HABITAT ANALYSIS REPORT
ALBUQUERQUE REACH
HABITAT ANALYSIS AND RECOMMENDATIONS STUDY,
MIDDLE RIO GRANDE ENDANGERED SPECIES COLLABORATIVE PROGRAM

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Table of Contents

List of Figures

List of Tables

1.0 INTRODUCTION AND PURPOSE

The purpose of the Habitat Analysis Report is to review and analyze the condition of existing habitat for the Rio Grande silvery minnow (*Hybognathus amarus*; silvery minnow) and the Southwestern Willow Flycatcher (*Empidonax traillii extimus*; flycatcher). The SWCA Environmental Consultants (SWCA) team focused on (1) summarizing existing and known proposed habitat restoration projects in the Albuquerque Reach of the Middle Rio Grande (MRG), (2) defining critical habitat needs for the species, (3) describing the current hydrological conditions and modeling the hydraulic conditions, and (4) describing potential suitable habitat for the silvery minnow and the flycatcher. We have not included much background information, such as geomorphic studies, water quality, etc., derived from the Interim Albuquerque Reach Plan, the Sandia Subreach Habitat Analysis and Recommendations Report (SWCA 2008), or other sources. We have chosen to focus on determining the critical conditions required to move forward with the next task—proposing and analyzing habitat restoration recommendations.

The Albuquerque Reach differs from the other Reach Analysis and Recommendations reports in that several habitat restoration projects, much of which has been funded by the Middle Rio Grande Endangered Species Collaborative Program (Collaborative Program), have been implemented. Several others, including the U.S. Army Corps of Engineers (USACE)—Bosque Feasibility Study, are proposed. These completed and planned projects will affect the condition of existing habitat and must be factored in the identification and analysis of restoration alternatives.

Hydrologic/hydraulic modeling was completed using existing data, including the most recent rangeline and cross-section data, updated FLO-2D models based on the 250-foot grid, and gage records for the Albuquerque gage at the Central Avenue Bridge. Models were built that will allow the SWCA team to analyze current hydrological conditions and to analyze the proposed habitat restoration recommendations.

We have focused on identifying critical habitat requirements for the flycatcher and the silvery minnow using existing peer-reviewed literature and recent studies funded by the Collaborative Program and/or its signatories. This information will be used to construct a structured context from which we will develop habitat recommendations in the next task.

Finally, using the tools available, such as hydrologic/hydraulic modeling and Level-1 geographic information systems (GIS) analysis, we have attempted to identify and describe the extent of potentially suitable habitat for the flycatcher and silvery minnow in the Albuquerque Reach. The available tools are coarse, but they should provide a base from which to work.

This report builds upon the work completed in the previous tasks—existing data availability and data gaps analysis—and will be used in the next task, restoration alternative identification. As we look forward, SWCA will utilize the information presented in this report along with the information developed in the next task in the upcoming presentation to the Collaborative Program's Habitat Restoration Workgroup.

2.0 EXISTING AND PLANNED HABITAT RESTORATION PROJECTS

2.1 HABITAT RESTORATION PROJECT OBJECTIVES AND TECHNIQUES

Numerous habitat restoration projects have been initiated in the Albuquerque Reach since 2003 (see Appendix A for locations of completed and proposed habitat restoration projects). Some habitat restoration projects have been completed, while others are still in the planning phase. Understanding the variety of components associated with each project is essential to planning future restoration projects. These project components not only include the location but the habitat restoration treatment, or technique, and the goals of the individual projects. The 2003 Biological Opinion (BiOp; U.S. Fish and Wildlife Service [USFWS] 2003) specifies the elements under reasonable and prudent alternatives (RPAs) that must be implemented by the signatories within the specified time compliance period of 10 years, including habitat restoration improvements.

According to the BiOp, nine items are identified: (1) minimizing flycatcher habitat loss during implementation of other elements; (2) improving river gaging and real-time monitoring of water operations; (3) completing a fish passage at Isleta Diversion Dam; (4) releasing spring floodwater to achieve overbank flooding when such water is physically available; (5) restoring and continuing on-going creation and monitoring of 1,600 acres of habitat/ecosystem restoration projects; (6) performing additional habitat restoration to off-set habitat losses from new river maintenance; (7) destabilizing islands, point bars, banks, and sandbars and preventing encroachment of saltcedar (*Tamarix* sp.) on the existing channel; (8) collaborating on river realignment and constructing a relocated San Marcial Railroad Bridge by 2008; and (9) increasing sediment transport through Cochiti, Galisteo, and Jemez Canyon dams in coordination with appropriate Pueblos and providing for overbank flooding when feasible. Only a few of the nine items are applicable to the Albuquerque Reach.

The objectives of habitat restoration projects required by the 2003 BiOp (RPAs Q–S, X) include increasing measurable habitat complexity in support of various life stages of the silvery minnow and the flycatcher by facilitating lateral migration of the river across islands, bars, and riverbanks during various flow stages to establish diverse mesohabitats and microhabitats. Other objectives of habitat restoration activities involve water conveyance efficiency, ecosystem recovery, water conservations, and fire hazard reduction. To this end, the habitat restoration projects document and evaluate the effectiveness of specific restoration techniques, as discussed in the *Habitat Restoration Plan for the MRG* (Tetra Tech 2004), in establishing diverse mesohabitats and microhabitats at a range of river flows.

Specific techniques have been implemented, monitored, and evaluated during the course of each project, and the restoration plans of subsequent activities or projects would be adjusted to increase treatments that are most effective in meeting the habitat needs of the silvery minnow and the flycatcher. Thirteen aquatic restoration/rehabilitation techniques (Table 2.1) and five riparian vegetation restoration/rehabilitation techniques (Table 2.2) have been identified because of their theoretical ability to improve available habitat for the silvery minnow and the flycatcher. The benefits of the 18 techniques are interrelated. For example, expected benefits to native riverine vegetation would potentially increase habitat for the flycatcher from proposed aquatic techniques.

Table 2.1. Aquatic Habitat Restoration Techniques

Restoration Technique	Description of Activity	Purpose of Technique
Passive restoration	Allows for higher-magnitude peak flows to accelerate natural channel-forming process and improve floodplain habitat.	Increases sinuosity and allows for development of complex and diverse habitat, including bars, islands, side channels, sloughs, and braided channels.
Terrace and bank lowering	Removal of vegetation and excavation of soils adjacent to the main channel to create potential for overbank flooding.	Could provide for increased retention of silvery minnow eggs and larvae. Increased inundation will benefit native vegetation, potentially increasing habitat for flycatcher.
High-flow ephemeral channels	Construction of ephemeral channels on inlands and islands to carry flow from the main river channel during high-flow events.	Creates shallow, ephemeral (normally dry), low-velocity aquatic habitats important for silvery minnow egg and larval development during high flow time periods. Increased inundation will benefit native vegetation, potentially increasing habitat for flycatcher.
High-flow bank-line backwater channels and embayments	Areas cut into banks where water enters, primarily during high-flow events, including spring runoff and floods.	Intended to retain drifting silvery minnow eggs and to provide rearing habitat and enhance food supplies for developing silvery minnow larvae. Increased inundation will benefit native vegetation, potentially increasing habitat for flycatcher.
Arroyo connectivity	Involves cutting arroyo channels to the same grade as the Rio Grande or reconnecting the arroyos to the Rio Grande. Technique may involve maintenance of sediment and planting woody vegetation.	Silvery minnow eggs and larvae may aggregate in associated habitat at the mouths of arroyos. Reconnecting the arroyos could potentially increase egg retention and also create habitat during periods of intermittency.
Main channel widening	Involves excavation of the banks and lateral expansion of the active channel. Excavates deep into the interior of the channel banks.	Geomorphic analysis and monitoring is needed to assess the benefits of the technique. Channel widening may increase mesohabitat diversity, producing shallow habitats for young-of-year.
Removal of lateral confinements, including jetty-jack removal	Reduction or elimination of structural features and maintenance practices that decrease bank erosion potential.	Creates wider floodplain with more diverse channel and floodplain features, resulting in increased net-zero and low-velocity habitat for silvery minnow.

Table 2.1. Aquatic Habitat Restoration Techniques, continued

Restoration Technique	Description of Activity	Purpose of Technique
Riverbar and island enhancement	Creation of terraces at elevations to become inundated at different stages of the local hydrograph.	Creates more complex habitat for silvery minnow by increasing variable habitats at mid-flows and low-flows, to support various life stages of the fish.
Destabilization of islands and bars	Physical disturbance (disking, mowing, root-plowing, and raking) of islands or bars to remove vegetation, allowing for the mobilization of island features during periods of high flow.	Creates more complex habitat for silvery minnow by reducing average channel depth, widening the channel, and increasing backwaters, pools, eddies, and runs of various depths and velocities. Increased inundation will benefit native riverine vegetation, potentially increasing habitat for flycatcher.
Gradient control structures	Low-head weirs typically constructed from steel pilings and rock to create or simulate riffles in the channel.	Creates mesohabitat diversity through variable depths and flow velocities. Mesohabitat created may include riffles and pools.
Woody debris	Placement of trees, root wads, stumps, or branches in the main river channel or along its banks.	Creates slow-water habitats for all life stages of silvery minnow, provides shelter from predators and winter habitat, and provides structure for periphyton growth to improve food availability for silvery minnow.
Sediment management	Addition of sediment into the Rio Grande by mobilizing the sediment behind dams and allowing it to reach the river.	Silvery minnow are commonly found near silt and sand substrate. Additional sediment to the system may have an important impact on channel morphology and the formation of mesohabitat.
Fish passage	Develop fish passage structures for silvery minnow.	Allows a safe passage for fish around human-made structures.

*Information adapted from Tetra Tech 2004.

While many of the proposed aquatic habitat restoration techniques are designed primarily to enhance silvery minnow habitat, they also promote riparian functionality and interconnectedness. For example, bank lowering would increase the frequency of inundation during periods of above base flow discharge (not annual events). The overbank areas would not remain flooded for significant periods of time and would not be intended to provide mesohabitat for adult silvery minnow, but to provide the necessary conditions for other processes that would result in residual habitat improvements and nursery habitat.

The following techniques have been identified as specifically benefiting riparian habitats.

Table 2.2. Riparian Habitat Restoration Techniques

Restoration Technique	Description of Activity	Purpose of Technique
Removal and control of exotic vegetation	Mechanical removal, prescribed fire, chemical or biological control, and flow regulation may contribute to the removal and control of exotic vegetation.	May benefit flycatcher by reducing the potential for catastrophic fires. Activity would minimize the amount of exotic species and contribute to the regeneration of natives, creating habitat for the flycatcher.
Passive restoration of riparian vegetation	Allows for higher-magnitude peak flows to accelerate natural channel-forming process and improve floodplain habitat.	Increases sinuosity and allows for development of complex and diverse habitat, including bars, islands, side channels, sloughs, and braided channels.
Active restoration of riparian vegetation	Removal of vegetation and excavation of soils adjacent to the main channel to create potential for overbank flooding.	Could provide for increased retention of silvery minnow eggs and larvae. Increased inundation will benefit native vegetation, potentially increasing habitat for flycatcher.
Hydromodification	Involves excavation of the banks and lateral expansion of the active channel. Excavates deep into the interior of the channel banks.	Geomorphic analysis and monitoring is needed to assess the benefits of the technique. Channel widening may increase mesohabitat diversity, producing shallow habitats for young-of-year.
Wetlands	Reduction or elimination of structural features and maintenance practices that decrease bank erosion potential.	Creates wider floodplain with more diverse channel and floodplain features, resulting in increased net-zero and low-velocity habitat for silvery minnow.

2.2 PREVIOUS HABITAT RESTORATION PROJECTS

Habitat construction and monitoring has taken place in riparian habitats to benefit the flycatcher and in riverine environments to benefit the silvery minnow in the Albuquerque Reach. These activities were designed to specifically meet the requirements of the 2003 BiOp for habitat restoration.

Habitat restoration projects that have been constructed in the Albuquerque Reach include the Bureau of Reclamation (Reclamation) Interstate 40 Bar Restoration (2005); New Mexico Interstate Stream Commission's (NMISC's) Riverine Restoration Project, Phase I (2006); NMISC's Riverine Restoration Project, Phase II (2007); City of Albuquerque Open Space

Division Riverine Restoration (2007); Bureau of Reclamation Bernalillo Priority Site (2007); and USACE Rio Grande Nature Center Project (2008). These projects have focused on aquatic habitat restoration to benefit the silvery minnow.

2.2.1 BUREAU OF RECLAMATION INTERSTATE 40 BAR PROJECT

Reclamation completed construction of the silvery minnow habitat restoration demonstration project immediately downstream of Interstate 40 in August 2005 (Table 2.3). The project was designed to evaluate habitat features for silvery minnow spawning and rearing habitat at flows between 500 and 6,000 cubic feet per second (cfs) (Reclamation 2005). The site was inundated at flows between 700 and 4,000 cfs during summer rainstorm events.

Table 2.3. Interstate 40 Bar Project Restoration Treatment Techniques

Restoration Technique	Action Sites (2005)	Phase I Acres Treated
		I-40/Central
Berms	3 sites	2.2
Bank Scouring and Scalloping	8 sites	1.9
Ephemeral Channels	6 sites	2.4
Contouring	Multiple sites	0.5
Total Acres by Action Site	**TBD**	**7.0**

2.2.2 NMISC RIVERINE RESTORATION, PHASE I

The NMISC completed construction for Phase I of the Middle Rio Grande Riverine Habitat Restoration project in April 2006 and implemented various habitat restoration techniques, which have been identified by the Collaborative Program to benefit the endangered silvery minnow within the Albuquerque Reach of the MRG (Table 2.4). The objective of the project was to continue and expand the habitat restoration currently being undertaken by the NMISC in the Albuquerque Reach and to increase measurable habitat complexity that supports various life stages of the silvery minnow, including egg retention, larval development and recruitment of young-of-year, and over-winter habitats to retain adult minnows (USFWS 2005). This phase of habitat restoration focused on island and bar modification in the North Diversion Channel, Interstate 40/Central, and South Diversion Channel subreaches of the Albuquerque Reach. Monitoring and evaluation of the project are ongoing.

Table 2.4. NMISC Phase I Restoration Technique Treatment Areas, by Subreach

Restoration Technique	Phase I Action Sites (2005-2006)	Phase I Acres Treated		
		North Diversion Channel	*I-40/ Central*	*South Diversion Channel*
Vegetated Island Modification and Evaluation		10.6	4.1	4.0
Bank Scouring and Scalloping	8 sites	0.5	0.9	1.9
Ephemeral Channels	7 sites	0.5	0.7	0.5
Large Woody Debris	Multiple sites	TBD	TBD	TBD
Total Acres by Action Site	**TBD**	**11.6**	**5.7**	**6.4**

* Numbers in the table above are pre-construction acreages.

2.2.3 NMISC Riverine Restoration, Phase II

The NMISC completed construction for Phase II of the Middle Rio Grande Riverine Habitat Restoration Project in April 2007 and implemented various habitat restoration techniques, which have been identified by the Collaborative Program to benefit the endangered silvery minnow within the Albuquerque Reach of the MRG (Table 2.5). The objective of the project was to continue and expand the habitat restoration currently being undertaken by the NMISC in the Albuquerque Reach and to increase measurable habitat complexity that supports various life stages of the silvery minnow, including egg retention, larval development and recruitment of young-of-year, and over-winter habitat to retain adult minnows (USFWS 2007a). Monitoring and evaluation of the project are ongoing.

Table 2.5. NMISC Phase II Restoration Technique Treatment Areas, by Subreach

Restoration Technique	Phase II Action Sites (2006–2007)	Phase II Acres Treated				Total Acres by Restoration Technique
		U.S. 550	*Paseo del Norte*	*I-40/ Central*	*South Diversion Channel*	
Vegetated Island Modification and Evaluation	16 islands	0.0	22.4	1.4	10.5	**34.3**
Riverbank Expansion/Terracing	12 sites	0.0	1.9	24.0	5.1	**31.0**
Ephemeral Channels	8 sites	8.7	1.5	0.0	1.1	**11.3**
Drain Enhancement	1 site	0	0.0	6.1	0.0	**6.1**
Backwater Channels	2 sites	0	0.0	4.4	0.0	**4.4**
Embayment Area	1 site	0.0	0.0	0.6	0.0	**0.6**
Jetty Jack Removal	2 sites	0.0	0.3	0.0	0.2	**0.5**
Large Woody Debris	TBD	TBD	TBD	TBD	TBD	**TBD**
Total Acres by Action Site	**TBD**	**8.7**	**26.1**	**36.5**	**16.9**	**88.2**

* Numbers in the table above are pre-construction acreages.

