5. Environmental Baseline

5.1 Historical Perspective

Largely due to the limited water supply and the highly variable streamflows in the Rio Grande, humans have modified the Rio Grande system over time to protect themselves from floods and to maximize their beneficial use of water. Human activities, taking advantage of flows in the Rio Grande system, extend back to the agricultural traditions of pueblo peoples since time immemorial. Pueblo oral histories convey, and the early Spanish accounts of the Rio Grande confirm, that pueblo peoples had developed advanced systems of irrigated agriculture long before the coming of Europeans. Beginning with the arrival of Spanish settlers in the late 16th century, these irrigation activities were expanded in such a way that they affected the flows in the Rio Grande system. The subsequent agricultural practices and administration of the river, as well as the intensive use of nonirrigated lands within the Rio Grande Basin, under the Spanish, Mexican, and American periods brought about changes to the shape and behavior of the river, the distribution of flows in time through that river, and the habitat of the species that depend on that river for life. The greatest of these changes, by far, have been made over the past century.

Modifications leading to current conditions include dam and levee construction, irrigation/drain system development, land use, and channelization activities, which took place from the 1930s to the 1970s, as well as ground water pumping, which has expanded greatly from the 1940s to the present, especially in the Angostura Reach. Operation of the flood control and water storage dams alter the shape of the hydrograph, as well as the amount of water that is conveyed through the river. The alteration of the hydrograph and highly variable streamflows that have resulted in cycles of drought on the MRG also have influenced vegetation changes on the MRG. Figure 10, below, diagrams the major events over the past century that have affected the hydrology and geomorphology—and, therefore, the habitat for listed species in the MRG.

Eight major dams (El Vado, Abiquiu, Nambe Falls, Cochiti, Galisteo, Jemez Canyon, Elephant Butte, and Caballo) plus three cross-river diversion structures and minor diversions between Embudo and Espanola have been constructed on the MRG or its tributaries over the past century by the Corps, Reclamation, the MRGCD, and in cooperation with other non-Federal partners. These dams and diversion structures affect the flow and sediment distribution in the MRG. They alter flows by storing and releasing water in a manner that generally decreases flood peaks and alters the distribution in time of the flows in the annual hydrograph. The major dams also trap significant amounts of sediment, causing buildup and increases in channel elevation upstream, and riverbed degradation and coarsening in the reaches below the dams.

