PROGRAMMATIC BIOLOGICAL ASSESSMENT

OF

BUREAU OF RECLAMATION'S WATER AND RIVER MAINTENANCE OPERATIONS, ARMY CORPS OF ENGINEERS' FLOOD CONTROL OPERATION, AND NON-FEDERAL ACTIONS ON THE MIDDLE RIO GRANDE, NEW MEXICO

March 1, 2003 – February 28, 2013

Partially incorporating the 2001 Biological Assessment
Submitted to the U. S. Fish and Wildlife Service

RIO GRANDE SILVERY MINNOW
BALD EAGLE

SOUTHWESTERN WILLOW FLYCATCHER
INTERIOR LEAST TERN

February 19, 2003

U. S. Department of the Interior
Bureau of Reclamation
Albuquerque Area Office
Albuquerque, New Mexico

U. S. Army Corps of Engineers
Albuquerque District
Albuquerque, New Mexico

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Biological Assessment Content and Scope

This biological assessment (BA) describes proposed federal actions on the Middle Rio Grande, including Bureau of Reclamation (Reclamation) water management operations and river management activities, the Corps of Engineers (Corps) flood control operation, and non-federal actions. The BA considers the effects of these proposed actions on federally protected species occurring in or near the Rio Chama watershed and the Rio Grande, including all tributaries, from the Colorado/New Mexico state line downstream to the headwaters of Elephant Butte Reservoir. This BA focuses on the Rio Grande silvery minnow (*Hybognathus amarus;* silvery minnow), the southwestern willow flycatcher (*Empidonax traillii extimus*; willow flycatcher), and the bald eagle (*Haliaeetus leucocephalus*). Reclamation and the Corps are submitting this BA to the Service pursuant to Section 7(a)(2) of the Endangered Species Act (ESA). This BA incorporates by reference and summarizes applicable and relevant portions of the BA submitted to the U. S. Fish and Wildlife Service (Service) on June 6, 2001. If the proposed actions are modified or affect listed species in ways not considered in this BA, reinitiation of consultation will be requested in accordance with 50 CFR Part 402.16.

Concurrent with this consultation, federal and non-federal stakeholders are working to develop the Middle Rio Grande ESA Collaborative Program (Collaborative Program) to protect and improve the status of endangered species, while protecting existing and future water uses and ensuring compliance with all applicable laws. The time frame of this Section 7 consultation is intended to cover a maximum period of ten years, anticipating completion of the long-term Collaborative Program and any related Section 7 consultation. Any resulting Section 7 consultation over the Collaborative Program and both short and long-term needs of the listed species will supercede this consultation.

This request for formal consultation, as stated in the cover letter, addresses Reclamation's and the Corps' determination of "may affect, likely to adversely affect" for the silvery minnow and willow flycatcher and "may adversely modify proposed critical habitat" for the silvery minnow. This consultation also addresses Reclamation's and the Corps' determinations of "may affect, not likely to adversely affect" for the bald eagle and interior least tern (*Sterna antillarum athalassos*).

1.2 Summary of Recent Consultation Activities

On June 6, 2001, Reclamation and the Corps submitted to the Service a BA for proposed federal actions related to water management operations and river management activities on the Middle Rio Grande and non-federal depletions and related actions (Reclamation, 2001). The Service issued a final biological opinion (BO) on June 29, 2001. The BO found that the proposed actions were likely to jeopardize the continued existence of listed species and contained a reasonable and prudent alternative and incidental take statement, which the federal agencies and non-federal actors implemented.

Although the consultation was to be effective through December 31, 2003, Reclamation in June 2002 predicted it would not be possible to meet the 2001 BO flow requirements for the remainder of the water year because of extreme drought. On August 2, 2002, Reclamation requested reinitiation of Section 7 consultation. Reclamation's proposal for managing the extremely limited water supply was further amended by an August 30, 2002 letter. On September 12, 2002, the Service issued a new BO addressing proposed water management through December 31, 2002. The new BO found that Reclamation's proposed action was likely to jeopardize the continued existence of the silvery minnow but that there was no reasonable and prudent alternative to the proposed action. On September 23, 2002, Chief U. S. District Judge James Parker issued an opinion declaring the September 12, 2002 BO arbitrary and capricious. Ultimately, late season rains enabled Reclamation to use its remaining supplemental water consistent with the June 2001 BO, including the incidental take statement. Therefore, the June 2001 BO remained in effect throughout the 2002 water year and remains in effect today. The later BO was never adopted.

1.3 Summary of Minnow v. Keys Litigation and 2003 Consultation Approach

In 1999, environmental groups represented by the Land and Water Fund of the Rockies ("Plaintiffs") sued Reclamation and the Corps for alleged violations of the ESA and the National Environmental Policy Act. As this litigation has progressed, Reclamation's authorities have been interpreted and defined by the federal District Court of New Mexico in two rulings. Among other things, the District Court held that Reclamation has authority to restrict diversions by the Middle Rio Grande Conservancy District (MRGCD) through the Middle Rio Grande Project and to use water from the San Juan-Chama (SJ-C) and/or Middle Rio Grande projects directly for endangered species purposes, even where shortages to project contractors would result.

Aspects of the District Court's ruling have been appealed by the United States and other parties, and oral arguments were heard by the Tenth Circuit Court of Appeals on January 14, 2003. We anticipate that the Tenth Circuit's ruling will further address the scope of Reclamation's authority and that the Tenth Circuit Court will issue its ruling in time to provide guidance for the 2003 irrigation season. However, the decision will likely be issued very near to when irrigation water deliveries would normally begin (March 1). Therefore, in order to prepare for either outcome by the Tenth Circuit Court in time to proceed for the 2003 irrigation season, the Department of Justice agreed before the District Court that the Federal agencies would consult on two "tracks" for 2003. The first would assume that the Tenth Circuit agreed with appellants that Reclamation's discretion is limited, and the second track would assume that the Tenth Circuit Court upholds the District Court's ruling regarding Reclamation's discretion over Project water and operations.

As a result, this consultation is designed to present one standard "proposed action" for Reclamation (contractual water deliveries and other Project operations) and then detail in two appendices Reclamation's available discretion to undertake measures to avoid jeopardy to or to protect and conserve listed species. Through this approach, Reclamation intends to consider alternatives within a manageable framework. In the event that the Service determines that the proposed actions are likely to jeopardize the continued existence of the listed species, Appendix A to this BA lists some actions that would be available as reasonable and prudent alternatives to the proposed action, as reasonable and prudent measures to reduce any incidental take associated with the proposed action, or to promote conservation and recovery of listed species pursuant to Section 7(a)(1) of the ESA. Appendix B details additional actions that would be available for such measures, consistent with the District Court's decision in the *Minnow v. Keys* litigation.

It should be noted that MRGCD filed cross claims in the *Minnow v. Keys* litigation to quiet title to the Middle Rio Grande Project facilities. Under the Quiet Title Act, there is a presumption of title in the United States while the matter is pending and for a specified period following a court decision on the issue.

2 AREA OF ACTION

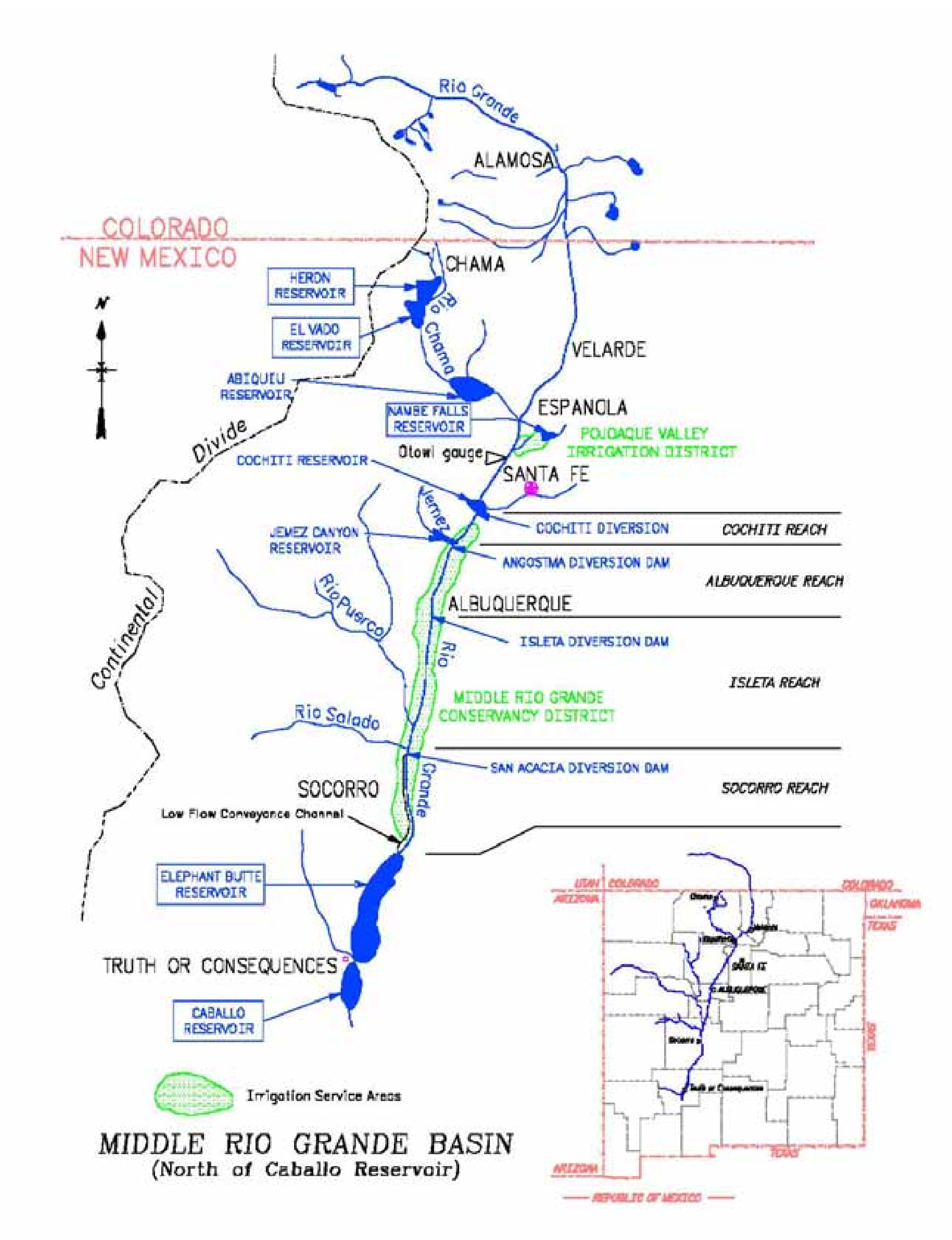
For reference in this document, the "Middle Rio Grande" is defined as the area of the Rio Chama watershed and the Rio Grande, including all tributaries, from the Colorado/New Mexico state line downstream to the headwaters of Elephant Butte Reservoir (Figure 1). For discussion of proposed federal actions related to water operations, the Middle Rio Grande below Cochiti Dam is further designated by four divisions/reaches defined by locations of mainstream irrigation diversion dams (Figure 1). The Cochiti Division/Reach extends from Cochiti Dam to Angostura Diversion Dam. The reach from Angostura Diversion Dam to Isleta Diversion Dam is called the Albuquerque Division/Reach. The Isleta Division/Reach is bounded upstream by Isleta Diversion Dam and downstream by San Acacia Diversion Dam. Finally, the reach below San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir is the Socorro Division/Reach.

For discussions about geomorphology and Reclamation's river maintenance program, the following reaches and associated designations will be used:

Reach Name	Description
Velarde	Velarde, New Mexico to Rio Chama Confluence
Española	Rio Chama Confluence to Otowi
White Rock Canyon	Otowi to Cochiti Reservoir
Cochiti	Cochiti Dam to Bernalillo - HWY 44
Middle	Bernalillo-HWY 44 to Isleta Diversion Dam
Belen	Isleta Diversion Dam to Rio Puerco Confluence
Rio Puerco	Rio Puerco Confluence to San Acacia Diversion Dam
Socorro	San Acacia Diversion Dam to River Mile 78
San Marcial	River Mile 78 to Headwaters of Elephant Butte Reservoir
Hot Springs	Elephant Butte Dam to headwaters of Caballo Reservoir

River maintenance analyses include all of the above reaches with the exclusion of the reach from Otowi to Cochiti Dam. At the Otowi gauge, the Rio Grande enters White Rock Canyon. This reach includes not only the deep narrow canyon, but also Cochiti Lake, a flood control facility operated by the Corps. No future river maintenance activities are expected to occur within this reach.

Figure 1. Map of the Rio Grande Basin in New Mexico and Colorado.
Major federal water project facilities and reach designations are displayed.



3 DESCRIPTION OF PROPOSED ACTIONS

3.1 Introduction

The following section describes proposed actions to be covered in this consultation process. The description includes both federal actions. Also included are non-federal actions on the basis of total river depletions. The intent is that coverage be extended to ordinary operations on the river as they have existed historically, as long as those operations are valid under state and federal law, consistent with historic operations, do not create additional net depletions on the river or depletions at a new time or place, or do not affect threatened or endangered species or their habitat beyond what is considered in this biological assessment, without further consultation with the Service.

The Rio Grande Compact of 1938 (Compact) sets depletion limits on the Rio Grande and administration by the State of New Mexico enforces those limits, resulting in a reliable general description of flows. Further, the Middle Rio Grande Basin is a Declared Ground Water Basin, which means that the New Mexico State Engineer has determined that ground water usage impacts surface flows of the Rio Grande and must be offset, creating further assurance that flow descriptions will be reliable, even if particular actions and actors maintaining those flows change. Thus, with respect to river flows, particular actions that do not affect net depletions of water are not specifically described.

Accordingly, the following gives general narrative descriptions of the types of actions taking place within the administration of the Compact, together with the depletion limits under the Compact. Generally, the actions under consultation are depletions and diversions of water as described in the sections below, although some specific actions under consultation are identified and described, e.g., river maintenance. With respect to types of actions that might affect threatened or endangered species or their habitat other than flows in the river, such actions are generally described for non-federal entities, and more specifically described for federal entities.

Depletions that result from the exercise of Federal Indian water rights are not subject to State law restrictions or administered by the State. In addition, pursuant to Article XVI of the Compact, no Indian water rights may be impaired by the State's compact management activities. Indian Pueblos and Tribes within the action area did not request to have the effects of their actions analyzed in this BA.

However, depletions related to existing Indian uses are included within the depletion figures compiled and provided by the State. Using the information provided for this consultation, Reclamation and the Corps are unable to identify the depletions attributable to individual water users, Indian or non-Indian. Thus, this BA analyzes the effects on the listed species from existing depletions that result from both Indian and non-Indian water uses within the action area. The Federal agencies recognize that who depletes and the amount they deplete may vary from year to year, consequently, the action agencies and non-Federal water users assume the risk that the future development of senior water rights, including Indian Pueblo and tribal water rights, may result in shortages of water to junior users. The Federal agencies are aware that the Indian Pueblos and Tribes do not concede that the ESA applies to their actions.

Included within these descriptions of depletions and withdrawals are the depletions and withdrawals from the exercise of valid and existing water rights of 18 Pueblos (Acoma, Cochiti, Isleta, Jemez, Laguna, Nambe, Picuris, Pojoaque, San Felipe, San Ildefonso, San Juan, Sandia, Santa Ana, Santa Clara, Santo Domingo, Tesuque, Taos, Zia), the Navajo Nation and certain Navajo allotees, and the Jicarilla Apache Nation. Federal Indian water rights are not: (1) impaired by the Compact, (2) subject to State law restrictions, and/or (3) administered by the State of New Mexico. Nonetheless, depletions resulting from the exercise of Indian water rights are included within the general descriptions in this section, for the reasons discussed above.

Given the pending Tenth Circuit Court of Appeals decision, there is uncertainty regarding what the court will determine to be the scope of federal discretionary authority by the time consultation is complete. Therefore, we are consulting on the effects of total river depletions on listed species, without identifying particular aspects of the overall action as "discretionary or non-discretionary." Under the depletion-based approach, the scope of federal discretion becomes most relevant at the stage of consultation where the action agency and the Service design reasonable and prudent alternatives, reasonable and prudent measures, or conservation measures. Reclamation, the Corps, and the Service are voluntarily including the non-federal actions within the scope of the consultation and any resulting incidental take statement and not out of any legal obligation.

3.2 Non-Federal Actions

Water uses on the Middle Rio Grande must be conducted in conformance with the Compact administered by the Rio Grande Compact Commission. The Commission is composed of a Commissioner from Colorado, New Mexico, and Texas, as well as a Federal Commissioner who chairs Commission meetings. Colorado is prohibited from accruing a debit, or under-delivery to the downstream states, of more than 100,000 acre-feet (af), while New Mexico's accrued debit to Texas is limited to 200,000 af. These limits may be exceeded if caused by holdover storage in certain reservoirs, but water must be retained in the reservoirs to the extent of the accrued debit. Any deviation from the terms of the Compact requires unanimous approval from the three state Commissioners.

In order to meet delivery obligations under the Compact, depletions within New Mexico are carefully controlled. Allowable depletions above Otowi gauge (located outside of Santa Fe, near the Pueblo of San Ildefonso) are confined to levels defined in the Compact. Allowable depletions below Otowi gauge and above the headwaters of Elephant Butte Reservoir are calculated based on the flows passing through Otowi gauge. The maximum allowable depletions below Otowi gauge are limited to 405,000 af in addition to tributary inflows. In an average year, when 1,100,000 af of water passes the gauge approximately 393,000 af of water is allowed to be depleted below Otowi gauge, in addition to tributary inflows. In the dry year of 1977, for example, allowable depletions were 264,600 af in addition to tributary inflows. Analysis of effects throughout this biological assessment assumes that all covered actions occur within the Compact framework, except as specifically described below and considering that no Indian water rights may be impaired by the State's Compact management activities.

The following is considered a non-exhaustive list of non-federal entities and proposed non-federal actions:

3.2.1.1 State of New Mexico

The State of New Mexico has a wide range of agencies that actively represent different aspects of the State's interest in water management:

The *N. M. State Engineer* has general supervision of the waters of the State and of the measurement, appropriation and distribution thereof (N. M. Stat. Ann. 72-2-1 Repl. Pamp. 1994). The Office of the State Engineer grants State water rights permits and is responsible for ensuring that applicants meet State permit requirements and otherwise enforcing the water laws of the State.

The *N. M. Interstate Stream Commission* is authorized to develop, conserve, protect and to do any and all things necessary to protect, conserve, and develop the waters and stream systems of the State and is responsible for representing New Mexico's interests in making interstate stream deliveries, as well as for investigating, planning, and developing the State's water supplies. The State cooperates with Reclamation to perform annual construction and maintenance work under the State of New Mexico Cooperative Program. In the past, this work has included some river maintenance on the Rio Chama, maintenance of Drain Unit 7, drain and canal maintenance within the Bosque del Apache National Wildlife Refuge, similar work at the state refuges, and temporary pilot channels into Elephant Butte Reservoir.

The *N. M. Department of Game and Fish* (NMDGF) administers programs concerned with conservation of endangered species and game and fish resources. It also manages the La Jolla State Game Refuge and Bernardo Waterfowl Area.

The *N. M. Environment Department* administers the State's water quality program.

3.2.1.2 Counties

All counties that border the Rio Grande and Rio Chama and their respective tributaries perform actions or can perform actions that may at least indirectly affect these rivers. The primary area in which county actions may influence water management is providing for general development and infrastructure of these counties, which activities may include pumping of wells or land use regulations within the immediate Middle Rio Grande watershed.

3.2.1.3 Villages, Towns, and Cities

Citizens in a multitude of villages, towns, and cities are served with municipal and industrial water systems. While most use groundwater exclusively, Santa Fe also uses surface water supplies and both the cities of Albuquerque and Santa Fe are planning to use surface water directly from the San Juan-Chama Project in addition to ground water. To the extent that future groundwater pumping or use of surface water depletes the river, the New Mexico State Engineer requires that these depletions be offset, either by acquiring other water rights, or with San Juan-Chama Project water. Many of these contractors have voluntarily entered into annual lease programs with Reclamation to enhance Middle Rio Grande valley water management. Municipalities also manage wastewater treatment systems that discharge into the Rio Grande.

3.2.1.4 Irrigation Interests

Irrigation interests include a variety of the acequias, individual irrigators, and ditches, as well as the Middle Rio Grande Conservancy District (MRGCD). Many of these irrigation interests have existed for hundreds of years. The MRGCD was established under state law in 1928 to address issues such as valley drainage and flooding, and currently operates the diversion dams of the Middle Rio Grande Project to deliver irrigation water to lands in the Middle valley, including areas on six Southern pueblos. Middle Rio Grande Project works are more fully described in the section on federal actions, below.

3.3 Federal Actions

3.3.1 Corps of Engineers

Proposed action: Corps reservoir operations and authorities were described in detail in the June 2001 BA (Reclamation 2001) and are incorporated here by reference. No new or additional actions are being proposed. Project operations of the Corps were described in detail in the June 2001 BA (Reclamation 2001). This BA incorporates by reference the description of facilities and operations found on pages 8-12 and 39-45 of that report. As mentioned above, the Corps has identified in Appendix A additional actions that would be available to be implemented as reasonable and prudent measures to reduce any incidental take associated with the proposed action, or to promote conservation and recovery of listed species pursuant to Section 7(a)(1) of the ESA.

A brief description of the major project features follows:

The Corps is responsible for operation and maintenance of five flood control dams on the Rio Grande and its tributaries: Abiquiu, Cochiti, Galisteo, Jemez Canyon, and Platoro dams. The purposes of these projects can be broadly defined as providing flood control, sediment control, water supply, recreation, and fish and wildlife conservation. Figure 1 shows the location of these facilities.

Platoro Dam is on the Conejos River about 80 miles above the confluence with the Rio Grande. Congressional Authority for the construction of Platoro Dam is contained in the Interior Appropriation Act of 1941. The dam was completed in 1951 by Reclamation as a multi-purpose facility for irrigation storage and flood control. The operation and maintenance responsibility has been transferred to the Conejos Water Conservancy District by Reclamation. The Corps is responsible for administering the flood control regulation.

Abiquiu Dam and Reservoir are on the Rio Chama about 32 river-miles upstream from its confluence with the Rio Grande. Abiquiu Dam was authorized for construction by the Flood Control Act of 1948, (PL 80-858) and the Flood Control Act of 1950 (PL 81-516). Abiquiu Reservoir operates for flood control, sediment retention and water supply. The reservoir’s storage allocations include 77,000 af for sediment control and 502,000 af for flood control. Construction of Abiquiu Dam was initiated in 1956 and the project was completed and placed into operation in 1963 by the Corps.

Cochiti Dam and Lake are located on the mainstem of the Rio Grande, about 50 miles north of Albuquerque and 25 miles southwest of Santa Fe. The lands for the dam and recreation pool are within Cochiti Pueblo’s territorial jurisdiction, with parts of the reservoir in Sandoval, Santa Fe and Los Alamos counties, New Mexico. Cochiti Dam also extends across the Canada de Cochiti and the Santa Fe River, tributaries of the Rio Grande draining from the east. The Flood Control Act of 1960 (PL 86-645) authorized the construction of Cochiti Dam for flood and sediment control on the mainstem Rio Grande. The reservoir’s storage allocations include 105,000 af for sediment control and approximately 500,000 af for flood control. In 1964, PL 88-293 authorized the establishment of a permanent pool for the conservation and development of fish and wildlife resources and recreation purposes. Subparagraph (e) specifically exempted storage for a permanent pool unless the water to fill and maintain the pool came from outside the Rio Grande Basin. Construction of Cochiti Dam began in 1965 by the Corps and the project was put in operation in 1975.

Galisteo Dam is on Galisteo Creek, about 12 miles upstream of its confluence with the Rio Grande. Galisteo Creek enters the Rio Grande about eight miles downstream of Cochiti Dam. Galisteo Dam was authorized by the Flood Control Act of 1960 for flood control and sediment control for the Middle Rio Grande Valley. The Corps completed Galisteo Dam in 1970. It is an earth-fill embankment 2,820 feet long with a maximum height of 158 feet above the streambed. The reservoir’s storage allocations include 10,200 af for sediment control and 79,600 af for flood control. Because the dam was constructed with uncontrolled outlet works, the reservoir passes all flood inflow up to approximately 5,000 cfs. Galisteo Reservoir is normally dry, with most inflows occurring in the summer months because of summer thunderstorm activity. The drainage area above Galisteo Dam includes 596 square miles.

Jemez Canyon Dam and Reservoir is on the Jemez River, 2.8 miles upstream of its confluence with the Rio Grande. It is located in Sandoval County, about 5 miles northwest of Bernalillo and about 22 miles north of Albuquerque. All lands associated with the project are held in trust by the United States for the benefit and use of the Pueblo of Santa Ana. Congressional authority for the construction of Jemez Canyon Dam is contained in the Flood Control Acts of 1948 and 1950. The Corps completed the dam in 1953. Jemez Canyon Dam regulates the Jemez River for flood and sediment control in conformity with PL 86-645. The reservoir’s storage allocations include 40,100 af for sediment control and 73,000 af for flood control.

3.3.2 Bureau of Reclamation

The Albuquerque Area Office of Reclamation is responsible for operation, maintenance, and/or oversight of federal projects on the mainstem Rio Grande and its upper basin tributaries. These Reclamation projects include the San Luis Valley Project-Closed Basin Division, the SJ-C Project, and the Middle Rio Grande Project. Figure 1 shows the location of these Reclamation project features.

In this BA, Reclamation proposes to meet its contractual obligations by delivering water as requested by contractors and other water users out of the SJ-C Project and Middle Rio Grande Project. As mentioned previously, given the pending Tenth Circuit Court of Appeals decision, there is uncertainty regarding what the court will determine to be the scope of federal discretionary authority by the time consultation is complete. The full extent of Reclamation's authority will become relevant at the stage of consultation involving the crafting of reasonable and prudent alternatives, reasonable and prudent measures, or conservation measures, as needed.

As mentioned above, Reclamation has identified in appendices A and B to this BA additional actions that would be available to be implemented as reasonable and prudent alternatives to the proposed action, as reasonable and prudent measures to reduce any incidental take associated with the proposed action, or to promote conservation and recovery of listed species pursuant to Section 7(a)(1) of the ESA. Only after the Tenth Circuit has ruled will Reclamation know the full scope of its discretion over project water and operations.

The following section describes the projects and facilities involving Reclamation's proposed actions on the Middle Rio Grande and Rio Chama.

3.3.2.1 Closed Basin Division, San Luis Valley Project

Reclamation has determined that the Closed Basin Division, San Luis Valley Project is extremely limited in its ability to provide water for downstream purposes during the ten-year scope of this assessment and does not affect any listed species. Thus, the biological assessment will not further address this project.

3.3.2.2 San Juan-Chama Project

The SJ-C Project was authorized by Congress in 1962 through PL 87-483, which amended the Colorado River Storage Act of 1956 (PL 84-485) to allow diversion of Colorado River Basin water into the Rio Grande Basin of New Mexico. The original planning projections for the SJ-C Project contemplated an ultimate diversion of 235,000 acre-feet per year, with an initial phase development to accommodate an average annual diversion of up to 110,000 acre-feet. Only the initial phase was authorized (by PL 87-483) and subsequently constructed by Reclamation. The Project takes water from the Navajo, Little Navajo, and Blanco rivers, which are upper tributaries of the San Juan River (of the Colorado River Basin) for use in the Rio Grande Basin, New Mexico.

Reclamation proposes delivering water to the following users at contractor's request (date of contract initiation and expiration appear parenthetically):

Municipal, domestic, and industrial purposes:	
City of Albuquerque (1963 – no expiration)	48,200 acre-feet
Jicarilla Apache (1992 – no expiration)[1]	6,500 acre-feet
City of Santa Fe and Santa Fe County (1976 – Dec. 31, 2016)	5,605 acre-feet
County of Los Alamos (1977 – Jan. 10, 2017)[2]	1,200 acre-feet
City of Española (1978 – Dec, 31, 2018)	1,000 acre-feet
Town of Belen (1990 – no expiration)	500 acre-feet
Village of Los Lunas (1977 – Dec. 31, 2017)	400 acre-feet
Town of Taos (1981 – Dec.31, 2021)	400 acre-feet
Town of Bernalillo (1988 – no expiration)	400 acre-feet
Town of Red River (1990 – no expiration)	60 acre-feet
Village of Taos Ski Valley (1978 – Dec. 31, 2017)	15 acre-feet
San Juan Pueblo (2001 – no expiration)	2,000 acre-feet
Allocated, but uncontracted, water currently identified for future Indian water rights settlements and or use:	
Taos Area	2,990 acre-feet
Irrigation:	
Middle Rio Grande Cons. District (1963 – no expiration)	20,900 acre-feet
Pojoaque Valley Irrigation District (1972 – no expiration)[3]	1,030 acre-feet
Recreation[4]:	
Corps - Cochiti Rec. Pool (1964 – no expiration)	Up to 5,000 acre-feet
Total Allocation:	96,200 acre-feet

None of the existing contracts expires within the next ten years. Potential renegotiation of the contracts and their terms is therefore not considered within this Biological Assessment.

With Article VII Rio Grande Compact restrictions in place, only SJ-C water for the six Middle Rio Grande Pueblos will be stored at El Vado Reservoir. In order to ensure adequate storage for the needs of the six Middle Rio Grande Pueblos, releases from Heron Reservoir (i.e., contract deliveries) will be adjusted to ensure native flows are stored at El Vado for those needs. At times, such operations will lead to flows on the Rio Chama well outside of the recommendations of the Rio Chama Instream Flow Assessment, and it is likely that releases below El Vado Dam could cease completely on occasion to ensure such storage.

Proposed Action
Reclamation proposes to operate Heron Reservoir within the following hydrological constraints:

- Meet contract obligations within the SJ-C Project firm yield to contractors listed above, to the extent water is available.
- Maximize storage to the extent water is available.
- Do not exceed safe storage amount of approximately 401,000 acre-feet.
- Request temporary waivers from contractors to modify the date of their water delivery into the following calendar year, if such waivers will benefit the United States (i.e., to provide improved overall management of upstream water supplies).
- Reclamation may dispose of contractor water if not called for by the contracted delivery date and where consistent with the terms of the contracts or if uncontracted water within the firm yield is available.

[1] Contract in effect mid-1999.
[2] County of Los Alamos obtained annual allocation from the Department of Energy in September 1998.
[3] A "soft" number is used to offset storage in Nambe Falls Reservoir. The figure has varied from 800 to 1300 acre-feet on an annual basis.
[4] Cochiti recreation pool allocations compensate for evaporation losses to maintain a minimum pool of 1,200 surface acres at Cochiti Lake (PL 88-293).

Pojoaque Tributary Unit
The Pojoaque Tributary Unit is a component of the SJ-C Project, PL 87-483, and provides supplemental water (1,030 af) for approximately 2,768 acres of irrigated land, of which Indian lands comprise approximately 34 percent of the total. The storage feature of the Pojoaque Tributary Unit is Nambe Falls Dam and Reservoir located on the Rio Nambe. It is a concrete and earth embankment structure which forms a reservoir of 2,020 af capacity. Construction of Nambe Falls Dam began in June 1974, and was completed in June 1976. The operation and maintenance of Nambe Falls Dam and Reservoir is performed by the Pojoaque Valley Irrigation District (PVID). Reclamation maintains oversight responsibilities for this work.

Water that is physically stored in the reservoir is native to the Rio Grande Basin. SJ-C water is released from Heron Reservoir to the river to offset depletions of native water as a result of reservoir operations at Nambe Falls Dam as described in the corresponding contract between the United States and the PVID (Contract #: 14-06-500-1986; 1972) which references PL 87-483 and in compliance with the Rio Grande Compact. Generally, three or four releases are made per year from Heron Reservoir to benefit the Rio Grande. Thus, the annual flow readings at the Otowi gauge on the mainstem of the Rio Grande effectively include the natural tributary input from the Rio Nambe. Reclamation does have some discretion over the timing of the releases.

Proposed Action: Reclamation releases water from Heron Reservoir to offset storage effects at Nambe Falls Reservoir. Reclamation has some discretion over the timing of the releases within the following hydrological constraints:

- Water is released in compliance with the Rio Grande Compact and in conjunction with other San Juan-Chama Project water management.

3.3.2.3 Middle Rio Grande Project

Built originally by the Middle Rio Grande Conservancy District in the 1930's, Middle Rio Grande irrigation structures are used to divert water and deliver it to MRGCD customers' lands, including 21,664 acres of Indian water right lands within MRGCD's service area.

The Department of the Interior determined that the United States obtained title to all of the Middle Rio Grande Project works, as anticipated by a 1947 Project Plan approved by federal legislation and a subsequent 1951 contract between Reclamation and the District.

The District operates the Cochiti heading and Angostura, Isleta, and San Acacia diversion dams as "transferred works" under the 1951 contract. According to the 1951 contract between Reclamation and the District, the District acts as the United States' agent when it operates those works. Reclamation currently operates El Vado Dam and Reservoir as "reserved works."

Also under the 1951 contract, Reclamation retained discretion to take back operation and maintenance of transferred works upon notice to the District. Reclamation did not, however, retain discretion over the day-to-day operations decisions at the facilities. Reclamation proposes to allow the District to continue to operate and maintain the transferred works and to continue to operate the reserved works consistent with current agreements. Since the District acts as the United States' agent at transferred works (Cochiti heading, Angostura, Isleta, San Acacia), and since Reclamation retains discretion to operate and maintain the facilities itself or to allow the District to operate and maintain the facilities, Reclamation is consulting over the broad parameters of use of those facilities and on the effects of that use on listed species, to ensure that its agent acts within the bounds of Federal law and within the scope of its conferred authority.

The release from storage, delivery of, and diversion of water for the six Middle Rio Grande Pueblos is also part of this proposed action. This water will be delivered primarily through Middle Rio Grande Project facilities. Reclamation will continue its operations, consistent with current agreements, to store water in El Vado Reservoir to ensure delivery of water to the six Middle Rio Grande Pueblos as allowed by the Rio Grande Compact.

Storage of native Rio Grande flows described herein will be done consistent with the prior appropriation doctrine in New Mexico, therefore any flows necessary to meet downstream senior flow rights will be bypassed for those needs. Reclamation will work with the Sate of New Mexico in determination of any such downstream senior flow rights and will adjust El Vado operations appropriately.

El Vado Dam and Reservoir
Reclamation operates El Vado Dam and Reservoir to meet the purposes of the 1951 contract and to insure the Pueblos' water rights. According to the 1951 contract and the state permits, the water in El Vado Reservoir is "for beneficial use in the project and for Indian lands in the project area, and which shall be held primarily for domestic, irrigation, and municipal use in the project and for Indian land in the project . . ."

Proposed Action: Operate and maintain El Vado Dam and Reservoir within the following hydrological constraints:

- Meet water user delivery requirements and MRGCD calls for water when available.
- Maintain safe storage elevation no higher than 6896.20' by June 1 except under specific exceptions that consider flood routing criteria, water surface elevation, and river flow in the middle valley.
- Exercise U. S. right to store natural flows as needed for the six Middle Rio Grande Pueblos and for the District when Article VII of the Rio Grande Compact is not in effect and to the extent water is available.
- Exercise U. S. storage right to store SJ-C water if requested by the District if allowed under the Compact.
- Store when available and release water for the six Middle Rio Grande Pueblos.

Diversion Dams
MRGCD built Cochiti, Isleta, San Acacia, and Angostura diversion dams in the 1930's. (Note: the MRGCD constructed the Isleta Diversion Dam on Pueblo of Isleta lands). Pursuant to the Middle Rio Grande Project authorization, Reclamation rehabilitated Isleta Diversion Dam in 1955, San Acacia Diversion Dam in 1957, and Angostura in 1958. Cochiti diversion dam was inundated by Cochiti Dam and its outlet works in 1975. The Sile and Cochiti Eastside Canal collectively make up the Cochiti Heading, which takes water directly out of the upper stilling basin of the Cochiti Dam outlet works.

Proposed Action: Allow the District to continue to operate and maintain diversion dams as agent of United States.

- Water for the six Middle Rio Grande Pueblos will be delivered primarily through Middle Rio Grande Project facilities.

Low Flow Conveyance Channel
Reclamation may perform some operations associated with the Low Flow Conveyance Channel (LFCC) in conjunction with its supplemental water management program. In response to drought conditions in 1996, Reclamation began operating an outfall from the LFCC to the river near Escondida, N. M. to return about 10 cfs to the Rio Grande. This outfall will continue to be used, as needed, to augment Rio Grande flow.

The only other water operation action that Reclamation currently performs on the LFCC is in response to requests by the MRGCD or the Bosque del Apache National Wildlife Refuge (Refuge) to check up flows in the channel at existing check structures, thus increasing the head on the water so that diversions by the MRGCD and the Refuge from the LFCC are more easily made. Requests for check structure gate adjustments by the MRGCD, for example, occur infrequently, about 1-3 times during an irrigation season.

Proposed Actions: In response to requests by the MRGCD and the Refuge, adjust gates in existing check structures to increase the head on the water in the LFCC. Maintain the LFCC temporary outfall and other potential returns to the river.

River Maintenance Program
Reclamation has authority for maintenance of the river channel for the Middle Rio Grande Project from Velarde to Caballo Dam authorized under the Flood Control Acts of 1948 and 1950. The goals of Reclamation's river maintenance program for the Project are to:

- conserve surface water in the Rio Grande Basin;
- provide for the effective transport of water and sediment to Elephant Butte Reservoir;
- protect certain riverside structures and facilities;
- reduce the rate of aggradation (i.e., bed raising through sediment accumulation) in the Rio Grande in the San Marcial area and headwaters of Elephant Butte Reservoir; and
- reduce the rate of channel degradation (i.e., channel bed lowering due to reduced sediment load) from Cochiti Dam south to Escondida, N. M.

Through the river maintenance planning process, Reclamation evaluates a wide range of alternatives to determine the best combination of activities that provide for the effective transport of water and sediment and the protection of riverside facilities. The activities must also be compatible with Rio Grande geomorphology to the maximum extent possible. Reclamation is also currently in the process of evaluating both in the laboratory and through field scale testing, various river bioengineering technologies to meet the previously mentioned objectives.

Appendix C contains a detailed description of the river maintenance program, updated from the June 2001 BA, including related activities such as river maintenance techniques, bioengineering, sediment removal, vegetation management, levee maintenance, and reach-specific activities.

It is also anticipated that this consultation will significantly reduce consultation efforts for future river maintenance projects. The Coordination Process subsection in the 2001 BA is incorporated by reference and outlines information and reports that will be developed as a part of the aforementioned coordination process and an environmental compliance document that will summarize activities associated with a project and document that the project falls within the sideboards established in this consultation. This streamlined process for specific projects should reduce the workload and time needed for future ESA compliance on river maintenance activities. Some activities that are defined and analyzed in the assessment with sufficient detail may not require future consultation. Projects that include significant actions not considered in this assessment or potentially significant adverse impacts to federally listed species will be consulted on separately. However, it is anticipated that the majority of river maintenance projects would fall within the sideboards established by the programmatic assessment.

Proposed Action: Maintenance of the river channel for the Middle Rio Grande Project from Velarde to Caballo Dam.

3.3.2.4 Annual Operating Plan

Each year, Reclamation, in cooperation with the Corps, prepares and distributes to interested parties an Annual Operating Plan (AOP) to address water operations in the Rio Grande Basin, including operations related to the San Juan-Chama and Middle Rio Grande Projects, and compliance with the Rio Grande Compact. The AOP addresses water operations in the Rio Grande Basin including operations related to SJ-C, MRGP, and compliance with the Rio Grande Compact. This document contains stream flow forecasts, including snowmelt runoff forecasts, anticipated operations outlooks for the various Reclamation and Corps-operated facilities along the river, and hydrographs reflecting reservoir operations, including actual (to the date of the plan's publication) and anticipated inflow, outflow, and storage. Much of the planning information in the report is developed through the coordination, cooperation, and agreement of various parties. The agencies provide monthly updates, informing interested parties of operations throughout the course of the water year.

The AOP process was described in detail on pages 46-47 in the 2001 BA (Reclamation, 2001). This BA incorporates the AOP process described therein by reference.

Proposed Action: The Annual Operating Plan process is an integral component of all of the aforementioned federal and non-federal water operations and should be considered as part of the collective action described in this BA.

3.3.2.5 Adaptive Management and Monitoring

Reclamation is committed to applying the concepts of adaptive management to all of the proposed federal actions described in this programmatic biological assessment. The general framework for adaptive management applications follows the scientific perspective of managing in the face of uncertainty. The underlying premises of adaptive resource management are (Williams, pers. comm., 1998):

- There is uncertainty in the systems we manage,
- Management is necessary despite existing uncertainty,
- Monitoring is required to evaluate decision making, and
- Learning is important to the extent that it helps managers achieve their objectives.

This approach is especially relevant to the issues facing water managers on the Middle Rio Grande. Reclamation will continue to attempt to develop meaningful management goals with involvement of all stakeholders in the Middle Rio Grande and attempt to implement and monitor actions related to those goals. Finally, based partly on the results of monitoring and research, Reclamation will use adaptive management principles to adjust future actions within the sideboards set forth in this document to benefit all resources.

Program monitoring is necessary to determine whether management actions have placed natural resources on a trajectory towards agreed-upon desired future conditions. Assessments of management programs also help to reveal information deficits and technical problems that directed research may be able to rectify. Likewise, program monitoring and evaluation, when focused on problem identification, can reveal limiting factors that underlie animal communities that fail to achieve their full potential. Finally, monitoring and evaluation of contemporaneous dynamic variables is required to adapt management practices to new circumstances. Without monitoring, innovation is discouraged, new knowledge is applied too slowly, and inefficiencies persist to the detriment of natural resources and the public.

For over a decade, Reclamation has been involved in biological, hydrological and geomorphic monitoring in the Middle Rio Grande to support project activities. A general monitoring plan was developed in 1997 and later updated that encompasses activities for biological studies and geomorphic and hydrological assessment to support both water operations and river maintenance activities and ensure water management goals are being achieved. Biological studies include regular fish population monitoring at about 16 sites below Cochiti Dam and willow flycatcher presence/absence surveys and nest monitoring. Winter bald eagle surveys will continue near the headwaters of Elephant Butte Reservoir. Reclamation and the Service will cooperatively monitor discharge at critical river locations to ensure that management goals are being achieved. Based in part on the results of these and other monitoring efforts, Reclamation will use adaptive management principles to adjust future actions within the sideboards set forth in this document to maximize benefits to all resources.

4 SPECIES STATUS AND LIFE HISTORY

4.1 Rio Grande Silvery Minnow

Sublette et al. (1990) describe the taxonomic characteristics of the silvery minnow with discussions, under separate headings, of coloration, head (including electron photomicrographs of the head and pharyngeal tooth apparatus), body, and fins. They also present an overview account of the life history, a list of synonyms (and their sources) employed regionally. They also provide an account of the distribution of the species, including a dot-distribution map that illustrates the changing distribution up to the date of publication. Bestgen and Propst (1996) provide a detailed morphomeristic study of the silvery minnow and document the distinctiveness of the species.

4.1.1 Status and Distribution

Through the 1950's, the silvery minnow was distributed throughout many of the larger order streams of the Rio Grande Basin upstream of Brownsville, Texas to points north in New Mexico primarily below 5500 ft elevation (1676 m). This elevation coincides with the approximate vicinities of Abiquiu on the Chama River, Velarde on the Rio Grande, and Santa Rosa on the Pecos River. Today, absent from much of its historic range, the silvery minnow is restricted to a variably perennial reach of the Rio Grande in New Mexico, from the vicinity of Bernalillo downstream to the head of Elephant Butte Reservoir, a distance that fluctuates as the size of the pool of water in storage in Elephant Butte Reservoir changes, but that approximates 150 river miles (241 km).[5]

The silvery minnow is currently listed as endangered on the New Mexico state list of endangered species, having first been listed May 25, 1979 as an endangered endemic population of the Mississippi silvery minnow (*Hybognathus nuchalis*; NMDGF, 1988). On July 20, 1994, the Service published a final rule to list the silvery minnow as an endangered species with proposed critical habitat (Federal Register, 1994).

The Service released the Draft EIS for Critical Habitat on June 6, 2002 (U. S. Fish and Wildlife Service, 2002a). This document considered several alternatives for silvery minnow critical habitat, including the Middle Rio Grande between Cochiti Dam and Elephant Butte Reservoir, the Lower Rio Grande around Big Bend National Park, and the Pecos River between Ft. Sumner Dam and Brantley Reservoir. All alternatives include the Middle Rio Grande, with different alternatives excluding the Cochiti and the San Acacia reaches. As proposed, the lateral extent of critical habitat includes those areas bounded by existing levees. In areas without levees, the lateral extent of critical habitat, as proposed, is defined as 91.4 meters (300 feet) of riparian zone adjacent to each side of the river.

4.1.2 Life History and Ecology

Historically, the silvery minnow was one of the most wide-ranging fish species in the Rio Grande Basin. The environmental variation encountered over such a vast area of the arid southwest was extreme (including chemical, physical, hydrological, climatic, and biological attributes). To survive, species exposed to strong environmental variation within generations may exhibit tolerance to such diverse conditions through physiological flexibility or through strong habitat selection. Without evidence of the latter strategy, one can deduce that the silvery minnow is a physiological generalist. Demographical evidence and natural history observations reveal fine distinctions in the quality of the preferred habitat for the silvery minnow and the capacities of different river reaches to provide the elements necessary for the successful completion of the life cycle of the silvery minnow, and hence, for stability, persistence and abundance of the species. However, it is important to acknowledge that all investigations of the life history and ecology of the silvery minnow have taken place within the species' contemporary range, an environment that has been dramatically altered over historic times. Observations from such investigations can easily lead to a misunderstanding of the species' habitat preferences and needs.

Dudley and Platania (1997) studied habitat preferences of the silvery minnow in the Middle Rio Grande at Rio Rancho and Socorro. They characterize habitat preference and habitat availability in terms of water depth, water velocity and stream substrate.[6] Both juvenile and adult silvery minnows primarily used mesohabitats with moderate depths (15-40 cm), low water velocities (4-9 cm/sec) and silt/sand substrates. Such velocities neither erode nor deposit bed materials of the sizes associated with the silvery minnow. Avoidance of swift water velocities by the

---

[5] Most descriptions of the contemporary range of silvery minnow cite the entire reach of the Rio Grande between Cochiti Dam and Elephant Butte Reservoir. However, that assertion cannot be made with certainty. The species' status in the Rio Grande between Cochiti Dam and Angostura Irrigation Diversion Dam is unknown; that reach of river has not been surveyed in recent years.

[6] Stream depth, velocity and substrate are often perceived as independent variables when in fact they covary. In many fisheries studies (speaking generally), "available habitat" is quantified with the implicit assumption that fish abundance is regulated by habitat availability. Yet, many examples exist in which year-to-year variation in fish abundance is large even though available habitat is held constant (e.g., Moyle and Blatz, 1985). At times of high abundance, fish are found in apparently marginal habitats from which they are otherwise missing. Other evidence suggests (again, speaking generally) that short-term changes in flow, excluding events of total channel drying, either natural or experimental, cause changes in the distribution rather than the abundance of fish.

silvery minnow is one means of conserving energy, a general life strategy shared by many lotic fish species (Facey and Grossman, 1992).

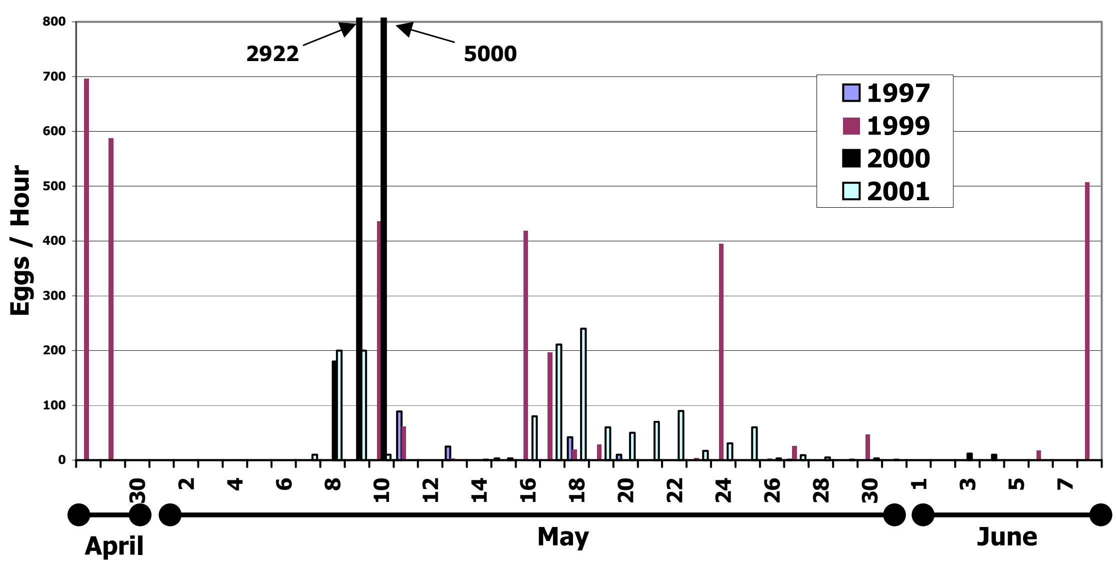
Young-of-year silvery minnows are generally found in shallower and lower velocity habitats than adult individuals. Seasonal changes in habitat use are most prevalent during winter months. At near-freezing water temperatures, silvery minnow become less active and seek habitats with cover such as debris piles and low water velocities.

