Monkey Spring	no	2005	AGFD unpub. data
	Sonoita Creek near Patagonia	no	2005	Killeen 2005
	Harshaw Creek	no	Reintro, 1982	Voeltz and Bettaso 2003
	O'Donnell Canyon	no	2004	D. Foster, AGFD, pers. com. 2004

SPECIES	LOCATION	IN PROJECT AREA?	LATEST RECORD	SOURCE
Gila chub *Gila intermedia*	O'Donnell Canyon	no	2004	Foster, AGFD, pers. com. 2004
	Monkey Spring	no	1969	Weedman et al. 1996
	Sheehy Spring	no	2005	Stefferud unpub. data
Speckled dace *Rhinichthys osculus*	Redrock Canyon below Falls	yes	2001	Stefferud unpub. data
	Sonoita Creek near Patagonia	no	2005	Foster & Mitchell 2005
Longfin dace *Agosia chrysogaster*	Redrock Canyon below Falls	yes	2003	Stefferud unpub. data
	Pig Camp Spring	yes	2002	Stefferud unpub. data
	Oak Grove Spring Canyon	yes	2001	Stefferud unpub. data
	Unnamed tributary from north to Oak Grove Spring Canyon in (west side Sec. 35)	yes	2002	Stefferud unpub. data
	Lampshire Canyon	yes	1992	Stefferud unpub. data
	Redrock Canyon Falls to Lampshire Canyon	yes	2001	Stefferud unpub. data
	Redrock Canyon Lampshire to Red Bank Well (inc. Gate Spring)	yes	2001	Stefferud unpub. data
	Redrock Canyon in Cott Tank Exclosure	yes	1993	Stefferud unpub. data
	Redrock Canyon above Cott Tank drainage	yes	1989	Stefferud unpub. data
	Cott Tank drainage below barriers	yes	1994	Stefferud unpub. data
	Harshaw Canyon	no	2002	Stefferud & Stefferud 2004
	Cottonwood Spring	no	2001	Stefferud unpub. data
	Sonoita Creek near Patagonia	no	2005	Killeen 2005
	O'Donnell Canyon	No	2004	D. Foster, AGFD, pers. com. 2004
	Santa Cruz River in the San Rafael Valley	No	2002	Voeltz and Bettaso 2003
Bullfrog *Rana catesbeiana*	Oak Grove Spring Canyon, SE Fork	yes	2002	Mitchell 2002
	Oak Grove Spring Canyon, middle tributary to North Fork	yes	2002	Mitchell 2002
	Lampshire Canyon	yes	2001	Stefferud unpub. data
	Redrock Canyon, Gate Spring	yes	2004	Stefferud unpub. data
	Redrock Canyon below confluence with Cott Tank drainage	yes	2000	Stefferud unpub. data
	Cott Tank drainage below barriers	yes	2006	Stefferud unpub. data
	Cott Tank drainage above barriers	yes	2004	Stefferud unpub. data
	Down Under Tank	yes	1996	Stefferud unpub. data

SPECIES	LOCATION	IN PROJECT AREA?	LATEST RECORD	SOURCE
	Unnamed tank in east fork of Kennedy Spring tributary to Redrock Canyon (First Tank)	yes	2006	Stefferud unpub. data
	Unnamed tank in unnamed tributary to Lampshire Canyon (Sink Hole Tank)	yes	2002	Mitchell 2002
	Unnamed tank in unnamed tributary to Oak Grove Spring Canyon in east ½ Sec. 35 = Dry Tank	yes	2002	Mitchell 2002
	Meadow Valley Tank & unnamed tank downstream (Hudson Tank)	yes	2002	Mitchell 2002
	Bog Hole	yes	2002	Fonseca 2002
	Sonoita Creek near Patagonia	yes	2006	Killeen, M. TNC, pers. com. August 2006
Mosquitofish *Gambusia affinis*	Redrock Canyon below Falls	yes	2002	Stefferud unpub. data
	Oak Grove Spring Canyon	yes	1990	Stefferud unpub. data
	Lampshire Canyon	yes	1987	Simons 1987
	Redrock Canyon, Falls to Lampshire Canyon	yes	2001	Stefferud unpub. data
	Redrock Canyon, Lampshire to Red Bank Well (inc. Gate Spring)	yes	2001	Stefferud unpub. data
	Redrock Canyon in Cott Tank Exclosure	yes	2006	Stefferud unpub. data
	Cott Tank drainage below barriers	yes	2006	Stefferud unpub. data
	Cott Tank drainage above barriers	yes	2002	Stefferud unpub. data
	Redrock Canyon above confluence with Cott Tank drainage	yes	1988	Stefferud unpub. data
	Down Under Tank	yes	1996	Stefferud unpub. data
	Unnamed tank in east fork of Kennedy Spring tributary to Redrock Canyon (First Tank)	yes	2006	G. Frederick, AGFD, pers. com. 2006
	Cott Tank	yes	1986	Simons 1987a
	Lampshire Tank	yes	1985	Scott 1995
	Sonoita Creek near Patagonia	no	2000	Rodgeveller 2000
	Harshaw Canyon	no	2002	Stefferud & Stefferud 2004
	Bog Hole	no	1997	Stefferud unpub. data
	Santa Cruz River in San Rafael Valley	no	2005	Stefferud unpub. data
	Sheehy Spring	no	2005	Stefferud unpub. data

SPECIES	LOCATION	IN PROJECT AREA?	LATEST RECORD	SOURCE
Green sunfish *Lepomis cyanellus*	Redrock Canyon in Cott Tank exclosure	yes	1987	Simons 1987a
	Redrock Canyon above confluence with Cott Tank drainage	yes	1987	Simons 1987a
	Cott Tank drainage above barrier	yes	1996	Stefferud unpub. data
	Lampshire Tank	yes	1985	Brooks 1986
	Down Under Tank	yes	1987	Simons 1987a
	O'Donnell Canyon	no	2002 (renovated)	Stefferud & Stefferud 2004
	Sonoita Creek near Patagonia	no	2005	Killeen 2005
	Bog Hole	no	1997	Stefferud unpub. data
	Santa Cruz River in San Rafael Valley	no	2005	Stefferud unpub. data
Largemouth bass *Micropterus salmoides*	Redrock Canyon Lampshire to Red Bank Well (inc. Gate Spring)	yes	1985	Brooks 1986
	Redrock Canyon above confluence with Cott Tank drainage	yes	1987	Simons 1987a
	Redrock Canyon below confluence with Cott Tank drainage	yes	1987	Simons 1987a
	Cott Tank drainage below barriers	yes	1995	Weedman & Young 1997
	Cott Tank drainage above barriers	yes	1993	Stefferud unpub. data
	Down Under Tank	yes	1987	Simons 1987
	Meadow Valley Tank	yes	1988	Stefferud 1988
	Bog Hole	yes	1994	Weedman 1994
	Sonoita Creek near Patagonia	no	1994	Gori 1997
	Santa Cruz River in San Rafael Valley	no	2000	Stefferud unpub. data
Bluegill *Lepomis macrochirus*	Redrock Canyon upstream of Redrock Well	yes	1990	Stefferud unpub. data
	Cott Tank drainage below barrier	yes	1993	Stefferud unpub. data
	Cott Tank drainage above barrier	yes	1996	Stefferud unpub. data
	Unnamed tank in east fork of Kennedy Spring tributary to Redrock Canyon (First Tank)	yes	1987	Simons 1987a
	Cott Tank	yes	1985	Stringer et al. 1985
	Down Under Tank	yes	1986	SONFISHES database
	Lampshire Tank	yes	1985	Brooks 1986
	Bog Hole	no	1994	Weedman 1994

Figure A-1. Locations of bullfrog.