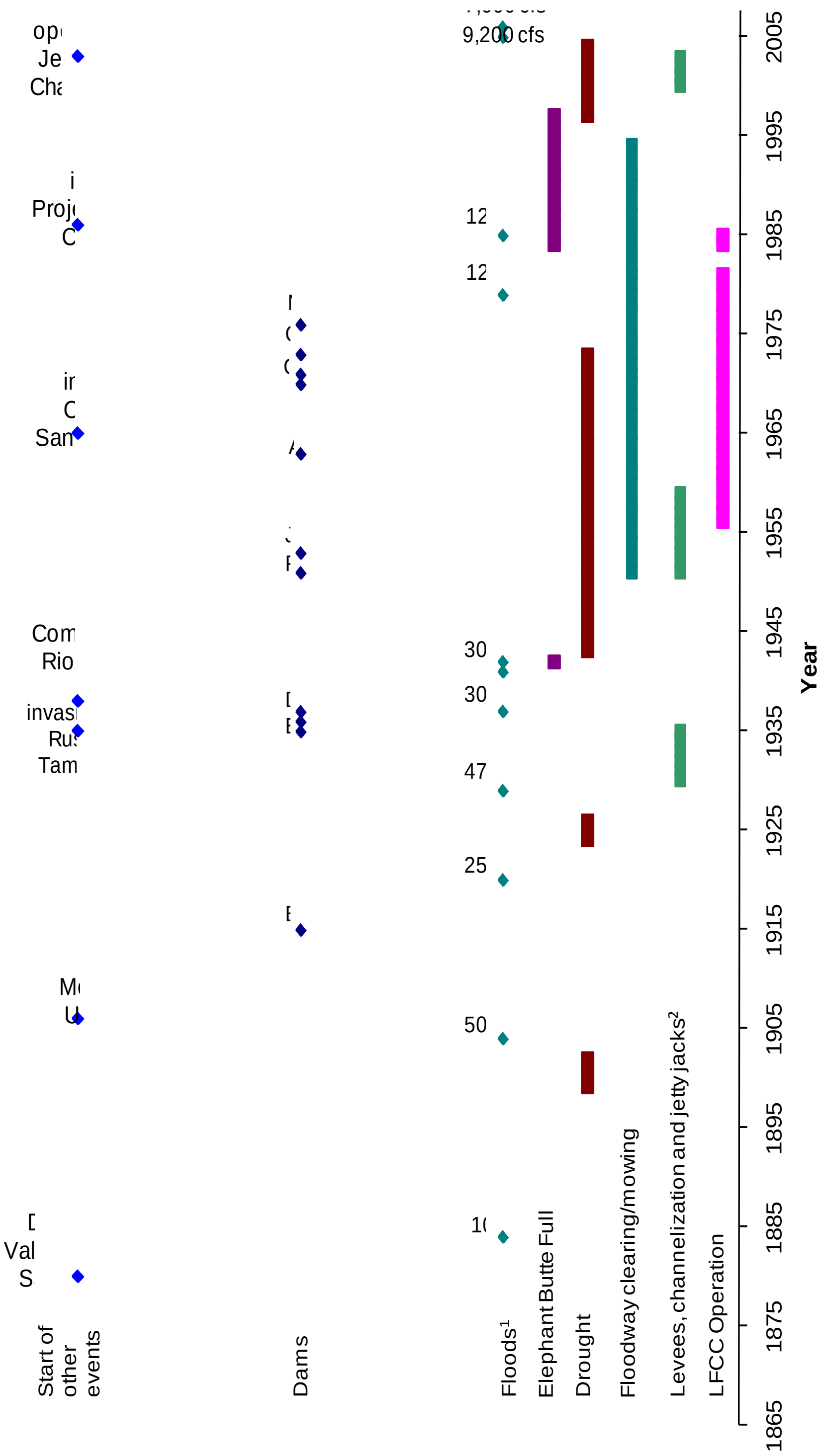

Figure 10. Timeline of significant events influencing the hydrology and geomorphology of the MRG. Flood events listed are measured at various locations between Otowi and San Marcial.

Ground water use has exceeded 170,000 AFY in the Albuquerque Basin and has caused ground water level declines of up to 160 feet. (McAda and Barroll, 2002). Ultimately, the water pumped is made up for by seepage from the river into the ground water system.

The historic development of the MRG has ongoing impacts on listed species. Silvery minnow use a diversity of wetted habitats throughout the year; low velocity habitats are important for all life stages, and egg and larval development are strongly tied to the magnitude and duration of runoff that inundates overbank habitats. Overbank flooding is needed to create shallow, low velocity backwaters that are used by silvery minnow larvae and maintains and restores native riparian vegetation for flycatcher habitat. Also, summertime river flows that supported both species were historically dependent on ground water inflows; today, losses from the river to the ground water system increase the chances of river drying, and decrease the longevity of isolated pools for minnow to refuge during periods of drying. Water and sediment management have resulted in a large reduction of suitable habitat for the flycatcher, as a result of the reduction of high flow frequency, duration, and magnitude that helped to create and maintain habitat for this species. Habitat elements for the flycatcher are provided by thickets of riparian shrubs and small trees and adjacent surface water, or areas where such suitable vegetation may become established (Service 2005).

