FINAL

FISH AND WILDLIFE COORDINATION ACT REPORT

ALL AMERICAN CANAL FEASIBILITY STUDY (SUPPLEMENT)

IMPERIAL COUNTY
CALIFORNIA

Prepared for the

U.S. Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada

by the

U.S. Fish and Wildlife Service
Laguna Niguel Field Office
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PREFACE

This document constitutes the U.S. Fish and Wildlife Service's (Service) final report regarding the Bureau of Reclamation's (Reclamation) All American Canal Feasibility Study. It has been prepared under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act, Public Law 85624 (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). Preparation of this report is also in keeping with the spirit and intent of the National Environmental Policy Act, Public Law 91190.

A draft Fish and Wildlife Coordination Act Report (Report) on the All American Canal Relocation Feasibility Study was initially prepared by the Service in April, 1985. That Report analyzed the impacts associated with relocating the All American Canal and constructing a wellfield to recapture seepage. A final Report was never issued although the Service and Reclamation extensively discussed mitigation for project impacts through both correspondence and meetings.

In May, 1986, Service personnel attended a planning meeting at Reclamation's Lower Colorado Regional Office in Boulder City, Nevada. At this meeting, Reclamation personnel from Denver, Colorado presented a new project alternative. This involved the inplace concretelining of the All American Canal from Pilot Knob to Drop 4. Based upon the verbal description provided at that meeting, Reclamation requested the Service to prepare a revised Fish and Wildlife Coordination Act Report which included an analysis of this alternative. The analysis of the new alternative was based on this presentation and the assumption that the impacts of lost seepage will be essentially the same as under the relocation alternative. Our analysis of the in-place lining alternative and the project alternative previously considered was discussed in a revised draft Report prepared by the Service in January, 1987. This final Report attempts to respond to the comments received by the Service on both draft reports.

Endangered species issues concerning the original project were addressed in a Biological Assessment, prepared by Reclamation (dated March 15, 1985), and in a Biological Opinion, prepared by the Service (dated July 3, 1985). Should Reclamation decide to pursue the inplace lining alternative, Reclamation should reinitiate formal Section 7 consultation, as required by the Endangered Species Act, to address potential impacts of that alternative on the endangered Yuma clapper rail.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

A. DESCRIPTION OF PROJECT AREA

The All American Canal (Canal) Feasibility Study area is located in Imperial County, California, immediately north of the international border with Mexico. The project area extends for 30 miles from the vicinity of Pilot Knob, near the Arizona border, to Drop 4, approximately 17 miles east of Calexico, California.

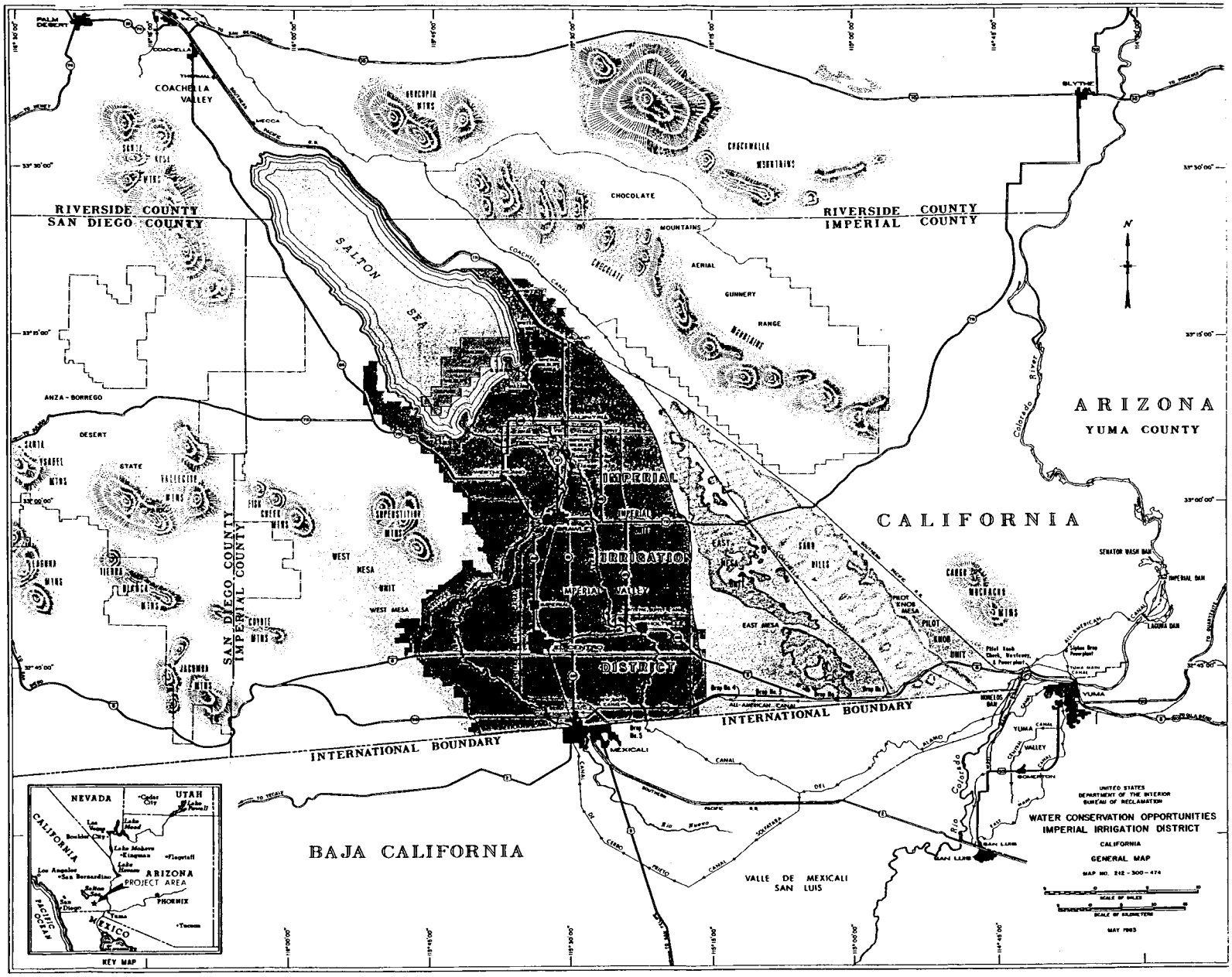
The Canal originates at Imperial Dam on the Colorado River and flows to the west, terminating in the Imperial Valley. This canal is the primary conveyance for irrigation waters to the Imperial Valley. The main water diversions from the Canal occur at the Pilot Knob hydroelectric plant and the Coachella, East Highline, Central Main, and Westside Main Canals (Figure 1). Approximately 5 million acre-feet of water intended for irrigation enter the Canal during an average year (Engineering Science 1980a). The Coachella Valley receives approximately 30% of this water via the Coachella Canal and another approximately 10% is lost through evaporation and seepage. Peak flow occurs during July when agricultural demand and evaporation are high; low flows in the December-February period are caused by lower agricultural demand and less evaporation (Engineering Science 1980a).

Except for short stretches of riprap and concrete lining above and below the drop structures, the Canal is unlined. Canal depths at mid-stream vary from 9 to 15 feet (2.7 to 4.6 meters). Canal widths range from approximately 100 to 210 feet (30.5 to 64 meters) at Pilot Knob and downstream from Drop 4, respectively. For most of the straight segments the width of the Canal varies between 175 and 185 feet (53 to 56.9 meters). Mid-stream flow velocities depend on the curvature, width, depth, and season; in general, velocities range from 0.38 to 3.49 feet per second (Engineering Science 1980a).

The project area occurs in the Colorado Desert region of the Sonora Desert. Mean temperatures over a 50-year period were 91.2°F for July and 53.9°F for January (Engineering Science 1980b). Rainfall, which averages approximately 3 inches per year, is divided between the winter and summer seasons (Engineering Science 1980b).

The area immediately adjacent to the Canal is primarily undeveloped. Four large drop structures and their maintenance facilities occur along the canal. The Algodones Dunes are popular with off-road vehicle recreationists, who also encroach on surrounding creosote bush scrub areas. Fishing occurs along the canals and the seep wetlands support the hunting of doves, quail, and waterfowl. A few abandoned agricultural fields, the Brock Research Center north of Drop 2, a San Diego Gas and Electric Company powerline south of the Canal, and some minor utility lines are the only other developments within the immediate project area.

The Canal transverses a number of topographic features as it passes through the project area. At the eastern end of the Canal, in the vicinity of Pilot Knob, the terrain is rugged and rocky for approximately 1.3 miles. To the



y Project Study Area, Imperial County,

west, approximately 1.5 miles of flat land are divided between desert pavement and the sandy substratum of a wash woodland. From the wash woodland to Interstate 8, the Canal transverses the eastern edge of the Algodones Dunes for 5.5 miles; low sand dunes are the primary topographic relief in this stretch. North of Interstate 8, the Canal cuts across the main axis of the dunes. A 1-mile long by 800-foot wide, flat, gravelly area lies about midway in these dunes. The remaining approximately 16.5 miles of the project area, west to Drop 4, are flat, with the exception of approximately 2 miles of small sand dunes between Drops 2 and 3. The substratum ranges from sand to small cobbles.

Sand dune-associated vegetation of the Algodones Dunes comprises the largest vegetational community within the project area. These dunes provide habitat for many endemic species, including at least 6 sensitive plant species. The next largest plant community, creosote bush scrub, covers most of the remaining project area, except for the wetland seeps. Wetlands and microphyll woodlands occupy smaller acreages; however, the increased productivity and the presence of water in these habitats make them extremely important to wildlife in the desert.

The project area supports a wide variety of animals, most of which are well-adapted for life in extremely arid conditions. However, many bird species not particularly adapted to desert habitats occur in the major seep wetlands between Drops 3 and 4. The presence of these mesic areas greatly increases the species diversity of the avian community. The wetlands serve as important stopover points for many species of migrants and also provide breeding habitat for many water-associated species, including the federally endangered Yuma clapper rail (Rallus longirostris yumanensis) and the State rare California black rail (Laterallus jamaicensis coturniculus).

The Algodones Dunes support many animal species, which, like the plants inhabiting this unique habitat, are endemic to the dunes and extremely well-adapted to exist on a substratum of loose sand. The Andrew's dune scarab beetle (Pseudocotalpa andrewsi), a dune endemic, is a candidate for listing as endangered under the Endangered Species Act.

B. DESCRIPTION OF ALTERNATIVE PLANS

The unlined All American Canal loses water to seepage along its entire length, with most of the seepage occurring in the eastern 40 miles. Between Imperial Dam and Pilot Knob, water seeping from the canal eventually reenters the Colorado River. However, between Pilot Knob and Drop 4, the water migrates underground to Mexico and is lost to the United States. Approximately 87,000 acre-feet of water per year would be prevented from seeping into the ground if this 30-mile stretch of canal was made impervious to water. The reduction of seepage in the Algodones Dunes alone would be approximately 64,000 acre-feet per year [Bureau of Reclamation (Reclamation) 1984b].

The Imperial Irrigation District (District) is the sponsoring agency for this project. As project sponsor, the District will receive water rights to approximately 2/3 of the water conserved or approximately 59,000 acre-feet per year. Reclamation would have rights to the remaining 28,000 acre-feet.

Reclamation intends for this water allotment to be used to replace waste brine water from its desalting plant at Yuma, Arizona. The remaining unused water could be utilized in the Imperial Valley or by municipal or industrial users elsewhere in southern California. It has been projected by Reclamation that the estimated cost of conserved water may be $123 per acre-foot which is currently considered unaffordable by agriculture interests. Hence, the most logical current use of the conserved water is for municipal or industrial users (Reclamation 1987a). The Metropolitan Water District has also expressed interest in sharing the cost of this project in return for a share of the water which would be conserved.

Currently, Reclamation is examining 4 major alternatives as part of the All American Relocation Study. Reclamation has identified in-place lining as its preferred alternative. The alternatives being studied are summarized below.

1. A Relocated Concrete-lined Canal from Pilot Knob to Drop 4

This alternative involves lining 30 miles of canal with concrete in a new alignment which would parallel the existing canal. The new canal would be located on the north side of the present canal from the Fort Yuma Indian Reservation near Pilot Knob to Drop 1. From the Interstate 8 bridge west of Drop 1 to Drop 4, the concrete canal would be relocated south of the existing Canal. The short section of canal between Drop 1 and the Interstate 8 bridge to the west would remain unlined. This alternative would prevent approximately 87,000 acre-feet of water per year from seeping from the Canal (Reclamation 1985b).

The concrete-lined canal would have a bottom width of 50 feet and would be constructed of 4.5-inch unreinforced concrete lining. Twenty-foot operation and maintenance roads on both sides of the canal are included in the project design. No borrow or fill would be required for this construction. Gravel for surfacing, concrete aggregate, and riprap can be obtained locally (Reclamation 1984a).

2. Placement of Wellfield Between Pilot Knob and Drop 1

This alternative would evaluate the construction of 25 wells along the banks of the present canal at 0.5-mile intervals between Pilot Knob and Drop 1. The wells would pump 70,400 acre-feet per year from the groundwater. The recovered water would be pumped directly back into the Canal (Reclamation 1985b).

3. In-place Concrete-lining from Pilot Knob to Drop 4

Reclamation is currently investigating the feasibility of lining the Canal in-place without taking it out of service. The initial step in this process would be to cut and fill the existing channel until the sides and bottom are smooth. The sides and bottom would then be covered by sheets of impermeable plastic that would be topped by 3 to 5 inches of concrete immediately after the plastic is laid. Because of its size, the Canal would be lined in 3 or 4 longitudinal sections. The plastic and concrete placement would be accomplished by a single machine, the design of which would be developed by private enterprise. This machine would be a self-propelled tracked vehicle that would travel on specially constructed tracks or roadways on each side of the canal.

The lined Canal would be approximately the same dimensions as the existing unlined Canal and would conserve an estimated 70,000 to 75,000 acre-feet of water annually (Reclamation 1987a.). The details of this alternative were presented to Reclamation's Lower Colorado Region office in Boulder City, Nevada on May 28, 1986 by Reclamation's Denver, Colorado office. This meeting was attended by Ray Bransfield, a staff biologist, from the Fish and Wildlife Service's (Service) Laguna Niguel Field Office.

Since the meeting, Reclamation has provided a brief description of a prototype in-place lining project that they plan to implement between Siphon 14 and 15 of the Coachella Canal. This 1.25 mile reach of the Coachella Canal would be lined prior to any in-place lining work being conducted in the All American Canal in order that cost estimates can be refined, design data requirements can be determined and machinery operations can be assessed before embarking upon a full-scale canal lining project. Estimated cost of the prototype project is $4 to $6 million (Reclamation 1987a.).

4. No Action

This alternative would evaluate no modifications by Reclamation to the present Canal. The Imperial Irrigation District may, in the absence of a Federal project, undertake lining of the Canal with at least a portion of the funding being provided through the sale of previously conserved water to the Metropolitan Water District. The District's plans call for a lined canal between Drop 1 and Pilot Knob (District 1986). Specific proposals are not currently available, but it can be assumed any relocation or in-place lining alternative selected by the District would closely resemble the Reclamation proposals.

C. AQUATIC RESOURCES

1. Existing Conditions

A sizeable freshwater fishery exists in the Canal and is thought to be primarily recruitment stock from the Colorado River. Engineering Science (1980a) speculated that some fish, particularly juveniles, may pass through the sedimentation structures at Imperial Dam. Another source of fish in the Canal exists from periodic stocking of fish by the California Department of Fish and Game (Department).

Introductions of fish species by the Department to the Canal has primarily been limited to channel catfish (Ictalurus punctatus). The District has never stocked the Canal (District 1985). Fish population levels are also undoubtedly maintained through reproduction of fish in the canal where appropriate velocity, cover, and substrate conditions can be found.

Fish sampling efforts in the Canal have been extremely limited. The first documented aquatic survey was conducted by Engineering Science (1980a) during the period of December 1978 through April 1979. Numerous sampling difficulties were encountered by Engineering Science in its fish collecting efforts in the Canal. Most sampling difficulties were a result of the physical configuration of the Canal and its associated high water velocities. The most severe

limitation in the effort to collect fish was the inability of Engineering Science to launch an electroshocking boat in the Canal due to its extremely steep sides. Fish collecting was limited to various netting techniques. Due to these difficulties Reclamation recommended, during feasibility planning, that an evaluation of the fishery resource of the lined and unlined sections of the Coachella Canal be made. This evaluation, it was argued, would be the best methodology available in predicting aquatic impacts associated with the proposed lining of the All American Canal. The Fish and Wildlife Service agreed with this approach, provided additional fish sampling was conducted in the All American Canal as well.

Fish sampling efforts in the 2 canals by Engineering Science, Reclamation, the Department, the Service, and Dr. Paul Beaty of the Coachella Valley Water District are discussed below. Results of the sampling efforts in the All American Canal are discussed first.

Engineering Science established 4 fish sampling stations in the All American Canal (1980a). These stations included a site 0.5 mile south of Pilot Knob and sites below Drops 1, 3, and 4. Through the use of hoop nets with winged leads, experimental gill nets, and dip nets, a total of 142 fish was collected. These fish represented 11 different species (Table 1). On December 4 and 5, 1984, another fish sampling effort was made with personnel from the Department, Reclamation, and the Service in the section of the Canal below Drop 1. Fish sampling gear used during the survey included monofilament and nylon gill nets, trotlines, and a tramel net. This resulted in the capture of 27 fish representing 5 species (Table 1).

A previously uncollected fish species was observed at Drop 3 by California Department of Fish and Game and Service biologists on August 26, 1986. This fish was the striped bass (Roccus saxatilis).

Three additional fish species were collected by the Service during its investigation of the All American Canal. These fish were collected in the recapture ditches which parallel the Canal in the seep wetlands between Drops 3 and 4. Fish collected include tilapia (Tilapia zilli), mosquitofish (Gambusia affinis), sailfin molly (Poecilia latipinna), and the Mexican molly (P. mexicana).

Fish inventories in the Coachella Canal have been far more extensive. The Department (1974) published a report which summarized electrofishing efforts for ten 0.5-mile sections of unlined canal habitat. A total of 688 fish was captured, including 557 largemouth bass (Micropterus salmoides), 78 carp (Cyprinus carpio), 28 flathead catfish (Pylodictis olivaris), 11 channel catfish, and 10 sunfish (i.e. bluegill (Lepomis macrochirus), green sunfish (Chaenobryttus cyanellus), crappie (Pomoxis sp.), redear sunfish (Lepomis microlophus,) and warmouth bass (Chaenobryttus gulosus)) (Table 2). Based upon its electrofishing results, the Department estimated that there was a minimum population of 1,500 fish per mile. Maximum fish population of the canal was estimated to be 3,000 fish per mile.

In addition to the fish noted above, the Department (1974) electroshocked yellow bullhead (Ictalurus natalis) and observed schools of golden shiner

Table 1. Fishes and Their Numbers Found in the All American Canal

Common Name	Scientific Name	Total Number of Each Species Collected ES[1]	CDFG[2], BR[3] and FWS[4]	
Bluegill	Lepomis macrochirus	41	--	
Redear sunfish	Lepomis microlophus	18	--	
Warmouth	Chaenobryttus gulosus	3	--	
Bluegill-green sunfish (hybrid)	Lepomis macrochirus x Chaenobryttus cyamellus hybrid	1	--	
Largemouth bass	Micropterus salmoides	14	1	
Smallmouth bass	Micropterus dolomieui	2	2	
White crappie	Pomoxis annularis	1	--	
Channel catfish	Ictalurus punctatus	8	6	
Flathead catfish	Pylodictis olivaris	2	1	
Carp	Cyprinus carpio	3	17	
Mosquitofish	Gambusia affinis	23	--	
Striped bass	Roccus saxatilis	--	--	1[5]
Total		142	27	1

[1] Engineering Science

[2] California Department of Fish and Game

[3] Bureau of Reclamation

[4] Fish and Wildlife Service

[5] A single individual of this species observed at Drop 3 on August 26, 1986 by biologists from California Department of Fish and Game and Fish and Wildlife Service.

Table 2. Common and Scientific Names of Fishes Collected from the Coachella Canal (Beaty et al. 1981 and Minckley et al. 1983)

Common Name	Scientific Name	CDFG[1] 1974	Beaty, et al. 1981	Minckley et al. 1983
Threadfin shad	Dorosoma petenense		X	X
Carp	Cyprinus carpio	X	X	X
Red shiner	Notropis lutrensis		X	X
Golden shiner	Notemigonus crysoleucas	X		
Channel catfish	Ictalurus punctatus	X	X	X
Yellow bullhead	Ictalurus natalis	X		X
Flathead catfish	Pylodictis olivaris	X	X	X
Mosquitofish	Gambusia affinis	X	X	X
Sailfin molly	Poecilia latipinna			X
Striped bass	Morone saxatilis			X
Largemouth bass	Micropterus salmoides	X	X	X
Green sunfish	Chaenobryttus cyanellus	X		
Bluegill	Lepomis macrochirus	X	X	X
Redear sunfish	Lepomis microlophus	X	X	X
Warmouth	Chaenobryttus gulosus	X[2]		X
Black crappie	Pomoxis nigromaculatus	X[2]	X[2]	X
Tilapia	Tilapia zillii		X	X
Bigmouth buffalo	Ictiobus cyprinellus		X	
Goldfish	Carassius auratus			X

[1] California Department of Fish and Game

[2] California Department of Fish and Game and Beaty only identified the fish captured as being Promoxis sp.