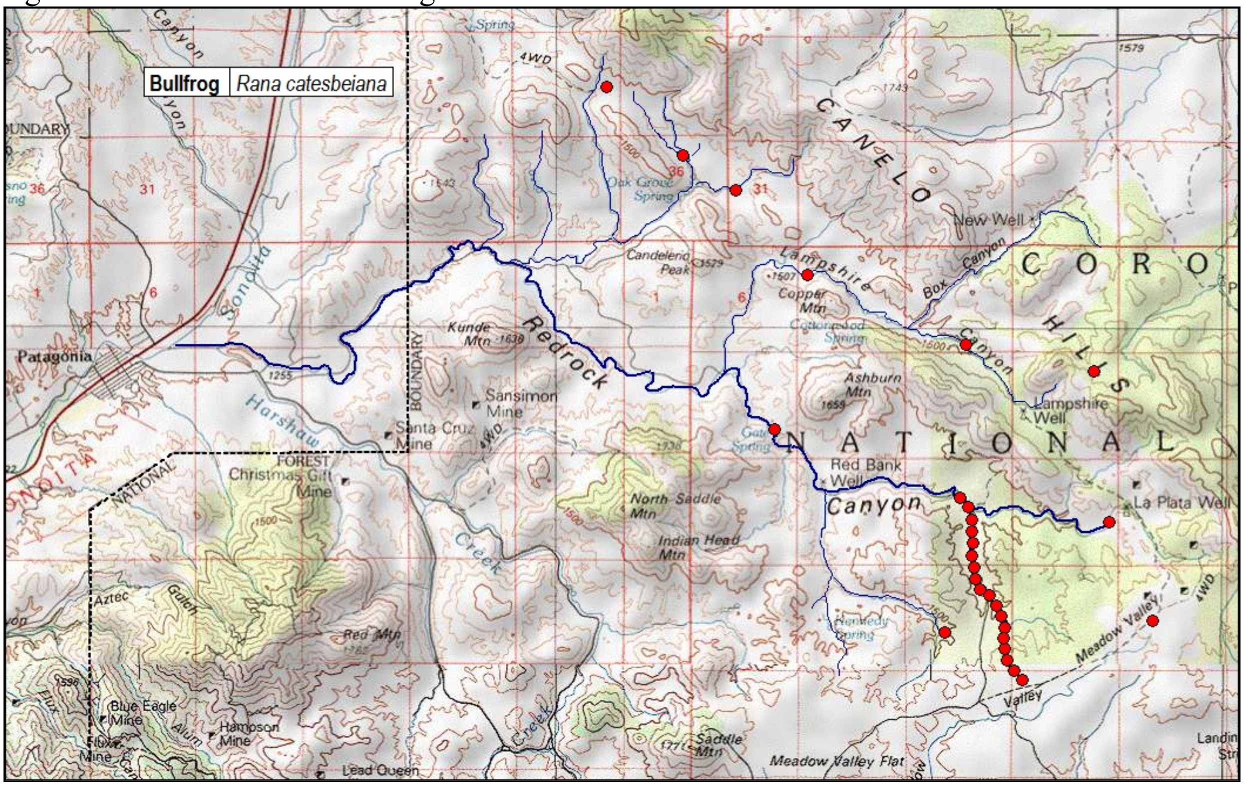


Figure A-2. Locations of mosquitofish

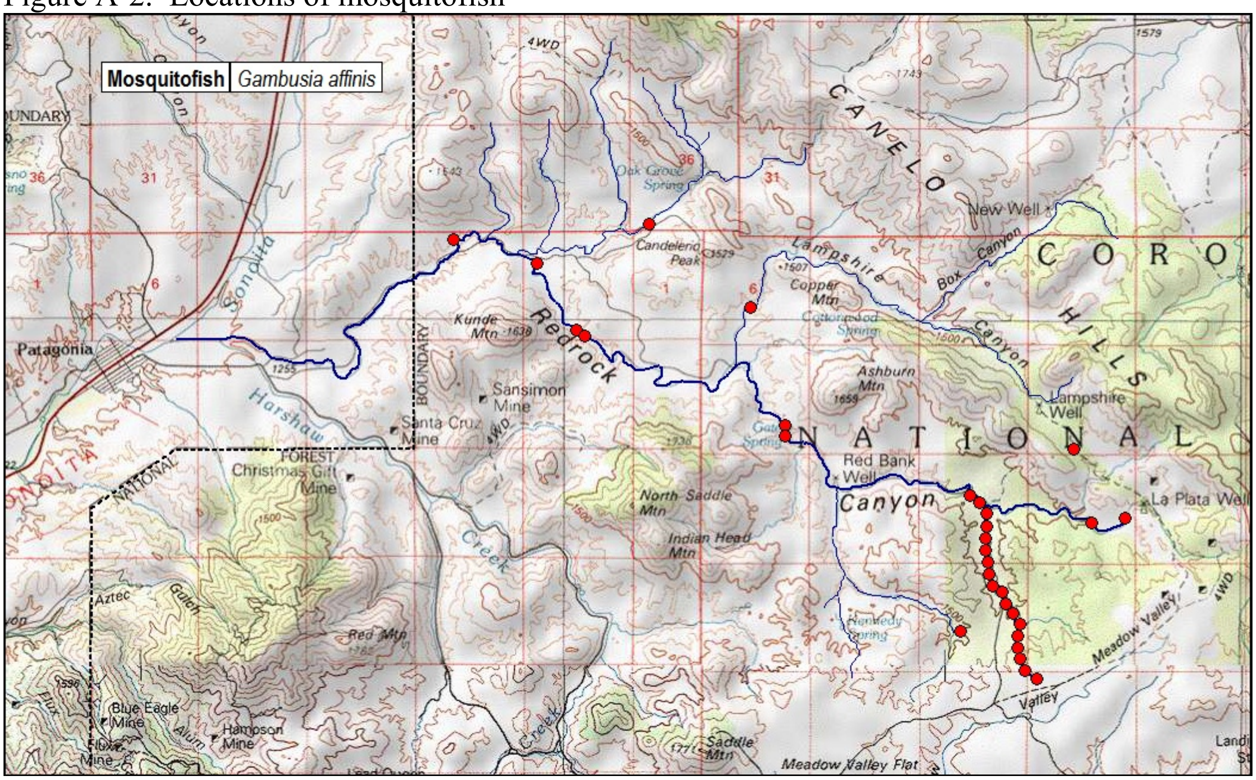
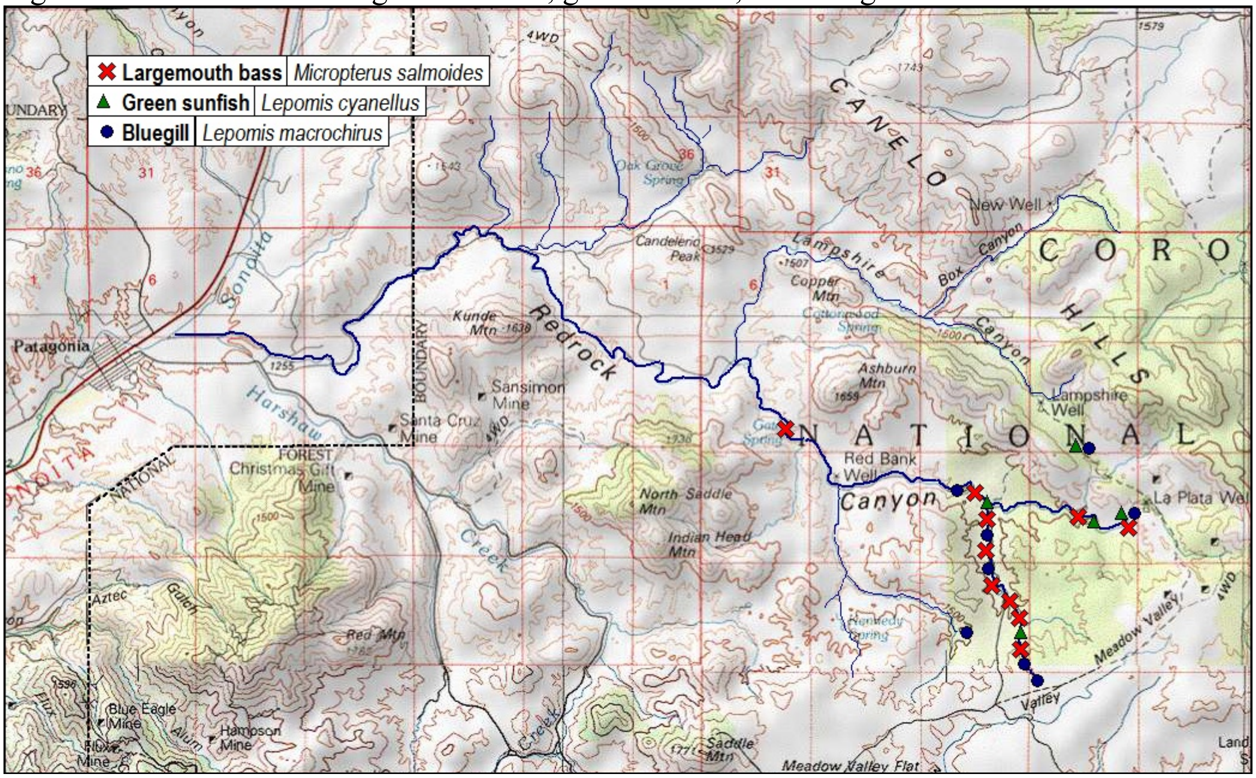