Silvery minnows are open substrate pelagic spawners, producing numerous semi-buoyant non-adhesive eggs that incubate as they drift downstream. Silvery minnows spawn in the spring, generally from late April through June and over a relatively narrow range of water temperature (20-25º C; Platania and Dudley, 1999 and 2001). Peak egg production occurs in mid to late-May (Figure 2) and generally coincides with high spring discharge produced by snowmelt. In the unimpounded and unconfined potamon of the Middle Rio Grande, such hydrologic events would historically inundate portions of the floodplain. Outside of spring runoff, flows in the Middle Rio Grande were historically extreme and highly erratic, including episodic events of flooding and, at times, intermittence (Hatch et al. 1998).

The reproductive strategy of the silvery minnow is adaptive to the "pre-development era" aquatic habitats of the Middle Rio Grande potamon. The pelagic mode of spawning occurs independent of the prevailing fine particle substrates (which can suffocate incubating eggs), and spawning coincides with a relatively predictable time of hydrologic abundance, affording as many young as possible access to productive, newly flooded, shallow areas created during a high discharge pulse. Given their small size, larval silvery minnows can be disadvantaged in low-food conditions. However, growth of silvery minnows can be rapid in habitats with high organic retention.

Egg hatching time is temperature-dependent, occurring in 24-48 hours (more quickly in warmer water). Recently hatched silvery minnow larvae are about 3.7 mm in length. The small size of newly hatched larvae is probably an adaptation to life in waters that can become seasonally low in dissolved oxygen (small body size facilitates absorption of oxygen by the entire surface of the fish). Beyond flow and temperature, there exist a number of environmental variables that could influence silvery minnow spawning (e.g., photoperiod, degree days, and water turbidity). Certainly, additional research is needed to properly delineate the linkages between the array of environmental variables and the timing and duration of silvery minnow spawning.

Figure 2. Analysis of Peak Silvery Minnow Spawning below San Marcial, New Mexico.



Generally, a population of silvery minnows consists of only two age classes. The majority of spawning individuals are Age 1 fish (1-year old); older and larger Age 2 fish normally constitute less than 10% of the spawning population. Reproductively mature females are typically larger than males. Each female produces several clutches of eggs during spawning, and Age 2 females are more fecund than the smaller Age 1 fish and may ultimately release up to 6,000 eggs. Very few adult silvery minnows are found in late summer and it is surmised that spawning adults may experience high mortality following spawning. By December, the majority (> 98%) of silvery minnows are Age 0. Age 1 fish usually constitute over 95% of the population just prior to spawning. Maximum longevity is about 25 months, but very few silvery minnows survive more than 13 months.

4.1.3 Reasons for Decline

The Federal Register (1993a) proposal to list the silvery minnow as an endangered species discusses many factors that led to the decline of the species.

Downstream of Elephant Butte Reservoir, several factors have operated in concert to eliminate silvery minnow from the Rio Grande, including:

- the imposition of cross channel irrigation diversions (that generally develop over time into barriers to the upstream movement of silvery minnows),
- the imposition of large mainstem dams (that interrupt the river continuum[7] and serve as barriers to the upstream movement of silvery minnows),
- geomorphic modifications of the river channel that have reduced the surface area and physical complexity of the habitat and reduced the retention time of water and organic matter, and
- efforts to regulate or otherwise alter the magnitude and variability of flow in the Rio Grande, coupled with extraction of water for consumptive uses.

Trevino-Robinson (1959) documented the early 1950's "cosmopolitan" occurrence of silvery minnows in the Rio Grande downstream of its confluence with the Pecos River where, for "the first time in recorded history," a portion of this reach of river went dry in 1953.[8] Although Trevino-Robinson (1959) could not document any "apparent undesirable or severe after effects" from the drought, silvery minnows have not been documented from this lower portion of the Rio Grande since the mid-1950's (in part, U. S. Fish and Wildlife Service, 1999). Edwards and Contreras-Balderas (1991) document the absence of the silvery minnow from the Rio Grande downstream of Falcon Dam. Their study concerned faunal changes at the community level; it did not focus specifically on the silvery minnow. They cite declining stream flows and deteriorating water quality as the suspected environmental stressors responsible for the observed faunal changes.

Hubbs et al. (1977) documented the "inexplicable" absence of silvery minnow from a reach of the Rio Grande of Texas between El Paso and its confluence with the Pecos River where Hubbs (1958) had earlier documented the species to occur. However, Chernoff et al. (1982) noted that the Rio Grande between El Paso and the mouth of the Rio Conchos is at times virtually dry. Sublette et al. (1990) documented the former occurrence of the silvery minnow in the Rio Grande between Caballo Reservoir, New Mexico and El Paso, Texas where the river channel is often dry.

Hybridization and/or competition with nonnative congener species have operated to displace the silvery minnow from its formerly occupied range in the Pecos River. The silvery minnow was displaced in the Pecos River of New Mexico by its congener *H. placitus* (plains minnow) that was apparently introduced during 1968 into the Pecos drainage, probably from the Canadian Drainage (Cowley, 1979). The displacement that ensued was complete in less than one decade. The plains minnow has also been introduced into the Rio Grande of Texas (U. S. Fish and Wildlife Service, 1999). Acknowledging that there is uncertainty about the mechanism and circumstances of displacement, and until there is conclusive evidence to the contrary, a conservative person would not refute the possibility that a similar outcome (displacement) would result if the two species of *Hybognathus* should come in contact in the Middle Rio Grande.

Predation and competition with other fish species has been cited as a factor possibility contributing to the decline of the species (e.g., U. S. Fish and Wildlife Service, 1999). Approximately 90 species of fish occurred sympatrically with the silvery minnow within the species' historic range, including piscivorous species and those with similar feeding habitats. That the silvery minnow evolved with competition and predation seems obvious. Furthermore, beginning in the late 1800's, accidental or purposeful releases of fishes outside of their native ranges, including those from bait and aquarium sources, have established a host of exotic fish species in the Rio Grande Basin (Sublette, 1990), each representing a potential competitor or predator with the silvery minnow. The effects of such stressors on populations of silvery minnow are unquantified. Competition among fish species often evokes resource partitioning through selective and interactive segregation. The turbidity of water that prevails over the contemporary range of the silvery minnow effectively serves to lessen the impacts of would-be predators because the effective predatory strike zone is shortened. The interactions alluded to in the previous paragraph, i.e., involving an exotic congener, are among the most readily apparent of the possible damaging interspecific interactions.

The aerographical extent and variability of historically occupied habitats, along with the spatial arrangement of those historic silvery minnow populations, once afforded the species relative security against extinction. The most

[7] "River continuum" refers to gradual changes in the biological community of a river as energy sources and physical conditions change from headwaters to lowlands. For more discussion, see Vannote et al., 1980).

[8] Edwards and Contreras-Balderas (1991) confirm that the only time the lower Rio Grande (downstream of Falcon Reservoir) went dry in recorded history was the 1950's event reported by Trevino-Robinson (1959).

important influence of spatial arrangement on overall viability is the extent to which populations of silvery minnow at different sites share the same fate at the same time. The risk of extinction is reduced with an increased number of high quality (extinction resistant) populations with independent fates. The former ability of silvery minnow populations to colonize habitats, especially potamon[9] habitats that are relatively environmentally benign, served to reduce the risk of extinction. Antithetical situations, typical within the contemporary range of silvery minnow, have the expected effect of increasing the probability of extinction.

The entrainment of silvery minnows (primarily eggs and larvae) in the infrastructure of irrigation systems that derive water directly from the Rio Grande has been cited as a factor contributing to the decline of the species (e.g., U. S. Fish and Wildlife Service, 1999). The Service has studied the effects of LFCC experimental operations on the fish community throughout the upper 11 miles of the Socorro Division. The study determined that silvery minnow eggs were entrained and that catch rates between paired LFCC and Rio Grande monitoring sites were not significantly different. Fish monitoring conducted monthly in the LFCC has also indirectly documented the entrainment of young-of-year and adult silvery minnow since the number of fish always significantly increased immediately after operation. The incidence of egg entrainment in irrigation canals has also been documented (e.g., Reclamation, 2003). Beyond this, there is a dearth of information about how irrigation practices and the infrastructure that accommodates such practices impinge directly on recruitment and indirectly on other components essential to the viability of the species. Prominent information deficits pertain to:

- a statistically reliable estimate of the number of silvery minnow eggs and larvae that become and remain entrained in irrigation canals;
- the impact of different river discharge flow rates and volumes of irrigation diversion on the incidence of egg and larvae entrainment and the rate of egg and larvae transport, i.e., the incidence of egg and larvae entrainment correlated to variation in flow, the timing and volume of irrigation diversion, irrigation head gate design, including any mediating provisions; and
- the biological significance of the foregoing issues in terms of silvery minnow prospects of long-term survival, e.g., how extinction probability varies with the rate of irrigation system entrainment of silvery minnow eggs and larvae.

The viability of contemporary populations of silvery minnow remains threatened by river engineering efforts to regulate or otherwise alter geomorphic processes in the river. Traditional river engineering activities within the Rio Grande have served to confine the Rio Grande to its channel and isolate it from the land for the purposes of preventing flooding and to remove water from catchments as soon as possible to, among other reasons, reduce depletions of water. Channels have been straightened and deepened, and aquatic plants and snags have been removed to lessen hydrologic resistance. Conventional river engineering projects have, therefore, reduced the retention time of water and organic matter. Likewise, conventional river engineering projects have reduced the surface area and physical complexity of the habitat, reduced refugial habitats, and altered the strength and outcome of species interactions.

The viability of the contemporary populations of silvery minnow remains threatened by efforts to regulate or otherwise alter the magnitude and variability of flow in the Rio Grande,[10] and by the out-of-channel extraction of water for consumptive uses, utilizing water either directly from the river or from groundwater sources. In general, the Rio Grande from approximately five miles downstream of N. M. Highway 49 at Los Lunas to the vicinity of Ft. Craig (a distance of approximately 90 river miles) could be classified as an influent[11] system. Approximately half of this reach (representing roughly 43 river miles) is very vulnerable to channel drying. General river reaches most vulnerable to channel drying include:

- Approximately five miles downstream of N. M. Highway 49 at Los Lunas to the Jarales Bridge, downstream of Belen (involving approximately 18 river miles).
- Approximately six miles downstream of Escondida Bridge to the south boundary of Bosque del Apache Wildlife Refuge (involving approximately 21 river miles).
- From San Marcial to the vicinity of Ft. Craig (involving approximately four river miles).

---

[9] *Potamon* refers to the warmer and lower gradient river of the lowlands. Unaltered, the potomon is characterized by slower currents, finer substrate materials, and variety of size, depth and flow of the river channel, including large river channels, oxbows, sloughs, and habitats of the floodplain. Autochthonous inputs of organic materials support a preponderance of detritivores, herbivores, and planktivores (compare rhithron; footnote 23).

[10] Bayley and Li (1996) offer general, yet compelling evidence of the dependence between year-to-year variability of fish population size and discharge.

[11] An *influent* stream reach commonly experiences a net loss of water as it flows downstream, including into the ground. Contrast this type with an *effluent*, or gaining river reach.

Near the upstream extension of the contemporary range of the silvery minnow, Cochiti Dam and Reservoir interrupts the continuum of the Rio Grande at a critical faunal transition zone, an area formerly characterized by a proliferation of fish species, rendering otherwise habitable and perennial portions of the species' historically occupied range wholly unsuitable for supporting a viable population of silvery minnow.[12] Within other portions of the species' contemporary range, ephemeral conditions, cross channel irrigation diversions (some of which have, over time, become barriers to the upstream movement of silvery minnows), and large mainstem dams have combined to fragment the remaining stocks of the species. Many of the resultant subpopulations have become less abundant and subject to a host of problems intrinsic to low population abundance, including most notably those associated with low productivity (i.e., depensatory deterministic effects[13]) and genetic processes (i.e., demographic stochasticity[14]).

The foregoing passages reference several "reasons for decline" that can be aggregated under the general heading "habitat loss." Loss of habitat can occur with channel drying (as a result of meteorological drought conditions, out-of-channel extraction of water for consumptive uses, including from groundwater sources, and reservoir storage of water), conversion of habitat features from potamon to rhithron (which, for example, can be caused by the imposition of large water impoundments and levees), channel straightening and other geomorphic channel alterations (which, for example, reduces surface area and physical complexity of the habitat, and reduces retention time of water and organic matter), and pollution.

4.2 Southwestern Willow Flycatcher

4.2.1 Status and Distribution

A final rule to list the southwestern United States population of the willow flycatcher as an endangered species under the ESA with proposed critical habitat was published in the Federal Register (February 27, 1995). The final rule designating critical habitat for the species range-wide did not include the Rio Grande (Federal Register, 1997). The willow flycatcher is classified as threatened by the State of New Mexico.

The species occurs in southern California, Arizona, New Mexico, southern portions of Nevada and Utah, western Texas, and possibly southwestern Colorado (Federal Register, 1995). In 2001, Arizona, New Mexico, and California accounted for 93% of the known willow flycatcher sites in this region; 88% of the total known territories within these states are found along the Gila River drainage while the Rio Grande in Colorado and New Mexico contribute the second largest number of territories to the overall population (Sogge et al., 2002).

In New Mexico, the willow flycatcher has been observed in the Rio Grande, Rio Chama, Zuni, San Francisco, and Gila River drainages. Willow flycatchers were first reported at Elephant Butte State Park in the 1970's, although the exact locations of the sightings were not documented (Hubbard, 1987). Because surveys have not been consistent or extensive prior to the listing of this species, a comparison of historic numbers to the current status, is not possible; however, the available native riparian habitat along the Rio Grande has declined over time and it is assumed that willow flycatcher populations have declined as well.

Since the initial surveys of the Rio Grande Valley in the 1990's, breeding pairs have been found within the Middle Rio Grande Project area from Elephant Butte Reservoir upstream to the vicinity of Española. Several locations along the Rio Grande have consistently been occupied by breeding flycatchers. These areas are considered core population sites or locations where one or more willow flycatcher pairs have established a territory in an attempt to breed and the birds returning to these same sites annually may be considered a meta-population. In some locations, these meta-populations appear to be expanding with an increased number of territories. Some populations have remained small (10-15 territories) but stable; other sites have become extirpated and no longer contain territorial flycatchers. Surveys for willow flycatchers in select areas of the Middle Rio Grande were conducted as a part of environmental compliance activities for various projects. Although a thorough and consistent survey effort throughout the riparian corridor of the Middle Rio Grande has not occurred, reaches of the river with the most suitable habitat for flycatchers have been routinely surveyed. Presence/absence and nest monitoring surveys along selected areas of the Rio Grande have been conducted from 1993 to 2002. With expanded or increased survey efforts during this nine-year period, several sites have been located where flycatcher territories have consistently been established. Once located, most of these population sites or core breeding areas have been monitored annually. Information concerning Middle Rio Grande breeding populations of willow flycatchers for 2001 and 2002 are considered in the biological baseline for the BA.

---

[12] Support for this assertion, including within the context of aquatic ecotonal areas, can be found in Gore (1996).
[13] *Deterministic density effects* fall into two competing processes: *compensation* (an increase in productivity with decreasing density) and *depensation* (a decrease in productivity with decreasing density).
[14] *Demographic stochasticity* refers to random events associated with mate choice, fecundity/fertility and sex ratios.

Six general locations of flycatcher population sites or metapopulations have been established throughout the Middle Rio Grande (Figure 3). The number of territories, pairs, nest attempts and successful nests in these areas has changed through the years.

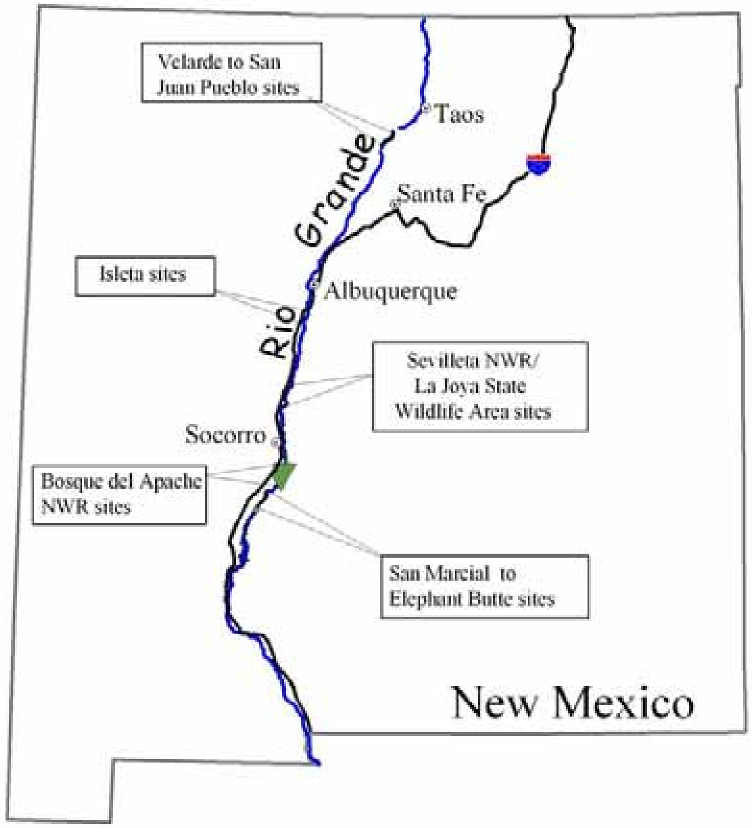


Figure 3. Six General Locations of Flycatcher Population Sites in the Middle Rio Grande of New Mexico.

The San Marcial Reach of the Middle Rio Grande has been surveyed for willow flycatcher by various researchers since 1994 (Mehlhop and Tonne, 1994; Henry et al., 1996; Ahlers and White, 1995- 1999; Ahlers et al., 2000-2002). This population site has increased and expanded since the initial surveys. In 1994, approximately 11 willow flycatcher territories were located south of the Bosque del Apache NWR (all near the railroad bridge). The population in this river reach remained between 9-12 territories through 1999. By 2000, the birds had dispersed and expanded with the development of new riparian vegetation in the receding reservoir pool. Approximately 63 territories were located in 2002 with all but 12 located within and adjacent to the delta of Elephant Butte Reservoir (receding conservation pool).

Portions of the Bosque del Apache NWR have been surveyed for willow flycatchers annually since 1993. The wetland areas within the inactive floodplain have consistently attracted between 2-4 territories during this period. The active floodplain channel, or river corridor encompassed by the refuge was recently surveyed in 2002 and three territories were located (Ahlers and Moore pers. com., 2002). An additional territory was located within a refuge management unit outside of the flood plain.

Flycatchers on the Sevilleta NWR and La Joya State WMA were initially discovered in 1999 with four territories. Surveys have continued in this area since that time, with 6 territories located in 2000, 11 territories in 2001 and 13 territories in 2002.

Three willow flycatchers territories were detected in the Isleta Reach in 1994 (Mund and Kimball, 1994). Surveys continued and expanded on the Isleta Pueblo in 1995 and 1996 with 3-4 territories located annually. Most recent surveys were conducted in 2000 with 14 territories located (Johnson and Smith, 2000).

Several areas have been surveyed on the San Juan Pueblo periodically from 1993 through 2000. Approximately 2-4 territories were located between 1993 and 1995. The population appeared to expand to 10 territories in 1996, 13 territories in 1997 and 16 territories (8 pairs and 8 nests) during the most recent survey in 2000.

Flycatcher surveys were initiated along the Rio Grande near Velarde, New Mexico in 1994. Several areas along the river and adjacent community acequias have been periodically surveyed from 1994 to 2002. In 1995, this area supported a maximum of six territories (between one to three territories at each of the following sites: La Canova, La Rinconada, El Guique and Garcia Inlet). During 1999 and 2001, this area supported only one territory and most recently in 2002, no territories were found. This population site appears to be the least stable with limited success possibly due to fragmented habitat near human development.

Surveys for willow flycatchers and surveys for suitable habitat for the species along the Rio Chama below Abiquiu Dam in 1994 failed to find any willow flycatchers and only small areas of potential habitat (Eagle Ecological Services, 1994). However, a Service biologist did record an unidentified *Empidonax* about a quarter-mile from the Rio Chama near Chili, New Mexico (Eagle Ecological Services, 1994). These data indicate the lower Rio Chama may be used by flycatchers to a limited extent. Between 2-4 willow flycatcher territories were identified each breeding season from 1993-1998 in the Rio Chama drainage near Parkview, above Heron Reservoir (NMDGF, 1993-1998). However, suitable willow flycatcher habitat along the Rio Chama is very limited, resulting in few occurrences of the species in this drainage. No surveys have been conducted since 1998.

Breeding willow flycatchers have been documented at various other sites on private lands within the Middle Rio Grande particularly in the San Marcial area. Cursory observation in 2000 indicated that at least eight territories were on private lands near the San Marcial Railroad Bridge; however, no official surveys have been conducted in these known or other suspected sites on private lands and data is not available.

4.2.2 Life History and Ecology

The willow flycatcher is a late spring/summer breeder that builds nests and lays eggs in late May and early June and fledges young in late June or early July (Sogge et al., 1993; Tibbitts et al., 1994). Based on data from flycatcher surveys and nest monitoring along the Middle Rio Grande, particularly at the San Marcial Reach, willow flycatchers have been documented in the area as early as May 6; however, actual nest initiation has been documented to occur later in May (Ahlers et al., 2001). Flycatchers that re-nest or produce a second brood can remain in the nesting area through the end of August. Flycatcher nesting chronology for the Middle Rio Grande generally occurs from May 30 to August 15 (detailed nesting chronology is described in baseline sections).

The willow flycatcher is an obligate riparian species occurring in habitats adjacent to rivers, streams, or other wetlands characterized by dense growths of willows (*Salix* sp.), seepwillow (*Baccharis* sp.) arrowweed (*Pluchea* sp.), saltcedar (*Tamarix* sp.), or other species (Federal Register, 1995). This habitat is often associated with a scattered overstory of cottonwood (*Populus* sp.) (Federal Register, 1995).

Nesting habitat for the willow flycatcher varies greatly by site and includes species such as willow, saltcedar, box elder *(Acer* spp.), and Russian olive (*Elaeagnus angustifolia*). Species composition, however, appears less important than plant and twig structure (Ahlers pers. comm.). Slender stems and twigs are important for nest attachment. Nest placement is highly variable. Nests have been observed at heights ranging from 0.5 m to 10 m and generally occur adjacent to or over water (Sogge, pers. comm.). Along the Middle Rio Grande, breeding territories have been found in young and mid-age riparian vegetation dominated by dense growths of willows at least 15 feet high as well as in mixed native and exotic stands dominated by Russian olive and saltcedar.

For nesting, a majority of the birds within the Middle Rio Grande select habitat patches dominated by native species, usually dense willows. Within these willow patches, nests have been found on individual saltcedar plants (35% n = 119), especially in older, taller willow patches where an understory of saltcedar provides suitable nesting substrate. It appears that the tree species with the vertical structure of more slender stems and twigs on younger plants in the understory vegetation is selected for nest placement. Most recently, nests located at the Sevilleta NWR and La Joya State Wildlife Management area have been established in areas adjacent to the river dominated by saltcedar and Russian olive; however, the overall vegetation type of most of the flycatcher territories established in the Middle Rio Grande is dominated by native species (76%, n = 119) and not saltcedar (12%, n = 19). More detailed habitat discussions are in the environmental baseline section.

A critical component for suitable nesting conditions is the presence of water usually provided by overbank flooding or some other hydrologic feature. Nests have been consistently found along the Rio Grande within 150 feet of surface water (usually a flowing channel). In rare cases in Arizona, birds have nested over 300 feet from water (Sogge et al., 2000). Nesting appears to be initiated only after high flows and groundwater levels have created and maintained at least moist soil conditions underneath the nest tree. In summary, the willow flycatcher depends on higher river flows in spring to create wet or moist soils near nest areas to provide optimum conditions for nest initiation. Frequent spring flooding enhances the development of new willow riparian habitat. Not all stream reaches have the potential to develop suitable breeding habitat. Even where conditions are optimal, and where the hydrological and ecological settings are appropriate for willow flycatcher habitat, other factors may prevent contiguous suitable habitat from developing along a stream reach (Sogge et. al., 2000).

Migrating willow flycatchers, along with many other migrant species of Neotropical land birds, use the Rio Grande riparian corridor as stop over habitat. Studies have shown that during the spring and fall migration, willow flycatchers are more commonly found in willow habitats than in other riparian vegetation types, including the narrow band of coyote willows that line the LFCC above the Bosque del Apache NWR (Finch et al., 1997). Migrating willow flycatchers are frequently observed throughout the Middle Rio Grande Project area during surveys in May and early June. These birds utilize a variety of vegetation types during migration, many of which are classified as "low suitability" breeding habitat (Ahlers and White, 1997).

4.2.3 Reasons for Decline

During the last two centuries, human induced hydrological and ecological changes have heavily influenced the composition and extent of floodplain riparian vegetation along the Middle Rio Grande (Bullard and Wells, 1992; Dick-Peddie, 1993). Introduction of exotic species, such as saltcedar, has decreased the availability of dense willow and associated desirable vegetation and habitat important to willow flycatchers. Fragmentation of forested breeding habitat may also play a role in population reduction of migratory birds (Lynch and Whigham, 1984; Wilcove, 1988). In addition, the rapid rate of deforestation in tropical areas has been cited as a possible reason for population declines in species of migrant forest dwelling land birds (Lovejoy, 1983; Rappole and McDonald, 1994; Robbins et al., 1989).

Brood parasitism by brown-headed cowbirds (*Molothrus ater*), has been implicated in the decline of songbirds including those found in the western riparian habitats (Gaines, 1974, 1977; Goldwasser et al., 1980; Laymon, 1987). Brown-headed cowbirds have increased their range as a result of human activities, including clearing forests, intensive grazing and agriculture. Willow flycatchers are more susceptible to brown-headed cowbird nest parasitism because of the ease of "egg dumping" in the flycatcher's open cup nest design. Habitat fragmentation and forest openings allow cowbirds easy access to host nests located near these edges. Nest parasitism combined with declining populations, have placed this species in a precarious situation (Mayfield, 1977; Rothstein et al., 1980; Brittingham and Temple, 1983; Laymon, 1987).

4.3 Bald Eagle

4.3.1 Status and Distribution

General

The bald eagle was federally listed as endangered in 1967 (32 FR 4001) and again in 1978 (43 FR 6233). The Service has reclassified the bald eagle from endangered to threatened in the lower 48 States (however, this action does not alter those conservation measures already in force to protect the species and its habitat). The bald eagle also occurs in Alaska and Canada, where it is not at risk and is not protected under the ESA. Bald eagles in Mexico are also not listed at this time. Bald eagles breed from Alaska to Newfoundland and southward to Baja California, Texas, Florida, and the southwestern United States.

According to the Federal Register announcing the reclassification (Federal Register, 1995), the bald eagle population has clearly increased in number and expanded in range. The improvement is a direct result of banning DDT and other persistent organochlorines, habitat protection, and other recovery efforts. The Service has recognized the achievement of specific recovery plan reclassification goals. In the Southwestern Recovery Region (Arizona, New Mexico, and Western Texas), these goals included 10-12 young per year over a 5-year period, and expansion of the population range to include one or more river drainages in addition to the Salt and Verde systems. The progress to date in the Southwestern Recovery Region includes 30 occupied breeding areas reported in 1994, with 21 young produced and expansion of the breeding range to include the Gila, Bill Williams, and San Carlos River systems in Arizona and the Rio Grande in New Mexico. Therefore, the reclassification criteria have been fully met (Federal Register, 1995).

New Mexico

In New Mexico, the bald eagle is a winter migrant from the northern border and southward to the Gila, lower Rio Grande, middle Pecos, and Canadian valleys. Key habitat areas include winter roost and concentration areas, such as Navajo Lake, the Chama Valley, Cochiti Lake, the northeastern lakes, the lower Canadian Valley, Sumner Lake, Elephant Butte Lake, Caballo Lake, and the upper Gila Basin. These sites have large numbers of waterfowl from November to March and fisheries supported by reservoirs that provide the prey base to support foraging eagles. Winter and migrant populations seem to have increased in New Mexico, apparently as the result of reservoir construction and the expansion of fish and waterfowl populations. This species is found occasionally elsewhere in New Mexico, in the summer. In the last decade, there have been two active bald eagle nests in New Mexico, one each in Colfax and Sierra counties.

The Corps has conducted two annual aerial winter surveys for bald eagles in the Middle Rio Grande (Albuquerque to Rio Chama confluence) and Rio Chama from 1988 through 1996. Table 1 presents results of these surveys. Some years have additional flights from February, but data here are limited to January surveys for comparison across years. The mean annual number of sightings from 1988 to 1996 is 64.

REACH	SAMPLE DATE								
	1/5/ 1988	1/18/ 1989	1/29/ 1990	1/8/ 1991	1/14/ 1992	1/22/ 1993	1/20/ 1994	1/24/ 1995	1/24/ 1996
Rio Grande - Albuquerque to Jemez River confluence	0	2	0	0	2	0	0	2	3
Jemez River - Rio Grande to Jemez Canyon Reservoir (included)	2	0	1	3	0	1	0	0	0
Rio Grande - Jemez River to Cochiti Dam	8	23	9	11	16	20	13	10	3
Cochiti Lake	18	1	3	4	9	7	5	6	4
Rio Grande - Cochiti Lake to Rio Chama	13	12	5	6	14	25	6	7	15
Rio Chama -Rio Grande confluence to Abiquiu Dam	9	6	9	8	7	4	6	6	6
Rio Chama - Abiquiu Reservoir	4	5	0	2	1	0	3	1	3
Rio Chama - Abiquiu Reservoir to El Vado Dam*	3	5	12	31	14	31	53	30	28
TOTALS	57	54	39	65	63	88	86	62	62

Table 1. Winter Counts of Bald Eagles on the Rio Grande (Albuquerque to Rio Chama Confluence) and Rio Chama. Data were obtained from aerial censuses conducted by the Corps during January each year from 1988 to 1996. Data include sightings for both adult and immature birds.
* Surveys in 1988 and 1989 did not include a portion of the Rio Chama below El Vado Dam.

The NMDGF conducted annual winter bald eagle surveys in seven areas of the state between 1982-1990. Table 2 presents a summary of the mid-winter bald eagle counts at Elephant Butte and Caballo reservoirs.

Year	Day	Number of Eagles at both Reservoirs	Number of Eagles in New Mexico	% of State Total
1982	Jan. 15	31	258	12.0
1983	Jan. 11	20	235	8.5
1984	Jan. 13	7	178	3.9
1985	Jan. 02	14	214	6.5
1986	Jan. 13	30	308	9.7
1987	Jan. 14	31	306	10.1
1988	Jan. 14	53	294	18.0
1989*	Jan. 06	57	219	26.0
1990	Jan. 17	113	512	22.1

Table 2. Mid-winter Counts of Bald Eagles at Elephant Butte and Caballo Reservoirs, January 1982-1990.
Data were obtained from aerial censuses (S. O. Williams, NMDGF, May 31, 1990).
* No aerial survey for bald eagles was conducted in 1989. These were counted during waterfowl transects using different survey techniques, and routes, and are not comparable to surveys in other years.

Surveys conducted by New Mexico State University between 1992 and 1995 along the Rio Grande from Las Cruces to Bosque del Apache NWR revealed a significant winter population of bald eagles at Elephant Butte Reservoir (Nicholopoulos and Zwank, 1996). In all but two months (April and May 1994), more eagles occurred at Elephant Butte than Caballo Reservoir or the Rio Grande above and below these reservoirs (Table 3). During the three year study period, bald eagles counted in January accounted for between 46-63 percent of the total number recorded at Caballo Reservoir and counts in February accounted for between 36-37 percent of the total numbers recorded. The daily peak number of eagles in each year all occurred in January; January 29, 1993 (22 eagles), January 28, 1994 (25 eagles), and January 25, 1995 (23 eagles). Bald eagle numbers were lowest in December (2-5 individuals), April (0-4 individuals) and May (0-3 individuals).

Month	Location	1992-1993	1993-1994	1994-1995
December	Caballo Reservoir	no census	2	5
	Elephant Butte	no census	6	23
	Rio Grande	no census	0	0
January	Caballo Reservoir	no census	17	19
	Elephant Butte	no census	48	36
	Rio Grande	no census	0	0
February	Caballo Reservoir	2	20	10
	Elephant Butte	17	61	27
	Rio Grande	0	0	0
March	Caballo Reservoir	0	4	10
	Elephant Butte	8	21	18
	Rio Grande	0	0	0
April	Caballo Reservoir	0	4	0
	Elephant Butte	5	3	5
	Rio Grande	0	0	0
May	Caballo Reservoir	no census	3	0
	Elephant Butte	no census	1	3
	Rio Grande	0	0	0

Table 3. Winter Counts of Bald Eagles in the Rio Grande Riparian Corridor from Las Cruces to Bosque Del Apache National Wildlife Refuge, New Mexico.
Data were obtained from aerial censuses conducted from December through May 1992-1995 (Nicholopoulos and Zwank, 1996).

Table 4 summarizes bald eagle counts and distribution as observed from a fixed-wing aircraft during 1997-99 over Rio Grande from San Acacia Diversion Dam to Narrows of Elephant Butte Reservoir.

River Reach	1/23/97	2/27/97	3/27/97	4/17/97 5/28/97	11/4/97	1/27/98	1/27/99	2/11/99
Socorro	0	0	0	0	0	0	NS	NS
Bosque del Apache (active floodplain)	3 (3/0)	0	0	0	0	0	3 (2/1)	0
Bosque del Apache (backwaters on east side)	0	2 (0/2)	0	0	0	2 (1/1)	0	0
San Marcial (active floodplain)	2 (2/0)	0	0	0	0	0	0	0
San Marcial (west side groundwater wetlands)	1 (1/0)	0	0	0	0	1 (1/0)	0	0
Elephant Butte Reservoir (east side) north of Dryland Road	0	2 (2/0)	0	0	0	4 (2/2)	6 (3/3)	3 (3/0)
Elephant Butte Reservoir (west side) wetlands north of Dryland Road	1 (0/1)	8 (6/2)	0	0	1 (1/0)	5 (3/2)	3 (2/1)	1 (1/0)
Elephant Butte Reservoir (east side) Dryland Road to Nogal Canyon	9 (6/3)	14 (8/6)	0	0	0	4 (2/2)	8 (5/0) 3 (3/0)*	0
Elephant Butte Reservoir (west side) Dryland Road to Nogal Canyon	12 (8/4) 45(30/15)*	9 (4/5) 16(17/9)*	6(3/3)	0	1 (0/1)	17 (9/8)	18(11/7) 28(16/12)*	3 (2/1)
Elephant Butte Reservoir (east side) Nogal Canyon to Narrows	6 (1/5)	1 (0/1)	0	0	0	0	2 (1/1) 12(6/6)*	1 (0/1)
Elephant Butte Reservoir (west side) Nogal Canyon to Narrows	5 (3/2)	6 (6/0)	0	0	2 (1/1)	9 (6/3)	3 (2/1)	9 (5/4)
TOTAL	32 (24/15)	42 (26/16)	6 (3/3)	0	4 (2/2)	42(24/18)	43(26/17)	17(10/7)

Table 4. Bald Eagle Counts and Distribution along the Rio Grande Riparian Corridor from San Acacia Diversion Dam to the Narrows of Elephant Butte Reservoir. Data were from fixed-wing aerial surveys. Numbers in parentheses indicate proportion of adult/immature bald eagles observed. * = bald eagles observed during on-ground evening roost survey. NS = reach not surveyed.

4.3.2 Life History and Ecology

Adults of this species are easily recognized by their white heads and tails and dark bodies. Immature bald eagles have pale areas on the head, back, breast and/or abdomen, and can be confused with golden eagles. The bald eagle is associated with aquatic ecosystems throughout most of its range, with nesting usually occurring within 2 miles of water. The typical diet of bald eagles is fish, with many other types of prey such as waterfowl and small mammals, depending on location, time of year, and population cycles of the prey species (Federal Register, 1995). In New Mexico, these birds typically roost in groups in trees at night, usually in protected areas such as canyons (NMDGF, 1988). The general daily routine for a wintering bald eagle is to leave its roost at dawn for its foraging grounds, feed until midmorning, perch for most of the midday, and possibly feed again in the late afternoon before returning to its roost site (Hawkwatch, 1993).

Nest sites are usually in large, sturdy trees along shorelines in relatively remote areas. The nest is often 6-9 feet across and more than 3 feet thick. Cliffs and rock outcrops are also selected as nest sites where large trees are not available (Federal Register, 1995).

4.3.3 Reasons for Decline

The main threats to wintering bald eagle populations are habitat loss and degradation, including declines in prey and availability of roost-sites. Disturbance, contamination, and illegal taking are also threats for the bald eagle (NMDGF, 1988). Various river developments have occurred over the past one hundred years that have eliminated or controlled the dynamic components of the historic river system. Without these natural processes constantly changing and shaping the floodplain characteristics, the abundance and quality of riparian vegetation has decreased. Particularly during low water or drought years, the most dynamic areas in the Middle Rio Grande are the receding headwaters of reservoirs. Human disturbance near foraging areas probably poses a substantial threat to wintering eagles since birds will choose to move to a more secluded area with possibly less prey.

The major threats in the foreseeable future are destruction and degradation of the bald eagle's habitat and environmental contaminants. Destruction and degradation of habitat occur through direct cutting of trees for shoreline development, human disturbance associated with recreational use of shorelines and waterways, and contamination of waterways from point and non-point sources of pollution. In the Southwestern Recovery Region, the accelerated pace of development activities within eagle habitat and the extensive area involved are the most significant limiting factors for the eagle. The cumulative effects of many development projects impinge on the ability to maintain current nesting populations and ultimately may limit the extent to which recovery may occur. A significant amount of new habitat has been created in the form of reservoirs.

4.4 Interior Least Tern

4.4.1 Status and Distribution

The interior least tern (*Sterna antillarum*) was listed as endangered by the Service in 1985 (50 CFR 21784). This species historically bred along the Colorado (in Texas), Red, Rio Grande (in Texas), Arkansas, Missouri, Ohio, and Mississippi river systems and has been found on braided rivers of southwestern Kansas, northwestern Oklahoma and southeastern New Mexico (American Ornithologists' Union, 1957). In New Mexico, the least tern was first recorded (including nesting) at Bitter Lake National Wildlife Refuge in 1949, and since then, it remained present essentially annually (Marlatt, 1984). The species occurs as a migrant in Eddy County, New Mexico and as a vagrant elsewhere, including Española, Sumner Lake, Bosque del Apache National Wildlife Refuge, near Glenwood, Las Cruces, and Alamogordo (NMDGF, 1988).

4.4.2 Life History and Ecology

Habitat requirements for this species include the presence of bare or nearly bare ground on alluvial islands or sandbars for nesting, the availability of food (primarily small fish), and the existence of favorable water levels during the nesting season so nests remain above water (Ducey, 1981). Breeding colonies contain from 5-75 nests. Although most nesting occurs along rivers, the tern also nests on barren flats of saline lakes and ponds.

4.4.3 Reasons for Decline

Loss of nesting areas through permanent inundation or destruction by reservoir and channelization projects was identified as the major threat to the species. Alteration of natural river or lake dynamics has caused unfavorable vegetation succession on many remaining islands, curtailing their use as nesting sites by terns. Recreational use of sandbars, releases of water from reservoirs, and annual spring floods often inundate nests.

5 ENVIRONMENTAL BASELINE

5.1 Introduction

Regulations implementing the ESA (50 CFR 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects that have undergone Section 7 consultation, and the impacts of State and private actions that are contemporaneous with the consultation in progress.

5.2 Corps of Engineers

Environmental baseline sections relevant to proposed actions of the Corps were described in detail in the June 2001 BA (Reclamation 2001). This BA incorporates by reference those relevant sections found on pages 141-156 of that report.

5.3 Proposed Federal Actions with Early or Completed Consultation

The following includes federal actions that are ongoing or proposed that have completed early, informal, or formal Section 7 consultation.

5.3.1 Rio Grande and Low Flow Conveyance Channel Modifications

Reclamation prepared a draft Environmental Impact Statement dated September 8, 2000 for the proposed action associated with Rio Grande LFCC modifications. On May 3, 2001, a biological assessment was submitted to the Service requesting formal consultation pursuant to Section 7 of the ESA for the preferred alternative, the "Bottom-up Realignment Alternative." The proposed action involves a significant realignment, to the west, of the Rio Grande and LFCC in the reach between San Marcial, New Mexico and Elephant Butte Reservoir. The proposed action involves only physical changes to the channel system. Operation of the LFCC and Rio Grande in that area is being considered separately as part of the Upper Rio Grande Basin Water Operations Review and EIS. The preferred alternative is to conduct the realignment beginning at the bottom (near the headwaters of Elephant Butte) and moving northward in phases. In the biological assessment, Reclamation has made the determination that the preferred alternative "may affect, and is likely to adversely affect" the silvery minnow and willow flycatcher. A determination of "may affect, is not likely to adversely affect" was made for the bald eagle. In addition, a determination of "will not result in the destruction or adverse modification of critical habitat" for the silvery minnow was made. Two extensions of the formal consultation have been requested by the Service and both were granted by Reclamation.

Environmental commitments for the Rio Grande and Low Flow Conveyance Channel Modifications Project include measures to minimize impacts to cottonwood snags and exclude construction activities within 0.25 miles of occupied willow flycatcher breeding territories and to minimize turbidity effects of construction activities.

5.3.2 Low Flow Conveyance Channel Experimental Operations

Reclamation reinitiated consultation (Cons. #2-22-95-I-131) for experimental operations of the LFCC in March 1999 to address more recent information concerning entrainment of silvery minnow (Smith and Hoagstrom, 1997). Based on conservation recommendations outlined in the previous consultation and additional mitigation and monitoring opportunities, the Service again concurred with Reclamation's determinations of may affect, not likely to adversely affect for the silvery minnow and willow flycatcher. LFCC experimental diversions may continue through the 2004 runoff season.

Diversion from the river into the LFCC may reduce the flows in the river and limit the frequency and magnitude of over bank inundation. The LFCC experimental diversions may affect, but are not likely to adversely affect, the development of riparian vegetation that currently is considered potential flycatcher breeding habitat. The riparian vegetation in some areas could develop into suitable flycatcher breeding habitat with additional growth enhanced with surface water.

Diversion of water from the river into the LFCC may alter aquatic habitat in the Rio Grande during the times diversions are made. The aquatic habitat in the Rio Grande will not be reduced to a level that would limit availability nor quality of habitats suitable to the silvery minnow. Thus, the proposed diversions for experimental operations are unlikely to affect the silvery minnow in this area of the Rio Grande, and will not result in an adverse modification or destruction of proposed critical habitat. Diversion of water into the Conveyance Channel may entrain silvery minnows or their eggs, which may affect, and is likely to adversely affect the silvery minnow. Silvery minnows entrained in the LFCC may be further adversely affected by efforts to remove aquatic plants.

As part of the environmental commitments for the LFCC experimental operations, Reclamation will monitor over-bank inundation, the extent and duration of wet/moist soils and the development of potential flycatcher breeding habitat components within the affected river reach.

Willow flycatcher environmental commitments associated with the LFCC Experimental Operations Project include:

- Maintenance of the LFCC outfall following experimental operations.
- Funding willow flycatcher presence-absence surveys and nest monitoring along the Middle Rio Grande. Habitat sites will be assessed for their potential for willow flycatchers.
- Coordination meetings will be scheduled with the Service each year to review proposed experimental operations, scheduling and river flows in the Socorro Reach.

Silvery minnow environmental commitments associated with the LFCC Experimental Operations Project include:

- Maintenance of the LFCC outfall following experimental operations.
- Conducting experimental operations outside of the peak spawning period (May 10 to May 25).
- Conducting surveys for fish in the LFCC before removal of parrot feather.
- Conducting surveys for fish in the LFCC at the conclusion of experimental operations to check for stranded silvery minnows.
- Conducting surveys for fish quarterly in the LFCC and the Rio Grande.
- Funding annual surveys of silvery minnow eggs during May in the Rio Grande and during May and June experimental operations in the LFCC.
- Collecting data regarding silvery minnow macrohabitat in the Socorro Reach.
- Developing a database and analysis tools to study aquatic habitat and fish communities in the Socorro Reach.
- Scheduling a coordination meeting with the Service each year to review proposed experimental operations, scheduling and river flows in the Socorro Reach.

5.3.3 Low Flow Conveyance Channel Mowing

In September 1996, Reclamation submitted a biological assessment to the Service addressing potential impacts of proposed mowing along the LFCC on the willow flycatcher, silvery minnow, and bald eagle (consultation number- #2-22-96-1-069). The Service concurred with Reclamation's determination of "may affect, not likely to adversely affect" for the willow flycatcher and bald eagle and "no affect" to the silvery minnow. Reclamation has modified its vegetation mowing program as described in the aforementioned assessment along a 23.7-mile reach of the LFCC (between Escondida Bridge and extending south to the Bosque del Apache NWR). The assessment provided a mowing plan that identified mowing between 20-31 percent of the LFCC within this reach on a rotational basis that would provide three age classes of vegetation every year, including the maximum amount of the most mature age class possible.

Environmental commitments for the LFCC mowing activities restrict the time and extent of mowing. Specifically, mowing will be limited to times outside of the April 1 – September 1 period, and each mowing will be restricted to 30% of the specified reach of the LFCC and will be performed on a rotational basis. Mowing will be suspended if a bald eagle is observed perched within 0.5 miles of the mowing operations.

The mowing plan was implemented as an interim plan in 1996 and continued until 2000. A request was submitted to the Service in December 2002, to extend the interim 4-year plan to a long-term mowing plan for this section of the LFCC, which is located outside the most current proposed realignment of the LFCC.

5.3.4 Elephant Butte Temporary Channel Project

In May 2000, Reclamation submitted a biological assessment to the Service for the construction of a temporary channel through the delta area of Elephant Butte Reservoir to increase the efficiency of sediment and water conveyance. An additional project goal was to initiate some degradation of the riverbed through the San Marcial Reach to increase overall channel capacity and potentially allow for higher peak releases from Cochiti Dam during subsequent spring runoff periods.

Measures were implemented to minimize impacts on the silvery minnow and willow flycatcher and their associated habitats and to enhance local riparian conditions. These environmental actions included adding sinuosity to the temporary channel, constructing the channel with variable width, constructing low water crossings along the temporary channel to allow overbank flows to inundate existing native riparian vegetation and encourage native revegetation, and a channel widening project in the southern reach of the Bosque Del Apache Refuge to improve aquatic and riparian habitat. The Service concurred with Reclamation's determination that the project may affect, but is not likely adversely affect, either the silvery minnow or the willow flycatcher provided that additional monitoring and annual reporting be included for the silvery minnow. Work on this project is ongoing.

5.3.5 Los Lunas Habitat Restoration Project

The Los Lunas Habitat Restoration Project is a joint effort of Reclamation, the Corps, and the MRGCD. The Project fulfills the June 29, 2001 Biological Opinion requirement for a habitat restoration project in the Belen Reach. The project is on the west bank of the river about five miles downstream of Los Lunas in an area of the bosque that was severely burned in 2000. Restoration of the site involved removal of jetty jacks and lowering of the bank along a 6,000-foot reach of the river. Some 80,000 cubic yards of material was excavated to lower 40 acres to a level that will be inundated at a river discharge of 2,500 cubic feet per second. Side channels and other habitat features were incorporated in the earthwork and grading. In addition, the project includes the removal of trees killed by the fire, revegetation, and construction of wetlands.

Earthwork at the site was substantially completed in the fall of 2002. Revegetation work is scheduled for 2003 if funding is available.