2.2.4 CITY OF ALBUQUERQUE OPEN SPACE DIVISION HABITAT RESTORATION PROJECT

The City of Albuquerque Open Space Division completed construction in May 2007. The project involved the design and implementation of various habitat restoration/rehabilitation techniques to restore aquatic and riparian habitat for the benefit of the silvery minnow and the flycatcher within the Albuquerque Reach of the MRG (Table 2.6). Specific rehabilitation and restoration activities would occur within the river floodplain at three locations within the Rio Bravo to South Diversion Channel Subreach. Site-specific projects would be implemented for the benefit of the silvery minnow, the flycatcher, and the riverine ecosystem as a whole (USFWS 2007b).

Table 2.6. City of Albuquerque Restoration Technique Treatment Areas

Restoration Technique	Action Sites (2007)	Phase I Acres Treated
		South Diversion Channel
Vegetated Island Modification and Evaluation	2 sites	17.6
Bank Scouring and Scalloping	6 sites	2.0
Ephemeral Channels	6 sites	8.2
Vegetation Management	Multiple sites	30.5
Total Acres by Action Site	**TBD**	**58.3**

* Numbers in the table above are pre-construction acreages.

2.2.5 BUREAU OF RECLAMATION BERNALILLO PRIORITY PROJECT

Reclamation has completed environmental compliance for the Levee Priority Site Project at Bernalillo and began construction in summer 2005. The project designs incorporated hydraulic features that protect the levee by redirecting flow away from the levees. These features also increased habitat complexity that should benefit the silvery minnow and other fish species (USFWS 2006a).

2.2.6 U.S. ARMY CORPS OF ENGINEERS HABITAT RESTORATION PROJECTS

The USACE has implemented, or is planning to implement a number of habitat restoration projects, including the Rio Grande Nature Center Project, the MRG Bosque Restoration Project, and the Bosque Revitalization @ Route 66 Project (Route 66 Project). The Rio Grande Nature Center Project is intended to partially fulfill the requirement of habitat restoration under RPA Element S. This project proposes to conduct habitat restoration projects in the MRG to benefit the silvery minnow and the flycatcher through reconnecting side channels at the project (USFWS 2007c). This project is located in the MRG bosque on the east side of the river at Rio Grande Boulevard and Candelaria Road in Albuquerque at the Rio Grande Nature Center State Park. The project site comprises approximately 15 acres. The proposed MRG Bosque Restoration Project will focus on bank stabilization, swale construction, vegetation management, and creating water features in the floodplain (USACE 2008a). The Route 66 Project includes removing jetty jacks and non-native phreatophytes, and enhancing existing high-flow channels and outfall wetlands to improve floodplain function (USACE 2008b).

2.2.7 OTHER HABITAT RESTORATION PROJECT

Other aquatic and riparian habitat restoration projects have been implemented by the Middle Rio Grande Conservancy District (MRGCD), the University of New Mexico, City of Albuquerque Open Space, and the Collaborative Program in the Albuquerque Reach. These projects have been primarily smaller in area then the projects discussed above. Future habitat restoration projects not previously discussed include the NMISC (Riverine Restoration Project, Phase IIa - 2009) and the Albuquerque Bernalillo County Water Utility Authority (Drinking Water Project Mitigation - 2009–2010).

3.0 HYDROLOGICAL ANALYSIS AND HYDRAULIC MODELING

The purpose of this report is to summarize the results of hydrological analysis and hydraulic modeling conducted by Wolf Engineering in subcontract to SWCA. Historic accounts of the surface water hydrology, summary of the geomorphic trends, and other issues will be discussed fully in the Final Report.

Wolf Engineering conducted hydrological analysis and hydraulic modeling of the Albuquerque Reach using the mean daily flow data from the Albuquerque gage (U.S. Geological Survey [USGS] Gage No. 08330000), located approximately in the middle of the project area, immediately upstream of the Central Avenue bridge and approximately 48 miles downstream of Cochiti Dam. Analysis was conducted for the pre-Cochiti era (1942–1974) and the post-Cochiti era (1975–present) in order to assess conditions that may be more reminiscent of the conditions in which the silvery minnow evolved. Further, analysis was divided into spring runoff (March 1–June 30), summer (July 1–September 30), and fall/winter (October 1–February 28) to capture conditions important to the life cycle needs of the silvery minnow. Analyses completed included flood frequency, flow duration, and volume duration frequency.

Hydraulic modeling included running the previously developed and calibrated HEC-RAS model (Mussetter Engineering, Inc. [MEI] 2008) to determine in-channel flow depths and average flow velocities for a range of steady-state discharges (1,500 cfs, 3,500 cfs, and 6,000 cfs). FLO-2D modeling using the 250-foot grid system developed by Riada Engineering (2008) and MEI (2008) was used to assess channel capacity, predict and track the locations of overbank flow, predict the duration of overbank flow, and provide reach averaged hydraulic conditions for the main channel (e.g., depth, velocity, topwidth, width to depth ratio, and energy slope).

Complete results are presented in Appendix B. Selected pertinent results as they relate to determining silvery minnow and flycatcher habitat are presented here.

3.1 SURFACE WATER HYDROLOGY

The natural flows of the Rio Grande are controlled by the climatic, geologic, and physical characteristics of the contributing watershed (Lee et al. 2004) and are derived largely from snowmelt (predominantly upstream) and summer thunderstorms often localized at lower elevations (USACE et al. 2006). The El Niño-Southern Oscillation strongly influences the timing and volume of flows because of its influence on seasonal cycles of temperature and precipitation (Lee et al. 2004). These cycles are exemplified by the dry period observed from the early 1940s to mid 1970s and the wet period from 1981 to the mid 1990s (Swetnam and Betancourt 1999; National Oceanic and Atmospheric Administration 2007). Spring snowmelt runoff is currently occurring earlier in the spring season because of changes in temperature and precipitation (Hall et al. 2006; Rahmstorf et al. 2007).

Dam operations on the river subsequently alter natural flows and ultimately determine actual flow rates by storing and releasing water in a manner that generally decreases the flood peaks and alters timing of the hydrograph but not necessarily annual flow volume (USACE et al. 2006). Dams, such as the one constructed at Cochiti, not only reduce flood peaks but also the inundation frequencies of the floodplain (Petts 1984). It has been well documented that the average annual maximum mean daily flow (AAMMDF) and infrequent large magnitude peak discharges have decreased in all reaches south of Cochiti Dam (USACE et al. 2006; MEI 2008; Parametrix 2008; SWCA 2008). This has implications for downstream ecosystem productivity and species diversity (Pollock et al. 1998). MEI (2008) reports that prior to the closure of Cochiti Dam, peak discharges regularly exceeded 10,000 cfs. However, since the closure of Cochiti Dam, no peak discharges exceeded 10,000 cfs, although the annual runoff volume increased from approximately 714,000 acre-feet to approximately 1,011,000 acre-feet, perhaps due to the wet period described above. Parametrix (2008) describes the effect of upstream water regulation has been to flatten the mean annual hydrograph by limiting peak flows to 7,000 cfs to prevent damage to levees and other infrastructure. The maximum flow analysis results conducted by Wolf Engineering are presented in Table 3.1. Flood Frequency curves are presented in Figure 3.1

Table 3.1. Post-Cochiti Era Computed Discharge Frequency at the Rio Grande Albuquerque Gage (USGS Gage No. 08330000)

RETURN INTERVAL (YEARS)	PRE-COCHITI PEAK DISCHARGE (CFS)	POST-COCHITI PEAK DISCHARGE (CFS)
2	6,887	4,894
5	10,763	7,131
10	13,463	8,551
25	16,116	9,858
50	16,269	11,477
100	22,318	12,643

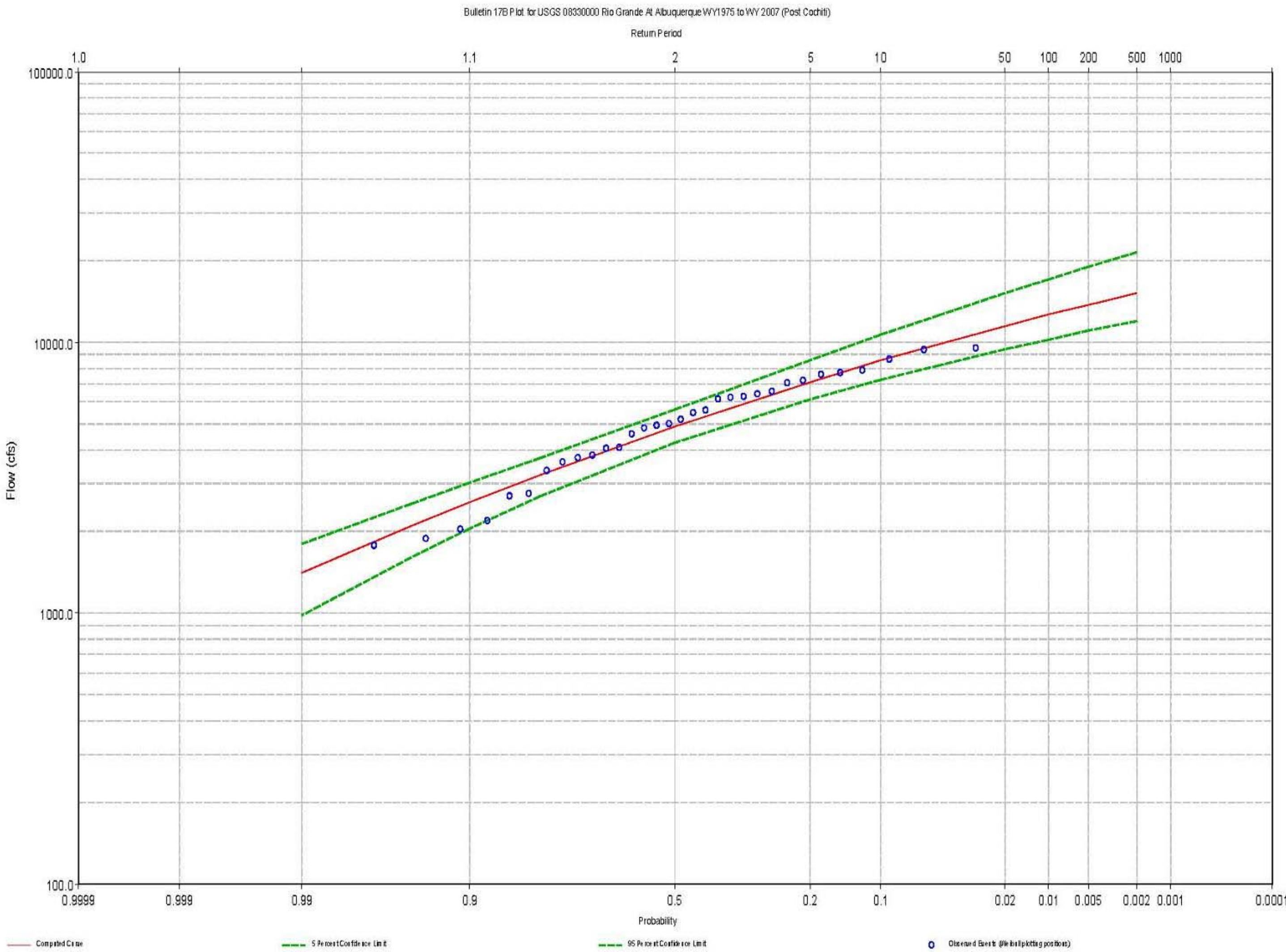

Figure 3.1. Computed Flood Frequency Curve for the Rio Grande at Albuquerque – Post Cochiti Period of Record (WY1975–WY2007)

However, the analysis of peak flows tells only part of the story. The historical record suggests that flows in the Rio Grande have been variable with periods of dry conditions and periods of wet conditions (Scurlock 1989). Evidence of the variability can be found within the recent period from 2005 to 2007, in which the Albuquerque Reach experienced a range of spring discharges, from very high spring discharge in 2005, to very low spring discharge in 2006 and an average spring discharge in 2007. Figure 3.2 illustrates the variability of the spring runoff hydrograph with the mean daily flow curve as calculated by MEI (2008). This suggests that it is important to evaluate and quantify the likelihood of sustained low flow periods when formulating and designing in-channel restoration alternatives for the silvery minnow.

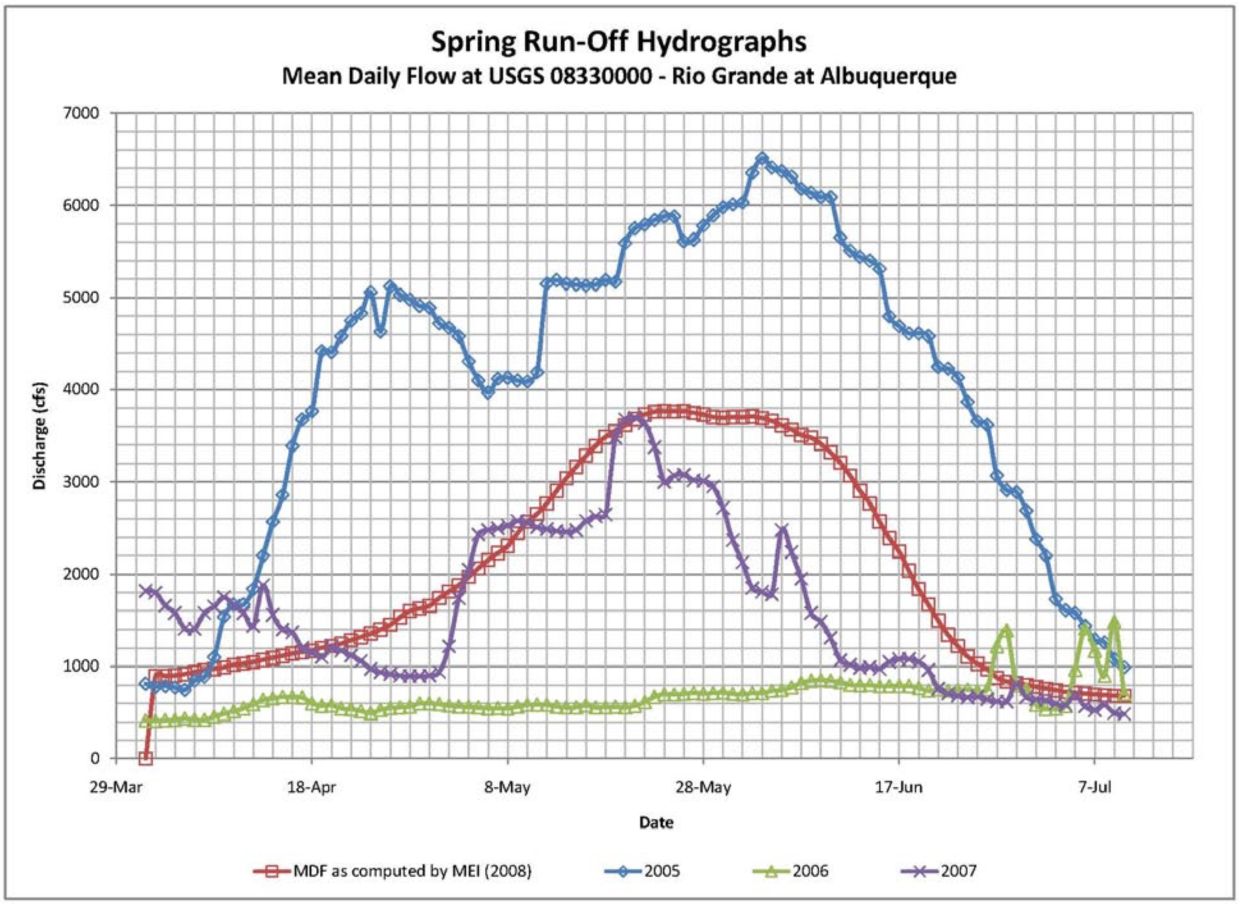

Figure 3.2. Spring hydrographs for the period 2005–2007.