(Notemigonus crysoleucas) and mosquitofish. The Department also speculated that since the water within the Coachella Canal was from the Colorado River, the following fish species could also be potentially found in the canal: threadfin shad (Dorosoma petenense), rainbow trout (Salmo gairdneri), black crappie (Pomoxis nigromaculatus), tilapia (Tilapia mossambica and T. zillii), red shiner (Notropis lutrensis), roundtail chub (Gila robusta), bonytail (G. elegans), fathead minnow (Pimephales promelas), Colorado squawfish (Ptychocheilus lucius), razorback sucker (Xyrauchen texanus), black bullhead (Ictalurus melas), desert pupfish (Cyprinodon macularius ssp.), smallmouth bass (Micropterus dolomieui), sailfin molly, striped bass, and white bass (Morone chrysops).

Another major fish inventory of the Coachella Canal was conducted in 1980 by Aquatic Research Group, Coachella Valley Water District (Beaty et al. 1981). Fish sampling was performed with a boat-mounted electrofishing system in an area located approximately 5 miles northeast of the Salton Sea (North Shore), California. Electrofishing efforts were concentrated below siphons 25, 26, 27, and 28 in the canal. The 4 canal reaches sampled ranged from 0.45 to 1.47 miles in length. All reaches were unlined and had emergent and terrestrial vegetation consisting of cattail (Typha sp.), smartweed (Polygonum spp.), bermuda grass (Cynodon dactylon), and common reed (Phragmites australis).

Twelve species of fish were collected from the Coachella Canal (Table 2). The bigmouth buffalo (Ictiobus cyprinellus) was the only fish species captured that was previously not recorded by the Department (1974). From their electrofishing efforts, Beaty et al. (1981) recorded total numbers of fish captured, including largemouth bass (286), common carp (107), bluegill (123), channel catfish (144), and flathead catfish (10). Percent of catch for these 5 species is 42.7, 16.0, 18.4, 21.5, and 1.5, respectively.

During November 1980, water was transferred from an unlined 48.5-mile section of the Coachella Canal to a newly concrete-lined section. During this dewatering, a major effort was made to collect a large sample size of the various fish species which utilize the canal so that refined fish composition, relative abundance, and standing crop estimates could be made (Minckley et al. 1983). Three separate areas of the canal were sampled. Sample stations (A, B, and C) included one section approximately 5 miles and 2 sections approximately 42.3 miles downstream of the All American Canal. Sample area (A) which was closest to the All American Canal included a pool-like area below Check Drop 5. Emergent vegetation was sparse and submergent vegetation was absent in this reach. Sample area (B) consisted of a straight reach of canal with no water control structures. Common reed was scattered along the banks, and sparse sage pondweed (Potamogeton pectinatus) and water milfoil (Myriophyllum sp.) occupied the sandy bottom. Sample area (C) was a double-barreled, concrete box siphon (Siphon 21). Siphons have been constructed within the Coachella Canal to handle runoff from flash floods. The siphon walls were found to be encrusted with periphyton and invertebrates, and the bottom was littered with debris.

Prior to the water outage resulting from the transfer of water from the unlined to the newly constructed concrete-lined Coachella Canal, each of the

sample reaches was blocked with 2.5-centimeter mesh nets to restrict fish movement. In addition, immediately before sampling, earthmoving equipment was used to isolate Sections A and B from residual canal flow with earthen dikes. Section C was mechanically pumped to lower water levels for sampling purposes.

Unlike previous fish collecting methods on the Coachella Canal, these isolated sample reaches were rotenoned. Fish were then collected by use of dip nets and seines. A total of 9,093 fish was recovered representing 16 different species (Table 2).

Threadfin shad and channel catfish dominated the catch in Section A with 2,919 and 962 fish collected, respectively. These 2 species represented 65.5 and 21.6%, respectively, of the total catch from this section.

In Section B, channel catfish, red shiner, and redear sunfish represented the bulk of the fish species caught. Total numbers and percentages of the total catch from this section for channel catfish, red shiner, and redear sunfish were 2,787 (78.8%), 407 (11.5%), and 178 (5.1%), respectively. In Section C, channel catfish was the dominant species with 925 being captured representing 83.3% of the total catch.

In reviewing the data concerning fish captured at all 3 sections, channel catfish was the main species found in the Coachella Canal with a total of 4,674 captured. This represented 51.4% of the total catch for all sections. Total numbers and percentage composition of other major fish species or group of species captured were: threadfin shad, 2,927 (32.2%); sunfishes (i.e. bluegill, warmouth, black crappie, largemouth bass, and redear sunfish), 702 (7.7%); red shiner, 564 (6.2%); carp, 233 (2.6%); and flathead catfish, 94 (1%). Although threadfin shad was second highest in total numbers collected, it was primarily collected in only one section of the canal. This area was below Check Drop 5 (Section A) where 99.7% of the total catch for this one species was collected.

Total biomass of the fishes collected was also calculated. Channel catfish, common carp, and flathead catfish collectively represented approximately 96% of the total biomass of all fish captured. Respectively, channel catfish and common carp comprised 42.4% and 33.9% of the total biomass for all 3 sections sampled.

During November 1980 when the Coachella Canal was being dewatered, another independent sampling effort was made by Beaty et al. (1981). Beaty reexamined a reach of the Coachella Canal below siphon 25 that he had sampled through electrofishing earlier in the year. Instead of re-electrofishing the area, Beaty took advantage of the low water conditions to make an actual count of the fish found in this reach. A comparison was then made between population estimates derived by electrofishing and actual numbers of fish counted for 5 species. These fish species included largemouth bass, common carp, bluegill, channel catfish and flathead catfish. The comparison showed a dramatic difference between electrofishing estimates and actual fish counts. A total of 1,749 fish was estimated compared to 4,388 fish actually collected

during the dewatering of the canal (Table 3). Thus, the fish population for this one reach was 2.5 times greater than had been previously estimated by electrofishing studies.

Actual fish counts also revealed that the determination of species composition and relative densities, based totally upon electrofishing information, appears to be highly suspect (Table 4). The bias of electrofishing toward centrarchids, as pointed out in Beaty's studies, was confirmed in information obtained from Minckley's (1983) sampling efforts using rotenone. Minckley found that out of 9,093 fish captured, 51.4% were channel catfish and only 6.6% were from the sunfish family (Centrarchidae).

Based upon large amounts of fishery information that had been collected on the Coachella Canal by Beaty et al. (1981), Minckley et al. (1983) and Reclamation (1985a), Reclamation developed a methodology whereby this information could be applied to the All American Canal to predict population levels in the unlined canal (Reclamation 1985a). Three major assumptions were made by Reclamation in their extrapolation of Coachella Canal fishery data to the All American Canal. These assumptions were: (1) the habitat and associated fishery community of the Coachella Canal is similar to that found in the All American Canal, (2) the carrying capacity of a surface unit of particular habitat (shoreline, drop and channel) is generally the same for both canals, and (3) the available data represented normal values or average conditions.

A calculation of fish population levels on the All American Canal from Coachella Canal data involved several steps. Species composition, biomass, and numbers of fish taken from the Coachella Canal were computed into units per surface area for 3 habitat types including shoreline, drop and channel habitat (Table 5).

The surface areas of the corresponding habitat types in the All American Canal were then determined (Table 6). The total surface area (meter^2) of each habitat was converted to hectares and multiplied by the density (fish/hectare) for similar habitat types found in the Coachella Canal. The sums of those values represent the total numbers of each species (Table 7). Calculations were also made for species composition and biomass (Table 7). Based upon this methodology, channel catfish are estimated to be the dominant fish species found in the All American Canal, comprising 91.6% of all fish found in the canal.

Based upon this analysis, Reclamation (1985a) calculated that the All American Canal would be expected to support approximately 945 fish per hectare. The entire project area is expected to support approximately 268,000 fish. Fish biomass is estimated to average 11.3 grams/meter^2 or approximately 30,200 kilograms of fish in the project area.

Angler use of the project area is unknown as no creel census or angler use surveys were conducted as part of the feasibility study for the project. However, anglers were observed fishing the Canal during Service field trips of July 23-25 and December 4-5, 1984. The majority of the fishermen were concentrated along the shoreline below the power drops. Brief interviews

Table 3. A Comparison of Population Estimates Derived from Electrofishing (Estimated) and Draining (Actual) Reach 25 of the Coachella Canal. Confidence Intervals (95%) are Enclosed in Parentheses[1]

Species	Number of Fish	
	Electrofishing	Draining
Largemouth Bass	250 (165-274)	103
Common Carp	146 (92-165)	148
Bluegill	280 (160-300)	46
Channel Catfish	1073 (913-1082)	4038
Flathead Catfish	No estimate	53
Total	1749	4388

[1] Table from Beaty et al. 1981.

Table 4. Relative Abundance of Fishes in Reach 25 of the Coachella Canal Derived from Electrofishing (Estimated) and Draining (Actual)[1]

Species	Method	
	Electrofishing	Draining
Largemouth Bass	28.2%	2.3%
Common Carp	25.2	3.4
Bluegill	23.6	1.0
Channel Catfish	21.6	92.0
Flathead Catfish	1.3	1.2

[1] Table from Beaty et al. 1981.

Table 5. Species Composition, Biomass, and Density of a Canal Fishery by Habitat Type[1]

	Drop Habitat[2]			Shoreline Habitat[3]			Channel Habitat[4]		
	Species Composition %	Biomass g/m^2	Density fish/ha	Species Composition %	Biomass g/m^2	Density fish/ha	Species Composition %	Biomass g/m^2	Density fish/ha
Threadin shad	65.5	16.46	3,636.9	0.2	tr[5]	2.4	1.2	tr	8.5
Carp	3.2	59.51	175.7	2.5	6.03	22.4	1.1	1.08	7.6
Channel catfish	21.6	23.75	1,198.6	91.6	14.13	1,073.7	96.3	2.74	829.0
Flathead catfish	0.3	0.43	15.0	1.3	0.81	13.7	0	0	0
Sunfish	3.8	0.55	220.5	2.2	0.44	31.5	0	0	0
Largemouth bass	2.4	1.15	132.1	2.4	0.48	24.2	tr	tr	0.2
Striped bass	0	0	0	tr	tr	1.0	0	0	0

[1] Table from Bureau of Reclamation 1985a.

[2] Data from Minckley et al. (1983) for an unlined section of the Coachella Canal. This habitat was designated as a result of Minckley's sampling efforts below a drop structure in which he found significant difference in species composition compared to sections of the canal.

[3] Data from Minckley et al. (1983), Beaty et al. (1981), and Beaty (1984) for an unlined section of the Coachella Canal. This habitat supports aquatic vegetation and provides cover for spawning, invertebrates and small fish. Shoreline habitat was defined as an area which extended from the canal's shoreline out towards the All American Canal's center for a distance of 15 meters.

[4] Data from Reclamation (1985a) for a concrete lined section of the Coachella Canal. This habitat was defined as an area in the center or thalweg of the canal. It is represented by deep water (4m), swift currents, little cover, and a sandy shifting substrate. These conditions were represented in the unlined as well as the lined section of the Coachella Canal.

[5] tr = 0.05

Table 6. Surface Area of Habitat Components of the Unlined All Americal Canal[1]

Section	Surface Area (m^2) of Habitat Component		
	Drop	Shoreline	Channel
1	-	652,212	652.212
2	8,682	256,054	204,840
3	8,535	256,054	196,305
4	8,388	256,054	187,770
Total	25,605	1,420,374	1,241,127

[1] Table from Bureau of Reclamation 1985a.

Table 7. Estimated Numbers, Biomass, and Species Composition of the Major Fishes Found in the All American Canal Relocation Study Area[1]

Species	Estimated Numbers	Biomass (kg)	Species Composition[2] (%)
Channel catfish	245,793	18,600	91.6
Threadfin shad	11,132	465	4.1
Carp	3,866	9,050	1.4
Sunfish	3,543	429	1.3
Largemouth bass	2,659	822	1.0
Flathead catfish	1,331	775	0.5
Striped bass	11	10	tr[3]
Total	268,335	30,151	99.9

[1] Table from Bureau of Reclamation 1985a.

[2] Calculated from estimated numbers shown in column 1 of the table

[3] Tr = less than 0.05%

conducted by the Service with approximately 10 fishermen revealed that anglers fishing the deep pool habitat below the drop structures were trying to catch large channel or flathead catfish. Other anglers encountered by the Service were shoreline fishermen who were interested in catching largemouth bass and various other sunfishes. These anglers concentrated their efforts in the shallow shoreline areas of the canal, particularly where heavy emergent vegetation was present.

Although good angler use information is lacking for the All American Canal, the Department previously made an angler use-day estimate for the Coachella Canal. Average total estimated angler use expended on the Coachella Canal was computed to be 6,100 angler use-days per year based on a 4-hour angler day (Department 1974). This total-use figure was projected from data extracted from Department creel censuses completed on District waters. While the alignment of the Coachella Canal does not go through the Imperial Valley, it is adjacent to the District's boundaries.

More recent creel census data have been collected in the Imperial Valley by the District's Hydrilla Control Research Program. Data were collected from November 1985 to May 1986 primarily from the East Highline, All American, Central Main and Westwide Main Canals. During this seven month period, there was a total of 49,028 hours of fishing effort with 17,664 hours recorded for the East Highline Canal, 16,236 hours recorded for the All American Canal, 12,572 hours recorded for the Central Main Canal and 2,556 hours recorded for the Westside Main Canal. It should be noted that the creel census study boundaries for the All American Canal included only that portion of the Canal west of Drop 4.

A total of 5,616 fish are estimated to have been caught in the censused area with large numbers of the fish being largemouth bass (2,234) and channel catfish (3,362) (Stocker et al. 1986).

2. Future Without the Project

If no project is implemented, the existing fishery resources of the Canal are expected to remain about the same as present day levels. This statement is based upon 2 major assumptions. These assumptions are: (1) there will be no significant change in the quality or quantity of water which is transferred from the Colorado River, and (2) the District will not be constructing additional hydropower facilities or other major structural features in the canal. Changes in quantity and quality of water, or the addition of structural features, would alter fishery habitat conditions in the canal and thus have a direct impact on the fishery.

If the District undertakes any sort of lining program without the financial support of Reclamation, the impacts to the Canal's fishery resources would be similar to Reclamation's proposals under Alternatives 1 and 3. Since the District's current plans specify that the Canal will be lined only from Pilot Knob to Drop 1, the impacts to the fishery will be primarily confined to this stretch and will therefore be proportionately less than if the Canal was to be lined to Drop 4.

3. Future With the Project

a. A Relocated Concrete-lined Canal From Pilot Knob to Drop 4

Under this project alternative, a new canal would be excavated adjacent to the existing All American Canal from Pilot Knob to Drop 4, a distance of approximately 30 miles. The new canal would be totally concrete-lined, except directly above and below the existing drop structures.

In order to predict impacts from the proposed lining of the Canal, an aquatic investigation of a concrete canal in the immediate project area was warranted. The Coachella Canal was the only major canal which had been lined within the Coachella Valley Water and Imperial Irrigation Districts. A 48.5-mile section was lined with concrete in 1980.

A major sampling effort was made during November 3-6, 1984 by Reclamation, the Coachella Valley Water District, the Service, and the Department to obtain fishery information from a 2-mile concrete lined section of the Coachella Canal. This sampling effort was conducted approximately 5 miles downstream of the Coachella Canal confluence with the All American Canal and occurred during a period when the Coachella Canal was dewatered. This sampling effort resulted in the collection of 3,110 fish. Channel catfish was the dominant fish species collected (2,996) representing 96.3% of the total catch (Table 8). Based upon the ability to capture actual numbers of fish along with the relatively large sample size that was taken, this effort probably closely represents fish species and abundance which can be expected to be found in concrete-lined canals in this area.

To quantify the differences between the expected fishery utilization of a concrete-lined canal and the existing earthen bank Canal, an evaluation must be made of potential fish habitat associated with each canal. Construction of a relocated concrete-lined canal would result in a narrower and deeper canal with approximately 40% less surface area than the existing unlined canal. The average width of the concrete-lined canal would be approximately 118 feet compared to the existing 196 foot width of the All American Canal (Reclamation 1985a).

The narrower and deeper concrete-lined canal would result in a significant loss of shoreline habitat and a slight increase in channel habitat. There would be no expected change in habitat associated with drop structures as the new canal would be connected to the existing power drops (Table 9). Shoreline habitat would be reduced from 142.04 to 1.93 hectares (Reclamation 1985a). Benthic habitat would be totally eliminated initially, except in the areas of the drop structures. However, recolonization by invertebrates of the lined canal should begin once water is flowing through it.

The same methodology used to estimate existing numbers, biomass, and species composition in the unlined Canal was used to predict impacts associated with the proposed lining of the Canal. The surface areas of drop, shoreline, and channel habitats (Table 9) were multiplied by the

Table 8. Fish Species Found in the Lined Section of the Coachella Canal During November 1984[1]

Species	Numbers of Fish Collected	Percent Composition
Channel catfish	2,996	96.3
Red shiner	41	1.3
Threadfin shad	37	1.2
Carp	35	1.1
Largemouth bass	1	*
Tilapia	Observed	*
Total	3,110	99.9

* 0.1% (combined)

[1] Table from Bureau of Reclamation 1985a.

Table 9. Habitat Availability[1] for the Unlined All American Canal and Relocated Concrete-lined Canal[1]

	Surface Area (Hectares) of Habitat			
	Drop	Shoreline	Channel	Total
Unlined	2.56	142.04	124.11	268.71
Lined	2.56	1.93	160.63	165.12

[1] Table from Bureau of Reclamation 1985a.

fishery measurements taken from similar habitats in the Coachella Canal (Table 5). Table 10 shows the numbers and biomass of each species of fish per habitat type that could be expected to be found in the relocated concrete-lined Canal (Reclamation 1985a). It is estimated that there would be 152,832 fish in the lined canal with a total biomass of 9,417 kilograms (Table 10).

The net impact to the fishery resources between the existing unlined and relocated concrete-lined canal is summarized in Table 11. It is projected that the relocated lined canal would result in a net loss of 115,503 fish or approximately 43% of the existing fishery resource. Game fish abundance would be reduced from 8,500 to 4,600 fish per mile. Reductions in total biomass of the fishery would be as great as 68.7%.

The greatest impact in terms of percent reduction of overall numbers would occur to 3 game fish species including flathead catfish (95.2%), largemouth bass (85.1%), and sunfish (82.4%). These same fish species also would show the greatest reduction in total biomass (Table 11).

Significant adverse impacts to the game fishes, particularly the centrarchids (largemouth bass and sunfish), would result primarily from a major reduction in shoreline habitat and an increase in water velocity. Lining of the canal would eliminate emergent and submergent vegetation. The loss of this vegetation would severely reduce invertebrates dependent upon aquatic vegetation. Invertebrates found on aquatic vegetation are an important food source for juvenile largemouth bass and bluegill. Lining of the canal would also eliminate cover for juvenile fishes and spawning substrate.

A narrower and deeper canal would also increase water velocities significantly. In the absence of cover, these higher velocities would almost completely eliminate available habitat for centrarchids which prefer sluggish to nonflowing waters.

A lined canal would be dominated by channel catfish which would be estimated to comprise 91.2% of the total population.

Threadfin shad and carp are estimated to make up 7.0% and 1.1%, respectively, of the remaining post-project fish populations.

Since flathead catfish, largemouth bass, and sunfish are the game fish most severely affected by the project, and these species provide an important recreational fishery to Imperial Valley, efforts should be made to reduce their losses through mitigation.

b. Construction of a Wellfield

Under this alternative, 25 wells would be constructed. They would be located south of the Canal between the western edge of the Sand Hills to Pilot Knob. The wells would pump 70,400 acre-feet per year from the groundwater and discharge it directly into the Canal. Preliminary test results indicate the water quality of the well water would be comparable to that of the water in the Canal (Reclamation 1985b).

Table 10. The Fishery Resource Expected for Specific Habitats for the Proposed Relocated Concrete-lined Canal[1]

Species	Drop Habitat		Shoreline Habitat		Channel Habitat	
	Biomass (kg)	Numbers	Biomass (kg)	Numbers	Biomass (kg)	Numbers
Channel catfish	608.1	3,068	272.7	2,072	4,532.0	134,190
Threadfin shad	421.5	9,310	tr	5	34.1	1,376
Carp	1,523.8	450	116.4	43	1,786.3	1,230
Sunfish	14.0	564	8.5	61	0	0
Largemouth bass	29.4	338	9.3	27	32.0	32
Flathead catfish	11.0	38	15.6	26	0	0
Striped bass	0	0	2.0	2	0	0
Total per Habitat Type	2,607.8	13,768	424.5	2,236	6,384.4	136,828

[1] Table from Bureau of Reclamation 1985a. (Total numbers of fish under "Shoreline Habitat" (Column 2) were modified from original table prepared by Reclamation to accurately reflect the total of species numbers.)

Table 11. Comparison of the Fishery Resource[1] of the Unlined All American Canal and Relocated Concrete-lined Canal

	Existing Conditions Unlined Canal			Future With Project Lined Canal			Net Change to Existing Fishery with Proposed Lining			
	Fish #	Biomass kg	Comp %	Fish #	Biomass kg	Comp %	Fish #	Impact %	Biomass kg	Impact %
Channel catfish	245,793	18,600	91.6	139,330	5,413	91.2	-106,463	-43.3	-13,187	-70.1
Threadfin shad	11,132	465	4.1	10,691	456	7.0	- 441	- 4.0	- 9	- 1.9
Carp	3,866	9,050	1.4	1,723	3,426	1.1	- 2,143	-55.4	- 5,624	-62.1
Sunfish	3,543	429	1.3	625	22	0.4	- 2,918	-82.4	- 407	-94.9
Largemouth bass	2,659	822	1.0	397	71	0.3	- 2,262	-85.1	- 751	-91.4
Flathead catfish	1,331	775	0.5	64	27	tr	- 1,267	-95.2	- 728	-96.4
Striped bass	11	10	tr	2	2	tr	- 9	-81.8	- 8	-80.0
Total	268,335	30,151		152,832	9,417		-115,503	-43.0	-20,714	-68.7

tr = Trace or less than 0.1

[1] Table from Bureau of Reclamation 1985a. (Some numbers associated Fish, Biomass, and Composition under "Lined Canal" (Column 2) and "Net Change with Project" (Column 3) were modified from original table prepared by Reclamation to accurately reflect information summarized in Table 10.)