Figure A-3. Locations of largemouth bass, green sunfish, and bluegill.



APPENDIX B

Distribution of Native and Nonnative Fishes in the Gila River Basin

Table B-1. Historical distributions, known extirpated populations, known occupied streams, and recommended replication sites for Federal- or State-listed fishes of the Gila River basin, excluding trouts.

Species	**Historical Distribution**	**Known Extirpated Populations**	**Known Occupied Streams (exclusive of restoration sites)**
Cyprinodon arcuatus (Ex) Santa Cruz (Monkey Spring) pupfish	Low-elevation streams, springs, cienegas, backwaters, and margins of larger rivers in the Santa Cruz River basin	Santa Cruz River Monkey Spring (Santa Cruz) Sonoita Creek (Santa Cruz)	Species is extinct
Cyprinodon macularius (E) Desert pupfish	Low-elevation streams, springs, cienegas, backwaters, and margins of larger rivers in the Gila River basin, including all major subbasins except the Santa Cruz River basin	Agua Fria River Gila River Hassayampa River Salt River San Pedro River Verde River	Gila River basin populations extirpated
Gila elegans (E) Bonytail	Low-intermediate elevation mainstem reaches of the Gila and Salt rivers	Gila River Salt River	Gila River basin populations extirpated
Gila intermedia (PE) Gila chub	Upper reaches of small-middle-sized streams of the Gila River basin, including all major subbasins	Agua Fria River (Gila) Queen/Arnett creeks (Gila) San Simon River (Gila) Cave Creek/Seven Springs (Salt) Fish Creek (Salt) San Pedro River Binghampton Pond (San Pedro) Garden Canyon (San Pedro) Turkey Creek (San Pedro) Santa Cruz River Monkey Spring (Santa Cruz) Big Chino Wash (Verde)	Indian Creek (Agua Fria) Larry Creek (Agua Fria) Little Sycamore Creek (Agua Fria) Lousy Canyon (Agua Fria) Silver Creek (Agua Fria) Sycamore Creek (Agua Fria) Bonita Creek (Gila) Eagle/East Eagle Creek (Gila) Mineral Creek/Devil's Canyon (Gila) Turkey Creek, NM (Gila) San Carlos River Blue River (San Carlos) Dix Creek (San Francisco) Harden Cienega (San Francisco) San Pedro River, Mexico Babocomari River (San Pedro) Hot Springs/Bass Canyon (San Pedro) Los Fresnos River, Mexico (San Pedro) O'Donnell Creek (San Pedro) Post/Freeman canyons (San Pedro) Redfield Canyon (San Pedro) Cienega Creek (Santa Cruz) Empire Gulch (Santa Cruz) Mattie Canyon (Santa Cruz) Sabino Canyon (Santa Cruz) Sheehy Spring (Santa Cruz) Red Tank Draw (Verde) Spring Creek (Verde) Walker Creek (Verde) Williamson Valley Wash (Verde)

Species	Historical Distribution	Known Extirpated Populations	Known Occupied Streams (exclusive of restoration sites)
Gila nigra (W/P, S) Headwater chub	Middle to headwater reaches of middle-sized tributary streams in the Verde, Tonto, San Carlos, and upper Gila River (NM) subbasins	Beaver Creek (E Fk Gila River) Taylor Creek (E Fk Gila River) Christopher Creek (Tonto) Horton Creek (Tonto) Sharp Creek (Tonto) Rye Creek (Tonto) Dry Beaver Creek (Wet Beaver)	Gila River, upper San Carlos River Ash Creek (San Carlos) Tonto Creek Buzzard Roost (Tonto) Gordon Creek (Tonto) Gunn Creek (Tonto) Haigler Creek (Tonto) Marsh Creek (Tonto) Rock Creek (Tonto) Spring Creek (Tonto) Deadman Creek (Verde) East Verde River (Verde) Fossil Creek (Verde) Webber Creek (Verde) Wet Bottom Creek (Verde)
Gila robusta (S) Roundtail chub	Middle-sized to larger streams of the Gila River basin, including all major subbasins except the Santa Cruz River basin	Boneyard Creek (E Fk Black) Gila River, middle reach (AZ) Salt River, upper reach San Francisco River (Gila) Blue River (San Francisco) San Pedro River N Fk White River (White) ?	Gila River, upper Eagle Creek (Gila) Salt River, lower reach Salt River Project canals Black River (Salt) Canyon Creek (Salt) Carrizzo Creek (Salt) Cedar Creek (Salt) Cherry Creek (Salt) Cibeque Creek (Salt) Corduroy Creek (Salt) Salome Creek (Salt) White River (Salt) ? Aravaipa Creek and tributaries (San Pedro) Verde River Fossil Creek (Verde) Oak Creek (Verde) West Clear Creek (Verde) Wet Beaver Creek (Verde)
Meda fulgida (T) Spikedace	Low-intermediate elevation streams in the Gila River basin, including all major subbasins except the Santa Cruz River basin	Agua Fria River Salt River San Francisco River San Pedro River, US and Mexico	Eagle Creek (Gila) Gila River, Middle Fork Gila River, West Fork Gila River, East Fork Gila River, middle reach (AZ) Mangus Creek (Gila) Aravaipa Creek (San Pedro) Verde River
Plagopterus argentissimus (E) Woundfin	Low-elevation streams in the Gila River basin, including all major subbasins except the Santa Cruz River basin	Gila River Salt River Verde River	Gila River basin populations extirpated