To evaluate the low flow periods, it is useful to use a minimum flow analysis (Dunne and Leopold 1978). The minimum flow analysis predicts the probability of not exceeding a given value for a given duration. Minimum flow curves were computed for the same 7-day and 25-day duration periods as the flow duration analysis. The results are presented in Table 3.2 and Table 3.3, and Figure 3.3 and Figure 3.4. The minimum flow analysis is similar to the flood frequency analysis, except the minimum flow analysis computes the probability of a flow not exceeding a given value. For example the 10 percent non-exceedance flow for the spring period in the Pre-Cochiti Period suggests that there is a 10 percent probability of flows occurring that are 12 cfs or less. Comparing the Pre-Cochiti Period with the Post-Cochiti Period suggests that there is a greater likelihood of encountering low flow periods in the Pre-Cochiti Period. The evidence is the higher flow values in the Post-Cochiti Period. This trend holds true for the 7-day flow duration across all non-exceedance probabilities and the 25-day flow duration at the 10 percent and 50 percent non-exceedance probabilities. However, the trend changes at the 90 percent non-exceedance probability, which shows a decrease in the Post-Cochiti Period, suggesting that there were higher magnitude flow events prior to the closure of Cochiti Dam.

Table 3.2. Volume Duration Frequency Data (cfs) – 7-Day Minimum Flow Analysis

Percent Chance Non-Exceedance	Pre-Cochiti Dam Period			Post-Cochiti Dam Period		
	Spring	Summer	Fall/Winter	Spring	Summer	Fall/Winter
10	12	1	3	212	31	27
50	146	18	50	623	224	242
90	1,057	279	442	1,176	764	701

Table 3.3. Volume Duration Frequency Data (cfs) - 25-Day Minimum Flow Analysis

Percent Chance Non-Exceedance	Pre-Cochiti Dam Period			Post-Cochiti Dam Period		
	Spring	Summer	Fall/Winter	Spring	Summer	Fall/Winter
10	20	9	2	282	143	67
50	294	73	88	897	452	340
90	2,273	560	1,416	1,719	854	764

Finally, we looked at a flow duration analysis of 7 days and 25 days. The duration periods were selected to represent the minimum period (thought to be 7–10 days) and an optimal period (approximately 25 days) required for silvery minnow recruitment. The 7- to 10-day flow-duration period represents what is thought to be a minimum time required for silvery minnow recruitment, while the 25-day period is hypothesized to be a desired flow duration period. A notable consequence of anthropogenic modification of the natural flow regime in the MRG is the reduction of high flow events that would result in heightened recruitment to the next age class. Figure 3.5 suggests a strong correlation between maximum annual consecutive days of strong recruitment stage discharge flows and average estimated density of silvery minnow for the period of 1993 to 2006. Indeed, moderate to high levels of silvery minnow recruitment to at least the juvenile stage usually result from flows that inundate floodplains for a minimum sustained period of 7 to 10 consecutive days. Higher levels of recruitment are expected with longer periods of sustained floodplain inundation. Minimal sustained duration of river channel-floodplain coupling is essential to allow adults a chance to occupy the floodplain and spawn, to allow time for embryo development and hatching, and finally to allow sufficient time for young-of-year silvery minnow development to at least the juvenile stage to effectively enable fish to evacuate draining floodplain habitats.

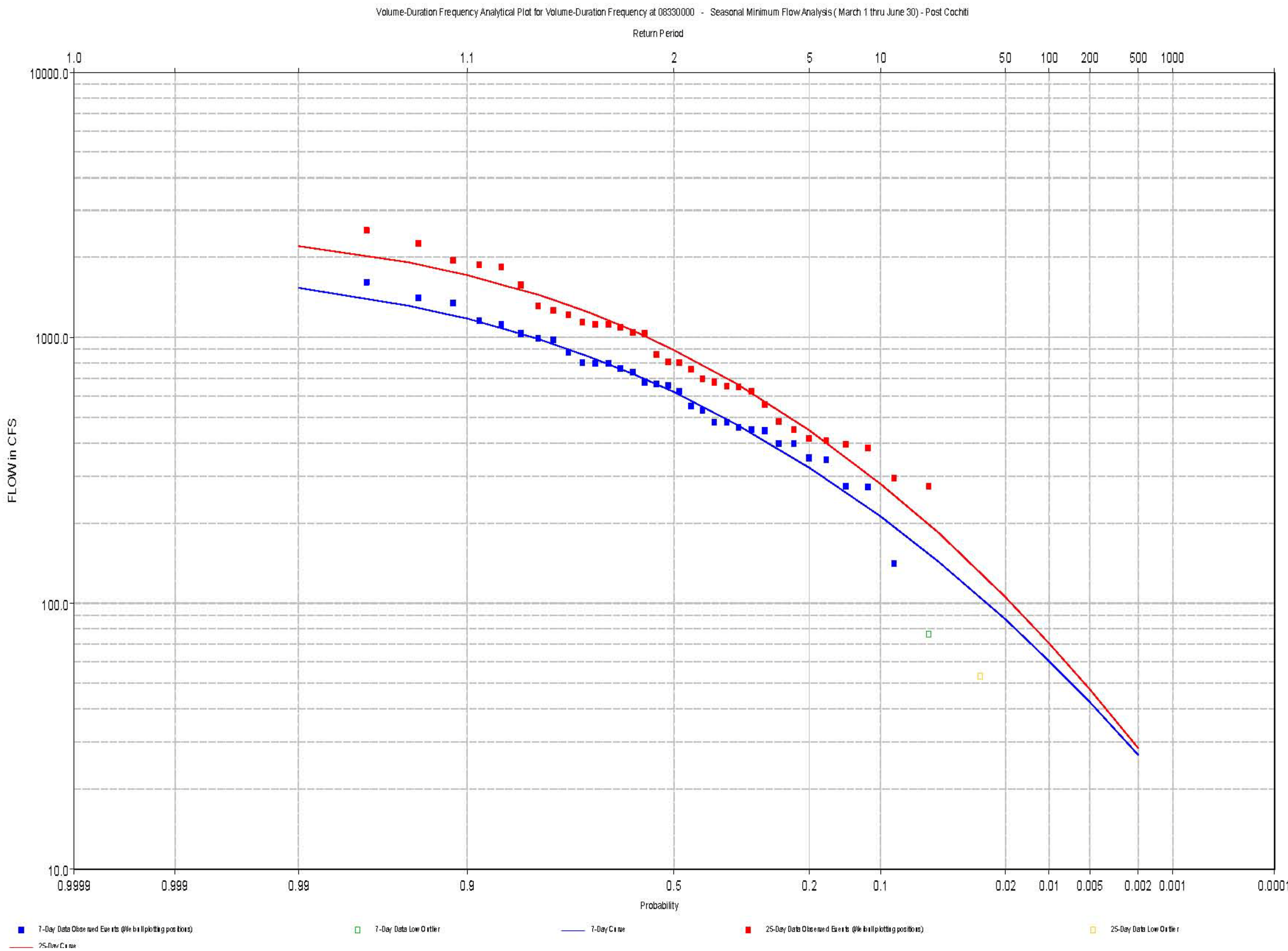

Figure 3.3. 7-day and 25-day Volume Duration Frequency Plots - Minimum Flow Analysis Pre Cochiti, WY1942–WY1974.

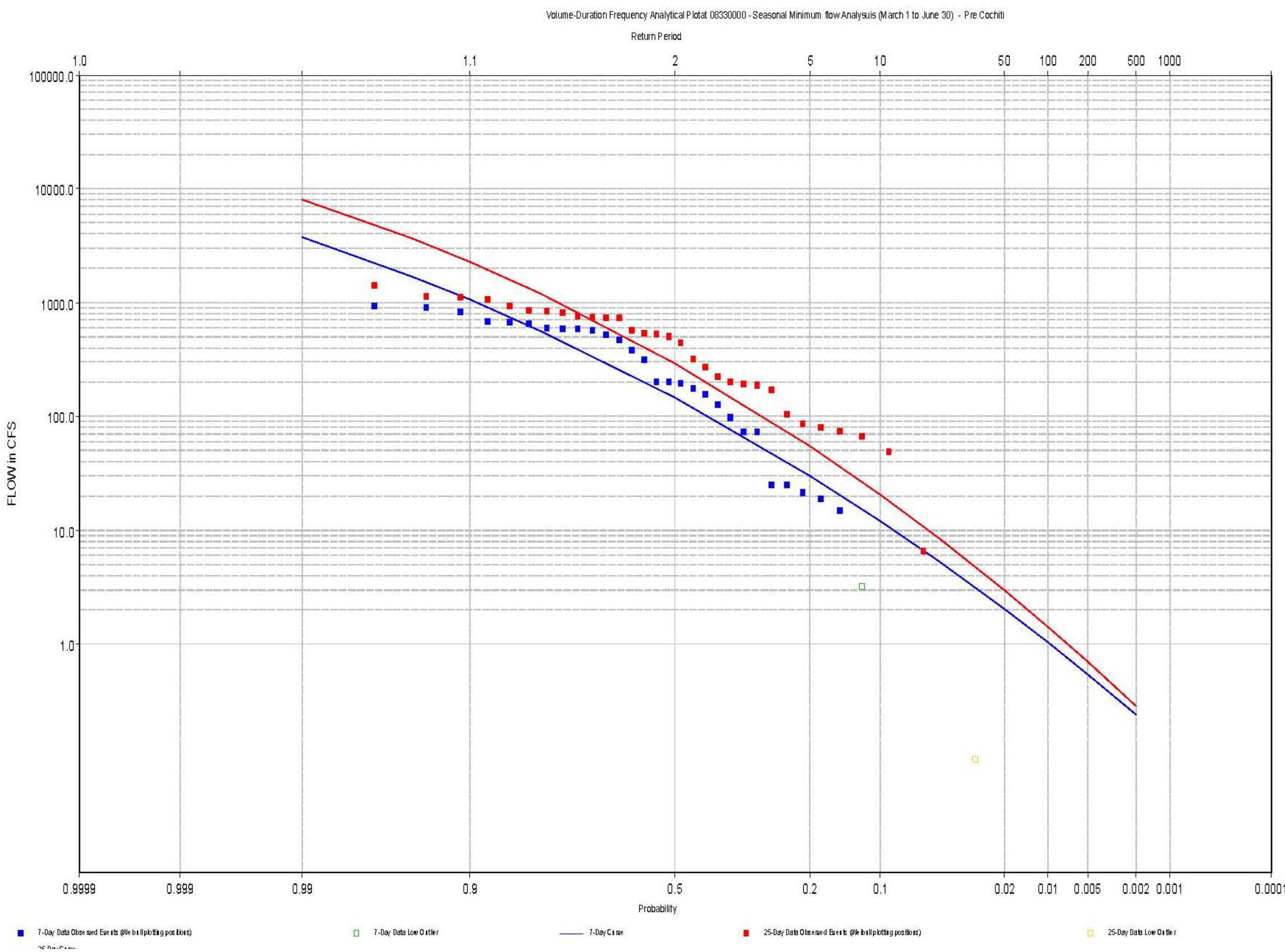

Figure 3.4. 7-day and 25-day Volume Duration Frequency Plots - Minimum Flow Analysis Post Cochiti, WY1975–WY2008.

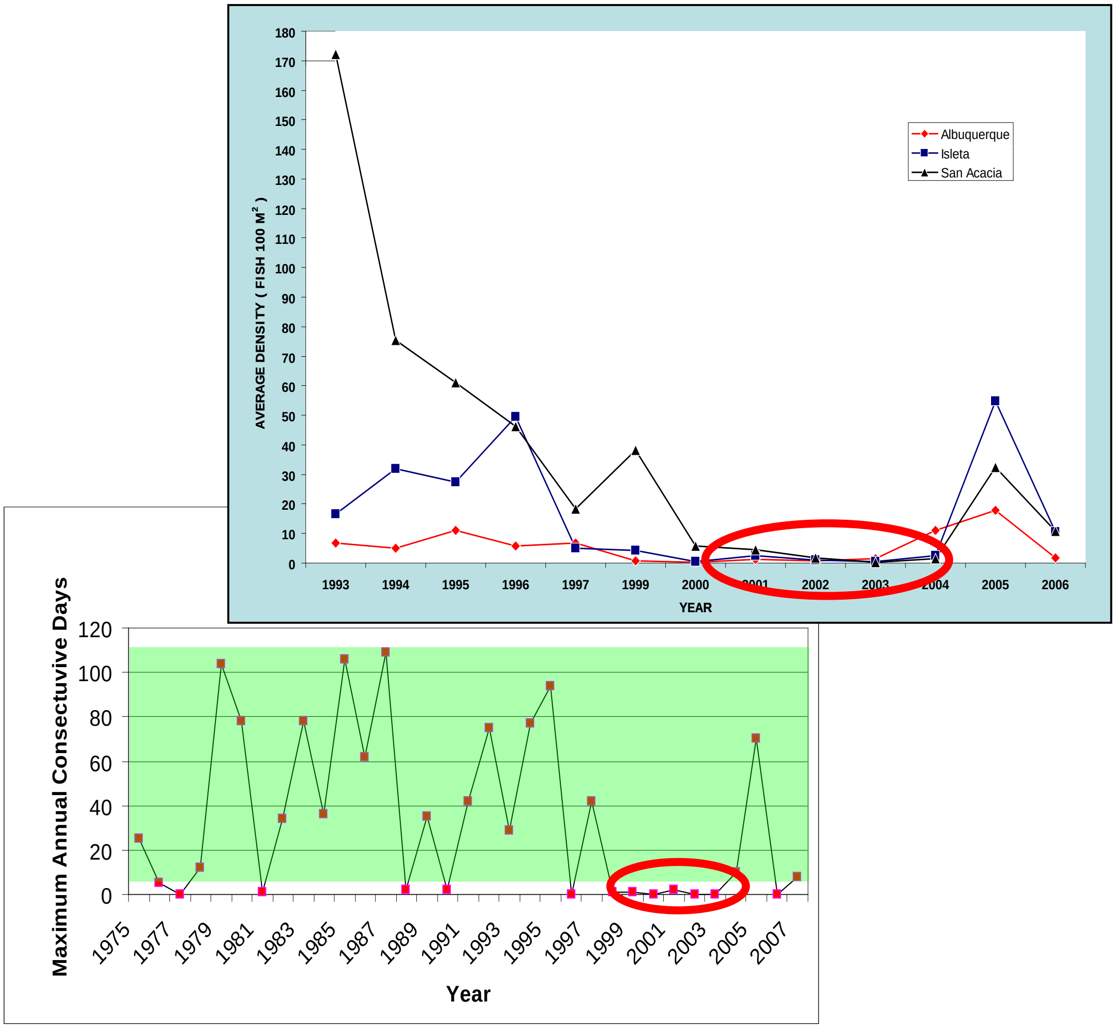

Figure 3.5. Overlay of graphs showing maximum annual consecutive days of strong recruitment stage discharge flows and estimated density of silvery minnow by river reaches. The contemporary (post-1974) record of consecutive days of strong recruitment stage discharge flows are indicated by red squares; the range of early settlement flow records (pre-1931) is indicated by the green shaded rectangle.

The mean daily flow data for the Albuquerque gage were used to develop the flow duration curves. The flow duration curves illustrate the magnitude and duration of flows. The spring runoff period (March 1–June 30) was analyzed as this is the critical for silvery minnow recruitment and coincides with flycatcher nesting. Results are provided in Figure 3.6 and Table 3.4. Seasonal flow duration curves are found in Appendix B.