This alternative is expected to have no significant impacts to the existing fishery resources of the Canal, provided preliminary test results on the water quality of the well water are correct.

c. In-place Concrete-lining from Pilot Knob to Drop 4

With implementation of this alternative, the All American Canal would be concrete-lined in place without dewatering the Canal or constructing coffer dams. Reclamation has determined that a plastic liner and concrete can be placed in a given reach of the Canal if two to three passes are made by the machine which simultaneously lays the liner and concrete. This operation would permanently seal the Canal from bank to bank. With this proposed methodology, fish should be able to avoid areas being lined.

The methodology used to estimate existing numbers, biomass, and species composition for the unlined Canal and the relocated canal was used for this alternative to predict fishery impacts. Like the previous alternative analysis the amount of drop, channel and shoreline was quantified. Unlike the relocated canal alternative, the current width of the Canal which is 196 feet would be maintained with in-place lining. Even though the width of the canal and associated surface acres of water would not be significantly reduced, there would be a total loss of shoreline habitat. It is assumed for this analysis that all shoreline habitat eliminated by concrete lining of the Canal would be converted to channel habitat which is characterized by swift currents, little cover and sandy shifting bottom substrate. There would be no change in the amount of habitat associated with drop structures (Table 12).

The surface areas of drop structures, shoreline, and channel habitats (Table 12) were multiplied by the fishery measurements taken from similar habitats in the Coachella Canal (Table 5). Table 13 shows the numbers and biomass of each species of fish per habitat type that could be expected to be found in the concrete-lined Canal. It is estimated that there would be 238,744 fish in the lined canal with a total biomass of 13,106 kilograms (Table 13).

The net impact to the fishery resources between the existing unlined and in-place lined Canal is summarized in Table 14. It is estimated that the in-place lining would result in a net loss of 29,591 fish or approximately 11% of the existing fishery resource. Reductions in total biomass of the fishery would be 56.5%.

Like the concrete, relocated canal alternative, the in-place lining alternative had a great impact on striped bass, flathead catfish, largemouth bass, and sunfish. In terms of percent reduction in overall numbers, striped bass, flathead catfish, largemouth bass and sunfishes (i.e. bluegill, redear sunfish and warmouth) were reduced by 100%, 97.1%, 85.3% and 84.1%, respectively. These estimated losses for the above noted species are almost equivalent to the losses projected with the concrete, relocated canal.

Table 12. Habitat Availability for the Unlined and In-place Concrete-lined All American Canal

	Surface Area (Hectares) of Habitat			
	Drop	Shoreline	Channel	Total
Unlined[1]	2.56	142.04	124.11	268.71
Lined[2]	2.56	0	266.15	268.71

[1] Table from Bureau of Reclamation 1985a

[2] U.S. Fish and Wildlife Service's predicted surface area of habitat based on in-place lining of the All American Canal.

Table 13. The Fishery Resource Expected for Specific Habitats for the Proposed Concrete-lined All American Canal

Species	Drop Habitat		Shoreline Habitat		Channel Habitat	
	Biomass (kg)	Numbers	Biomass (kg)	Numbers	Biomass (kg)	Numbers
Channel catfish	608.1	3,068	0	0	7,451.5	220,638
Threadfin shad	421.5	9,310	0	0	56.1	2,262
Carp	1,523.8	450	0	0	2,938.0	2,023
Sunfish	14.0	564	0	0	0	0
Largemouth bass	29.4	338	0	0	53.0	53
Flathead catfish	11.0	38	0	0	0	0
Striped bass	0	0	0	0	0	0
Total per Habitat Type	2,607.8	13,768	0	0	10,498.6	224,976

Table 14. Comparison of the Fishery Resource of the Unlined and In-place Concrete-lined All American Canal

	Existing Conditions Unlined Canal			Future With Project Lined Canal			Net Change to Existing Fishery with Proposed Lining			
	Fish #	Biomass kg	Comp %	Fish #	Biomass kg	Comp %	Fish #	Impact %	Biomass kg	Impact %
Channel catfish	245,793	18,600	91.6	223,706	8,060	93.7	- 22,087	- 9.0	-10,540	- 56.6
Threadfin shad	11,132	465	4.1	11,572	478	4.8	+ 440	+ 4.0	+ 13	+ 2.8
Carp	3,866	9,050	1.4	2,473	4,462	1.0	- 1,393	-36.0	- 4,588	- 50.7
Sunfish	3,543	429	1.3	564	14	0.2	- 2,979	-84.1	- 415	- 96.7
Largemouth bass	2,659	822	1.0	391	82	0.2	- 2,268	-85.3	- 740	- 90.0
Flathead catfish	1,331	775	0.5	38	11	tr	- 1,293	-97.1	- 744	- 98.5
Striped bass	11	10	tr	0	0	tr	- 11	-100.0	- 10	-100.0
Total	268,335	30,151		238,744	13,107		- 29,591	-11.0	-17,024	-56.5

tr = Trace or less than 0.1

The in-place, lined Canal would be dominated by channel catfish which would be estimated to comprise 93.7% of the total population. Threadfin shad were estimated to increase slightly in overall numbers after lining the Canal. Shad were predicted to comprise 4.8% of the total population after lining, an increase of 0.7% over existing conditions in an unlined Canal.

In addition to fishery resources, the concrete lining of the Canal would impact the invertebrates that inhabit this waterbody. Macroinvertebrates are an important food resource in sustaining high levels of fish production in canals. Marsh (1983) investigated the diversity and abundance of invertebrates in concrete-lined and earthern (unlined) portions of the Coachella Canal. A total of sixteen taxa of aquatic invertebrates was collected during November 1982 and May 1983 from the concrete-lined portion of the canal. Nineteen taxa of aquatic invertebrates were collected in the earthen portion of the canal.

While relative numbers of invertebrate taxa were similar in the lined and earthen reaches of the canal, total abundance of benthic macroinvertebrates was about 4 times as great in the concrete compared with the earthen canal. Mean densities in the concrete canal in November 1982 were 12,951 and 17,032/m^2 in sidewall and bottom substrates, respectively, compared with 158 and 4,050/m^2 in mid-channel and bank habitats in the earthen canal in November 1980. These differences reflect substantial increases in numbers of Chironomidae (midges), Oligochaeta (annelids), Hydracarina (watermites), and Corbicula (freshwater clam). Chironomidae was the predominent macroinvertebrate taxon in the lined canal. It accounted for nearly one-half (49%) of all individuals collected. Notably, most of the difference in invertebrate abundance between concrete and earthen canal reaches was a function of increased numbers of organisms associated with canal sidewalls.

Although total abundance of benthic macroinvertebrates was greater in the concrete lined canal when compared to the earthen canal, biomass of benthic invertebrates as measured in mg DW/m^2 (milligrams dry weight/meter^2) was considerably greater in the earthern canal. Total benthic invertebrate biomass in the earthen canal was found to be 2,000 to 7,500 mg DW/m^2 and 400 mg DW/m^2 in the concrete reach. This was due to the large numbers of Corbicula, a freshwater clam, found in the earthen canal. Large Corbicula (1-2 cm) constituted about 98% of the total biomass with other taxa contributing only minor percentages (Marsh 1983).

It was found in Marsh's (1983) investigation that the concrete sidewalls of canals add a habitat dimension not found in earthen canals. These habitats provide a stable attachment surface for micro and macro algae which in turn function as fine sieves which entrap fine particulate materials suspended in the water column. Certain benthic invertebrates, Chironomidae and Oligochaeta in particular, apparently find refuge within this epiconcretic matrix and utilize algae or entrained fine organic matter as food. In contrast the bottom of a concrete lined canal, except in areas immediately adjacent to structures, are for the most part uniformly shifting sand material having low numbers of most aquatic invertebrates.

An additional impact resulting from the implementation of this alternative would be an increase of pH in the canal waters downstream of where the concrete is being applied. The pH of waters in the All American Canal range between 7.0 and 8.0. It has been estimated by California Department of Fish and Game that the pH of the canal water could increase by as much as 2 units downstream of that portion of the canal being lined. Associated with the rise in pH would be a corresponding elevated level of un-ionized ammonia in the canal water. Un-ionized ammonia has been demonstrated to be the principle toxic form of ammonia to aquatic life and could be a major environmental problem when the canal is being concrete lined. For example, it has been predicted an increase in pH levels of 2 units when canal waters are 20°C (68°F) could cause un-ionized ammonia concentrations to increase from 3.8% to 80%. This shift would be toxic to most resident fish species downstream of the concrete lining operation (Courtois 1987).

d. No Action Plan

If no project is implemented, there would be no change in existing fishery resources within the Canal.

D. TERRESTRIAL RESOURCES

1. Existing Conditions

a. Vegetation

Within the project area, creosote bush scrub typical of the Colorado Desert is by far the largest plant community represented, covering most of the intermountain alluvial fans where coarse, well-drained soil with a total salinity of less than 0.02% is found (Burk 1977). Approximately 545 acres of creosote bush scrub are located adjacent to the canal in the area which would be directly affected by a relocation alternative (Table 15). Creosote bush (Larrea tridentata) and burrobush (Ambrosia dumosa) are dominant members of the creosote bush scrub community; other species found within this and other project area communities are listed in Appendix 1. A relatively small area of desert pavement lies between Pilot Knob and the eastern edge of the Algodones Dunes. The substratum in this area is composed of small rocks overlying very fine soil. Considered as a type of creosote bush scrub, vegetation within the desert pavement area is generally sparse with individual creosote bushes and burrobushes being smaller than average. A few ironwoods (Olneya tesota) also occur here.

The Algodones Dunes, perhaps the most spectacular geological feature in the southern California desert, encompass approximately 190,000 acres. The dunes extend for approximately 40 miles in a northwesterly direction from below the international border to the vicinity of Mammoth Wash (Engineering Science 1980b). Wind-blown sands from the shores of Lake Cahuilla, moving to the southeast, are probably responsible for the formation of the Algodones Dunes (WESTEC 1977).

Table 15. Vegetative Communities of the All American Canal Project Area and Losses Associated with Project Alternatives (Reclamation 1984b).

			Relocation		In-place Lining	
Community	Project area	Well-field	Direct losses due to construction	Add'l. losses due to loss of seepage	Direct losses due to construction	Add't. losses due to loss of seepage
Wetland	887	0	125	762	0	887
Cattail marsh	52	0	43	9	0	52
Riparian	835	0	82	753	0	835
Sand dune	190,000	79	785	0	?	0
Microphyll woodland	20	0	17	0	0	0
Creosote bush scrub	-	0	545	0	?	0
Canal bank and berm	207	0	207	0	?	0
Bank	30	0	30	0	30	0
Berm	177	0	177	0	?	0
Subtotals	-	79	1,679	762	?	887
Total acreage loss	-	79	2,441		?	

? indicates unquantified habitat losses for borrow, fill, or staging areas.

Approximately 785 acres of sand dune habitat are located within the proposed construction right-of-way (Reclamation 1984b). Total plant cover at 3 sites along the proposed relocation route varied from 11.4 to 13.9% (Engineering Science 1980b). Desert buckwheat (Eriogonum deserticola) and plicate coldenia (Coldenia plicata) provided a large percentage of the relative cover. Bugseed (Dicoria canescens) and giant Spanish needles (Palafoxia arida var. gigantea) were also important because of their numerical abundance (Engineering Science 1980b). Other surveys of dune vegetation have been done by the Service (1981) and WESTEC (1977). A list of plant species found within the Algodones Dunes is contained in Appendix 1.

The unique habitat afforded by the mobile substratum in the dunes supports a wide variety of plants endemic to the dune system. Several plant species of the Algodones Dunes are considered sensitive by the California Native Plant Society (Society) or are candidates for listing as endangered under the Endangered Species Act. Service and Reclamation personnel surveyed an approximately 600-foot wide corridor along the proposed realignment route for sensitive plant species on April 10-12, 1984.

Giant Spanish needles was the most common of the sensitive plant species found in the project area. This species occurred more commonly in the larger dunes to the north of Interstate 8; distribution varied from widely spaced individuals to dense clumps. Giant Spanish needles is a Category 2 candidate for Federal listing and is on the Society list of plants which have a limited distribution in California, but are not rare at this time (Society 1984, List 4).

Borrego milk-vetch (Astragalus lentiginosus var. borreganus), the second most common sensitive plant species, was extremely common in the low dunes south of Interstate 8, but absent from the area to the north of the freeway. Many of the plants were very small in size; all were concentrated in level areas of coarser substratum between the dunes. This species is considered a List 4 plant by the Society (1984) and has no Federal or State status.

Wiggin's croton (Croton wigginsii) was the third most abundant sensitive plant species. The vast majority of the plants were found in the western section of the dunes north of the interstate. The croton is listed by the State as an endangered plant and is also considered endangered by the Society. This plant is considered relatively common outside California (Society 1984, List 2) and has no Federal status.

Peirson's milk-vetch (Astragalus magdalenae var. peirsonii), the fourth most common sensitive plant species, was found only among the large dunes north of Interstate 8, primarily in a small number of dense clumps. This species is a State listed endangered species, a Category 2 candidate for Federal listing, and a Society rare and endangered plant (1984, List 1b).

The desert sunflower (Helianthus niveus ssp. tephrodes), next in order of abundance among the sensitive plants, grew in the large dunes north of Interstate 8. The desert sunflower was very often found growing on the steep sides of dunes. This species is a Category 2 candidate for Federal listing, a State listed endangered species, and listed as rare and endangered by the Society (1984, List 1b).

Sand food (Ammobroma sonorae), an obligate root parasite of numerous species, occurred throughout the dunes on level or very gently sloped areas. Distribution was very sporadic and numbers varied from individual plants to colonies of a few square meters. Sand food is no longer being considered for endangered status by the Federal government (Federal Register, Vol. 48, No. 229, November 28, 1983), is not State listed, but is considered rare and endangered by the Society (1984, List 1b).

Thurber's pilostyles (Pilostyles thurberi) is an obligate parasite of Dalea emoryi, which is fairly common within the Algodones Dunes. This species was not found in the project area in the current survey or by Engineering Science (1980b). The pilostyles is not listed by either the State or Federal government; the Society considers it rare in California, but common elsewhere (1984, List 2.).

Wetland communities, ranging from ponded water bordered by narrow-leaved cattail (Typha angustifolia) to drier, open stands of arrowweed (Pluchea sericea), occupy approximately 887 acres within the project area (Table 15). The largest wetland area is located south of the Canal between Drops 3 and 4 and extends south into Mexico.

A recapture ditch, dug by the District to return seepage to the Canal, parallels the Canal for approximately 2 miles. Cattails, black willows (Salix gooddingii), Fremont cottonwoods (Populus fremontii), salt cedar (Tamarix spp.), and dense arrowweed comprise most of the wetland vegetation. A similar but smaller wetland, with a recapture ditch of approximately 1.7 miles, lies to the north of the Canal in this area and extends north to Route 98. Beyond the wettest areas of these seeps, honey mesquite (Prosopis glandulosa var. torreyana), screwbean (P. pubescens), and salt cedar form dense thickets. Smaller seep wetlands are located from Drop 3 east to the western intersection with Interstate 8. These wetlands vary from small clumps of salt cedar and mesquite with surrounding arrowweed to large areas of dense salt cedar. A species list for these communities is contained in Appendix 1.

The berms and banks of the Canal have become established with a number of species. Within the Algodones Dunes, the vegetation on these berms is characteristic of the sand dunes; elsewhere along the Canal, creosote bush and long-leaved Mormon tea (Ephedra trifurca) are common. Narrow bands of common reed line both shores of the Canal at the water's edge, except where concrete and rock have been used to stabilize the banks.

Two major microphyll woodlands are located in the project area: at the far eastern edge of the Algodones Dunes and within the dunes just west of the eastern intersection of the Canal with Interstate 8. Both washes contain numerous very large palo verdes (Cercidium floridum) and a smaller number of desert willows (Chilopsis linearis); the eastern wash also supports smoke trees (Dalea spinosa). Numerous smaller washes run south from Pilot Knob to the Canal. Shrubs such as desert lavender (Hyptis emoryi), catclaw (Acacia greggii), and cheesebush (Hymenoclea salsola) grow in these areas.

No extensive areas of saltbush or alkali scrub communities occur in the project area; however, local areas of high soil salinity and moisture support some members of these communities. Wingscale (Atriplex canescens) and allscale (A. polycarpa) are common members of the saltbush scrub community, growing in soils which range from 0.2 to 0.7% total salinity (Burk 1977). Alkali scrub, with total soil salinities of 0.5 to 2.0%, is characterized by iodine bush (Allenrolfea occidentalis) and quailbrush (Atriplex lentiformis) (Burk 1977).

b. Invertebrates

No systematic surveys of invertebrates of the project area were done. Typical species assemblages for the habitats present are expected to occur. The seep wetlands are probably important areas for breeding for many species with life histories requiring aquatic stages. The Algodones Dunes support many species which are uniquely adapted for life in mobile sands. Included among these dune-adapted species is the Andrew's dune scarab beetle, a Category 2 candidate for Federal listing under the Endangered Species Act. Adult beetles are active for approximately 6 weeks in April and May; host plants and activity patterns of larvae are unknown (Hardy and Andrews 1979). This species was not observed during field investigations by Reclamation, Service, or Engineering Science personnel; however, this is not surprising, given the brief daily activity period of the beetle and the unfamiliarity of the investigators with this species. Records for this beetle are primarily along the eastern edge of the dunes, southeast of Glamis, but on at least one occasion, the Andrew's dune scarab beetle was located within one mile of the proposed realignment route (Hardy and Andrews 1979). Therefore, the possibility exists that this species resides within the area to be affected by the project.

c. Amphibians and Reptiles

A large variety of reptiles is known from the desert region of California, largely because of the temperate climate. The presence of aquatic habitat, contributed by the Canal and its seeps, further increases the diversity of the project area's herpetofauna. Seven species of amphibians and 34 species of reptiles are known or suspected to occur within the project area. Appendix 2 presents a list developed primarily from Engineering Science (1980b) field work and literature searches. Field work by Service and Reclamation biologists has supplemented this list.

Creosote bush scrub provides habitat for 36 species of reptiles and amphibians, more than any other community type in the project area. (Table 16 provides the numbers of species of vertebrates found in each community type.) The zebra-tailed lizard (Callisaurus draconoides) is probably the most common species in this community, especially in open sandy areas. Within the Algodones Dunes, Colorado Desert fringe-toed lizards (Uma notata) were frequently observed running on the surface of the loose sand. The most commonly observed species along the wetlands' recapture ditches was the leopard frog (Rana pipiens). Only 5 species of reptiles and amphibians were reported from the wetlands within the project area. However, this number probably greatly underestimates the species present; the secretive nature of most reptiles and amphibians and the extremely dense vegetative cover probably contribute to the low number of species observed in the wetlands.

Two Category 2 candidates for listing under the Endangered Species Act occur among the reptiles within the project. The desert tortoise (Gopherus agassizii) has been known to occur within the project area. Berry and Nicholson (1984) report densities in the area of 0-20 individuals per square mile. The tortoise was not found by Engineering Science, the Service, or Reclamation during their field investigations.

The flat-tailed horned lizard (Phrynosoma mcallii) is a Category 2 candidate for listing under the Endangered Species Act and is designated as fully protected by the Department. This species inhabits open areas of wind-blown sand within the creosote bush scrub community; the entire proposed canal relocation route probably provides suitable habitat, except for the Algodones Dunes north of Interstate 8 and the wetlands between Drops 3 and 4 (Rorabaugh 1984). Reclamation and Service biologists surveyed 25.4 miles of the proposed canal relocation route on May 15 to 17, 1984, searching for horned lizards and their scat. No lizards, but 23 scat were observed. Seventeen scat were found in low sand dunes in a 3-mile section of the route, on the eastern edge of the Algodones Dunes south of Interstate 8. Using an abundance index developed by Turner and Medica (1982), Rorabaugh (1984) calculated an abundance index of 0.7 for the project area, which does not differ significantly ($p<0.05$) from the results of Turner and Medica's (1982) survey of flat-tailed horned lizard habitat in Imperial, San Diego, and Riverside counties.

d. Birds

Two hundred, twenty-three species of birds have been reported from the Canal project area (Engineering Science 1980b, Service 1984). Appendix 3 contains that species list. The wetland seeps support 179 species, far more than any other community in the project area. The shallow, open water and dense vegetative cover and food offered by cattails, willows, cottonwoods, and mesquite offer a highly diversified and productive habitat for seasonal visitors and year-round residents. Cover and water provided by the wetlands make these areas very attrac-

Table 16. Numbers of Vertebrate Species Found by Habitat Type in All American Canal Project Area (from Engineering Science 1980b and Service 1984).

	Amphibians	Reptiles	Birds	Mammals
Creosote bush scrub	7	29	64	47
Sand dunes	1	20	29	21
Microphyll woodlands	2	16	79	19
Saltbush-alkali scrub	2	13	41	11
Salt cedar-mesquite woodlands	0	11	99	21
Wetlands	3	1	179	26
Canal-levee	5	5	89	23

tive to migrants that use the seeps as stopovers during spring and fall migrations. Reclamation biologists detected 58 species of birds in the seep wetland south of the Canal between Drops 3 and 4 during census work in April and May, 1984. The 3 most common species were common yellowthroat (Geothlypis trichas), mourning dove (Zenaida macroura), and Wilson's warbler (Wilsonia pusilla). Wilson's warblers are strictly transients in this area while mourning doves are primarily year-round residents. Probably a small number of common yellowthroats are year-round residents of the wetland; migrants and transients substantially augment the numbers during the spring (Garrett and Dunn 1981).

Canal-levee habitat supports the next highest number of bird species (88). The proximity of water in an extremely arid environment draws many species to the canal-levee area. Sand dune habitat, with its relative scarcity of plant cover, attracts only 29 species of birds, the lowest of any major community type in the project area.