5.3.6 City of Albuquerque Drinking Water Project

On November 12, 2002, Reclamation submitted a biological assessment to the Service for the proposed City of Albuquerque Drinking Water Project and requested formal Section 7 consultation. The City proposes to construct and operate a surface water diversion of the Rio Grande, with associated water treatment and transmission facilities, to use the City's San Juan-Chama Project water to provide a sustainable drinking water supply for its citizens. The preferred diversion method has been identified as a new inflatable surface diversion dam to be constructed on the Rio Grande north of Paseo del Norte in Albuquerque. Reclamation is serving as the lead federal action agency because a Reclamation license, or Reclamation approval of a license, between the MRGCD and the City would be required for project construction. Reclamation has granted applicant status to the City pursuant to 50 CFR 402.02. Reclamation has determined in the BA that the proposed action, "may affect, is likely to adversely affect" the silvery minnow and "may adversely affect, modify or destroy proposed critical habitat" for the species. In addition, Reclamation has determined that the proposed action, "may affect, is not likely to adversely affect" the willow flycatcher and bald eagle. By letter dated January 13, 2003, the Service responded that a biological opinion would be provided on or before May 21, 2003.

Environmental commitments associated with the proposed City of Albuquerque Drinking Water Project include numerous environmental enhancement elements: bank lowering, bank destabilization, bank/terrace channel cuts, sediment management, exotic vegetation removal, native plant revegetation, construction of a fishway, pipeline routes that minimize activity in undisturbed areas, support of aquaculture efforts, fish salvage during construction, maintenance of an open channel during construction, restricting diversion-structure construction to the winter low-flow period, and a diversion-structure design that incorporates screens and a sluice-way to protect fish.

5.3.7 Elephant Butte and Caballo Reservoirs Resource Management Plan EIS

Reclamation submitted a biological assessment to the Service by letter dated August 15, 2000 for the proposed Elephant Butte and Caballo Reservoirs Resource Management Plan (RMP). Reclamation determined that the proposed action "may affect, is not likely to adversely affect" the silvery minnow, willow flycatcher, and bald eagle. Reclamation also determined that the proposed action "will not destroy or modify critical habitat" for the silvery minnow. The Service concurred with Reclamation's determinations by letter dated November 8, 2002, provided that the following conditions are followed: 1) utilization monitoring as described in the project proposal; 2) existing exclosures are not compromised by livestock use; 3) utilization by livestock of available current year's growth does not exceed 30 percent in the potential habitat areas identified by the interagency working group; 4) construction of the additional proposed enclosures occurs as identified in the biological assessment; and 5) monitoring in both suitable and potential habitat shows that livestock grazing use at the prescribed levels is not having negative effects on threatened or endangered species or their habitats.

5.3.8 General Environmental Commitments from Early or Completed Consultations

The following are general environmental commitments from the aforementioned consultations:

5.3.8.1 Southwestern Willow Flycatcher

Construction disturbance will be avoided near occupied and known flycatcher territories from April 15 through August 15. A predetermined, standard-setting buffer distance around willow flycatcher territories has not been established; instead, such buffer zones will be defined on a case-by-case basis (Reclamation, 2001).

Future project sites with occupied or suitable habitat shall be surveyed for at least one breeding season prior to the start of any project activities. If flycatchers are detected within the boundaries of proposed projects, consultations will be initiated with the Service. It is Reclamation's intent to use the principles of adaptive management and monitor project sites sufficiently to accumulate the necessary data and information for future decision-making (Reclamation, 2001).

Reclamation will minimize the number of new transects that are cleared in conjunction with river surveying activities. As referenced in the 2001 BA, the collection and use of hydrographic data from transects provides for better management of the Middle Rio Grande floodplain and river channel. Transect clearing or maintenance will not occur in occupied habitat. Out-of-use transects will be allowed to revegetate. Brushing will occur only when necessary for project purposes. In the event that transect brushing is necessary, brushing or surveys during the breeding period (April 15 through August 15) shall be avoided to minimize disturbance. Suitable or potential flycatcher habitat can also be avoided in certain cases by limiting brushing to the river's edge and not clearing beyond that point. All sites proposed for transect clearing will be reviewed by Reclamation biologists. If it is determined that the site is not suitable or potential willow flycatcher habitat, transect clearing will proceed under the above conditions (Reclamation, 2001).

By restoring the active river channel through sediment plug management in the San Marcial Reach, Reclamation's river maintenance program helps to prevent prolonged, detrimental inundation of riparian and willow flycatcher habitat.

5.3.8.2 Rio Grande Silvery Minnow

Reclamation will continue to conduct fish population monitoring at established locations in the Middle Rio Grande between Angostura Diversion Dam and the headwaters of Elephant Butte Reservoir. Pre- and post-construction monitoring for fish species will continue at constructed and proposed river maintenance sites through the Middle Rio Grande (Reclamation, 2001).

If it is necessary to redirect flows away from a construction site, steps will be taken to allow flows to recede from the area gradually so silvery minnow can avoid entrapment. Any disconnected aquatic habitat, e.g., isolated pools, associated with a river maintenance site will be sampled for silvery minnow which, if found, will be relocated into adjacent areas of flowing water (Reclamation, 2001).

Construction activities requiring the movement of equipment within the river channel will avoid potential silvery minnow habitat to the extent possible. When feasible, xeric conditions will be sought to minimize direct impacts of construction activities to silvery minnow. While many of the proposed habitat enhancement activities involve extensive construction activity in or near the river channel, disturbance to the aquatic environment will be minimized (Reclamation, 2001).

5.3.8.3 Bald Eagle and Interior Least Tern

Reclamation will continue to conduct winter bald eagle surveys from Elephant Butte Dam to the southern boundary of the Bosque del Apache National Wildlife Refuge (Reclamation, 2001).

If an eagle is present within 0.25 mi upstream or downstream of the active project site in the morning before project activity starts, or following breaks in project activity, the contractor will be required to suspend all activity until the bird leaves of its own volition, or Reclamation biologists, in consultation with the Service, determines that the potential for harassment is minimal. However, if an eagle arrives during construction activities or if an eagle is beyond that distance, construction need not be interrupted. If bald eagles are found consistently in the immediate project area during the construction period, Reclamation will contact the Service to determine whether formal consultation is necessary (Reclamation, 2001).

5.4 Contemporary Non-Federal Actions

As discussed above, anticipated future non-federal actions related to water operations for which consultation is sought are specified in the Description of Proposed Actions Section. Other non-federal actions which are not described as proposed actions in this BA but are contemporaneous with the consultation in process include activities that may affect habitat other than river flow, such as building a road, clearing vegetation, or enhancing aquatic or terrestrial habitat.

5.5 Geomorphology

The geomorphic characterization of the Middle Rio Grande provides a framework within which resource managers can effectively communicate morphologic and hydraulic river conditions. Aquatic and riparian habitat condition can also be represented through a geomorphic characterization. Numerous river classification methodologies are available, varying in geomorphic and hydraulic detail and perspective. A historical geomorphic description of the Middle Rio Grande using six geomorphic characterization techniques was presented in the June 2001 BA to provide a thorough description of the current channel planform. The Middle Rio Grande from Velarde to the headwaters of Elephant Butte Reservoir was divided into ten subreaches (as defined in the Area of Action section); Velarde, Española, White Rock Canyon, Cochiti, Middle, Belen, Rio Puerco, Socorro, San Marcial, and Hot Springs. Subreach delineation was based on similarities in channel processes and patterns and the known position of channel controls. Representative morphologic and hydraulic channel parameters were quantified for each reach, with the exception of the White Rock Canyon Reach.

This BA incorporates by reference the detailed description of environmental baseline geomorphology on pages 113 to 137 in Reclamation's 2001 BA (Reclamation, 2001).

5.6 Hydrology

Introduction

While the Middle Rio Grande has become a regulated and confined river system, the general character of the annual hydrograph remains the same. Figure 4 displays the mean monthly discharge (cfs ± one standard deviation) of the Rio Grande at Otowi gauge above Cochiti Lake based on U. S. Geological Survey data from 1895-1999. It is emphasized that maximum (peak spring runoff and summer rain events) and minimum (low/zero flow during dry periods) discharges are not illustrated in this type of presentation. Figure 4 reveals the general characteristics of the Rio Grande hydrograph at Otowi gauge as having a relatively low baseline condition from about August through February followed by an increase in discharge associated with spring runoff from mid-March through mid-July, which, as indicated, is highly variable.

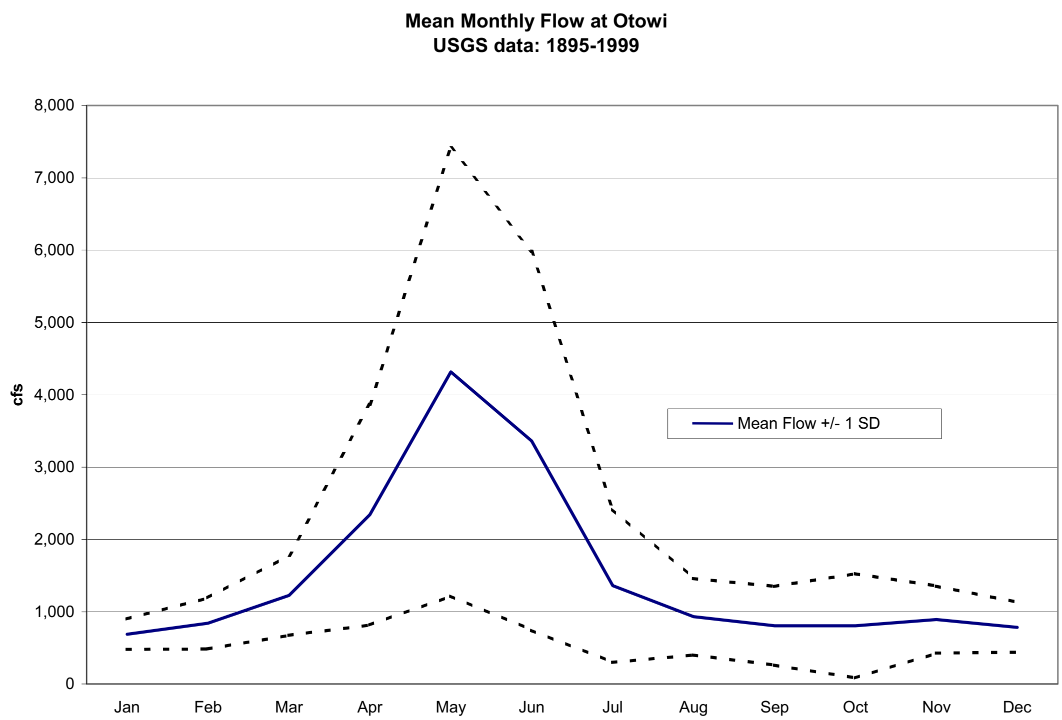


Figure 4. Mean Monthly Discharge (cfs; ± one standard deviation) of the Rio Grande at the Otowi Gauge. (U. S. Geological Survey data, 1895-1999).

Prediction of flow in the Rio Grande, instantaneous or some time-delimited aggregate, is difficult given the variability of the hydrograph. A distinction should be made between predictions arising from projection and those made from inference. In making predictions, a scientist may extrapolate future events from a model of past and present trends. In such a projection or forecast from past trends, one is assuming (1) that causal relations will continue to operate as they have in the past, and (2) that the model (or equation) being used to fit past data accurately reflects all sources of past and future variability in the magnitude of the event. In other words, we assume that the future will behave like the past and that we know accurately what the past has been like. In making predictions about complex systems, like the fluvial system of the Rio Grande, we may not be able to arrive at a prediction through projection, either because (1) we may not have adequate past observations on which to build a model for extrapolation or (2) we may have reason to believe that the future may not be like the past.

Predictions by inference may involve estimations of likelihood of some event occurring, based on past performance from analogous situations. The inferential measure always has a probabilistic base.

5.6.1 Article VII of the Rio Grande Compact - Historic Duration of Storage Restrictions

Under Article VII of the Rio Grande Compact, whenever usable water in Project storage is less than 400,000 acre-feet, neither New Mexico nor Colorado may increase the storage of native Rio Grande Basin water in upstream reservoirs constructed after 1929. Usable water is defined as water in Elephant Butte and Caballo reservoirs that is available for release to the Rio Grande Project. During July 2002, Article VII storage restrictions went into effect for the first time since June of 1979. The following paragraphs provide a brief description of historic episodes during which Article VII restrictions have been active.

Article VII of the Rio Grande Compact has been in effect approximately 30% of the time from 1940 through 2002. Based on an analysis of this entire 62-year period, storage restrictions have remained in effect for an average period of approximately one year once storage restriction under Article VII are declared. The average length of time with no Article VII storage restrictions is slightly over two years, based on the entire 62-year history.

A significantly different pattern emerges if the relatively wet climatic years of the 1980's and 1990's are removed from the analysis. If only the years from 1940 through 1979 are considered, Article VII restrictions have been in effect approximately 47% of the time. The average period with Article VII restrictions is approximately one year, and the average period with no Article VII restrictions is just slightly over one year in length. There are frequent periods during which Article VII storage restrictions have been alternately invoked then removed over periods as short as one to six months, as Rio Grande Project usable storage oscillates around 400,000 acre-feet. Alternatively, there have been five episodes between 1951 and 1980 where Article VII compact restrictions were in place for 20 or more consecutive months before being lifted.

Article VII restrictions were essentially in effect during the entire 7-year period from August 1950 through August 1957. During this time span, there were only three periods that sum to less than eight months when added together, when there were no storage restrictions under Article VII. The longest consecutive period under Article VII restrictions lasted longer than four years, during the period between the spring of 1953 and the summer of 1957.

Restrictions imposed by Article VII nearly completely prohibit the ability to store native Rio Grande water upstream of Elephant Butte Reservoir. In New Mexico, the primary impacts of Article VII storage prohibitions are experienced at El Vado Reservoir. Under normal operations, Reclamation will capture and store water during the spring runoff to help insure that an adequate supply is available for full Middle Rio Grande Project (MRGP) operations throughout the irrigation season. Without the ability to capture and store during the spring runoff, MRGP facilities rely on direct diversions from the Rio Grande mainstem. If native Rio Grande flows drop to minimal levels and the annual allocation of trans-basin SJ-C water is depleted, irrigation must be curtailed within the MRGP facilities. Early cessation of MRGP operations can have an adverse impact on endangered species through the reduction of return flows to the Rio Grande.

5.6.2 Recent Water Operations

Recent annual water operations for the years 1996 – 2000 were described in the 2001 BA (Reclamation, 2001). This BA incorporates by reference the description of past hydrology found on pages 97 – 110 of that report.

The following summarizes the annual water operations that have occurred since the 2001 BA was finalized.

2001 Operations

The 2001 spring runoff began in mid April, and continued through mid to late June. Runoff peaked at Otowi gauge in mid May with a maximum discharge of approximately 3,300 cfs. The estimated unregulated runoff volumes for the Rio Grande Basin were generally much lower than forecasted, resulting in below average stream flows along most of the watershed. March-July runoff stream flows at Otowi Bridge and San Marcial are estimated to be 98% and 82% of average, respectively.

Reclamation repaid 14,245 af of the 20,900 af owed to MRGCD as specified in the August 2, 2000 Agreed Order in *Minnow v. Keys.* Of this total, 9,255 af was leased from various SJ-C contractors, and 4,990 af was uncontracted 2001 SJ-C water.

Approximately 2,600 af of the City of Albuquerque's San Juan-Chama Project water was released and exchanged with native Rio Grande water from June 23 through July 4 to provide a gradual recession of flows as spring runoff terminated. MRGCD also assisted the managed recession through the release of approximately 900 af of native Rio Grande water from June 23 through June 28. These coordinated releases provided for a managed recession that did not exceed the recommended flow reduction rate of $\leq$ 50 cfs over a two-day period.

A Memorandum of Understanding and Conservation Water Agreement were executed between the State of New Mexico and the United States allowing for the interim establishment and operation of the Middle Rio Grande Endangered Species Conservation Pool (Conservation Pool) in Abiquiu and Jemez Canyon reservoirs for the benefit of the silvery minnow (U. S. Army Corps of Engineers, 2001). The volume of stored Conservation Pool water peaked on June 17, 2001 when the combined Conservation pools in Abiquiu and Jemez contained 50,115 af. A total of 25,624 af of water was released from the Conservation Pool from July 2 through October 29. There were several days during this time when no releases occurred. The average release was just under 100 cfs. At the end of the year, 26,945 af remained in storage within Abiquiu

Reservoir for 2002 operations. All of the Conservation Water Agreement storage in Jemez Canyon Reservoir (7,627 af) was released in 2001 for the benefit of the silvery minnow and the entire sediment retention pool was released from Jemez Canyon Reservoir completely draining the reservoir by the end of October 2001.

Reclamation operated and maintained 16 pumps between Socorro and Elephant Butte Reservoir to transfer water from the LFCC to the Rio Grande during the 2001 irrigation season. Approximately 25,000 af was pumped from the LFCC to the Rio Grande between June 21 and November 1, 2001.

A near average snow pack and summer monsoons along with the cooperative management of Conservation Pool water and flexible irrigation operations generally maintained continuous flow throughout the Middle Rio Grande during the 2001 irrigation season. Limited river drying occurred, however, intensive monitoring and salvage efforts led to the successful rescue of silvery minnow from critical reaches.

2002 Operations

During 2002, extreme drought conditions prevailed in the Rio Grande Basin of New Mexico, resulting in the worst spring runoff on record. Hydrologic conditions in 2002 were much like those in 1977, the second most severe drought on record, except there was no natural spike in spring runoff flows in 2002. At the start of irrigation season, reservoir storages in the Rio Grande Basin of New Mexico were below normal – storage was 79% of the 1971-2000 normal. March-July total discharges at Otowi Bridge and San Marcial were estimated to be 42% and 5% of average, respectively. August-October total discharges at Otowi Bridge and San Marcial were estimated to be 69% and 38% of average, respectively. At the end of the 2002 irrigation season, reservoir storage in the Rio Grande Basin was 34% of the 1971-2000 normal.

Supplemental water was released from Abiquiu Reservoir at the rate of 300 cfs from May 2, 2002 through May 30, 2002. This volume of water, along with agreed-upon operational protocol with the MRGCD assured a flow of 150 cfs at San Acacia Diversion Dam.[15] However, flows at San Marcial dropped well below 50 cfs (the June 29, 2001 BO standard of flow for that place and time) on several occasions during May and June 2002. No effects on the listed species resulted from these low flow events beyond those already considered in the June 29, 2001 BO. From June 2002 until the end of the irrigation season, flow remained above the June 29, 2001 BO requirements at all locations. San Marcial gauge flows remained well over 200 cfs from mid-November to the end of the year.

In an attempt to continue to meet the June 29, 2001 BO standards of flow, Reclamation leased approximately 2,300 af of supplemental water from willing San Juan-Chama contractors, managed nearly 27,000 af of water stored by the State of New Mexico under the Conservation Water Agreement, and entered into a contract with the City of Albuquerque for up to 40,000 af of additional supplemental water managed in concert with 70,000 af of water provided to MRGCD for continued irrigation. However, even with access to the aforementioned City of Albuquerque water (totaling 110,000 af), Reclamation did not anticipate being able to meet the June 29, 2001 BO standards of flow by late September 2002. It was anticipated that MRGCD would run out of irrigation water in early September 2002.[16] Likewise, it was anticipated that Reclamation's supplemental water supply would be depleted by late September.[17] However, late season precipitation allowed Reclamation to remain in compliance with the June 29, 2001 BO to date.

MRGCD used more than 180,000 af of water to meet its irrigation demands in 2002. MRGCD non-Indian storage in El Vado Reservoir was depleted on September 7, 2002, and under requirements of the Rio Grande Compact, will not be refilled for use in 2003 because Article VII of the Rio Grande Compact, which went into effect on July 2, 2002 for the first time in 23 years, prohibits storage of native Rio Grande Basin waters in post compact reservoirs, including El Vado Reservoir.[18] This compact storage prohibition will continue until "usable" stored water in Elephant Butte and Caballo reservoirs – water that is legally available and obligated to meet downstream water demands in New Mexico, Texas, and Mexico – increases to more than 400,000 af.

During 2002, channel drying occurred in the Rio Grande from Jarales to Bernardo, Louis Lopez (downstream of Socorro) to Tiffany (including the reach of river adjacent to Bosque del Apache Refuge), and at numerous shorter "spot" segments south of San Marcial within Elephant Butte Lake State Park.

---

[15] The Rio Grande Water Management Agreement dated June 29, 2001 was established, in part, to ensure compliance with the reasonable and prudent alternatives and measures in the June 29, 2001 Biological Opinion for water operations on the Middle Rio Grande. In that agreement, the Middle Rio Grande Conservancy District agreed to "provide sufficient water from whatever non-Indian source to assure that 50% of the amount of water delivered by the United States at Isleta Diversion Dam is passed over San Acacia."

[16] Irrigation releases are required for effective supplemental water delivery for the silvery minnow.

[17] In reality, the last supplemental release was made on October 20, after which all released water has been native Rio Grande or SJ-C "letter water" released under the direction of the State to account for depletions of various SJ-C contractors.

[18] This limitation does not apply to water storage by the United States to guarantee sufficient water supply for the six Middle Rio Grande Pueblos' Prior and Paramount water rights. On November 1, 2002, Reclamation began capturing and storing water in El Vado Reservoir for the senior Indian water rights of the six Middle Rio Grande Pueblos, which pre-date the compact.

The documented discretionary flow-mediated incidental take of silvery minnow was limited to 248 adults during 2002 (Jude Smith, U. S. Fish and Wildlife Service, personal communication) – a level of mortality that is within the Incidental Take statement allowance.[19] Intensive monitoring and salvage efforts led to the successful rescue of silvery minnow from critical reaches. Salvage efforts have transferred over 3,500 silvery minnows to upstream areas and several hundred thousand eggs to rearing facilities.

[19] The Service anticipates that up to 25,000 adult silvery minnows and 75,000 silvery minnows under 30 millimeters in total length may be taken in any year due to the federal and non-federal actions described and analyzed in the biological opinion. On August 1, 2002, the Service issued a revised method for enumerating incidental take of adult silvery minnows, allowing for a total observed take of 500 adults.

5.6.3 Environmental Baseline Hydrology

Ongoing drought conditions in the Rio Grande and San Juan basins have greatly affected reservoir levels within the Rio Grande Basin. Heron Reservoir, part of the San Juan-Chama Project, ended 2002 at approximately 40% of full capacity. At the end of 2002 there remained less than 6% and 24% of full capacity at El Vado and Abiquiu Reservoirs respectively. These depleted reservoir conditions, coupled with Article VII Rio Grande Compact restrictions anticipated to be in place for all of 2003 described in Section 5.6.1, set the stage for the 2003 water year.

Reclamation developed a hydrologic baseline for the BA that, in accordance with ESA implementing regulations, excludes the effects of the proposed action from the baseline. This approach is taken to assist in incrementally determining the effects of the proposed action on the species when compared to the baseline condition.

Constraints and Assumptions

The following constraints were selected as defining the Environmental Baseline conditions for the development of hydrologic scenarios:

- No diversion into Middle Rio Grande Project (MRGP) facilities for the purposes of irrigation of MRGCD Indian and non-Indian lands.
- National Wildlife Refuges will be allowed to take water as required for their operations.
- No dedicated operations for six Middle Rio Grande Pueblos at El Vado Reservoir.
- No San Juan – Chama Project (SJ-C) releases for any purpose.
- Constant inflow of 70 cfs from City of Albuquerque's wastewater treatment plant.
- No actions specifically intended to provide benefits to endangered species.

Hydrologic scenarios developed for at least the years of 2003 and 2004 must also comply with the constraints imposed by Article VII of the Rio Grande Compact in addition to those constraints selected to define the Environmental Baseline. Under Article VII, no water can be captured for storage within post-1929 reservoirs, with the exception of water for the six Middle Rio Grande Pueblos, when usable storage within Elephant Butte and Caballo reservoirs drops below 400,000 acre-feet, a condition which occurred in early July of 2002. Article VII with its associated impacts is expected to remain in effect into 2004 and possibly beyond, depending on the climatic conditions that occur in New Mexico and southern Colorado.

All contributions from precipitation downstream of La Puente on the Rio Chama, Embudo on the Rio Grande, and Jemez on the Rio Jemez are not included because no viable way could be identified to predict and then model the impact of storm inflows.

Methodology

The analysis used to develop the descriptions of potential hydrologic conditions for the various scenarios was largely qualitative in nature, because there does not currently exist a method for accurately modeling and predicting the hydrologic conditions within the Rio Grande to the resolution required to predict the timing, location, and lateral extent of river drying or intermittency. Because of the time constraints imposed for completion of this BA and in the absence of an appropriate model, qualitative descriptions of potential hydrologic conditions were developed using the methodology described in the following paragraphs.

Hydrographs were created to approximate the hypothetical flows that would occur below Cochiti Dam if only native Rio Grande water were passing through the system, and no releases or storage of native Rio Grande occurred at upstream reservoirs. These hydrographs were created using historic flows recorded at the following gauging stations: Rio Grande at Embudo, Rio Chama near La Puente, and Jemez River near Jemez. These stations are all located upstream of all major reservoirs and diversions within the mainstem of the respective rivers in which they are located. The contributory flow that originates from the City of Albuquerque's discharge of treated wastewater was included because of the consistent nature of this inflow. This was incorporated as a constant inflow of 70 cfs just upstream of the Isleta Diversion Dam.

The historic flows recorded at Embudo and La Puente for the selected year were summed to derive an approximate hydrograph representative of the Rio Grande at Otowi Bridge. No lags were applied to account for different travel times from Embudo to Otowi, and La Puente to Otowi. Accepted standard channel loss rates were then applied to this approximate native Rio Grande at Otowi hydrograph to derive the approximate hydrograph below Cochiti Dam. A lag time was not applied to temporally shift the hydrograph between Otowi Bridge and Cochiti Dam. This same technique was then applied to develop approximate hydrographs at other downstream locations using approximate channel loss rates derived from historic URGWOM reach losses.

Historic flows recorded for the Jemez River near Jemez were added at the confluence of the Jemez River and the Rio Grande. Flow lag times and loss rates were not applied to temporally and quantitatively shift flows within the reach of the Jemez River from the gauge location to the River's confluence with the Rio Grande. Hydrographs created to represent conditions downstream of the confluence of the Jemez River and the Rio Grande include the application of approximate channel loss rates.

Using the described methodology, hydrographs were created to approximate native Rio Grande flows at Cochiti, San Felipe, Central Avenue Bridge at Albuquerque, Isleta, Bernardo, San Acacia, and San Marcial. These hydrographs were then used to evaluate and describe the potential occurrences of drying within the various river reaches based on historic observations of river drying episodes. This analysis is particularly difficult to perform for the constraints specified by the environmental baseline because of either the complete lack of historic precedence and data for the specified conditions, or the lack of data for any reasonably recent occurrence of conditions similar to those specified by the constraints.

In order to take advantage of modeling work completed by the URGWOM Team for Reclamation's 2003 water operations, the 1996 calendar year was used to approximate conditions for the dry runoff scenario of the Environmental baseline. Hydrology from the 1989 calendar year was used to approximate conditions for the average runoff scenario of the environmental baseline.

It is extremely important to note that these hydrographs neglect all contributions from precipitation that are not already reflected within the historic gauge flows measured at Embudo, La Puente, and Jemez, because no viable way could be identified to predict and then model the impact of storm inflows. A brief analysis of historic precipitation data recorded at Socorro, Albuquerque, Santa Fe, Taos, and Chama indicates that monthly monsoonal precipitation in excess of 0.25 inches occurred during 53% to 85% of the months of May depending on location, and 93% to 97% of the months of August. Monthly monsoonal precipitation in excess of one inch occurred during 16% to 55% of the months of May depending on location, and 64% to 91% of the months of August. It is clear from this brief analysis that the assumption of no monsoonal moisture is extremely conservative and unlikely to represent actual conditions. The period of record that was utilized for this brief analysis contains 70 years of data for Socorro, Albuquerque, and Santa Fe, and 53 years of data for Taos and Chama.

By neglecting any benefits derived from monsoonal moisture, the described hydrologic conditions approach the worst case for the particular scenarios that are described. Depending on the occurrence and magnitude of monsoonal storms, actual conditions could vary from the near worst-case scenarios that are described, through conditions that result from a favorable monsoon season with little or no river drying and intermittency.

Description of Environmental Baseline – Dry Hydrologic Scenario

Absent the proposed actions, Rio Grande drying could occur below San Acacia as early as the 3rd or 4th week in May. Historic records for San Marcial indicate that drying could occur earlier than April, as flows less than 1 cfs have been recorded during every month of the year from January 1st through December 31st.

Based on historic observations, initial drying would likely occur near the center of Bosque del Apache National Wildlife Refuge, and extend rapidly to the north and south over the following weeks. By mid to late June, complete river drying could extend from north of San Acacia Diversion Dam to a point south of the Fort Craig pumping station and north of Elephant Butte Reservoir. Complete rewetting of the river through these reaches for the remainder of the year would likely occur in late August or early September. Historic records for San Marcial indicate that the river could remain dry or intermittent well into November before complete rewetting occurs. Assuming no monsoonal moisture, 50 to 60 miles of river from north of San Acacia to south of Fort Craig could remain intermittent or dry for as long as 17 weeks (Figure 5).

During this same period, periodic and intermittent drying could occur within a 30 to 40 mile stretch of the Rio Grande between Tome and San Acacia. Assuming no monsoonal moisture, intermittency within this area could occur from early June through late August (Figure 5).

The stretch of Rio Grande from below Cochiti Dam to Isleta would remain nearly continuous throughout the year. Flows could drop below 100 cfs for extended periods within the limits of the City of Albuquerque, but north of the City's treated wastewater discharge point in the South Valley. Albuquerque's waste water treatment plant discharges a continuous flow of approximately 70 cfs into the Rio Grande approximately nine miles north of Isleta Diversion Dam. Sporadic and isolated short-term periods of intermittency could possibly occur north of the City's wastewater discharge point during the months of July and August (Figure 5).

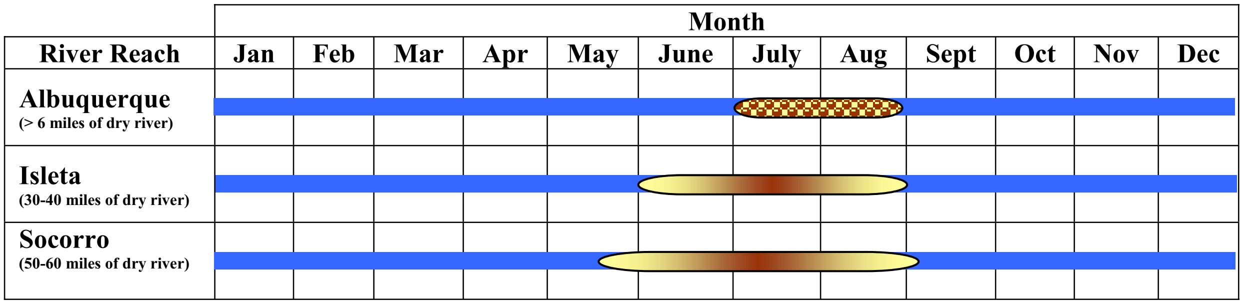


Figure 5. Spatial and Temporal Representation of Anticipated Baseline Intermittent flow under "Dry" Hydrologic Conditions.

The blue bar indicates continuous flow. Brown indicates intermittent flow; yellow indicates recession or progression of flows; brown spots against a yellow background indicate sporadic and short-term periods of intermittency. The blending of colors (brown vs. yellow) indicates a time of transition as conditions change from perennial to intermittent, or the antithetical condition.

Comparison of Environmental Baseline – Dry Hydrologic Scenario to Historic Gauge Data

A database was assembled that contains historic daily river flows measured at Albuquerque, San Acacia, and San Marcial over the 45 year period from 1956 through 2000. This database was used to provide some analysis of conditions using actual historic flow data for comparison with the hypothetical scenarios described in the Environmental Baseline.

It must be noted that these percentages represent actual historic zero flow occurrences under river management practices that existed at the time that the measurements were made. River management practices that were employed at various times from 1956 through 2000 can include active and complete diversion of the Rio Grande into the Low Flow Conveyance Channel at San Acacia, diversion into MRGP facilities and irrigation of Indian and non-Indian land by MRGCD, active operation of all existing reservoirs for storage and release, SJ-C water releases, and actions specifically targeted to benefit endangered species. Thus, this comparison is only used to verify the dry environmental baseline hydrologic scenario and is not considered part of the baseline.

Based on the total annual flow recorded at Embudo and La Puente, 1996 represents the 10th driest year from 1956 through 2000 with a recorded flow of 417,526 acre-feet. The driest year occurred in 1977, with a total annual combined flow at Embudo and La Puente of 256,256 acre-feet. The wettest year within this record occurred in 1985, when the combined Embudo and La Puente flow was 1,872,072 acre-feet. The average of the flows recorded at Embudo and La Puente over the entire 45-year period is 853,141.

For this analysis, the 45-year record was subdivided into three categories representative of "dry years," "average years," and "wet years." These divisions were simply made by sorting the years using the annual summed flows recorded for Embudo and La Puente, and then categorizing the years into 15 year slots. This results in a slightly different categorization when compared to the technique used in the previous BA, where "dry years" were defined as < 80% of average, "normal years" were defined as 80% to 120% of average, and "wet years" were defined as > 120% of average.

Using the definition of the previous BA where a measured flow less than 1 cfs was slotted as equivalent to zero flow (dry river) at a gauge, the number of zero flow days was summed by month for Albuquerque, San Acacia, and San Marcial. This analysis is summarized in Table 5 for "dry years" in terms of percentage of days with zero flow for the months of May through October.

Historic Percentage of Days with Zero Flow – "Dry Years"						
Location	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**
Albuquerque	3%	12%	17%	9%	6%	20%
San Acacia	0%	13%	31%	11%	24%	13%
San Marcial	65%	73%	62%	44%	45%	54%

Table 5. Historic Percentage of Days with Zero Flow – "Dry Years"

Description of Environmental Baseline – Average Hydrologic Scenario

Rio Grande drying could occur below San Acacia as early as the 3rd or 4th week in June. Based on historic observations, initial drying would likely occur near the center of Bosque del Apache National Wildlife Refuge, and extend rapidly to the north and south over the following weeks. By late June, complete River drying could extend from south of San Acacia Diversion Dam to a point south of the Fort Craig pumping station and north of Elephant Butte Reservoir. Complete rewetting of the river through these reaches for the remainder of the year would likely occur in late August or early September. Assuming no monsoonal moisture, as much as 50 miles of river from south of San Acacia to south of Fort Craig could remain intermittent or dry for as long as 11 weeks (Figure 6).

During this same period, periodic and isolated episodes of river intermittency could occur within a 30 to 40 mile stretch of the Rio Grande between Tome and San Acacia. Assuming no monsoonal moisture, intermittency within this area could occur from early July through late August (Figure 6).

The stretch of Rio Grande from below Cochiti Dam to Isleta would likely remain continuous throughout the year. Flows could drop below 150 cfs for extended periods within the limits of the City of Albuquerque, but north of the City's treated wastewater discharge point in the South Valley. Albuquerque's waste water treatment plant discharges a continuous flow of approximately 70 cfs into the Rio Grande approximately nine miles north of Isleta Diversion Dam. Sporadic and isolated short-term periods of intermittency could possibly occur north of the City's wastewater discharge point during the months of July and August (Figure 6).

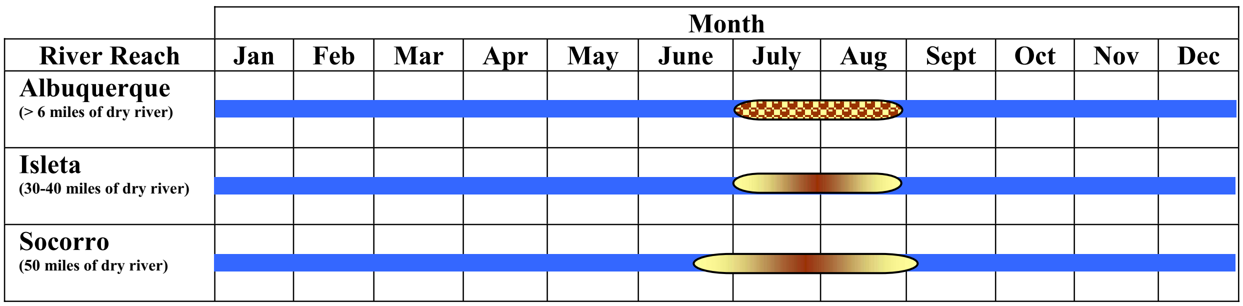


Figure 6. Spatial and Temporal Representation of Anticipated Baseline Intermittent Flow Under "Average" Hydrologic Conditions.
The blue bar indicates continuous flow. Brown indicates intermittent flow; yellow indicates recession or progression of flows; brown spots against a yellow background indicate sporadic and short-term periods of intermittency. The blending of colors (brown vs. yellow) indicates a time of transition as conditions change from perennial to intermittent, or the antithetical condition.

Comparison of Environmental Baseline – Average Hydrologic Scenario to Historic Gauge Data

Based on the total annual flow recorded at Embudo and La Puente, 1989 represents the 17th driest year from 1956 through 2000 with a recorded flow of 622,032 acre-feet. Although 1989 is slotted as an "average" year using the methodology previously described, it ranks near the extreme dry end of the average slot. As a result, the description of "average" hydrologic conditions, as represented by the 1989 hydrograph, should be considered conservative.

It must be noted that these percentages represent actual historic zero flow occurrences under river management practices that existed at the time that the measurements were made. River management practices that were employed at various times from 1956 through 2000 can include active and complete diversion of the Rio Grande into the Low Flow Conveyance Channel at San Acacia, diversion into MRGP facilities and irrigation of Indian and non-Indian land by MRGCD, active operation of all existing reservoirs for storage and release, SJ-C water releases, and actions specifically targeted to benefit endangered species. Thus, this comparison is only used to verify the average environmental baseline hydrologic scenario and is not considered part of the baseline.

Using the definition of the previous BA where a measured flow less than 1 cfs was considered equivalent to zero flow (dry river) at a gauge, the number of zero flow days was summed by month for Albuquerque, San Acacia, and San Marcial. This analysis is summarized in Table 6 for "average years" in terms of percentage of days with zero flow for the months of May through October.

Historic Percentage of Days with Zero Flow – "Average Years"						
Location	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**
Albuquerque	0%	0%	0%	0%	5%	9%
San Acacia	0%	3%	3%	8%	8%	3%
San Marcial	11%	30%	54%	38%	45%	54%

Table 6. Historic Percentage of Days with Zero Flow – "Average Years"

5.7 Biology

5.7.1 Ichthyofauna

This section describes the collective historic anthropogenic impacts to the native ichthyofauna of the Rio Grande of New Mexico, with emphasis on the silvery minnow, its associated biological community, and its habitat in the action area. The focus of this section is on organizing information so that the many potential consequences, or impacts, of the proposed action can be assessed. Such analysis consists largely of making observations about program elements – the contemporary situation, proposed management activities, and expected outcomes – and relating them to one another. The crux of analysis (section 6) involves a comparison of the expected resultant condition with the "no action" environmental baseline. Beyond this, the environmental baseline reveals how chronic environmental stressors, independent of the proposed action, have operated to the detriment of the regional fauna, including the silvery minnow.

The effects of environmental stressors on fishes in the Rio Grande of New Mexico have traditionally been assessed at low levels of biological organization. Retrospective assessments of stress on aquatic communities have had two foci. First, stress assessment has been oriented toward the health of individual fish and it has focused on measuring physiological functions of individual fish, rates of deformities or disease, condition, incidence of parasitism, and tolerance to specific contaminants. The second perspective for assessment of stress in fish has been focused on site-specific trends in the abundance, growth rate, and distribution of populations.

Edwards and Contreras-Balderas (1991) remark on the problematic nature of interpretations of fish faunal changes over time as derived from historical collection records. They cite variation in collection results associated with: different numbers of collections between different periods in time, different collection methods, and different personnel. To this we add: differences in collecting purposes (e.g., involving selective sampling), size selection in preserved specimens (large specimens are less practical to preserve), differences in legal constraints governing collections, different hydrological conditions at the time of collection, uneven sampling of representative habitats, and different levels of collecting effort. The approach taken in this ichthyological environmental baseline avoids many of these problems.

Efforts will be made in this assessment to extend the spatial scale of assessment to a regional framework and to expand the scale of analysis to the community level of biological organization,[20] thereby revealing large-scale anthropogenic impacts to the ichthyofauna.[21] To accomplish this, we need to understand the fundamental patterns that exist in the geographic distribution of native fish species in New Mexico. Historic changes in the fish fauna of the Middle Rio Grande are succinctly documented from several perspectives to reveal how such changes have been structured by prominent underlying features of the environment. The case history of fish-environment relationships is related to the proposed action in a dialectic fashion – revealing how past environmental conditions from natural or cultural events can be incompatible with contemporary purposes. Presentation will progress from perspectives that are regional to those that are site specific, and from high levels of biological organization to low. The regional, community perspective is based on expected fish community structure and fish-environment relationships. The site specific, population-based metrics are based on generalized patterns in population response.

5.7.1.1 Regional, Community-based Perspectives of Diversity and Faunal Change

Historically, the richness of the probable native fish fauna of the Rio Grande in New Mexico was a predictable function of basin size, phylogeny and reproductive guild (figures 7, 8, and 9). As such, these relationships provide the bases for the measure of change in a fish community over time that is indicative of environmental stress.

A statistical association between richness of the probable native fish fauna of the Rio Grande in New Mexico and basin size, phylogeny and reproductive guild (as presented in the subsections of 5.7.1.1) does not establish causation. We have merely offered statistical associations that can be used for predictive purposes and that can be used to contrast with contemporary conditions. Fish species, including the silvery minnow, respond to local features of habitat regardless of overarching patterns of downstream transition of streams from one suite of conditions to another.

---

[20] An observation is made that constraints to life-history strategies for a specific species can often be detected through a broad comparative view across many taxa and across multiple drainages with shared taxa.

[21] Much of this analysis is based on the work of Hatch et al. (1999).

5.7.1.1.1 Species Diversity as a Predictive Function of Watershed Area

It is well known that species diversity (richness) is positively related to watershed area (Matthews, 1998).[22] On a global scale, Oberdorff et al. (1995) stated that river basin area is the most important factor influencing fish species richness. It is also well known that environmental stressors can lead to alterations in fish community richness (e.g., Bayley and Li, 1996).

Historically, the richness of the probable native fish fauna of the Rio Grande in New Mexico was a predictable function of basin size (Figure 7). As such, that relationship can provide a basis for the measure of change in a fish community over time that is indicative of environmental stress.

From Figure 7, it is apparent that the contemporary fish fauna is depauperate of native species compared to the largely unaltered (circa 1550) condition (i.e., the diversity of the contemporary fauna is lower than expected in relation to watershed area). Deviation from the natural condition increases and becomes more variable with increasing watershed area. The contemporary fauna is distinguished by many locations for which there are no native species. The contemporary pattern of native fish diversity no longer represents a predictable function of basin size. Instead, the modern pattern of native fish species diversity of the Rio Grande of New Mexico resembles that of unaltered fish communities in streams tributary to the Rio Grande with intermittency at their confluence with the mainstem. Such communities were maintained by repeated cycles of colonization.

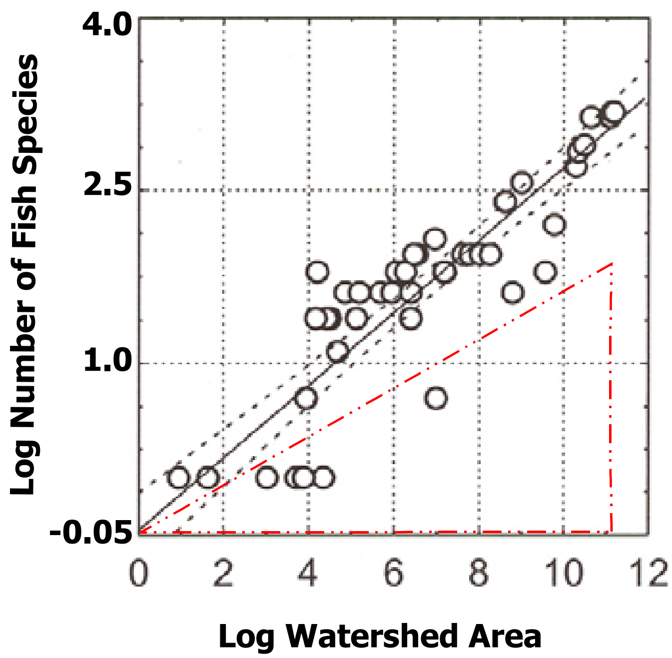


Figure 7. Linear Relationship of Fish Species Richness versus Watershed Area (km^2) for the Rio Grande Drainage of New Mexico.

Data representing the near natural (circa 1550) condition appear as black open circles with an accompanying black regression line with dashed 95% confidence interval. The red, long-dash-dot-dot triangle encompasses the scatter of contemporary data points for native fish species. The historic range of silvery minnow includes watershed areas larger than 5550 km^2 (log transformed = 8.6). Figure adapted from Hatch et al. (1998).

Apart from considerations of native-exotic distinctions, the contemporary fish fauna is aligned with natural patterns of species diversity in Rio Grande Basin streams of New Mexico with small contributing watersheds (i.e., less than approximately 150 km^2 (log transformed = 5.0). However, the contemporary pattern of species diversity for sites with larger contributing watersheds deviates from the natural pattern, suggesting an intrinsic decreased capacity of the Rio Grande of New Mexico to support former realized levels of diversity.

[22] Watershed area increases with distance downstream. Watershed area is positively correlated with abstract variables like "stream order" and other expressions of longitudinal zonation and subsumes individual habitat measurements (dimensions).

5.7.1.1.2 Species Diversity as a Predictive Function of Phylogeny

A general positive linear relationship existed historically between native fish species and families in Rio Grande Basin streams of New Mexico (Figure 8). Departures from this relationship existed historically in instances involving four and five fish families in which a proliferation of species within families is evident. The reach of the Rio Grande roughly between Otowi and Bernalillo is one geographical area at the interface of diverging natural patterns of species diversity (the other area is at much higher altitudes involving low order streams). This "Otowi to Bernalillo" reach of river represented a transition zone from a fauna of predominately mountain (rhithron[23]) species to one of lowland (potamon) species. Such "ecotonal" areas are naturally characterized by a heightened degree of habitat complexity that is supportive of a unique assemblage of fish species. That several extirpated native cyprinid species from the Rio Grande were last know from this reach into the 1960's is evidence of the former habitat qualities in the "Otowi to Bernalillo" reach, including its environmentally benign nature (most notably, its perennial quality).

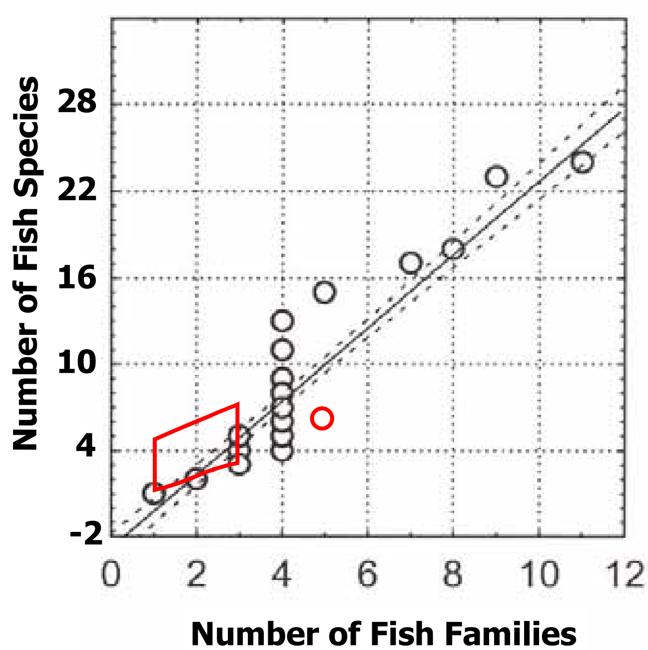


Figure 8. Linear Relationship of Fish Species Richness and Diversity of Fish Families for the Rio Grande Drainage of New Mexico.
Data representing the near natural (circa 1550) condition appear as black open circles with an accompanying black regression line with dashed 95% confidence interval. The red polygon and the single red open circle illustrate the contemporary situation. Figure adapted from Hatch et al. (1998).

From Figure 8 it is evident that the contemporary ichthyofauna of the Rio Grande of New Mexico is depauperate of native species and families. Absent from contemporary collections are species of the families Acipenseridae, Anguillidae, Characidae, Lepisosteidae, and Sciaenidae. Large water impoundment structures have precluded the upstream migration of the catadromous *Anguilla rostrata* (Anguillidae). The Neotropical *Astyanax mexicanus* (Characidae), a peripheral occurrence in the Rio Grande of New Mexico (northern distributional limits), likely succumbed to events of channel drying coupled with cold temperatures by the 1950's. Species of Acipenseridae, Lepisosteidae, and Sciaenidae are all large-bodied main channel species. To the degree that deep perennial pools of the potamon were limiting, such forms would be disadvantaged in times of drought (relative to small bodied species). These species probably succumbed to channel drying events no later than the 1890's.