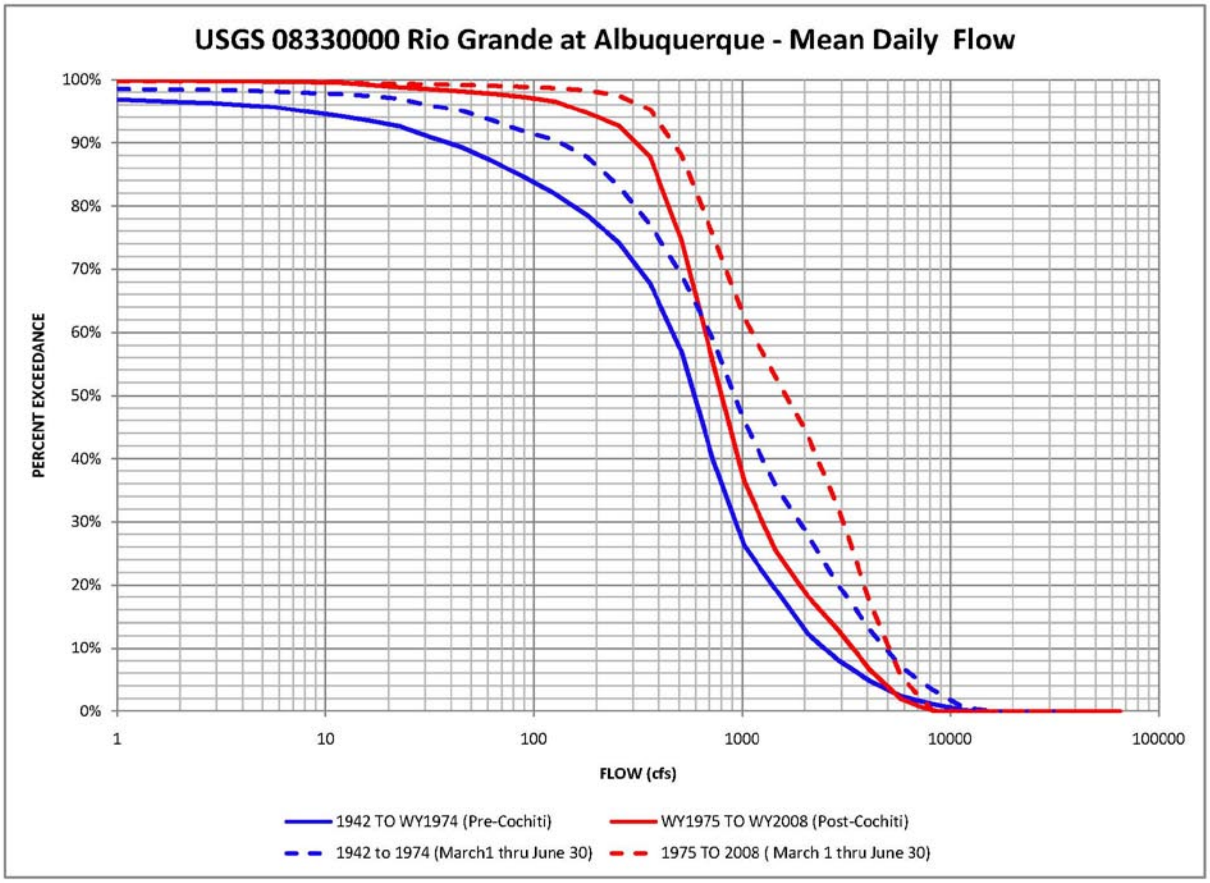

Figure 3.6. Flow Duration Curve for Pre and Post Cochiti Dam - USGS Stream Gage 08330000 Rio Grande at Albuquerque

Table 3.4. Flow Duration Data for Pre and Post Cochiti Dam – USGS Stream Gage 08330000 Rio Grande at Albuquerque

Percent Exceedance	Pre Cochiti Annual	Post Cochiti Annual	Pre Cochiti Spring	Post Cochiti Spring
10%	2,500	3,400	4,700	5,100
50%	590	800	910	1,750
90%	40	310	130	470

3.2 HYDRAULIC MODELING

3.2.1 HEC-RAS RESULTS

The HEC-RAS modeling provides an assessment of in-channel flows through computing water surface elevations over a range profile data for discharges of 1,500, 3,500, and 6,000 cfs (see Appendix B). Water velocities profiles were created for each subreach. It was not possible to map each bar and island to model inundation depth and duration due to the lack of a suitable topographic model. The effort was limited by the lack of Light Detection and Ranging (LiDAR) topographic data and a digital elevation model (DEM), which would have facilitated this effort.

However, analysis of the profiles shows that flows up to approximately 3,500 cfs are confined to the active channel and that the 6,000 cfs profile approximates the bankfull conditions with intermittent areas of overbank flows. These results are in agreement with the analysis conducted by MEI (2008) in support of the Bosque Feasibility Study and are corroborated by the data collected during the Overbank Monitoring of the 2005 spring high flow events (Tetra Tech 2005). The channel velocities are relatively uniform throughout the project area. Flows vary from approximately 2 to 3 feet per second (fps) at 1,500 cfs to approximately 3 to 5 fps at 6,000 cfs. However, upon closer examination, there are areas where the velocity profiles converge, dip, or cross (with 1,500 cfs discharges having a higher discharge than the 3,500 and 6,000 cfs discharges). These results suggest areas where islands and bars are inundated, representing potential silvery minnow habitat.

A review of the thalweg depth elevations suggests that the channel incision has progressed from 2002 aggradation/degradation surveys to 2007 upstream of Montaño Bridge. These results may be an artifact of the data collected in 2002, but generally corroborate the results reported by Leon (1998), Ortiz (2003), Bauer (2004), Massong (2005a, 2005b), and Massong et al. (2007) of continuing channel degradation.

3.2.2 FLO-2D RESULTS

The calibrated FLO-2D model was run for the following hydrologic scenarios:

1. A stepped hydrograph from 500 to 6,500 cfs with the discharge increasing in 500 cfs increments every 60 hours.
2. A steady release from Cochiti Dam of 1,500 cfs for 10 days.
3. The spring runoff hydrograph from 2007 as recorded at the Albuquerque gage.
4. A steady release of 6,000 cfs from Cochiti Dam for 25 days.
5. A steady release of 7,000 cfs from Cochiti Dam for 25 days.

The primary purpose of modeling each scenario is as follows:

1. To provide a tool for quickly computing depth-averaged hydraulic conditions within any subreach of the overall project reach.
2. To evaluate flood routing, flow depths, and flow velocity for a dryer than normal spring runoff.
3. To evaluate flood routing, flow depths, and flow velocity for a normal spring runoff.
4. To evaluate flood routing, flow depths, and flow velocity in the channel and overbank, and for duration of inundation in the overbank for a wetter than normal spring runoff.
5. To evaluate flood routing, flow depths, and flow velocity in the channel and overbank, and for duration of inundation in the overbank for the maximum controlled release from Cochiti Dam.

The results of the FLO-2D modeling are presented in Appendix B as a series of maps indicating overbank inundation depths at the varying discharges modeled. A review of the results indicates that overbank inundation is predicted to occur in the lower portion of the project area (Subreach

5) where inundation occurs below 6,000 cfs. Inundation at 6,000 and 7,000 cfs occurs in Subreaches 4 and 5 (downstream of the Central Avenue Bridge). Very little overbank inundation occurs upstream of the Central Avenue Bridge.

The results of hydrologic scenario 1 are summarized in Table 3.5, which outlines the depth-averaged channel hydraulic conditions within the Albuquerque Reach. The parameters selected represent parameters thought to be important indicators of suitable silvery minnow habitat.

Table 3.5. 250-foot FLO-2D Computed Channel Hydraulic Conditions

Depth-averaged Channel Hydraulic Conditions within the Albuquerque Reach							
Subreach	**Discharge (cfs)**						
	500	**1,000**	**2,000**	**3,000**	**4,000**	**5,000**	**6,000**
	Thalweg Depth						
A	5.0	6.6	7.8	8.6	9.0	9.5	9.9
B	3.5	4.7	6.0	6.7	7.3	7.7	8.1
1	2.5	3.5	4.3	4.8	5.1	5.5	5.8
2	2.8	3.4	4.2	4.7	5.1	5.5	5.7
3	2.5	3.1	3.9	4.5	5.0	5.4	5.8
4	2.3	3.0	3.7	4.2	4.6	4.9	5.3
5	2.4	3.4	4.2	4.8	5.3	5.8	5.9
Velocity (ft/sec)							
A	0.98	1.24	1.55	1.77	2.02	2.24	2.44
B	1.43	1.88	2.20	2.51	2.79	3.07	3.28
1	0.93	1.40	1.82	2.15	2.44	2.70	2.95
2	1.17	1.43	1.78	2.07	2.32	2.55	2.81
3	1.00	1.36	1.85	2.24	2.56	2.86	3.11
4	0.87	1.25	1.68	2.03	2.34	2.61	2.87
5	0.92	1.40	1.90	2.30	2.65	2.94	3.10
Top Width (ft)							
A	214	330	479	572	578	582	586
B	173	247	363	426	461	482	496
1	232	501	594	633	649	655	658
2	387	493	607	664	690	699	703
3	429	441	451	457	463	468	474
4	457	541	573	580	583	586	588
5	363	424	437	444	447	450	482
Width to Depth Ratio (W/D)							
A	39	51	62	68	65	62	60
B	46	53	61	64	64	63	61
1	103	148	146	139	131	124	118
2	145	149	148	143	137	130	124
3	180	150	122	107	98	91	86
4	189	187	158	141	129	120	112
5	134	130	109	97	88	82	84
Energy Slope (ft/ft)							
A	0.000276	0.000324	0.000385	0.000400	0.000411	0.000422	0.000425
B	0.000552	0.000584	0.000582	0.000580	0.000581	0.000581	0.000586
1	0.000486	0.000648	0.000659	0.000658	0.000658	0.000658	0.000656
2	0.000667	0.000658	0.000637	0.000631	0.000626	0.000621	0.000622
3	0.000649	0.000637	0.000623	0.000622	0.000619	0.000617	0.000607
4	0.000581	0.000640	0.000635	0.000637	0.000637	0.000638	0.000642
5	0.000484	0.000539	0.000525	0.000523	0.000517	0.000515	0.000563

4.0 SOUTHWESTERN WILLOW FLYCATCHER HABITAT ANALYSIS

4.1 HABITAT CHARACTERISTICS

The Southwestern Willow Flycatcher (*Empidonax traillii extimus*) is one of four subspecies of willow flycatcher currently recognized (Unitt 1987), although Browning (1993) posits a fifth subspecies (*E. t. campestris*) occurring in the central portions of the United States (Figure 4.1). The flycatcher breeds in dense, mesic riparian habitats at scattered, isolated sites in New Mexico, Arizona, southern California, southern Nevada, southern Utah, southwestern Colorado, and, at least historically, extreme northwestern Mexico and eastern Texas (Unitt 1987).

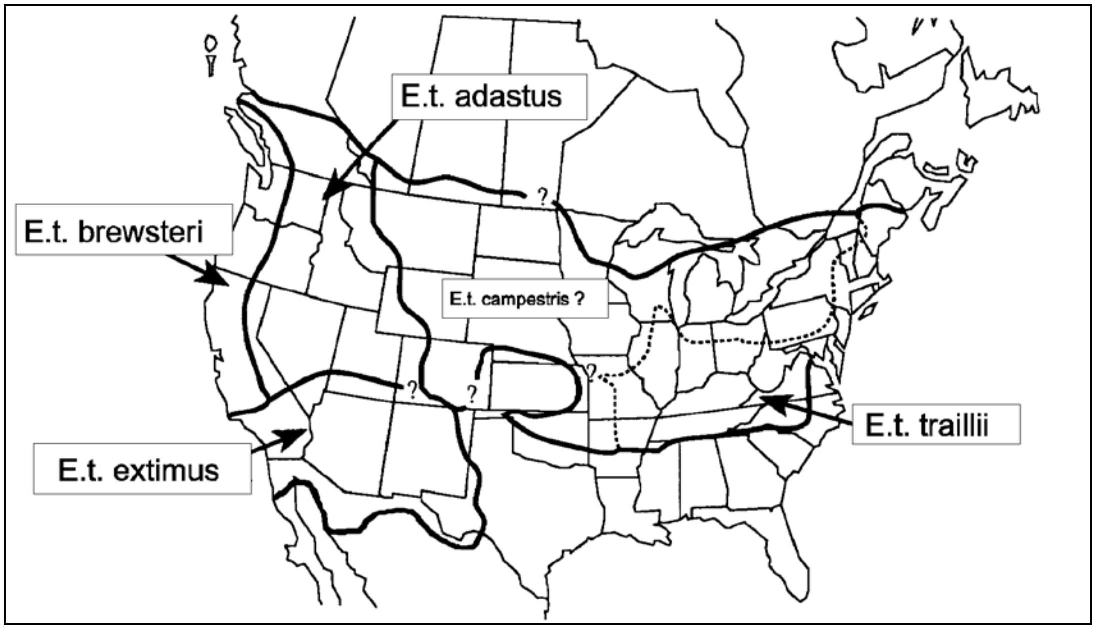

Figure 4.1. Breeding range distribution of the subspecies of the willow flycatcher. Adapted from Unitt (1987), Browning (1993), and Sogge et al. (1997).

In the Southwest, most flycatcher breeding territories are found within small breeding sites containing five or fewer territories (Sogge et al. 2003). One of the last long-distance neotropical migrants to arrive in North America in spring, the flycatcher has a short, approximately 100-day breeding season, with individuals typically arriving in May or June and departing in August (Sogge et al. 1997). All four subspecies of willow flycatchers spend the non-breeding season in portions of southern Mexico, Central America, and northwestern South America (Stiles and Skutch 1989; Ridgely and Tudor 1994; Howell and Webb 1995; Unitt 1997), with wintering ground habitat similar to the breeding grounds (Lynn et al. 2003). On the wintering grounds, both sexes maintain and defend mutually exclusive territories using song and aggressive behaviors similar to those exhibited on the breeding grounds (Sogge et al. 2007). Willow flycatchers have been recorded on the wintering grounds from central Mexico to southern Central America as early as mid-August (Stiles and Skutch 1989; Howell and Webb 1995), and wintering, resident individuals have been recorded in southern Central America as late as the end of May (Koronkiewicz et al. 2006).

The USFWS has defined suitable habitat and habitat occupancy criteria in the Southwestern Willow Flycatcher Recovery Plan (USFWS 2002). Suitable habitat is defined as a riparian area with all the components needed to provide conditions suitable for breeding; these conditions are generally dense, mesic riparian shrub and tree communities 0.25 acres or greater in size within floodplains large enough to accommodate riparian patches at least 10 m (33 feet) wide, measured perpendicular to the channel (USFWS 2002). Currently, this definition of suitability is based solely on habitat characteristics, not on measures of flycatcher productivity or survival. Suitable habitat may be occupied or unoccupied; any habitat in which flycatchers are found breeding is, by definition, suitable. Definitions of occupancy are as follows:

- Occupied suitable habitat is that in which flycatchers are currently breeding or have established territories.
- Unoccupied suitable habitat appears to have physical, hydrological, and vegetation characteristics within the range of those found at occupied sites but does not currently support breeding or territorial flycatchers. Some sites that appear suitable may be unoccupied because they may be missing an important habitat component not yet characterized. Other sites are currently suitable but unoccupied because the flycatcher population is currently small and spatially fragmented, and flycatchers have not yet colonized every patch where suitable habitat has developed.
- Potentially suitable habitat (potential habitat) is defined as a riparian system that does not currently have all the components needed to provide conditions suitable for nesting flycatchers (as described above), but could—if managed appropriately—develop these components over time.
- Regenerating potential habitats are those areas that are degraded or in early successional stages but have the correct hydrological and ecological setting to be become, under appropriate management, suitable flycatcher habitat.
- Restorable potential habitats are those areas that could have the appropriate hydrological and ecological characteristics to develop into suitable habitat if not for one or more major stressors and that may require active abatement of stressors in order to become suitable. Potential habitat occurs where the floodplain conditions, sediment characteristics, and hydrological setting provide potential for development of dense riparian vegetation. Stressors that may be preventing regenerating and restorable habitats from becoming suitable include, but are not limited to, dewatering from surface diversion or groundwater extraction, channelization, mowing, recreational activities, overgrazing by domestic livestock or native ungulates, exotic vegetation, and fire.