Forty-two species of birds found within the project area are listed as sensitive by the Service, the Department, or the National Audubon Society (Table 17).

The Yuma clapper rail is a State rare and federally listed endangered species. The Yuma clapper rail is migratory and breeds in freshwater marshes from Needles south along the Colorado River, and in marshes near the Salton Sea and along irrigation canals in the Imperial Valley (Department 1980). Dense cattails are required for nesting and crayfish form a major portion of this bird's known diet (Bennett and Ohmart 1978). Service biologists detected 17 Yuma clapper rails in the seep wetland south of the Canal between Drops 3 and 4 on April 30-May 1, 1981. On May 16, 1984, 3 clapper rails responded to taped vocalizations. Reasons for the decrease in numbers are unclear. The flooding on the Colorado River during the 1983 nesting season may have affected 1984 population levels. Additionally, we observed an absence of crayfish and a general lack of vigorous new cattail growth between Drops 3 and 4 (as compared with that at the wetland near the East Highland Canal turnout). These conditions apparently combined to reduce temporarily the attractiveness of this area to clapper rails. However, the high numbers of Yuma clapper rails found here in the past and the uncertainty connected with breeding habitats on the Colorado River and the Salton Sea underscore the importance of the wetland between Drops 3 and 4 as rail breeding habitat.

Pursuant to Section 7 of the Endangered Species Act, Reclamation prepared a Biological Assessment dated March 15, 1985 which described potential project impacts to the Yuma clapper rail from implementation of the relocation and wellfield alternatives (Alternatives 1 and 2). The Service's Biological Opinion, dated July 3, 1985, stated that the wellfield and relocation alternatives would not jeopardize the continued existence of the Yuma clapper rail. This Biological Opinion contained reasonable and prudent measures to minimize incidental take of rails, which formed the basis of our non-jeopardy opinion. If the in-place lining alternative (Alternative 3) is selected, formal consultation must be reinitiated to address the impacts of the alternative.

Table 17. Sensitive Bird Species of the All American Canal Project Area (from Tate 1986, Service 1985, and Remsen 1978, respectively)

	Audubon#	FWS	CDFG
Common loon	X	X	X
Western grebe	X		
Horned grebe	X		
Double-crested cormorant	X		X
American bittern	X		
Least bittern	X		
White-faced ibis		X@	X
Great blue heron	X		
Black-crowned night-heron	X		
Fulvous whistling-duck	X	X@	X
Canvasback	X		
Turkey vulture	X		
Osprey	X		X
Northern harrier	X		X
Sharp-shinned hawk	X		X
Cooper's hawk	X		
Ferruginous hawk	X	X@	
Swainson's hawk	X	X@	
Harris' hawk	X		X
Merlin	X		X
Yellow rail			X
Black rail		X@	X*
Yuma clapper rail		X+	X+
California gull			X
Gull-billed tern			X
Black tern	X		
Mountain plover		X@	
Yellow-billed cuckoo	X	X@	X
Common barn-owl	X		
Western screech-owl	X		
Burrowing owl	X		X
Long-eared owl	X		X
Short-eared owl	X		X
Willow flycatcher	X	X	X
Eastern phoebe	X		
Bank swallow	X		X
Cliff swallow	X		
Western bluebird	X	X	
Black-tailed gnatcatcher	X		X
Bendire's thrasher			X
Le Conte's thrasher			X
Crissal thrasher			X
Loggerhead shrike	X	X	
Yellow warbler	X		X
Yellow-breasted chat			X

Includes Blue-listed, Special Concern, and Local Concern species
@ FWS category 2 candidate species
* State listed rare (Department 1980)
+ Federal and State endangered

The bald eagle (Haliaeetus leucocephalus), a State and Federally endangered species, has been recorded in the project area by Engineering Science (1980b). Garrett and Dunn (1981) note that wintering eagles can be found almost annually at the Salton Sea. Bald eagle use of the Canal is probably limited to occasional visitations and foraging trips by migrating or wintering birds.

The California black rail is a State rare species and a Category 2 candidate for Federal listing. Inland marsh habitat for this sparrow-sized rail is usually characterized by sedges (Carex spp.), saltgrass (Distichlis spp.), and bulrush (Scirpus spp.) (Wilbur 1974). In the seep wetlands between Drops 3 and 4, black rails were heard calling primarily from cattails, but also from areas containing willows, tamarisk, arrowweed, and pampas grass (Cordaderia atacamensis). On April 10, 1984, 33 black rails responded on the south side of the Canal and 5 additional birds were heard on the north side; thus, 38 birds represent the minimum number of black rails using these wetlands. This census indicated that the seep wetlands between Drops 3 and 4 contain a significant breeding population of California black rails. Additional surveys of this area revealed 2 black rails in spring, 1979 (Engineering Science 1980b) and 10 on April 30-May 1, 1981 (Service 1981).

Other candidate species encountered in the project area include: white-faced ibis (Plegadis chihi), fulvous whistling-duck (Dendrocygna bicolor), Swainson's hawk (Buteo swansoni), ferruginous hawk (B. regalis), mountain plover (Charadrius montanus), and western yellow-billed cuckoo (Coccyzus americanus occidentalis).

All of these species are Category 2 candidates for listing. The following locational information is from Garrett and Dunn (1981). The white-faced ibis is described as a fairly common transient and summer visitant at the Salton Sea, remaining uncommonly in winter. The ibis forages in agricultural fields, retiring to adjacent marshes to roost. The fulvous whistling-duck inhabits dense cattail marshes and adjacent shallow water and is most commonly found along the Alamo River and at the south end of the Salton Sea year-round, with increased numbers in the summer. The Swainson's hawk is considered a rare to uncommon transient and rare summer resident in the Imperial Valley. The scattered trees of the seep wetlands could provide roosting and perching sites, while the surrounding creosote scrub and agricultural fields would offer foraging habitat. The ferruginous hawk is a fairly common winter visitant to the project area, using much the same habitat as the Swainson's hawk. Winter flocks of mountain plovers occur regularly in the agricultural areas of the Imperial Valley; Canal wetlands may also serve as resting areas during migration. The western yellow-billed cuckoo, designated as rare by the Department, is currently considered an uncommon summer resident along the Colorado River. Within the immediate project area, the tamarisk-mesquite woodland west of Drop 4 and the two large seep wetlands along the Canal could provide habitat for migrating cuckoos. However, none of these areas meets habitat requirements generally thought to be necessary to sustain breeding pairs. Gaines and Laymon (1984) state that

extensive stands of willows and cottonwoods with nearby surface water, in the form of oxbows, sloughs, and marshes, are common environmental features of sites where cuckoos currently occur. The habitat within All American Canal project area does not meet this description. The yellow-billed cuckoo may also require large insects in great abundance to breed successfully. Field work in the project area by Service biologists did not detect unusually high quantities of cicadas, caterpillars, or other large-bodied insects. It is possible that large populations of these insects can not be supported by the salt cedar-dominated vegetation of the wetlands.

e. Mammals

The project area provides habitat for 52 species of mammals, including 22 rodents, 14 bats, and 11 carnivores (Appendix 4). Creosote bush scrub, with the highest mammalian representation, supports 47 species; this diversity is probably a result of the large acreage of creosote and its proximity to other habitat types. Table 16 contains the numbers of mammalian species associated with the various communities found in the project area.

The burro deer (Odocoileus hemionus eremicus) frequents washes and valleys which contain willows, mesquite, ironwood, and palo verde. Currently, the population is estimated at 900-2,000 individuals along the Colorado River and through the Chocolate Mountains (Harvey and Stanley Associates undated). Burro deer occasionally migrate substantial distances. Therefore, the seep wetlands between Drops 3 and 4, the tamarisk-mesquite woodland west of Drop 4, and the 2 microphyll woodlands east of the Algodones Dunes may occasionally support deer (Garcia pers. comm.).

The Yuma puma (Felis concolor browni) is a Category 2 candidate for listing under the Endangered Species Act. The abundance of the puma is unknown, although it has never been considered to be common (Harvey and Stanley Associates undated). Little is known about its ecology, although riparian woodlands along the Colorado River appear to be its principal habitat and burro deer its principal food. Sightings have occurred near Calexico and the Coachella Canal which indicate that the Yuma puma may frequent the project area (Harvey and Stanley Associates undated).

f. Habitat Quality

The presence of the All American Canal in an otherwise extremely arid region has produced great benefits for fish and wildlife. In addition to providing an extensive aquatic environment and a year-round source of water, the canal seepage has produced an area, the seep wetlands between Drops 3 and 4, which contains very high wildlife values, as evidenced by the diversity and abundance of birds observed in the wetlands. The presence of the canal and the dense vegetation have combined to make this area relatively inaccessible to human disturance. Elsewhere throughout the project area, off-road vehicle use has severely degraded large sections of habitat. However, areas farther removed from freeway exits

and drop structures are remarkably well preserved. The steeper dunes north of Interstate 8, almost the entire stretch of low dunes south of the freeway, and much of the creosote bush scrub between Drop 3 and the western intersection of the freeway and the All American Canal have escaped serious degradation and remain high in wildlife value.

g. Hunting

Use of the project area by hunters was not quantified during the investigation. Also, no hunting was directly observed. However, the presence of shotgun shells, particularly along dirt roads through the wetlands, indicated that at least some hunting occurs in the area. Gambel's quail (Callipepla gambelii), mourning dove, white-winged dove (Zenaida asiatica), common snipe (Gallinago gallinago), and waterfowl are game species which are present in numbers in the wetlands. Five species of mammals found in the project area are considered furbearers with seasonal hunting permitted; 2 additional furbearers, the ringtail (Bassariscus astutus) and the kit fox (Vulpes macrotis), are fully protected (Appendix 4). The Audubon cottontail (Sylvilagus audubonii) and the black-tailed hare (Lepus californicus) are considered resident small game. The bobcat (Lynx rufus) is a nongame animal; special permits are required to take it. Burro deer are big game animals with seasonal hunting and limits set by the California Fish and Game Commission. Audubon cottontail and black-tailed hares are found throughout the project area and probably receive low to moderate hunting pressure. Muskrats are occasionally trapped in District canal systems to reduce the damage of their burrowing. Deer hunting probably does not occur because of the unpredictable presence of this species in the project area.

2. Future Conditions Without the Project

Environmental conditions would be anticipated to undergo no significant and rapid changes if a project was not built. Off-road vehicle use would probably continue to increase at a slow rate; however, barring construction of facilities permitting increased access, the areas affected by this sort of recreation should not increase in the near future. Although the Bureau of Land Management (Bureau) intends to increase access to recreationists in this area, these measures will not be implemented until the mid 1990's and are contingent on available funding. If the District undertakes a lining project without Reclamation's participation, the impacts identified in the following sections as occurring from Pilot Knob to Drop 1 in a Reclamation project would also occur under a District project.

3. Future Conditions With The Project

a. A Relocated Concrete-lined Canal From Pilot Knob to Drop 4

Actual construction of the relocation alternative would result in the direct loss of approximately 1,500 acres (Reclamation 1984b). Table 15 contains a breakdown of acreages by habitat type.

The old, unlined Canal would probably support a mixed community of invasive exotics and fast-growing natives for a short period of time.

However, use of the old canal by off-road vehicle enthusiasts, as has occurred on the old Coachella Canal, will probably prevent the establishment of any wildlife habitat in this area.

Wetland seeps will also be affected indirectly as the reduced seepage results in a water table that is farther from the surface of the ground. When the first 49 miles of the Coachella Canal were lined, the water table dropped 5 feet in approximately 3 years at wells 0.5 to 1.0 mile away from the canal (Leroy Crandell 1983). The initial impacts of the lowered water table would include the drying of the cattail marshes and open water habitats. As the water table continued to drop, the less deeply rooted wetland plants would die as their roots dried out. Eventually, only mesquite with deep root systems would probably survive. Reclamation (1984b) has calculated that an additional 9 acres of cattail marsh and 753 acres of riparian habitat would be secondarily affected by the loss of seepage water. The composition of successional communities is uncertain; the soil salinity may severely limit the number of species which could recolonize this area. With these secondary impacts, a total of 2,264 acres would be affected by the relocation alternative.

Loss of the cattail marshes and riparian habitat would eliminate numerous bird species as breeders in the area and substantially reduce the densities of numerous other species. Seventeen of the 58 species (29%) detected by Reclamation personnel during the spring, 1984, census are assumed to use the wetland areas as breeding habitat. These species, including the federally endangered Yuma clapper rail and the State rare California black rail, would be lost as breeders if the relocation alternative was to be implemented. An additional 11 species (19%) would continue to breed in the area, but would probably do so in much lower densities. Additionally, the loss of this mesic habitat with its open waters will result in a decrease in the production of insects. It is very likely that a concomitant decrease in insectivorous vertebrate species will occur with this decline in the food base.

Loss of 30 acres of common reed-lined canal edge would result in additional loss of wildlife values. Presently, the presence of reeds and an earthen bank permits access to water for many vertebrate species. A steep, concrete-lined bank would prevent wildlife from having relatively easy access to drinking water and would result in drownings of some vertebrates. The long-term reduction in available water would probably result in an overall decrease in wildlife numbers.

Some vertebrates are expected to drown when they fall into a concrete-lined canal. A primary concern would be the potential loss of burro deer as a result of drowning in the canal. Deer lost in canal systems of the western United States is a significant problem. A minimum of 29 deer drowned during the construction of the Coachella Canal in 1980. In 1981 and 1982, after the Coachella Canal was constructed, an additional 18 deer were reported drowned. All deer drownings occurred in the summer. In some instances, the deer had to cross approximately 1 to 5 kilometers of sand

dunes to reach the canal (Rautenstrauch and Krausman 1986). The tamarisk-mesquite woodland west of Drop 4 and the 2 microphyll woodlands east of the Algodones Dunes contain suitable habitat that could be used by deer. It is in these locations that deer would most likely to try to obtain water and could potentially fall into the canal.

An additional concern with a cement-lined canal would be absence of reeds that grow along some shoreline reaches of the earthern canal. The loss of reed habitat will result in the loss of nighttime roosting habitat for thousands of blackbirds that feed in nearby agricultural fields.

b. Placement of a Wellfield Between Pilot Knob and Drop 1

This alternative would involve the placement of 25 wells along the south levee of the Canal. Direct impacts would involve construction of wells on approximately 4 acres of dune habitat. If a new power-line is required, an additional 75 acres of dunes would be lost during construction activities. If an access road is maintained, increased use by off-road vehicles of the south side of the canal would result in additional impacts to wildlife habitat.

The results of a groundwater modeling study of the project area suggest that no decline in groundwater levels will occur within the seep wetlands if groundwater pumping occurred east of Drop 1 (Loeltz and Leake 1979). Therefore, the seep wetlands would remain undisturbed under this alternative.

c. In-place Concrete-lining from Pilot Knob to Drop 4

The in-place lining alternative could probably be implemented without the major, direct disturbances to terrestrial habitats in the project area that would be associated with the relocation alternative. Disturbances could result from the need to deposit materials dredged from the Canal or from borrow sites used to obtain fill. Several equipment staging areas may be needed along the Canal because the drop structures and bridges will require that the construction equipment be moved around these obstacles. Quantification of direct impacts is not possible at this time, because the number of staging areas and the quantities of dredge and fill materials remain unknown. Likewise, the specific locations which would be affected by construction are currently unknown, although it seems reasonable to the Service that disturbed areas, such as the Canal berms and abandoned agricultural fields, could be extensively used, thus reducing impacts to wildlife habitat.

An additional direct loss would be the 30 acres of common reed habitat which currently lines the Canal's edge. The biological impacts of this loss under the in-place lining alternative would be the same as those described for the relocation alternative.

The indirect impacts of the in-place lining alternative would be the eventual loss of approximately 887 acres of seep wetlands. As under the relocation alternative, the major portion of these wetlands occurs south of the Canal between Drops 3 and 4. However, the smaller pockets of

wetlands scattered along the Canal from Drop 4 to Pilot Knob would eventually perish as well. The resulting impacts to wildlife habitat and the potential for deer drownings would be as described above for the relocation alternative.

d. No Action

If Reclamation does not undertake a project to prevent or recover water seepage from the Canal, the District may institute its own project. At this time, no information is available on alternatives which would be considered by the District. However, relocation and groundwater mining are likely candidate projects. In the event these alternatives were used, the project impacts would be similar to those anticipated for a Reclamation project.

E. MITIGATION PLAN

To develop mitigation plans for the subject project, the Service categorizes habitats based on the values of the areas to evaluation species, the uniqueness of the habitats on a national or regional basis, and the ability to replace habitat values that may be lost.

Based on our evaluations of the habitat types present in the project area, the Service has concluded that only habitats requiring mitigation goals of no net loss of in-kind habitat value and no net loss of habitat value while minimizing the loss of in-kind habitat value occur onsite. For this reason, only these goals will be discussed further. The goal of no net loss of inkind habitat value is sought when habitat is of high value to evaluation species and is scarce or becoming scarce on a national or ecoregion basis. Using presentday scientific and engineering skills, the values exhibited by these habitats could be replaced inkind if the project were implemented by creation of new habitat or enhancement of existing values. Within the project area, the Service has identified the seep wetlands between Drops 3 and 4 and the microphyll woodlands as deserving of this mitigation goal. This determination is based on the extremely high wildlife values and the scarce nature of wetlands in southern California, in general, and in the desert, in particular. Microphyll woodlands also occupy a very small percentage of the desert's land area while supporting a large density and diversity of species, including migratory birds.

The remaining habitat types found in the project area, the aquatic habitat of the Canal, creosote bush scrub, sand dune and canal edge, exhibit characteristics which would facilitate achieving a mitigation goal of no net loss of habitat value while minimizing loss of in-kind habitat value. These characteristics include relative abundance on a national level (such as creosote bush scrub, the Canal's fishery, and canal edge) or regional level (such as the sand dunes). For this reason, in-kind replacement of habitat values was sought where possible for these habitats. Out-of-kind replacement is suggested in one instance where suitable in-kind mitigation does not seem feasible. The following section provides a detailed discussion on the mitigation goals and plans recommended by the Service.

1. A Relocated Concrete-lined Canal Alternative

a. Aquatic

Based on estimates of over 268,000 fish of 12 different species projected to occur within the project area, the mitigation goal for loss of aquatic habitat of the All American Canal is no net loss of habitat value while minimizing loss of in-kind habitat value. Lining of 30 miles of the Canal will substantially decrease the value of the warmwater fishery. The lined canal is projected to support 152,832 fish, a decrease of 43% from the existing conditions. Since flathead catfish, largemouth bass, and sunfish are the game fish most severely affected by the project, and have a high recreational value to fishermen who utilize the Canal, efforts should be made to reduce their losses through mitigation.

Taking advantage of the project's design where the lined canal will "tie in" to the existing canal, a series of 10 backwaters could be created. Six backwater areas could be formed by constructing one backwater area each above and below Power Drops 1, 2, and 3. Four additional backwater areas could be constructed at the beginning of the lined canal at Pilot Knob, above Drop 4, and above and below the Service's proposed unlined canal section between Drops 3 and 4. The 10 proposed backwaters are shown on Figure 2. Mueller (pers. comm.) estimated that the construction of 8 backwater areas of 1.9 acres each (approximately 175 feet wide x 479 feet long) would mitigate 50% of the largemouth bass, 63% of the bluegill, and 10% of the channel catfish losses. It was also estimated by Mueller (pers. comm.) that water seepage would amount to 1,360 to 1,500 acre-feet annually.

To achieve fuller mitigation for the loss of game fish, the Service proposes enlarging Mueller's suggested backwater areas. Using Mueller's mitigation estimate, cited above, the creation of 10 backwaters of 3.1 acres each (approximately 175 feet wide x 780 feet long) would mitigate approximately 100% of the largemouth bass and bluegill and 20% of the channel catfish losses. The 10 backwaters would require approximately 2,775 to 3,060 acre-feet of water annually based on Mueller's seepage estimate.

Water circulation within the upper end of the backwaters could be improved through installation of a large pipe from the Canal to the backwater (Figure 3). Improved water circulation may be critical during the summer months when mean air temperature for this area is 92°F.

Additional techniques should be employed in each of the backwaters to improve their carrying capacities further and more fully mitigate projected fishery losses. The use of vitrified clay pipes can be used to construct fish attractors (Wilbur 1974). The pipes are bundled with plastic binding material to form a pyramid or irregular shape. Pipes of different sizes (4 inches and larger in diameter and 2 to 5 feet long) are incorporated to create habitat diversity. Several units are placed in aggregate. The inclusion of several single, short, large-diameter pipes in a grouping may be desirable. In one study (Wilbur 1978), vitrified clay pipes attracted more fish (bluegills, largemouth bass, white catfish, and brown bullheads) than were present in control areas.