Species	Historical Distribution	Known Extirpated Populations	Known Occupied Streams (exclusive of restoration sites)
Poeciliopsis occidentalis (E) Gila topminnow	Low-intermediate elevation streams, springs, cienegas, backwaters, and margins of larger rivers in the Gila River basin, including all major subbasins	Gila River Ash Creek, North Fork (Gila) Salt Creek (Gila) San Simon River (Gila) San Carlos River (Gila) Salt River Tonto Creek (Salt) Frisco Hot Spring (San Francisco) San Pedro River Arivaca Creek (San Pedro) Cocio Wash (Santa Cruz) Potrero Creek (Santa Cruz) Sabino Canyon (Santa Cruz) Sheehy Spring (Santa Cruz) Tanque Verde Creek (Santa Cruz) Verde River Other unnamed waters	Bylas Springs (Gila) Santa Cruz River, upper reach (US and Mexico) Cienega Creek (Santa Cruz) Cottonwood Spring (Santa Cruz) Monkey Spring (Santa Cruz) Sharp Spring (Santa Cruz) Sonita Creek complex (Santa Cruz) Redrock Canyon Fresno Canyon Coal Mine Canyon Sonoita Creek
Ptychocheilus lucius (E) Colorado squawfish	Low-intermediate elevation streams in the Gila River basin, including all major subbasins except the Santa Cruz River basin	Gila River Salt River San Pedro River Verde River	Gila River basin populations extirpated
Tiaroga cobitis (T) Loach minnow	Low-high elevation streams in the Gila River basin, including all major subbasins except the Santa Cruz River basin	Gila River (AZ portion) Salt River San Pedro River, US and Mexico Verde River	Aravaipa Creek and tributaries (San Pedro) Black River, North Fork of East Fork (Salt) Blue River, and tributaries (San Francisco) Eagle Creek (Gila) Gila River, Middle Fork Gila River, West Fork Gila River, East Fork San Francisco River and NM tributaries White River, North Fork (Salt) White River (Salt) White River, East Fork (Salt)
Xyrauchen texanus (E) Razorback sucker	Low-intermediate elevation streams in the Gila River basin, including all major subbasins except the Santa Cruz River basin	Gila River Salt River San Pedro River Verde River	Gila River basin populations extirpated

T = threatened, E = endangered, S = State listed, Ex = Extinct, PE = proposed endangered; W/P = warranted but precluded finding on petition to list. Parentheticals denote major subdrainage affiliations, question marks denote uncertain status.

Table B-2. Partial list of established[15] nonnative fishes in the Gila River basin.

SPECIES		STATUS	
		DISTRIBUTION	TREND
Family Atherinidae - silversides	Inland silverside, *Menidia beryllina*	L	R
Family Clupeidae – herrings	Threadfin shad, *Dorosoma petenense*	L	S
	Gizzard shad, *Dorosoma cepedianum*	L	R
Family Cyprinidae – minnows	Common carp, *Cyprinus carpio*	W	E
	Fathead minnow, *Pimephales promelas*	W	E
	Golden shiner, *Notemigonus crysoleucus*	L	R
	Goldfish, *Carassius auratus*	L	S
	Grass Carp, *Ctenopharyngodon idella*	L	E
	Red shiner, *Cyprinella lutrensis*	W	E
Family Catostomidae – suckers	Bigmouth buffalo, *Ictiobus cyprinellus*	L	S
	Black buffalo, *Ictiobus niger*	L	S
	Smallmouth buffalo, *Ictiobus bubalus*	L	S
Family Ictaluridae – catfishes	Black bullhead, *Ameiurus melas*	W	E
	Channel catfish, *Italurus punctatus*	W	E
	Flathead catfish, *Pylodictis olivaris*	W	E
	Yellow bullhead, *Ameiurus natalis*	W	E
Family Esocidae – pikes	Northern pike, *Esox lucius*	L	R
Family Salmonidae – trouts	Arctic grayling, *Thymallus arcticus*[16]	L	S
	Brook trout, *Salmo trutta*	W	S
	Brown trout, *Salvelinus fontinalis*	W	S
	Rainbow trout, *Oncorhynchus mykiss*[1]	W	S
Family Poecilidae - livebearers	Guppy, *Poecilia reticulata*	L	S
	Sailfin molly, *Poecilia latipinna*	L	S
	Western mosquitofish, *Gambusia affinis*	W	E
Family Moronidae – temperate bass	Striped bass, *Morone saxatilis*	L	E
	White bass, *Morone chrysops*	L	E
	Yellow bass, *Morone mississippiensis*	L	S

[15] Established = reproducing population on a multigeneration timeframe.
[16] Routinely stocked

SPECIES		STATUS	
		DISTRIBUTION	TREND
Family Centrarchidae – sunfishes and black bass	Black crappie, *Pomoxis nigromaculatus*	W	S
	Bluegill, *Lepomis macrochirus*	W	E
	Green sunfish, *Lepomis cyanellus*	W	E
	Largemouth bass, *Micropterus salmoides*	W	E
	Redear sunfish, *Micropterus microlophus*	W	S
	Smallmouth bass, *Micropterus dolomieu*	W	E
	White crappie, *Pomoxis annularis*	L	S
Family Percidae – perches	Walleye, *Stizostedion vitreum*	L	S
	Yellow perch, *Perca flavescens*	L	R
Family Cichlidae - ciclids	African cichlids, *Tilapia* and *Oreochromis* spp.	L	E

Distribution acronyms are W = widespread, L = localized, R = rare. Trend acronyms are E = expanding distribution, S = stable distribution, R = recently introduced, trend uncertain.

APPENDIX C

Fish Barrier Design

Figure C-1. Profile view of fish barrier.