Within the contemporary range of silvery minnow, fish collection records chronicle the loss of several native fish species of the families Catostomidae and Cyprinidae. *Cycleptus elongatus* and *Moxostoma congestum*, two large-bodied, main channel catostomid species, were extirpated from the Rio Grande of New Mexico by the 1940's, a time immediately preceded by events of channel drying and the advent of large-scale irrigation practices.

Within the Rio Grande of New Mexico, three small-bodied, pelagic spawning species of Cyprinidae survived the drought of the 1950's, including: *Notropis simus*, *Macrhybopsis aestivalis* and the silvery minnow. *N. simus* and *M. aestivalis*

---

[23] *Rhithron* refers to the cooler and higher gradient river of the uplands. Unaltered, the rhithron is characterized by fast currents, larger substrate materials, and a limited variety of size, depth and flow of the river channel. Allochthonous inputs of organic materials support a preponderance of drift feeders and benthic invertivores (compare potamon; footnote 9).

persisted into the 1960's but were extirpated following the impoundment of water in Cochiti Reservoir. There is no evidence that *N. jemezanus* or *N. orca*, two other native small-bodied, pelagic spawning species of Cyprinidae, survived in the Rio Grande of New Mexico beyond the late 1940's.

The impoundment of water in Cochiti Reservoir interrupted the continuum of the Rio Grande, and in so doing, altered the spatial structure[24] of populations and heightened the probability of extinction. This same event eliminated, or nearly eliminated, the population of silvery minnow from the "Otowi to Bernalillo" transition zone. Before water was impounded in Cochiti Reservoir, this population of silvery minnow factored prominently in the probability of colonization of empty downstream habitat patches (e.g., a recently rewetted river channel). Absent significant immigration of silvery minnow from a stable and viable upstream source, a heightened probability of extirpation exists for subpopulations in downstream habitat patches that are subject to repeated episodes of channel drying.

[24] Spatially structured populations are generically referred to as "metapopulations." A population's spatial structure depends fundamentally on habitat quality, spatial configuration, and dynamics, as well as the dispersal characteristics of individuals in a population.

5.7.1.1.3 Species Diversity as a Predictive Function of Reproductive Guilds

A general positive linear relationship existed historically between native fish species and reproductive guilds (Figure 9). Departures from this relationship exist in instances involving five and six reproductive guilds in which a smaller than expected number of species within reproductive guilds is evident. The reach of the Rio Grande roughly between Otowi and Bernalillo is at the interface of diverging natural patterns of species diversity based on reproductive guilds (as is the case for the predictive function of species diversity based on families).

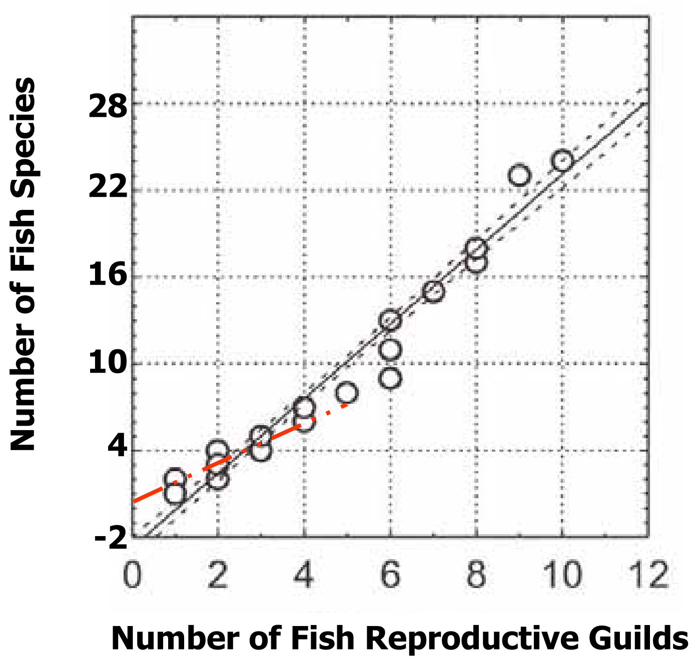


Figure 9. Linear Relationship of Fish Species Richness and Diversity of Reproductive Guilds for the Rio Grande Drainage of New Mexico.

Data representing the near natural (circa 1550) condition appear as black open circles with an accompanying black regression line with dashed 95% confidence interval. The red, long-dash-dot-dot regression line illustrates the contemporary situation. Figure adapted from Hatch et al. (1998).

The contemporary native fish fauna exhibits a significantly lower rate of species addition within reproductive guilds compared to the same relationship for the unimpacted native fish fauna (Figure 9). Furthermore, the contemporary decrease in native species richness has been accompanied by a reduction in the number of reproductive guilds represented at any one site[25] and a reduction in the total number of reproductive guilds represented in the Rio Grande Basin of New Mexico. These combined deviations from the natural pattern are indicative of a decrease in habitat volume over time coupled with habitat simplification and fragmentation (the absence of fluvial integration that is necessary for source-sink exchanges between populations).

Without regard to native-exotic distinctions, the contemporary fish fauna exhibits a significantly lower rate of species addition within reproductive guilds and a reduced number of reproductive guilds represented at any one site compared to the unimpacted native fish fauna. This deviation from the near natural pattern is suggestive of a decreased intrinsic capacity of the Rio Grande of New Mexico to support former realized levels of diversity.[26]

[25] Only two "native species" reproductive guilds, both non-guarding open substrate spawners, have been lost from the Rio Grande of New Mexico, including phyto-lithophils (nonobligatory plant spawners) and phytophils (obligatory plant spawners).

[26] If a biological community is saturated, then "new species could not join the community without the compensative disappearance of others" (Ricklefs, 1987).

5.7.1.2 Site-specific, Community-based Perspective of Diversity and Faunal Change

5.7.1.2.1 Index of Diversity

Over the course of history, 13 native fish taxa,[27] representing eight families, have become extirpated or have become extinct from the Rio Grande of New Mexico (Appendix D). This represents 48% of the region's native fish fauna. In some instances, the loss of native species has been accompanied by the introduction and persistent existence of nonnative species. One quantitative expression of the relative degree to which the fauna has changed in historic times is the sum of the number of native species extirpated and the number of nonnative species. A graphical representation of this metric is presented in Figure 10 for an array of sites representative of aquatic habitats in New Mexico, including sites within the contemporary range of silvery minnow. As Figure 10 makes apparent, the degree of faunal change within the contemporary range of silvery minnow is rivaled in New Mexico only by the degree of change within the former range of silvery minnow in the Pecos River.

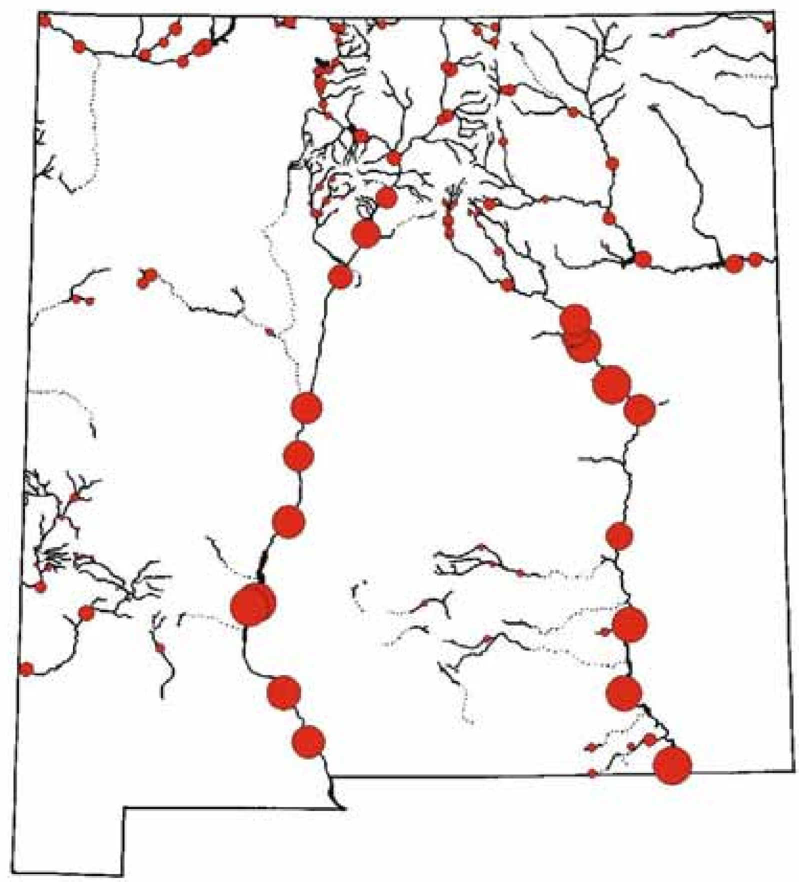


Figure 10. Change in Fish Faunal Communities of New Mexico from Historic to Contemporary Times. Change is represented as the Sum of the Number of Extirpated Native Species and the Number of Extant Nonnative Species. This figure is derived from information in Sublette et al. (1990) and Hatch et al. (1998). Data are illustrated for 154 different sample locations that are intended to be broadly representative of aquatic habitats in New Mexico; circle size is directly proportional to the magnitude of change in the fish community at the indicated location.

[27] *Taxa* is the plural form of *taxon*. It refers to any formal taxonomic unit or category of organisms.

5.7.1.3 Population Level Perspectives

5.7.1.3.1 Population Monitoring – 1994-2002

The need to identify the relative effect of multiple stressors is fundamental to the effective management of fishery resources. Knowledge of population dynamics is critical in this diagnostic process. To this end, systematic surveys for silvery minnow have been conducted since 1994 (with the exception of 1998) in the Rio Grande of New Mexico between Angostura Irrigation Diversion Dam (upstream of Bernalillo) and Elephant Butte Reservoir. Results of these surveys exist as count data, i.e., silvery minnow captured per 100 m^2 of surface water sampled.[28] Dudley and Platania (2002) presented a synthetic report on the results of these surveys that document the dynamics in the relative abundance of silvery minnow in the Middle Rio Grande since 1994 (figures 11 and 12). Data from that report are presented in this section.

The relative abundance of silvery minnow generally increases in a downstream direction over the length of the Middle Rio Grande. Consistently, the 1994-2002 population monitoring data have indicated that the majority of individuals occur in the San Acacia Reach, whereas decisively fewer silvery minnow are found in the Angostura and Isleta reaches (figures 11 and 12). This spatial structure of population abundance is the result of a combination of factors. The imposition of cross-channel irrigation diversions has, since the 1930's, served to restrict movement between subpopulations of silvery minnow to downstream transport processes, most notably involving the downstream drift of eggs and larvae. Upstream subpopulations began to decline after 1973 when Cochiti Reservoir first impounded water, thereby interrupting the continuum of the Rio Grande and rendering otherwise habitable and perennial portions of the river wholly unsuitable for supporting viable populations of silvery minnow.[29]

Dudley and Platania (2002) reported that over 98% of the silvery minnow catch was from the San Acacia Reach, indicating that a significant portion of the population resides in that reach (it does not indicate that 98% of the population was in that reach).

[28] Count data is more practically obtained than estimates of population size and can be expressed as "rate of catch" or relative density. These metrics can theoretically be indexed to abundance and are more relevant to depensatory population effects than population abundance.

[29] Filtering collector benthic macroinvertebrates, which predominate upstream of Cochiti Reservoir, are replaced immediately downstream of Cochiti Dam to Elephant Butte Reservoir by gathering collectors. This suggests an evolution of system inputs, caused by Cochiti Dam and Reservoir, from fine particulate organic matter (FPOM) in transport (suspended) to FPOM in storage in sediments (deposited in the benthos) (derived from data attendant to Jacobi et al., 2001). The inability of the system to revert to normal energy processing pathways (or at least the system's sluggish response) can be attributed to the paucity of tributary inputs of organic material and periodic near intermittent conditions.

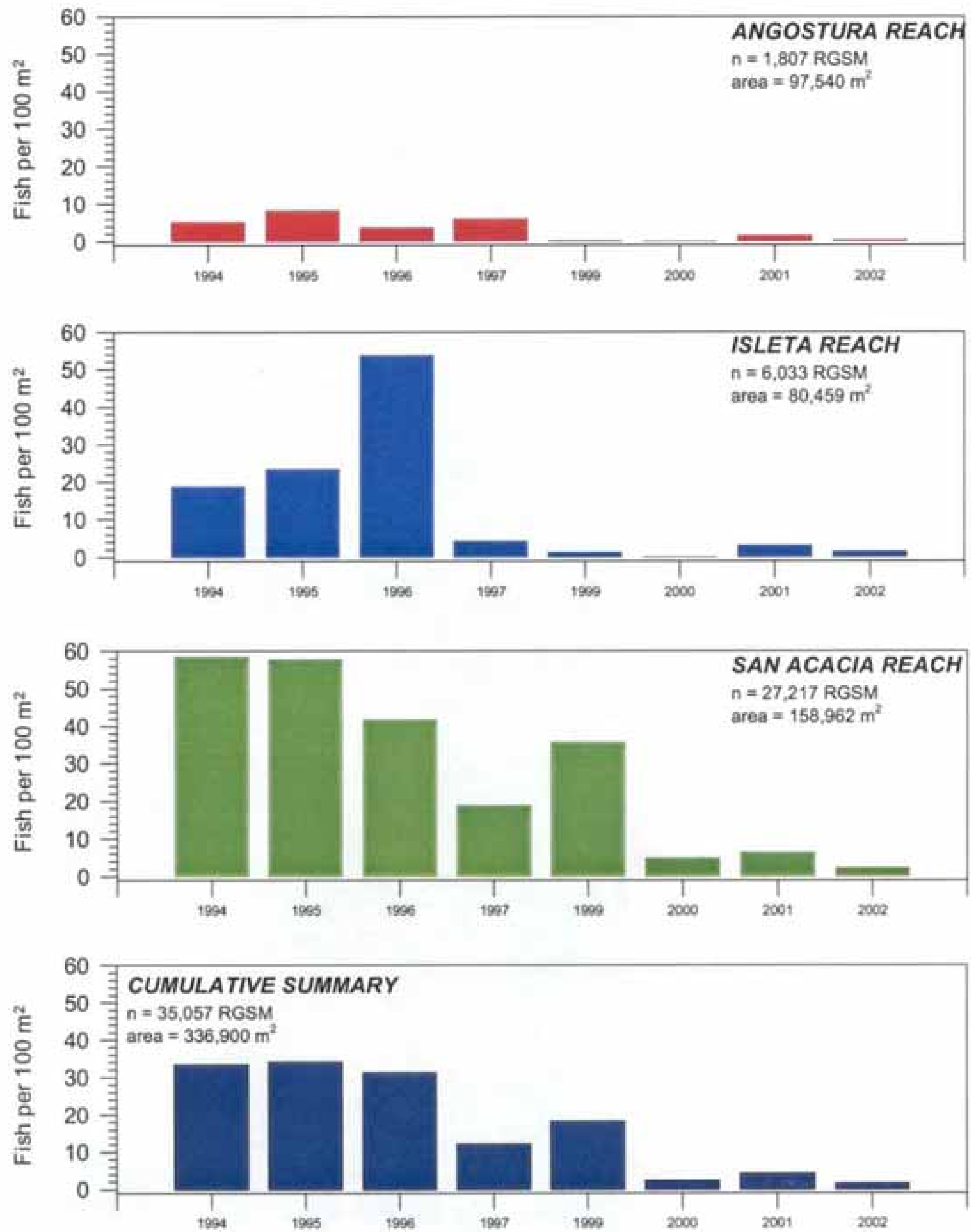


Figure 11. Reach Specific Annual Silvery Minnow Catch Rates between 1994 and 2002. (Dudley and Platania, 2002). (Note: the high catch rate of silvery minnow indicated within the Isleta Reach in 1996. This catch rate is the result of a sampling anomaly: silvery minnow were confined to isolated pools during river drying events).

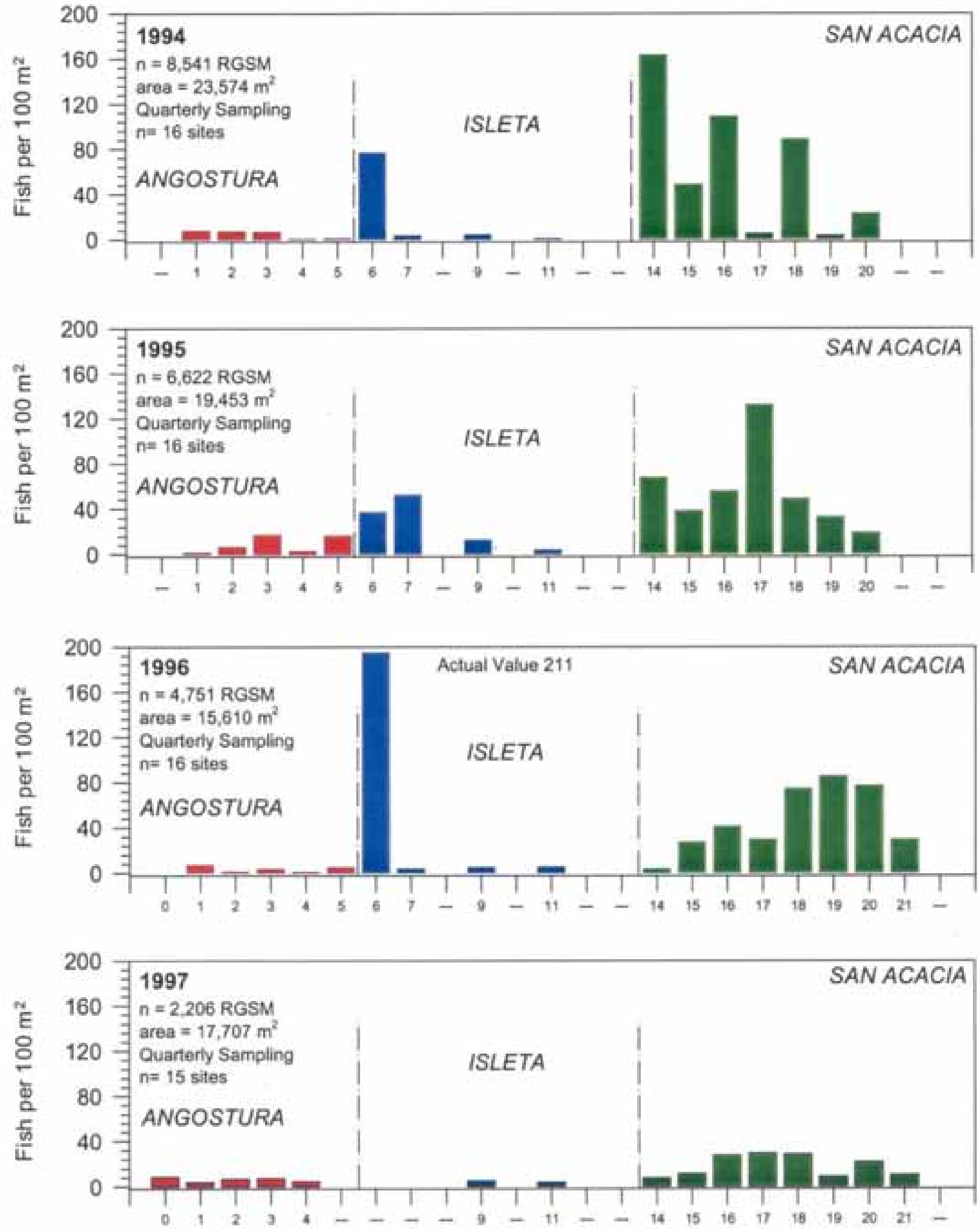


Figure 12. Cumulative Annual Silvery Minnow Catch Rates by Reach between 1994 and 2002.
(Dudley and Platania, 2002). (Note: the high catch rate of silvery minnow indicated within the Isleta Reach at Site 6 in 1996. This catch rate is the result of a sampling anomaly: silvery minnow were confined to isolated pools during river drying events).

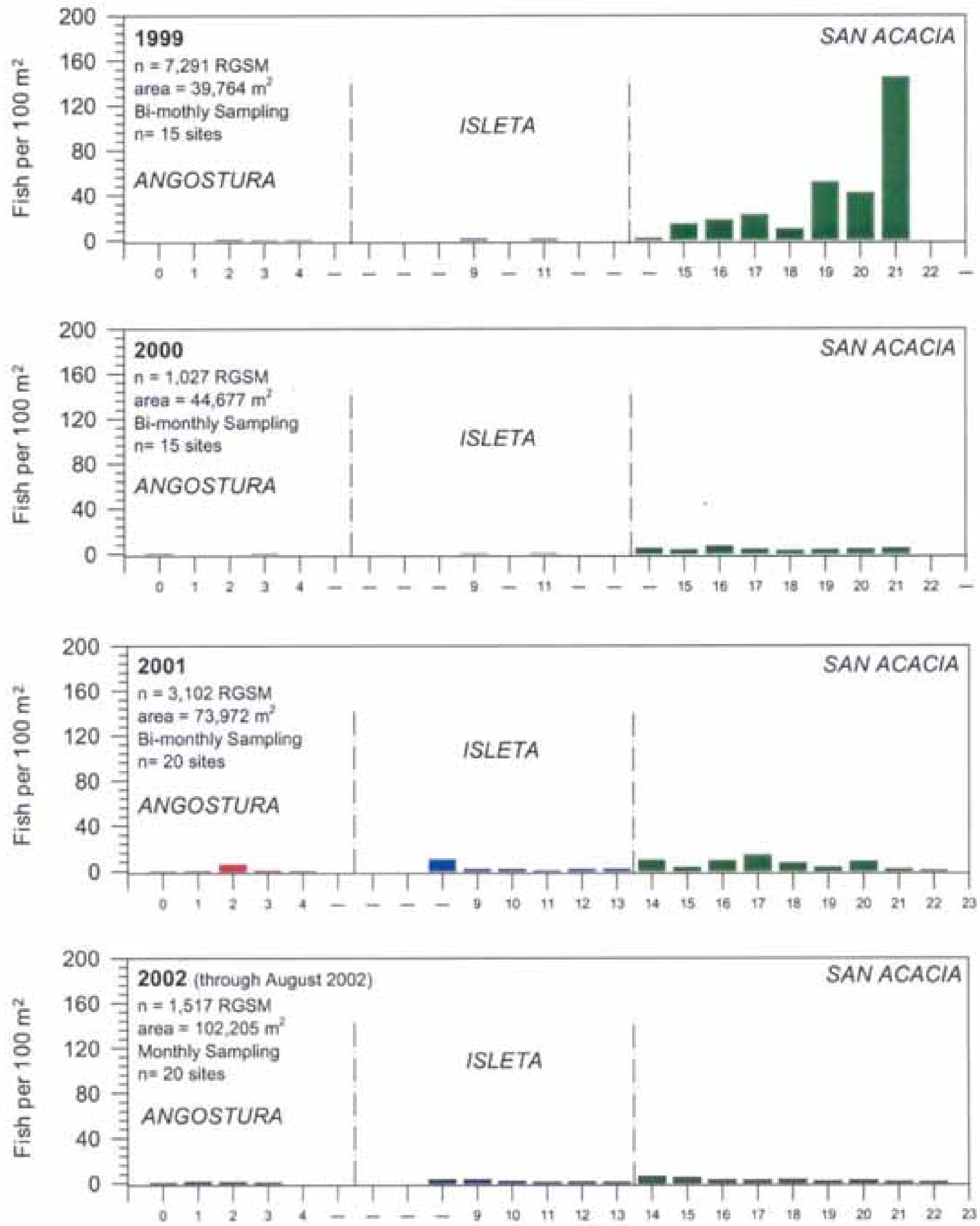


Figure 12 (continued). Cumulative Annual Silvery Minnow Catch Rates by Reach between 1994 and 2002. (Dudley and Platania, 2002).

5.7.1.3.2 2002 Population Monitoring Summary

The number of silvery minnow collected exhibited a steady decline throughout 2002 (Figure 13; Dudley and Platania (2002). The highest number of individuals was taken during the first 2002 sampling effort (January; n = 548) while the fewest specimens were taken during a recent 2002 sampling occasion (August; n = 38). This level of abundance is extremely low and dissimilar from pre-2000 study years. The number of silvery minnow collected in August 2002 is one of the lowest ever recorded over the course of the 1994-2002 population monitoring study (Dudley and Platania, 2002).

As has been well documented over the years, density (number of fish per 100 m^2 sampled) of silvery minnow during 2002 continued to be highest in the Socorro Reach (the most downstream section of river and first reach to experience variable channel drying) and lowest in the Albuquerque Reach, the most upstream reach of the river (Dudley and Platania, 2002).

Results of the 2002 population monitoring efforts indicate that spawning success of silvery minnow (during 2002) was poor (Dudley and Platania, 2002). Collections from May-June 2002 (the period after spawning would have occurred) produced few age-0 fish (i.e., those hatched during 2002). This lack of age-0 fish indicates that few larvae survived. The low number of silvery minnow present in August 2002 population monitoring efforts and the lack of age-0 individuals (n = 14) suggest that further declines will likely continue into 2003 (Dudley and Platania, 2002).

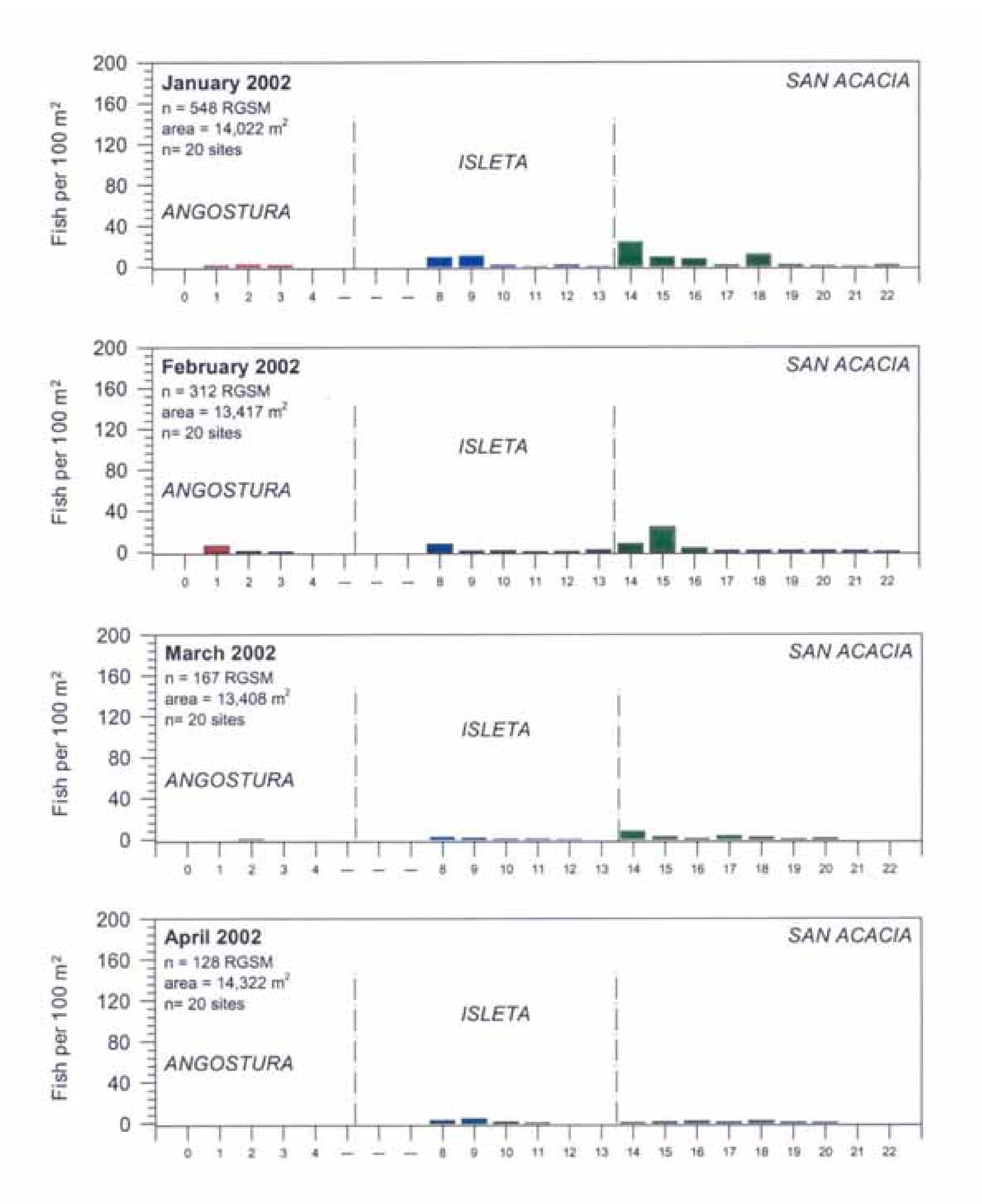


Figure 13. Rio Grande Silvery Minnow Catch Rates by Month and Reach during 2002.
(Dudley and Platania, 2002).

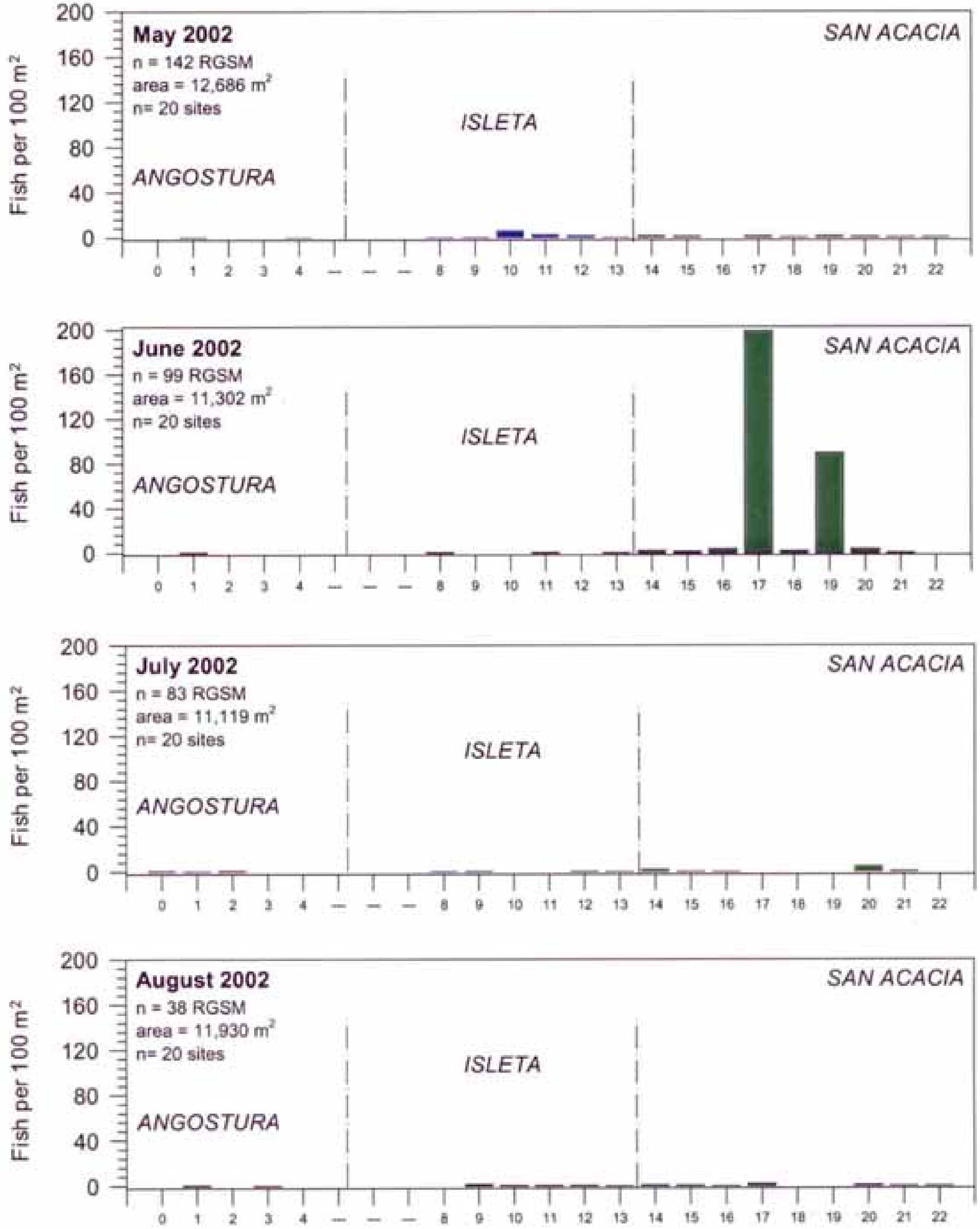


Figure 13 (continued). Rio Grande silvery minnow catch rates by month and reach during 2002. (Dudley and Platania, 2002).

5.7.1.3.3 Generalized Patterns of Rio Grande Silvery Minnow Population Response

Silvery minnow populations react to environmental stressors in a variable, but predictable and categorical manner. Silvery minnow exhibit four distinct population response patterns (as deduced from the time series of silvery minnow population density data presented by Dudley and Platania, 2002; see Figure 12), depending on the nature and magnitude of the stimulus and the relationship between parental stock density and the production of progeny. These include "noncritical"[30] responses of "moderate" density populations (51-150 silvery minnow per 100 m^2), "critical" and "noncritical" responses of "low" density populations (35-50 per 100 m^2), and "critical" responses of "at risk" density populations, i.e., those below 35 silvery minnow per 100 m^2. A contemporary time-series data set for "high" density silvery minnow populations (> 150 silvery minnow per 100 m^2) does not exist.

At moderate densities, dynamics of silvery minnow populations appear to be regulated by compensatory mechanisms[31] in response to environmentally driven changes in stock density. The limits to which compensatory mechanisms can maintain populations at moderate density equilibrium are largely dependent on energy and nutrient inputs, net rates of dispersal (immigration minus emigration), and habitat availability.

Under environmentally benign conditions, moderate density populations are relatively stable or growing. Nonetheless, such populations may suffer large population losses caused by extreme environmental conditions (e.g., channel drying) that can result in collapse or extirpation of the stock in a relatively short time. Highly variable populations will continue to be prone to rapid declines in population abundance and possible extirpation caused by a chance sequence of years with low recruitment/high mortality, even when such populations become large. This is especially true of silvery minnow, a short-lived species, in which year-to-year population dynamics are intrinsically highly variable.

Low-density populations of silvery minnow appear unable to attain/regain a higher class of density largely because of depensatory deterministic effects.[32] Densities of such populations subtly fluctuate at low-density levels of stability. These densities are likely non-critical in circumstances involving benign environmental conditions and where recruitment is derived from autochthonous[33] and allochthonous[34] sources. In contrast, such densities appear to be critical in instances where recruitment is restricted, or nearly restricted, to autochthonous sources and movement between subpopulations of silvery minnow is restricted to downstream transport processes.

"At risk" population densities are likely caused by some underlying sub-lethal environmentally driven phenomenon such as habitat that is qualitatively unsuitable or quantitatively insufficient. These populations exist at extremely low-density equilibriums, the dynamics of which are dominated by depensatory deterministic effects. Population fluctuations are subtle, but are nonetheless characterized by a long-term declining trend leading to an eventual collapse and extirpation of the stock. As is true for all of the generalized population response categories, environmentally driven mortality associated with harsh environmental conditions (e.g., channel drying) may ultimately prove to be the decisive factor in the fate of "at risk" populations.

5.7.1.3.4 Classification of Rio Grande Silvery Minnow Population Dynamics by Generalized Population Response

The time series of density estimates for the silvery minnow population in the Albuquerque Reach of the Rio Grande is illustrative of a population with densities subtly fluctuating within the bounds of the "at risk" category of generalized population responses over the entire span of monitoring (1994 – 2002). Benign environmental conditions may allow such populations to endure for long periods. However, because pre-juvenile recruitment is restricted or nearly restricted to autochthonous sources, it is unlikely that such recruitment can be augmented by sources outside of the Albuquerque Reach. However, it is possible that immigration of post-larval silvery minnow from the Isleta Reach[35] could augment this population, but probably not to the degree necessary to improve the status of the population in the long-term.

---

[30] Critical and noncritical designations refer to the relative degree of subpopulation risk of extirpation. The critical designation specifies a population in imminent danger of extirpation. The noncritical designation specifies a population that is not in imminent danger of extirpation, but one for which extirpation is foreseen at some early time horizon.
[31] Compensatory mechanisms result in an increase in productivity with decreasing density.
[32] Depensatory deterministic effects result in a decrease in productivity with decreasing density.
[33] *Autochthonous* refers to being derived from within a system (compare allochthonous).
[34] *Allochthonous* refers to being derived from outside a system (compare autochthonous).
[35] Upstream movement of silvery minnow may be only partially restricted by Isleta Diversion Dam at extreme low and high flows.

The densities of silvery minnow at some locations in the Isleta Reach of the Rio Grande are classified as “low” during 1994 and 1995. However, the density estimates from most sites in this reach and during this time are “at risk.” In retrospect, we know the population response pattern of this mix of “low” and “at risk” density sites to be “critical.” Beyond this time, populations suffered high mortality during channel drying events of 1996, 2000, 2001, and 2002. Since 1995, estimates of silvery minnow density for this reach nearly consistently qualified for “at risk” designation. The only exception to this rule involves samples from 1996 where it is known that sample counts imperfectly reflected the true magnitude of variation at the population level (samples included captures of silvery minnow confined to isolated pools; Dudley and Platania, 2002). Recruitment within this reach is nearly restricted to autochthonous sources because of the “at risk” densities of upstream populations. Likewise, post-larval population augmentation from outlying areas would be minimal from upstream sources and nonexistent from downstream sources because San Acacia Diversion Dam precludes the upstream movement of silvery minnow.

The time series of density estimates for the silvery minnow population in the Socorro Reach of the Rio Grande are illustrative of a population existing at moderate densities from 1994 to 1995, and that subsequently suffered high mortality during channel drying events of 1996, 2000, 2001, and 2002. Contemporary estimates of population densities are classified as “at risk.” However, the autochthonous recruitment of this population has been significantly augmented in the past by allochthonous upstream sources: the Albuquerque and Isleta reaches. Likewise, the post-larval component of this population can be significantly augmented by immigration from the two upstream reaches. Therefore, even though the demographics of this population would intrinsically result in a “critical” population response, inputs from outlying areas may “rescue” this population under environmentally benign conditions.

5.7.1.3.5 Regression Analysis of Rio Grande Silvery Minnow Count Data

Even with contemporary data pertaining to population size and knowledge of both the average rate and degree of variation of population change (growth or decline), only probabilistic statements can ever be made about the number of individuals a population will include at some future date. Because realizations of population growth diverge over time, due largely to stochastic and other temporally variable environmental effects, population trends are not good predictors of the future. The farther into the future predictions about the likely population density (or other population abundance-based index) are made, the less precise they become. As such, a large part of the science of silvery minnow conservation involves understanding and predicting the effects of population size and devising and implementing management strategies that will result in viable populations (with intrinsic degrees of risk).

Models provide a means of using data collected in a study together with other information to gain knowledge of the population or process from which the information was collected. Many such models have been developed to predict the likely future status of a population or collection of populations of conservation concern. Unfortunately, such analysis for the silvery minnow at this time would not yield credible results, given the constraints of contemporary data sets. Either the basic requisite data are lacking (e.g., for projection matrix models), or analytical assumptions cannot be met (e.g., for geometric growth models). Analytical assumptions that preclude geometric growth model analysis of the data provided by Dudley and Platania (2002) include, but are not limited to:

- sample counts that imperfectly reflect the true magnitude of population variation (e.g., some samples included captures of silvery minnow confined to isolated pools), and
- inter-annual environmentally-driven variation that is extreme.

For silvery minnow populations with a long history of depensatory regulated population dynamics, such as those in the Albuquerque and Isleta reaches, a retrospective analysis of population density dynamics through regression analysis cannot provide additional insight with management utility. In contrast, the Socorro Reach population, until relatively recently, was dominated by compensatory-regulated dynamics punctuated with intervals of depensatory-regulated dynamics. Regression analysis of the log-transformed time-series of population densities from this reach yields a negative slope (-0.4209). The entire confidence interval about the slope of the regression (± 2s) is less than one, suggesting that 95% of the average of population trajectories will decrease. Furthermore, the count data do not decrease smoothly over time, but instead show considerable variation over time ($s^2 = 0.8052009$).[36] One factor that contributes to such fluctuations in density is inter-annual variation in the environment. The greater the environmentally driven fluctuations in population growth rate the greater will be the risk of extirpation at early time horizons.

---

[36] s^2 is large relative to the slope, i.e., s^2 is nearly equal to two times the slope. The F-statistic for the regression indicates the regression is statistically nonsignificant, precluding hypothesis testing. However, this does not undermine all utility of the data. Linear regression is employed here to find best-fit values of the parameters given the data, not to statistically test any particular hypothesis.

5.7.1.4 Linking Environmental Variables to Viability Components

There are five components vital to a viable population[37] of silvery minnow (or any species for that matter). These include: an adequate supply of food and cover, successful annual reproduction and recruitment, and maintenance of genetic diversity. A number of abiotic and biotic factors can affect these components. Sections within 5.7.1 identified several factors most responsible for the observed changes of the ichthyofauna of the Rio Grande of New Mexico (with specific reference to the action area). These include: the degree of variability in river flow, the extent and frequency of near intermittent conditions,[38] the amount of potamon habitat (including intact elements of the river continuum), habitat complexity (most notably involving the transition reach from Otowi to Bernalillo), metapopulation configuration and dynamics (including population dispersal characteristics), and the degree of deterministic density effects. How the various components of the proposed action will modify these factors, individually or in various aggregations, will have a direct bearing on the viability of the silvery minnow and the community of which it is a part.

Flow variability and near intermittent conditions are negatively correlated to population viability, whereas the amount of potamon habitat and habitat complexity are positively correlated. Metapopulation configuration and dynamics of silvery minnow subpopulations will enhance prospects of species survival to the degree that habitats occupied by each subpopulation are environmentally benign (i.e., environmental catastrophes are unlikely), to the degree that the fates of subpopulations are uncorrelated (temporal environmental variation for all subpopulations is not influenced by common factors), and to the degree that populations are isolated (a high dispersal rate enables areas to be recolonized and populations of low density to be augmented). Finally, prospects of species survival are enhanced to the extent that population densities can be maintained above levels subject to depensatory deterministic effects (i.e., at or above moderate densities as described in section 5.7.1.3.3).

Only qualitative assessment of the foregoing environmental variables, i.e., negative, positive or “no change” impacts, on the silvery minnow and its associated community is possible. It is important to note that a species’ prospect of long-term survival is variably governed by the greatest limiting factor. It is possible that limitations found in one environmental variable can be ameliorated by the quality or quantity of another environmental variable with a net beneficial effect. However, favorable conditions with regard to one environmental variable generally will not compensate for a different and essential environmental variable that is limiting.

---

[37] A viable animal population might be qualitatively defined as one that is self-sustaining in the absence of active management intervention and one that is composed of a sufficient number of individuals to permit adaptation and long-term persistence to occur. A quantitative and time delimited definition, one useful at the operational level, could be formulated by the Rio Grande Silvery Minnow Recovery Team.

[38] A *near intermittent* condition is referenced because factors other than catastrophes can drive extinctions. In particular, environmental fluctuations can result in extinctions that are driven by a series of poor, but not catastrophic, years.

5.7.2 Avifauna

5.7.2.1 Southwestern Willow Flycatcher

5.7.2.1.1 Current Status

The status of southwestern willow flycatcher (flycatcher) in the Middle Rio Grande from 1993 to 2000 was presented in the *Final Programmatic Biological Assessment of Proposed Bureau of Reclamation and Corps of Engineers Discretionary Actions and Related Non-federal Actions Regarding Water Management in the Middle Rio Grande, June 2001.* Presence/absence surveys have continued at selected sites along the Rio Grande from Velarde, New Mexico to the delta of Elephant Butte Reservoir during the 2001 and 2002 breeding season. The summaries of flycatcher surveys and nest monitoring in the Middle Rio Grande from 2001 and 2002 will provide the environmental baseline for the southwestern willow flycatcher for the current BA.

Several core breeding sites for willow flycatchers have been identified and documented during various survey efforts in the Middle Rio Grande between 1993 and 2002. Once identified, these sites have continued to be surveyed and nests monitored on an annual basis in most cases. These population sites consist of one or more pairs that have established territories in an attempt to nest. Established breeding sites occur at the following Middle Rio Grande locations: Velarde and Española, San Juan Pueblo, Isleta Pueblo, Sevilleta National Wildlife Refuge (NWR) and La Joya State Wildlife Management Area (WMA), Bosque del Apache NWR, and the San Marcial Reach, which begins at the south boundary of the Bosque del Apache NWR and continues to Elephant Butte Reservoir. Table 7 presents the results of surveys for flycatchers at these sites from 2000 through 2002.

	Number of Territories		
River Reach	**2000**	**2001**	**2002**
Velarde *(Ahlers et al., 2000-2002)*	2	1	0
San Juan Pueblo *(Williams, 2000)*	16	not surveyed	not surveyed
Isleta Pueblo *(Johnson and Smith, 2000)*	14	not surveyed	not surveyed
Miscellaneous areas** (*Ahlers and Moore, 2002)*	not surveyed	not surveyed	1 (Belen) 4 (SADD- BDA NWR)
Sevilleta NWR *(Ahlers et al., 2001,2002)*	8	11	13
Bosque del Apache NWR *(Taylor, 2000-2002*)	1	2	4
San Marcial *Ahlers et al., 2001,2002)*	23	25	63
From South boundary of Bosque del Apache NWR to the Delta of Elephant Butte*	4	3	6
Elephant Butte Reservoir Delta	19	22	57
Totals	63	39	85

Table 7. Breeding Season Estimates of Southwestern Willow Flycatcher Territories along the Middle Rio Grande from 2000 through 2002.
*Private lands were surveyed on a limited bases in 2002 for a specific project.
** In 2002, complete flycatcher surveys were conducted within the Belen Division and San Acacia Diversion Dam to Bosque del Apache NWR as part of the ESA Collaborative Program for baseline flycatcher information. One territory was located along an irrigation ditch adjacent to the river near Belen and four single males established territories in the Socorro Division (between SADD and north BDA NWR); no pairs were documented.

The San Marcial Reach, which begins at the south boundary of the Bosque del Apache NWR and continues to the delta of Elephant Butte, is considered one site in the recovery unit. In this table, the flycatcher territories located within the conservation pool of Elephant Butte Reservoir have been identified separately because this habitat area is unique within the reach.

5.7.2.1.2 Current Populations at Key Southwestern Willow Flycatcher Breeding Sites

Isleta Pueblo and San Juan Pueblo

Flycatcher surveys were conducted most recently on these Pueblo lands in 2000. On the Isleta Pueblo lands, 14 territories and 9 nests were located. On the San Juan Pueblo, 16 territories and 8 nests were located. It is probable that flycatchers continued to nest in these areas in similar numbers. Although these sites have not been consistently surveyed, the numbers of territories documented with survey efforts indicate a stable or slowly increasing breeding population.

Velarde, New Mexico

Since 1993, four areas along the Rio Grande have been surveyed for willow flycatchers (La Canova, La Rinconada, Garcia inlet and El Guique). At La Canova (2 km north of Velarde), one pair was observed in 2000 and 2001. A nest was located in 2000 but the outcome was undetermined. No nest was located in 2001. No pairs were detected in 2002. Previously this site had supported flycatchers since 1995. La Rinconada (located near the community of Velarde) also supported one pair in 2000. A nest was located but the outcome was undetermined. No territories were located in 2001 and 2002. This population is likely unstable with limited nest success possibly due to high predation and fragmented habitat near human development.

La Joya State Wildlife Management Area

In 2001, seven territories and five nests were located. The five nests were monitored and three were successful, one failed and the outcome of one was unknown. Two nests were parasitized with a cowbird egg; however, one successfully fledged two flycatcher young. In 2002, six territories and five nests were located. Three nests were successful and two nests were parasitized by cowbirds of which one successfully fledged a flycatcher young.

Sevilleta National Wildlife Refuge

In 2001, four territories and four nests were located. Three of the nests were successful and one failed. Three nests were parasitized with cowbird eggs, of which two still successfully fledged two flycatcher young. In 2002, six territories and eight nests were located (two re-nests). Five nests were successful and one nest was parasitized. The number of breeding flycatchers at these two sites are relatively small, however the continued presence of territories and nesting attempts are a good indication of an established (a fairly stable) breeding population. The occurrence of cowbird parasitism in this area may be a factor in preventing population increases.