Riparian vegetation at flycatcher breeding sites can be dominated by either native or exotic species. Trees and shrubs recorded at breeding sites (USFWS 2005) include Goodding's willow (*Salix gooddingii*), coyote willow (*Salix exigua*), Geyer's willow (*Salix geyerana*), arroyo willow (*Salix lasiolepis*), red willow (*Salix laevigata*), yewleaf willow (*Salix taxifolia*), pacific willow (*Salix lasiandra*), boxelder (*Acer negundo*), saltcedar (*Tamarix ramosissima*), Russian olive (*Eleagnus angustifolia*), buttonbush (*Cephalanthus occidentalis*), cottonwood (*Populus* *fremontii*), stinging nettle (*Urtica dioica*), alder (*Alnus rhombifolia, A. oblongifolia, A. tenuifolia*), velvet ash (*Fraxinus velutina*), poison hemlock (*Conium maculatum*), blackberry (*Rubus ursinus*), seep willow (*Baccharis salicifolia, B. glutinosa*), oak (*Quercus agrifolia, Q. chrysolepis*), rose (*Rosa californica, R. arizonica, R. multiflora*), sycamore (*Platinus wrightii*), false indigo (*Amorpha californica*), Pacific poison ivy (*Toxicodendron diversilobum*), grape (*Vitus arizonica*), Virginia creeper (*Parthenocissus quinquefolia*), Siberian elm (*Ulmus pumila*), and walnut (*Juglans hindsii*).

Species composition, however, appears less important than vegetation structure. Allison et al. (2003), Sogge and Marshall (2000), and McLeod et al. (2008) have concluded that breeding riparian birds in the Southwest are exposed to extreme environmental conditions and that dense vegetation at the nest may be needed to provide a more suitable microclimate for raising offspring. Results of a five-year vegetation study (2003–2007) conducted by McLeod et al. (2008) along the lower Colorado and Virgin rivers and tributaries showed that vertical foliage density at willow flycatcher nest sites was generally greatest around mean nest height (3.2 m [10.5 feet]; SE = 0.1). Allison et al. (2003) found the greatest foliage density to be at nest height at three large willow flycatcher breeding sites in Arizona. Paradzick (2005) also found occupied willow flycatcher sites to have denser foliage in the upper (7–9 m [23–30 feet]) strata of the canopy than unoccupied sites. Greater canopy closure, taller canopy height, and dense foliage at or immediately above nest height may facilitate a more favorable nesting microclimate and may be useful parameters in predicting preferred willow flycatcher riparian breeding habitat within the larger expanses of riparian vegetation (McLeod et al. 2008). However, Moore (2007) found occupied nesting sites in the southern portion of the Middle Rio Grande to lack the upper strata of vegetation canopy. Four main types of preferred flycatcher habitat have been described (adapted from Sogge et al. 1997):

- **Monotypic high-elevation willow:** nearly monotypic stands of willow, 3 to 9 m (10–23 feet) in height with no distinct overstory layer; often associated with sedges, rushes, nettles and other herbaceous wetland plants; usually very dense structure in the lower 2 m (7 feet); live foliage density is high from the ground to the canopy.
- **Monotypic non-native:** nearly monotypic, dense stands of non-natives such as saltcedar or Russian olive, 4 to 10 m (13–33 feet) in height forming a nearly continuous, closed canopy (with no distinct overstory layer); the lower 2 m (7 feet) often is difficult to penetrate due to branches; however, live foliage density may be relatively low, 1 to 2 m (3–7 feet) above ground, but increases higher in the canopy; canopy density uniformly high.
- **Native broadleaf-dominated:** composed of single species or mixtures of native broadleaf trees and shrubs, including cottonwood, willows, boxelder, ash, alder, and buttonbush from 3 to 15 m (10–50 feet) tall; characterized by trees of different size classes; often a distinct overstory of cottonwood, willow, or other broadleaf tree, with recognizable subcanopy layers and a dense understory of mixed species; non-native/ introduced species may be a rare component, particularly in the understory.
- **Mixed native/non-native:** Dense mixtures of native broadleaf trees and shrubs mixed with non-native/introduced species, such as saltcedar or Russian olive; non-natives are often primarily in the understory, but may be a component of overstory; the native and non-native components may be dispersed throughout the habitat or concentrated as a

distinct patch within a larger matrix of habitat; overall, a particular site may be dominated primarily by natives or non-natives or be a roughly equal mixture.

The most recent (2006 breeding season) range-wide flycatcher population estimate is approximately 1,262 territories (Durst et al. 2008). In New Mexico, the species has been observed in the Rio Grande, Rio Chama, Zuni River, San Francisco River, and Gila River drainages, with 443 territories recorded statewide in 2006 (Durst et al. 2008). Including the San Luis Valley, 280 territories were identified in the Rio Grande Basin in 2006 (Durst et al. 2008).

Based on historical breeding records, the current range of the flycatcher within the MRG drainage is nearly the same as its historical range (Unitt 1987). Although the species has disappeared from portions of the MRG drainage, such as the vicinity of Las Cruces and Española, the drainage still contains one of the largest breeding metapopulations of flycatchers in the U.S. (USFWS 2002). In the MRG valley, the San Marcial site has continued to grow, from approximately 20 flycatcher territories in 1999 (Ahlers and White 2000) to 232 territories in 2007 (Moore and Ahlers 2008). Demographic studies conducted from Velarde to the delta of the Elephant Butte Reservoir have shown large, stable breeding populations within the reservoir fringe (Ahlers and White 1998, 2000; Ahlers et al. 2001, 2002; Moore and Ahlers 2003, 2004, 2005, 2006, 2008).

The only flycatcher nesting territories recorded within the Albuquerque Reach have occurred at the Pueblo of Isleta, with seven pairs (14 adults) recorded in 2004; habitat at Isleta consisted of Russian olive, coyote willow, and saltcedar (Smith and Johnson 2005, 2008). A 1994 survey conducted in the Corrales bosque area detected no flycatchers (Mehlhop and Tonne 1994). Surveys for flycatchers in the greater Albuquerque metropolitan area were conducted at the Interstate 40, Central Avenue, and Montaño bridges; Tingley Beach; Zoo Sidebar; and Calabacillas Islands in 1995 and 1996 by Reclamation and the USFWS. No flycatchers were detected during these surveys (Cooper 1996, 1997). Surveys performed in 2001 at the proposed diversion site detected no nesting flycatchers in the construction areas along the Rio Grande (EMI 2001).

4.1.1 Spatial Placement of Southwestern Willow Flycatcher Restoration Sites

Flycatcher habitat creation and restoration projects are likely to be most effective, in terms of colonization by flycatchers, if they are located near existing breeding sites. Natal dispersal is greater than adult dispersal in most passerine birds (Gill 1995), including the flycatcher, and occasional juvenile dispersal between flycatcher sub-populations is likely an important population variable in terms of both gene flow and the establishment of new populations (Paxton et al. 2007; McLeod et al. 2008). Juvenile movements contribute to an understanding of the observed patterns of high genetic diversity within and low genetic isolation among flycatcher populations (Busch et al. 2000). Long-term flycatcher demographic data collected as part of the Lower Colorado Multi-species Conservation Program at breeding sites along the Lower Colorado, Virgin, Muddy, and Bill Williams rivers and tributaries (McLeod et al. 2008), and those of the USGS at Roosevelt Lake Reservoir and along the San Pedro and Gila rivers (Paxton et al. 2007), indicate that flycatcher juvenile dispersal among local populations is largely limited to within river drainages, and most dispersal distances are between 30 and 40 km (19–25 miles) or less. The frequency of flycatcher dispersal generally decreases as the distance between patches increases; although more remote sites can be colonized, the frequency of flycatcher dispersal to more distant sites is lower. Strategically placing riparian improvement or creation projects near existing flycatcher breeding areas can also serve to strengthen the local meta-population.

In the MRG dispersal distances have been speculated to be much less than the 30 to 40 km (19–25 miles) suggested by Paxton et al. (2007). This may be the result of noting the source of dispersing birds when new habitat patches or areas were colonized by flycatchers on the Rio Grande. However, there have not been any mark-recapture studies completed on the MRG to document dispersal distances (R. Doster, personal communication 2008)

4.1.2 QUANTIFICATION OF SUITABLE SOUTHWESTERN WILLOW FLYCATCHER BREEDING HABITAT: VEGETATION

Flycatchers breed only in dense riparian vegetation near surface water and/or saturated soil. Regardless of plant species composition, occupied sites always have dense vegetation within 3 to 6 m (10–20 feet) of the ground and standing water and/or saturated soil nearby. Although flycatchers breed in widely different types of riparian habitat across a large elevational range and geographical area in the Southwest, certain vegetation structure patterns emerge and are seen at most sites (Sogge and Marshall 2000; Koronkiewicz et al. 2006). Vegetation studies designed to quantitatively describe flycatcher breeding habitat (see Alison et al. 2003; Paradzick 2005; Moore 2007; McLeod et al. 2008) suggest there are no major structural differences at sites across the Southwest. Structural similarity regardless of plant species composition at flycatcher sites across the species range is important in terms of habitat creation and restoration because the results derived from habitat studies designed to describe and replicate flycatcher habitat at one site or river drainage are likely applicable for restoration purposes at other sites at similar elevations.

Sogge and Marshall (2000), Allison et al. (2003), and McLeod et al. (2008) found that breeding willow flycatchers in the desert Southwest are exposed to extreme environmental conditions and that dense vegetation at the nest may be needed to provide a more suitable microclimate for raising offspring. Paradzick (2005) found occupied flycatcher sites in south-central Arizona to have denser foliage in the upper strata (7–9 m [23–30 feet]) of the canopy than unoccupied sites. At seven flycatcher breeding sites long the Lower Colorado River and tributaries, McLeod et al. (2007) found vertical foliage density was greatest at and immediately above mean nest height. Allison et al. (2003) also found the greatest foliage density to be at nest height at three large flycatcher breeding sites in Arizona. McLeod et al. (2008) and Allison et al. (2003) had shown that the vertical foliage density profiles at flycatcher nest sites across a large portion of the species range exhibit a unimodal vertical structural profile (Figure 4.2–Figure 4.6). This unimodal vertical structure is similar to the Type III vegetation structural type identified by Anderson and Ohmart (1984). Greater canopy closure, taller canopy height, and denser foliage at or immediately above nest height may facilitate a more favorable nesting microclimate and may be useful parameters in predicting preferred flycatcher riparian breeding habitat within the larger expanses of riparian vegetation (McLeod et al. 2008).

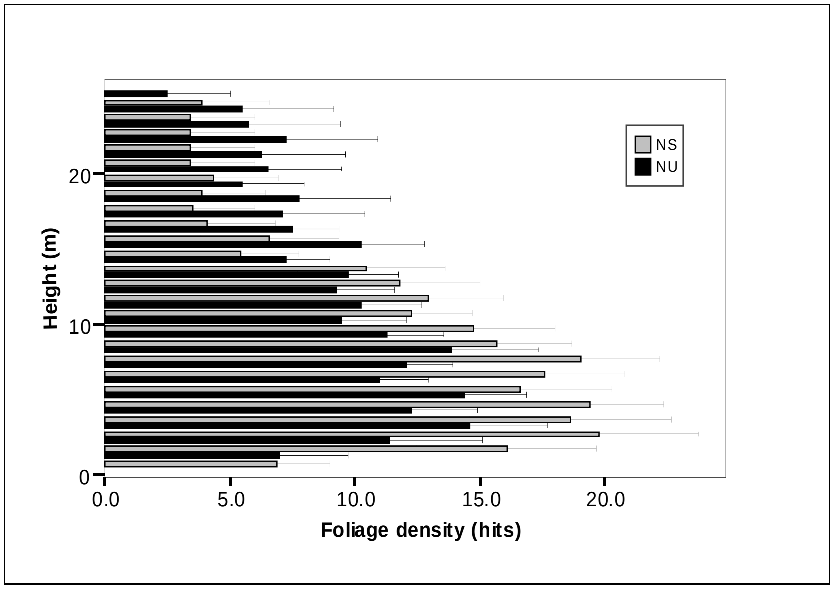

Figure 4.2. Vertical foliage density and standard error at flycatcher nest (NS) versus non-use sites (NU) at Pahranagat National Wildlife Refuge, Nevada, 2007 (per McLeod et al. 2008).

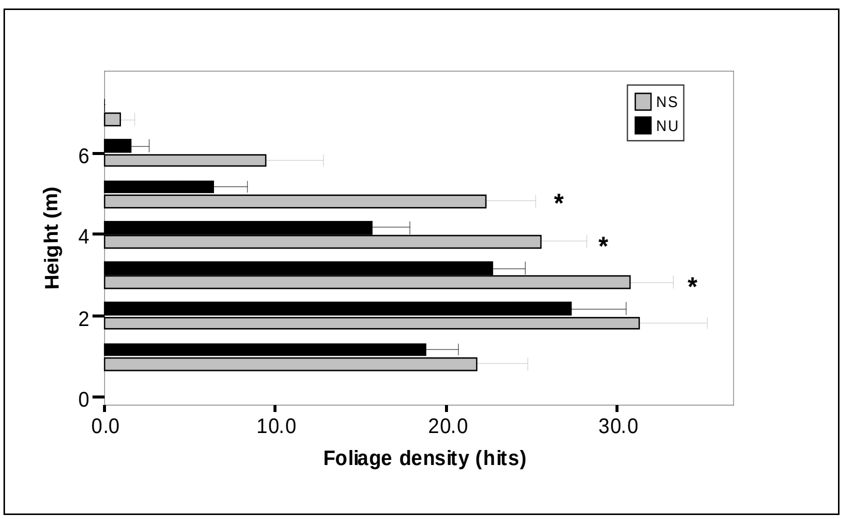

Figure 4.3. Vertical foliage density and standard error at flycatcher nest (NS) vs. non-use (NU) sites at Mesquite, Nevada, 2007. Differences (Student's t-test, α=0.05) between nest and non-use sites within a given meter interval are indicated by asterisks (per McLeod et al. 2008).

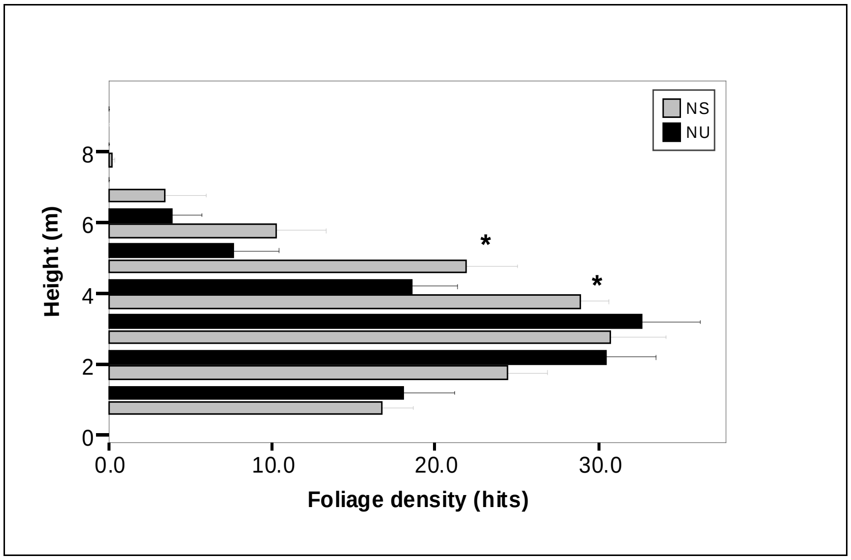

Figure 4.4. Vertical foliage density and standard error at flycatcher nest (NS) vs. non-use (NU) sites at Mormon Mesa, Nevada, 2007. Differences (Student's t-test, α=0.05) between nest and non-use sites within a given meter interval are indicated by asterisks (per McLeod et al. 2008).