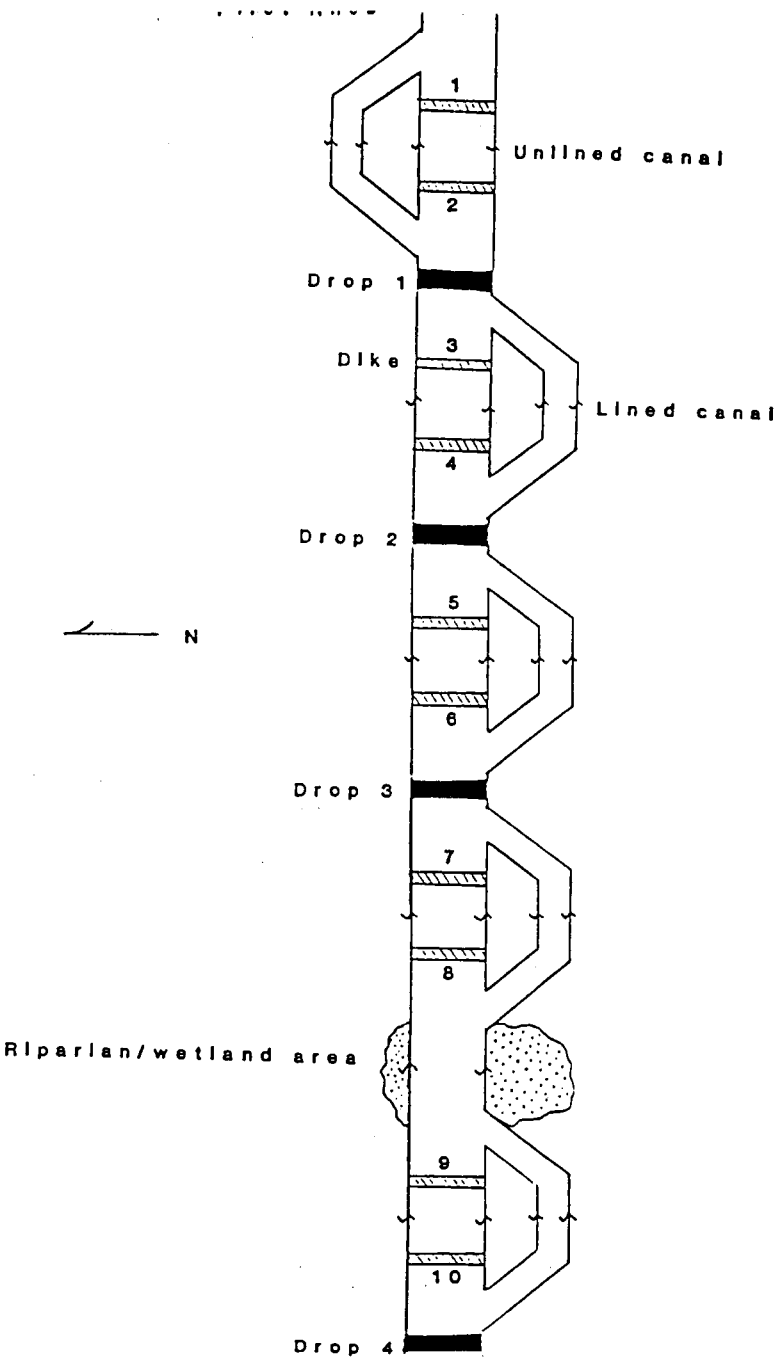


Figure 2. Schematic representation of ten backwater areas proposed as project mitigation features for the fishery resources of the All American Canal. The proposed location of the backwater areas are shown as numbers 1 through 10 (not drawn to scale).

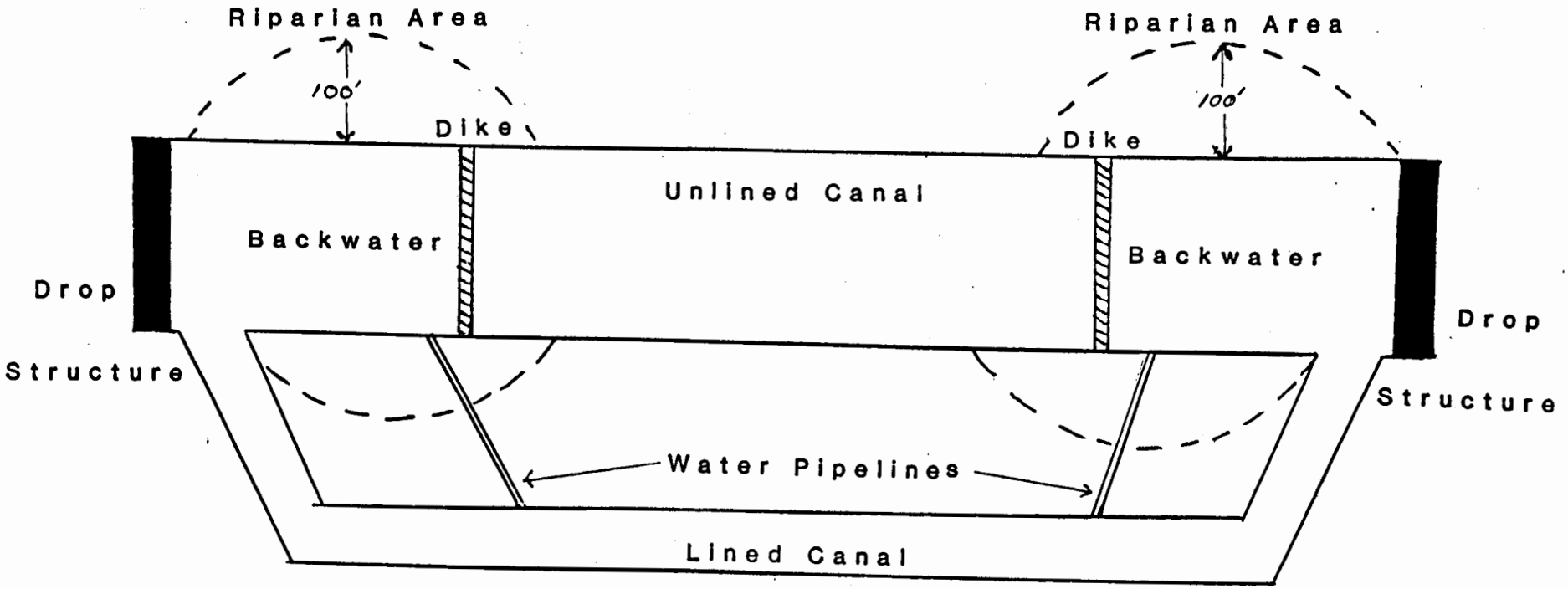


Figure 3. Conceptual plan of fish and wildlife backwater area and associated features.

Stacked brush frames are also popular means of providing cover for fish. These fish attractors are made from a series of bundled logs to form a box structure. The box structure is then filled with brush. Figure 4 shows a particular brush frame known as Wisconsin log crib (Schnick et al. 1982). Gravels varying between 1/2 to 3/4 inch can be placed under and around the stacked brush frames to provided potential spawning substrate for largemouth bass and bluegill.

Other methods can be used to increase the productivity of the backwaters for fish. These methods include planting shade trees, such as willows and cottonwoods, along the bank, creating shallow water areas in the backwaters, and planting aquatic vegetation such as cattails. Riparian and marsh vegetation plantings would provide habitat for insects which are a substantial portion of the diets of juvenile fish. The vegetation would also provide resting, feeding, and breeding habitat for wildlife (Figure 3). The overall best mitigation approach would be to use a combination of all of the above methods to increase productivity and overall carrying capacity of the backwater.

Another important fishery mitigation concept would be to have a fish salvaging operation once dewatering of the Canal commences. In conjunction with the fish salvaging effort, several sections of the abandoned Canal should be sampled by biologists from Reclamation, the Department, the Service, and the District to verify the accuracy of the fishery estimates made in the report. The information collected from this sampling effort should be analyzed and a report prepared on the effort.

b. Terrestrial

Approximately 545 acres of creosote bush scrub will be destroyed by construction of a lined canal. The mitigation goal for loss of creosote bush scrub habitat is no net loss of habitat value while minimizing loss of in-kind habitat value, based on the abundance of the habitat type and the presence of the flat-tailed horned lizard, a Category 2 candidate for listing under the Endangered Species Act. Mitigation measures to protect this habitat type should include an effort to minimize loss of habitat during construction. Reestablishment of creosote bush scrub habitat within the old canal would probably be infeasible; for this reason the Service recommends compensation for 545 acres of creosote bush scrub. Creosote bush scrub habitat utilized by flat-tailed horned lizards in the East Mesa or Yuha Basin area of Imperial County should be purchased and transferred to the Bureau as wildlife management areas. Currently, the Bureau is interested in obtaining various parcels of land in these areas to increase protection for the flat-tailed horned lizard (Olech pers. comm.).

The mitigation goal for loss of sand dune habitat within the project area is the same as for creosote bush scrub. Approximately 785 acres will be destroyed during project construction. Minimizing the area of disturbance

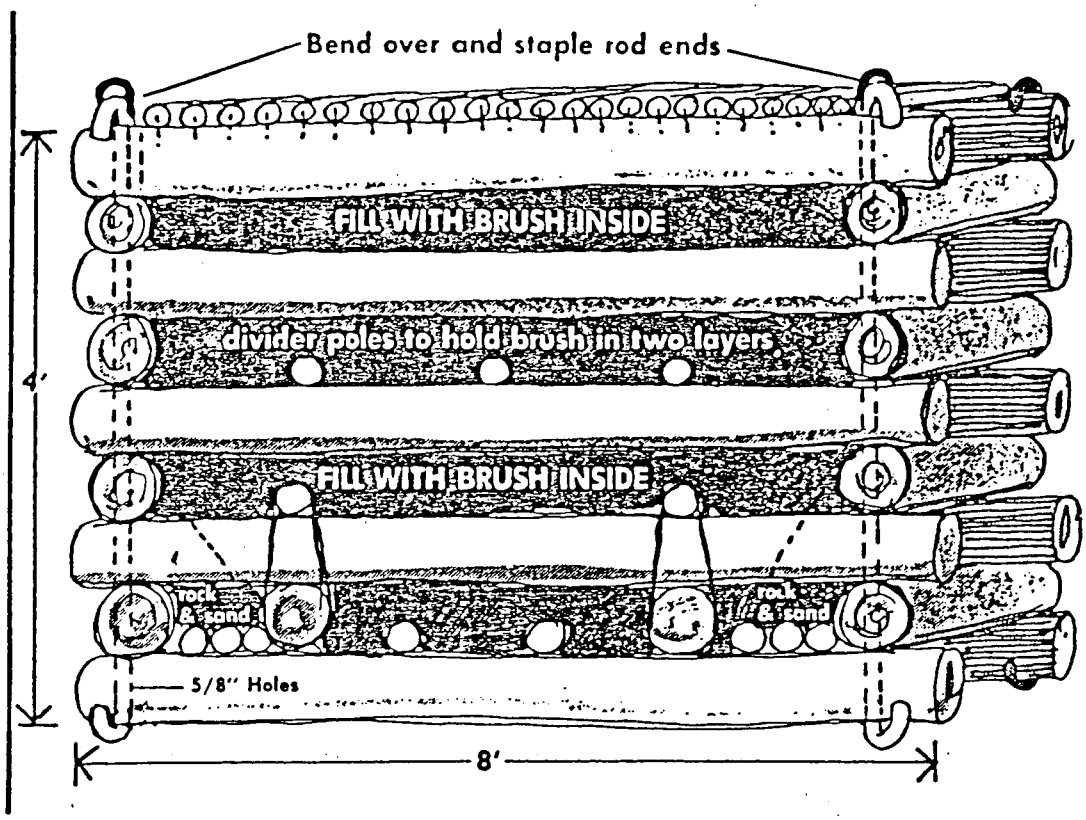


Figure 4. Diagram of a Wisconsin log crib for use as a fish attractor (drawing by the Wisconsin Department of Natural Resources, La Crosse (Schnick et al. 1982)).

is an important mitigation concept within the Algodones Dunes. Careful removal prior to construction, storage, and replanting of some sensitive plant species and seeding with material collected from the construction zone should reduce negative impacts to this area. The old, unlined canal in the stretch south of the new canal and north of Interstate 8 will probably receive too much off-road vehicle use to make any revegetation in this area feasible.

Since the Bureau manages the entire Algodones Dunes area, the Service contacted them concerning potential dune habitat which could be purchased or enhanced as project mitigation. The Bureau knew of no dune habitat which could be acquired or enhanced (Olech pers. comm.). As in-kind mitigation was not possible to achieve, the Service investigated other mitigation options.

A wildlife habitat area of particular significance in the project area is the seep wetland located between Drops 3 and 4. The Service is extremely interested in protecting this habitat. To ensure protection of this habitat over the life of the project, it is recommended that water rights equal to the amount of estimated seepage needed to maintain this area be reserved as a wildlife mitigation feature.

The habitat values of the canal edge, which covers 30 acres for the project area, also are applicable to a goal of no net loss of habitat values while minimizing loss of in-kind habitat values. Construction of the backwater ponds to mitigate for fishery losses should include at least 30 acres of cattail and reed habitats to improve access to the water for wildlife. Berm habitat of a similar size to the unlined canal, 177 acres, will probably exist along the lined canal. Reclamation should seed or plant the newly constructed berm with native vegetation to reduce the temporal loss of wildlife value.

A steep-sided, concrete-lined canal could also result in drownings of wildlife. Big game guzzlers should be installed at the 2 microphyll woodlands east of the Algodones Dunes to provide a water source for mammals. A deer escape ramp should also be placed near the eastern edge of the Algodones Dunes to lessen the probability of burro deer drownings. The most likely location for a deep escape ramp would be downstream of the large microphyll woodland wash which intersects the Canal from the north. The Service agrees that an escape ramp may not be necessary if providing ledges in the canal sides proves effective in allowing deer to escape. This method is described under the in-place lining alternative.

Microphyll woodlands of the project area, which include species such as smoketree, palo verde, desert willow, and ironwood, have high value for sensitive species and are relatively scarce or becoming scarce on a national and regional basis. Our goal is to mitigate all losses of in-kind habitat value. Seventeen of 20 acres of microphyll woodlands

within the project area will be destroyed by this alternative. Mitigation should include restriction of the construction zone to as narrow a strip as possible. Revegetation with native wash vegetation and irrigation should be considered, if necessary, on 34 suitable acres within the washes to create replacement of microphyll woodland habitat. The Service recommends a 2 to 1 replacement ration in this situation because of the temporal loss of habitat values until the newly planted vegetation attains the structural diversity of the original woodland.

The construction alternative would directly affect 125 acres of riparian habitat within the project area and secondarily affect, by the loss of seep water, another 762 acres. The extremely high wildlife values and relatively scarce nature of wetlands in the desert combine to make a mitigation goal of no net loss of in-kind habitat value appropriate for this habitat type. Accordingly, mitigation should include the reestablishment of equivalent wetland values on adjacent areas of lower value habitat. The acreage necessary to reconstitute in-kind habitat values would vary, depending upon the exact location of the canal alignment. However, the Yuma clapper rail, a federally listed endangered species, resides in the marshes directly adjacent to the Canal. The goals discussed in this section do not apply to federally listed threatened or endangered species and their habitats. Simply stated, the planning objectives for these species will be that adverse impacts will be avoided. Therefore, leaving an approximately 2.5-mile section of the Canal unlined between Drops 3 and 4, roughly equivalent and adjacent to the recapture ditch on the south side of the Canal, should avoid adverse impacts to this riparian area.

2. Wellfield Alternative

This alternative would require permanent disturbance of 4 acres of sand dune habitat for pump sites and the possibility of temporarily or permanently disturbing an additional 75 acres for an access road. Since the dunes are relatively abundant on a regional basis, no net loss of habitat value with a minimum loss of in-kind habitat value is the mitigation goal. Specifically, avoiding disturbance to dense concentrations of sensitive plant species, minimizing the area of disturbance, and revegetating temporarily disturbed areas are important mitigation concepts. The quality of the water being returned to the Canal should be tested on a regular basis to ensure that the addition of this water will not harm the aquatic resources present in the Canal. Reclamation should also institute a monitoring program to follow changes in the water table caused by pumping and the effects of any changes in the water table on vegetation in the area of the draw-down cone.

3. In-place Concrete-lining from Pilot Knob to Drop 4

a. Aquatic

With implementation of the in-place lining alternative, the existing fishery population of the canal would decline from an estimated 268,335 to 238,744 fish, a net loss of 11%. Unfortunately, the major losses occur to fish species such as the flathead catfish, largemouth bass, sunfish and channel catfish which have a high recreational value to local and regional fishermen.

An appropriate form of mitigation for losses to fish species that include largemouth bass, flathead catfish, channel catfish, and sunfish (i.e. redear sunfish and warmouth) would be to create a large quiet water area with abundant cover. To determine a relative estimate of the size mitigation area needed to replace the lost fishery values of a lined canal the following methodology was used. The net number of largemouth bass, channel catfish, and sunfish that were estimated to be lost as a result of concrete lining of the canal (Table 14) was divided by the densities for each of these species found in an unlined section (Section A) of the Coachella Canal (Minckley et al. 1983). Fish densities from this reach of the Coachella Canal were used because they were obtained from habitat that was in part "pool-like" and may be similar to fish habitat created under the proposed mitigation effort. Table 18 provides an example of the methodology utilizing largemouth bass as evaluation species.

Utilizing the methodology shown in Table 18 for largemouth bass, it is estimated that 43.0, 35.1 and 45.5 acres would be needed to replace largemouth bass, sunfish and channel catfish losses, respectively, resulting from the proposed in-place lining of the All American Canal (Table 19). Acres of habitat needed for fishery mitigation purposes, as determined by fish density figures obtained from the Coachella Canal, should not be viewed as the sole basis for mitigating impacts. Because the habitat within the fishing mitigation area can be specifically designed to have high biological values for target species, the size of the water body can be the lowest acreage calculated to mitigate fishery losses (Table 19). Fish numbers per unit of area in a water body created for fishery mitigation purposes can easily surpass those found in the Coachella Canal given that a vast majority of the canal has little cover habitat which is extremely important to all life stages of largemouth bass, sunfish and channel catfish.

To mitigate the proposed fishery losses, it is recommended that a 35 acre pond be excavated south of the Canal between Drops 3 and 4 (Figure 5). This area is an abandoned agriculture field which currently is almost entirely devoid of native vegetation. The pond would be contoured so that it would have the following bottom depths: 35% between 18 and 22 feet, 50% at approximately 12 feet, and 15% between 0 and 8 feet. The pond should have a total of 12 coves with 3 coves each of 1/4, 1/2, 1-2, and 3-4 acres. The number and size of coves proposed to be created is an attempt to maximize shoreline habitat which is heavily utilized by centrarchids. It is estimated that 781,290 cubic yards of earth would have to be excavated to create this 35 acre pond.

Due to the high water table in the location of the proposed area to be excavated, the pond will probably fill with ground water during digging, thereby increasing the cost of the project. A preliminary estimate of excavation costs associated with the creation of the pond is $2.75/a cubic yard (Lee pers. comm.). Based on the estimated number of cubic yards to be excavated, the proposed pond would cost $2,148,547.50. A disposal site for the excavated material needs to be determined.

Table 18. A Methodology for Estimating Relative Size of Mitigation Area Needed Utilizing the Largemouth Bass as an Evaluation Species

	Equations Used In the Methodology			Actual Largemouth Bass (LMB) Numbers		
STEP #1	$\frac{\text{Number of largemouth bass (LMB)/square meter } (m^2) \text{ unlined section of Coachella Canal (Minckley et al. 1983)}}{\text{Number of hectares (ha) per } m^2}$	=	Number of LMB per ha	$\frac{0.013 \text{ LMB}/m^2}{0.0001}$	=	130 LMB/ha
STEP #2	$\frac{\text{Net number of LMB estimated would be lost from lining American Canal (Table 14)}}{\text{Number of LBM/ha in unlined section of Coachella Canal}}$	=	Number of ha estimated to be needed to replace LMB losses resulting from proposed canal lining	$\frac{2268 \text{ LMB}}{130 \text{ LMB/ha}}$	=	17.4 ha
STEP #3	Conversion of ha to acres		1 ha = 2.471 acres			17.4 ha X 2.471 acres= 43 acres

Table 19. Calculations and Fish Numbers Used to Estimate the Number of Acres Needed to Replace Largemouth Bass, Sunfish and Channel Catfish Losses Resulting From the Proposed In-Place Lining of All American Canal.

FISH SPECIES	Density of fish/m^2 (1)	Density of fish/ha	Net Number of fish estimated to be lost from canal lining (2)	Number of ha estimated to be needed to replace fish losses	Number of acres estimated to replace fish
Largemouth Bass	0.013	130	2,268	17.4	43.0
Sunfish (3)	0.021	210	2,979	14.2	35.1
Channel Catfish	0.120	1200	22,087	18.4	45.5

(1) Data are from Table 2 (Sample Section A) in Minckley et al. (1983).
(2) Data are from Table 14 of this report.
(3) Sunfish is a collective name for bluegill, redear sunfish, and warmouth.