Bosque del Apache National Wildlife Refuge

In 2001, one territory was located during surveys of suitable habitat within actively managed wetland and riparian units of the refuge and/or along water conveyance facilities. In the past, one territory was located in 2000 and 2 –3 territories in 1999. There are two sites on the refuge that have been used fairly consistently since 1994. Nest searches are not conducted on the refuge; therefore, nest status and productivity cannot be confirmed. In 2002, the river corridor was surveyed in addition to selected areas within the inactive floodplain of the refuge. Three territories were located along the river however no pairs or nests were found. One territory was located within the refuge's seasonally flooded marsh units (Taylor, 2001, 2002).

San Marcial (Fort Craig and Headwaters of Elephant Butte Reservoir)

In 2001 and 2002, 3 and 12 territories respectively, were located in the area above Elephant Butte Reservoir/Delta. Only one nest were located in 2001 and two nests were located in 2002.

The largest known concentrations of the flycatcher population within public lands of the Middle Rio Grande are distributed within the delta of Elephant Butte Reservoir. This population has more than doubled between 2001 and 2002 and is expanding into newly developed native riparian vegetation within the receding reservoir pool. In 2001, this area had the highest concentrations of nesting flycatchers within the reach with 22 territories. These 22 pairs produced 35 nests including four re-nesting attempts and 10 second broods. Twenty-six nest attempts were successful and nine failed (seven were predated and two were abandoned). In 2002, 51 territories were established within the delta and the breeding flycatchers noticeably dispersed south into the newly developed habitat. Sixty-five nests were located including 6 incidents of second broods and 14 incidents of re-nesting. Thirty-five nests were successful and 30 failed. In 1997, a series of high water years allowed the conservation pool to fill and the delta of the reservoir was inundated. During the following five years, receding water levels created moist soil conditions in the delta and young successional stage native riparian vegetation, primarily Gooding's willow (*Salix goodingii*) became established. Within approximately five years, this vegetation developed the structural and density components to become attractive to breeding flycatchers. The habitat features at this location are very different then other occupied breeding habitats in the Middle Rio Grande. This area has developed into a mosaic of dense patches of Gooding's willow intermixed with emergent wetlands, and open wet meadows. Soils within the delta generally remain wet or moist throughout the breeding season because of flows and seepage from the LFCC.

Year	TERRITORIES ADJACENT TO OR WITHIN ELEPHANT BUTTE RESERVOIR/DELTA	TOTAL TERRITORIES	PAIRS	NESTS
1994	0	11	8	5
1995	0	8	5	5
1996	7	20	3	1
1997*	9	10	3	2
1998*	7	11	4	2
1999*	4	12	5	5
2000*	19	23	20	19
2001*	22	25	25	36
2002*	51	63	52	67

Table 8. The Status of Breeding Southwestern Willow Flycatchers within the San Marcial Reach from 1994 – 2002. (Mehlhop and Tonne, 1994; Henry et al., 1996; Ahlers and White, 1995- 1999; Ahlers et al., 2000-2002). *Private lands above the railroad bridge either were not surveyed/or partially surveyed.

5.7.2.1.3 Breeding Chronology in the Middle Rio Grande

Flycatcher breeding chronology in the lower portion of the Middle Rio Grande is presented in Figure 14 and falls within the generalized breeding chronology of southwestern willow flycatchers (based on Unitt, 1987; Brown, 1988; Whitefield, 1990; Skaggs, 1996; Sogge, 1995; Maynard, 1995; Sferra et al., 1997; Sogge et al., 1997b). Extreme dates for any given stage of the breeding cycle may vary as much as a week from the dates presented. Egg laying begins as early as late May but more often starts in early to mid June. Chicks can be present in nests from mid-June through early August. Young typically fledge from nests from late June through mid-August but remain in the natal area 14 to 15 days. Adults depart from breeding territories as early as mid-August, but may stay until mid-September in later nesting efforts. Fledglings probably leave the breeding areas a week or two after adults.

Each stage of the breeding cycle represents a greater energy investment in the nesting effort by the flycatcher pair and may influence their fidelity to the nest site or their susceptibility to abandon if the conditions in the selected breeding habitat become adverse.

During the 2001 and 2002, the chronology of flycatcher nesting was determined or estimated from backdating at the nests monitored by the Bureau of Reclamation in the Sevilleta NWR/La Joya State WMA and San Marcial locations.

Although the sample size is much smaller for the nests monitored at the Sevilleta site in 2001 (N = 7), the chronology is similar between the nests located at Sevilleta and San Marcial (N = 23). The earliest egg laying was documented or estimated in the last week of May or first week of June. The latest fledging occurred during the third week in August (Figure 14).

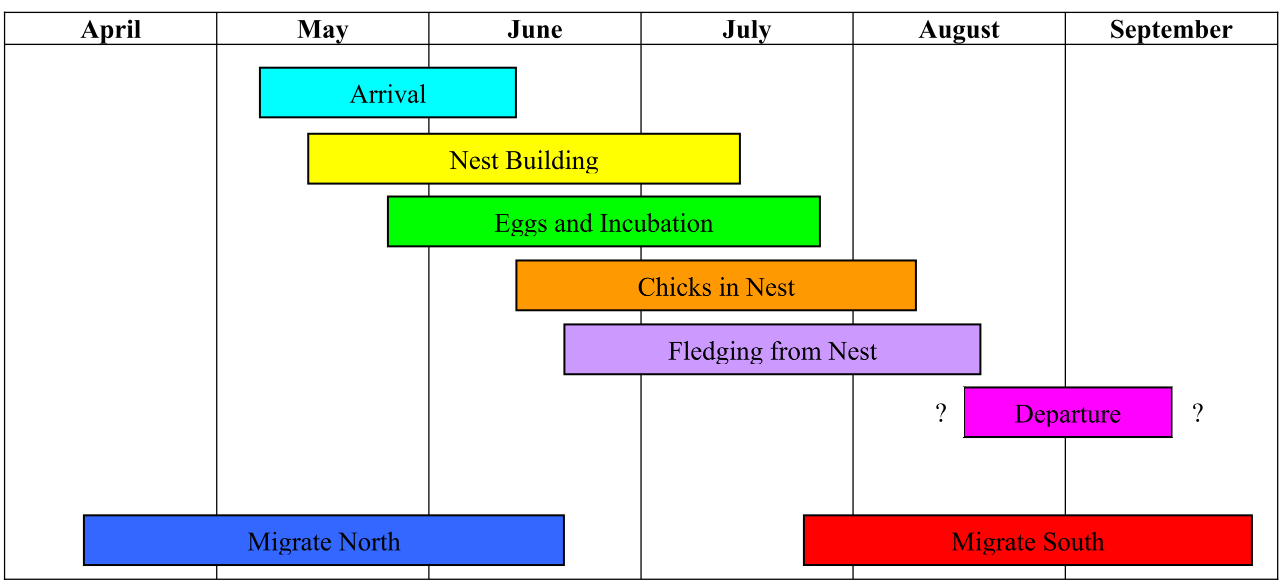


Figure 14. General Nesting Chronology for Southwestern Willow Flycatchers.
(Sogge in Finch et al., 2000).

Nest Stage	Study Area	Earliest Date	Latest Date
Egg-Laying	Sevilleta	June 2	July 27
	San Marcial	May 28	July 24
Hatching	Sevilleta	June 15	August 10
	San Marcial	June 12	August 8
Fledging	Sevilleta	June 27	August 21
	San Marcial	June 24	August 19

Table 9. Flycatcher Chronology for the Sevilleta NWR/La Joya WMA and San Marcial Nests Monitored in 2001. (Ahlers et al., 2001).

		Egg Laying		**Hatching**		**Fledging**	
Month	**Week**	**San Marcial N = 32**	**Sevilleta N = 7**	**San Marcial N = 32**	**Sevilleta N = 7**	**San Marcial N = 31**	**Sevilleta N = 7**
May	4	6					
June	1	6	1				
	2	3		6	1		
	3	4	1	5		1	
	4	3		4		4	1
July	1	5	3	4	1	5	
	2	3	1	2	1	5	1
	3	1		7	2	3	
	4	1	1	3	1	7	3
August	1			1	1	4	1
	2					1	
	3					1	1
	4						

Table 10. Southwestern Willow Flycatcher Nests Documented or Estimated with First Egg, Hatching or Fledging During the 2001 Breeding Season.
(Ahlers et al., 2001). Fledging was not estimated for the nests that failed during incubation.

5.7.2.1.4 Features of Southwestern Willow Flycatcher Breeding Habitat

Many flycatcher breeding sites are composed of spatially complex habitat mosaics, often including both exotic and native vegetation. Within a site, flycatchers often use only a part of the patch, with territories frequently clumped and or distributed near the patch edge. Therefore, the vegetation composition of individual territories may differ from the overall composition of the patch (Sogge et al., 2002).

Generally, four broad categories have been developed to describe species composition at breeding sites and include the following:

Native - > 90% native vegetation
Mixed - > 50% native (50-90% native vegetation)
Mixed - >50% exotic (50-90% exotic vegetation)
Exotic - > 90% exotic vegetation

Habitat patches comprised of native vegetation account for approximately half (48%) of the known flycatcher territories in the southwest. Although only 9% of territories occur at exotic sites, another 39% are located within sites where the habitat includes native and exotic mixtures. In many cases, exotics are contributing significantly to the habitat structure by providing the dense lower-strata vegetation that flycatchers prefer (Sogge et al., 2002).

In the Middle Rio Grande, the degree to which flycatchers breed in habitat dominated by a particular tree species was summarized from nest data collected in 1999-2001. Over 76% (n = 119) of territories are found at sites where native species (*Salix* spp) is the dominant tree species and 12% (n = 19) of the nests are in patches where saltcedar is the most common habitat component.

Data collected and analyzed on nest substrate and surrounding habitat patch communities (specifically in the Sevilleta NWR/La Joya WMA and San Marcial river reaches) in the Middle Rio Grande, indicate that flycatchers may key in on areas dominated by native vegetation, but often select exotic vegetation, particularly saltcedar as a nest substrate. Saltcedar may actually be the flycatchers substrate of choice due to its dense and vertical twig structure. From 1999-2002, approximately 49% of 156 nests located in this river reach were on exotic plants (Russian olive and saltcedar). The surrounding habitat patch was typically dominated by natives (cottonwood and willow) at 119 of the nest sites (76%); exotic vegetation dominated the nesting patch at 19 locations (12%) and mixed native/exotic vegetation surrounded 18 nests sites (12%).

Evidence gathered during multi -year studies of color-banded populations shows that although most male flycatchers return to former breeding areas, southwestern willow flycatchers regularly move among sites within and between years. Between 1996 and 1997, 29% of banded willow flycatchers in Arizona returned to the breeding site of the previous year, while 11% moved to other breeding areas within the same major drainage (Paxton et al., 1997). The remaining 60% of flycatchers were not relocated in 1997, and may have died or moved to undiscovered breeding sites. Distance moved ranged from 20-900 m. There were also two cases of movement (>500m) within a breeding site during the course of a breeding season. Although most returning flycatchers showed site fidelity to breeding territories, a significant number move within and among sites. The mechanism controlling the decision to return or move, as well as the adaptive value of movement between sites, is unknown.

In two different situations, flycatchers were forced to move because of catastrophic habitat loss by fire. Occupied flycatcher habitat was destroyed because of fire along the San Pedro River in Arizona (Paxton et al., 1996) and along the Gunnison River in Colorado (Owen and Sogge, 1997). In Arizona, occupied habitat was destroyed as nesting was underway on seven flycatcher territories. All flycatchers abandoned the site and were not seen again in the burned area. Displaced flycatchers had moved to unburned areas within the breeding site or to other breeding areas within 2 and 28 km of the original site. In Colorado, after a fire destroyed flycatcher habitat, some flycatchers returned to the burned area and attempted to breed even in an area without any live vegetation.

These situations demonstrate that some flycatcher pairs will return to the general breeding area to nest in subsequent years if previously occupied sites become unavailable.

5.7.2.1.5 Riparian Habitat Descriptions by Reach

Riparian habitat within all the reaches of the Middle Rio Grande where flycatcher population sites occur includes dense stands of willows and other woody riparian plants adjacent to or near the river channel. Other reaches in the Middle Rio Grande support local areas of suitable willow flycatcher habitat, e.g., middle reaches, however no birds have been observed establishing territories. Dense monotypic stands of saltcedar are more prevalent in the Isleta, and Socorro reaches.

The Velarde Reach has a riparian zone with limited recruitment of natives, stands of willow in small fragmented patches and exotic vegetation composed mostly of Russian olive. Habitat quality and vegetation varies considerably within this reach. Some bosque areas contain older, more mature trees that are 30-50 ft tall. Russian olive and Siberian elm (*Ulmus pumila*) trees occur on some bank lines and river bars. Other areas support stands of dense willows with canopy trees. Overbank flooding is localized but regular. The high potential for bank erosion may increase the dynamics of riparian vegetation loss and regeneration. All habitat patches within this reach where birds have been detected in the past were dominated by willow and were inundated by overbank flooding or irrigation return flows. Nearby habitat included mature cottonwoods, open areas and Russian olives.

The bosque in the Cochiti and Middle reaches contains mainly single-aged stands of older cottonwoods and lack the diversity of a healthy, multi-aged riparian forest. Exotic vegetation such as Russian olives and Siberian elms are also becoming established. Significant channel narrowing and degradation has significantly limited overbank flooding and reduced the potential for recruitment of native riparian vegetation, especially cottonwoods and willows.

Known willow flycatcher habitat in the Isleta Reach consists of dense willow and cottonwood stands associated with floodplain marshes near the Isleta Diversion Dam. Known willow flycatcher habitat in the Rio Puerco reach (Sevilleta NWR/ La Joya State WMA) occurs adjacent to the river and is dominated by saltcedar and Russian olive. The trend of channel narrowing and degradation reduces the amount of overbank flooding and the potential to enhance existing sites or establish new native vegetation.

5.7.2.1.6 Flycatcher Breeding Habitat Suitability Model

In 1998, Reclamation initiated development of a habitat suitability model for flycatchers based on habitat features preferred by nesting flycatchers within the Middle Rio Grande floodplain. Riparian vegetation has been mapped between Bernardo to Elephant Butte Reservoir based on the Hink and Ohmart (1984) classification system through a cooperative effort with the U. S. Forest Service. The system identifies vegetation polygons based on structure and dominant and/or codominate species in the canopy and shrub layers. By grouping these classifications based on habitat structure and density required by breeding willow flycatchers, it was possible to delineate areas based on habitat suitability. These groupings were based on the best biological opinion and habitat requirements of the willow flycatcher. Vegetation overlay maps classifying riparian habitat along the Middle Rio Grande into categories of suitability for breeding flycatchers have been developed and assist in determining the amount of suitable habitat available for a potentially expanding population of breeding flycatchers.

Based on the available literature and Reclamation's experience with the San Marcial reach, a hydrologic component was incorporated into the model. Breeding habitat suitability was refined by identifying all areas that are within 100 meters of existing watercourses, ponded water, or in the zone of peak inundation. Overbank flooding during spring runoff is important to willow flycatchers since nest sites in New Mexico are nearly always over or adjacent to water. The recession of water from the immediate vicinity of a nest site after runoff may not be as critical to nest success as water availability during the early breeding season. It is common for nest sites to contain surface water early in the breeding season but to be dry by mid-summer (Muisnieks et al., 1994; Sogge et al., 1997). Throughout the Middle Rio Grande valley, there is also water available within the floodplain associated with the water delivery systems.

The defined Hink and Ohmart riparian vegetation classification for the San Acacia and southern reaches were placed in habitat categories representing different levels of suitability for breeding willow flycatchers based on the location of known breeding territories, proximity to water, plant species composition, vegetation density, and height. The five categories of willow flycatcher habitat that lie within 100 meters of water are defined as:

- Highly Suitable Native Riparian – Stands dominated by willow and/or cottonwood.
- Suitable Mixed Native/Exotic Riparian – Includes stands of natives mixed with various compositions of exotics.
- Marginally Suitable Exotic Riparian Stands – composed of monotypic saltcedar or stands of saltcedar mixed with Russian olive.
- Potential with Future Riparian Vegetation Growth and Development – Includes stands of very young sparse riparian plants on river bars that could develop into stands of adequate structure with growth and/or additional recruitment. This category requires regular monitoring to ascertain which areas contain all the parameters to become willow flycatcher habitat.
- Low Suitability – Includes areas where native and/or exotic vegetation lacks the structure and density to support breeding willow flycatchers, or exceeds the hydrologic parameter of >100 meters from water.

The Rio Grande in the San Acacia Reach supports a high value riparian ecosystem. The native riparian trees and shrubs are interspersed with stands of introduced invasive riparian plants (exotics), primarily saltcedar and Russian olive. Another factor that contributes to the habitat value of this area is its proximity to native desert habitat on both sides of the floodplain. This area is unlike reaches of the Rio Grande where agricultural and urban development has encroached on the outside edges of the floodplain. Thus, this area represents a relatively intact landscape with associated high biological values. For this reason, the area is considered to have high potential for riparian restoration.

5.7.2.1.7 Current Availability of Breeding Habitat for Willow Flycatchers

The extent of suitable and potential habitat from Bernardo to the delta of Elephant Butte Reservoir was delineated in 2000 using the habitat model and previous vegetation mapping efforts and is presented in Table 11. This mapping effort is being updated with current digital images and the area of coverage expanded (250 miles) from the delta of Elephant Butte to Velarde with ESA Collaborative and other funding sources in 2002-2003. The model continues to be refined as additional nest sites are located, as vegetation develops over time and as new habitat features that influence flycatcher nest site selection are identified.

The area in the delta of Elephant Butte Reservoir has quickly established into very suitable habitat because of the moist soil conditions of the receding reservoir pool and perennial low velocity flows and ground water seepage associated with the LFCC. As a result, the acreages of suitable and potential habitat within the delta and reservoir pool have increased and are represented in the table as minimum acreages. An update of these acreages will be available in late 2003. As of 2000, 24,949 ha of riparian vegetation have been identified between Highway 60 (Bernardo) to delta of Elephant Butte Reservoir. An additional 3,708 ha of wetland and open water have also been identified. Of the total, approximately 2,051 ha (8%) were identified to be highly suitable or suitable breeding habitat and most of this (71%) is located along the existing river channel downstream of Bosque del Apache NWR (Ahlers et al., 2000). It is uncertain how much of the potential habitat occurring along the existing river channel will develop into suitable habitat, because many of the areas currently do not have geomorphic and/or other parameters that would support further vegetation development.

	Hectares Per Reach						
Willow Flycatcher Habitat Category	**Sevilleta /La Joya**	**Upper north**	**Upper south (including Tiffany area)**	**Lower east**	**Lower west**	**Delta**	**Total**
Highly suitable	217	19	184	255	77	65 (minimum)	817
Suitable	757	85	192	119	35	46 (minimum)	1,234
Marginally suitable	898	169	729	59	134	6 (minimum)	1,995
Potential	1,081	426	183	50	35	37(minimum)	1,812
Low suitability	11,204	2,264	2,372	133	1,440	1,678	19,091
Totals:	14,157	2,963	3,660	616	1,721	1,832 (minimum)	24,949

Table 11. Quantification of Southwestern Willow Flycatcher Habitat on the Rio Grande between Highway 60 (Bernardo) and the Delta of Elephant Butte Reservoir.
Data pertain to categories and assessments as delineated in 2001 by Ahlers et al., (2001).

5.7.2.1.8 The Development of Suitable Southwestern Willow Flycatcher Breeding Habitat Within the Middle Rio Grande

It is commonly recognized that one of the primary causes for the decline of Neotropical migrants, along with numerous other terrestrial species, is the decrease in the abundance of riparian vegetation over the past hundred years. The reason for this decline in riparian vegetation is due to the removal of the dynamic components of river systems.

The Rio Grande and associated riparian areas have historically been a very dynamic system in constant change and without this change, the diversity and productivity decreases. Sediment deposition, scouring flows, inundation, and irregular flows, are natural dynamic processes that occurred frequently enough in concert to shape the characteristics of the Rio Grande channel and floodplain. Through the development of dams, irrigation systems and controlled flows, the dynamics of the river system have been eliminated except for very localized areas such as the reservoirs where water storage levels frequently change with releases and inflows.

The interaction of river discharge (timing and magnitude), river channel morphology and floodplain characteristics are vital components that can favor the establishment of native vegetation and enhance the development of suitable willow flycatcher breeding habitat within the Middle Rio Grande. To recreate these dynamic process in a very static river system, man made procedures have been developed and implemented such as mechanical disturbance, herbicide treatments, prescribed fire, channel realignment, operational flows, avulsions and river realignment. These man-made processes manipulate the river and floodplain in an attempt to restore the diversity of a healthy river system. It is no coincidence that flycatchers have expanded and dispersed within the delta of the Elephant Butte Reservoir. In the previous several years, this area has had the only dynamic components within the Middle Rio Grande – changing reservoir elevations. Cottonwoods and willows are aggressive colonizers of disturbed sites in a variety of ecological situations (Reichenbacher, 1984).

Successful cottonwood and willow recruitment has been shown to coincide with the descending limb of the spring runoff hydrograph. The timing and rate of decline of receding flood flows such as those that occur at the headwaters of Elephant Butte have been documented as important factors affecting seedling survival (Sprenger et al., 2002).

Several years of prolonged inundation has killed many saltcedar stands within the reservoir pool. The receding reservoir pool has exposed new areas for establishment of native vegetation. Newly scoured area of the river channel or floodplain and areas where sediment has been deposited, also provide conditions for regeneration of native species.

In the San Marcial reach, as part of ongoing reviewed and approved projects, Reclamation is conducting non native vegetation clearing, floodplain expansion, riparian vegetation plantings, channel avulsions, channel widening, and bank destabilization, all of which are man-induced processes to provide the dynamic conditions to enhance the recruitment of cottonwoods and willows.

5.7.2.1.9 Cowbird Parasitism and Breeding Southwestern Willow Flycatchers

Brood parasitism by cowbirds can be a contributing factor to the decline of the flycatcher, as well as other Neotropical migrant land birds. Reclamation implemented a brown-headed cowbird *(Molothrus ater*) (cowbird) control program from 1996 through 2001 in the San Marcial area. This was an effort to reduce brood parasitism on the endangered southwestern willow flycatcher as mitigation for the presence of cattle within Elephant Butte public lands. Between 1997 through 2001, approximately 3,599 cowbirds were captured in the study area in the absence of cattle (except trespass cattle). During this time, the number of cowbirds trapped during the summer resident period remained constant, which appeared to indicate that trapping did not reduce the breeding population of cowbirds at Elephant Butte Reservoir over time. However, the number of cowbirds were reduced on a seasonal basis.

Factors influencing cowbird density include, host nest availability, habitat quality, presence of livestock, and availability of forage areas such as grain fields. Cowbird and Neotropical bird observations along the riparian corridor of the Middle Rio Grande were compared between sites with different land use practices using the point count methodology. These counts indicate that Sevilleta NWR attracted the highest number of nesting Neotropical birds species likely to provide host nests for cowbirds. This reach is also characterized by the narrowest riparian corridor of the four reaches. Point counts indicate that Sevilleta NWR and BDA NWR attracted the highest number of cowbirds. Both of these refugees are not grazed. Increased cowbird numbers may be in response to better habitat or the availability of Neotropical bird host nests.

The effects of cowbird trapping on the success of breeding flycatchers and other Neotropical birds on Elephant Butte public lands was assessed for the period 1999 – 2001. In the Elephant Butte public lands study area, parasitism in Neotropical bird nests was 31% and 5% in flycatcher nests from data sets combining nests monitored from 1999 through 2001 (Ahlers pers.com., 2001). This data indicates that possibly factors other then trapping may be responsible for the low incidence of parasitism on the flycatcher nests. Within the reservoir delta, a dramatic increase in the number of breeding flycatchers occurred since 1999. In 2001, nest success for the breeding flycatchers in the delta was 75% in comparison to a 50% nest success of Neotropical birds in the same area. No parasitism had occurred in the flycatcher nests from 1999 through 2001. The increase of breeding pairs and the absence of parasitism in this specific area most likely is a response to high quality habitat. When comparing the Neotropical bird nest data between Elephant Butte public lands with cowbird trapping, and San Acacia and BDA NWR reaches where no trapping occurs, there was no statistical difference between nest success observed within the trapped versus untrapped areas. This data indicates that trapping cowbirds does not affect Neotropical bird nest success.

5.7.2.2 Bald Eagle

5.7.2.2.1 Current Status

Reclamation's ongoing bald eagle studies monitor population abundance and distribution on the Rio Grande from San Acacia Diversion Dam to the Narrows of Elephant Butte Reservoir using aerial and ground surveys. Table 4 summarizes the results of surveys during the winters of 1997, 1998, and 1999. Results from these surveys are consistent with peak counts in 1996-97 Corps surveys from the same reach (Table 1, section 4.3.1) and suggest that bald eagles are concentrated along the west shore of Elephant Butte Reservoir from Dryland Road (about river mile 58) south. A few bald eagles are usually observed in flooded cottonwood snags in the wetlands between Quates Canyon and Dryland Road. Since no eagles were observed during the April and May 1997 surveys, it is suspected that no nesting is currently occurring in the headwaters area of Elephant Butte Reservoir. However, habitat in this reach appears suitable to sustain nesting bald eagles in the future.

The City of Albuquerque studied bird populations in the Rio Grande Valley State Park, about 20 miles of Rio Grande bosque through Albuquerque and Bernalillo County, between December 1996 and June 1997 (Stahlecker and Cox, 1997). Wintering bald eagles were more often encountered in the southern and northern portions of the park than through the center of Albuquerque. Three to five individuals were counted during surveys downstream from Rio Bravo Bridge and two to four individuals were observed above Alameda Bridge. Up to 18 bald eagles are known to roost in this reach.

The status of the bald eagle along the Rio Grande and Rio Chama upstream from Albuquerque must be inferred from Corps winter surveys discussed in Table 1 (section 4.3.1). In 1996, the Corps found bald eagles distributed throughout the Middle Rio Grande north of Albuquerque to the confluence of the Rio Chama and upstream on the Rio Chama to El Vado Dam. The two areas of greatest concentration were around Cochiti Lake and the reach of the Rio Chama from Abiquiu Reservoir to El Vado Dam. Bald eagles also occur on the Middle Rio Grande north of Española to Velarde.

The bosque in the Cochiti and Middle reaches contains mainly single-aged stands of older cottonwoods and lacks the diversity of a healthy, multi-aged riparian forest. Exotic vegetation such as Russian olives and Siberian elms are also becoming established. Significant channel narrowing and degradation has significantly limited overbank flooding and reduced the potential for recruitment of native vegetation, especially cottonwoods and willows.

Reclamation has conducted winter bald eagle surveys since 1997, to monitor population abundance and distribution along the Rio Grande from San Marcial to the "narrows" in Elephant Butte Reservoir using aerial and ground surveys. In 1999, surveys were expanded to include the area from the "narrows" in Elephant Butte Reservoir to Caballo Dam. Table 12 summarizes the results of surveys conducted during January or February of 1997 through 2003. Since no eagles were observed during the April and May 1997 surveys, it is suspected that no nesting is currently occurring in the headwaters area of Elephant Butte Reservoir. However, habitat in this reach appears suitable to sustain nesting bald eagles in the future.

River Reach	1/23/97	1/27/98	1/27/99	1/9-10/01	2/1/02	1/16/03
San Marcial (active floodplain)	2 (2/0)	0	0	1 (1/0)	0	0
San Marcial (west side groundwater wetlands)	1 (1/0)	1 (1/0)	0	2 (2/0)	0	2(2/0)
Elephant Butte Reservoir (east side) North of Dryland Road	0	4 (2/2)	6(3/3)	0	0	0
Elephant Butte Reservoir (west side) wetlands north of Dryland Road	1 (0/1)	5 (3/2)	3(2/1)	1 (1/0)	2(2/0)	0
Elephant Butte Reservoir (east side) Dryland Road to Nogal Canyon	9 (6/3)	4 (2/2)	8(5/0) *3(3/0)**	4 (1/3)	5(2/3)	1(1/0)
Elephant Butte Reservoir (west side) Dryland Road to Nogal Canyon	12 (8/4) *45 (30/15)**	17 (9/8)	18(11/7) *28(16/12)**	12 (7/5)	8(6/2)	8(2/6)
Elephant Butte Reservoir (east side) Nogal Canyon to Narrows	6 (1/5)	0	2(1/1) *12(6/6)**	13 (8/5)	11(8/3)	6(4/2)
Elephant Butte Reservoir (west side) Nogal Canyon to Narrows	5 (3/2)	9 (6/3)	3(2/1)	8 (4/4)	7(5/2)	14(9/5)
SUBTOTAL	**32 (24/15)**	**42 (24/18)**	**43 (26/17)**	**41 (24/17)**	**33(23/10)**	**31(18/13)**
Elephant Butte Reservoir (east side) Narrows to Dam	NS	NS	5(3/2) *3(3/0)**	16 (10/6)	25(14/11)	15(12/3)
Elephant Butte Reservoir (west side) Narrows to Dam	NS	NS	9(8/1)	12 (7/5)	12(9/3)	15(11/4)
ELEPHANT BUTTE RESERVOIR TOTAL	–	–	**54(35/19)**	**69 (41/28)**	**70(46/24)**	**61(41/20)**
Rio Grande Elephant Butte Dam to Caballo Delta	NS	NS	1(1/0) *1(1/0)**	1 (1/0)	0	0
Caballo Reservoir (east side)	NS	NS	5(3/2) *6(3/3)**	16 (9/7)**	7(4/3)	3(3/0)
Caballo Reservoir (west side)	NS	NS	5(1/4) 2(2/0)*	8 (5/3)	1(1/0)	2(2/0)
CABALLO RESERVOIR TOTAL	–	–	**10(4/6)**	**25 (15/10)**	**8(5/3)**	**5(5/0)**
GRAND TOTAL			**68(42/26)**	**94 (56/38)**	**78(51/27)**	**66(46/20)**

Table 12. January Counts of Bald Eagles in the Rio Grande Riparian Corridor from San Marcial to Caballo Dam. Data are generally from mourning surveys. Numbers in parentheses (# adults/# immatures - w/o white heads)
* observed during evening roost surveys.
** includes eagles on east side of Rio Grande within Caballo Reservoir delta = 4 adults/1 immature.

5.7.2.3 Interior Least Tern

The interior least tern can be considered a vagrant on the Middle Rio Grande and no interior least tern nesting has been recently documented.

6 ANALYSIS OF EFFECTS OF PROPOSED ACTIONS

"Effects of the action" refers to the direct and indirect effects of the proposed action on listed species or critical habitat together with the effects of other activities that are interrelated or interdependent with that action. These effects are considered along with the environmental baseline to determine the overall effects on the species 50 CFR Part 402.02. For purposes of this BA, effects on listed species and proposed critical habitat for the silvery minnow are analyzed individually with respect to the proposed actions.

Analysis of effects of the proposed actions on the Rio Chama and the Middle Rio Grande above Cochiti Lake will consider the bald eagle and the willow flycatcher. Similar analyses below Cochiti Dam will also consider the silvery minnow. The various existing and future components of the environmental baseline discussed above, e.g., hydrology, geomorphology, aquatic and riparian habitat, and species distribution and abundance, will be the basis upon which the proposed actions will be assessed.

6.1 Corps of Engineers

Analysis of effects relevant to the Corps' proposed actions were described in detail in the June 2001 BA (Reclamation, 2001). This BA incorporates by reference those relevant sections found on pages 181-201 of that report.

6.2 Rio Chama System

6.2.1 Rio Chama Water Operations – Effects Restricted to the Rio Chama System

As discussed in the Description of Proposed Action section, some of the effects of water operations at Heron and El Vado reservoirs are limited to the Rio Chama. For example, Reclamation's issuance of temporary waivers to contractors to modify the date of their water deliveries into the following calendar year can be used to improve overall management of upstream water supplies, and generally affects flow between Heron, El Vado and Abiquiu reservoirs.

6.2.1.1 Southwestern Willow Flycatcher

The Rio Chama may have suitable habitat for willow flycatcher even though only a few territories have been recorded in riparian habitat within the drainage. Limited presence/absence surveys have been conducted to date. The proposed actions may have some effects on discharge in the Rio Chama during the willow flycatcher breeding season but will not affect the general availability of water adjacent to potential nesting habitat or the development of future, suitable habitat. Thus, the proposed actions will not directly or indirectly impact the willow flycatcher within the Rio Chama system.

6.2.1.2 Rio Grande Silvery Minnow

The silvery minnow does not occur in the Rio Grande Basin upstream of Cochiti Dam.

6.2.1.3 Bald Eagle

The bald eagle does not occur within the Rio Chama Basin after April. Thus, no direct impacts to bald eagles from the planned actions during and after spring runoff are anticipated. In addition, there are no foreseeable indirect effects of the proposed actions during the irrigation season on riparian habitats within the Rio Chama that are used by wintering bald eagles. Depletions from Abiquiu Reservoir are replaced by the end of the irrigation season. Heron reservoir level may be "reset," but not necessarily at the previous years level, depending on diversions available and possible shortages in the San Juan River Basin.

The Rio Chama between El Vado Dam and Abiquiu Reservoir is heavily used by bald eagles during the winter. During normal winter operations, Reclamation has historically enhanced flows below El Vado and Abiquiu dams through the release of San Juan-Chama Project water from Heron Reservoir and the bypass of some native flows through El Vado, when these actions are physically and operationally feasible. San Juan-Chama Project water deliveries include releases to Abiquiu Reservoir for storage by the City of Albuquerque and other contractors, and to Cochiti Lake (Cochiti Recreation Pool replacement water). Flow in the Rio Chama below Abiquiu Dam will not be impacted by San Juan-Chama operations, as natural inflows to Abiquiu Reservoir will be passed through the dam as normal.

During years when native Rio Grande storage in El Vado is relatively low following the end of the irrigation season, Reclamation may halt native releases in order to maximize storage for the Prior and Paramount needs of the six Middle Rio Grande Pueblos. These operations may adversely impact the trout fishery between El Vado and Abiquiu as a result of increased variability or minimal streamflow during dry years with relatively low natural streamflow in the Rio Chama. However, operations that maximize storage in El Vado Reservoir will also increase the reservoir surface area, and the foraging area available for bald eagles.

With Article VII Rio Grande Compact restrictions in place, only SJ-C water for the six Middle Rio Grande Pueblos will be stored at El Vado Reservoir. In order to ensure adequate storage for the needs of the six Middle Rio Grande Pueblos, releases from Heron Reservoir (i.e., contract deliveries) will be adjusted to ensure native flows are stored at El Vado for those needs. At times, such operations will lead to flows on the Rio Chama well outside of the recommendations of the Rio Chama Instream Flow Assessment, and it is likely that releases below El Vado Dam could cease completely on occasion to ensure such storage.

Flows in the Rio Chama below Abiquiu Dam may be reduced when maximizing storage of native flows in El Vado and delaying delivery of San Juan-Chama Project water destined below Abiquiu (i.e., Cochiti Recreation Pool replacement water) during the winter, thus producing a small impact by this action.

When compared with existing and potential future baseline hydrologic scenarios and effects between riverine and reservoir habitat, the proposed actions should not negatively impact the bald eagle within the Rio Chama System.

6.2.2 Maintenance Activities at El Vado Dam

Maintenance activities at El Vado Dam are generally scheduled in such a manner as to take advantage of existing and anticipated reservoir conditions. In the event that a maintenance activity requires the modification of reservoir content or releases, conjunctive management with Abiquiu Reservoir will alleviate effects on flows below Abiquiu Dam.

No willow flycatcher or silvery minnow occur near El Vado Dam. Bald eagles will be present at El Vado only during the winter season. As with river maintenance activities, Reclamation will suspend maintenance work at El Vado Dam if a bald eagle is observed perching or roosting within 0.5 miles of a project site. Work will not recommence until the eagle leaves the area of its own volition. Thus, maintenance activities at El Vado Dam will have no effect on endangered species.

6.2.3 River Maintenance

The Rio Chama is not within Reclamation's authorized river maintenance area and thus no river maintenance activities are proposed for this reach.

6.2.4 Rio Chama Water Operations – Effects on the Middle Rio Grande

The following is an analysis of effects of the operation and maintenance of El Vado Dam and Reservoir on the endangered species considered in the BA.

Storage of native water in El Vado Reservoir typically occurs during spring runoff and summer rain events. This storage results in a proportional decrease in the volume of water that is passed through Abiquiu and Cochiti reservoirs and is thus available to the Middle Rio Grande below Cochiti Dam. Depending on reservoir storage contents, El Vado Reservoir can capture part or all of the flow associated with spring runoff and rain events. For example, the volume of spring runoff on the Rio Chama in 2000 was very low due to drought conditions. The available storage space in El Vado Reservoir was sufficient to capture all of these flows.

Normally, during irrigation season (beginning March 1) native flows into El Vado are bypassed up to 100 cfs for the Rio Chama Acequias below Abiquiu Dam. If after March 1, the operation is to continue maximizing the storage of native flows in El Vado Reservoir, the contributions from the Rio Chama will be solely from intervening flow between El Vado Dam and Abiquiu Reservoir and below Abiquiu (e.g., Rio Ojo Caliente). This may have a small impact on the mainstem flows through the Middle Valley during the first part of irrigation season.

It should be noted that spring runoff on the Rio Chama is one component of the overall runoff on the Middle Rio Grande below Cochiti Dam. Runoff from the mainstem of the Rio Grande is the other significant source of water during this time. The relative volume of spring runoff flow contributed by the Rio Chama and the mainstem of the Rio Grande is largely dependent on local snow pack conditions. Thus, the relative significance of runoff flows from the Rio Chama on the Rio Grande is also dependent on the volume of runoff from mainstem flows. However, a cursory review of the last 20 years of record indicates the Rio Chama contributes about 30-45%. In years with high mainstem runoff, an increased volume of Rio Chama runoff flow could be stored without causing harm to endangered species downstream. However, in years with little to no peak flow input from the mainstem Rio Grande, the impacts of storing Rio Chama runoff flows at El Vado Reservoir may be more critical.

The storage of base flows from the Rio Chama watershed in El Vado Reservoir during the non-irrigation season (November through February) has imperceptible effects on Rio Grande flows through the Middle Valley, as these river flows are maintained by undiverted mainstem base flows. During the irrigation season, the effects of Rio Chama base flow storage in El Vado Reservoir are masked by managed water deliveries and spring runoff flows. Post-runoff base flow on the Rio Chama (July through October) generally averages less than 20% of the combined Rio Chama-Rio Grande native flow.

6.2.4.1 Southwestern Willow Flycatcher

Overbank flooding associated with spring runoff and summer rain events creates moist soils that are conducive to willow flycatcher nest initiation and breeding success (see section 4.2.2). Reduction in overbank flooding downstream due to the storage of peak native flows in El Vado Reservoir may affect willow flycatcher nest establishment and the rearing and fledging of juveniles at sites throughout the Middle Rio Grande below Cochiti Dam. The presence of overbank flooding to provide low-velocity flooded vegetation or moist soils has been cited as key components in breeding habitat selected by willow flycatchers. Willow flycatcher territories upstream of the confluence of the Rio Chama with the Rio Grande would be unaffected by operations at El Vado Dam and Reservoir.

Reduction in overbank flooding may also indirectly affect the maintenance, development and establishment of riparian vegetation downstream. High discharges are important for the creation and maintenance of the riparian ecosystem, and specifically, migratory and nesting habitat for willow flycatchers. In addition, the rate and timing of the recession of spring runoff is important to recruitment of native cottonwood and willow vegetation.

Thus, storage of native flow in El Vado Reservoir may affect, and is likely to adversely affect, the willow flycatcher.

6.2.4.2 Rio Grande Silvery Minnow

The storage of native water in El Vado Reservoir during spring runoff may reduce flow downstream of Cochiti Dam, which is an important cue for silvery minnow spawning during the months of May and June. In past years, bypassing at least a portion of spring runoff flows at El Vado Dam when the reservoir was full contributed to conditions conducive to silvery minnow spawning. A reduction of peak flows associated with summer rain events that occur in the watershed above El Vado Reservoir has insignificant impacts on the silvery minnow if it occurs after the spawning season. This is because rain events also occur in the much larger portion of the Rio Grande Basin below El Vado Dam. The resultant runoff is passed through Cochiti Dam.

Effects of reducing peak flows in the Rio Grande by storing native flows in El Vado Reservoir during spring runoff include: 1) the reduction in overbank flooding and associated loss of low velocity overbank habitat that may be used by larval and juvenile silvery minnow, and 2) the continued narrowing of the Rio Grande channel downstream due to the long-term reduction in channel-forming discharge. Channel narrowing reduces the availability of shallow, low velocity habitat that is used by all life stages of silvery minnow.

Thus, storage of native flow in El Vado Reservoir during spring runoff may affect, and is likely to adversely affect, the silvery minnow and is likely to adversely affect proposed critical habitat for the species.

6.2.4.3 Bald Eagle

The bald eagle is not present on the Rio Grande or Rio Chama during the spring runoff and summer monsoon season and thus the storage of native flow in El Vado Reservoir will have no direct effect on the species. Potential indirect effects on riparian vegetation were discussed above for the willow flycatcher and are less significant for the bald eagle since existing habitat in the project area appears suitable to sustain bald eagles into the future.

Storage of native flow in El Vado Reservoir results in increased reservoir levels and should therefore result in increased surface area available for foraging, more reservoir habitat for prey species, e.g., fish, and higher suitability of shoreline habitat. For example, successive wet years in the early 1990’s and a concomitant increase in reservoir storage (El Vado and Abiquiu reservoirs), along with larger releases from both reservoirs led to a rise in the number of bald eagles on the Rio Grande and Rio Chama. Thus, the storage of native flow in El Vado Reservoir may affect, but is not likely to adversely affect, the bald eagle.

6.3 Middle Rio Grande System

To determine the effects of the proposed actions on the listed species, the BA compares potential intermittent flow conditions both spatially and temporally for the proposed action to the environmental baseline. The difference in effects is the incremental effect that can be attributed to the proposed actions.

6.3.1 Water Operations

Constraints and Assumptions

The following assumptions used in developing the hydrologic scenarios for the analysis of effects include the proposed actions.

- Normal MRGCD demand for diversion into MRGP facilities above San Acacia for the purposes of irrigation of Indian and non-Indian lands.
- MRGCD diverts 50 cfs into MRGP facilities at San Acacia Diversion Dam from March 1 through October 31.
- Return flow equal to 30% of MRGCD diversions made at Isleta Diversion Dam (but not less than 50 cfs) returns to the Rio Grande floodway at the Lower San Juan Drain.
- Return flows from San Acacia Diversion Dam are collected by the LFCC, and do not return to the Rio Grande Floodway.
- Non-federal depletions allowable under the Rio Grande Compact.
- Constant inflow of 70 cfs from City of Albuquerque's wastewater treatment plant.
- No actions are included that are specifically intended to benefit endangered species.

As discussed in the Environmental Baseline Section, hydrologic scenarios developed for at least the years 2003 and 2004 must also comply with the constraints imposed by Article VII of the Rio Grande Compact. Contributions from precipitation downstream of Cochiti Dam are not included in this hydrologic analysis because no viable way could be identified to predict and then model the impact of stream flows.

Methodology

URGWOM model runs simulating normal operations during 2003 were already available using 1996 (dry scenario) and 1989 (average scenario) hydrology. Hydrographs representative of Rio Grande flow at Cochiti, San Felipe, Central Avenue Bridge at Albuquerque and Isleta were simply exported from the RiverWare model containing the model run. It is generally felt that the URGWOM model is capable of modeling the Rio Grande above Isleta to a resolution and accuracy sufficient for the analysis performed for this BA.

For river reaches downstream of Isleta, a methodology similar to what was described for the Environmental Baseline was employed. Approximate channel loss rates derived from historic URGWOM reach losses were applied to the URGWOM developed hydrograph for Isleta to approximate total Rio Grande flows at Bernardo, San Acacia, and San Marcial. Lag times were not applied to temporally shift the hydrograph between the various stations along the river.

A return flow based on 30% of Isleta Diversion Dam diversions, but not less than 50 cfs, was applied upstream of San Acacia to account for MRGP Lower San Juan Drain irrigation return flows. Diversions at Isleta Diversion Dam were estimated based on values contained within the URGWOM model. A diversion of 50 cfs was assumed at San Acacia Diversion Dam, but return flows from this diversion were neglected because they currently return to the LFCC rather than the Rio Grande floodway. Because this scenario only represents normal operations, actions such as the release of supplemental water and LFCC pumping activities are not included.

The hydrographs created using the described methodology were then used to evaluate and describe the potential occurrences of drying within the various river reaches based on historic observations of river drying episodes.

It is extremely important to note that these hydrographs neglect all contributions from precipitation that are not included within the historic gauge flows measured above Isleta. As described previously for the environmental baseline, the hydrologic conditions described for Normal Operations approach the worst case for the scenarios that are presented. Depending on the occurrence and magnitude of monsoonal storms, actual conditions could vary from the near worst-case scenarios that are described, through conditions that result from a favorable monsoon season with little or no river drying and intermittency.

Description of Normal Operations – Dry Hydrologic Scenario

Rio Grande drying could occur below San Acacia as early as late April or early May. As described for the Environmental Baseline, historic records for San Marcial suggest the possibility that drying could occur earlier than April.

Based on historic observations, initial drying would likely occur near the center of Bosque del Apache National Wildlife Refuge, and extend rapidly to the north and south over the following weeks. By the end of May, complete River drying could extend from San Acacia Diversion Dam to a point south of the Fort Craig pumping station and north of Elephant Butte Reservoir. Complete rewetting of the river through these reaches for the remainder of the year might not occur until late October or mid-November. Assuming no monsoonal moisture, more than 50 miles of river from San Acacia to south of Fort Craig could remain intermittent or dry for as long as 25 weeks (Figure 15).

During this same period, river intermittency as well as extensive reaches of completely dry riverbed could occur within a 30 to 40 mile stretch of the Rio Grande between Tome and the Lower San Juan Drain of the Middle Rio Grande Project. Assuming no monsoonal moisture, intermittency or extensive drying could occur within this area from early May through mid-September. Intermittency could extend an additional nine miles north of Tome to Isleta during the months of July and August. The Rio Grande would likely remain continuous throughout the year within the 10-mile stretch between the Lower San Juan Drain and the San Acacia Diversion Dam (Figure 15).

During mid-June through mid-October, sporadic and short-term intermittency could occur within a stretch of river more than six miles long from north of Central Avenue in Albuquerque to the City's waste water treatment discharge point near Rio Bravo Boulevard. It is likely that the remainder of the river to the north of Central Avenue would remain continuous throughout the year. The nine mile stretch of river from the waste water discharge point south to Isleta Diversion Dam would likely remain continuous throughout the year, with a minimum flow equivalent to the City's treated waste water discharge rate (Figure 15).

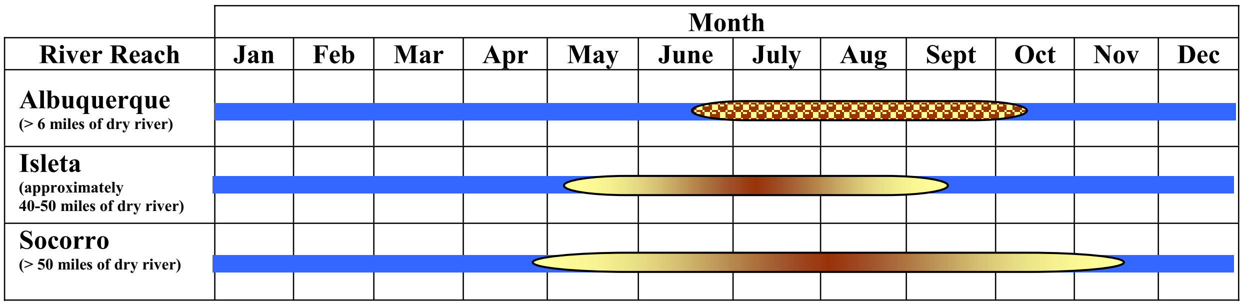


Figure 15. Spatial and Temporal Representation of Anticipated "Normal Operations" Intermittent Flow Under "Dry" Hydrologic Conditions.
The blue bar indicates continuous flow. Brown (dark) indicates intermittent flow; yellow (light) indicates recession or progression of flows; brown spots against a yellow background indicate sporadic and short-term periods of intermittency. The blending of colors (brown vs. yellow) indicates a time of transition as conditions change from perennial to intermittent, or the antithetical condition.