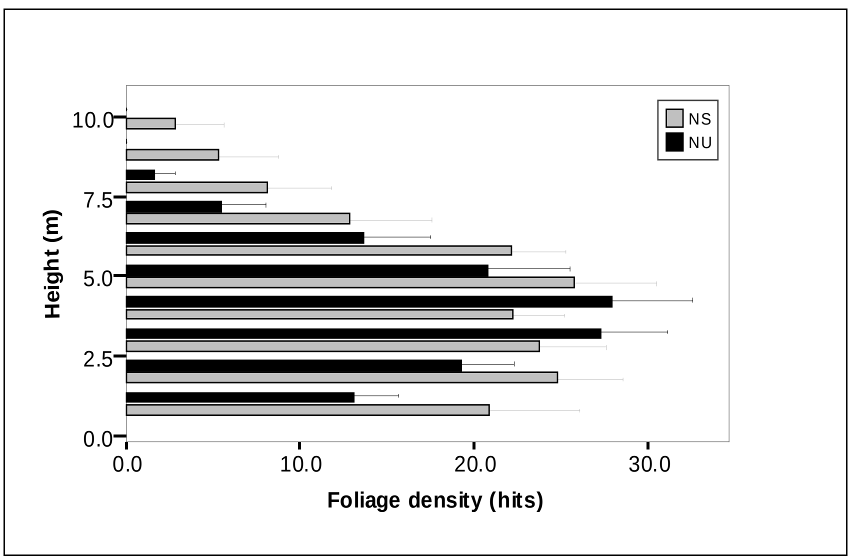

Figure 4.5. Vertical foliage density and standard error at willow flycatcher nest (NS) vs. non-use (NU) sites at Topock Marsh, Arizona, 2007 (per McLeod et al. 2008).

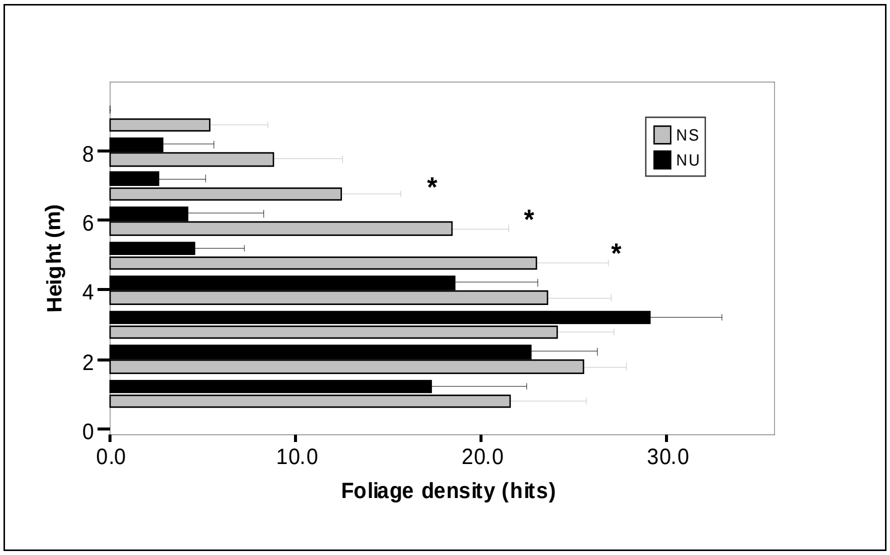

Figure 4.6. Vertical foliage density and standard error at willow flycatcher nest (NS) vs. non-use (NU) sites at Muddy River, Nevada, 2007. Differences (Student's t-test, α=0.05) between nest and non-use sites within a given meter interval are indicated by asterisks (per McLeod et al. 2008).

A five-year vegetation study conducted by McLeod et al. (2008) provides strong evidence that vegetation structure and microclimate influence habitat selection by the flycatcher. The researchers found that manipulation of vegetation structure is the most practical means for restoration practitioners to create or restore the preferred microclimate for flycatcher nesting habitat. A summary of the researchers vegetation structure recommendations for the creation and/or restoration of flycatcher nesting habitat, the recommended direction in which to manipulate each vegetation characteristic, and important microclimate variables can be found in Table 4.1 and Table 4.2. As a guide to monitoring the success of restoration efforts in duplicating vegetation and microclimate conditions of occupied flycatcher habitat, McLeod et al. (2008) also calculated the minimum, 25th percentile, median, 75th percentile, and maximum values observed for each of the vegetation and microclimate variables at occupied and unoccupied flycatcher sites; these values are shown in Table 4.3. Likewise, vegetation and microclimate ranges provided by the researchers (see Table 4.3) can also be used to determine potential suitability of existing riparian habitat for the flycatcher.

Table 4.1. Vegetation Variables, Management Actions, Microclimate Response, and Recommended Ranges for the Creation of Suitable Nesting Habitat for the Flycatcher along the Lower Colorado River and Tributaries*

Vegetation Variables	Recommended Management Action[1]	Recommended Statistical Range of Variable (mean ± standard error)
Canopy height (m)	increase	6.1 ± 0.1
Canopy closure (%)	increase	92.8 ± 0.3
No. shrub stems (<2.5 cm dbh) per ha	decrease or minimize	<6714.9
No. shrub stems (2.5–8.0 cm dbh) per ha	increase	8349.1 ± 246.1
No. shrub stems (>8.0 cm dbh) per ha	increase	893.1 ± 60.0
Percent basal area that is native	increase	41.4 ± 2.2
Vertical foliage density (hits) above nest	increase	69.0 ± 2.1
Vertical foliage density (hits) at nest	ignore	N/A
Vertical foliage density(hits) below nest	decrease or minimize	<48.2

* These recommendations are based on findings from single- and multiple-effects models. Data from flycatcher nest sites and territories (total sample size = 350) provided the basis for recommendations, including the recommended statistical range for each vegetation variable. Vegetation variables shown in bold are those that were significant predictors of flycatcher nest locations in models combining vegetation and microclimate variables. N/A = not applicable.

[1] Vegetation variables should be managed simultaneously, not separately, to meet the recommended range for each.

Source: McLeod et al. 2008.

Table 4.2. Recommended Microclimate Goals for Flycatcher Microclimate Measures*

Microclimate Variable	Recommended Statistical Range of Variable (mean ± standard error)
Soil Moisture	
Mean soil moisture (mV), 2005–2007**	751.9 ± 15.5
Temperature	
Mean maximum diurnal temperature (°C)	43.0 ± 0.2
Mean diurnal temperature (°C)	31.1 ± 0.1
Mean no. of 15-min. intervals above 41°C each day	4.5 ± 0.3
Mean minimum nocturnal temperature (°C)	16.4 ± 0.1
Mean nocturnal temperature (°C)	24.6 ± 0.1
Mean daily temperature range (°C)	**19.6 ± 0.2**
Humidity	
Mean diurnal relative humidity (%)	53.0 ± 0.6
Mean diurnal vapor pressure (Pa)	2,200.2 ± 26.0
Mean nocturnal relative humidity (%)	64.6 ± 0.5
Mean nocturnal vapor pressure (Pa)	**1,964.7 ± 20.6**

* These measures are the mean and standard errors for occupied flycatcher territory (nest sites and within territory plots combined). Bold indicates the microclimate variables that were significant in regression models comparing occupied to unoccupied flycatcher habitat.

Source: McLeod et al. 2008.

Table 4.3. Recommended Minimum, 25th Percentile, Median, 75th Percentile, and Maximum Vegetation and Microclimate Values for Occupied and Unoccupied Flycatcher Sites along the Lower Colorado River and Tributaries

Variable	Within-Territory Sites (nest sites and within territory plots combined)					Unoccupied Sites				
	Min	25%	Median	75%	Max	Min	25%	Median	75%	Max
Soil moisture (mV)	128.5	649.0	819.5	911.3	994.0	94.5	334.3	597.2	807.1	955.4
Diurnal temperature (°C)	26.1	29.5	30.9	32.4	39.7	25.2	31.6	33.7	36.2	41.4
Nocturnal temperature (°C)	19.2	23.2	24.9	26.1	29.3	18.0	23.2	24.8	26.1	29.4
Diurnal relative humidity (%)	24.7	46.1	53.7	59.9	87.4	18.4	36.8	44.6	51.9	72.6
Diurnal vapor pressure (Pa)	996.0	1,899.9	2,235.3	2,529.6	3,307.5	883.0	1,696.4	1,973.4	2,385.8	3,157.9
Nocturnal relative humidity (%)	36.7	58.8	65.3	71.3	95.6	36.3	56.9	63.3	69.3	91.2
Nocturnal vapor pressure (Pa)	1,016.0	1,758.9	2,024.3	2,215.8	2,730.8	981.8	1,625.5	1,891.9	2,156.9	2,523.5
Canopy height (m)	2.8	5.0	6.0	7.0	13.4	1.0	3.5	4.5	5.5	11.0
Canopy closure (%)	55.7	90.0	94.2	97.0	100.0	4.2	73.0	88.0	94.8	100.0
No. shrub stems (<2.5 cm dbh) per ha	0.0	3,437.9	5,602.5	9,040.4	29,158.5	127.3	3,947.2	6,748.5	10,441.1	57,680.4
No. shrub stems (2.5–8.0 cm dbh) per ha	254.6	5,093.2	7,767.1	11,205.0	29,413.2	0.0	2,801.3	6,239.2	10,059.1	24,829.3
No. tree stems (> 8.0 cm dbh) per ha	0.0	127.3	636.6	1,400.6	14,643.0	0.0	0.0	254.6	891.3	3,947.2
Percent basal area that is native	0.0	0.0	29.7	88.4	100.0	0.0	0.0	0.0	44.0	100.0
Vertical foliage density above nest (hits)	5.0	42.0	61.3	93.0	266.0	0.0	9.0	25.0	54.0	152.0
Vertical foliage density at nest (hits)	5.0	19.0	25.0	33.0	60.0	0.0	15.0	24.0	34.0	76.0
Vertical foliage density below nest (hits)	0.0	23.0	38.0	66.0	198.0	4.0	26.0	45.0	82.0	213.0
Distance to water (m)	0.0	1.0	5.0	27.0	675.0	0.0	7.0	38.0	80.0	740.0

Source: McLeod et al. 2008.

Quantitative vegetation studies conducted by Moore (2007) at flycatcher breeding sites along the southern MRG were designed for the purpose of habitat assessments and to act as a guide for restoration efforts aimed at creating flycatcher breeding habitat. Results of that Rio Grande study supported the findings of McLeod et al (2008) and Allison et al. (2003), showing that flycatchers preferred nesting sites with dense vegetation in the mid-canopy layer between 3 and 4 m (10–13 feet) high. At all study areas, Moore (2007) found the average density and height of mid-canopy trees were significantly higher in flycatcher nest plots that at random sites, and vertical foliage density was greatest at and immediately above mean nest height (3.0 m [9.8 feet]; n = 112). Importantly, the research had shown whether one looks at plant density based on size class, canopy class (upper vs. mid- vs. shrub layer), or canopy cover by height zone, vegetation densities are higher at flycatcher nest sites at the mid-canopy at or just above flycatcher nest height.

Some researchers have suggested that saltcedar is unsuitable habitat for the flycatcher, primarily because it is assumed that saltcedar supports a smaller and less diverse invertebrate community than native habitats (Liesner 1971; Yong and Finch 1997; DeLoach et al. 2000; Dudley and DeLoach 2004). However, Owen et al. (2005) captured and blood sampled 130 flycatchers breeding in native and saltcedar-dominated habitats in Arizona and New Mexico and measured variables of physiological condition. Owen et al. (2005) found few habitat-based differences in flycatcher physiological condition and no evidence that flycatchers breeding in saltcedar habitats exhibit poorer nutritional condition or were suffering negative physiological affects. Furthermore, although most flycatcher breeding sites are dominated by native vegetation, approximately 22% of breeding territories range-wide are in habitats dominated by saltcedar (Durst et al. 2008). Recent flycatcher productivity studies have found no negative effects from breeding in saltcedar-dominated habitats (McLeod et al. 2008, Paxton et al. 2007).

In a 9-year study of nesting success in the MRG, Moore and Ahlers (2008) reported that 79.5% of flycatcher nests were in willow-dominated stands (defined as greater than 90% *Salix* species), 14.1% were in mixed-dominance territories, and 6.3% of the nests were in saltcedar-dominated stands. However, the nesting success in willow-dominated territories, saltcedar-dominated territories, and mixed territories were similar: 56.8%, n = 764; 57.1%, n = 9; and 46.7%, n = 135; respectively. Moore and Ahlers (2008) found flycatcher habitat use to be uncommonly associated with typical MRG riparian woodlands with a high overstory (Figure 4.7) and more often associated with willow stands lacking an overstory layer (Figure 4.8). Details of the summary data are presented in Table 4.4.

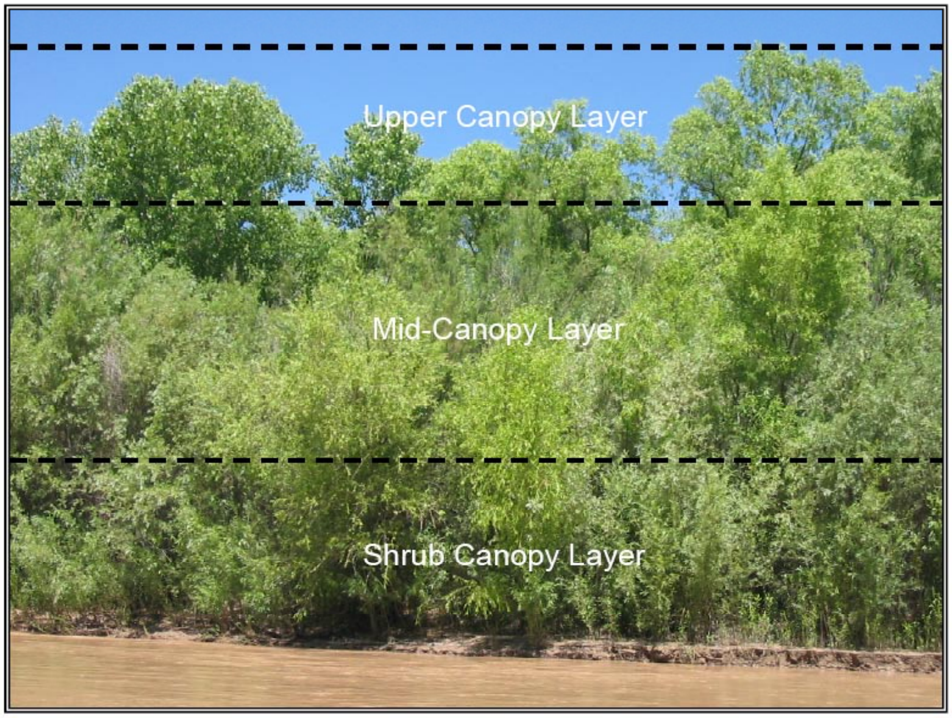

Figure 4.7. Photograph from Moore (2007) showing typical MRG riparian woodland habitat with three different canopy height layers.

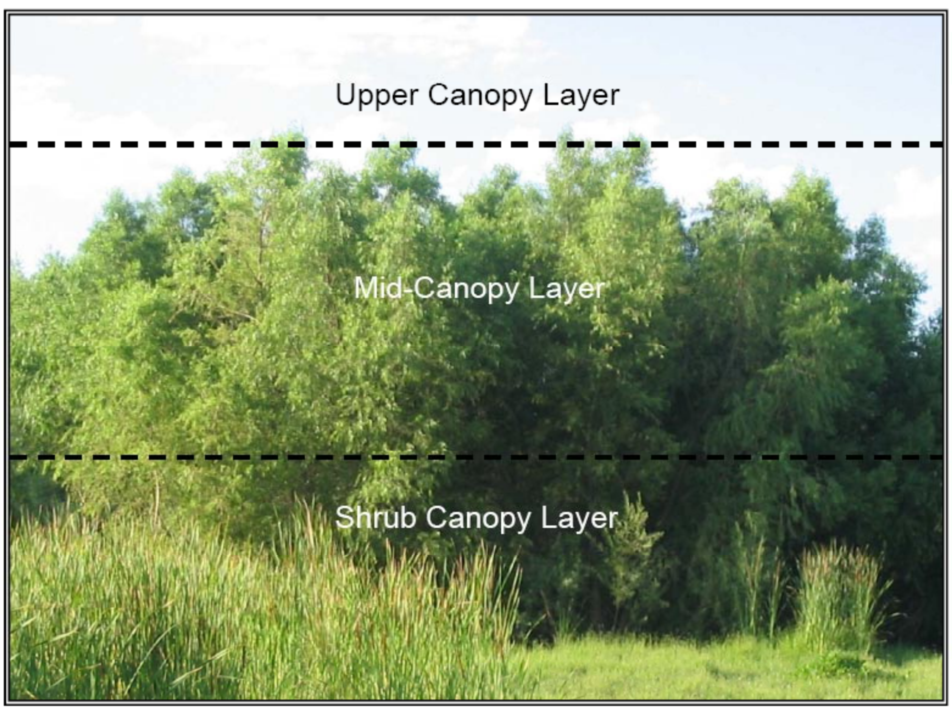

Figure 4.8. Photograph from Moore (2007) showing typical southern MRG flycatcher habitat lacking an upper canopy layer.