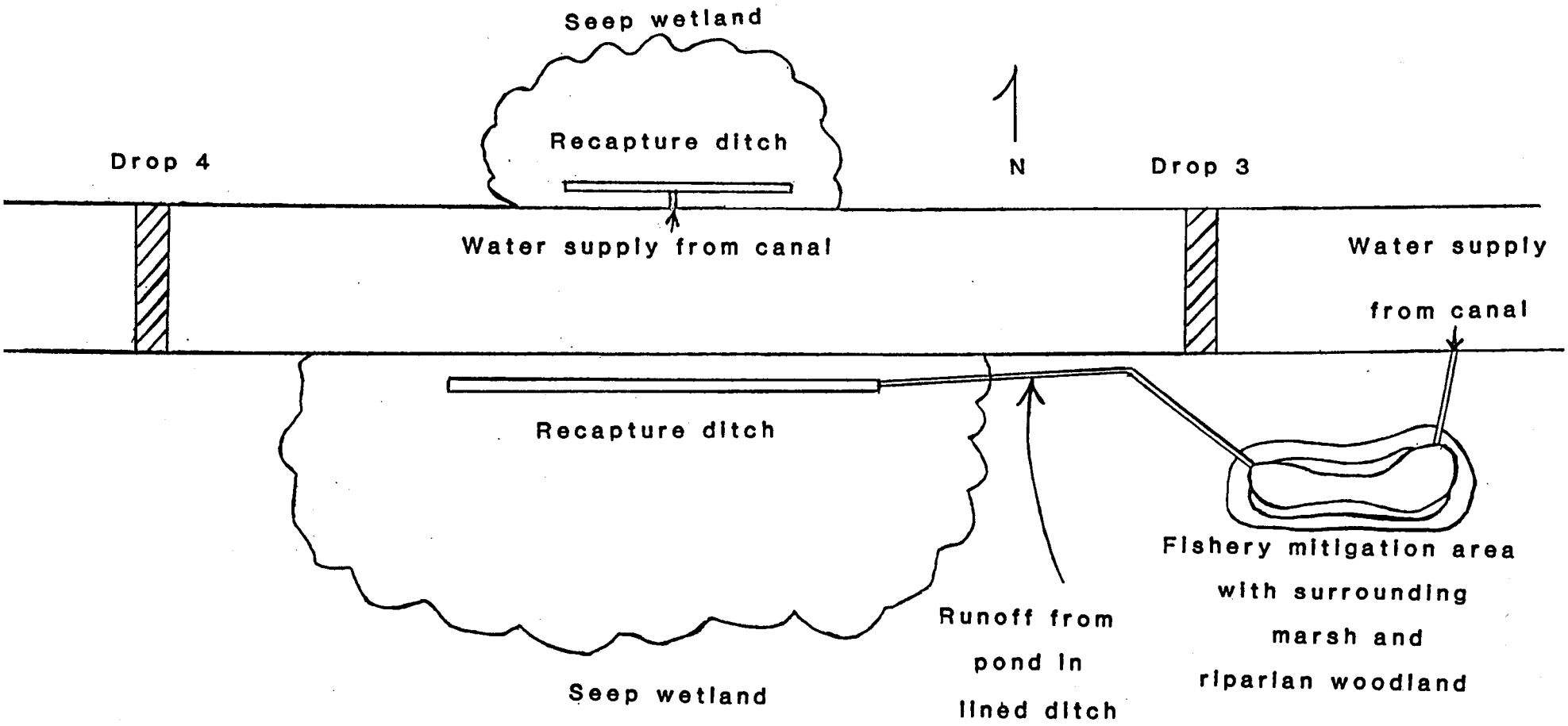


Figure 5. Conceptual fishery and wildlife mitigation plan. The major features of this plan include a 35 acre pond to mitigate for fishery losses, a 30 acre revegetation site to compensate for loss of the common reed habitat along the Canal, and structures to provide water to these areas and the existing wetlands between Drops 3 and 4.

Two measures shown to increase fish production in water bodies are fertilization and placement of artifical reefs. Swingle and Smith stated that fertilized ponds in Alabama support four or five times as great a weight of fish as unfertilized ones; and consequently, the former has much better fishing (Bennett 1971). The pond should also be fertilized with a combination of alfalfa pellets and super phosphate (0250). The recommended application rate should be 250 pounds per surface acre for the alfalfa pellets and 25 pounds per surface acre for the super phosphate. The alfalfa pellets cost $10.50 for an 80 pound bag (Nicol pers. comm.). An 80 pound bag of super phosphate (0250) cost $16.25 (Ccaja pers. comm.). Total costs associated with fertilizing a 35 acre pond would be approximately $1,333.75.

Placement of artificial reefs in water bodies has also been shown to increase fish abundance. Prince et al. (1975) summarized the findings of four investigations of artificial reefs in freshwater lakes in Michigan and a reservoir in Virginia. In one investigation, a sandy shoal of Crystal Lake, Michigan where a brush shelter had been placed, was seined. A total of 6,941 fish was captured from the area of the lake containing the brush shelter compared to 48 fish captured with the same seine in a similar area of the lake that lacked a shelter. In another study conducted along the shoreline of Douglas Lake, Michigan, catches of fish with seines averaged approximately 4 times greater in shelter areas than in nonshelter areas. In a more recent study that utilized SCUBA equipment to count fish, fish abundance was again investigated at three sites in Douglas Lake including a brush shelter that had been in the lake for 30 years, a recently installed brush shelter, and a control area. Ratios of sport fish abundance averaged 10.5:1 and 4.8:1 for the new shelter and the old shelter, respectively, as compared with the control area. The most current investigation summarized the relative abundance of fishes before and after installation of a 2,250 m^2 tire reef in Smith Mountain Lake, a reservoir in Virginia. Standardized SCUBA transect counts were made along the same shoreline area of the lake in the spring, summer and fall of 1973 and 1974. Counts of fish made in 1973 occurred before placement of the tire reef, while fish counts made in 1974 were after installation of the reef. Ratios of fish counted in 1974, compared with 1973, were 12:1 in spring, 5.6:1 in summer, and 28:1 in fall. Centrarchid basses composed about 18 percent of the fish counted during each season.

H.G. Swingle looked at various biological means of increasing productivity in ponds. He reported ponds half filled with brush produced 65 percent more largemouth bass and bluegills than did ponds without brush (Prince et al. 1975).

Another important benefit of artificial reefs is increased numbers of plankton and benthos associated with the reef structure. Increase numbers of plant and animal organisms can provide important food items for juvenile sunfish and bass.

Brush shelters which are shown in Figure 4 can be placed in the coves to to provide cover for fish. We recommend that 48 brush shelters be constructed. Costs associated with construction of one brush shelter are estimated to range between $50 to $75 (Giusti pers. comm.). Total costs for 48 brush shelters would be approximately $2,400 to $3,600.

The pond can be further enhanced by placement of gravel patches and drain pipes. Gravel patches can provide potential spawning substrate for largemouth bass and bluegill. River washed gravel ranging in size between 1/2 to 3/4 inch should be placed in 10 foot wide by 10 foot long by 1 foot deep patches within coves where water depths are 2 to 10 feet. To create 48 gravel patches with the above mentioned dimensions, 4,800 cubic feet or of 178 cubic yards of gravel would be needed. The approximate purchase and transportation cost of the gravel would be $10 to $12 per cubic yard (Lee pers. comm.) Total costs for gravel and having it delivered would be $1,780 to $2,136. Brush shelters should be placed immediately adjacent to or partially on gravel areas. Centrarchids have been found spawning near artificial reef structures in several fishery studies. Largemouth bass were observed spawning adjacent to brush shelters in Sand Pond, Maine and Bull Shoals Reservoir and adjacent to tire reefs in Smith Mountain Lake, Virginia. Largemouth bass nests in the latter study were nestled against tires of the reef (Prince, et al. 1975).

Concrete drain pipes or vitrified clay pipes can also be placed in the pond to create additional habitat diversity and provide cover which would be utilized by channel catfish. It is recommended that 150 drain pipes be placed in the pond. A concrete drain pipe with a 12 inch opening, 3 feet in length costs $6.75 per pipe. Costs to transport the pipe to the mitigation site would be an additional $2.00 per pipe. Total costs for 150 concrete drain pipes delivered to the site would be approximately $1,312.50.

Other fishery habitat improvements which should be considered are placement of logs and boulder reefs adjacent to the shoreline. Logs, depending if a source can be found, should be anchored to the shoreline in a random manner around the perimeter of the pond. Boulder reefs can be constructed by placing large rocks 2 to 3 feet in diameter in a contiguous line to form an underwater bar. The bar should begin in water depths of approximately 1 foot and extend into areas of the pond up to 12 feet in depth.

In addition to in-water structural improvements, narrow-leaved cattail and bulrush (Scirpus robustus) should be planted along the edge of the pond to stabilize the shoreline and provide cover for juvenile centrarchids. Rooted plants of the species can be transported from nearby areas and planted in the pond to establish marsh habitat.

The pond should be stocked with largemouth bass, bluegill, redear sunfish and channel catfish. Vanicek and Miller (1973) recommended stocking a combination of 1,000-1,500 bluegill fingerlings and 100-150 largemouth

bass fingerlings per surface acre in California ponds. Similar stocking ratios were recommended by H.S. Swingle who was one of the pioneers of bass and bluegill stocking in small impoundments in Alabama. Swingle recommended stocking 100 largemouth bass fingerlings and 1,000 fingerling bluegills per acre (247 and 2,471 per hectare) (Dillard and Novinger 1975).

Bluegill are known to be among the most prolific warmwater game fishes with egg counts of a single female ranging from 2,360 to 49,400 (Calhoun 1966). In order to ensure that the bluegill population has less potential for overpopulating the pond, it was agreed that the stocking ratio of bluegill to bass should be reduced from 10:1 to 5:1. It was also suggested that redear sunfish be planted with bluegill to add diversity to the fisherman's catch as long as the 5:1 stocking ratio is maintained. It was recommended for every 1,000 sunfish planted 750 of the fish be bluegill and 250 be redear sunfish (Vanicek pers. comm.). Planting a combination of redear sunfish and bluegill was also recommended as a management strategy for new reservoirs. The redear sunfish do not stunt, and they frequently hydridize with bluegill, thereby reducing the reproductive potential of the sunfish population (Calhoun 1966).

Channel catfish were recommended to be stocked at a rate 1,000 to 2,000 per surface acre (Nicol pers. comm.). It should be noted that channel catfish may have to be restocked periodically because survival of young channel catfish in clear ponds containing largemouth bass and bluegill populations is often low even when adequate spawning habitat is present. Low survival is attributed largely to predation (Calhoun 1966).

Costs of obtaining largemouth bass from a commercial source in the Imperial Valley were $5.00 per individual fish under 1 pound. Largemouth bass over a pound are sold at $5.00 per pound. Bluegill are sold at $1.00 per pound (Widmann pers. comm.). A large number of channel catfish are raised by the Department in hatcheries and could be used in any planned stocking effort for the pond.

It is recommended that a total of 30 acres surrounding the pond be planted with riparian plant species. Fifteen acres is nearly equivalent to planting a 114 foot wide band of riparian vegetation around the perimeter of the pond. Plant species that should be utilized include black willows, Fremont cottonwoods, honey mesquite, screwbean, quailbrush, and narrow-leaved willow (Salix exigua). The large trees (i.e. black willows and Fremont cottonwoods) should be planted on 20 foot centers throughout the 15 acre band around the pond. Honey mesquite, screwbean, and quailbrush should be randomly planted in the area between black willows and Fremont cottonwoods. Narrow-leaved willow should be planted in scattered clumps adjacent to the cattail-bulrush edge. Approximately 15 acres of narrow-leaved willows, bulrushes and cattails should be planted at the edge of the pond, with the remaining 15 acres planted between the coves. This total of 30 acres of revegetation would be mitigation for the loss of the 30 acres of emergent wetlands along the Canal's edge.

Riparian vegetation would provide benefits to both fish and wildlife. Riparian vegetation would provide shade to the shallow water areas of the pond. Leaf litter from riparian vegetation provides a substantial proportion of food for aquatic invertebrates, which in turn constitute a significant proportion of many fish species' diets. Terrestrial invertebrates are often found in water bodies associated with riparian vegetation and become an important component in the diet of fishes.

The proposed pond would be filled with water pumped from the Canal. An outlet would be located at the western end of the pond. Water leaving the pond through this outlet would be conveyed in a concrete-lined drainage ditch to the recapture ditch on the south side of Canal between Drops 3 and 4. Water would then be allowed to seep from the existing earth bank ditch to maintain the habitat value of the large wetland area between Drops 3 and 4 (Figure 5).

Reclamation has estimated that approximately 3,455 acre-feet of water per year would be needed to replace water that would be lost from the 35 acre pond. The 52 acres of marsh and 835 acres of riparian habitat between Drops 3 and 4 were calculated to have an annual consumptive use of 441 and 5,402 acre-feet, respectively (Reclamation 1987b). Based on the above information, a total of 9,298 acre-feet of water need to be pumped annually from the Canal to maintain the pond and existing wetlands.

The monitoring of water quality to protect aquatic resources is an additional issue that will have to be addressed during the concrete lining operation of the Canal. Lining operations have the potential to significantly raise pH levels and un-ionized ammonia concentrations of canal waters. High concentration levels of un-ionized ammonia particularly during the hot summer months could cause mortalities to a significant number of fish. Reclamation has proposed monitoring water quality conditions during the future in-place concrete lining of the 1.25 mile section of the Coachella Canal to learn alternative strategies that can be employed during the lining operation to maintain acceptable water quality conditions for fish species that live in the canal.

Courtois (1987) determined several ways to substantially reduce or minimize impacts to water quality during canal lining operations. These included: (a) keep all fresh concrete covered until set, (b) reduce the amount of time required for the concrete to set, (c) increase the volume of water flowing past the application site, (d) buffer the water flowing past the application site to maintain pH within normal limits for the canal at the time of year when work is carried out, (e) shorten the number of hours concrete is applied each day, and (f) undertake the work during the winter months when canal temperatures are reduced.

b. Terrestrial

As stated above, the potential impacts of the cut and fill operations needed to smooth the sides of the Canal cannot be determined at this time. If the amount of dredged material roughly equals the amount of needed fill, borrow and disposal sites should be unnecessary. If temporary

storage areas are needed, careful site selection should be able to avoid significant impacts. Conversely, if fill material or disposal sites are needed, impacts could become significant. Use of the existing berms and the abandoned agricultural field near Drop 3 for borrow and disposal sites could significantly decrease impacts to undisturbed wildlife habitat. Equipment staging areas will probably also be required; use of previously disturbed areas and minimizing the size of these sites will be important mitigation concepts.

For those direct impacts occurring in upland habitats, the Service recommends careful site selection, minimizing the amount of habitat lost, and restoration of the disturbed habitat through recontouring the soils and seeding and/or planting appropriate native plant species. Furthermore, we recommend that biologists from the Department, Service, and Reclamation accompany Reclamation's engineers and/or contractors on-site to denote the actual areas to be used as borrow, disposal, and equipment staging sites.

The direct loss of 30 acres of common reed along the edges of the Canal will need to be mitigated through creation of 30 acres of cattail and/or reed habitat within the project area and provision of a water supply to maintain this habitat. The location for this marsh should be adjacent to the fishery mitigation site as discussed above. The small seep wetlands east of Drop 3 will also eventually dry up; these areas should be examined by Department, Service, and Reclamation biologists, quantified, and their loss mitigated through creation of at least equal acreage adjacent to the wetland between Drops 3 and 4 or at Drop 3. Costs for recreating riparian habitat in desert areas can vary greatly. A 75 acre revegetation site along the Colorado River cost approximately $95,000; a 12 acre site along the Rio Grande in Texas was $75,000 (Anderson pers. comm.). Careful integration of the construction of the proposed pond for fishery mitigation with the development of a riparian area will need to be accomplished for either to be successful. Planning these two mitigation features in concert could also reduce the cost of the mitigation.

Reclamation should procure the rights to 5,843 acre-feet of water per year, in addition to the water needed for the fishery mitigation. This water should be allowed to flow into the existing recapture ditches north and south of the Canal at rates which will maintain the existing wetlands at the present size. Reclamation should fund a hydrological study to determine the appropriate release rates to achieve this goal. A monitoring program, including aerial photographs, of the wetlands should be initiated and reviewed annually for at least 5 years to determine the success of this mitigation effort.

Implementation of this alternative would result in a steep-sided, concrete-lined canal that could result in wildlife drownings. A species of particular concern is the burro deer. In an effort to avoid accidental drownings of deer in the concrete-lined canal consideration is being given to the creation of small ledges along the sides of the canal for its entire length that would serve as steps that deer could potentially use as an escape device.

The location of these ledges in relation to the water level in the canal is critical as deer must be able to effectively use their rear legs and hoofs to project themselves to the earthern portion of the canal bank if they are going to have a high degree of success in escaping the confines of the canal.

Reclamation will attempt to create the small ledges along the side of the canal when they conduct the prototype in-place concrete lining of 1.25 miles of the Coachella Canal between siphons 14 and 15. The ledges would be created by the lining machine as the cement is being placed. The Service believes the ledges should run parallel to the length of the canal from a point at least three feet below the lowest expected water level to the top of the canal at one foot intervals. The effectiveness of creating ledges with the lining machine and their potential use by deer will be further evaluated after completion of the prototype lining.

The value of the concrete ledges as a deer escape device would have to be demonstrated before they could be considered effective. Guenther et al. (1979) described steps cut into the concrete wall of the Mohawk Canal in Arizona as being ineffective because deer could not locate them or recognize them as escape structures. If concrete ledges are incorporated into the Canal and it is found that deer drown in the Canal, Reclamation would be responsible for installing more convential escape devices such as escape ramps with director cables. Escape ramp designs are described in Rautenstrauch et al. (1986).

4. No Action

If no project is implemented, there will not be a need to consider fish and wildlife mitigation measures to offset project-induced losses. If the District decides to proceed with lining without Reclamation's participation, the Service will attempt to protect public wildlife values through the Clean Water Act, Section 404, permitting process. The Los Angeles District Corps of Engineers has indicated that the All American Canal is considered a navigable water and that a 404 permit will be required to place fill in the Canal. Under this permitting process, the Service will pursue the same mitigative measures it is currently discussing with Reclamation.

F. RECOMMENDATIONS

Placement of a wellfield between Pilot Knob and Drop 1 would result in much less disturbance to the environment of the project area than the relocation or in-place alternatives. Hence, of the 3 action alternatives, the wellfield is preferred by the Service.

The direct impacts to terrestrial habitats associated with the in-place lining alternative should be greatly mitigated through careful site selection of work areas. Indirect impacts, such as a decrease in fishery habitat and drying of the wetland seeps, could be mitigated through creation of a ponded area adjacent to the Canal and providing water to the existing seeps. Of the alternatives which involve lining the Canal, the in-place lining alternative should present fewer impacts to public fish and wildlife values and provide better opportunities to mitigate those impacts.

Under the relocation alternative, the Service does not believe that enough mitigation sites are available to fully mitigate project losses to creosote bush scrub and sand dune habitats within the immediate project area. However, should the proposed project be constructed, we believe that a mitigation plan incorporating the concepts presented below would offset impacts to a great extent.

1. Relocation Alternative

a. Ten backwater areas shall be created to partially offset fishery losses resulting from the project. Each backwater shall be 3.5 acres in size (approximately 175 feet wide x 780 feet long). The proposed locations of these backwater areas are shown in Figure 2.

b. Pipes or other water conveyance facilities shall be constructed between the lined canal and each of the 10 backwaters for the purpose of increasing water circulation within the ponded areas.

c. Reclamation shall reserve the rights to 3,455 acre-feet of water per year to account for seepage from the 10 backwater areas.

d. The 10 backwater areas and surrounding uplands should be designed to promote habitat diversity and aid in production of fish. Methods to be used include: 1) mechanically grading the bottoms of the backwaters to create a combination of shallow and deepwater habitats; 2) placement of vitrified clay pipes and stacked brush frames; 3) planting shallow water areas within the backwaters with cattails; and 4) planting uplands surrounding the backwaters with black willows, Fremont cottonwoods, honey mesquite, screwbean, quailbrush, and narrow-leaved willows.

e. A fish salvaging effort shall be made by personnel from Reclamation, the Service, the Department, and the District, when the unlined section of the Canal is dewatered during project construction.

f. The Canal shall remain in an unlined condition for approximately 2.5 miles in its present channel, through the seep wetlands between Drops 3 and 4. This unlined stretch shall parallel the length of the recapture ditch located on the south side of the Canal. Allowing seepage to continue in this area would avoid serious impacts to approximately 887 acres of wetlands, including habitat of the federally listed endangered species, the Yuma clapper rail.

g. For the loss of 785 acres of Algodones Dunes habitat, out-of-kind mitigation shall be pursued. Reclamation shall reserve the rights to 5,843 acre-feet of water a year which shall be used in preserving the wetland/riparian area between Drops 3 and 4.

h. Within the Algodones Dunes, fruits of sensitive plant species shall be collected at the appropriate times of the year prior to construction and redistributed after construction within historic, suitable habitat, again at the proper times of the year. Perennial species within the

construction zone, such as the desert sunflower, should be transplanted to suitable habitat designated by the Service and the Department near the construction zone in such a manner that any existing plants in that area will not be affected.

i. For the loss of 545 acres of creosote bush scrub, Reclamation shall purchase habitat for flat-tailed horned lizards in the East Mesa or Yuha Basin areas of Imperial County and transfer these lands to the Bureau to be managed as wildlife areas. The Mitigation Policy specifies that fee transfers are not strictly mitigation measures, therefore, specific acreages and areas to be acquired would be determined through direct consultation among Reclamation, the Bureau, the Department and the Service.

j. A deer escape ramp shall be placed on the northern side of the Canal east of the Algodones Dunes and north of the junction of Interstate 8 and the Canal. Service and Department personnel familiar with the burro deer herd in Imperial County should be consulted for the specific location and design of the ramp.

k. Windmill-driven water sources for burro deer should be placed in the same general vicinity as the escape ramp. Service and Department personnel familiar with the burro deer herd in Imperial County should be consulted for the specific location and design of the guzzlers.

l. All construction activities, including access roads, machinery storage areas, and stockpiling areas for excavated earth and imported gravel, shall be strictly confined to the 600-foot wide right-of-way. Whenever possible, decreasing the width of the right-of-way should be done as this would result in decreased damage to the habitats.

m. Only those areas within the actual alignment of the new canal shall be cleared. Vegetation within all other areas of the 600-foot wide right-of-way needed for construction purposes shall be trimmed or crushed and left in place, allowing for resprouting from the remaining root system.

n. After the completion of the lined canal, the berms shall be seeded with appropriate native species, including creosote bush and long-leaved Mormon tea.

o. The areas within 100-foot radii surrounding the 10 backwaters shall be planted with black willow, Fremont cottonwoods, and mule fat (see Figure 3).

p. The entire right-of-way route within the creosote bush scrub community shall be seeded with native plant species immediately following project construction to ensure the reestablishment of the natural plant community.

q. All fish and wildlife mitigation measures specified above shall be implemented by Reclamation concurrently with project construction.

r. All operation and maintenance activities and fees associated with the above fish and wildlife mitigation measures (a through q) over the life of the project impacts shall be the responsibility of Reclamation.