Description of Normal Operations – Average Hydrologic Scenario

Rio Grande drying could occur below San Acacia as early as mid-May. Based on historic observations, initial drying would likely occur near the center of Bosque del Apache National Wildlife Refuge, and extend rapidly to the north and south over the following weeks. By early June, complete river drying could extend from San Acacia Diversion Dam to a point south of the Fort Craig pumping station and north of Elephant Butte Reservoir. Complete rewetting of the river through these reaches for the remainder of the year might not occur until mid-October. Assuming no monsoonal moisture, more than 50 miles of river from San Acacia to south of Fort Craig could remain intermittent or dry for as long as 20 weeks (Figure 16).

During this same period, river intermittency as well as extensive reaches of completely dry riverbed could occur within a 30 to 40 mile stretch of the Rio Grande between Tome and the Lower San Juan Drain of the Middle Rio Grande Project. Assuming no monsoonal moisture, intermittency or extensive drying could occur within this area from late May through mid-September. Sporadic and isolated episodes of short-term intermittency could occur between Isleta and Tome during the months of July and August (Figure 16). The Rio Grande would likely remain continuous throughout the year within the 10-mile stretch between the Lower San Juan Drain and the San Acacia Diversion Dam.

During July through September, sporadic and short-term intermittency could occur within a stretch of river more than six miles long from north of Central Avenue in Albuquerque to the City's waste water treatment discharge point near Rio Bravo Boulevard (Figure 16). It is likely that the remainder of the river to the north of Central Avenue would remain continuous throughout the year. The nine mile stretch of river from the waste water discharge point south to Isleta Diversion Dam would likely remain continuous throughout the year, with a minimum flow equivalent to the City's treated waste water discharge rate.

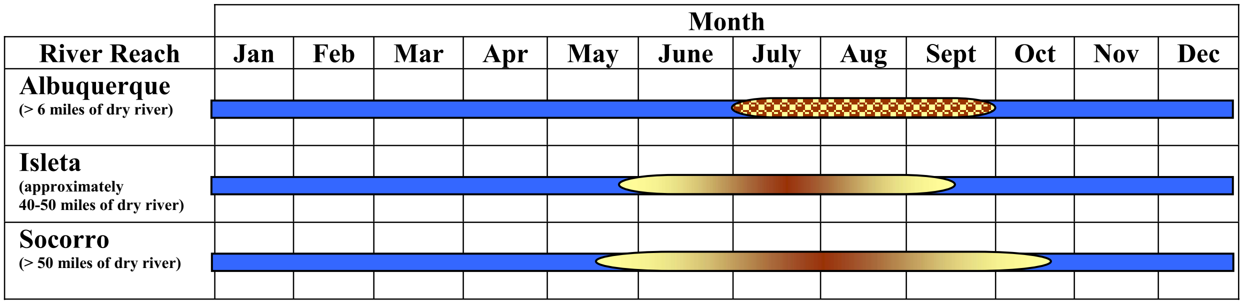


Figure 16. Spatial and Temporal Representation of Anticipated "Normal Operations" Intermittent Flow Under "Average" Hydrologic Conditions.

The blue bar indicates continuous flow. Brown (dark) indicates intermittent flow; yellow (light) indicates recession or progression of flows; brown spots against a yellow background indicate sporadic and short-term periods of intermittency. The blending of colors (brown vs. yellow) indicates a time of uncertainty as conditions change from perennial to intermittent, or the antithetical condition.

6.3.1.1 Southwestern Willow Flycatcher

Above Cochiti Lake

The proposed actions do not impact the annual hydrograph of the Rio Grande above the confluence with the Rio Chama and therefore do not impact the willow flycatchers that are found in the Velarde Division.

Proposed water management actions on the Rio Chama will influence flows in the Española Division. However, proposed actions should not significantly alter the pre-spring runoff, spring runoff, summer, or winter baseline hydrographs within this reach. Runoff conditions under proposed operations should provide similar, localized areas of overbank flooding that are necessary for regeneration of native vegetation. No willow flycatcher territories have been located on the Rio Grande between the confluence of the Rio Chama and Otowi. Singing males have been observed but are presumed migratory individuals. There are local areas of suitable willow flycatcher habitat within the Española Division. As mentioned above, proposed water management actions should support riparian habitat within this reach to the same extent as under baseline conditions. Thus, proposed water operations will not impact the willow flycatcher on the Rio Grande upstream from Cochiti Lake.

Below Cochiti Dam

Irrigation Season – through Spring Runoff

It is common for flycatcher nest sites to contain water early in the breeding season but to be dry by mid-summer (Muisnieks et al., 1994; Sogge et al., 1997). Water availability during the early breeding season may be more critical to nest success then the recession of water from the immediate vicinity of a nest site after runoff. Sources of water adjacent to the currently occupied willow flycatcher habitat within the Middle Rio Grande below Cochiti include flows in the river channel, overbank flooding flows from the tributaries such as the Rio Puerco, agricultural return flows to the river (Isleta drains, San Juan Drain), and seasonally flooded wetlands associated with the La Joya State WMA, Sevilleta and Bosque del Apache NWRs. Additional sources of water in the lower reaches of the Socorro Division (San Marcial flycatcher population sites) include wetlands associated with the LFCC, and moist soil wetlands associated with receding water levels of Elephant Butte Reservoir. The locations where the populations are thriving and expanding are associated with surface water hydrology (LFCC outflows) within the nest site throughout the nesting season. In 2002, three sites adjacent to the LFCC where nests were still active (fledglings present in the nest) in late August had standing water under the nest tree. The number of flycatcher territories at the San Juan Pueblo, Isleta Pueblo, and Sevilleta NWR are stable and slowly increasing. Nest sites in these locations are generally located within 150 feet of a flowing channel or the river. During the 2000-2002 breeding seasons, river flows were low, and overbank flooding did not occur in most areas; however flycatchers continued to nest at these locations. The correlation between nest initiation and late spring high flows and moist soil is supported by the incident of breeding flycatchers abandoning a known cluster of nests along the river in the San Marcial Reach in 1996 when the Rio Grande became dry. This area has not been surveyed since 1996 due to private land access; however, there are indications of flycatcher territories within the vicinity of this site in subsequent years.

In the dry hydrologic conditions, Reclamation's proposed actions will have no affect on the potential occurrence of overbank inundation. River flows, as described in section 6.3.1., would be less than the minimum flows needed to induce overbank flooding and inundation of riparian habitat. Therefore, Reclamation's proposed activities would have no affect on the spring conditions of suitable habitat for willow flycatchers.

However, with higher spring discharge flows, Reclamation's proposed actions could reduce the total discharge in the river channel below diversion points and could impact the frequency and occurrence of overbank flooding and the acres of riparian habitat inundated. With reduced frequency or eliminated overbank events, no opportunities would occur to generate new riparian areas, enhance existing potential or suitable habitat with moist /wet soils throughout any of the reaches of the Middle Rio Grande. The lack of moist or wet soils in suitable habitat during spring runoff, could affect flycatchers internal mechanisms to establish territories and initiate nesting. Reclamation's proposed diversions during the spring runoff in normal water years could have adverse affects on the suitability of existing flycatcher habitat by preventing overbank flooding or inundation in the core breeding locations. The elimination of wetted or moist soils would decrease the quality of the suitable riparian habitats and could influence the species' internal mechanisms to initiate nesting. Additionally, elimination of overbank inundations would impact the development of young riparian vegetation.

In summary, Reclamation's proposed water operations during spring runoff in "dry" years would not directly or indirectly affect flycatchers. However, proposed water operations during spring runoff in "normal" water years could directly affect flycatcher nest initiation and indirectly affect the development of potential flycatcher breeding habitat.

Irrigation Season – Post-Runoff
There are currently six sites with flycatcher breeding populations along the Middle Rio Grande below Cochiti Dam, distributed in several different divisions of the river. The populations at each site are measured by the number of flycatcher territories (single bird or pair) established each year; however, each site is not always surveyed or monitored on an annual basis. Baseline populations (the number of territories), at each site have been shown to be variable and may be influenced by an assortment of factors including hydrologic conditions. Without annual surveys and nest monitoring at each site or an analysis of other environmental factors on specific populations, it is difficult to predict just the impacts of hydrologic conditions on the status of flycatchers populations at each location.

During all environmental baseline scenarios, there is the potential that the river will be dry in the general vicinity of some of the known willow flycatcher nesting territories. Summer thunderstorm activity may temporarily wet some of these areas. Sferra et al. (1997) indicates that there has been successful nesting at some sites in Arizona even in a total absence of water or visibly saturated soil for several years. However, it is unknown how long such sites will support nesting willow flycatchers.

Under the dry hydrologic conditions, Reclamation's proposed water operations would cause river drying to initially occur earlier in the season in late April to early May, with the river becoming completely dry by the end of May in some reaches. Under average conditions, Reclamation's proposed water operations would also cause river drying to begin earlier in the season, possibly by mid-May, and complete river drying would occur in early June. Locations with drying would be similar to environmental baseline conditions starting at the Bosque del Apache NWR and continuing to Fort Craig and north to the San Acacia Diversion Dam. These earlier dry river conditions from May and June, could affect the number of flycatchers that establish territories and the number of pairs that initiate nesting. In both scenarios, Reclamation's proposed water operations would increase the magnitude and duration of intermittency and drying in July and August. Increased dry conditions could extend north of Tome towards Isleta Diversion Dam to the lower San Juan Drain (just below the Rio Puerco Confluence). Increased dry river conditions in July and August could affect the success of paired birds that have established nests along the river in these reaches. Under both scenarios, Reclamation's proposed water operations do not affect the continuation of flows from the wastewater discharge point in Albuquerque to the Isleta Diversion Dam and from San Juan Drain to the San Acacia Diversion Dam. In addition, under both scenarios, addition of river flow, when compared to baseline conditions, is provided within the 10-mile stretch between the lower San Juan Drain and the San Acacia Diversion Dam.

Currently, two populations of breeding willow flycatchers (Isleta and Sevilleta/La Joya) occur in these reaches where continuous flows are expected during both the dry and average hydrologic conditions. Populations in the Isleta Reach would be unaffected by Reclamation's proposed water operations. Populations in the Sevilleta/La Joya reach would be benefited by increased return flows due to Reclamation's proposed actions. Breeding of willow flycatchers at the head of Elephant Butte Reservoir, primarily influenced by the flows of the LFCC, would be unaffected by the proposed actions.

The populations of birds most at risk with the river drying augmented by Reclamation's proposed water operations are those birds establishing territories along the river from San Acacia Diversion Dam through Fort Craig. In 2002, 13 territories were established in these two reaches. Eleven territories were established by single birds (males). Two territories actually had an established pair; however, only one nesting attempt was documented. In 2002, this nest attempt failed.

Under the "dry" or "average" hydrologic river conditions, Reclamation's proposed Middle Rio Grande water operations activities would extend the onset of river drying into the period when flycatchers are establishing territories or initiating nesting in late May and June. Proposed activities could affect the timing of complete river drying in certain river reaches, which could affect the nest success of those pairs with active nests in the incubation or nestling stages later in the breeding season. However, as indicated previously, the reaches of the river that would become dry or intermittently dry because of Reclamation's proposed actions would directly affect approximately 13 territories with only two pairs (2002 data). Reclamation's proposed Middle Rio Grande water operations, diversions at the four diversion points during the irrigation season may affect, and are likely to adversely affect, the willow flycatcher.

6.3.1.2 Rio Grande Silvery Minnow

Although the duration of near intermittent conditions is longer under "dry" versus "average" hydrologic conditions, the spatial arrangement and areal extent of near intermittent conditions, and the biological consequences of such conditions, are indistinguishable. As such, it is reasonable to expect that the fates of silvery minnow would be identical under either hydrologic scenario.

All subpopulations of silvery minnow are currently "at risk" in response to an array of underlying sub-lethal environmentally driven phenomenon such as habitat that is qualitatively unsuitable or quantitatively insufficient (section 5.7.1.3.4). These populations exist at extremely low-density equilibriums, the dynamics of which are dominated by depensatory deterministic effects. Fluctuations in abundance among subpopulations over the recent past have been characteristically subtle, but nonetheless document a long-term declining trend leading to eventual collapse and extirpation of the stock within an early time horizon.

Several environmental variables that directly affect population viability components, as discussed throughout section 5.7.1 and summarized in section 5.7.1.4, will be affected by the flow-based proposed actions. These involve: the degree of variability in river flow, the extent and frequency of near intermittent conditions, the amount of potamon habitat (including intact elements of the river continuum), metapopulation configuration and dynamics, and the degree of deterministic density effects.

The frequency and severity of flow variability and near intermittent conditions will increase temporally and spatially in response to the proposed flow-based actions. Likewise, the amount of potamon habitat is expected to decrease. Flow variability and near intermittent conditions are negatively correlated to population viability whereas the amount of potamon habitat is positively correlated. Because multiple reaches of river, covering a large portion of the contemporary range of the silvery minnow, are expected to go dry or have near intermittent conditions, the fates of subpopulations are moderately, perhaps even highly correlated (the temporal environmental variation for all subpopulations is highly influenced by common factors). The Cochiti Reach, which does not represent potamon habitat required by the silvery minnow, is an exception to this generalization, i.e., it is expected to have reduced flows but remain perennial. Finally, because population densities of all subpopulations of silvery minnow are at levels subject to depensatory deterministic effects (i.e., below moderate densities as described in section 5.7.1.3.3), further silvery minnow mortality induced by the proposed flow-based actions will only intensify such effects. A summary of the effects of the proposed flow-based actions on the silvery minnow is presented in Table 13.

	Impact* by River Reach			
Environmental Variable	**Cochiti**	**Albuquerque**	**Isleta**	**Socorro**
Flow variability	No change	Negative	Negative	Negative
Near intermittent conditions	No change	Negative	Negative	Negative
Amount of potamon habitat	No change	Negative	Negative	Negative
Metapopulation configuration and dynamics	No change	Negative	Negative	Negative
Depensatory deterministic effects	Negative / ?	Negative	Negative	Negative

Table 13. A synthesis of the Direct Effects of Proposed Middle Rio Grande Water Operations on the Rio Grande Silvery Minnow under Dry and Average Hydrologic Conditions.
* All references to *impacts* pertain to effects on the silvery minnow. Impacts may be "positive," "negative," or "no change;" "?" indicates an unknown impact.

An early onset of intermittent flow in the Rio Grande due to the proposed actions could coincide with the peak in silvery minnow spawning. This could result in a missing year class of silvery minnows and intensify depensatory deterministic effects, seriously threatening the species' prospects of survival.

From the foregoing, it seems apparent that the proposed flow-based actions are likely to adversely affect, the silvery minnow and are likely to adversely affect the species' proposed critical habitat.

6.3.1.3 Bald Eagle

The proposed actions do not impact the annual hydrograph of the Rio Grande above the confluence with the Rio Chama and therefore do not impact bald eagles that are found in the Velarde Division. Proposed water management actions on the Rio Chama will not influence flows in the Española Division.

Bald eagles generally leave the Middle Rio Grande by about mid-March. Thus, proposed actions during this season will have no direct or indirect effects on the species.

The bald eagle is not present on the Rio Grande or Rio Chama between April and November. Thus, the proposed actions during this season will have no direct effect on the species. Potential indirect effects on riparian vegetation were discussed above and are considered minimal.

There are no foreseeable indirect impacts of proposed actions on riparian habitat below Cochiti Dam that may be used by wintering bald eagles during the irrigation season.

The proposed winter actions will have no impact on the bald eagle in the Middle Rio Grande below Cochiti Dam.

6.3.1.4 Interior Least Tern

No interior least tern nesting has been recently documented within the Middle Rio Grande and thus impacts from proposed water operations are considered remote. Potential impacts from river maintenance activities are also considered remote. Site visits are conducted at all river maintenance areas to survey for potential occurrence of threatened and endangered species.

6.3.2 Irrigation System Infrastructure Impacts

The following is an analysis of effects of the operation and maintenance of the Cochiti Heading, Angostura Diversion Dam, Isleta Diversion Dam, and San Acacia Diversion Dam on the endangered species considered in the BA. The effects of irrigation system facilities operations on river flow are discussed above (see section 6.3.1). The following analysis focuses on additional effects of the irrigation system maintenance, operation and physical placement.

The Cochiti Heading and the three downstream diversion dams are operated conjunctively to satisfy the irrigation needs of the four MRGCD divisions. The maximum diversion is a function of the capacity of the dam and associated main canals. The general effects of diversion at the dams are the same under most operational scenarios. For example, entrainment of fish and barriers to upstream movement of silvery minnow occurs during any diversion operation. The effects of diversions from the river channel at these three diversion points from early March to the end of October vary by month and by species.

6.3.2.1 Rio Grande Silvery Minnow Entrainment in Irrigation Systems

Entrainment of silvery minnow does not occur at the Cochiti Heading since it is outside of the current range of the silvery minnow and diverts water from the upper stilling basin. The incidence of silvery minnow entrainment in irrigation canals fed by Angostura, Isleta, and San Acacia diversion dams has been documented (primarily involving eggs; Porter, pers. comm.). However, estimates of the quantity of silvery minnows entrained at these diversion dams are not statistically reliable. Furthermore, the biological significance of silvery minnow entrainment in terms of silvery minnow prospects of long-term survival has never been investigated, i.e., to determine, for instance, how extinction probability varies with the rate of silvery minnow eggs entrained.

Because population densities of all subpopulations of silvery minnow are at levels subject to depensatory deterministic effects (i.e., below moderate densities as described in section 5.7.1.3.3), further silvery minnow mortality induced ancillary to the out-of-river diversion of water for irrigation purposes will only heighten such deterministic density effects.

6.3.2.2 Irrigation Diversions as Barriers to the Movement of Rio Grande Silvery Minnow

Movement between subpopulations (i.e., source-sink exchanges) is vital to the maintenance of the species' overall metapopulation structure. Movement between populations occupying habitat patches serves to reduce the probability of species extinction so long as the fates of subpopulations are uncorrelated.

The imposition of cross-channel irrigation diversions has, since the 1930's, served to restrict movement between subpopulations of silvery minnow to downstream transport processes, most notably involving the downstream drift of eggs and larvae. The Cochiti Heading is not a barrier to the upstream movement of the silvery minnow (although Cochiti Dam would be depending on whether the silvery minnow still exists in the Cochiti Reach). Angostura and San Acacia diversion dams represent complete barriers to the upstream movement of the silvery minnow. Upstream movement of silvery minnow may be only partially restricted by Isleta Diversion Dam at extreme low and high flows.

The status of all subpopulations of silvery minnow is currently "at risk," the consequence of an array of underlying sub-lethal environmentally driven phenomenon such as habitat that is qualitatively unsuitable or quantitatively insufficient (see section 5.7.1.3.4). These populations exist at extremely low-density equilibriums. Such densities, by default, are considered "critical" (see section 5.7.1.3.3), but this is especially the case in instances where recruitment is restricted, or nearly restricted, to autochthonous sources and movement between subpopulations of silvery minnow is restricted to downstream transport processes.

Before water was impounded in Cochiti Reservoir, the population of silvery minnow in the Otowi to Bernalillo Reach of the Rio Grande factored prominently in the probability of colonization of empty downstream habitat patches (e.g., a recently rewetted river channel). Today, absent significant immigration of silvery minnow from a stable and viable upstream source, a heightened probability of extirpation exists for subpopulations in habitat patches downstream of Cochiti Reservoir that are subject to repeated episodes of channel drying.

Multiple reaches of river, covering a large portion of the contemporary range of the silvery minnow, are expected to go dry in 2003 or have near intermittent conditions. As such, the fates of subpopulations are moderately, perhaps even highly correlated (i.e., the temporal environmental variation for all subpopulations is highly influenced by common factors). In this instance of drought, the degree of isolation between subpopulations factors less prominently in the silvery minnow's prospect of survival than in an antithetical situation. The ability to colonize unoccupied or sparsely occupied habitats would be most advantageous in instances involving subpopulations with highly independent fates. Likewise, without the provision of in-channel refugial habitats, efforts to accommodate upstream and downstream movement of fish will only prove beneficial outside of periods of severe drought. Absent significant immigration of silvery minnows from some stable and viable source, a heightened probability of extirpation exists for subpopulations in habitat patches that are subject to repeated episodes of channel drying.

6.3.3 Irrigation System Infrastructure Maintenance

6.3.3.1 Southwestern Willow Flycatcher

There is no suitable or potential willow flycatcher habitat within the immediate vicinity of the Cochiti Heading, or the Angostura, Isleta, and San Acacia diversion dams that would be impacted by maintenance activities. Thus, maintenance activities at the diversion dam would have no effect on the southwestern willow flycatcher.

6.3.3.2 Rio Grande Silvery Minnow

Isolated aquatic habitat in the immediate vicinity of any maintenance activity that is being conducted from the river channel, e.g., work on the downstream aprons, will be sampled for silvery minnow. All silvery minnow collected by Reclamation are moved to suitable habitat away from the maintenance area. Permission from the Isleta Pueblo is required for any monitoring or movement of fish at the Isleta Diversion Dam. Most maintenance on diversion dams is accomplished from the diversion dams and does not affect the river channel. Activities on the downstream side of the dam are conducted in dry conditions with flow being directed elsewhere in the river channel.

Maintenance activities at Angostura, Isleta, and San Acacia diversion dams may affect, but are not likely to adversely affect, the silvery minnow and are not likely to adversely affect proposed critical habitat.

6.3.3.3 Bald Eagle

No cottonwoods that may provide roost sites for bald eagles are impacted by maintenance activities. Thus, annual maintenance activities at Angostura, Isleta, and San Acacia diversion dams, or the Cochiti Heading, would have no effect on the bald eagle.

6.3.4 River Maintenance

This section in the June 2001 BA evaluates potential river maintenance projects on a reach-by-reach basis. A listing of anticipated river maintenance activities that could be utilized by Reclamation for a specific reach is presented. A hypothetical river restoration/maintenance project is also described for each reach based on site-specific problems and goals. An example of a recently completed or ongoing project similar to the hypothetical project is presented to further quantify the proposed actions. Finally, a summary table qualitatively demonstrates the effect of specific river maintenance activities to the following geomorphic channel parameters: sinuosity, slope, channel width, channel depth, floodplain width, and width-to-depth ratio.

This analysis of effects of river maintenance was described in detail on pages 207 to 244 and Appendix L in the 2001 BA (Reclamation, 2001). This BA incorporates that section by reference.

6.3.5 River Maintenance and Water Operations Interactions

This section in the June 2001 BA shows the relationship between river channel maintenance and the effects on channel width and habitat as related to the rate of water release from Cochiti Dam. In the Middle Rio Grande below Cochiti Dam, reservoir releases are dictated by the channel's maximum flow capacity. The Corps operates Cochiti Reservoir under the philosophy of matching inflows with outflows until the outflows become large enough to threaten the levee system or other riverside facilities. A fundamental goal of Reclamation's river maintenance program is to address all of these bottlenecks so that a more natural hydrograph can be experienced for the entire Middle Rio Grande below Cochiti Dam. This will serve to enhance available habitat within the bosque and river channel. It will also allow the river system to do the majority of its own river maintenance.

This analysis of effects of river maintenance and water operations interactions was described in detail on pages 244 to 248 in the 2001 BA (Reclamation, 2001). This BA incorporates by reference that section.

6.3.6 Cumulative Effects

Cumulative effects are those effects of future non-federal (state, local governments, or private) activities on endangered and threatened species or critical habitat that are reasonable certain to occur within the action area of the actions subject to consultation. This cumulative effects analysis considers those non-federal activities that may occur over the two-year period covered by this consultation. This BA includes non-federal actions that result in allowable depletions under the Rio Grande Compact for coverage in the consultation process and therefore non-federal actions resulting in decreased river flow are not included as cumulative effects.

The continued growth of human population and water-based industry in the Middle Rio Grande affects the availability of all water supplies, both ground and surface water and native and imported water. Increased consumptive use of water in the Rio Grande Basin, not only in New Mexico but also upstream in Colorado and downstream in Texas, limits the water available to support the river ecosystem and the listed species.

Non-federal entities are also expected to engage in activities beneficial to the endangered species. Various state, local, and private organizations will continue to participate with federal agencies in the Middle Rio Grande Endangered Species Act Collaborative Program. The Collaborative Program is being developed to protect and improve the status of listed species while existing and future water uses in compliance with applicable laws, are protected. The State of New Mexico's lead role in the development of naturalized refugia to support silvery minnow populations and propagation is an example.

6.3.6.1 Rio Grande Silvery Minnow

Anticipated future non-federal actions that may affect the silvery minnow include activities that may affect water quality. Municipal wastewater discharge provides stable return flow to various locations in the Middle Rio Grande. However, uncontrolled releases have been documented to contain levels of certain constituents that could be harmful to silvery minnow. Urban and agricultural runoff and chemical use in vegetation control will continue to affect Rio Grande water quality.

Commercial baitfish marketing and personal use of baitfish can dramatically effect silvery minnow populations. Silvery minnow was displaced in the Pecos River of New Mexico by its congener (plains minnow) that was likely a baitfish introduction from the Canadian Drainage. Stocking of exotic sport fishes by State or private organizations may also place a competitive stress on silvery minnow populations in the Middle Rio Grande.

6.3.6.2 Southwestern Willow Flycatcher

Non-federal actions affecting the willow flycatcher primarily include activities that disturb riparian habitat. The State of New Mexico and some private entities clear salt cedar mechanically or in combination with chemicals. The loss of this habitat, absent an appropriate revegetation program, can reduce available habitat for riparian species such as the willow flycatcher.

6.3.6.3 Bald Eagle

As mentioned in the Species Description Section, in the Southwest Recovery Region, the accelerated pace and extensive area of development activities within eagle habitat is the most significant factor affecting the eagle.

7 CONCLUSIONS

Based on the information and analysis of effects presented in this biological assessment, the following determinations were made for the southwestern willow flycatcher, silvery minnow, bald eagle and interior least tern.

7.1 Southwestern Willow Flycatcher

The Corps' proposed flood control operation is not likely to adversely affect the southwestern willow flycatcher.

Reclamation's proposed river maintenance actions and proactive floodplain management strategy include both traditional methods and bioengineering techniques. This is the best approach to manage the Rio Grande for maximizing hydrologic and geomorphic goals and for environmental benefits over the long term, including minimizing impacts on the southwestern willow flycatcher.

The proposed Reclamation and non-Federal flow-based actions are likely to adversely affect the southwestern willow flycatcher.

Combined, the proposed Federal and non-Federal actions may affect, and are likely to adversely affect the southwestern willow flycatcher.

7.2 Rio Grande Silvery Minnow

The Corps' proposed flood control operation is not likely to adversely affect the silvery minnow.

Reclamation's proposed river maintenance actions and proactive floodplain management strategy should minimize negative impacts on the silvery minnow and its proposed critical habitat.

Maintenance activities at Angostura, Isleta, and San Acacia diversion dams may affect, but are not likely to adversely affect, the silvery minnow and are not likely to adversely affect proposed critical habitat.

Proposed actions that have direct bearing on the continuity of Rio Grande aquatic habitats in time and space and the magnitude of non-flood flows in the river are likely to adversely affect, the silvery minnow, and are likely to adversely affect the species' proposed critical habitat.

Silvery minnow mortality, induced ancillary to the out-of-river diversion of water for irrigation purposes, will heighten deterministic depensatory density effects, given that contemporary estimates of all subpopulation densities are classified as "at risk." Therefore, the physical diversion of water from the Rio Grande at Angostura, Isleta, and San Acacia diversion dams and the ancillary entrainment of silvery minnows in the irrigation system are likely to adversely affect, the silvery minnow.

The physical presence of Angostura, Isleta, and San Acacia diversion dams is interrelated to the proposed water operations actions that has and will continue to restrict movement between subpopulations of silvery minnow to downstream transport processes, most notably involving the downstream drift of eggs and larvae. Such effects are likely to adversely affect, the silvery minnow, and are likely to adversely affect the species' proposed critical habitat.

Combined, the proposed Federal and non-Federal actions may affect, and are likely to adversely affect the silvery minnow. The proposed actions are also likely to adversely modify proposed critical habitat for the silvery minnow.

7.3 Bald Eagle and Interior Least Tern

The Corps' proposed flood control operation is not likely to adversely affect the bald eagle and interior least tern.

The proposed Reclamation and non-Federal flow-based actions are not likely to adversely affect the bald eagle and interior least tern.

Reclamation's proposed river maintenance actions and proactive floodplain management strategy is not likely to adversely affect the bald eagle and interior least tern.

Combined, the proposed Federal and non-Federal actions may affect, but are not likely to adversely affect, the bald eagle and interior least tern.

8 LITERATURE CITED

Ahlers, D. and R. Tisdale. 1999. Cowbird control program. Middle Rio Grande, New Mexico. 1998. Report submitted to Albuquerque Area Office, Bureau of Reclamation. 47 pp.

Ahlers, D. and L. White. 1995. 1995 southwestern willow flycatcher survey results - selected sites along the Rio Grande from Velarde, New Mexico, to the headwaters of Elephant Butte Reservoir. Report submitted to Albuquerque Area Office, Bureau of Reclamation.

Ahlers, D. and L. White. 1996. 1996 Southwestern Willow Flycatcher Study Results: Selected Sites along the Rio Grande from Velarde, New Mexico to the headwaters of Elephant Butte Reservoir and along the Pecos River from the Headwaters of Lake McMillan to Avalon Dam. U. S. Bureau of Reclamation, Denver, CO. 92 pp.

Ahlers, D. and L. White. 1997. 1997 Southwestern Willow Flycatcher Study Results: Selected Sites along the Rio Grande from Velarde, New Mexico to the headwaters of Elephant Butte Reservoir. U. S. Bureau of Reclamation, Denver, Co. 38 pp.

Ahlers, D. and L. White. 1999. 1998 Southwestern Willow Flycatcher Study Results: Selected Sites along the Rio Grande from Velarde, New Mexico to the headwaters of Elephant Butte Reservoir. U. S. Bureau of Reclamation, Denver, Co. 72 pp.

Ahlers, D. and L. White. 2000. 1999 Southwestern Willow Flycatcher Study Results- selected sites along the Rio Grande from Velarde, New Mexico, to the headwaters of Elephant Butte Reservoir. Report submitted to Albuquerque Area Office, Bureau of Reclamation. 110 pp.

Ahlers, D., E. Best, and J. Sechrist. 2001. 2000 Southwestern Willow Flycatcher Study Results - selected sites along the Rio Grande from Velarde, New Mexico, to the delta of Elephant Butte Reservoir. Report submitted to Albuquerque Area Office, Bureau of Reclamation. 55 pp.

Ahlers, D., C. Solohub, E. Best, and J. Sechrist. 2001. 2001 Southwestern Willow Flycatcher Study Results- selected sites along the Rio Grande from Velarde, New Mexico, to the delta of Elephant Butte Reservoir. Report submitted to Albuquerque Area Office, Bureau of Reclamation. 56 pp.

Ahlers, D., and D. Moore. 2003. 2002 Southwestern Willow Flycatcher Study Results- selected sites along the Rio Grande from Velarde, New Mexico, to the delta of Elephant Butte Reservoir. Report submitted to Albuquerque Area Office, Bureau of Reclamation. (in preparation).

Allen, C., B. Hanson, and C. Mullins. 1993. Cochiti Reservoir reregulation interagency biological report. A report prepared for the U.S. Army Corps of Engineers, Albuquerque District, by an interagency team of contributors. June 30, 1993. 64 pp.

American Ornithologists' Union. 1957. Checklist of North American Birds. Fifth ed. Baltimore, American Ornithol. Union. 691 pp.

Bayley, P. B. and H. W. Li. 1996. Riverine fishes. In: River biota – diversity and dynamics. G. Petts and P. Calow (eds). Blackwell Science, Ltd. Cambridge, Mass.

Bestgen, K. R. and S. P. Platania. 1991. Status and conservation of the Rio Grande silvery minnow, *Hybognathus amarus*. Southwestern Naturalist. 36(2):225-232.

Bestgen, K. R. and D. L. Propst. 1996. Redescription, geographic variation, and taxonomic status of Rio Grande silvery minnow, *Hybognathus amarus* (Girard, 1856). Copeia 1996: 41-55.

Brittingham, M. C. and S. A. Temple. 1983. Have cowbirds caused forest songbirds to decline? Bioscience 33: 31-35.

Brown, B. T. 1988. Breeding ecology of the willow flycatcher population in the Grand Canyon, Arizona. Western Birds 19 (1): 25-33.

Bullard, T. F. and S. G. Wells. 1992. Hydrology of the Middle Rio Grande from Velarde to Elephant Butte Reservoir, New Mexico. U. S. Department of the Interior, Fish and Wildlife Service Research Publication 179.

Chernoff, B., R. R. Miller and C. R. Gilbert. 1982. *Notropis orca* and *Notropis simus*, cyprinid fishes form American Southwest, the description of a new subspecies. Occ. Pap. Mus. Zool. Univ. Mich. 618: 1-49.

Costa, J. E., A. J. Miller, K. W. Potter, and P. R. Wilcock, eds. 1995. Natural and anthropogenic influences in fluvial geomorphology. AGV, Washington, D.C.

Darby, S. E. and A. Simon. 1999. Incised River Channels - processes, forms, engineering and management. John Wiley and Sons, New York.

Dick-Peddie, W. A. 1993. New Mexico vegetation: past, present and future. University of New Mexico Press, Albuquerque, N. M. 244 pp.

Dudley, R. K. and S. P. Platania. 1997. Habitat use of Rio Grande silvery minnow. Report to U. S. Bureau of Reclamation, Albuquerque. 88 pp.

Dudley, R. K. and S. P. Platania. 2002. Summary of population monitoring of Rio Grande silvery minnow. N. M. Ecological Services Field Office, Albuquerque, N. M., U. S. Fish and Wildlife Service.

Eagle Ecological Services. 1994. Southwestern willow flycatcher surveys, Rio Chama between Abiquiu Dam and the Rio Grande. Report to the U. S. Army Corps of Engineers, Albuquerque District. 26 pp.

Edwards, R. J. and S. Contreras-Balderas. 1991. Historical changes in the ichthyofauna of the lower Rio Grande (Rio Bravo del Norte), Texas and Mexico. Southwestern Naturalist 36(2):201-212.

Facey D. E., G. D. Grossman. 1992. The relationship between water velocity, energetic costs, and microhabitat in four North American stream fishes. Hydrobiologia 239: 1-6.

Federal Interagency Steering Team. 1998. Stream corridor restoration principles, processes, and practices. Government Printing Office.

Federal Register. 1978. Endangered and threatened wildlife and plants: final rule to list the bald eagle as an endangered species.

Federal Register. 1986. Interagency Cooperation - Endangered Species Act of 1973, as amended; Final Rule. 50 CFR Part 402. June 3, 1986. 51(106):19926-19963.

Federal Register. 1993a. Endangered and threatened wildlife and plants; proposed rule to list the Rio Grande silvery minnow as endangered, with critical habitat. 50 CFR Part 17, RIN 1018-AB88. March 1, 1993. 58(38):11821-11827.

Federal Register. 1993b. Endangered and threatened wildlife and plants: proposed rule to list the southwestern willow flycatcher as endangered with critical habitat. 50 CFR Part 17, RIN 1018-AB97. July 23, 1993. 58(140):39495-39522.

Federal Register. 1994. Endangered and threatened wildlife and plants: final rule to list the Rio Grande silvery minnow as an endangered species. 50 CFR Part 17, RIN 1018-AB88. July 20, 1994. 59 (138): 36988-36995.

Federal Register. 1995. Endangered and threatened species: southwestern willow flycatcher: final rule. 50 CFR Part 17, RIN 1018-AB88. February 27, 1995. 10694-10715.

Federal Register. 1995b. Bald eagle reclassification.

Finch, D. M. and S. H. Stoleson, eds. 2000. Status, ecology and conservation of the Southwestern Willow Flycatcher. Gen. Tch. Rep. RMRS-GTR-60. Ogden, Ut; U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 131 p.

Finch, D. M., and W. Yong. 1997. Use of willow habitat along the Low Flow Conveyance Channel by willow flycatchers and other migratory birds. 1996 progress report to the Bureau of Reclamation.

Fogg, J. L., B. L. Hanson, H. T. Mottl, D. P. Muller, R. C. Eaton, and S. Swanson. 1992. Rio Chama Instream Flow Assessment. Bureau of Land Management Report (BLM/SC/PT-931 001+7200) 133 pp.

Gaines, D. 1974. A new look at the nesting riparian avifauna of the Sacramento Valley, California. W. Birds 5:61-80.

Gaines, D. 1977. Birds of the Yosemite Sierra. California Syllabus, Oakland.

Goldwasser, S., D. A. Gaines and S. Wilbur. 1980. The Least Bell's Vireo in California: a de facto endangered race. American Birds 34:742-745.

Gordon, N. D., T. A. McMahon, B. L. Finlayson. 1992. Stream hydrology, an introduction for ecologists. John Wiley and Sons, N. Y.

Gore, J. A., 1996. Responses of aquatic biota to hydrological change. Chapter 11. In: J. Petts and P. Calow (eds). River biota – diversity and dynamics. Balckwell Science. Cambridge, Ma.

Gore, J. A., and G. E. Petts, eds. 1989. Alternatives in regulated river management. CRC Press, Boca Raton, Florida.

Hatch, M. D., D. E. Cowley, J. E. Sublette, G. Z. Jacobi, and S. J. Herrmann. 1999 - In press. Native Fish Faunal Regions of New Mexico. New Mexico Department of Game and Fish. Santa Fe, N. M.

Hawkwatch. 1993. Bald eagle behavior.

Henry, A., P. Mehlhop, and C. Black. 1996. 1995 surveys for the southwestern willow flycatcher (*Empidonax traillii extimus*), near San Marcial, New Mexico. Report to the U. S. Army Corps of Engineers, Albuquerque District by the New Mexico Natural Heritage Program. 68 pp.

Hey, R. D. 1994. "Environmentally sensitive river engineering." In: The rivers handbook, hydrological and ecological principles. P. Calow and G. E. Petts (eds). Blackwell Scientific Publications, England.

Hink, V. C. and R. D. Ohmart. 1984. Middle Rio Grande Biological Survey. Army Corps of Engineers Contract No. DACW47-81-C-0015. Albuquerque, N. M.

Hubbard, J. P. 1987. The Status of Willow Flycatchers in New Mexico. Endangered Species Program, New Mexico Department of Game and Fish, Santa Fe, N. M. 29 pp.

Hubbs, C. 1958. List of fishes known or expected to belong to the fauna of Big Bend National Park. Mimeograph report to Big Bend National History Association.

Hubbs, C., R. R. Miller, R. J. Edwards, K. W. Thompson, E. Marsh, G. P. Garrett, G. L. Powell, D. J. Morris, and R. W. Zerr. 1977. Fishes inhabiting the Rio Grande, Texas between El Paso and the Pecos confluence. Symposium on the importance, preservation and management of riparian habitat, July 9, 1977, Tucson, Az.

Jacobi, G. Z., J. E. Sublette, S. L. Herrmann, D. E. Cowley and M. D. Hatch. 2000. Investigations of indices of biotic condition for streams in New Mexico. Federal Aid in Sport Fish Restoration Act performance report, Grant F-59-R. New Mexico Department of Game and Fish. Santa Fe, N. M.

Jansen, P. P., L. van Bendegom, J. can den Berg, M. de Vries, and A. Zanen. 1979. Principles of River Engineering. Pitman Publishing Company, San Francisco, Cal.

Johnson, K., P. Mehlhop, C. Black, and K. Score. 1996. The Southwestern Willow Flycatcher on the Middle Rio Grande: Results of 1996 Surveys and Nest Monitoring. U.S. Bureau of Reclamation contract with New Mexico Natural Heritage Program, Albuquerque, N. M. 28 pp.

Johnson, K. and H. Smith 2000. Southwestern Willow Flycatcher Surveys at Isleta Pueblo, New Mexico. New Mexico Natural Heritage Program, Report submitted to the U.S. Army Corps of Engineer. 11 pp.

Kelly, J. F, D. M. Finch, and M. D. Means. 1998. 1997 Annual Report on Bird Migration along the Low Flow Conveyance Channel in the Bosque del Apache National Wildlife Refuge. USDA- Forest Service, Rocky Mountain Research Station, Albuquerque, N. M. 9 pp.

Laymon, S. A. 1987. Brown-headed cowbirds in California: historical perspective and management opportunities in riparian habitats. W. Birds 18:1-96.

Lovejoy, T. 1983. Tropical deforestation and North American migrant birds. Bird Conservation 1:126-128.

Lynch, J. F. and D. F. Whigham. 1984. Effects of forest fragmentation on breeding bird communities in Maryland, USA. Biological Conservation 28:287-324.

Marlatt, S. L. 1984. History and Management Recommendations for the Interior Least Tern in New Mexico. New Mexico Department of Game and Fish Endangered Species Program.

Maynard, W. R. 1995. Summary of 1994 survey efforts in New Mexico for southwestern willow flycatcher (*Empidonax traillii extimus*). Contract #94-516-69. New Mexico Department of Game and Fish. Santa Fe, N. M. 48 p.

Massong, T. 2000. Suspended Sediment/Flow Discharge Relationship Analysis for U.S.G.S. Gauges, United States Bureau of Reclamation, Albuquerque Area Office, Technical Services Division.

Matthews, W. J. 1998. Patterns in Freshwater Fish Ecology. Chapman and Hall, N. Y.

Mayfield, H. F. 1977. Brown-headed cowbird: agent of extermination? American Birds.31: 107-113.

Mehlhop, P. and P. Tonne. 1994. Results for surveys for the southwestern willow flycatcher - Rio Grande floodway, San Acacia to Bosque del Apache Unit, Socorro County, New Mexico. Report submitted to U.S. Army Corps of Engineers, Albuquerque District.

Moyle, P. B. and D. M. Baltz. 1985. Microhabitat use by an assemblage of California stream fishes: developing criteria for instream flow determinations. Trans. Am. Fish . Soc., 114, 695-704.

New Mexico Department of Game and Fish. 1988. Handbook of species endangered in New Mexico. Santa Fe, N. M.

New Mexico Department of Game and Fish. 1995. November 2, 1995 letter from Sandy Williams (Nongame/Endangered Birds Coordinator) to BioWest, Inc. regarding records of southwestern willow flycatcher occurrences near Heron Reservoir, New Mexico. Santa Fe, N. M. 1 p.

New Mexico Department of Game and Fish 1998. Southwestern Willow Flycatcher Breeding Site and Territory Summary from 1993-1998. Endangered Species Program, New Mexico Department of Game and Fish, Santa Fe, N. M.

Newson, M. D. 1995. "Fluvial geomorphology and environmental design" *in* Changing river channels. Edited by A. Gurnell and G. E. Petts. John Wiley and Sons, N. Y.

Nicholopoulos, J. and P. Zwank. 1996. Ecology of Wintering and Nesting Bald Eagles at Caballo Reservoir, New Mexico. Cooperative Agreement No. 3-FC-40-23790 between New Mexico State University and U. S. Bureau of Reclamation. 35 pp.

Paxton, E., S. M. Landridge and M. K. Sogge. 1997. Banding and population genetics of southwestern willow flycatchers in Arizona-1997 summary report. U.S.G.S. Colorado Plateau Field Station report. 63 p.

Paxton, E., J. Owen and M. K. Sogge. 1996. Southwestern willow flycatcher response to catastrophic habitat loss. U.S.G.S. Colorado Plateau Research Station/Northern Arizona University report. 12 p.

Platania, S. P. 1995. Reproductive biology and early life-history of Rio Grande silvery minnow, *Hybognathus amarus*. Report to the U. S. Army Corps of Engineers, Albuquerque District. 23 pp.

Rappole, J. H. and M. V. McDonald. 1994. Cause and effect in population declines of migratory birds. Auk 111:652-660.

Reclamation and U. S. Army Corps of Engineers. 2001. Programmatic Biological Assessment of proposed Bureau of Reclamation's Discretionary actions related to water management, U. S. Army Corps and Engineers water-operation rules, and related non-federal actions on the Middle Rio Grande, New Mexico. Albuquerque.

Reichenbacher, F. W. 1884. Ecology and evolution of southwestern riparian plant communities. Desert Plants, Volume 6.

Ritter, D. F., Kochel, R. C., and J. R. Miller. 1995. Process Geomorphology, Third Edition, W. C. Brown Communications, Inc., Dubuque, Ia.

Robbins, C. S., J. R. Sauer, R. S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the neotropics. Proc. Natl. Acad. Sci., USA 86:7658-7662.

Rosgen, D. 1996. Applied river morphology. Wildland Hydrology. Pagosa Springs, Co.

Rothstein, S. I., J. Verner, and E. Stevens. 1980. Range expansion and diurnal changes in dispersion of the brown-headed cowbird in the Sierra Nevada. Auk 97:253-267.

Schumm, S. A. 1969. River metamorphosis. Journal of the Hydraulics Division. ASCE, 95:255-273.

Sferra, S. J., T. E. Corman, C. E. Paradzick, J. W. Rourke, J. A. Spencer and M. W. Sumner. 1997. Arizona Partners in Flight Southwestern Willow Flycatcher survey: 1993-1996 summary report. Technical Report 113. Arizona Game and Fish Department, Nongame and Endangered Wildlife Program. Phoenix, Arizona. 46 pp.

Skaggs, R. W. 1996. Population size, breeding biology and habitat of willow flycatchers in the Cliff-Gila, New Mexico-1995. Final Report. New Mexico Department of Game and Fish. 38 p.

Smith, J. R. and C. W. Hoagstrom. 1997. Fishery Investigations on the Low Flow Conveyance Channel Temporary Outfall Project and on Intermittency in the Rio Grande. Progress report submitted to the Bureau of Reclamation.

Sogge, M. K., T. J. Tibbitts, and S. J. Sferra. 1993. Status of the southwestern willow flycatcher along the Colorado River between Glen Canyon Dam and Lake Mead - 1993. Summary report. National Park Service Cooperative Park Studies Unit/Northern Arizona University, U.S. Fish and Wildlife Service and Arizona Game and Fish Department Report. 69 pp.

Sogge, M. K. 1995. Southwestern willow flycatcher (*Empidonax traillii extimus*) monitoring at Tuzigoot National Monument. 1995 progress report to the National Park Service. National Biological Service Colorado Plateau Research Station/Northern Arizona University report. 20 p.

Sogge, M. K., R. M. Marshall, S. J. Sferra, and T. J. Tibbitts. 1997. A Southwestern Willow Flycatcher natural history summary and survey protocol. Technical report NPS/NAUCPRS/NRTR-97/12. National Park Service, Colorado Plateau Research Station at Northern Arizona University. 37 pp.

Sogge, M. K., R. M. Marsahll, S. J. Sferra and T. J. Tibbitts. 1997. Southwestern Flycatcher Natural History and Summary and Survey Protocol. National Park Service Technical Report. NPS/NAUCPRS/NRTR-97/12. 37 pp.

Sogge, M. K., J. S. Sferra, T. McCarthey, S. O. Willimas, and B. E. Kus. 2001. Southwestern Willow Flycatcher Breeding Site and Territory Summary-2000. U.S. Geological Survey, Flagstaff, Az.

Sogge, M. K., J. S. Sferra, T. McCarthey, S. O. Willimas, and B. E. Kus. 2002. Southwestern Willow Flycatcher Breeding Site and Territory Summary-2001. U.S.G.S. Report to the Southwestern Willow Flycatcher Recovery Team, U. S. Fish and Wildlife Service, Region 2, Albuquerque N .M. 20 pp

Sogge, M. K., T. J. Tibbitts and J. R. Petterson. 1997(b). Status and ecology of the Southwestern Willow Flycatcher in the Grand Canyon. Western Birds 28:142-157.

Sprenger, M. D., L. M. Smith and J. P. Taylor. 2002. Restoration of riparian habitat using experimental flooding. Wetlands Vvo.22, No 1. 9 pp.

Stahlecker, D. W. And N. S. Cox. 1997. Bosque biological monitoring program: bird populations in Rio Grande Valley State Park, winter 1996-97 and spring 1997. Report submitted to the City of Albuquerque, Open Space Division. 28 pp.

Sublette, J.E., M. D. Hatch, and M. Sublette. 1990. The Fishes of New Mexico. University of New Mexico Press, Albuquerque, N. M. 393 pp.

Taylor, J. P., D. B. Wester, and L. M. Smith. 1998 (in review). Soil disturbance and riparian woody plant establishment in the Rio Grande floodplain. Wetlands. 19 pp.

Taylor, J. P. 2000. Southwestern Willow Flycatcher Surveys on the Bosque del Apache National Wildlife Refuge. Unpublished Report. 5 pp.

Taylor, J.P. 2001. Southwestern Willow Flycatcher Surveys on the Bosque del Apache National Wildlife Refuge. Unpublished Report. 3pp.