Table 4.4. Summary of Vegetation Characteristics of Flycatcher Nest Sites Compared to Adjacent Random Points in the Southern MRG

Vegetation parameter	Nest site (n = 112)	Random site (n = 89)
Shrub Stem Density #/m^2 (sd)	3.64 (2.4)	3.5 (2.6) [W = 4,721.0, *P* = 0.522]
Shrub Stem Species Composition % (sd)		
Salix gooddingii	37.2 (38.6)	31.5 (37.2) [W = 4,486.5, *P* = 0.465]
Salix exigua	31.4 (34.6)	34.6 (35.8) [W = 5,027.0, *P* = 0.518]
Both *Salix* species	68.5 (37.0)	66.1 (36.5) [W = 4,727.0, *P* = 0.907]
Populus deltoides	1.3 (4.6)	1.4 (6.5) [W = 4,541.0, *P* = 0.305]
Tamarix sp.	23.4 (33.1)	27.8 (34.3) [W = 5,030.0, *P* = 0.499]
Eleagnus angustifolia	6.1 (19.2)	2.5 (9.5) [W = 4,559.5, P = 0.353]
Dead Shrubs %	37.0 (21.3)	35.4 (29.0) [W = 4,399.0, *P* = 0.154]
Tree Stem Density #/ha (sd)	**2,829 (1,330)**	**2,019 (1,101) [t = 4.60, *P* < 0.001]**
Tree Stem Species Composition % (sd)		
Salix gooddingii	71.5 (38.3)	68.8 (40.7) [W = 4,947.5, *P* = 0.962]
Salix exigua	5.1 (12.8)	3.7 (11.3) [W = 4,301.5, *P* = 0.060]
Both *Salix* species	76.6 (38.1)	72.4 (38.8) [W = 4,563.5, *P* = 0.357]
Populus deltoides	3.4 (9.7)	7.9 (19.8) [W = 5,043.5, *P* = 0.737]
Tamarix sp.	11.9 (26.8)	12.8 (24.2) [W = 5,379.5, *P* = 0.213]
Eleagnus angustifolia	8.1 (24.2)	5.6 (18.7) [W = 4,828.5, P = 0.691]
Dead Trees % (sd)	4.0 (6.5)	6.2 (9.5) [W = 5,202.0, *P* = 0.479]
Tree DBH Size Class Composition % (sd)		
Class 1	70.1 (16.3)	74.1 (18.0) [W = 5,703.0, *P* = 0.057]
Class 2	**29.0 (15.9)**	**24.3 (16.6) [W = 4,047.5, *P* = 0.030]**
Class 3	0.9 (2.1)	1.6 (3.9) [W = 5,175.5, *P* = 0.448]

Table 4. Summary of 2004-2006 nest and random plot shrub and tree stem count data and statistics (α = 0.5) for all nests in study **(boldface = significant difference between nest and random plots)**.

Vegetation parameter	Nest site (n = 112)	Random site (n = 98)
Shrub Canopy Layer		
Mean Plant Density (sd)	7,470/ha (7,533)	5,991/ha (6,185) [W = 5,013.5, *P* = 0.157]
Mean Plant Height (sd)	2.69 m (0.77)	2.61 m (0.69) [W = 5,329.5, *P* = 0.475]
Mean Plant Crown Width (sd)	1.00 m (0.35)	0.97 m (0.41) [W = 5,096.0, *P* = 0.215]
Mid-Canopy Layer		
Mean Plant Density (sd)	**3,079/ha (2,318)**	**2,079/ha (1,602) [W = 4,000.0, *P* < 0.001]**
Mean Plant Height (sd)	**8.05 m (1.56)**	**7.50 m (1.21) [W = 4,133.5, *P* = 0.002]**
Mean Plant Crown Width (sd)	2.89 m (1.03)	2.90 m (1.13) [W = 5,477.0, *P* = 0.893]
Upper Canopy Layer	n = 11	n = 8
Mean Plant Density (sd)	850/ha (698)	916/ha (812) [W = 49.0, *P* = 0.710]
Mean Plant Height (sd)	11.98 m (1.80)	11.80 m (2.42) [W = 43.5, *P* = 1.000]
Mean Plant Crown Width (sd)	6.08 m (3.01)	4.56 m (1.88) [t = 1.25, *P* = 0.227]
Mean Cover Value (sd)*		
0 – 3 m	28.6% (14.3%)	29.9% (17.1%) [W = 5,628.5, *P* = 0.950]
3 – 6 m	**33.4% (13.6%)**	**25.4% (12.5%) [W = 3,566.0, *P* < 0.001]**
>6 m	**20.1% (12.4%)**	**13.2% (12.8%) [W = 3,371.0, *P* < 0.001]**

* Values based on mid-point of Daubenmire ranking of 0 to 6: 0 = 0%; 1 = 5%(1-10%); 2 =18%(11-25%); 3 = 38%(26-50%); 4 = 63% (51-75%); 5 = 83%(76-90%); 6 =95%(>90%)

Source: Reproduced from Moore (2007).

4.1.3 HYDROLOGICAL CHARACTERISTICS OF SUITABLE SOUTHWESTERN WILLOW FLYCATCHER BREEDING HABITAT

The affinity of breeding flycatchers with standing water and saturated soil is noted consistently in the literature, and the presence of water may be a factor in sustaining particular vegetation features at breeding sites (Paradzick 2005) and providing a more suitable microclimate for raising offspring (Sogge and Marshall 2000; McLeod et al. 2008). Moreover, the fluctuating availability of surface water at flycatcher breeding sites is likely one factor influencing residency and breeding at a site in any given year, with flycatchers breeding in years when sites contain standing water (Weddle et al. 2007; McLeod et al. 2008).

Anthropogenic or natural modifications to surface water resources (e.g., fluvial hydrology and geomorphology) can modify existing and potential flycatcher breeding habitat and therefore have the potential to modify flycatcher abundance, distribution, and nesting success (Graf et al. 2002). For example, nine flycatcher territories at San Marcial on the MRG in New Mexico exhibited a near absence of nesting attempts in 1996 when a combination of drought, upstream dam operations, and upstream withdrawals for irrigation removed all surface water (Johnson et al. 1999). This was in contrast to previous (1994, 1995) and subsequent (1997) years when active nests were documented at the site, with the river flowing in those years. A nearby control site that contained water exhibited multiple nesting attempts during all four years, leading Johnson et al. (1999) to suggest that the presence of water was a fundamental requirement for nesting. A similar pattern was observed along the Lower Gila River in Arizona when decreased streamflow from 2002 to 2004 resulted in the number of flycatcher territories declining by nearly half each year (Munzer et al. 2005). Since 2004, flows within the Gila River have been greater and more consistent, resulting in a continuing increase in flycatcher territories (14 to 62) from 2004 to 2008 (Graber and Koronkiewicz 2008). The high degree to which flycatchers are associated with standing water can also be seen by correlating flycatcher habitat occupancy and breeding patterns with the presence/absence of standing water in areas like Bill Williams River in Arizona, with flycatchers breeding only in years when sites contained standing water (McLeod et al. 2008).

Studies conducted by McLeod et al. (2008) along the Lower Colorado and tributaries found flycatcher nest sites to be significantly closer to surface water or saturated soil during nesting than at unoccupied sites within the same breeding patches. McLeod and Koronkiewicz (2008) found the hydrological conditions recorded in occupied territories showed that flycatcher territories contained damp or wet soils, with the distance to surface water generally being less than 30 m (98 feet), and in most cases between 10% and 50% of the surrounding area within 50 m (164 feet) containing saturated or inundated soils during each visit to the site; the soil moisture conditions observed in occupied territories generally mirrored those observed at the same sites in previous years (Koronkiewicz et al. 2004, 2006; McLeod et al. 2005, 2007, 2008).

Along the MRG, Moore and Ahlers (2008) compared site hydrology data (dry all season, saturated/flooded then dry, saturated all season, flooded all season) to flycatcher nest productivity measures (success, productivity, predation and brood parasitism rates). The researchers found 95% of flycatcher nests were within 50 m (164 feet) of water. Nest success, predation, and brood parasitism rates were similar among all hydrologic conditions, regardless of nest distance to water and hydrology under the nest. However, in areas that were flooded all season, first nests were more successful than subsequent nests, and successful nests that were either above saturated soil all season or above standing water all season produced more young than successful nests that were above dry soil all season. Therefore, standing water and/or saturated soil under flycatcher nests may increase juvenile flycatcher survivorship because flycatchers that fledge late in the season have been shown to have a lower survival rate than those that fledge early in the season (Paxton et al. 2007). McLeod et al. (2008) also found similar effects of fledge date on juvenile survival to those reported by Paxton et al. (2007), with juvenile survival decreasing with later fledge dates.

4.2 EXISTING HABITAT AVAILABILITY

4.2.1 ASSESSMENT OF POTENTIAL SUITABLE FLYCATCHER HABITAT

Based upon the known characteristics of flycatcher habitat as discussed above, SWCA completed a Level-1 GIS assessment of potential suitable flycatcher habitat within the Albuquerque Reach through an examination of the most recent available GIS map layers representing: 1) Hink and Ohmart (1984) vegetation structural types (Milford et al 2006); 2) wetlands (USFWS 2008); 3) aerial images (Mid-Region Council of Governments Mosaic 2006); and 4) FLO-2D inundation models (see Appendix B). Hink and Ohmart vegetation types, wetland status, and aerial image data layers were first visually examined simultaneously to identify and mark polygons representing potential flycatcher habitat throughout the entire Albuquerque Reach. The FLO-2D layer was then applied to those selected polygons to assess inundation potential. Those select polygons were marked and numbered, and the amount of land area was determined for each by subreach. An example of the analysis is presented in Figure 4.9.

Figure 4.9. Example of potential suitable flycatcher habitat map.

Particular criteria were used to determine which GIS polygons represented potential flycatcher habitat. Hink and Ohmart vegetation Type 3, and to a lesser extent Type 4, are those most likely to represent potential suitable flycatcher habitat based on the vertical structure and complexity of woody vegetation, particularly in the zone of 3 to 15 m (10–49 feet) above the ground surface. Appendix C provides examples of the different Hink and Ohmart vegetation structure types. Suitable flycatcher habitat also should include contiguous areas of appropriate vegetation and hydrological features that cover a spatial area of a minimum of 100 m in length by 10 m (33 feet) in width, or an equivalent area of 0.1 ha (0.25 acre). Thus only Type 3 and Type 4 polygons of at least 0.1 ha (0.25 acre) with a minimum width of 10 m (33 feet) were considered. Examination of an aerial photography overlay also was used to help identify potential flycatcher habitat. Only Type 3 and Type 4 polygons that appeared to have more than 75% ground cover by woody vegetation as viewed from aerial imagery were chosen as potential habitat. Some of the Type 3 and Type 4 vegetation polygons, or large portions of the polygons, were represented by open barren areas not suitable for flycatcher habitat.

Assessing potential flycatcher habitat and restoration sites should include examination and mapping of perennial, intermittent, and ephemeral water as well as the status of groundwater table data. Areas that contain high water tables and receive intermittent flows should be considered the most potentially suitable for flycatchers. In areas where hydrology and streamflow are human controlled, inundation of riparian habitat should occur prior to flycatcher settlement in spring (late April–early May). Although the exact timing of when sites should be inundated has yet to be determined; inundation should be timed such that the riparian vegetation has enough time to reach its zenith (i.e., leaf out) prior to flycatcher arrival in spring, thus potentially increasing the chances of flycatcher settlement. Complete leaf out of the riparian vegetation prior to flycatcher arrival and standing water and/or saturated soils under the vegetation also ensure increased biomass of the local arthropod communities (i.e., the flycatcher's prey base). Additionally, sites should remain inundated as long as possible because it has been shown that first nesting attempts at sites that are inundated all season are more successful than subsequent nests, and inundated sites produce more young than dry sites (Moore and Ahlers 2008), which in turn may increase juvenile flycatcher survivorship (Paxton et al. 2007).

Wetland polygons that overlapped with Type 3 and Type 4 vegetation polygons, and/or wetlands classified as having woody vegetation and of 0.1 ha (0.25 acre) in size also were included as potential flycatcher habitat, assuming that such areas provided wet soil or surface water during the flycatcher breeding season. Finally, an overlay of FLO-2D inundation polygons were used to determine Type 3 and Type 4 vegetation polygons that were not also wetland and that would be inundated by river water at Rio Grande flow rates of 3,400 and 6,000 cfs. All appropriate polygons based on the above assessment that were inundated at 3,400 cfs were chosen to represent potential flycatcher habitat. Inundation at 6,000 cfs was noted for all polygons chosen as yes or no relative to restoration potential.

A complete listing of all polygons representing potential flycatcher habitat throughout the Albuquerque Reach and their characteristics are presented in Appendix D. Individual site polygons and summed total potential flycatcher habitat areas are portioned by subreach in Appendix D to provide both a total reach and subreach assessment of existing potential flycatcher habitat area. Note that this assessment of potential flycatcher habitat within the

Albuquerque Reach is based entirely from a Level-1 GIS analysis of existing map data and includes no site visits or on-the-ground assessments of polygons. This assessment is therefore only as accurate as the GIS data layers that were used to produce the potential habitat polygons.

4.3 Factors Limiting Habitat Availability

The Flycatcher Recovery Plan (USFWS 2002) identifies loss of habitat as the primary threat to the flycatcher in New Mexico. The Flycatcher Recovery Plan emphasizes the need to restore vegetation communities that provide habitat to the flycatcher, along with establishing the physical integrity of the river systems. The factors limiting flycatcher habitat in the Albuquerque Reach appear to be largely due to the loss of pre-existing native riparian vegetation communities, along with critical hydrological features and functions that are necessary to maintain such vegetation communities and habitat. Although there are currently no known existing nesting flycatcher sites in the Albuquerque Reach, flycatchers are known to nest to the south as close as the Isleta Reach (Smith and Johnson 2005, 2008). It is unknown why flycatchers are not currently utilizing potential existing nesting habitat within the Albuquerque Reach. We recommend ground studies to verify and document the vertical structure, size, and hydrological conditions of the areas we have labeled as potential suitable habitat patches.

One could hypothesize about the factors limiting habitat availability. As stated above, the hydrology during breeding season is a critical factor. Open water or moist soil conditions throughout the nesting season are an important parameter. The structure of the vegetation, particularly the vertical structure and stem density may also be a factor. Minimum patch sizes may not be met. Suitable migratory corridors may be absent. We were unable to differentiate species composition and stem density through the GIS analysis. Nest predation from the brown-headed cowbird may also be a factor, especially in the South Valley where agriculture persists. A unique environmental feature of the Albuquerque Reach relative to reaches to the south where flycatcher do nest is the potential influence of human activity and the surrounding urban environment. An assessment of the proximity of potential existing habitat locations to human activity and disturbances, such as roads, residential areas, recreational activities, etc., should also be conducted. Finally, the known nesting territories to the south may simply not be saturated. If known nesting sites are not saturated there may be no mechanism for forcing dispersal.

As stated above, our assessment of potential existing flycatcher habitat availability was based entirely from an analysis of existing GIS map information. The results of the Level-1 GIS analysis suggest there may be potential suitable flycatcher habitat within the Albuquerque Reach that meets geomorphic, hydrological, and vegetation structural requirements. While our current Level-1 GIS analysis may not be able to answer these questions, we will utilize the available information presented above regarding vegetation structure and hydrology to propose habitat restoration treatments for the benefit of the flycatcher.

5.0 RIO GRANDE SILVERY MINNOW

5.1 HABITAT CHARACTERISTICS

5.1.1 OVERVIEW OF HABITAT PREFERENCES

Dudley and Platania (1997) studied habitat preferences of the silvery minnow in the MRG in Rio Rancho and Socorro, and they characterized habitat preference and habitat availability in terms of water depth, water velocity, and stream substrate.[1] This information was reported by TetraTech (2004) and the USFWS (2007d), and is summarized below.