2. Wellfield Alternative

a. Site selection for the 25 one-sixth-acre pumps shall be done to avoid dense concentrations of the sensitive plant species found in the area. Biologists from the Service, the Department, and Reclamation should assist project engineers on site to evaluate alternative locations and provide input to the selection of final pump sites. Site inspection shall be done in April or May to permit identification of sensitive annual species.

b. If a 75-acre access road and powerline are to be installed, alternative construction sites need to be evaluated. Areas of dense concentrations of sensitive plants shall be avoided. Reclamation and Service biologists shall be on site to identify such areas during April or May.

c. Revegetation of any areas temporarily disturbed by construction activities shall be done with native species found in that area of the project. All stockpiled materials and equipment shall be removed upon completion of the project.

d. Reclamation shall conduct periodic water quality tests to ensure what wellfield water remains of such chemical composition that the aquatic resources of the Canal will not be adversely affected. If well water quality deteriorates to a level detrimental to the Canal's aquatic life, pumping shall be suspended until the water quality problem is corrected.

e. Reclamation shall monitor changes in the water table in relation to the pumping of groundwater. Concurrently, a monitoring program shall be implemented to document any changes in the vegetation of the area within the draw-down cone.

f. All operation and maintenance activities and fees associated with the above fish and wildlife mitigation measures (a through e) over the life of the project shall be the responsibility of Reclamation.

3. In-place Lining Alternative

a. A 35 acre backwater shall be created to compensate fully for project losses to largemouth bass and sunfish and partially offset losses to channel catfish.

b. The pond shall be constructed so it would have the following bottom depths: 35% between 18 and 22 feet, 50% at 12 feet, and 15% between 0 and 8 feet.

c. The pond shall have 12 separate coves with the following areas: 3 coves (¼ acre), 3 coves (½ acre), 3 coves (1-2 acres), and 3 coves (3-4 acres).

d. The pond shall be planted with 100-150 largemouth bass, 400 bluegill, 100 redear sunfish and 1,000-2,000 channel catfish per surface acre.

e. Forty-eight brush shelters shall be constructed and placed in locations within the pond designated by the Service and the Department.

f. Forty-eight gravel patches which are 10 feet long by 10 feet wide by 1 foot deep shall be placed in locations within the pond designated by the Service and the Department. The gravel used shall be smooth river washed rock ranging between 1/2 to 3/4 inch in size.

g. One hundred and fifty concrete drain pipes or vitrified clay pipes having 12 inch openings, 3 feet in length shall be placed in locations within the pond designated by the Service and the Department.

h. Narrow-leaved cattail and bulrush shall be planted along the edge of the pond to stabilize the shoreline and provide cover for juvenile centrarchids.

i. The pond shall be fertilized with alfalfa pellets and super phosphate (0250) prior to it being stocked with fish. The application rate for the alfalfa pellets and super phosphate would be 250 and 25 pounds per surface acre, respectively.

j. Fifteen acres (i.e. equivalent to a 114 foot wide band) shall be planted around the perimeter of the 35 acre pond. Plant species to be planted shall be black willows, Fremont cottonwoods, screwbean, honey mesquite, quailbrush, and narrow-leaved willows. The large trees (i.e. black willows and Fremont cottonwoods) shall be planted on 20 foot centers throughout the entire 15 acre site. Mesquite and quailbrush shall be randomly planted in the area between black willows and Fremont cottonwood. Narrow-leaved willow shall be planted in scattered clumps adjacent to the cattail-bulrush edge. Fifteen acres of cattails, bulrush, and narrow-leaved willows shall be planted at the pond's edge. This 30 acre revegetation area could be designated as replacement for loss of the common reed along the Canal's edge.

k. Reclamation shall reserve the rights to 3,455 acre-feet of water per year to account for seepage from the 35 acre pond area.

l. To reduce the loss of upland habitat during construction, Reclamation shall, six months prior to the start of construction, identify its requirements for all work locations, such as equipment staging areas, within the project area. In conjunction with the Service and the Department, Reclamation shall select areas of the lowest possible habitat value and designate the boundaries of these areas. All construction equipment and activities shall be required to remain within these areas.

m. If canal material disposal or borrow sites are required, Reclamation shall, six months prior to the start of construction, conduct a site

visit with biologists from the Service and the Department to determine the locations of these areas. As mentioned previously, the existing Canal berms and the abandoned agricultural fields at Drop 3 are currently low in habitat value and are thus considered good candidates for these activities. All disposal or removal activities shall be confined to these locations.

n. All areas disturbed by construction activities, including the borrow and disposal areas, shall be seeded with appropriate native annuals at the proper time of the year upon the completion of construction. The timing, method of seeding, and the species to be used shall be established by representatives of the Department, the Service, and Reclamation prior to initiation of construction.

o. For the loss of 30 acres of common reed, Reclamation shall create 30 acres of wetland habitat containing native plant species found in the project area. The location of this wetland shall be at the 35 acre backwater acre described in mitigation measure "a".

p. For the loss of small, isolated seep wetland habitat east of Drop 3, Reclamation shall conduct a field inspection with biologists from the Service and the Department. Any areas containing wetland values shall be marked on aerial photographs and quantified. Reclamation shall then create wetland habitat of equal acreage at the fishery mitigation site or at any one of the major seep wetlands. These areas should be identified six months prior to the start of construction.

q. Reclamation shall submit to the Service and the Department a plan outlining its proposals for creating mitigation areas for the loss of common reed and isolated seep wetlands. This plan should be submitted prior to the onset of construction and should include grading plans, water delivery systems, and the numbers, species, and locations of plants to be planted. A survival rate of 80 percent should be attained; Reclamation shall have a plan to replant any mitigation site which does not meet this criterion.

r. Reclamation shall conduct a study of the project area's hydrology to determine the amount of water necessary to maintain the areas designated under conditions 3.o. and 3.p. at a soil moisture level which will support the growth of cattails, bulrush, willows, and/or cottonwoods.

s. Reclamation shall procure the rights to the amount of water recommended by the study noted in condition 3.q. to maintain the mitigation areas for loss of common reed habitat and the isolated seep wetlands.

t. Reclamation shall procure the rights to 5,843 acre-feet of water per year to ensure the continued survival of the seep wetlands north and south of the Canal between Drops 3 and 4.

u. Reclamation shall conduct a hydrological study of the seep wetlands north and south of the Canal between Drops 3 and 4 to determine the best method of using the Canal water to maintain the wetlands at their present sizes and to maintain the existing habitat quality.

v. Reclamation shall monitor the wetland seeps yearly for at least 5 years to ensure that the existing seeps and newly created mitigation areas do not decrease in size or habitat quality. Aerial photographs of these areas shall be obtained yearly and examined by Reclamation, Service, and Department biologists to determine the progress of the mitigation work. Reclamation shall submit a monitoring plan to the Service which details their proposed procedures prior to the onset of construction.

w. The concrete lining machine used in the Canal should be designed to create small ledges along the sides of the canal as the cement is placed. These ledges would run parallel to the length of the canal from a point at least three feet below the lowest expected water level to the top of the canal at one foot intervals. These ledges would potentially act as as an escape device for burro deer that might accidently fall into the Canal. If concrete ledges are incorporated into the project and it is found that deer drown in the Canal, Reclamation would be responsible for installing more conventional escape devices such as escape ramps with director cables.

x. Windmilldriven water sources for burro deer and wildlife resources shall be placed in the vicinity of the two microphyll woodlands east of the Algodones Dunes.

y. All fish and wildlife mitigation measures specified above shall be implemented by Reclamation concurrently with project construction.

z. All operation and maintenance activities and fees associated with the above fish and wildlife mitigation measures (a through y) over the life of the project shall be the responsibility of Reclamation.

aa. Reclamation shall monitor the water quality parameters of temperature, pH, ammonia, turbidity, and dissolved oxygen with the proposed prototype inplace concrete lining of 1.25 miles of the Coachella Canal between siphons 14 and 15 to determine means of avoiding impact to fish and other aquatic resources. Information concerning the avoidance of water quality impacts during the placement of concrete in the prototype project shall be applied in the lining of the Canal.

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APPENDICES

Appendix 1. Vascular Plants Found in the All American Canal Project Area (from Engineering Science 1980b and Service and Reclamation Field Surveys). Key: Creosote Bush Scrub, CBS; Sand Dunes, SD; Microphyll Woodlands, W; Saltbush-alkali Scrub, SAS; Tamarisk-mesquite Woodland, TM; Wetland Seeps, WL; Canal-levee, CL.

		CBS	SD	W	SAS	TM	WL	CL
GNETAE								
EPHEDRALES								
EPHEDRACEAE								
Ephedra californica	California Mormon tea	X						
E. nevadensis	Nevada Mormon tea	X	X					
E. trifurca	Long-leaved Mormon tea	X						
ANGIOSPERMAE								
DICOTYLEDONES								
AIZOACEAE								
Sesuvium verrucosum	Sea-purslane				X			X
AMARANTHACEAE								
Tidestromia oblongifolia	Honey-sweet			X				
ASCLEPIADACEAE								
Asclepias subulata	Skeleton milkweed	X						
Sarcostemma cynanchoides ssp. *hartwegii*	Common climbing milkweed			X				
S. hirtellum	Rambling milkweed			X				
ASTERACEAE								
Ambrosia dumosa	Burrobush	X					X	
A. ilicifolia	Holly-leaved burbush			X				
Aster exilis	Slender aster				X			
A. spinosus	Mexican devilweed			X				X
Atrichoseris platyphylla	Tobacco-weed	X		X				
Baccharis emoryi	Emory baccharis			X				
B. glutinosa	Mule fat				X			X
B. sergiloides	Squaw waterweed				X			
Baileya pauciradiata	Desert-marigold	X	X					
Bebbia juncea	Sweetbush			X				
Chaenactis carphoclinia	Pebble pincushion	X		X				
C. stevioides var. *brachypappa*	Esteve pincushion	X		X				
Dicoria canescens	Bugseed		X					
Encelia farinosa	Brittlebush			X				
E. frutescens	Rayless encelia			X				
Geraea canescens	Desert sunflower	X	X	X				

		CBS	SD	W	SAS	TM	WL	CL
ASTERACEAE (cont.)								
Haplopappus acradenius ssp. *eremophilus*	Paleleaf goldenweed	X			X			X
Helianthus annuus	Sunflower			X				
H. niveus ssp. *tephrodes*	Silver-leaved sunflower		X					
Heterotheca subaxillaris	Telegraph weed	X						
Hymenoclea salsola	Cheesebush	X						
Lactuca serriola	Wild lettuce						X	
Machaeranthera tephrodes	Pinon aster	X						
Monoptilon bellioides	Desert star	X		X				
Palafoxia arida var. *arida*	Spanish needles	X						
P. arida var. *gigantes*	Giant Spanish needles		X					
Pectus papposa	Chinch weed			X				
Perityle emoryi	Rock daisy	X						
Pluchea purpurascens	Marsh fleabane							X
P. sericea	Arrowweed						X	X
Porophyllum gracile	Odora	X		X				
Psathyrotes ramosissima	Velvet rosette	X		X				
Psilostrophe cooperi	Paper flower	X						
Rafinesquia neomexicana	California chicory	X		X				X
Sonchus asper	Sow thistle							X
Stephanomeria pauciflora	Desert straw	X		X				X
Trixis californica	Trixis			X				
BIGNONIACEAE								
Chilopsis linearis	Desert willow			X				
BORAGINACEAE								
Coldenia palmeri	Palmer coldenia	X	X					
C. plicata	Plicate coldenia		X	X				X
Cryptantha angustifolia	Narrow-leaved forget-me-not	X	X	X				
C. barbigera	Bearded forget-me-not	X	X	X				
C. costata	Ashen forget-me-not			X				
C. holoptera	Rough-stemmed forget-me-not	X						
C. maritima	White-haired forget-me-not	X	X	X				
Heliotropium curassavicum var. *oculatum*	Heliotrope	X		X				
Pectocarya heterocarpa	Comb-bur	X						
BRASSICACEAE								
Brassica tournefortii	Mustard	X		X				X
Descurainia pinnata	Tansy mustard	X		X				
Dithyrea californica	Spectacle-pod	X		X				
Lepidium lasiocarpum	Pepper grass	X		X				

		CBS	SD	W	SAS	TM	WL	CL
BUXACEAE								
Simmondsia chinensis	Jojoba	X		X				
CACTACEAE								
Opuntia basilaris	Beavertail cactus	X		X				
O. echinocarpa	Silver cholla	X						
O. munzii	Munz cholla	X		X				
CAMPANULACEAE								
Nemocladus glanduliferus var. *orientalis*	Glandular thread plant			X				
CARYOPHYLLACEAE								
Achyronychia cooperi	Frost-mat	X						
CHENOPODIACEAE								
Allenrolfea occidentalis	Iodine bush				X	X		
Atriplex canescens	Wingscale	X			X			X
A. lentiformis	Quailbrush				X			
A. polycarpa	Allscale	X			X			
Bassia hyssopifolia	Five hook bassia				X			
Salsola iberica	Russian thistle			X			X	
Suaeda torreyana var. *ramosissima*	Seepweed				X			
CONVOLVULACEAE								
Cressa truxillensis	Alkali weed				X			
CUCURBITACEAE								
Cucurbita palmata	Coyote melon			X				
EUPHORBIACEAE								
Croton californicus	Desert croton	X		X				
C. wigginsii	Wiggin's croton		X	X				
Ditaxis adenophora	Lance-leaved ditaxis			X				
D. serrata	Saw-toothed ditaxis		X					
Euphorbia albomarginata	Rattlesnake weed	X						
E. eriantha	Desert poinsettia	X		X				
E. micromera	Sonoran sand-mat	X			X			
E. polycarpa	Small-seeded sand-mat	X						
Stillingia spinulosa	Tooth-leaf	X		X				
FABACEAE								
Acacia greggii	Catclaw			X				
Astragalus aridus	Locoweed		X					
A. crotalariae	Desert rattle-pod				X			X
A. insularis var. *hardwoodii*	Sand-flat locoweed		X	X				
A. lentiginosus var. *borreganus*	Borrego dapple-pod		X					

		CBS	SD	W	SAS	TM	WL	CL
FABACEAE (cont.)								
A. magdalenae var. *peirsonii*	Satiny milkvetch		X					
Calliandra eriophylla	Fairy duster	X		X				
Cassia armata	Desert senna	X		X				
Cercidium floridum	Palo verde			X				
Dalea emoryi	Emory dalea			X				
D. mollis	Silk dalea	X						
D. schottii	Indigo-bush			X				
D. spinosa	Smoke tree			X				
Lotus tomentellus	Hairy lotus	X		X				
Lupinus arizonicus	Arizona lupine			X				
Melilotus albus	White sweet clover							X
Olneya tesota	Desert-ironwood			X				
Prosopis glandulosa var. *torreyana*	Honey mesquite			X		X	X	
P. pubescens	Screwbean			X		X	X	
Sesbania exaltata	Colorado River hemp							X
FOUQUIERIACEAE								
Fouquieria splendens	Ocotillo			X				
GENTIANACEAE								
Centaurium exaltatum	Centaury						X	
Eustoma exaltatum	Catchfly gentian							X
HYDROPHYLLACEAE								
Phacelia crenulata var. *ambigua*	Notch-leaved phacelia			X				
P. distans	Wild heliotrope	X		X				
P. minutiflora	Small-flowered phacelia		X					
Nama demissum var. *deserti*	Desert purple-mat	X						
N. hispidum	Hispid nama	X	X					
KRAMERIACEAE								
Krameria grayi	White ratany	X						
LAMIACEAE								
Hyptis emoryi	Desert lavender			X				
LENNOACEAE								
Ammobroma sonorae	Sand food		X					
LOASACEAE								
Mentzelia involucrata	Sand blazing star			X				
M. longiloba	Panamint blazing star		X					
Petalonyx thurberi	Thurber sandpaper-plant	X	X					

		CBS	SD	W	SAS	TM	WL	CL
MALVACEAE								
Eremalche rotundifolia	Desert fivespot			X				
Hibiscus denudatus	Rock hibiscus	X		X				
Malva parviflora	Cheeseweed						X	
Sida leprosa var. *hederacea*	Alkali mallow				X			
Sphaeralcea ambigua	Desert mallow	X		X				X
S. coulteri	Coulter globe mallow				X			
S. emoryi	Emory globe mallow	X	X					
S. orcuttii	Orcutt globe mallow				X			X
NYCTAGINACEAE								
Abronia villosa	Hairy sand-verbena	X	X					
Allionia incarnata	Windmills	X	X					
Boerhaavia sp.	Boerhaavia	X	X					
Mirabilis bigelovii var. *retrorsa*	Four o'clock	X	X					
ONAGRACEAE								
Camissonia boothii	Booth primrose	X		X				
C. brevipes	Yellow cups	X						
C. cardiophylla	Heart-leaved primrose		X	X				
C. claviformis ssp. *aurantiaca*	Brown-eyed primrose	X						X
C. claviformis ssp. *yumae*	Yuma brown-eyed primrose	X						
C. refracta	Narrow-leaved primrose			X				
Oenothera deltoides	Dune primrose	X	X					
O. primiveris	Large yellow desert primrose	X						
PAPAVERACEAE								
Arctomecon munita ssp. *argentea*	Bear poppy	X						
Eschscholzia minutiflora	Little gold-poppy	X		X				
E. parishii	Parish gold-poppy	X						
PLANTAGINACEAE								
Plantago insularis var. *fastigiata*	Woolly plantain	X	X	X				
POLEMONIACEAE								
Gilia latiflora	Broad-leaved gilia			X				
POLYGONACEAE								
Chorizanthe rigida	Rigid spineflower	X						
Eriogonum deflexum	Skeleton weed	X						

		CBS	SD	W	SAS	TM	WL	CL
E. deserticola	Desert buckwheat	X	X					
E. inflatum	Desert trumpet	X						
E. insigne	Buckwheat	X						
E. thomasii	Thomas buckwheat	X		X				
PORTULACACEAE								
Calandrinia ambigua	Desert pot-herb		X					
RESEDACEAE								
Oligomeris linifolia	Cambess	X		X			X	X
RHAMNACEAE								
Condalia globosa var. *pubescens*	Abrojo	X						
SALICACEAE								
Populus fremontii	Fremont cottonwood						X	X
Salix exigua	Narrow-leaved willow				X			
S. gooddingii	Black willow				X		X	X
S. lasiolepis	Arroyo willow						X	X
SOLANACEAE								
Datura discolor	Jimsonweed	X		X				
D. meteloides	Jimsonweed			X				
Lycium andersonii	Box-thorn			X				
L. brevipes	Frutilla	X		X				
L. cooperi	Peach-thorn	X						
L. fremontii	Fremont box-thorn			X	X			
Nicotiana trigonophylla	Desert tobacco			X				
Physalis crassifolia	Thick-leaved ground cherry		X					
Solanum elaeagnifolium	Silverleaf-nettle							X
TAMARICACEAE								
Tamarix aphylla	Tree tamarisk						X	X
T. chinensis	Salt cedar				X	X		X
T. ramosissima	Salt cedar				X		X	X
VISCACEAE								
Phoradendron californicum	Desert mistletoe			X				
ZYGOPHYLLACEAE								
Larrea tridentata	Creosote bush	X		X				
MONOCOTYLEDONES								
AGAVACEAE								
Agave deserti	Desert agave	X		X				
ARECACEAE								
Washingtonia filifera	Fan palm						X	X

		CBS	SD	W	SAS	TM	WL	CL
CYPERACEAE								
Cyperus erythrorhizos	Umbrella sedge						X	X
Eleocharis geniculata	Spike rush						X	X
Scirpus robustus	Tule						X	
JUNCACEAE								
Juncus acutus	Rush				X			
J. cooperi	Rush				X			
LILIACEAE								
Hesperocallis undulata	Desert lily	X						
NAJADACEAE								
Najas guadalupensis	Water-nymph							X
POACEAE								
Aristida adscensionis	Sixweek threeawn	X						
A. californica	Mojave threeawn	X	X					
Arundo donax	Giant reed						X	X
Bouteloua barbata	Grama grass			X				
Bromus rubens	Foxtail chess		X					
Cortaderia atacamensis	Pampas grass						X	
Cynodon dactylon	Bermuda grass							X
Distichlis spictata	Saltgrass				X			X
Echinochloa colonum	Jungle-rice							X
Eragrostis caroliniana	Carolina lovegrass							X
E. neomexicana	New Mexico lovegrass							X
Hilaria rigida	Woolly galleta	X		X				
Leptochloa uninervia	Mexican spangle-top							X
Panicum urvilleanum	Desert panic grass		X					
Phalaris minor	Canary grass							X
P. paradoxa	Candy grass							X
Phragmites australis	Common reed							X
Polypogon interruptus	Ditch beard-grass							X
Schismus barbatus	Schismus							X
Sporobolus airoides	Alkali sacation							X
TYPHACEAE								
Typha angustifolia	Narrow-leaved cattail						X	

Appendix 2. Amphibians and Reptiles of the All American Canal Project Area (from Engineering Science 1980b and Service 1984). Key: Creosote Bush Scrub, CBS; Sand Dunes, SD; Microphyll Woodlands, W; Saltbush-alkali Scrub, SAS; Tamarisk-mesquite Woodland, TM; Wetland Seeps, WL; Canal-levee, CL.