Taylor, J.P. 2002. Southwestern Willow Flycatcher Surveys on the Bosque del Apache National Wildlife Refuge. Unpublished Report. 8 pp.

Thorne, C. R., R. D. Hey, and M. D. Newson. 1997. Applied Fluvial Geomorphology for River Engineering and Management. John Wiley and Sons, N. Y.

Trevino-Robinson, D. 1959. The ichthyofauna of the lower Rio Grande, Texas and Mexico. Copeia 1959 (3): 253-256.

U. S. Army Corps of Engineers. 2001. Finding of No Significant Impact and Environmental Assessment, Abiquiu and Jemez Canyon Reservoirs, Supplemental Water Storage and Release. April 2001.

U. S. Bureau of Reclamation. 2003. Rio Grande silvery minnow egg entrainment in irrigation canals during 2002. Albuquerque.

U. S. Bureau of Reclamation and U. S. Army Corps of Engineers. 2001. Programmatic Biological Assessment of proposed Bureau of Reclamation's Discretionary actions related to water management, U. S. Army Corps and Engineers water-operation rules, and related non-federal actions on the Middle Rio Grande, New Mexico. Albuquerque.

U. S. Fish and Wildlife Service. 1999. Rio Grande Silvery Minnow Recovery Plan. Albuquerque, New Mexico.

U. S. Fish and Wildlife Service. 2002a. Draft Environmental Impact Statement – Designation of critical habitat for the Rio Grande silvery minnow. U. S. Fish and Wildlife Service, Albuquerque, N. M.

U. S. Fish and Wildlife Service. 2002b. Final Southwestern Willow Flycatcher Recovery Plan. U. S. Fish and Wildlife Service, Albuquerque, N. M.

Unitt, P. 1987. *Empidonax traillii extimus*: an endangered subspecies. Western Birds 18: 137-162.

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Science 37:130-137.

Wang, S. S. Y., E. J. Langendoen, and F. D. Shields Jr., eds. 1997. Management of landscape disturbed by channel incision. Center for Computational Hydroscience and Engineering. University of Mississippi, Oxford, Miss.

Whitefield, M. J. 1990. Willow flycatcher reproductive responses to brown-headed cowbird parasitism. Master's Thesis, California State University, Chico, Cal. 25 p.

Wilcove, D. S. 1988. Changes in the avifauna of the Great Smoky Mountains: 1947-1983. Wilson Bulletin 100:256-271.

Williams, S. O. III. 2000. Summary of Willow Flycatcher Surveys in New Mexico during 1993-2000. Unpublished Summary provided by the Endangered Species Program, New Mexico Department of Game and Fish, Santa Fe, N. M. 8 pp.

9 APPENDIX A

Potential Actions for Reasonable and Prudent Alternatives, Reasonable and Prudent Measures, or Conservation Recommendations.

A. Introduction

Reclamation has identified a number of discretionary actions that assist with protection, conservation and/or recovery of the listed species. Reclamation has been conducting many of these activities over the past several years as part of its ESA, Section 7(a)(1), responsibilities. Included in these actions is Reclamation's acquisition and release of available supplemental water and pumping of water from the Low Flow Conveyance Channel (LFCC) to the river. Reclamation would consider continuing to participate, along with other partners, in implementing the following actions, subject to funding. The actions described in this Appendix could be used as elements of a reasonable and prudent alternative (RPA) to the proposed action, as reasonable and prudent measures to reduce any incidental take associated with the proposed action, or to promote conservation and recovery of listed species pursuant to Section 7(a)(1). Actions identified and selected for implementation would be accomplished during the time of this BA.

Any RPA to avoid jeopardy must be consistent with the intended purpose of the action, implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, and must be economically and technically feasible.

B. Supplemental Water Program

Reclamation has developed a program to lease water and work cooperatively with downstream water users to enhance Rio Grande flows. When Reclamation leases San Juan-Chama water from willing contractors, that water is subject to the limits of the Project's authorizing legislation, state law, and relevant compacts. Because of limitations on authorized uses of Project water imposed by these laws, e.g., San Juan-Chama Project water must be put to beneficial consumptive use within the State of New Mexico, Reclamation considers the cooperation of downstream users essential to the success of its supplemental water program. MRGCD cooperates in this conservation activity by using the water leased by Reclamation and, in return, bypassing an equal amount of native Rio Grande flow at downstream diversion facilities.

Leasing available supplemental water is contingent on the availability of water from willing sellers. Reclamation expects to be able to lease only up to 15,000 acre-feet of supplemental water in 2003. Because of court-ordered mediation for the *Minnow v. Keys* litigation in 2000, Reclamation has an outstanding commitment to repay the City of Albuquerque 15,000 acre-feet of water by the year 2014. Leased water could be used for repayment purposes after 2003 and to provide additional flows in the Middle Rio Grande to enhance aquatic habitat and benefit silvery minnow. Reclamation will continue to seek out and negotiate with willing sellers as sources of additional water for the future, although no minimum quantity of supplemental water can be guaranteed. Over the long term, and in cooperation with water users, the Federal agencies will consider implementing a water acquisition program that may involve elements of water use forbearance and water banking.

A critical component of the supplemental water program is the ongoing water operations inter-agency coordination process. A key to the success of water operations since 1996 has been the weekly, often daily, communications that developed between Reclamation, the Corps, the Service, MRGCD, the State of New Mexico, and other parties during the irrigation season. This process involves meetings, conference calls, and information exchange. This process is fully integrated with the Annual Operating Plan process described in the Description of Proposed Actions section.

C. Low Flow Conveyance Channel Pumping

As a result of court-ordered mediation in 2000, Reclamation has acquired and installed pumps along the LFCC with a total capacity sufficient to move a maintainable minimum combined flow of 75 to 100 cfs from the LFCC to the river at points below San Acacia Diversion Dam to Elephant Butte. During emergencies, it is possible that Reclamation could move up to an additional 50 cfs to the Rio Grande. The actual output of the LFCC pumps depends on the availability of water in the river and in the LFCC itself. Fifteen pumps are currently available to supplement flows in the mainstem of the river and fill depressions in river flow that are observed moving downstream during the irrigation season. Pumping is also used to manage river recession during dry periods. Permanent pumping facilities could also be installed, subject to available funding.

Potential pumping locations include Neil Cupp, north boundary of the Bosque del Apache National Wildlife Refuge, south boundary of the refuge, the Tiffany area, and Ft. Craig. Depending on how the river responds to pumping operations, some pumps could be moved at least once to maximize the benefits of increased flow on aquatic habitat.

Flows from the LFCC within the Elephant Butte Reservoir pool seep from the channel and create moist and wetted soil conditions conducive to breeding flycatcher from nest initiation in May through fledging in late August. Flows vary throughout the summer depending on the water usage, upstream diversions and recapture of agricultural drain water. However, pumping water from the LFCC to the river could significantly reduce the discharge of the LFCC in this expanding flycatcher breeding area. The flows within the LFCC and diversions through pumping could be monitored along with hydrologic components within selected sites of the reservoir pool with previously known nests. Through an adaptive management program coordinated with the Service, the pumping may be managed to provide adequate flows in the LFCC to maintain soil moisture through a period of nesting when a majority of nests have fledged.

D. Coordinate Facility Operations with Water Users
Reclamation will work with the MRGCD to develop an agreement addressing the reoperation of project facilities to support environmental and ESA-related needs.

Reclamation can manage the timing of releases from Heron Reservoir to offset depletions to the Rio Grande caused by storage of native water in Nambe Falls Reservoir to increase flow in the Rio Grande. Reclamation can also evaluate issuance of storage exceptions at El Vado Reservoir based not only on safety of dam and flood inflow considerations, but also on river flow in the Middle Valley. This consideration should address potential impacts of these storage exceptions on Middle Valley flows during periods of low flow.

E. Support for Fish Rescue Efforts
Should isolated pools be found that sustain significant numbers of silvery minnow, Reclamation and Corps will cooperate with the Service in rescue operations to relocate any stranded fish. Relocation of silvery minnow may also occur during periods of continuous flow if there is a need to augment upstream or captive populations.

Reclamation and the Corps will closely monitor low flow or river drying events as they occur. Reclamation and/or the Corps will notify the Service of potential low flow conditions with sufficient lead-time to ensure an adequate response time for rescue efforts. The Service has the lead for calling and coordinating a rescue event. Other Federal and non-federal parties will provide assistance with rescue efforts upon request of the Service. The primary method for coordinating with the Service during these critical periods will be the daily conference call.

F. Environmental Commitments
The following environmental commitments are from the June 2001 BA (Reclamation, 2001):

- Reclamation will carry out its actions to encourage seasonal overbank flooding and associated low velocity aquatic habitats in or near suitable willow flycatcher habitat within the bounds of the expected natural hydrograph.
- Reclamation will review the Southwestern Willow Flycatcher Recovery Plan and update the environmental commitments related to the willow flycatcher as appropriate.
- Reclamation will work with the MRGCD to: 1) facilitate fish passage at the three main diversion dams to allow upstream movement of the silvery minnow, 2) investigate the effects of fish, eggs and larvae passage over the structures, and 3) alleviate the entrainment of silvery minnow into the irrigation system. Reclamation is currently conducting a planning study that focuses on some of these issues at San Acacia Diversion Dam.
- Reclamation will pursue habitat restoration along the Middle Rio Grande, in coordination with other parties, which includes the restoration of the river channel to create and enhance aquatic habitat for the silvery minnow and native riparian habitat for the willow flycatcher and bald eagle. The principles of adaptive resource management will be incorporated into habitat restoration. Reclamation, as a component of the river maintenance program, will perform two river restoration projects annually.
- Increase the number and distribution of overbank flooding sites and sites with shallow, low velocity water conditions to enhance silvery minnow habitat, assist in regeneration of native vegetation, and provide for flooding in suitable habitat for the willow flycatcher during the breeding season. Monitoring will be conducted to quantify the extent of overbank flooding.
- Eliminate mowing of native riparian vegetation unless it contributes to habitat restoration or is required for safe conveyance of flood flows.
- In areas where impacts to mature cottonwoods cannot be avoided, Reclamation will replace the trees at a 10:1 ratio.
- Reclamation will continue to work with the MRGCD to improve gauging and real-time monitoring of water operations.

The following is an additional environmental commitment, separate from those offered in the June 2001 BA (Reclamation, 2001):

- Initiate efforts to define a suite of characteristics important for flycatcher habitat occupancy and nesting success. Conduct a preliminary examination and assessment of habitat parameters of occupied habitat within the delta of Elephant Butte Reservoir (near the LFCC) to determine features that characterize optimal habitat selected by flycatchers.

G. Additional Potential Corps Actions

Cochiti Dam and Lake Studies

The Corps of Engineers and the Pueblo de Cochiti propose, subject to the availability of funding, the conduct of an array of studies to characterize the interactions of reservoir operation with Tribal resources. The proposed studies, jointly developed by the Corps and the Pueblo, would provide a baseline against which the impacts of any future operational changes may be evaluated. The studies would include analyses of surface and subsurface hydrology; sediment dynamics; contaminants and hazardous risk; and ecological, cultural, and economic resources.

Jemez Canyon Dam and Reservoir Activities

The Corps of Engineers and the Pueblo of Santa Ana propose, subject to the availability of funding, an integrated plan of design, construction, and monitoring to significantly increase the sediment contribution of Jemez River to the Rio Grande. The proposed projects, developed jointly by the Corps and the Pueblo, include construction of a grade-stabilizing weir on the Jemez River upstream from the dam to protect aquatic, riparian, and wetland habitats from degradation; design and modeling of modifications to the dam's tower and outlet works to facilitate passage of accumulated sediment; and monitoring for potential impacts to the Pueblo of Santa Ana's natural, cultural, and economic resources.

H. Appendix A Water Operations Effects Estimation

Predicted hydrologic effects of the water operations presented in Appendix A are described to assist the Service in assessing their utility as potential RPA elements.

Constraints and Assumptions

- Normal MRGCD demand for diversion into MRGP facilities above San Acacia for the purposes of irrigation of Indian and non-Indian lands.
- MRGCD diverts 50 cfs into MRGP facilities at San Acacia Diversion Dam from March 1 through October 31.
- Return flow equal to 30% of MRGCD diversions made at Isleta Diversion Dam (but not less than 75 cfs) returns to the Rio Grande floodway at the Lower San Juan Drain. Lower San Juan Drain returns are greater as result of increased efficiency and cooperation from MRGCD.
- Return flows from San Acacia Diversion Dam are collected by the LFCC, and do not return to the Rio Grande Floodway.
- Constant inflow of 70 cfs from City of Albuquerque’s wastewater treatment plant.
- 13,000 acre-feet of supplemental water available for endangered species release.
- No losses applied to supplemental water releases in reaches above Isleta Diversion Dam.
- Pumping stations located at Neil Cupp, North Boundary, South Boundary, and Fort Craig are available for endangered species operations.
- Article VII of Rio Grande Compact is in effect.

Contributions from precipitation downstream of Cochiti Dam are not included because no viable way could be identified to predict and then model the impact of storm inflows.

Methodology

The methodology in this analysis is essentially identical to what was applied to develop the hydrographs for the Normal Operations without Endangered Species Actions scenarios presented in the Analysis of Effects section. Hydrographs representative of Rio Grande flow at Cochiti, San Felipe, Central Avenue Bridge at Albuquerque, and Isleta were exported from the URGWOM RiverWare model containing the 2003 model run based on 1996 hydrology (dry scenario) and 1989 (average scenario).

For river reaches downstream of Isleta, approximate channel loss rates derived from historic URGWOM reach losses were applied to the URGWOM developed hydrograph for Isleta to approximate total Rio Grande flows at Bernardo, San Acacia, and San Marcial. Lag times were not applied to temporally shift the hydrograph between the various stations along the river.

A return flow based on 30% of Isleta Diversion Dam diversions, not less than 75 cfs, was applied upstream of San Acacia to account for MRGP Lower San Juan Drain irrigation return flows. Diversions at Isleta Diversion Dam were estimated based on values contained within the URGWOM model. A diversion of 50 cfs was assumed at San Acacia Diversion Dam, but return flows from San Acacia Diversion were discounted because they currently return to the LFCC rather than the Rio Grande floodway. It was assumed that 13,000 acre-feet of supplemental water was available for release to benefit endangered species. It was assumed that all existing pumping locations would be available for transferring water from the LFCC into the Rio Grande Floodway.

The hydrographs created using the described methodology were then used to evaluate and describe the potential occurrences of drying within the various river reaches based on historic observations of river drying episodes.

The hydrologic conditions described for Appendix A water operations approach the worst case for the described scenarios. Depending on the occurrence and magnitude of monsoonal storms, actual conditions could vary from those described.

Description of Appendix A Water Operations – Dry Hydrologic Scenario

By early May, flows south of San Acacia may no longer be sufficient to maintain a continuous wetted channel without the release of supplemental water and the use of LFCC pumping operations. Even with these actions, it is possible that intermittency could be experienced between San Acacia and San Marcial as early as late May (Figure A-1). Based on past observations, initial drying would likely occur near the center of Bosque del Apache National Wildlife Refuge, and drying could extend south as far as the south boundary of the Bosque del Apache NWR and north toward the north boundary of Bosque del Apache NWR within a few days. Historically, as much as 10 miles of river can become dry within the boundaries of Bosque del Apache for periods up to several days before complete rewetting occurs.

Similar intermittent and sporadic drying could occur between the Neil Cupp Pumping Station and the north boundary of Bosque del Apache, and between San Acacia and the Neil Cupp Pumping Station. Up to five miles has historically become intermittent between the Neil Cupp Pumping Station and the North Boundary Pumping Station for several days at a time. Intermittency between Neil Cupp and San Acacia is less likely to occur, although intermittency or complete drying could potentially extend for more than 10 miles north of the Neil Cupp Pumping Station for several days. During periods of intermittency, the LFCC pumping stations can effectively becomes isolated reaches of flow that can extend from less than a mile to several miles downstream.

It is likely that LFCC pumping operations could maintain a continuous wetted river channel from the south boundary of Bosque del Apache NWR to a point north of Elephant Butte Reservoir for the majority of the year, although sporadic and isolated incidences of stream intermittency would likely occur.

The described intermittent conditions south of San Acacia could occur between early May and late October (Figure A-1). Assuming no monsoonal moisture, more then 40 miles of river could be impacted through either complete drying or through sporadic and isolated stretches of intermittency. Rewetting of the river with continuous and sustained flows might not occur south of San Acacia until late October (Figure A-1).

During this same period, river intermittency as well as extensive reaches of completely dry riverbed could occur within a 30 to 40 mile stretch of the Rio Grande between Tome and the Lower San Juan Drain of the Middle Rio Grande Project. Assuming no monsoonal moisture, intermittency or extensive drying could occur within this area from mid-July through August, after the run-out of all supplemental minnow releases (Figure A-1). Intermittency could extend an additional nine miles north of Tome to Isleta during the months of July and August after the run-out of supplemental minnow water. The Rio Grande would likely remain continuous throughout the year within the 10-mile stretch between the Lower San Juan Drain and the San Acacia Diversion Dam.

During late July through mid-October, infrequent and short-term intermittency could occur within a stretch of river more than six miles long from north of Central Avenue in Albuquerque to the City's waste water treatment discharge point near Rio Bravo Boulevard (Figure A-1). It is likely that the remainder of the river to the north of Central Avenue would remain continuous throughout the year. The nine mile stretch of river from the waste water discharge point south to Isleta Diversion Dam would likely remain continuous throughout the year, with a minimum flow equivalent to the City's treated waste water discharge rate.

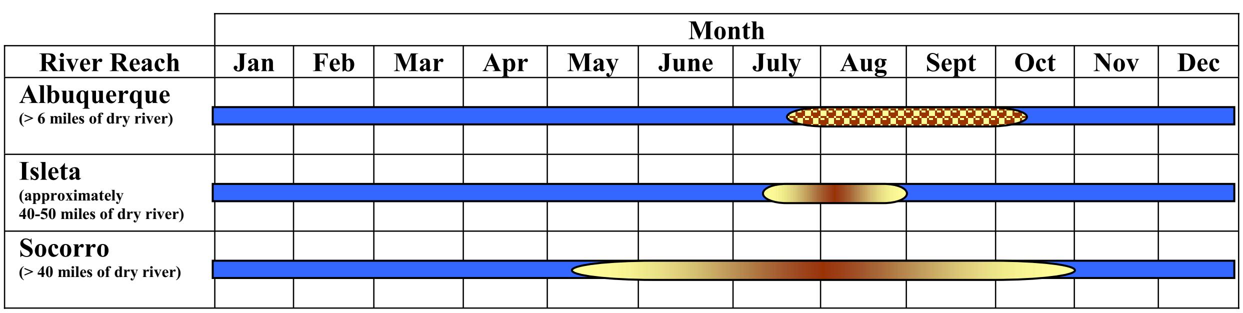


Figure A-1. Spatial and Temporal Representation of Anticipated Intermittent flow with "Appendix A Water Operations" under "Dry" Hydrologic Conditions.
The blue bar indicates continuous flow. Brown (dark) indicates intermittent flow; yellow (light) indicates recession or progression of flows; brown spots against a yellow background indicate sporadic and short-term periods of intermittency. The blending of colors (brown vs. yellow) indicates a time of transition as conditions change from perennial to intermittent, or the antithetical condition.

Description of Appendix A Water Operations – Average Hydrologic Scenario
By late May, flows south of San Acacia may no longer be sufficient to maintain a continuous wetted channel without the release of supplemental minnow water and the use of LFCC pumping operations. Even with these actions, it is possible that intermittency could be experienced between San Acacia and San Marcial as early as June (Figure A-2). Based on past observations, initial drying would likely occur near the center of Bosque del Apache National Wildlife Refuge, and drying could extend south as far as the south boundary of the Bosque del Apache NWR and north toward the north boundary of Bosque del Apache NWR within a few days. Historically, as much as 10 miles of river can become dry within the boundaries of Bosque del Apache for periods up to several days before complete rewetting occurs.

Similar intermittent and sporadic drying could occur between the Neil Cupp Pumping Station and the north boundary of Bosque del Apache, and between San Acacia and the Neil Cupp Pumping Station. Up to five miles has historically become intermittent between the Neil Cupp Pumping Station and the North Boundary Pumping Station for several days at a time. Intermittency between Neil Cupp and San Acacia is less likely to occur, although intermittency or complete drying could potentially extend for more than 10 miles north of the Neil Cupp Pumping Station for several days. During periods of intermittency, the LFCC pumping stations can effectively becomes isolated reaches of flow that can extend from less than a mile to several miles downstream.

It is likely that LFCC pumping operations could maintain a continuous wetted river channel from the south boundary of Bosque del Apache NWR to a point north of Elephant Butte Reservoir for the majority of the year, although sporadic and isolated incidences of short-term stream intermittency would likely occur.

The described intermittent conditions south of San Acacia could occur during late May through September. Assuming no monsoonal moisture, more then 40 miles of river could be impacted through sporadic and isolated episodes of intermittency. Rewetting of the river with continuous and sustained flows might not occur south of San Acacia until mid to late October (Figure A-2).

During this same period, river intermittency could occur within a 30 to 40 mile stretch of the Rio Grande between Tome and the Lower San Juan Drain of the Middle Rio Grande Project. Assuming no monsoonal moisture, intermittency could occur within this area from mid-July through August, after the run-out of all supplemental minnow releases (Figure A-2). Sporadic and isolated episodes of intermittency could occur between Isleta and Tome during the months of July and August after the run-out of supplemental minnow water. The Rio Grande would likely remain continuous throughout the year within the 10-mile stretch between the Lower San Juan Drain and the San Acacia Diversion Dam.

During the months of August through September, infrequent and short-term intermittency could occur within a stretch of river more than six miles long from north of Central Avenue in Albuquerque to the City's wastewater treatment discharge point near Rio Bravo Boulevard (Figure A-2). It is likely that the remainder of the river to the north of Central Avenue would remain continuous throughout the year. The nine mile stretch of River from the waste water discharge point south to Isleta Diversion Dam would likely remain continuous throughout the year, with a minimum flow equivalent to the City's treated waste water discharge rate.

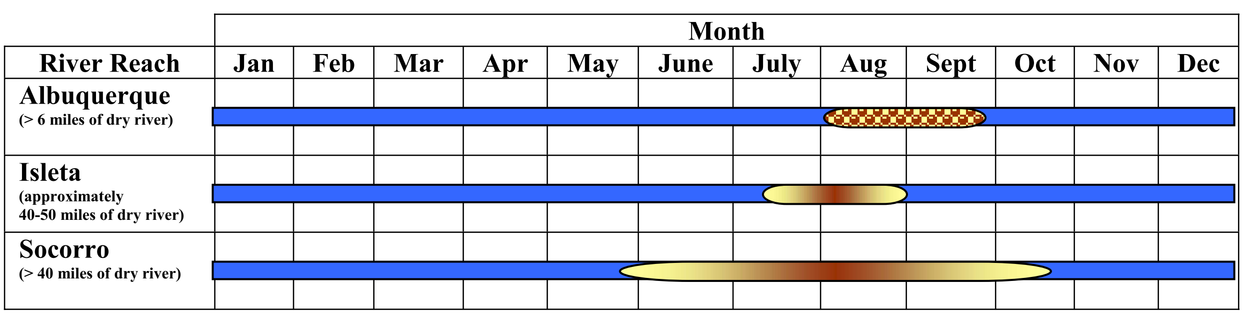


Figure A-2. Spatial and Temporal Representation of Anticipated Intermittent Flow with "Appendix A Water Operations" under "Average" Hydrologic Conditions.
The blue bar indicates continuous flow. Brown (dark) indicates intermittent flow; yellow (light) indicates recession or progression of flows; brown spots against a yellow background indicate sporadic and short-term periods of intermittency. The blending of colors (brown vs. yellow) indicates a time of transition as conditions change from perennial to intermittent, or the antithetical condition.

10 APPENDIX B

This appendix describes actions that, in addition to those listed in Appendix A, could be available as RPAs, RPMs, conservation measures, or terms and conditions if the Tenth Circuit Court of Appeals upholds the District Court's rulings regarding the scope of federal agency discretion related to Middle Rio Grande and San Juan-Chama Project water operations.

Current storage reservoirs have been depleted due to drought and increased release of stored water during the last several years because of drought and endangered species' needs. Reclamation's web site (http://albuq.uc.usbr.gov/info/wo) presents a chart estimating the current total amount of water in storage to provide guidance to the Service in developing its Biological Opinion and to meet the District Court's order that we consider possible water management contingencies for 2003. Reclamation will provide updates as requested.

In its September 23, 2002 order, the District Court directed the following:

> If necessary to meet flow requirements in 2003, either under the June 29, 2001 Biological Opinion or under a new Biological Opinion resulting from reinitiation of consultation, **the Bureau of Reclamation must reduce contract deliveries under the San Juan-Chama Project and/or the Middle Rio Grande Project, and/or must restrict diversions by the Middle Rio Grande Conservancy District under the Middle Rio Grande Project**, consistent with the Bureau of Reclamation's authority as determined in the Court's April 19, 2002 Memorandum Opinion and Order.

Therefore, the following actions are available consistent with the Bureau of Reclamation's authority as determined by the District Court. These actions will be available for implementation if the Tenth Circuit Court of Appeals upholds the District Court's rulings and if needed to meet ESA requirements. The actions are not described in a priority implementation order.

Middle Rio Grande Project-Related Actions

A. Restrict Direct Diversions of Natural Rio Grande Flows Through Middle Rio Grande Project Facilities for Non-Indian Water Users.

Diversions of natural Rio Grande flows made through the Middle Rio Grande Project for non-Indian water users could be restricted to target flows and flow conditions at various locations on the river if necessary in accordance with the final BO. The irrigation season begins on March 1 and extends to October 31 for non-Indian irrigators, although MRGCD has raised the issue of possibly starting the irrigation season earlier, if allowable under state and federal law.

B. Bypass Natural Rio Grande Water Instead of Storing it in El Vado Reservoir for Non-Pueblo Lands.
Under normal conditions, Reclamation captures natural Rio Grande water in El Vado Reservoir and stores it for Middle Rio Grande Project water users. Such storage occurs mainly during the spring runoff season. Consistent with the District Court's decisions, and if needed to meet target flow requirements or other ESA requirements, Reclamation could bypass the water instead of storing it for non-Pueblo lands.

At this time, however, Reclamation does not anticipate capturing any natural Rio Grande flows for non-Pueblo storage in El Vado Reservoir in 2003 because of restrictions imposed by the Rio Grande Compact. Storage to insure the rights of the six Middle Rio Grande Pueblos is not affected by this Compact requirement.

C. Release Water Stored in El Vado Reservoir for Non-Indian Middle Rio Grande Project Water Users
Release of native Rio Grande water stored for use by non-Indians within the MRGCD out of El Vado Reservoir normally occurs throughout the irrigation season when direct flow does not meet Project needs. This stored water would be released in a manner to help meet target flows. No such water is currently stored in El Vado, however, and we do not anticipate additional storage will be allowed in 2003 because of Compact restrictions.

San Juan–Chama Project – Related Actions

A. Reduce San Juan-Chama Project Contractors' 2003 Allocations and Release Water Directly for Target Flows.
Reclamation operates Heron Reservoir to meet contract obligations within the San Juan-Chama Project firm yield to its contractors and to deliver Cochiti Lake recreation pool evaporation replacement water. This water is delivered consistent with calls from contractors regarding timing and volume of releases. Shortages to yearly contractor allocations could occur to help meet target flows. Shortages would not be applied to the Cochiti Lake recreation pool evaporation replacement water, due to lack of discretion under PL 88-293.

B. Release Stored (Firm-Yield Pool) San Juan-Chama Project Water Directly for Target Flows
The Firm-Yield Pool is water carried over in Heron Reservoir to ensure that San Juan-Chama Project deliveries can be achieved in years with below-average inflow to Heron. Consistent with the District Court's ruling, this stored water could be released in a manner to help meet target flows, even if shortages to Project contractors result.

Six Middle Rio Grande Pueblos Water Deliveries Through the Middle Rio Grande Project

The District Court did not address the issue of whether Pueblo water deliveries would be affected by its interpretation of ESA requirements. If the six Middle Rio Grande Pueblos' water use is ultimately determined to be subject to curtailment to meet ESA flow requirements, the following actions would be considered, consistent with the Implementation Guidelines section of this Appendix.

A. **Restrict Direct Diversions of Natural Rio Grande flows through Middle Rio Grande Project facilities for Pueblo Newly-reclaimed Lands.**

B. **Restrict Direct Diversions of Natural Rio Grande Flows through Middle Rio Grande Project Facilities for Prior and Paramount Lands for the Six Middle Rio Grande Pueblos.**

C. **Bypass Natural Rio Grande Flows Instead of Storing in El Vado Reservoir for Pueblo Newly-reclaimed Lands.**

D. **Bypass Natural Rio Grande Flows Instead of Storing in El Vado Reservoir for Pueblo Prior and Paramount Lands.**

E. **Release Water Stored in El Vado for Pueblo Newly-reclaimed Lands.**

F. **Release Water Stored in El Vado for Pueblo Prior and Paramount Lands.**

G. **Release Water Stored in El Vado for the six Middle Rio Grande Pueblos to the Pueblos, but restrict Middle Rio Grande Project Diversions of Natural Flows for the Pueblos.**

Implementation Guidelines

Upon completion of a BO, Reclamation will also consider the following factors in determining how to implement the above actions, if necessary to meet BO requirements.

A. **Application of actions across projects**
- Appropriate balance between within-basin solutions and trans-basin solutions
- Prior Appropriation Doctrine
- Causal connection between actions and impacts.
- Sources of water that are unavailable

B. **Implementation of actions within a project**

1. Middle Rio Grande Project
- Priority of shortages.
- Prior Appropriation Doctrine.
- Six Middle Rio Grande Pueblos' water needs.

2. San Juan-Chama Project
- Application of contract shortage provisions.
- Pueblo and tribal water.
- Shortage of yearly contract allocations versus firm yield pool.

11 APPENDIX C

It is Reclamation's policy to analyze river maintenance sites by performing geomorphic analysis and investigations prior to implementation. One of the goals of these investigations is to identify the underlying geomorphic causes of problems such as excessive erosion, deposition, and excessive channel instability as suggested by Newson (1995) and determine the future river conditions using the qualitative methods developed by Schumm (1969) and other quantitative methods available. These methods relate changes in sediment and water discharge to changes in width, depth, velocity, channel slope, sinuosity, and width-depth ratio.

Studies of the entire Middle Rio Grande reach are in progress and appropriate sediment transport models (i.e., HEC-6T, G-STARS, FLO-2D, and others) are continually being developed. The intention of these studies and modeling efforts are to understand erosional and depositional sediment transport characteristics and the associated impacts on channel morphology to develop appropriate projects to meet all of the objectives. Some of the geomorphic studies include detailed analysis of historic, current, and estimates of future channel morphology based on trend analysis and modeling. Reclamation is also studying the effects of reduced sediment loads and peak flows on the channel substrate size and width. Reclamation's river maintenance program is evolving with regards to river engineering techniques and the spatial scope of analysis. Instead of focusing our efforts mainly on the symptoms of channel instabilities, e.g., bank erosion, we are increasingly analyzing and addressing the causative processes within the scope of our authority.

Presently the applicability of such techniques to large rivers such as the Rio Grande is not documented and tested. The hydraulic laboratory modeling is evaluating new maintenance techniques such as those proposed by Rosgen (1996) for their applicability to the Middle Rio Grande channel morphology and hydrology. The subsequent description of bio-engineering techniques, river training works, and sediment removal techniques were developed from experience gained on the Rio Grande over the last several years and review of recent publications on river engineering and geomorphic design. The authors reviewed are; Brizga and Finlayson (2000), Darby and Simon (1999), Thorne et al. (1997), Brookes (1988), Gordon et al. (1992), Hey (1994), Gore and Petts (1989), Costa et al. (1995), Wang et al. (1997), Rosgen (1996), and the Federal Interagency Steering Team (1998).

The following section lists and describes the specific river maintenance activities that could occur within the Middle Rio Grande Project. Activities are categorized by their primary objective. A combination of these activities will be used to successfully meet river maintenance objectives. Examples of how a combination of these techniques may be utilized in project designs is included under the "Hypothetical River maintenance Project/Projects" heading for each reach in the Analysis of Effects of Proposed Actions Section.

1. River Maintenance Techniques

River maintenance techniques include a variety of methods for influencing flow alignment, bank stabilization, and controlling and managing overbank flow. Each maintenance project may require subsequent maintenance due to changing river conditions and the Section 404 permit obligation to maintain permitted works. The following activities include traditional techniques as well as recent advances in the river engineering profession. Many of the techniques listed below fit into the category of river engineering termed bioengineering. Combinations of these activities will most likely be employed in maintenance designs.

Terrace and Overbank Lowering (Re-establish floodplain hydrologic connectivity) - This type of work activity would be to allow for the expansion of the active floodplain and to reconnect the river channel to the floodplain. Through an increase in the active floodway, velocities may be reduced at moderate to high discharges resulting in a reduction of bank erosion. Expansion of the active floodplain may also permit higher discharges to be released from upstream dams since there would be a decrease in the risk to threatened riverside facilities.

Channel Widening/Bank Destabilization - Widening the main river channel via vegetation clearing and bank destabilization to increase the flow area allowing for higher discharges to be released from upstream dams. Bank destabilization would be accomplished with jetty removal, clearing vegetation via root plowing, and bankline lowering.

Woody Debris Snags and Boulder Placements - Woody debris snags and boulders would be placed at locations within the river channel or along river banks to provide bank erosion protection by deflecting flows away from the bankline. Boulder placement would most likely occur in the upstream river channel reaches, e.g., Velarde and Espanola.

High Flow Side Channels - Provide an increase in flow area thereby increasing the ability to pass higher discharges. The activity would most likely involve pilot channel excavation, inner channel terracing, and bank material removal or de-stabilization.

Removal of Lateral Confinements - In areas where the river channel is constricted, the removal and/or relocation of confining terraces, levee, low flow channel, and jetties could be performed for floodplain expansion. If relocation of either a levee or low flow channel is pursued landowner permission would be necessary. Under the Middle Rio Grande project congressional authorization, Reclamation does not have authority to purchase or condemn lands.

Vegetation planting - Vegetation planting would be used in conjunction with other methods to provide erosion protection along the river channel as well as along structures such as levees/berms and deformable banklines. Potential methods include individual pole and willow whips, willow bundles/mats, or other planting methods.

Gradient Restoration Facilities (GRF'S) - Gradient restoration facilities are low head grade control structures with an apron designed to mimic naturally occurring riffles. These structures are utilized to halt channel degradation, reduce upstream velocities, trap finer sediments, and increase water surface elevations. Downstream sediment transport is not permanently reduced as sediment is only trapped by the GBF until an upstream equilibrium channel slope is attained. In addition, the amount of sediment deposited upstream of the GRF's is only a few percent of the Rio Grande's annual sediment load.

Increasing the Sand Load to Channel Reach - Mechanical introduction of sand into the river channel where the sediment transport capacity of the sand load is in excess of the available sediment supply and where the river is becoming gravel bedded. This activity will assist in raising the riverbed, changing the gravel substrate to sand, increasing the channel width, and decreasing the average depth. The activity may involve either moving river terrace sediment deposits with land-based equipment or even possibly hauling of sediment materials from upland areas for placement in the river channel. Under Reclamation's authority, we could not address the issues of passing more sediment through Cochiti or Jemez Canyon Dam.

Oxbow Re-establishment - Re-establishing a flow source to an Oxbow to increase the flow area and reduce the average velocity. Such activities may permit an increase in passable discharges.

Deformable Bankline(s) - A deformable bankline consists of a stone toe that is sized to be mobile at the five-year return interval flood event, and native vegetation plantings. The stone toe is required to temporarily stabilize the bank to allow planted vegetation to become established. Riprap, sized to erode in the 5 to 10 year frequency flood (relatively small rock) is placed beneath several layers of fabric-encapsulated soil. Willow and native tree species will be planted through the fabric-encapsulated soil. After the fabric degrades and the toe becomes mobile by subsequent events, the vegetation/soil interaction and natural fluvial processes will control the bank shape. Deformable bank lines can also be comprised of fabric encapsulated soils without a stone toe dependant on its location in the floodplain and stability criteria. Deformable bank lines will most often be established on newly created banks through activities such as channel re-alignment and terrace lowering.

Non-Native Vegetation Clearing and Floodplain Expansion - Mechanical clearing of exotic species vegetation adjacent to the river channel to expanding the floodplain and reducing vegetative consumption of water. This includes creating paths for river waters to occupy within the cleared area during peak spring runoff flows. Such activities will increase the flow area and the ability to increase discharges released from upstream dams.

Rock Weirs - Varying types of rock weir structures would be utilized for bed control and raising the river bed/water surface elevation. They are Vortex and "W" rock weirs and cross vanes. These structures are intended to alleviate excessive bank erosion and create grade stabilization. The apex of Vortex rock weirs is pointing upstream while the apexes of "W" rock weirs are pointing both upstream and downstream.

Channel Realignment/Channel Avulsions/Pilot Channel Work - Relocation of the river channel away from an existing riverside facility that is threatened by erosion and/or to bring the channel to an equilibrium slope and planform. Channel realignment may incorporate deformable banks to establish the new channel pattern and allow for natural fluvial process to shape the banks. Pilot channels are excavated to establish new river courses. Pilot channels may require stabilization with revetments or other works and will most likely be needed in areas where channel alignments are least defined and sediment plug formation is a problem. Pilot cuts encourage the river to move the sediment and reform the channel and allow for minimal disturbance as opposed to channel dredging.

Culvert and Low Water Crossings - Installation of culverts and low water crossings to provide water to disconnected areas of the floodplain and increase the flow area during higher discharges.

River Bar/Island Maintenance –This activity would involve maintenance of river bars or islands for the purpose of increasing flow area within the river channel and providing a more efficient channel for the delivery of water and sediment. Methods used to accomplish this activity may include vegetation clearing, lowering, and pilot channel construction. This activity can also be used in conjunction with other techniques to expand the active floodplain, dissipate stream energy, and reduce shear stress along vulnerable bankline.

Jetty/Snag Removal - Perform the removal of jetty jacks from areas where their function is no longer necessary as means to establish new banklines or where the jetties have been moved into main river channel as a result of erosional processes and may pose a hazard. Snags (vehicles, trash, etc.) may be removed from the river in rare occasions to prevent them from posing a serious public hazard. They may also be removed in instances where they are deflecting flows into a bankline causing significant bank erosion.

Rock Vanes - These weir structures are intended to deflect flows away from eroding bankline, and break up the secondary circulation cells which add to the stress in the near bank region.

Toe Revetment Plantings - These structures utilize a combination rock or riprap material and willow planting to protect an eroding bank. The rock or riprap material is placed at the toe of the bank to prevent erosion at the toe and the undercutting of a bank. The plantings are placed along the top of the bank or on terraces along the bank to prevent overland erosion to the bankline.

Native Material Bank Stabilization-rock and/or Log Spurs - These structures are intended to provide bank stabilization through various alternatives of root wad and boulder placement, J-Hook and Root wad Vanes, cross vanes, log revetments, and vegetation planting.

Groins/Bendway Weirs- Groins and Bendway Weirs are embankments or dikes projecting from the bank into the channel to regulate river flow alignments. Both may be perpendicular to the bank or angled either up or down stream in an "L" or "T" shape. These can be used in combination with bar reconstruction to move the channel away from a trouble spot along a safer alignment. Groins and Bendway Weirs could be used in all reaches except the Velarde Reach where the river is generally too narrow to make them practical. These are essentially the same structure as rock vanes but have larger top widths to enable heavy equipment to place the rock.

Training dikes- Training dikes are constructed more or less parallel to the channel to guide the flow. Most future training dikes would be built in conjunction with revetment works or channel re-alignment/pilot channel projects and would most likely be used in the Middle Reach and below where the riverbanks are low.

Freeboard dikes- Freeboard dikes are built to contain high flows with an adequate factor of safety to protect other works or facilities. Freeboard dikes are most often required in areas where there are no levees, or development or farmland is at the river's edge.

Revetments- A revetment is a facing placed on a riverbank to resist and prevent further erosion. Many types of materials and systems are available for revetting banks. Economic consideration, feasibility of construction considerations and aesthetic factors govern the choice of a particular revetment system. All types of bank stabilization work require periodic maintenance. Rock riprap has generally been used in all reaches to revet banks; however, the use of native material for revetments is currently being explored.

Windrows- Windrows are used alone or in conjunction with revetments to limit future bank erosion. Riprap is piled in a windrow on top of the bank along a desired alignment. When the bank erodes back to the windrow, the rock is undermined and drops down the bank controlling erosion. After the rock begins to drop down the bank, additional rock is required to redress and shape the bank. Windrows could be used in all reaches to stabilize bank erosion.

Permeable jetties- Steel or wood Kellner jacks (jetty jacks) have been previously used to stabilize the Rio Grande. The effectiveness of permeable Jetties depends on an adequate supply of sediment being transported by the river and on site-specific hydraulic conditions. Currently no jetty jack installations are planned for the Middle Rio Grande Project, however this item is left in for the remote possibility of future installations.

Curve shaping- The realignment of river banks may be necessary in all reaches. Curve alignments are determined by right-of-way considerations and hydraulic parameters. This activity could be a component of previously mentioned river training works techniques or be used alone.

Stabilized soil, Manufactured revetment units, and Cellular confinement systems- The chemical treatment of soils makes them less susceptible to erosion. The most common soil treatment is soil cement. Soil and cement are mixed and compacted to make an erosion-resistant material. Soil cement cannot be constructed underwater. This technique would only be used in unusual circumstances. Several types of manufactured units are available for revetment construction. These units are typically made of concrete and are designed to be laid on the bank in interlocking patterns. The high cost of these systems would limit their use to very special cases. Plastic grid systems designed to limit movement of soils can be used to prevent erosion. These systems use a honeycomb cell sheet anchored to the bank to contain fill material. These systems may be practical in conditions where erosion potential is small.

2. Sediment Removal
Removal of sediment from the river channel by mechanical means may be needed to maintain flow capacity. Disposal of spoil material is an important consideration when planning these operations.

> Arroyo Plug Grading and Removal- Sediment deposited in the river channel at the mouths of tributary arroyos sometimes must be removed by excavation. As a result of regulation by dams, main stem flow is often inadequate to remove arroyo plugs containing large gravel or cobble sized materials. Very large arroyo plugs can diminish channel capacity or deflect flows into banklines and/or riverside facilities. Reclamation would undertake arroyo plug grading or removal only in these instances.
>
> Dredging/Sediment settling basins - Dredging includes all underwater excavation of bottom material. Dredging may be done by machines scooping the bottom material up in buckets (bucket dredging) or by pumping a solid/water mixture and discharging the mixture through pipes (hydraulic dredging). Hydraulic dredging often requires the construction of settling ponds where the discharged solids are separated from the water. Construction of settling ponds usually requires building up embankments or dikes to contain the dredged material and overflow structures to decant the water. Size of settling ponds depends on the quantity of material being discharged and the type and size of the solids to be settled out. In open water areas, silt curtains may be used to diminish or limit turbidity effects caused by dredging. Dredging would be used to construct or maintain channels in areas where sediment is depositing and reducing the efficiency of water delivery such as at the delta of Elephant Butte.

3. Vegetation Management
The objectives of vegetation management are to maintain floodway capacity and reduce net depletions. Historically, vegetation management activity was concentrated in the Middle Reach and the upper portions of the Belen Reach where river bars were mown annually to prevent growth of woody vegetation. Under the current mowing program, Reclamation desires not to eliminate mowing but to further evaluate its effectiveness in meeting Reclamation's river maintenance goals as outlined in this document. Until further analysis and studies are performed, the mowing of native riparian vegetation on river bars is temporarily postponed. This program is currently being re-evaluated based on current geomorphic, hydrologic, and environmental conditions. Vegetation management will also likely be needed as the Elephant Butte Reservoir pool recedes, and salt cedar grows on the exposed delta.

> Transect Brushing – To accomplish successful river engineering, data collection of current river channel and floodplain conditions are necessary. Vegetation may be trimmed to create a clear line of sight along a transect as part of Reclamation's data collection program for river channel monitoring. Not only is the data used for studies and modeling for projects to assess the best course of action, but the data is also used to quantify project requirements, to determine quantities for permits, and assessing site conditions for construction purposes. The collection of hydrographic data from transects also provides information for better management of the Middle Rio Grande floodplain and river channel.
>
> Mowing- Vegetation may be cut with mowers. Mowing controls development of woody and perennial species while minimizing disturbance to grasses and forbs.
>
> Root Plowing- A root plow is a large blade that is pulled through the ground beneath the surface by a tractor to destroy underground rootstocks. Root plowing would ordinarily be used to eliminate exotic woody species such as salt cedar and Russian olive trees. Vegetative debris could be piled and left within the cleared area, stacked and burned within the cleared area, or removed to an offsite location.
>
> Clearing of Understory Vegetation - This activity would involve the removal of deadfall and/or exotic species vegetation beneath a native species vegetation canopy. This activity would reduce net depletions in the riverine corridor and increase the available flow area.

4. Levee Maintenance
Reclamation regularly maintains the levee system in the Socorro, Bosque del Apache, San Marcial and Elephant Butte Reaches. In other areas, Reclamation may perform levee maintenance on an intermittent, occasional or emergency basis at the request of MRGCD. Levee failure caused by bank erosion at less than flood flows is also a Reclamation responsibility. Levee maintenance includes raising levee heights, reinforcing by widening levee bases, filling and repairing washouts, stabilization with revetments or groins, drainage improvements, grading, shaping, and road graveling. Under the current levee maintenance program, impacts to endangered species and their habitat are avoided.

Another alternative for reaches below Cochiti Dam would be to relocate the levees, irrigation canals, and riverside drains in selected locations. This option would increase the available floodplain width, and will be explored at each site. Under the Middle Rio Grande Project Congressional authorization, Reclamation does not have authority to condemn and/or purchase land. Therefore, Reclamation would need landowner approval to pursue this river engineering technique. Reclamation is considering moving the levee, river channel and LFCC south of the San Marcial Railroad Bridge where Reclamation owns the land. This is part of a longer-term study currently underway to evaluate operational and structural modifications to the river and LFCC system. Separate Endangered Species Act and National Environmental Policy Act compliance will be developed for this work.

5. Access and Construction Requirements

Haul roads and operating areas - Access construction may require clearing, placement of fill, grading, installation of culvert pipes, and graveling.

Stockpiles - Sites for stockpiling material may require clearing, grading, and fencing. Material may be stockpiled for a particular construction project or may be stored for unspecified maintenance. Stockpiles may be in place temporarily or permanently.

Cofferdams/Inflatable water bladders - Cofferdams or inflatable water bladders are sometimes needed to divert water temporarily during construction operations.

Borrow areas for fill material - Fill material for bank shaping or embankment construction may be imported from borrow areas off site or excavated from adjacent bars or islands.

Spoil areas - Excess material excavated or dredged from the river channel is disposed in designated spoil areas.

Storage yards - Temporary storage of equipment, material and supplies is often needed at a job site and they need to be conveniently located. Storage areas may require clearing, grading, graveling, drainage, and fencing.

6. Reasonable Alternative Techniques for River maintenance

Traditional river maintenance techniques performed by Reclamation have evolved over time between the 1950's and current. Legislation such as NEPA, Clean Water Act, ESA, and river system needs have influenced the evolution into the exploration of new river maintenance techniques that go beyond the original goal of effective water and sediment transport. Promising new technology for river maintenance activities would be evaluated for effectiveness, cost, and environmental effects as the need arises. Those new and future methods found to be practical and appropriate may be used in future river management projects. These methods will be defined over time as they develop.

7. Reach Specific Activities

The following section describes and lists the specific river maintenance activities that could occur within a given reach. Refer to the previous section for a general description of each activity. All of the activities described for each reach in the following sections are the most likely to be pursued but every technique previously identified may possibly be used in each reach. Each reach has different river maintenance activities identified due to various anthropogenic, hydrologic, and geomorphic conditions and influences. A hypothetical river maintenance project is also described for each reach based on site-specific problems and goals. An example of a recently completed or ongoing project similar to the hypothetical project is presented to further quantify the proposed actions. Finally, a summary table qualitatively demonstrates the effect of specific river maintenance activities to the following geomorphic channel parameters: sinuosity, slope, channel width, channel depth, floodplain width, and width to depth ratio.

Velarde, New Mexico, to Rio Chama Confluence - (Velarde Reach)

The Velarde Reach is currently maintained for the safe and effective passage of flow discharges up to 5,000 cfs. The control of bank erosion is the most prevalent ongoing maintenance requirement. The most likely maintenance activities would be the following.