Silvery minnow are restricted to environments within the MRG that are characterized by low to moderate water velocity (86% of fishes sampled: <10 cm/sec [3.9 inches/sec]; 11% of fishes sampled: 11–30 cm/sec [4.3–11.8 inches/sec]), which includes side channels, backwaters, and eddies formed behind debris piles and islands. Silvery minnow are rarely found in habitats with flow greater than 40 cm/sec (16 inches/sec). The most frequently used habitats by adult silvery minnow are eddies formed by debris piles (40% of fish), pools (36% of fish), and backwaters (14% of fish). Few silvery minnow are found in main channel runs, which is the most abundant mesohabitat. Preferred substrates are characterized by silt (91% of fish) and sand (8% of fish). Gravel and cobble substrates apparently are not important habitats for silvery minnow. Substrate preference does not change with size or season.

Silvery minnow habitat occupancy varies by season. During the summer months (April–September) silvery minnow prefer shallow pools and backwaters with a median depth of 11 to 20 cm (4–8 inches). During the winter months (October–March) silvery minnow prefer deeper water environments (31–40 cm [21–16 inches]) associated with instream debris piles.

Larval and proto-larval silvery minnow use shallow, still water with a silty substrate. Such habitats are not found in the main river channel. Larvae and young silvery minnow are typically found in shallow backwaters, pools, and shallow shoreline habitats. Adult silvery minnow typically occur in a variety of shallow, low-velocity waters, including main and side channel habitats mentioned above.

5.1.2 SPAWNING AND NURSERY HABITAT

Little or no information exists regarding silvery minnow habitat preferences during spawning. Recent investigations during a significant spring runoff (peak discharge greater than 5,000 cfs) have resulted in collections of reproductively mature silvery minnow and their eggs in low-velocity, low water exchange lateral habitats, including backwater and other hydrologic retentive floodplain features (Hatch and Gonzales 2008). These habitats serve to reduce the displacement of larvae and eggs during flooding and provide suitable nursery habitat for larval and proto-larval fish (Pease et al 2006; Hatch and Gonzales 2008).

[1] Stream depth, velocity, and substrate are often perceived as independent variables when in fact they covary. In many fisheries studies, 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 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.

Porter and Massong (2003, 2004, 2006) conducted studies to determine how silvery minnow egg and larval fish retention are affected by geomorphology and hydrology. In 2003, Porter and Massong (2003) examined egg drift and retention in constructed inlets. Their results suggest that sites with a large drift zone area (areas of no measurable velocity or flow direction) and substantial inflow and outflow at the inlet mouth are most effective for retention. Retention was influenced by the length of the inlet, inlet shape, and location of the exit flow. Inlets that had through-flows at the back were found to have reduced retention. In 2004, a low water year, Porter and Massong (2004) examined natural habitat features at the confluences of arroyos. Their results suggest that inundated shelves were the most effective at retaining eggs and larval fish. In 2005, Porter and Massong (2006) characterized geomorphological features according the NMISC/MEI 2005 bar classification system (MEI 2006) (e.g., linguoid bars, Level 1 and 2 braid bars, Level 1 and 2 mid-channel bars, alternate bars, and Level 1 and 2 bank attached bars). The results indicate that a range of macro-habitat features provide nursery habitat and is a function of flow levels. Gellan bead (and presumably egg retention) was highest on mid-channel bars and Level 2 braid bars, while bank attached bars held more larval fish. Micro-habitat characteristics influenced egg retention; areas with wide ranging shelf depths provided the best conditions for capturing and retaining eggs. Porter and Massong (2006) conclude that "these patterns suggest that egg drift below the flow threshold for inundating pointbars and islands results in massive downstream transport of silvery minnow eggs and larvae, reducing survival and recruitment. As flows increase the time and area of inundated terrestrial surfaces, egg drift decreases and egg retention increases with corresponding survival and recruitment."

When threshold flows for inundation are met, inundated floodplains of the MRG provide an increased abundance of low-velocity habitats that serve as refuge and nursery habitat for developing stages of fish relative to the active channel (Valett et al. 2005; Pease et al. 2006). Silvery minnow growth can be especially rapid in newly flooded habitats that support a highly productive food chain (Schlosser 1991; Valett et al. 2005). Floodplain productivity is further enhanced by the lower water exchange rates, the subsidy of allochthonous energy inputs, and heightened temperatures that are characteristic of such areas (Schlosser 1991; Valett et al. 2005). The productivity of these habitats can be lost if the river channel-floodplain becomes uncoupled prematurely (i.e., before eggs hatch and fish mature to post larval stages) or if flows are abruptly reduced to strand fish.

5.1.3 Refugial Habitats During Drought

Assertions about the habitat preferences of the silvery minnow are clearly predicated on a relative abundance of water. However, such conditions are exceptional or at best episodic in much of the species' historic range in the Rio Grande Basin. In fact, it seems that a monotonous "wide channel, shallow, low-velocity" condition, so often cited as attributes of preferred habitat of the silvery minnow, may be disadvantageous during an "ecologic crunch" period associated with drought—a time in which habitat used by the silvery minnow is limiting, both in terms of quantity and quality. During the height of summer and during times of hydrologic scarcity, such habitats have the potential to become very warm with low levels of dissolved oxygen. Furthermore, they offer little protection from predation. In recent "fish rescue collections," silvery minnows were not commonly found in such habitats (USFWS 2006b). Instead, the species sought out deeper habitats, generally in reaches relatively heterogeneous in channel features, often in association with relatively well-defined channels. During periods of extreme water scarcity, the species appears to seek out habitats that are cooler and deeper, including pools and an array of habitats in association with overhead cover, irrigation drain return flows, and shallow groundwater.

During periods of river intermittency, Hatch et al. (2008) found that longer and deeper pools with abruptly steep sides (i.e., low surface area to depth ratio) are inherently superior as refugial habitats for fish due primarily to their enhanced temporal environmental stability compared to smaller pools. Baker and Ross (1981), Gorman (1988a, 1988b), and Labbe and Fausch (2000) all reported similar relationships between environmental stability and water depth. Larger pools tend to support a greater diversity of fish species, which is conducive to the maintenance of stable and persistent fish assemblages. Plausible mechanistic explanations for this relationship include habitat selection coupled with habitat heterogeneity, and increased probabilities of local extinction in small areas (e.g., MacArthur and Wilson 1967).

Logically, environmental stability of prospective refugial pools would be enhanced to the degree that they are periodically refreshed with water from unpolluted surface or groundwater sources. Likewise, the incidence of fish disease would be expected to be negatively correlated with increased rates of water exchange and reduced crowding of fish (Hatch et al. 2008). Also, in concurrence with Power (1987), Hatch et al. (2008) generally observed that deep, steep-sided pools offered greater protection against avian predators compared to shallow, high width-to-depth ratio pools.

Corroborating the findings of Detenbeck et al. (1992), Hatch et al. (2008) found that pools adjacent to flowing river segments had a heightened degree of environmental stability and, due to proximity, had a heightened potential for rapid fish recolonization, especially by silvery minnows given their apparent high vagility. Hatch et al. (2008) hypothesized that closely spaced pools, aligned with the thalweg and at intervals no greater than five to seven times the active channel width,[2] are of particular importance to conservation purposes because they would allow for dispersal success of silvery minnows and would serve to reduce silvery minnow mortality that often attends pulsed (short-term), small volume, expansion–contraction flow disturbances. Such reserve design considerations are consistent in concept with the ideas advanced by Diamond (1975).

5.2 EXISTING HABITAT AVAILABILITY

FLO-2D model results indicate a relative scarcity of potential suitable habitat for silvery minnow at flows below 6,000 cfs (

[2] The theoretical longitudinal pool-riffle spatial sequencing in unbound rivers is five to seven times the stream width (Leopold and Langbein 1966).

Table 5.1). The current modeling strategy relies on 250-foot grid scale and is likely too course too adequately capture microhabitat features that provide suitable habitat for silvery minnow at flows below 6,000 cfs. At 6,000 and 7,000 cfs, floodplain inundation results in potential suitable habitat for silvery minnow at three and five different reaches, respectively. At 6,000 cfs floodplain inundation occurs at Reaches 3, 4, and 5 and is greatest at reach 4. At 7,000 cfs floodplain inundation occurs at Subreaches B, 2, 3, 4, and 5, and increases consistently from upstream to downstream sites. Throughout the entire reach the area of inundation is 56% greater at 7,000 (891 acres) than at 6,000 (499 acres) cfs. Figure 5.1 provides an example of potential suitable channel conditions for silvery minnow habitat.

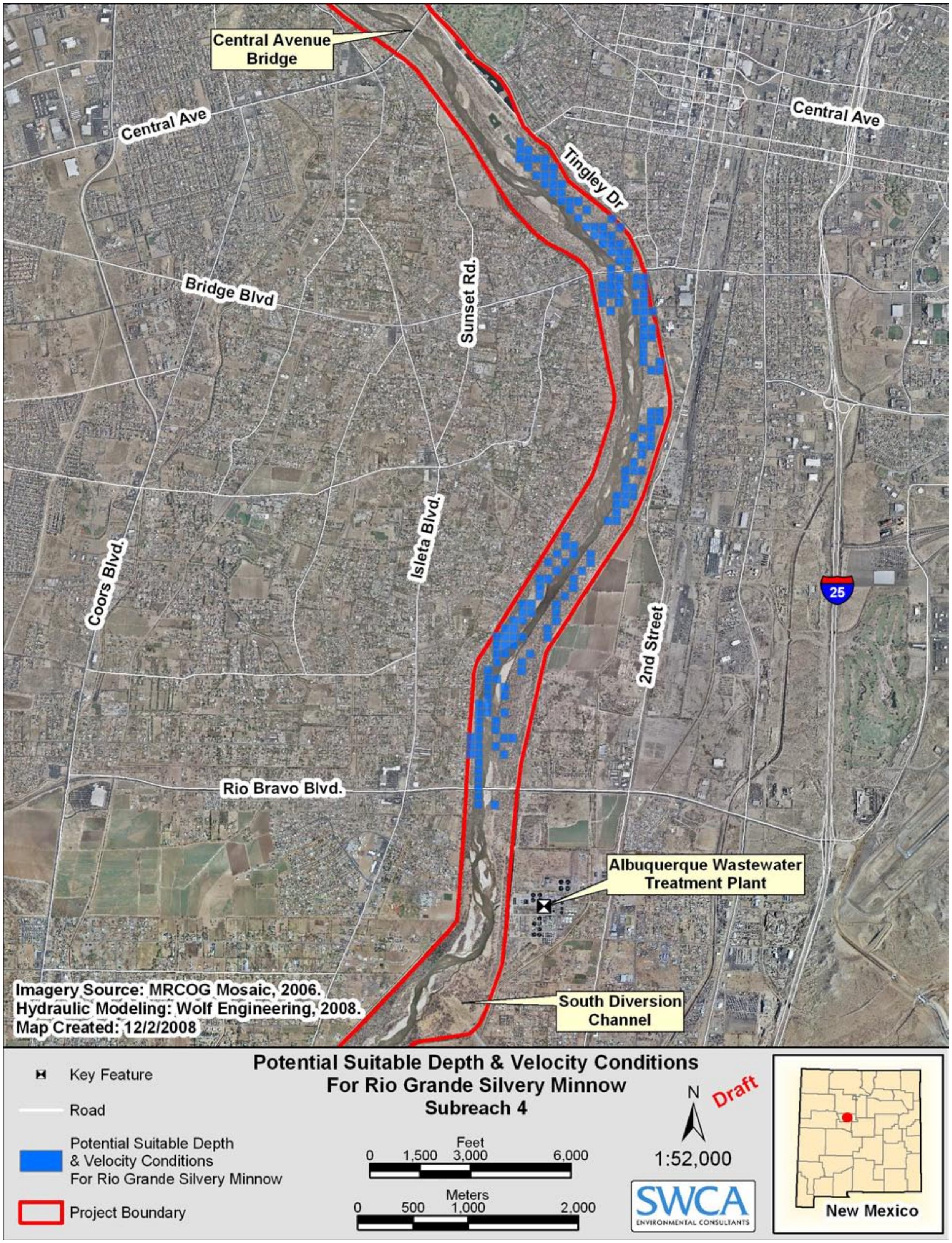

Figure 5.1. Potential suitable channel conditions for silvery minnow habitat.

Table 5.1. Modeled Potential Silvery Minnow Preferred Habitat Availability at 6,000 and 7,000 cfs by Project Subreach

Subreach Name and Location	6,000 cfs		7,000 cfs	
	Area in Acres	Area in Hectares	Area in Acres	Area in Hectares
Reach A - Angostura	0	0	0	0
Reach B - US 550 to Corrales Siphon	0	0	4.30	1.74
Reach 1 - Corrales Siphon to Alameda	0	0	0	0
Reach 2 - Alameda to Montano	0	0	11.48	4.65
Reach 3 - Montano to Central	2.87	1.16	31.57	12.77
Reach 4 - Central to SDC	253.96	102.77	367.31	148.64
Reach 5 - SDC to Isleta Pueblo	242.48	98.13	476.35	192.77
Total	**499.31**	**202.06**	**891.01**	**360.58**

Note: Preferred habitat criteria was based on depths less than or equal to 0.6 m (2 feet) and velocities less than or equal to 1 fps.

A qualitative census was conducted to enumerate the number of bank attached bars and vegetated islands throughout the project reach (**Table** 5.2). A total of 56 vegetated islands and 37 bank attached bars were identified. Vegetated islands were most numerous in Subreach 2, while attached bars were most numerous in Subreach 4. Collectively, the highest number of both features was recorded in Subreach 2. No vegetated islands were recorded in Reach A, and only one island was recorded in Subreach B.

Table 5.2. Bank Attached Bars and Vegetated Islands by Project Subreach

Subreach Name and Location	Bank Attached Bars	Vegetated Islands
Reach A - Angostura	3	0
Reach B - US 550 to Corrales Siphon	2	1
Reach 1 - Corrales Siphon to Alameda	4	8
Reach 2 - Alameda to Montano	7	17
Reach 3 - Montano to Central	7	9
Reach 4 - Central to SDC	8	7
Reach 5 - SDC to Isleta Pueblo	6	14
Total	**37**	**56**

5.3 FACTORS LIMITING HABITAT AVAILABILITY IN THE ALBUQUERQUE REACH

Silvery minnow habitat availability throughout the Albuquerque Reach is a result of river channelization, reduced magnitude of frequently occurring peak flows, reduced upstream sediment supply resulting in channel degradation, and the presence of non-native vegetation (MEI 2002, 2006; SWCA 2008). Channelization and a reduced sediment supply have increased channel incision, resulting in a reduced diversity of aquatic habitats. These changes have reduced the availability of low velocity habitats, decreased the amount of wetted area through the loss of meandering side channels, and have isolated the main channel from its floodplain.

5.3.1 RIVER MODIFICATION

In the MRG, the construction of flood control dams on the main stem and its primary tributaries have resulted in modified flows (including reductions in some peak flows, increases in base flows, and, on occasion, truncated snowmelt and summer monsoon flows) and the realignment of the river channel, including straightening the river, jetty jack installation, and placing spoil embankments. These factors have contributed to a system with modified hydrology and geomorphology, including isolating an incised main channel from the historic floodplain.

During summer months the loss of sinuous side channel, backwater, and oxbow habitats results in the loss of low-velocity habitat that is preferred by the silvery minnow. Channel incision results in a monotonous, high-velocity main channel habitat that is beneficial for water transport but detrimental for various life stages of silvery minnow. Habitat that is preferred by silvery minnow comprises only a small portion of the available habitat (Dudley and Platania 1997), making additional losses of an already rare habitat especially problematic (USFWS 2007d).

During spring runoff, the loss of floodplain connectivity results in the reduction of low-velocity refuge habitat during high flows (Schlosser 1991; Valett et al. 2005), a reduction in habitats suitable for larval fish and egg retention (Porter and Massong 2003, 2004, 2006; Fluder et al. 2007; Hatch and Gonzales 2008), and a reduction in nursery habitat for larval and proto-larval fish (Pease et al. 2006; Hatch and Gonzales 2008).

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Appendix A Existing and Planned Habitat Restoration Projects

Appendix B Hydrology and Hydraulic Modeling

Appendix C Hink and Ohmart

Appendix D Potential Suitable Southwestern Willow Flycatcher Habitat