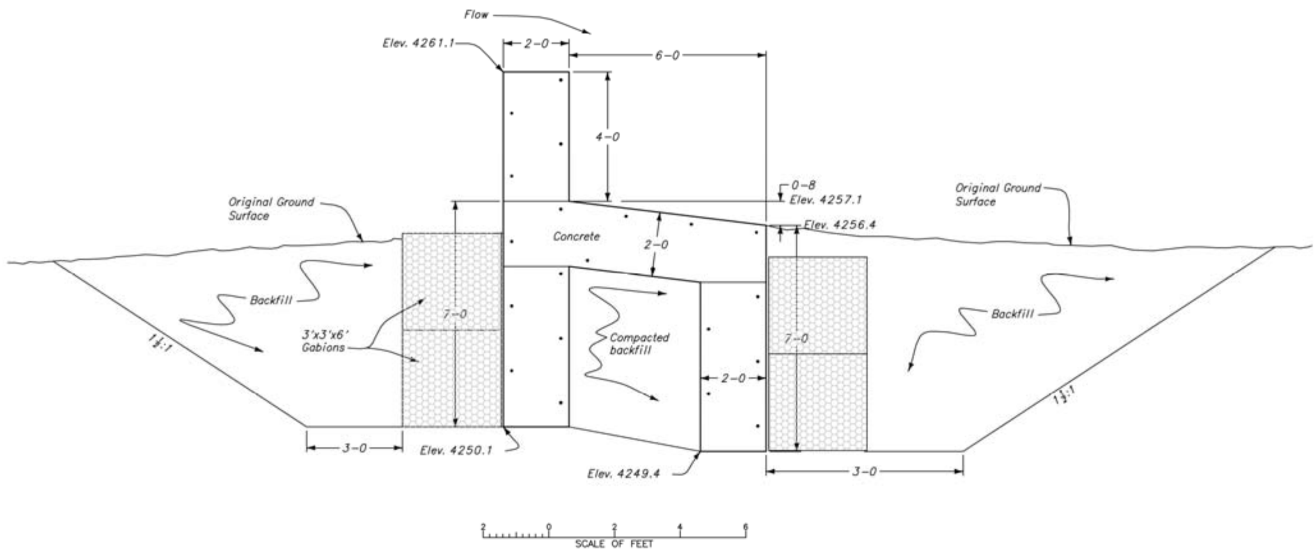
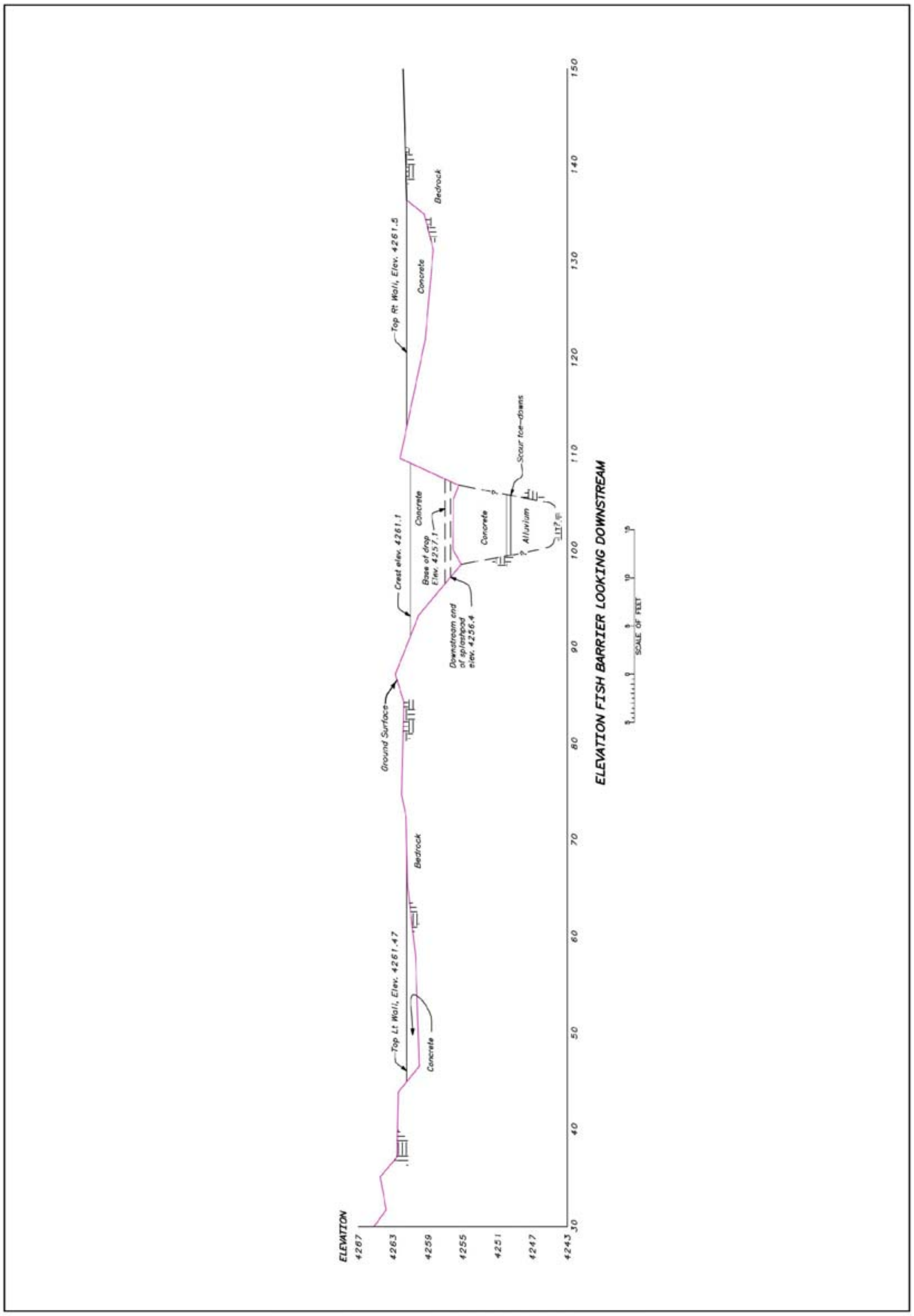


Figure C-2. Cross section view of channel and floodplain with fish barrier.



APPENDIX D

List of Stream Renovation Projects in the Lower Colorado River Basin

Table D-1. Annotated list of stream renovation projects using antimycin in the lower Colorado River basin, and the Rios Sonoyta and Yaqui drainages in Arizona.

STATE/ COUNTY	STREAM	DATE OF PROJECT	PURPOSE OF PROJECT (primary species targeted for benefit)	NO. OF TREAT-MENTS	DID PROJECT ACHIEVE PURPOSE?	REPORT OF RENOVATION
AZ/Pinal	Arnett Creek	1996	remove nonnative fish for conservation of native fish (longfin dace, desert sucker, Gila topminnow)	1	yes	Bizios 1997
AZ/Apache	Bearwallow Creek	1981 1987	remove nonnative fish for conservation of native fish (Apache trout)	2	1981 yes* 1987 yes	Rinne and Turner 1991 AGFD and USFS unpub. records
AZ/Graham	Bylas Springs complex	1982 1984 1996 1997 2000	remove nonnative fish for native fish conservation (Gila topminnow)	3	1982 no 1984 yes* 1996-2000 yes	Marsh and Minckley 1990 Meffe 1983 Rinne and Turner 1991 Schleusner 2000a Schleusner 2000b
NM/Catron	Dry Creek	1984 1985	remove nonnative fish for conservation of native fish (Gila trout)	2	yes	Propst *et al.* 1992 FWS 1993
Yavapai, Gila	Fossil Creek	2004	remove nonnative fish for conservation of native fish (spikedace, loach minnow)	2	yes	Weedman and Sponholtz 2005
AZ/Apache	Hay Creek	1989	remove nonnative fish for conservation of native fish (Apache trout)	1	yes*	AGFD and USFS unpub records
AZ/Apache, Greenlee	Home Creek	1987	remove nonnative fish for conservation of native fish (Apache trout)	1	yes	Rinne and Turner 1991 AGFD and USFS unpub. data
NM/Catron	Iron Creek	1981	remove nonnative fish for conservation of native fish (Gila trout)	?	no	Propst *et al.* 1992 FWS 1993 Coman 1981
AZ/Apache	Lee Valley Creek	1982 1987 2002	remove nonnative fish for conservation of native fish (Apache trout)	3	1982 yes* 1987 yes* 2002 not yet known	Rinne and Turner 1991 AGFD and FWS unpub. data