- Rock Weirs
- Deformable Bankline
- Vegetation planting
- Non-native Vegetation Clearing and Floodplain Expansion
- Terrace Lowering (Re-establish Floodplain Hydrologic Connectivity)
- River Bar/Island Maintenance
- Oxbow Re-establishment
- Jetty/Snag Removal
- Woody Debris Snags and Boulder Placement
- Rock Vanes
- Toe Revetment Planting
- Native Material Bank Stabilization - Rock and/or Log Spurs.
- Freeboard dikes
- Revetments and Windrows
- Curve Shaping
- Arroyo Plug Grading and Removal
- Transect Brushing

The preferred methodology for the control of bank erosion includes bioengineering techniques and floodplain interaction. On a limited basis due to lack of flood control regulation freeboard dikes may be necessary for the protection of property. Islands and bars may also be used as a convenient source of borrow material in conjunction with reconnecting the river with the floodplain.

Hypothetical River Maintenance Project /Projects
A hypothetical project for the Velarde Reach would be a stream bank protection project. Project goals would include: 1) Preventing damage to riverside facilities, 2) protection of water delivery and irrigation facilities, and 30 prevent excessive flooding of infrastructure. There is no levee system in this reach, unlike downstream within the city of Espanola. Discharges are unregulated and private property and agricultural land is subject to continuous flooding and erosion. Other components to this hypothetical project would be intensive native species plantings along any disturbed areas to prevent further bank erosion. In working with the landowners, other activities that may be pursued include River Bar/Island Maintenance and Oxbow reestablishment. Such activities would increase the wetted perimeter of the channel at higher flows and reduce the flooding potential.

An example of a recent project within this reach is the La Rinconada Dike Project. Reclamation analyzed the effects of constructing and enhancing two earthen freeboard dikes, respectively, in the Velarde Reach. As mentioned above, significant damages have occurred to agricultural lands between Velarde and the mouth of the Rio Chama as a result of flooding. The project included the construction of an approximately 3,700 feet long earthen dike along the eastern bank of the Rio Grande between the mouth of Truchas Arroyo and La Rinconada Diversion Dam. The dike has a top width of approximately 6 feet and an average height of 4 feet. The bottom width, or footprint, varies between 15-24 feet dependent on the height of the dike and level of protection necessary. Culverts were installed for cross drainage from agricultural lands to the river channel. An existing dike along the west side of the river was enhanced with additional fill material and an approximately 130 feet long tie back was constructed to connect the dike to higher ground. There was no change to the footprint of the existing, west side dike except for the tie back portion.

Rio Chama Confluence to Otowi - (Espanola Reach)
The channel capacity in the Espanola Reach increases to 7,850 cfs. Groins and root wad/boulder placement have been used at some sites to protect eroding riverbanks. Oxbow re-establishment has been performed in this reach through culvert installation, and small pilot channel and pond excavation. The most likely river maintenance activities would be the following.

- Rock Weirs
- Deformable Bankline
- Vegetation planting
- Non-native Vegetation Clearing and Floodplain Expansion
- Channel Realignment/Channel Avulsions/Pilot Channel
- Terrace Lowering (Re-establish Floodplain Hydrologic Connectivity)
- River Bar/Island Maintenance
- Oxbow Re-establishment
- Jetty/Snag Removal
- Channel Widening/Bank Destabilization
- Woody Debris Snags and Boulder Placement
- Rock Vanes
- Toe Revetment Planting
- Native Material Bank Stabilization -Rock and/or Log spurs
- Groins/Bendway Weirs
- Freeboard dikes
- Revetments and Windrows
- Curve Shaping
- Arroyo Plug Grading and Removal
- Transect Brushing

The river widens considerably below the Rio Chama confluence and it is at this location that bioengineering techniques may provide better methods to influence the river's future alignment while controlling excessive and damaging bank erosion. Islands and bars may also be used as convenient sources of borrow material in conjunction with reconnecting the river with the floodplain.

Hypothetical River Maintenance Project/Projects
A hypothetical project for the Espanola Reach would be a bioengineering stream bank protection project. Project goals would include: 1) Protection of water delivery and irrigation facilities and 2) Preventing damage to riverside facilities. A bioengineering stream bank protection project would likely use a combination of different activities including the installation of deformable bank lines and the placement of cottonwood root wads and boulders. The project would involve the installation of deformable bank lines allowing for temporary stabilization of the bankline until planted vegetation becomes established. The placement of native material revetments such as cottonwood root wads and boulders would be used along an eroding bank to deflect flows away from the bank. Other maintenance activities such as the placement of weir structures (Vortex, W, Rock Vanes) into or across the river channel could also be used to stabilize an eroding bankline. Willow/cottonwood plantings and terracing could also be performed along the bank lines for bank protection and to reconnect portions of the main channel to the historical floodplain, respectively.

An example of a recent stream bank protection project in the Espanola Reach is a pilot bioengineering bank stabilization project completed by Reclamation on the Santa Clara Pueblo in early 1997. The project consisted of installing combinations of root wads, boulders, and riprap in several treatments to determine which method provided the greatest bank stabilization. About 1,250 ft of stream bank was protected using these methods. All work was done with land-based equipment. Trees were placed into 3-4 feet wide by 20 feet long trenches with root balls exposed to the current. About

4,000 cubic yards of material was excavated for the trench work. Spoil material was spread on the top of the bank and seeded with native grasses. About 300 cubic yards of rock was placed between the root wads.

Initially only Russian olive root wads were used. However, the root masses were small and additional work was conducted to install larger cottonwood root balls, acquired from the Corps' Corrales Levee Project. The floodplain in this area is generally wide with numerous river bars and therefore, river bar/island maintenance activities such as clearing of exotic vegetation, bar lowering, and side channel work could occur on the opposite side of any bank stabilization activity. These activities would widen the river channel and allow the river to adjust to the presence of any newly introduced deflectors and provide high flow side channels to increase the flow area during high discharges. The re-establishment of ox-bows would also be an appropriate activity in this area.

Cochiti Dam to Hwy 44 Bridge, Bernalillo - (Cochiti Reach)
Maximum releases from Cochiti are expected to be in the 7,000-10,000 cfs range. However, recent releases have been less than this range because of floodway capacity constraints. To compound matters, the water released from Cochiti is clear, causing the riverbed to degrade (i.e. river bed lowering through sediment removal), the channel width to reduce, and the material to coarsen from a sand substrate to a gravel substrate. If the magnitude of peak flow releases out of Cochiti is increased during the spring runoff season, the river channel will have a tendency to migrate laterally due to the armoring of the river channel downstream of the dam. Problems associated with bank erosion could be particularly severe in this reach because the dam has diminished the sediment supply.

The most likely river maintenance activities would be the following:

- Woody Debris Snags and Boulder Placement
- High Flow Side Channels
- Increase Sand Load to Reach
- Grade Restoration Facilities
- Rock Weirs
- Deformable Bank lines
- Vegetation planting
- Non-native Vegetation Clearing and Floodplain Expansion
- Channel Realignment/Channel Avulsions/Pilot Channels
- River Bar/Island Maintenance
- Oxbow Re-establishment
- Jetty/Snag Removal
- Levee Maintenance
- Clearing of Under story Vegetation
- Removal of Lateral Confinements
- Channel Widening/Bank Destabilization
- Terrace Lowering (Re-establish Floodplain Hydrologic Connectivity
- Rock Vanes
- Toe Revetment Planting
- Native Material Bank Stabilization -Rock and/or Log spurs
- Groins/Bendway Weirs
- Training Dikes
- Revetments and Windrows
- Curve Shaping
- Arroyo Plug Grading and Removal
- Transect Brushing
- Mowing and Root Plowing

In many arroyos, the sediment deposits are sand sized materials. These deposits are readily washed away during high flows and provide a sediment supply for the river. Below Cochiti Dam, additional sediment supply is badly needed and arroyo sediments provide some sediment enrichment. Very large arroyo plugs, however, can diminish channel capacity or deflect flows excessively into riverside facilities and only in these instances would Reclamation undertake Arroyo plug removal or grading. Islands and bars may be cleared of vegetation, reshaped or destabilized increase the channel's width as part of reconnecting the river with the floodplain/and channel widening. Reclamation would perform levee maintenance in the Cochiti Reach on an intermittent basis at the request of MRGCD.

Hypothetical River Maintenance Project/Projects for the Cochiti Reach

A hypothetical project for the Cochiti Reach would be a gradient restoration, stream bank protection, and terrace-lowering project. Project goals would include 1) protecting levees and riverside facilities 2) reverse the trend of channel degradation 3) deceasing net depletions (i.e., evapotranspiration) and 4) increasing the flow area at higher discharges.

Stream bank protection and a gradient restoration project may use a combination of different activities including a bioengineering method of deformable bankline installation to protect a severely eroding bend. Installation of river training works such as rock vanes or bendway weirs may be necessary where a critical erosion problem exists. Installation of gradient restoration facilities which encourage localized sedimentation and grade stabilization would also help restore the function of the river channel in this reach offset by the current degradational trend. Channel realignment may also be a component of this project to relocate the river channel away from the threatened riverside facility. Newly created riverside terraces would be constructed at an elevation that would be inundated during the average spring runoff flow re-establishing floodplain\hydrologic connectivity and increasing the flow area during higher discharges.

The Santa Ana Bank Reconstruction and Stabilization Project is an example of an annual stream bank protection project that is identified after spring runoff and needs to be completed prior to the next runoff period. The project involved stabilizing a section of bank (levee) being eroded by high shearing flows of the Rio Grande. The angle of attack of high flows of the river on the Santa Ana Pueblo, just downstream from the confluence of the Jemez River, caused severe erosion and an adjacent levee was in imminent danger of failing during a future high flow event.

About 900 cubic yards of riprap (> 24" nominal) was used to stabilize the bank. All work was performed in the dry from the top of the existing bankline. Water quality impacts were minimal. This was a temporary stabilization project prior to the complete analysis and development of the long-term stabilization project described below.

An example of a long-term project in the Cochiti and Middle reaches is the Santa Ana Pueblo Rio Grande Project. Project objectives include protecting current irrigation and flood control facilities and widening the active floodplain. The Santa Ana Pueblo Rio Grande Project encompasses approximately 6,500 feet of the Rio Grande. The Project consists of three phases being constructed over a three to five year period. Phase 1 consisted of the installation of a gradient restoration facility (GRF), an accompanying fish passage apron, the excavation of a 25-foot pilot channel, installation of river dikes to block off the existing river channel, and excavation of trenches along the estimated bankline position to install bioengineering features. A cofferdam was established around the GRF construction. The bankline bioengineering consists of willows planted along the bankline and the toe protection of six-inch rock along the toe of the bank. The six-inch rock will be wrapped in biodegradable coir fabric. The coir fabric will keep the rock in place until vegetation is established on the bankline. The rock is sized such that it will move during a five-year flood event. The bankline will also have root balls and footer logs installed. The bioengineered bankline is to provide future bank protection.

The widening of the river may take longer than one year depending on the next spring runoff. Phase 2 began after the pilot channel has widened into the new river channel. This phase will consist of excavating and planting the remaining floodplain areas and the installation of bendway weirs. The bendway weir may be constructed in Phase 3 if the channel is continuing to adjust to the new alignment during Phase 2. Phase 3 will also consist of the installation of a second GRF and additional revegetation efforts along with under story vegetation clearing to offset net depletions.

The introduction of a streambank protection and gradient restoration project with these various components if carefully managed and planned would positively influence sinuosity, slope, width, depth, floodplain width, width to depth ratio, overbank wetted area, and main channel velocity from a river system stability standpoint (see summary table).

Hwy 44 Bridge, Bernalillo to Isleta Diversion Dam - (Middle Reach)
The average river width is about 600 ft. in this reach and has remained fairly constant since the installation of jetty jacks. However, the river channel is partially gravel bedded and has a slightly meandering planform in the upper section of the reach resulting in bank erosion. The maximum channel depth has been increasing and there is a disconnection between the river channel and the floodplain suggesting that the reach is incising. The most likely river maintenance activities would be the following:

- Woody Debris Snags and Boulder Placement
- High Flow Side Channels
- Increase Sand Load to Reach
- Terrace Lowering (Re-establish Floodplain Hydraulic Connectivity)
- Grade Restoration Facilities
- Rock Weirs
- Deformable Banklines
- Vegetation planting
- Non-native Vegetation Clearing and Floodplain Expansion
- Channel Realignment/Pilot Channels/Channel Avulsions
- River Bar/Island Maintenance
- Oxbow Re-establishment
- Jetty/Snag Removal
- Clearing of Understory Vegetation
- Removal of Lateral Confinements
- Channel Widening/Bank Destabilization
- Rock Vanes
- Toe Revetment Planting
- Native Material Bank Stabilization-Rock and/or Log spurs
- Groins/Bendway Weirs
- Training Dikes
- Revetments and Windrows
- Curve Shaping
- Arroyo Plug Grading and Removal
- Transect Brushing
- Levee Maintenance
- Mowing and/or Root Plowing

The degradation trend now manifesting throughout this reach may result in increased future bank erosion. Islands and bars may be cleared of vegetation, reshaped, or destabilized to increase the channel's width as part of reconnecting the river with the floodplain. Reclamation would perform levee maintenance in the Middle Reach on an intermittent basis at the request of MRGCD.

Hypothetical River Maintenance Project/Projects for the Middle Reach
In the Middle Reach, extensive bank stabilization works, e.g., jetty jacks, has led to the current stable bankline now consisting of the very dense Bosque vegetation and root material and minimizes the need for bank protection. The reach was extensively stabilized because it is the most heavily populated reach and contains many riverside facilities. The reach also contains many alternate river bars.

A hypothetical river maintenance project for the Middle Reach would be river bar/island maintenance. Project goals include: 1) protecting levees and riverside facilities, 2) reverse the trend of channel degradation, 3) deceasing net depletions (i.e., evapotranspiration), and 4) increasing the flow area at higher discharges.

Reclamation completed construction on the Albuquerque Overbank Project prior to the 1998 spring runoff. This activity is an example of a river bar/island maintenance project and was developed to help determine the effectiveness of clearing exotic vegetation on a river bar and lowering the bar to allow for overbank flooding during spring runoff. About 4 acres of the lower portion of a river bar near Albuquerque was cleared of vegetation. Stockpiled vegetation was later removed from the site. Portions of the exposed bar were lowered 2 feet by land-based equipment and terraced to mimic natural topographic variability. Nearly 8,000 cubic yards of material was excavated and spread out in newly forming depositional areas at the downstream end of the bar.

Significant bosque exists between the levees throughout this reach. A river bar/island maintenance project could potentially involve the removal of jetty jacks, clearing exotic vegetation, and lowering or destabilization of riverbanks. This work would be conducted during low flow conditions. These activities would serve to widen the river channel and increase the available overbank area thereby positively influence the sinuosity, slope, width, depth, floodplain width, width to depth ratio, overbank wetted area, and main channel velocity from a river system stability/habitat standpoint (see summary table).

Isleta Diversion Dam to Rio Puerco Confluence - (Belen Reach)
Conditions and river maintenance needs in the Belen Reach are very similar to the Middle Reach. The most likely river maintenance activities would be the following.

- Woody Debris Snags and Boulder Placement
- High Flow Side Channels
- Increase Sand Load to Reach
- Terrace Lowering (Reestablish Floodplain Hydraulic Connectivity)
- Grade Restoration Facilities
- Rock Weirs
- Deformable Banklines
- Vegetation planting
- Non-native Vegetation Clearing and Floodplain Expansion
- Channel Realignment/Channel Avulsions/Pilot Channels
- River Bar/Island Maintenance
- Oxbow Re-establishment
- Jetty/Snag Removal
- Clearing of Understory Vegetation
- Removal of Lateral Confinements
- Toe Revetment Planting
- Native Material Bank Stabilization-Rock and/or Log spurs
- Groins/Bendway Weirs
- Training Dikes
- Revetments and Windrows
- Curve Shaping
- Arroyo Plug Grading and Removal
- Transect Brushing
- Mowing and/or Root Plowing
- Levee Maintenance
- Rock Vanes
- Channel Widening/Bank Destabilization

Riverbanks in the Belen Reach have been stabilized by extensive jetty jack fields. However, the degradation trend now manifesting throughout this reach may result in increased future bank erosion. In a degrading channel environment, it is unlikely that extensive new jetty jack fields would be installed. Islands and bars may be cleared of vegetation, reshaped, or destabilized to increase the channel's width. Reclamation would perform levee maintenance in the Belen Reach on an intermittent basis at the request of MRGCD.

Hypothetical River Maintenance Project/Projects for the Belen Reach
As with the Middle Reach, the Belen Reach contains extensive bank stabilization works, e.g., jetty jacks which, has led to the current stable bankline now consisting of the very dense bosque vegetation and root material and minimizes the need for bank protection. The upper portion of this reach was extensively stabilized because it is heavily populated and contains many alternate bars and riverside facilities.

A hypothetical river maintenance project in the Belen Reach would be river bar/island maintenance. Project goals include: 1) protecting levees and riverside facilities, 2) reverse the trend of channel degradation, 3) deceasing net depletions (i.e., evapotranspiration), and 4) increasing the flow area at higher discharges. The specific activities associated with this project are the same as those discussed above for the Middle Reach. The Albuquerque Overbank Project also serves as a case study for this reach. Numerous saltcedar stands exist throughout the Belen, reach which would provide another hypothetical river maintenance project in the form of non-native vegetation clearing/floodplain expansion. These activities would serve to widen the river channel and decrease the net depletions.

Rio Puerco Confluence to San Acacia Diversion Dam - (Rio Puerco Reach)
The river channel and floodplain through the Rio Puerco Reach is generally wide and braided with extensive infestation of exotic species vegetation. The river is also now a partially gravel bed channel. The most likely maintenance activities would be the following.

- Woody Debris Snags and Boulder Placement
- High Flow Side Channels
- Increase Sand Load to Reach
- Terrace Lowering (Re-establish Floodplain Hydraulic Connectivity)
- Rock Weirs
- Deformable Bankline
- Vegetation planting
- Non-native Vegetation Clearing and Floodplain Expansion
- Channel Realignment/Channel Avulsions/Pilot Channels
- River Bar/Island Maintenance
- Oxbow Re-establishment
- Jetty/Snag Removal
- Channel Widening/Bank Destabilization
- Rock Vanes
- Removal of Lateral Confinements
- Grade Restoration Facilities
- Toe Revetment Planting
- Native Material Bank Stabilization-Rock and/or Log spurs
- Groins/Bendway Weirs
- Training Dikes
- Revetments and Windrows
- Curve Shaping
- Arroyo Plug Grading and Removal
- Transect Brushing
- Mowing and Root Plowing
- Clearing of Understory Vegetation
- Levee Maintenance

Some levee maintenance may be necessary below the confluence of the Rio Puerco because of changing geomorphic conditions and the location of various critical riverside facilities for both the State of New Mexico and MRGCD.

Hypothetical River Maintenance Project/Projects for the Rio Puerco Reach
The river through the Rio Puerco Reach is strongly influenced by the Rio Puerco and Rio Salado. These tributaries are a source of heavy sediment inflow during thunderstorm activity.

In the Rio Puerco and Socorro reaches, a hypothetical project would be channel rehabilitation. Project goals would include 1) protecting levees and riverside facilities 2) reverse the trend of channel degradation 3) deceasing net depletions (i.e., evapotranspiration), 4) increasing the flow area at higher discharges and 5) increasing the sand load to the reach. An example project would involve a combination of different activities including engineering techniques such as deformable banklines, installation of Gradient Restoration Facilities, terrace lowering to increase the sand load, and a method of rock vane/bendway weirs to protect severely eroding bends. Channel realignment may also be a component of this project to relocate the river channel away from the threatened riverside facility. Woody debris snag may be placed in the river channel to encourage sediment deposition and maintain channel width and planform. Other activities such as new floodplain creation by terrace lowering in areas where older age cottonwood stands may also be a component. Understory vegetation clearing may also be performed to decrease net depletions. As is the case in the Belen Reach, hypothetical river maintenance projects in the Rio Puerco Reach would include river bar/island maintenance and non-native vegetation clearing.

The introduction of a channel rehabilitation and stream bank protection project with the aforementioned components, through careful planning and management, would positively impact the sinuosity, slope, width, depth, floodplain width, width to depth ratio, overbank wetted area, and main channel velocity from a river system stability/habitat standpoint (see summary table).

San Acacia Diversion Dam to River Mile 78 (middle of BDANWR) - (Socorro Reach)

Channel degradation is occurring below San Acacia Diversion Dam through the Escondida/Socorro area due to changing upstream geomorphic factors that have diminished the sediment supply. The river channel is in a condition of instability characterized by vertical incision and lateral erosion. Vertical incision or bed lowering has resulted in a disconnection of the river channel from the floodplain. Lateral erosion is on effect of the change in planform of the river from a wide braided channel to a narrow single threaded, slightly sinuous channel. The channel bed between San Acacia Diversion and Escondida Bridge is mostly gravel with a sand veneer. It has been estimated that the sand veneer may be gone in approximately 3 to 5 years depending on the hydrologic conditions. The bank erosion is threatening the levee in areas downstream of San Acacia Diversion Dam. A levee system exists on the west side of the floodplain to protect the Low Flow Conveyance Channel and to control valley flooding. The most likely river maintenance activities would be the following.

- Woody Debris Snags and Boulder Placement
- High Flow Side Channels
- Increase Sand Load to Reach
- Terrace Lowering (Re-establish Floodplain Hydraulic Connectivity)
- Grade Restoration Facilities
- Rock Weirs
- Deformable Banklines
- Vegetation planting
- Clearing of Understory Vegetation
- Non-native Vegetation Clearing and Floodplain Expansion
- River Bar/Island Maintenance
- Oxbow Re-establishment
- Jetty/Snag Removal
- Rock Vanes
- Removal of Lateral Confinements
- Channel Widening/Bank Destabilization
- Toe Revetment Planting
- Levee Maintenance
- Native Material Bank Stabilization-Rock and/or Log spurs
- Groins/Bendway Weirs
- Training Dikes
- Channel Realignment/Avulsions/Pilot Channels/Pilot Cuts
- Revetments and Windrows
- Curve Shaping
- Arroyo Plug Grading and Removal
- Transect Brushing
- Mowing and/or Root Plowing

Activities associated with levee maintenance would be anticipated below San Acacia Diversion Dam because of changing geomorphic conditions and deterioration of the levee. Islands and bars may be cleared of vegetation, reshaped, or destabilized to increase the channel's width.

Hypothetical River Maintenance Project/Projects for the San Acacia Reach

A hypothetical river maintenance project in the San Acacia Reach would be similar to those described in the Belen and Rio Puerco reaches. Project goals would include 1) protecting levees and riverside facilities 2) reverse the trend of channel degradation 3) deceasing net depletions (i.e., evapotranspiration), 4) increasing the flow area at higher discharges and 5) increasing the sand load to the reach. An example project would involve a combination of different activities including engineering techniques such as deformable banklines, installation of Gradient Restoration Facilities, terrace lowering to increase the sand load, and a method of rock vane/bendway weirs to protect severely eroding bends. Channel realignment may also be a component of this project to relocate the river channel away from the threatened riverside facility. Woody debris snag may be placed in the river channel to encourage sediment deposition and maintain channel width and planform. Other activities such as new floodplain creation by terrace lowering in areas where older age cottonwood stands may also be a component. Understory vegetation clearing may also be performed to decrease net depletions. As is the case in the Belen Reach, hypothetical river maintenance projects would include river bar/island maintenance and non-native vegetation clearing.

The introduction of a channel rehabilitation and stream bank protection project with the aforementioned components, through careful planning and management, would positively impact the sinuosity, slope, width, depth, floodplain width, width to depth ratio, overbank wetted area, and main channel velocity from a river system stability/habitat standpoint (see summary table).

River Mile 78 (middle of BDANWR) to headwaters of Elephant Butte Reservoir - (San Marcial Reach)

The river channel throughout this reach is aggrading due to influences of the reservoir pool and a constricted floodplain established by the levee system. Due to its aggradational nature, the river channel (lying between the eastern mesa and the levee) in this reach is characterized as a perched channel being elevated above the western portions of the valley floor.

Temporary Channels, culvert and low water crossings, channel avulsions, non-native vegetation clearing, and floodplain expansion will be used to maintain the channel flow capacity and will be the most used river maintenance practices in this reach. The most likely river maintenance alternatives would be the following:

- Woody Debris Snags and Boulder Placement
- High Flow Side Channels
- Deformable Bankline
- Vegetation planting
- Clearing of Understory Vegetation
- Non-native Vegetation Clearing and Floodplain Expansion
- Channel Realignment/Channel Avulsions/Pilot Channels/Pilot Cuts
- Culvert and Low Water Crossing
- River Bar/Island Maintenance
- Oxbow Re-establishment
- Jetty/Snag Removal
- Rock Vanes
- Rock Weirs
- Removal of Lateral Confinements
- Channel Widening/Bank Destabilization
- Native Material Bank Stabilization-Rock and/or Log spurs
- Groins/Bendway Weirs
- Training Dikes
- Revetments and Windrows
- Permeable Jetties
- Curve Shaping
- Transect Brushing
- Mowing and Root Plowing
- Levee Maintenance
- Dredging/Sediment Settling Basins
- Toe Revetment Planting

Levee Maintenance, e.g., raising, widening, and repairing, is necessary to maintain a 8,500 cfs capacity with 2 ft. of freeboard and to maintain the levee's integrity by preventing seeps, slope, and foundation failure. Maintenance of a river channel to the reservoir pool will involve channel excavation and temporary berm construction. Pilot cut excavation, sediment plug removal, and riverside berm maintenance may be necessary to maintain channel flow capability up to 8,500 cfs and efficiently move sediment. Re-establishment of an outfall from the LFCC to the river is dependent on reservoir and river conditions. Native material, bioengineering, and other bank protection works may be utilized to protect the LFCC and existing levees. Excavation of sediment detention ponds in the reservoir delta may occur to capture and better distribute some of the in flowing sediment.

Levee maintenance on the levee at its current location is anticipated to continue another 5 to 8 years. During this time, Reclamation plans to move the river and the low flow channel to the west side of the valley below San Marcial. This future action is contingent upon completion of an Environmental Impact Statement, a favorable separate Biological Opinion from the Fish and Wildlife Service, and congressional appropriations. All activities associated with the river and low flow realignment will require separate ESA and NEPA compliance.

Hypothetical River Maintenance Project/Projects

The river channel in the San Marcial Reach is greatly influenced by the presence of saltcedar, an overabundant sediment supply, a minimal valley slope, past channelization activities, and changing reservoir levels. The San Marcial railroad bridge and embankment, the levee system, and Reclamation's LFCC are the primary riverside facilities that require protection. River channel capacity through this reach is a major bottleneck for the entire Middle Rio Grande below Cochiti Dam.

Two dominant river maintenance needs are sediment plug removal and maintaining a river channel to the reservoir pool. The purpose of sediment plug removal is to restore river channel capacity. The purpose of maintaining a river channel to the reservoir pool is to effectively transport water and sediment into the reservoir pool thereby decreasing aggradation upstream, preventing the loss of an active, flowing channel, and water delivery.

A hypothetical sediment plug removal project would involve a small pilot cut through a sediment plug thereby aiding natural fluvial processes in removing the overall plug. Removal of sediment plugs would increase channel capacity as well as allow for higher discharges throughout the entire Middle Rio Grande below Cochiti Dam. An example of a sediment plug removal project is the Tiffany Plug Removal Project. Reclamation excavated an approximately 4-mile long pilot cut through portions of a sediment plug between Bosque del Apache National Wildlife Refuge and San Marcial during 1996 and early 1997. A total of 10,000 cubic-yards of material was excavated from the pilot channel (dimensions: 10 feet top width, 5 feet bottom width, and 5 feet deep). Higher winter base flows and short-term increases in discharge prior to spring runoff removed a large portion of the sediment plug and high spring runoff flows moved the remainder of sediment downstream. Excavated material was placed along the pilot channel and was dispersed downstream with high flows. As a result, channel capacity through this critical reach of the Middle Rio Grande Valley was increased. Excavation work in the river channel was done primarily in the dry. Access to the site through the adjacent floodplain was limited to areas with predominantly saltcedar growth.

A hypothetical temporary channel to the reservoir pool would involve channel excavation through the exposed delta with the material placed on either side of the channel. An example of a temporary channel project is the Elephant Butte Temporary Channel Project. Reclamation constructed a temporary channel through the reservoir delta during early 1997 to efficiently deliver water and sediment into Elephant Butte Reservoir. A goal of this project was to relocate the active delta to a more strategic location to alleviate upstream channel aggradation and evenly distribute the sediment load across the headwaters region. The work involved construction of a temporary berm to direct flows and excavation of a new channel alignment to the reservoir pool. The temporary channel was about 1 mile long, averaged about 200 feet wide and 4-5 feet deep, and involved about 100,000 cubic yards of excavation. Approximately 20,000 cubic yards of fill material was used to construct the temporary berm, which was about 3,800 feet long. Two high flow side channels were constructed with center islands at the midway point of the temporary channel.

Reclamation's policy in maintaining a channel to the reservoir pool will be highly dependent on reservoir levels. For any established channel at reservoir contents between 1.9 and 2 million acre-feet, only the environmental features of the channel will be maintained on an annual basis. For reservoir content levels of below 1.9 million acre-feet, Reclamation will pursue performing maintenance to the established channel. For reservoir content levels below 1.6 million acre-feet, Reclamation will pursue establishing a new channel alignment at least once every five years. Establishing a new channel alignment would be accomplished to more evenly distribute sediment deposition across the delta.

The reasonable worst case scenario of a multi-year prolonged drought developed for the water operations analysis can also be used to develop a measure of potential Elephant Butte Reservoir content reduction and the associated extent of newly exposed channel for which river maintenance may be necessary. The content of the reservoir in the last year of this scenario dropped to about 1.1 million acre-feet. The reservoir pool would then be located several miles above the Narrows and about 6-8 miles downstream from the current location. It was also estimated that after five consecutive years of only 60% normal runoff, the reservoir would go from its present content approximately 1,990,000 acre-feet to 435,000 acre-feet. The hypothetical new reservoir pool location would be miles below the Narrows and within the lower sub-basin, about 15 to 20 miles downstream from the current location. Should each of the runoff volumes for the next five years be at or above normal, Elephant Butte Reservoir would remain at the current content of about 400,000 acre-ft.

Hot Springs Reach

The river channel in the Hot Springs Reach was channelized in 1985 and is relatively stable. Consequently, it is unlikely that any large-scale projects (i.e., beyond the scope of annual maintenance) would be required in this reach.

- Woody Debris Snags and Boulder Placement
- High Flow Side Channels
- Deformable Bankline
- Vegetation planting
- Clearing of Understory Vegetation
- Non-native Vegetation Clearing and Floodplain Expansion
- Jetty/Snag Removal
- Rock Vanes
- Rock Weirs
- Low Flow Stage Control Dikes
- Groins/Bendway Weirs
- Training Dikes
- Revetments and Windrows
- Permeable Jetties
- Curve Shaping
- Transect Brushing
- Mowing and Root Plowing
- Dredging/Sediment Settling Basins
- Toe Revetment Planting
- Arroyo Plug Grading and Removal

The most prominent aspect of annual maintenance in the Hot Springs Reach would be excavation of sediment in the river channel by arroyos. The four primary arroyos in the reach are Mescal Arroyo, Cuchillo Negro Arroyo, Arroyo Hondo, and Palomas Arroyo; the largest amounts of sediment accumulate at the mouths of Mescal and Cuchillo Negro arroyos. Some of the sediment travels a significant distance downstream from the arroyo mouths. Sediment excavation would occur during periods of non-release from Elephant Butte Reservoir. Flow in the river at this time consists of dam seepage and is less than 50 cfs. Excavation equipment would include a bulldozer, excavator, and/or scraper. Easements have been obtained for placement of spoil materials on property adjacent to Mescal and Cuchillo Negro arroyos; Arroyo Hondo and Palomas Arroyo are located on Reclamation lands with ample area for placement of spoil materials. All excavated material would be placed at sites away from the river channel, where there would be low probability of the material re-entering the channel during rainfall events. Existing access ramps to the river channel would be maintained. The average amount of excavated material would be about 40,000 cubic yards per year.

Since the channelization in 1985, Reclamation's policy has been to provide bank protection for infrastructure that existed prior to 1985. In accordance with this policy, riprap would be placed to control bank erosion at sites where pre-1985 structures were threatened. Additionally, dislodged riprap would be replaced at the two existing grade control structures in this reach. Total annual riprap placement would probably average approximately 850 cubic yards.

During periods of non-release from Elephant Butte Reservoir, a temporary low flow stage control dike would be built at a site within the city of Truth or Consequences. The dike would be removed immediately prior to the resumption of releases from the reservoir. A suitable site has been identified and has been in use since 1996. The dike would raise the water level in the channel and adjacent groundwater, which would increase flow rates at nearby hot springs. The 1985 channelization project lowered the bed of the channel, which resulted in a lower water table in the adjacent aquifer during periods of low flow in the river. Construction of the stage control dike would require approximately 600 cubic yards of riprap, most of which could be recovered when the dike was removed.

8. Geomorphology

In the following table, a positive symbol (+) denotes that the net effect to this geomorphic parameter would be an increase in magnitude. The negative symbol (-) indicates that the net effect to this geomorphic parameter would be a decrease in magnitude. Both symbols (+ or -) indicate that the activity has the potential of either increasing or decreasing the associated parameter’s magnitude. For these cases, the river channel’s response would be highly dependent on the specific usage of a given maintenance activity. The controlling factors are how the activity is used in combination with other activities and the exact location the activity is applied. The (N/A) symbol identifies activities that would not influence the specified geomorphic parameter.

Qualitative analysis of effects for specific river maintenance activities on geomorphic channel parameters by river reach. Reach specific deviations from the general channel response are shown parenthetically. The following river reach codes are used: V=Velarde, E=Espanola, C=Cochiti, M=Middle, B=Belen, RP=Rio Puerco, SO=Socorro, SM=San Marcial, HS=Hot Springs. (+) indicates an increase, (-) indicates a decrease, (N/A) indicates No Affect.

Maintenance Activity	**Applicable Reach**	***Sinuosity***	**Slope**	**Channel Width**	**Channel Depth**	**Floodplain Width**	**Width to Depth Ratio**	**Overbank Wetted Area**	**Velocity**
Gradient Restoration Facilities	C,M,B RP,SO,HS	N/A	-	.+.	-	.+.	.+.	.+.	-
Rock Weirs	V,E,C,M B,RP,SO	+	-	+ or -	+	N/A	+ or -	.+.	-
Deformable Bankline	V,E,C,M B,RP,SO SM	+ or -	N/A	+ or N/A	+ or N/A	+ or N/A	+ or N/A	+ or N/A	- or N/A
Vegetation Plantings	ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Non-native Vegetation Clearing and Floodplain Expansion	ALL	+ or -	+ or -	+ or N/A	- or N/A	+	.+.	.+.	- or N/A
Channel Avulsions	E,C,M,B RP,SO,SM	+	+ or -	+ or N/A	- or N/A	+	+	+ or N/A	- or N/A
Culvert and Low Water Crossings	SM	N/A	N/A	N/A	N/A	N/A	N/A	.+.	N/A
Re-establish Floodplain Connectivity	V,E,C,M B,RP,SO	+ or -	-	+ or N/A	- or N/A	.+.	+ or N/A	.+.	N/A
River Bar/Island Maintenance	V,E,C,M B,RP,SO SM	N/A	N/A	+ or N/A	N/A	+ or N/A	+ or N/A	+ or N/A	N/A
Oxbow Re-establishment	V,E,C,M B,RP,SO SM	N/A	N/A	N/A	N/A	.+.	N/A	.+.	N/A
Jetty/Snag Removal	ALL	+ or N/A	+ or N/A	+ or N/A	- or N/A	+ or N/A	+ or N/A	N/A	- or N/A
Channel Widening/Bank Destabilization	E,C,M,B RP,SO,SM	+ or N/A	+ or N/A	+	-	+ or N/A	+	+ or N/A	-
Strategic Bank Boulder/ Snag Placements	ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Terrace Lowering	V,E,C,M B,RP,SO SM	N/A	N/A	N/A	N/A	.+.	N/A	.+.	N/A
Rock Vanes	ALL	+ or -	+ or - (V=+)	+ or -	+ or -	+ or -	+ or -	+ or -	+ or -
High Flow Side Channel	C,M,BRP,SO,SM	N/A	N/A	+ or N/A	- or N/A	+ or N/A	+ or N/A	.+.	- or N/A
Removal of Lateral Confinements	C,M,B RP,SO,SM	+ or N/A	N/A	N/A	N/A	+ or N/A	N/A	+ or N/A	N/A
Increase Sand Load	C,M,B RP,SO,SM	-	.+.	.+.	-	.+.	-	.+.	-
Understory Vegetation Clearing	C,M,B RP,SO,SM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Toe Revetment Planting	ALL	+ or -	+ or -	+ or -	+ or -	+ or -	+ or -	N/A	+ or -
Native Material Revetment-Rock and/or Log Spurs	V,E,C,M B,RP,SO SM	+ or -	+ or -	+ or -	+ or -	+ or -	+ or -	N/A	+ or -
Groins/Bendway Weirs	E,C,M,B RP,SO,SM HS	+ or -	+ or -	+ or -	+ or -	+ or -	+ or -	N/A	+ or -
Training Dikes	C,M,B RP,SO SM,HS	N/A	N/A	N/A	N/A	- or N/A	N/A	-	N/A
Freeboard Dikes	V,E	N/A	N/A	N/A	N/A	-	N/A	-	N/A
Channel Realignment/Pilot Channels	C,M,B RP,SO,SM	+ or -	+ or -	+ or N/A	- or N/A	.+.	.+.	+ or N/A	- or N/A
Revetments and Windrows	ALL	N/A	N/A	- or N/A	+ or N/A	N/A	- or N/A	N/A	+ or N/A
Permeable Jetties	SM	+ or -	+ or -	- or N/A	+ or N/A	- or N/A	- or N/A	N/A	+ or N/A
Curve Shaping	ALL	N/A	N/A	-	+	- or N/A	-	N/A	+ or N/A
Low Flow Stage Control Dikes	HS	N/A	N/A	-	+	- or N/A	-	N/A	+ or N/A

Arroyo Plug Grading and Removal	V,E,C,M B,RP,SO HS	N/A	N/A	.+.	-	N/A	.+.	N/A	-
Dredging	SM,HS	+ or -	+ or -	+ or -	+ or -	+ or -	+ or -	N/A	+ or -
Sediment Settling Basins	SM,HS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Transect Brushing	ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mowing/Root Plowing	M,B,RP SO,SM	N/A	N/A	+ or N/A	- or N/A	+ or N/A	+ or N/A	+ or N/A	- or N/A
Levee Maintenance (existing levees)	C,M,BRP,SO,SM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

9. River Maintenance Schedule

The following schedule (Table 2) estimates future, proposed river maintenance activities by reach over the next three to five year period based on current river conditions. Key river maintenance and environmental issues are listed for each project. The order of projects, by reach, gives a rough approximation of relative priority. It must be emphasized that the schedule is tentative and project priorities are often adjusted based on changing river conditions, new problem areas, workload limitations, or political considerations. These projects are considered long term river maintenance activities as opposed to unforeseen annual or emergency projects. Thus, this schedule represents a subset of potential projects.

Table 2. Bureau of Reclamation river maintenance project scheduling timeline (Note: Bold action items denote critical points of involvement for Fish and Wildlife Service staff.)

River Reach	Project Name	Key Issues
1)Velarde, New Mexico to Rio Chama Confluence (Velarde Reach)	Lyden Ditch Bank Repairs	- uncontrolled river flows into an irrigation system
2) Rio Chama Confluence to Otowi (Espanola Reach)	Espanola Dikes Cross Drainage Phil Blood Pipe San Ildelfonso Pond Santa Cruz Vigil Ditch Area Phase 7	- provide drainage for agricultural lands - provide drainage for wetlands (wetland maintenance) - river bank erosion threatening tribal lake, river needs reclamation from gravel mining - river threatening bridge abutment, levee, sewer lift station - river threatening irrigation facilities and river reclamation from gravel mining
3) Cochiti Dam to Bernalillo-HWY 44 (Cochiti Reach)	Santa Ana Phases 2 and 3 (already consulted on) San Felipe Phase 3 Cochiti Pueblo Phase 1, 2, 3 Santo Domingo Phase 4	- channel degradation and levee threatened via erosion - bio-engineering for bank stability - channel degradation and levee threatened via river bank erosion - channel degradation and levee threatened via erosion
4) Bernalillo-HWY 44 to Isleta Diversion Dam (Middle Reach)	Albuquerque Overbank Phase 2, 3 Albuquerque Area Channel Widening Phase 1,2,3 Hwy. 44 to Corrales Reach Albuquerque Area Bernalillo/Sandia Pueblo	- floodplain expansion , clearing of understory vegetation - flow area expansion, clearing of understory vegetation. - floodplain expansion , clearing of understory vegetation. - floodplain expansion , clearing of understory vegetation. - river threatening levee that protects irrigation facilities and the town of Bernalllillo
5) Isleta Diversion Dam to Rio Puerco Confluence (Belen Reach)	Isleta Reach	- floodplain expansion, , clearing of understory vegetation.
6) Rio Puerco Confluence to San Acacia Diversion Dam (Rio Puerco Reach)	Rio Puerco Reach La Joya Overbank Project Phase 2	- floodplain expansion, clearing of understory vegetation - floodplain expansion

7) San Acacia Diversion Dam to River Mile 78 (Socorro Reach)	San Acacia to Escondida Reach Socorro Channel Widening	- floodplain expansion, clearing of understory vegetation - floodplain expansion , clearing of understory vegetation
8) River Mile 78 to Headwaters of Elephant Butte Reservoir (San Marcial Reach)	Tiffany Mitigation & Channel Widening Tiffany Mitigation San Marcial Channel Avulsion BDANWR - San Marcial Levee BDANWR Overbank Project Ph. 2 San Marcial Berm Phases 2 & 3 Temporary Channel into Elephant Butte	- floodplain expansion - floodplain expansion - floodplain expansion - channel aggradation/sediment deposition(channel capacity) - floodplain expansion , - channel aggradation/sediment deposition(channel capacity) - channel aggradation/sediment deposition(channel capacity)

The following is an estimate of the total number of proposed and unforeseen river maintenance projects over the next five-year period, by reach, including long-term, annual and emergency work. Consideration was given to the number of projects constructed in recent years, current workload limitations, and the evolution of the river maintenance program.

Reach Name	Number of Projects
Velarde	3
Espanola	4
Cochiti	8
Middle	3
Belen	2
Rio Puerco	2
Socorro	7
San Marcial	19
Total	**40**

The above list represents a total river maintenance effort of about 8 projects per year.

10. Coordination Process

The timely coordination of river maintenance activities with the Service and other resource management agencies is essential to insure efficient project completion. While all river maintenance projects include intensive effort by Reclamation staff and numerous internal meetings, there are main points of coordination with the Service that are critical for effective ESA consultation. These include early project scoping, alternative development, and project design and description.

A series of meetings were held between Reclamation and the Service in 1995 to develop a scheduling process for critical river maintenance projects. The timeline presented in Table 2 represents time frames discussed during the 1995 meetings and subsequent refinements to reflect more current issues and processes.

As mentioned above, long-term projects allow for advanced planning and more time for hydrologic, geomorphic, and biological surveys. The general scheduling steps also apply to long-term projects but the time frame is often extended over several years. The same meetings and project reports would be developed for long-term projects.

Project scoping, analysis, and description and ESA compliance report guidelines follow. These report guidelines not only present the general content of each report but also a systematic approach to riverine problem solving. This is a general outline and will be customized for each project. It should be emphasized that informal consultation involving the Service will begin early and occur as often as needed for specific projects.

Scoping Report - In general this report introduces the goals and objectives of the project, summarizes the historic, current and future geomorphology of the reach, and addresses environmental concerns.

- Intro, purpose of paper
- project location
- description of current situation
- description of project need
- document and analyze historical and current channel geomorphology
- estimate future geomorphic trends
- characterization and summary of biological condition and trends with interpretation based on river morphologic condition, issues, or concerns
- endangered species
- general fish and wildlife

Alternative Analysis Report - In general, the Alternative Analysis paper summarizes the project and reach geomorphology, analyzes the alternatives and evaluates their feasibility, and defines the preferred alternative.

- Intro, purpose of paper
- project location
- description of current situation
- description of project need
- summary of geomorphology
- systematic engineering/geomorphic analysis of alternatives
- evaluate engineering/environmental/economic feasibility of alternatives and define preferred alternative

Project Description (Draft and Final) - In general this report summarizes the previous two reports and details the preferred alternative design.

- Intro, purpose of paper
- project location
- description of current situation
- description of project need
- summary of geomorphology
- summary of alternatives and why the preferred alternative was chosen
- summary of environmental issues/concerns and environmental features of the preferred alternative
- detail of the preferred alternative (distances, quantities, materials, alignment, etc.)
- project description drawings

ESA Compliance Report - In general, this report will 1) reference information from the above reports, 2) document the ESA coordination process followed for a specific project, and 3) confirm compliance with conditions/sideboards developed through this programmatic consultation. It is anticipated that the majority of river maintenance projects will fit within the sideboards developed in this document. Two additional reports are prepared after completion of the river maintenance project.

Construction Report - Summary of construction procedures and inspection reports

Project Evaluation Report (s) - In general this/these post construction reports evaluate the project effectiveness and impacts on upstream/downstream geomorphology.

- short term geomorphic response
- long term geomorphic response

The scheduling process for emergency projects is necessarily truncated but still must contain the same critical points of coordination with the Service, project scoping, alternative development, and project design. The development of ESA compliance documentation will take place during and after completion of the project. Reclamation would, as standard procedure, follow-up with adequate analysis once the immediate threat has become manageable. At this point, Reclamation would determine if additional long term planning needs to occur at the site.

The aforementioned coordination guidelines have been established for developing successful projects. These guidelines are not all-inclusive or meant to be project management “recipes.” They are intended to provide a framework around which meetings and reports can be developed, ultimately leading to a sound engineering design and ESA, section 7, compliance.

12 APPENDIX D

A comparison of historic and contemporary occurrences of fish species in the Rio Grande basin upstream of Elephant Butte Reservoir to the New Mexico/Colorado State Line (adapted from Sublette et al. 1990).

FAMILY	SPECIES*	HISTORIC	CONTEMPORARY
ACIPENSERIDAE	*Scaphirhynchus platorynchus (n)*	X	-
ANGUILLIDAE	*Anguilla rostrata (n)*	X	-
CATOSTOMIDAE	*Carpiodes carpio (n)*	X	X
	Catostomus (Catostomus) commersoni (e)	-	X
	Catostomus (Pantosteus) plebeius (n)	X	X
	Cycleptus elongatus *(n)*	X	-
	Ictiobus bubalus (n)	X	-
	Moxostoma congestum (n)	X	-
CENTRARCHIDAE	*Lepomis (Chaenobryttus) cyanellus (e)*	-	X
	Lepomis (Lepomis) macrochirus (n)	X	X
	Micropterus punctulatus (e)	-	X
	Micropterus salmoides salmoides (e)	-	X
	Pomoxis annularis (e)	-	X
CHARACIDAE	*Astyanax mexicanus (n)*	X	-
CLUPEIDAE	*Dorosoma cepedianum (n)*	X	X
CYPRINIDAE	*Carassius auratus (e)*	-	X
	Cyprinella lutrensis (n)	X	X
	Cyprinus carpio (e)	-	X
	Dionda episcopa (n)	X	-
	Gila pandora (n)	X	X
	Hybognathus amarus (n)	X	X
	Macrhybopsis aestivalis aestivalis (n)	X	-
	Notemigonus crysoleucas (e)	-	X
	Notropis jemezanus (n)	X	-
	Notropis orca (n)	X	-
	Notropis simus simus (n)	X	-
	Pimephales promelas (n)	X	X
	Platygobio gracilis (n)	X	X
	Rhinichthys cataractae (n)	X	X
ICTALURIDAE	*Ameiurus melas (e)*	-	X
	Ameiurus natalis (e)	-	X
	Ictalurus punctatus (e)	-	X
	Ictalurus furcatus (n)	X	-
	Pylodictis olivaris (n)	X	X
LEPISOSTEIDAE	*Lepisosteus osseus (n)*	X	-
POECILIIDAE	*Gambusia affinis (n)*	X	X
	Poecilia latipinna (e)	-	X
SALMONIDAE	*Oncorhynchus mykiss (e)*	-	X
	Oncorhynchus ssp. X clarki hybrid (e)	-	X
	Oncorhynchus clarki virginalis (n)	X	-
	Salmo trutta (e)	-	X
SCIAENIDAE	*Aplodinotus grunniens (n)*	X	-

* The parenthetic "*e*" and "*n*" respectively refer to a species exotic or native occurrence in the Rio Grande of New Mexico.