		CBS	SD	W	SAS	TM	WL	CL
AMPHIBIANS								
FAMILY PELOBATIDAE								
Scaphiopus couchi	Couch's spadefoot toad	X	X					
FAMILY BUFONIDAE								
Bufo alvarius	Colorado River toad	X		X				X
B. cognatus	Great Plains toad	X						X
B. punctatus	Red-spotted toad	X		X			X	
B. woodhousi	Woodhouse's toad	X			X			X
FAMILY RANIDAE								
Rana catesbeiana	Bullfrog	X					X	X
R. pipiens	Northern leopard frog	X			X		X	X
REPTILES								
FAMILY KINOSTERNIDAE								
Kinosternon sonoriense	Sonoran mud turtle							X
FAMILY TESTUDINIDAE								
Gopherus agassizii	Desert tortoise	X		X				
FAMILY TRIONYCHIDAE								
Trionyx spiniferus	Spiny softshell turtle							X
FAMILY GEKKONIDAE								
Coleonyx variegatus	Banded gecko	X	X	X	X			
FAMILY IGUANIDAE								
Callisaurus draconoides	Zebra-tailed lizard	X	X	X	X	X		X
Crotaphytus collaris	Collared lizard	X		X				
Dipsosaurus dorsalis	Desert iguana	X	X	X	X	X		
Gambelia wislizenii	Leopard lizard	X	X		X			
Phrynosoma mcallii	Flat-tailed horned lizard	X	X	X				
P. platyrhinos	Desert horned lizard	X	X	X	X			
Sauromalus obesus	Chuckwalla	X						
Sceloporus magister	Desert spiny lizard	X	X	X				
Uma notata	Colorado Desert fringe-toed lizard	X	X	X	X			

		CBS	SD	W	SAS	TM	WL	CL
FAMILY IGUANIDAE (cont.)								
Urosaurus graciosus	Long-tailed brush lizard	X	X	X	X	X		
U. ornatus	Tree lizard	X				X	X	
Uta stansburiana	Side-blotched lizard	X	X	X		X		
FAMILY TEIIDAE								
Cnemidophorus tigris	Western whiptail	X	X	X		X		
FAMILY LEPTOTYPHLOPIDAE								
Leptotyphlops humilis	Western blind snake	X						
FAMILY BOIDAE								
Lichanura trivirgata	Rosy boa		X			X		
FAMILY COLUBRIDAE								
Arizona elegans	Glossy snake	X	X		X			X
Chilomeniscus cinctus	Banded sand snake	X	X					
Chionactus occipitalis	Western shovel-nosed snake	X	X		X			
Hypsiglena torquata	Night snake	X	X					
Lampropeltis getulus	Common kingsnake				X			
Masticophis flagellum	Coachwhip	X	X	X	X	X		
Phyllorhynchus decurtatus	Spotted leaf-nosed snake	X						
Pituophis melanoleucus	Gopher snake	X	X					
Rhinocheilus lecontei	Long-nosed snake	X			X			
Salvadora hexalepis	Western patch-nosed snake	X	X		X			
Sonora semiannulata	Western ground snake	X				X		
Thamnophis marcianus	Checkered garter snake	X						X
Trimorphodon lambda	Lyre snake			X				
FAMILY VIPERIDAE								
Crotalus atrox	Western diamondback rattlesnake	X		X		X		
C. cerastes	Sidewinder	X	X	X		X		

Appendix 3. Birds of the All American Canal Project Area and Their Habitats (from Engineering Science 1980b and Service 1984). Key: Creosote Bush Scrub, CBS; Sand Dunes, SD; Microphyll Woodlands, W; Saltbush -alkali Scrub, SAS; Tamarisk-mesquite Woodland, TM; Wetland Seeps, WL; Canal-levee, CL.

		CBS	SD	W	SAS	TM	WL	CL
FAMILY GAVIIDAE								
Gavia arctica	Arctic loon						X	
G. immer	Common loon						X	
FAMILY PODICIPEDIDAE								
Podilymbus podiceps	Pied-billed grebe						X	
Podiceps auritus	Horned grebe						X	
P. nigricollis	Eared grebe						X	
Aechmophorus occidentalis	Western grebe						X	
FAMILY PHALACROCORACIDAE								
Phalacrocorax auritus	Double-crested cormorant						X	
FAMILY FREGATIDAE								
Fregata magnificens	Magnificent frigate-bird						X	
FAMILY ARDEIDAE								
Botaurus lentiginosus	American bittern					X	X	
Ixyobrychus exilis	Least bittern						X	
Ardea herodias	Great blue heron						X	
Casmerodius albus	Great egret					X	X	X
Egretta thula	Snowy egret						X	
Bubulcus ibis	Cattle egret					X	X	X
Butorides striatus	Green-backed heron					X	X	X
Nycticorax nycticorax	Black-crowned night-heron						X	
FAMILY THRESKIORNITHIDAE								
Plegadis chihi	White-faced ibis						X	
Ajaia ajaja	Roseate spoonbill						X	
FAMILY CICONIIDAE								
Mycteria americana	Wood stork						X	
FAMILY ANATIDAE								
Dendrocygna bicolor	Fulvous whistling-duck						X	
D. autumnalis	Black-bellied whistling duck						X	
Anser albifrons	Greater white-fronted goose						X	
Chen caerulescens	Snow goose						X	

		CBS	SD	W	SAS	TM	WL	CL
FAMILY ANATIDAE (cont.)								
Branta canadensis	Canada goose						X	
Aix sponsa	Wood duck						X	
Anas crecca	Green-winged teal						X	X
A. platyrhynchos	Mallard						X	X
A. acuta	Northern pintail						X	
A. discors	Blue-winged teal						X	X
A. cyanoptera	Cinnamon teal						X	X
A. clypeata	Northern shoveler						X	
A. strepera	Gadwall						X	
A. americana	American wigeon						X	
Aythya valisineria	Canvasback						X	
A. americana	Redhead						X	
A. collaris	Ring-necked duck						X	
A. marila	Greater scaup						X	
A. affinis	Lesser scaup						X	
Bucephala clangula	Common goldeneye							X
B. albeola	Bufflehead						X	X
Lophodytes cucullatus	Hooded merganser						X	
Mergus merganser	Common merganser							X
M. serrator	Red-breasted merganser						X	
Oxyura jamaicensis	Ruddy duck						X	X
FAMILY CATHARTIDAE								
Cathartes aura	Turkey vulture						X	
FAMILY ACCIPITRIDAE								
Pandion haliaetus	Osprey						X	X
Haliaeetus leucocephalus	Bald eagle						X	
Circus cyaneus	Northern harrier	X	X				X	X
Accipiter striatus	Sharp-shinned hawk					X	X	
A. cooperii	Cooper's hawk	X				X	X	
Parabuteo unicinctus	Harris' hawk					X	X	
Buteo jamaicensis	Red-tailed hawk	X	X	X		X	X	
Aquila chrysaetos	Golden eagle	X						
FAMILY FALCONIDAE								
Falco sparverius	American kestrel	X	X	X		X	X	X
F. columbarius	Merlin					X		
F. peregrinus	Peregrine falcon						X	
F. mexicanus	Prairie falcon	X	X	X				
FAMILY PHASIANIDAE								
Phasianus colchicus	Ring-necked pheasant					X		
Callipepla gambelii	Gambel's quail	X		X	X	X	X	X
FAMILY RALLIDAE								
Coturnicops noveboracensis	Yellow rail						X	
Laterallus jamaicensis	Black rail						X	X

		CBS	SD	W	SAS	TM	WL	CL
FAMILY RALLIDAE (cont.)								
Rallus longirostris	Clapper rail						X	X
R. limicola	Virginia rail						X	
Porzana carolina	Sora						X	X
Gallinula chloropus	Common moorhen						X	X
Fulica americana	American coot						X	
FAMILY CHARADRIIDAE								
Charadrius vociferus	Killdeer		X				X	X
C. montanus	Mountain plover	X						
FAMILY RECURVIROSTRIDAE								
Himantopus mexicanus	Black-necked stilt						X	X
Recurvirostra americana	American avocet						X	
FAMILY SCOLOPACIDAE								
Tringa melanoleuca	Greater yellowlegs						X	
T. flavipes	Lesser yellowlegs						X	
T. solitaria	Solitary sandpiper						X	
Catoptrophous semipalmatus	Willet						X	X
Heteroscelus incanus	Wandering tattler				X			
Actitis macularia	Spotted sandpiper						X	X
Numenius phaeopus	Whimbrel						X	
Calidris mauri	Western sandpiper						X	
C. minutilla	Least sandpiper						X	
C. melanotos	Pectoral sandpiper						X	
C. himantopus	Stilt sandpiper						X	
Limnodromus scolopaceus	Long-billed dowitcher						X	
Gallinago gallinago	Common snipe					X	X	X
Phalaropus tricolor	Wilson's phalarope						X	
P. lobatus	Red-necked phalarope						X	
FAMILY LARIDAE								
Larus pipixcan	Franklin's gull						X	
L. philadelphia	Bonaparte's gull						X	
L. canus	Mew gull						X	
L. delawarensis	Ring-billed gull						X	
L. californicus	California gull						X	
L. argentatus	Herring gull						X	
L. thayeri	Thayer's gull						X	
Sterna nilotica	Gull-billed tern						X	
S. caspia	Caspian tern						X	X
S. forsteri	Forster's tern						X	X
Chlidonias niger	Black tern						X	X
FAMILY COLUMBIDAE								
Zenaida asiatica	White-winged dove			X		X	X	
Z. macroura	Mourning dove	X	X	X	X	X	X	X
Columbina passerina	Common ground-dove			X		X	X	X

		CBS	SD	W	SAS	TM	WL	CL
FAMILY CUCULIDAE								
Coccyzus americana	Yellow-billed cuckoo					X		
Geococcyx californianus	Greater roadrunner	X	X	X	X	X	X	X
FAMILY TYTONIDAE								
Tyto alba	Common barn-owl					X	X	
FAMILY STRIGIDAE								
Otus kennicottii	Western screech-owl			X				
Bubo virginianus	Great horned owl	X		X				
Athene cunicularia	Burrowing owl	X					X	
Asio otus	Long-eared owl			X		X		
A. flammeus	Short-eared owl						X	
Aegolius acadicus	Northern saw-whet owl				X	X		
FAMILY CAPRIMULGIDAE								
Chordeiles acutipennis	Lesser nighthawk	X	X	X	X	X	X	X
Caprimulgus nuttallii	Common poorwill			X	X	X		X
FAMILY APODIDAE								
Chaetura vauxi	Vaux's swift	X	X	X	X	X	X	X
Aeronautes saxatalis	White-throated swift			X			X	
FAMILY TROCHILIDAE								
Archilochus alexandri	Black-chinned hummingbird	X				X	X	
Calypte costae	Costa's hummingbird	X	X	X	X	X	X	
Stellula calliope	Calliope hummingbird			X			X	
Selasphorus rufus	Rufous hummingbird	X		X		X	X	
FAMILY ALCEDINIDAE								
Ceryle alcyon	Belted kingfisher						X	X
FAMILY PICIDAE								
Sphyrapicus varius	Yellow-bellied sapsucker					X	X	
Picoides scalaris	Ladder-backed woodpecker			X		X	X	
Colaptes auratus	Northern flicker			X		X	X	
FAMILY TYRANNIDAE								
Conoptus borealis	Olive-sided flycatcher			X		X	X	
C. sordidulus	Western wood-pewee			X		X	X	X
Empidonax traillii	Willow flycatcher	X		X	X	X	X	X
E. hammondii	Hammond's flycatcher	X		X	X	X	X	X
E. oberholseri	Dusky flycatcher	X		X	X	X	X	X

		CBS	SD	W	SAS	TM	WL	CL
FAMILY TYRANNIDAE (cont.)								
E. wrightii	Gray flycatcher	X		X	X	X	X	X
E. difficilis	Western flycatcher	X		X	X	X	X	X
Sayornis nigricans	Black phoebe						X	X
S. phoebe	Eastern phoebe							X
S. saya	Say's phoebe	X	X	X	X	X	X	X
Myiarchus cinerascens	Ash-throated flycatcher	X	X	X		X	X	
Tyrannus verticalis	Western kingbird	X		X		X	X	X
FAMILY ALAUDIDAE								
Eremophila alpestris	Horned lark	X	X		X			
FAMILY HIRUNDINIDAE								
Tachycineta bicolor	Tree swallow	X		X	X	X	X	X
T. thalassina	Violet-green swallow	X			X	X	X	X
Stelgidopteryx serripennis	Northern rough-winged swallow						X	X
Riparia riparia	Bank swallow						X	X
Hirundo pyrrhonota	Cliff swallow						X	X
H. rustica	Barn swallow	X	X	X	X	X	X	X
FAMILY CORVIDAE								
Aphelocoma coerulescens	Scrub jay					X		
Corvus corax	Common raven	X	X	X		X	X	X
FAMILY PARIDAE								
Parus gambeli	Mountain chickadee					X		
FAMILY REMIZIDAE								
Auriparus flaviceps	Verdin	X	X	X	X	X	X	X
FAMILY TROGLODYTIDAE								
Campylorhynchus brunneicapillus	Cactus wren	X		X		X	X	X
Salpinctes obsoletus	Rock wren			X			X	X
Troglodytes aedon	House wren			X		X	X	
Cistothorus palustris	Marsh wren						X	X
FAMILY MUSCICAPIDAE								
Regulus calendula	Ruby-crowned kinglet	X		X		X	X	X
Polioptila caerulea	Blue-gray gnat-catcher	X		X	X	X	X	
P. melanura	Black-tailed gnat-catcher	X		X	X	X	X	
Sialia mexicana	Western bluebird					X		
S. currucoides	Mountain bluebird	X				X		
Catharus ustulatus	Swainson's thrush	X	X	X	X	X	X	X
C. guttatus	Hermit thrush			X		X	X	X

		CBS	SD	W	SAS	TM	WL	CL
FAMILY MUSCICAPIDAE (cont.)								
Turdus migratorius	American robin					X	X	
Ixoreus naevius	Varied thrush						X	
FAMILY MIMIDAE								
Mimus polyglottos	Northern mockingbird			X	X	X	X	X
Oreoscoptes montanus	Sage thrasher	X		X	X	X		
Toxostoma rufum	Brown thrasher					X		
T. bendirei	Bendire's thrasher					X		
T. curvirostre	Curve-billed thrasher					X		
T. dorsale	Crissal thrasher			X	X	X	X	
T. lecontei	Le Conte's thrasher	X	X	X				
FAMILY MOTACILLIDAE								
Anthus spinoletta	Water pipit						X	X
FAMILY BOMBYCILLIDAE								
Bombycilla cedrorum	Cedar waxwing					X	X	
FAMILY PTILOGONATIDAE								
Phainopepla nitens	Phainopepla			X		X	X	X
FAMILY LANIIDAE								
Lanius ludovicianus	Loggerhead shrike	X	X	X	X	X	X	X
FAMILY STURNIDAE								
Sturnus vulgaris	European starling						X	X
FAMILY VIREONIDAE								
Vireo solitarius	Solitary vireo	X	X	X	X	X	X	
V. gilvus	Warbling vireo	X	X	X	X	X	X	
FAMILY EMBERIZIDAE								
Vermivora celata	Orange-crowned warbler	X		X	X	X	X	X
V. ruficapilla	Nashville warbler	X		X	X	X	X	X
V. luciae	Lucy's warbler					X	X	
Parula americana	Northern parula					X		
Dendroica petechia	Yellow warbler	X		X	X	X	X	X
D. pensylvanica	Chestnut-sided warbler					X		
D. coronata	Yellow-rumped warbler	X	X	X	X	X	X	X
D. nigrescens	Black-throated gray warbler	X		X		X	X	X
D. townsendi	Townsend's warbler	X		X	X	X	X	X
D. occidentalis	Hermit warbler	X		X	X	X	X	X
D. striata	Blackpoll warbler			X				

		CBS	SD	W	SAS	TM	WL	CL
FAMILY EMBERIZIDAE (cont.)								
Seiurus noveboracensis	Northern waterthrush						X	
Oporornis tolmiei	MacGillivray's warbler			X		X	X	X
Geothlypis trichas	Common yellowthroat						X	X
Wilsonia pusilla	Wilson's warbler	X	X	X	X	X	X	X
Icteria virens	Yellow-breasted chat						X	X
Piranga ludoviciana	Western tanager	X		X	X	X	X	X
P. rubra	Summer tanager					X		
Pheucticus ludovicianus	Rose-breasted grosbeak					X		
P. melanocephalus	Black-headed grosbeak	X		X		X	X	
Guiraca caerules	Blue grosbeak					X	X	X
Passerina amoena	Lazuli bunting		X	X		X	X	
Pipilo chlorurus	Green-tailed towhee			X		X	X	
P. erythrophthalmus	Rufous-sided towhee			X		X	X	
P. aberti	Abert's towhee			X	X	X	X	X
Spizella passerina	Chipping sparrow	X		X				
S. breweri	Brewer's sparrow	X	X	X	X			
Pooecetes gramineus	Vesper sparrow	X						
Chonestes grammacus	Lark sparrow	X						
Amphispiza bilineata	Black-throated sparrow	X		X			X	
A. belli	Sage sparrow	X	X	X	X		X	
Calamospiza melanocorys	Lark bunting	X	X	X				
Passerculus sandwichensis	Savannah sparrow							X
Passerella iliaca	Fox sparrow					X		
Melospiza melodia	Song sparrow						X	X
M. lincolnii	Lincoln's sparrow						X	X
M. georgiana	Swamp sparrow						X	
Zonotrichia atricapilla	Golden-crowned sparrow			X		X		
Z. leucophrys	White-crowned sparrow	X	X	X	X	X	X	X
Junco hyemalis	Dark-eyed junco	X		X		X	X	
Agelaius phoeniceus	Red-winged blackbird					X	X	X
Sturnella neglecta	Western meadowlark							X
Xanthocephalus xanthocephalus	Yellow-headed blackbird						X	X
Euphagus cyanocephalus	Brewer's blackbird						X	
Quiscalus mexicanus	Great-tailed grackle					X	X	X
Molothrus ater	Brown-headed cowbird	X		X		X	X	
Icterus galbula	Northern oriole			X		X	X	
FAMILY FRINGILLIDAE								
Carpodacus mexicanus	House finch	X	X	X		X	X	X
Carduelis pinus	Pine siskin						X	

		CBS	SD	W	SAS	TM	WL	CL
FAMILY FRINGILLIDAE (cont.)								
C. psaltria	Lesser goldfinch			X				
C. lawrencei	Lawrence's goldfinch	X		X				
FAMILY PASSERIDAE								
Passer domesticus	House sparrow					X		X

Appendix 4. Mammals of the All American Canal Project Area and Their Habitats (from Engineering Science 1980c and Service 1984). Key: Creosote Bush Scrub, CBS; Sand Dunes, SD; Microphyll Woodlands, W; Saltbush-alkali Scrub, SAS; Tamarisk-mesquite Woodland, TM; Wetland Seeps, WL; Canal-levee, CL.

		CBS	SD	W	SAS	TM	WL	CL
ORDER MARSUPIALIS								
Didelphis marsupialis	Common opossum							X
ORDER INSECTIVORA								
Notiosorex crawfordi	Gray shrew	X						X
ORDER CHIROPTERA								
Antrozous pallidus	Pallid bat	X	X			X	X	
Eptesicus fuscus	Big brown bat	X	X					
Euderma maculatum	Spotted bat	X	X			X		
Eumops perotis	Western mastiff bat	X	X			X		
Macrotis californicus	California leaf-nosed bat	X	X					
Myotis californicus	California myotis	X		X	X	X		
M. occultus	Arizona myotis	X						
M. velifer	Cave myotis	X					X	
M. volans	Long-legged myotis	X						
M. yumanensis	Yuma myotis	X						
Pipistrellus hesperus	Western pipistrelle	X		X	X			X
Plecotus townsendii	Lump-nosed bat	X	X			X		
Tadarida brasiliensis	Brazilian free-tailed bat	X	X			X	X	
T. femorosacca	Pocketed free-tailed bat	X	X			X		
ORDER LAGOMORPHA								
°*Lepus californicus*	Black-tailed hare	X		X	X	X		X
@*Sylvilagus audubonii*	Audubon cottontail	X	X	X	X	X	X	X
ORDER RODENTIA								
Ammospermophilus leucurus	Antelope ground squirrel	X		X				X
**Castor canadensis*	Beaver							X
Citellus tereticaudus	Round-tailed ground squirrel	X	X	X	X	X	X	X
Dipodomys deserti	Desert kangaroo rat	X	X	X	X	X		
D. merriami	Merriam's kangaroo rat	X	X	X	X	X		X

ORDER RODENTIA (cont.)		CBS	SD	W	SAS	TM	WL	CL
Mus musculus	House mouse	X	X				X	X
Neotoma albigula	White-throated wood rat	X				X	X	X
N. lepida	Desert wood rat	X		X			X	X
*Ondatra zibethica	Muskrat						X	X
Onychomys torridus	Southern grasshopper mouse	X						
Perognathus baileyi	Bailey pocket mouse	X						
P. formosus	Long-tailed pocket mouse	X		X			X	
P. longimembris	Little pocket mouse	X		X		X		
P. pencillatus	Desert pocket mouse	X	X	X	X	X	X	
P. spinatus	Spiny pocket mouse	X		X			X	X
Peromyscus boylii	Brush mouse						X	
P. crinitus	Canyon mouse	X	X					
P. eremicus	Cactus mouse	X	X	X	X		X	X
P. maniculatus	Deer mouse	X	X			X	X	
Reithrodontomys megalotis	Western harvest mouse	X					X	X
Sigmodon hispidus	Hispid cotton rat	X		X			X	X
Thomomys bottae	Botta pocket gopher	X			X		X	X
ORDER CARNIVORA								
**Bassariscus astutus*	Ringtail	X					X	X
Canis latrans	Coyote	X	X	X		X	X	X
Felis concolor browni	Yuma puma			X		X	X	X
#*Lynx rufus*	Bobcat	X				X	X	
Mephitis mephitis	Striped skunk	X	X			X	X	X
Mustela frenata	Long-tailed weasel	X						
**Procyon lotor*	Raccoon	X					X	X
Spilogale putorius	Spotted skunk	X						
**Taxidea taxis*	Badger	X	X		X			
**Urocyon cinereoargenteus*	Gray fox	X					X	
**Vulpes macrotis*	Kit fox	X	X	X				
ORDER ARTIODACTYLA								
+*Odocoileus hemionus eremicus*	Burro deer	X		X		X	X	

Furbearers: * w/season and no limit ** fully protected
Big Game: + w/season and limit
Nongame: # w/special provisions for taking
Resident Small Game: @ w/season and limit ° w/year-round hunting and no limit

All other species are considered nongame animals.

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