NM/Catron	Little Creek	1982	remove nonnative fish for conservation of native fish (Gila trout)	?	?	Propst *et al*. 1992 FWS 1993
NM/Catron, Grant	Mogollon Creek	1987 1988 1989	remove nonnative fish for conservation of native fish (Gila trout)	3	yes	Propst *et al*. 1992 FWS 1993
AZ/Santa Cruz	O'Donnell Creek	2002	remove nonnative fish for conservation of native fish (Gila chub)	3	yes	H. Blasius, AGFD, pers. comm., July 2002
AZ/Apache	Ord Creek	1977 1978 1980	removal of nonnative fish for conservation of native fish (Apache trout)	2	no (1977, 78,80)	Rinne *et al*. 1981 Minckley and Mihalick 1981 Rinne and Turner 1991
AZ/Pima	Sabino Canyon	1999	remove nonnative fish for conservation of native fish (Gila chub)	2	yes	Hayes 1999
AZ/Santa Cruz	San Rafael Valley stock tanks	2006	remove nonnative fish and bullfrogs for conservation of Sonora tiger salamander	1	not yet known	USFS 2006
AZ/Greenlee	Snake Creek	2002	remove nonnative fish for conservation of native fish (Apache trout)	1	not yet known	AGFD unpub. records
AZ/Apache	Stinky Creek	1994 2002	remove nonnative fish for conservation of native fish (Apache trout)	2	1994 yes* 2002 not yet known	AGFD and USFS unpub. records
NM/Catron	Trail Canyon	1986 1987	remove nonnative fish for conservation of native fish (Gila trout)	2	yes	Propst *et al*. 1992 FWS 1993
AZ/Apache	West Fork Black River, including Burro Creek and Thompson Creek	1996	remove nonnative fish for native fish conservation (Apache trout)	1	yes	AGFD and USFS unpub. records
AZ/Cochise	West Turkey Creek	1999	remove nonnative fish for conservation of native fish (Yaqui catfish, longfin dace)	2	yes	Coleman and Minckley 1999
NM/Catron	White Creek	1991	remove nonnative fish for conservation of native fish (Gila trout)	?	yes	Stefferud *et al*. 1991

AZ/Apache	Wildcat Creek	1988	remove nonnative fish for conservation of native fish (Apache trout)	1	yes	Rinne and Turner 1991 AGFD and USFS unpub. records
NM/Catron	Woodrow Canyon	1987 1988	remove nonnative fish for conservation of native fish (Gila trout)	2	yes	Propst *et al.* 1992 FWS 1993

* Treatment was apparently successful, but reinvasion occurred, either from adjacent waters or by illegal introduction by humans.

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APPENDIX E

Use of Piscicides and Neutralization Compounds

Historic Use of Piscicides to Manage Fisheries

Fisheries managers rely on a variety of tools to manage and assess fish populations. Historically, these have included the use of piscicides. Two piscicides, rotenone and antimycin A, are currently registered by EPA for general use in the United States under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). By law, the EPA is authorized to register a pesticide only if it will not cause unreasonable adverse effects on human health or the environment.

Originally, piscicides were mainly used to control out-of-balance or undesirable fish populations so that sport fish could be stocked for recreational purposes. Today, antimycin and rotenone are used in fisheries management for a variety of purposes, including (Finlayson et al. 2000):

- Eradication of nonnative fish,
- Restoration of threatened and endangered fish,
- Support of recreational fisheries by controlling undesirable fish,
- Eradication of fish to control disease,
- Quantification of populations of aquatic organisms,
- Eradication of competing fish in rearing facilities or ponds prior to restocking.

Although physical removal methods (e.g., nets, traps, seines, electrofishing, dewatering, and combinations of physical control techniques) are available for reducing or controlling fish communities, they are generally incapable of eradicating fish (Finlayson et al. 2000). Meronek et al. (1996) review of fish control projects found that success rates for physical removal methods ranged from 33 percent to 57 percent. In most streams, only piscicide applications or complete dewatering can eradicate entire populations of undesirable fish (Schnick 1974).

Rotenone

Rotenone has been used in the United States to manage fish populations since the 1930s and is the piscicide of choice for application in ponds and lakes. According to the American Fisheries Society (Finlayson et al. 2000), rotenone has been routinely used for management of fish populations in 34 states and several Canadian provinces. Formulations of rotenone are manufactured (under the brand names Pro-Noxfish®, Nusyn-Noxfish®, Prenfish®, and others) and shipped in either a powdered or liquid form.

In addition to applicability as a piscicide, other formulations of rotenone are registered in the United States as an insecticide for domesticated pets (dogs and cats), cattle, sheep, ornamental plants, trees, and turf; and foliar preharvest application to vegetables, berries, tree fruit, nuts, forage crops, and sugar cane.

Rotenone is a naturally occurring compound extracted from the roots of certain species of the bean family that has been used for centuries to capture fish (Finlayson et al. 2000).

As a piscicide, rotenone interrupts cellular respiration in gill-breathing animals by blocking the transfer of electrons in the mitochondria. Acute exposure to toxic levels reduces cellular uptake of blood oxygen, resulting in increased cellular anaerobic metabolism and associated production of lactic acid causes blood acidosis (Fajt and Grizzle 1998). Death results from tissue anoxia, which typically produces cardiac and respiratory failure (Ling 2003). Scientists believe that fish are more sensitive to rotenone because it is rapidly absorbed into the bloodstream from water flowing across the gill membrane. Although both fish and aquatic macroinvertebrates are highly susceptible to rotenone (Skaar 2001), most macroinvertebrate populations quickly recover to pre-treatment levels (Lennon 1971, Schnick 1974b). Gill-breathing amphibians (i.e., frog and toad tadpoles and larval salamanders) are also adversely affected (Hamilton 1941). Amphibian adults and reptiles are less sensitive than fish and should not be harmed when rotenone is applied at concentrations typically used in fisheries management (Farringer 1972). Fall applications of rotenone reduce or eliminate impacts on amphibians because most species are in the adult stage of development.

When applied at recommended doses for fish control (0.005 to 0.250 mg/L), rotenone has low toxicity to non-aquatic organisms. Extensive research has demonstrated that rotenone does not cause birth defects (Hazelton 1982), reproductive dysfunction (Spencer and Sing 1992), gene mutations (Biotech 1981, Goethem et al. 1981, NAS 1983) or cancer (EPA 1981, Tisdel 1985). The results of chronic feeding studies in which rats and dogs that were fed forms of rotenone as part of their diet for 6 months to 2 years resulted in non-lethal effects such as diarrhea, decreased food consumption, and weight loss (Skaar 2001). No adverse chronic effect was reported when rats where given 100 mg/L Pro-Noxfish® (2.5 percent rotenone) in drinking water for 70 weeks (Brooks and Price 1961). Ellis et al. (1980) found that 10 mg/kg/day rotenone administered orally to beagles for 26 weeks had no adverse chronic effect. Skaar (2001) reported that a 20-pound dog would have to consume 660,000 pounds of rotenone-tainted fish to receive a lethal dose, and bird mortality would require 1,000 to 10,000 times greater rotenone levels than used in piscicide applications (Skaar 2001). A bird weighing a quarter of a pound would have to eat more than 40 pounds of fish and invertebrates killed by rotenone within 24 hours before receiving a lethal dose (Finlayson et al. 2000). Studies that examined avian exposure report that a 1,000 to 10,000-fold increase in levels normally used for fisheries management would be required for lethality (Skaar 2001).

Several hazard assessments for human health have also been conducted. Simulated lethal oral dosage for a human is variously estimated between 300 to 500 mg/kg (Ray 1991, Gosselin et al. 1984). Gleason et al. (1969) estimated the lowest dose for lethality would require a 60-kg person to consume 180,000 liters of water containing 0.1 mg/L rotenone, or eat 180 kg of rotenone–killed fish at one sitting. Although ingestion of rotenone-killed fish is not recommended, the rotenone level in fish considered safe for human consumption has been estimated at 10 ppm (Lehman 1950). Skaar (2001) notes that the National Academy of Sciences established in 1983 a "suggested no-adverse response level" of rotenone in drinking water of 0.014 mg/L, assuming a 70-kg person drinks 2 liters of water per day for a lifetime. In 1997, the EPA established a human ingestion risk value (reference dose for chronic exposure) of 0.004 mg/kg/day.[17]

An Emory University study (Betarbet et al. 2000) reported finding anatomical, neurochemical, and behavioral symptoms characteristic of Parkinson's disease in laboratory rats when rotenone was administered chronically and intravenously. However, several researchers in Parkinson's disease (including J. Langston, Director of the Parkinson's Institute) have stated the Emory University does not show evidence that exposure to rotenone causes Parkinson's disease. The continuous jugular vein infusion of rotenone lead to continuously high levels of rotenone in the bloodstream and included dimethyl sulfoxide to enhance tissue penetration. This mode of administration to laboratory rats was unnatural and cannot be used as a model for any environmental exposure to rotenone. The normal exposure to rotenone in humans from its use in fisheries management would be ingestion, inhalation, or through the skin. Rotenone that is ingested by mammals (and birds) is rapidly broken down by enzymatic action in the gut and excreted by the liver and kidney. Approximately 20 percent of the oral dose (and probably most of the absorbed dose) is excreted within 24 hours (Ray 1991). In the Emory University study, Betarbet et al. (2000) concluded that "rotenone seems to have little toxicity when administered orally."

Rotenone is very unstable in the environment (half-life measured in days) and completely breaks down within 1 to 4 weeks depending on pH, alkalinity, temperature, dilution, and exposure to sunlight (Schnick 1974b). It also adsorbs strongly to organic matter in sediment and is rapidly degraded (Dawson et al. 1991). Rapid neutralization (oxidation) occurs when rotenone is mixed with potassium permanganate or sodium permanganate (Engstrom-Heg 1971, 1972, 1973; Finlayson et al. 2000). Inert ingredients in the liquid formulation of rotenone consist of petroleum hydrocarbons as solvents and emulsifiers (primarily naphthaline, methylnaphthalenes, trichloroethylene, and xylenes). Studies of residual concentrations in water treated with liquid formulations indicate that solvent levels are below toxic thresholds (Ling 2003). In a study of rotenone-treated streams and lakes in Californian, concentrations of trichloroethylene never exceeded the Federal drinking water standard (Maximum Contaminant Level) of 5 ug/L and similarly the concentrations of xylene never exceeded the drinking water standard (Health Advisory) of 620 ug/L (Finlayson et al. 2001). Drinking water standards for naphthalenes and methynaphthtalenes have not been established. Finlayson et al. (2001) noted that all the volatile and semivolatile organic compounds disappeared before rotenone dissipated from the treated waters. There are no Federal or Arizona water quality standards for rotenone.

Rotenone does not easily enter groundwater because of its tendency to bind rapidly with organic material in soil and surface water (DOE 2004). In a California groundwater study, no trace of rotenone (including any of the compounds in the formulated product) was detected in 26 wells that were placed in aquifers adjacent to and downstream of nine rotenone-treated water bodies (CDFG 1994). A similar study at Tetrault Lake, Montana, failed to detect rotenone in a nearby domestic well that was sampled 2 and 4 weeks after

[17] A reference dose is an estimate of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

treatment of the lake with 90 ug/L of the piscicide (DOE 2004). The Tetrault Lake well site was studied because it was downgradient from the lake and drew water from the same aquifer that fed and drained the lake. In another study, water from a well located 65 feet from a rotenone-treated pond near Kalispell, Montana, was analyzed and showed no sign of piscicide contamination (DOE 2004).

The major risks to human health from rotenone come from exposure during application. This is the only time when humans (applicators) are exposed to high concentrations of the piscicide. Personal protective equipment is required by the product label and material safety data sheet to reduce respiratory and dermal exposure. For liquid and powder rotenone formulation application, personnel must wear approved air purifying respirators, goggles, rubber gloves, and protective clothing.

Any threat to recreational users during treatment can be readily mitigated through cautionary signing at access points, temporary closures, and posting agency personnel within the treatment area.

Antimycin A

The only other piscicide registered for general use in the United States is antimycin A (Finlayson et al. 2000). Antimycin A was first patented for piscicide use in 1964. It is also approved for use in commercial catfish farms by the Food and Drug Administration. Formulations of antimycin A are registered under the brand name Fintrol®.

Like rotenone, antimycin inhibits cellular respiration in gill-breathing animals (Schnick 1974a). When used in appropriate concentrations for fisheries management, antimycin is often less harmful to non-target aquatic organisms than rotenone. Some studies have shown effects on aquatic insects vary according to species and stream setting. Cerreto et al. (2003) found that antimycin had little to no effect on aquatic macroinvertebrates in high elevation (approximately 7,900 feet) streams in Bridger-Teton National Forest in Wyoming. Lennon et al. (1971) stated that antimycin is the ideal piscicide because of its selective effects and effectiveness at low concentrations in a wide range of water qualities, it is not repulsive to fish, and it leaves no toxic residue.

Antimycin A is an organic compound that was isolated from the bacterium *Streptomyces girseus* at University of Wisconsin in 1945 (Leben and Keitt 1948, Dunshee, et al. 1949). The chemical formula of antimycin is $C_{28}H_{40}N_2O_9$ (Rinne and Turner 1991:237), and it inhibits growth of some fungi but does not affect most bacteria. The formulations often used for fish control in streams are Fintrol-Concentrate (liquid form antimycin A) and Fintrol 15 (antimycin A coated sand). Antimycin A consists of 10 percent antimycin and inert constituent components (soy lipds, Diethyl phthalate, Nonoxyl-9 detergent [or nonylphenol polyglycol ether], and acetone).

Degradation of antimycin is by the following pathway (Hussain 1969):

antimycin A1 → blastmycic acid + antimycin lactone → fatty acids

Temperature and pH strongly influence the efficacy and rate of degradation of antimycin (Chapman et al. 2003). Antimycin degrades slower in lower temperature water, but it is also less effective, probably because at lower temperatures the metabolism and respiration rate in fish decrease, thereby affecting the rate of toxicant uptake (Berry and Larkin 1954). Marking and Dawson (1972) reported the following half lifes of antimycin based on pH: pH 6 to 6.5 = 310 hours, pH 7.5 = 120 hours, and pH 8 = 100 hours. Degradation of antimycin occurs quickly under natural stream conditions because of dilution, adsorption to organic material and sediments, and oxidation created by sunlight and water turbulence (Lee et al. 1971). Other compounds that will readily bind with antimycin to detoxify it include leafy vegetation and water plants (Grisak 2003). Rapid neutralization occurs when antimycin is mixed with potassium permanganate or sodium permanganate (Marking and Bills 1975). The degradation compounds have very low toxicity for either fish or mammals (Herr et al. 1967). Drinking water standards have not been established for the commercial piscicide formulation of antimycin A. There are no Federal or Arizona water quality standards for antimycin A.

A review of toxicity studies relating to antimycin indicates that vertebrate animals must ingest high dosages before any adverse effect is apparent (Schnick 1974a). In laboratory tests, oral LD_{50} values for mammals ranged from 1.0 mg/kg for lambs to 55 mg/kg for mice (Herr et al. 1967). Oral LD_{50} is defined as the amount of antimycin administered orally over a specified period of time that causes the death of 50 percent of the group of test animals. For example, if a person weighing 70 kg consumed 1.5 liters from a stream treated with 200 ug/L antimycin (recommended concentrations typically range from 5 to 25 ug/L), that person would ingest 300 ug of antimycin, or 0.0042 mg/kg of body weight. A 154 pound person would have to drink about 167 gallons of treated water during the period that antimycin is active to ingest the amount required to achieve the LD_{50} for the most sensitive mammal tested (Guinea pig, LD_{50} = 1.8 mg antimycin/kg body weight). This translates to a water consumption rate of about 28 gallons per hour during an active treatment period lasting 6 hours. Similarly, an 800-pound horse would have to ingest about 860 gallons of water with levels similar to piscicide treatment before there could be a significant chance of death (Herr et al. 1967).

Consumption of antimycin in water was alleged to have caused organ abnormalities and stillbirth of two lambs in northern New Mexico in 1998 (Begel 2001). However, no evidence implicating antimycin in the stillbirth of the two lambs was produced, and no adverse effects on animals in the surrounding area were reported (AFSFMCS et al. 2001). In addition, an independent medical microbiologist contracted by Grant and Catron counties in New Mexico to review the potential public health hazards of antimycin concluded that it was an effective and safe fish control agent for removal of fishes from streams with no potential for public health issues when applied at recommended concentrations (Brooks and Propst 2001). Vezina (1967) reported that antimycin is not hazardous to humans, livestock, and wildlife when applied at concentrations appropriate for fisheries management.

The potential effects of consuming dead fish produced by stream renovation are poorly studied, but there have never been any reports of negative effects to humans or wildlife from ingestion of antimycin-killed fish (Berger et al. 1967, Gilderhus et al. 1969). Ritter and Strong (1966) reported that 21 humans who consumed between one and five 4-ounce servings of fish killed by antimycin suffered no ill effects. Schnick (1974) reported that antimycin is not hazardous to humans whether it is consumed in food or water. In a study on waterfowl, Vezina (1967) found that consumption of 2,900 mg antimycin/kg body weight was required to cause mortality of 50 percent of test mallard ducks in the laboratory. Similar tests on 4.5 kg domestic dogs required consumption of 5,000 mg/kg antimycin to cause mortality of 50 percent of the test population. In another laboratory study, trout killed with 10 ug/L antimycin contained 76 to 388 ug/kg antimycin in their tissues (Ritter and Strong 1966).

The major risks to human health from antimycin come from exposure during application. This is the only time when humans (applicators) are potentially exposed to high concentrations of the piscicide. Personal protective equipment is required by the product label and material safety data sheet to reduce respiratory and dermal exposure. For liquid and powder antimycin formulation application, personnel must wear approved air purifying respirators, goggles, rubber gloves, and protective clothing.

Any threat to recreational users during treatment can be readily mitigated through cautionary signing at access points, temporary closures, and posting agency personnel within the treatment area.

Potassium Permanganate and Sodium Permanganate

Potassium permanganate ($KMnO_4$) is the chemical most often used to quickly neutralize (oxidize) rotenone and antimycin, and recently sodium permanganate ($NaMnO_2$) has also been used for this purpose. Since permanganate itself may be toxic to aquatic organisms at high dosages, detoxification procedures would utilize calibrated equipment to achieve minimum effective concentration of permanganate to neutralize the piscicide. Monitoring stations consisting of caged live fish would be placed at the downstream limit of the treatment area to verify detoxification of the piscicide and permanganate.

*Potassium Permanganate***.** Potassium permanganate reduces the half-life of antimycin to 7 to 11 minutes in a laboratory setting. Horton (1997) recommends a 20-minute neutralization period for rotenone in non-alpine streams. Potassium permanganate is a strong oxidizing agent that quickly breaks down to naturally occurring compounds (Archer 2001). Kemp et al. (1966) and Marking and Bills (1975) found that organic material and inorganic oxidation substances rapidly decrease the activity of potassium permanganate.

Potassium permanganate can be toxic to fish (Tucker and Boyd 1977, Archer 2001, Grisak et al. 2002). In the laboratory, exposure to 2 mg/L $KMnO_4$ was lethal to rainbow trout (Archer 2001). When applied at 1.5 mg/L in the absence of readily oxidizable substances, potassium permanganate achieved lethality in westslope cutthroat trout after 16 to 24 hours of exposure (Grisak et al. 2002). Potassium permanganate is quickly broken down when it reacts to organic material and antimycin or rotenone in stream water. Breakdown components of potassium permanganate (potassium, manganese, and water) are common in nature and have no deleterious environmental effects at concentrations used for neutralization of piscicides (Finlayson et al. 2000).

Potassium permanganate is also one of the most widely used inorganic chemicals for the treatment of municipal drinking and wastewater. According to the American Waterworks Association's Water Industry Data Base, potassium permanganate is listed as the second most widely used chemical for predisinfection and oxidation by treatment plants processing surface waters. Hundreds of drinking water treatment plants use this chemical to oxidize iron, manganese, and arsenic; to remove color; and to treat for biofilm in raw water intake pipes.

Potassium permanganate is also used in fish farming to prevent or alleviate oxygen shortages in rearing ponds. The chemical works by oxidizing decaying plant matter and other organics so that they consume less oxygen, thereby relieving oxygen depletions that otherwise could result in fish kills.

Sodium Permanganate. Sodium permanganate is another strong oxidizing agent that can be used to neutralize rotenone and antimycin. Like potassium permanganate, this permanganate compound has a low estimated lifetime in the environment and is readily degraded by organic material and inorganic oxidation substances (Sino-American 2002). In a stream, sodium permanganate will quickly degrade as it neutralizes the piscicide and reacts to any organic material. The breakdown components of sodium permanganate are sodium, manganese, and water.

Sodium permanganate is also used for in situ chemical oxidation of chlorinated organic contaminants in soil and groundwater. Liquid sodium permanganate is injected into the soil or groundwater and allowed to disperse through the contaminated media. In situ chemical oxidation using sodium permanganate is an effective and environmentally acceptable method of remediating contaminated soil and groundwater.

Piscicide Use and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

FIFRA requires that all persons who apply pesticides classified as restricted use (such as piscicides) be certified according to the provisions of the Act, or that they work under the supervisions of a certified applicator. Commercial and public applicators must demonstrate a practical knowledge of the principles and practices of pest control and safe use of pesticides. In addition, applicators using or supervising the use of any restricted-use pesticides purposefully applied to standing or running water are required to pass an exam (*Aquatic Pest Control*) to demonstrate competency as described in the Code of Federal Regulations (40 CFR 171.4), as follows:

> *Aquatic applicators shall demonstrate practical knowledge of the secondary effects which can be caused by improper application rates, incorrect formulations, and faulty application of restricted pesticides used in the category. They shall demonstrate practical knowledge of various water use situations and*

the potential for downstream effects. Further, they must have practical knowledge concerning potential pesticide effects on plants, fish, birds, beneficial insects, and other organisms which may be present in aquatic environments. Applicants in this category must demonstrate practical knowledge of the principles of limited area application.

Piscicide Use and the Clean Water Act

Under FIFRA, EPA is charged to consider the effects of pesticides on the environment by determining whether a pesticide will perform its intended function without unreasonable adverse effects. In an agency guidance letter dated July, 11, 2003, EPA recognized the inherent value of pesticide applications to control nonnative species and stated that when a pesticide is applied directly to waters of the United States according to its "intended purpose" as allowed under FIFRA, it is not a pollutant under the Clean Water Act. The EPA further noted that the application of a pesticide in compliance with FIFRA requirements does not require an NPDES permit under the Clean Water Act when the pesticide is applied to water to control pests. A decision by the United States Court of Appeals for the Ninth Circuit (*Fairhurst vs. Hagener*) reaffirmed EPA's decision that a pesticide applied to a river for the purpose of "eliminating pestilent fish species is not a pollutant for the purposes of the Clean Water Act…and thus not subject to the Act's permit requirements."

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