Prior to documented development of water resources, the MRG had a high sediment load and an active, braided river channel with a mobile sand bed. The river's active watercourse was up to a half-mile wide, and included numerous braids. Over time, the active watercourses filled with sediment, then broke out into the flood plain and possibly avulsed to create new active watercourses. This process would cause aggradation across the flood plain. During periods in which peak flows were low for several years in a row, the active channel narrowed, through vegetation encroachment along the channel margins and colonization of bars. Sediment stored during these low flow times would be remobilized during subsequent large floods, which would re-establish a wider active channel. This process caused sediment to build up fairly uniformly across the flood plain. This active channel and flood plain connection provided habitat for all life stages of the silvery minnow and various successional stages of vegetation along the riparian corridor, used as breeding habitat by flycatchers.

Today, the river through much of the MRG is a single–thread channel as a result of both anthropogenic and natural changes throughout the system that is now confined into a narrow corridor between levees. Between Cochiti Dam and Elephant Butte Reservoir headwaters, there are 235 miles (378 km) of levees (includes distances on both sides of the river) (Service 2005). Changes on the MRG in the last century have increased the channel uniformity, eliminating thousands of acres of the shallow, low velocity habitats required by both silvery minnow and flycatchers. The loss of habitat complexity may cause eggs and larvae of the silvery minnow to drift downstream longer distances than in more complex channels. A comparison of river habitat changes between 1935–1989 shows a 49% reduction of river channel habitat from 22,023 acres (8,916 ha) to 10,736 acres (4,347 ha) (Crawford et al. 1993). The MRG also has been fragmented by cross-channel diversion structures, which silvery minnow can pass in a downstream direction but not in an upstream direction. Due to the reproductive strategies of silvery minnow, upstream reaches continually lose offspring to lower reaches.

The channel in the upstream portion of the MRG is deeper and swifter and more isolated from the surrounding flood plain, which is now the bosque. The abandonment of the flood plain in these reaches and the establishment of exotic species, such as Russian olive and saltcedar, have made overbank habitat inaccessible to the silvery minnow and decreased the availability of dense willow and associated native vegetation and habitat important to flycatchers.

The lower portion of the MRG, below San Acacia Diversion Dam, currently is a combination of an upstream incised channel isolated from the historical flood plain and a downstream perched river for much of which the LFCC (that currently functions like a riverside drain) serves as the low point in the valley in many areas. River flow is lost to the surrounding flood plain, drains, and ground water system. The perched river system, in turn, makes the river channel more prone to drying under low flow conditions. Overbank inundation also occurs more often in the downstream portions of this reach; however, there is not always a direct path back from the overbank areas to the river, which may cause fish to be stranded as the flows drop. Today, this reach generally is aggrading with some channel degradation occurring when the Elephant Butte Reservoir pool is low, as is currently the case.

These changes in hydrology and construction of major features along the river also have modified the river in ways that directly affect the habitat of listed species. Historically, the silvery minnow occupied the Rio Grande from approximately Espanola, NM, to the gulf coast of Texas and also occupied some of the larger tributaries. Today, silvery minnow are restricted to a reach of the Rio Grande in New Mexico, from the vicinity of Bernalillo downstream to the headwaters of Elephant Butte Reservoir, approximately 150 river miles.

The channel narrowing trend in the Rio Grande and the resulting degradation of aquatic habitat will continue under the current river management regime. Returning the river to its earlier state—wide, braided, and sandy—would require recurring major flow events, which would exceed the safe channel capacity below Cochiti Dam. As an alternative, Collaborative Program participants have undertaken efforts to mechanically construct features that provide more favorable habitat conditions for aquatic species under the available hydrologic conditions. Generally, these efforts attempt either to modify the banks of the Rio Grande to encourage overbanking or to expand lower elevation channel capacity to create springtime habitat more suitable for silvery minnow spawning and riparian conditions more suitable for the growth of native vegetation. In most years, native flows cause inundation of these “habitat restoration sites”; however, in some low water years, releases of spikes of water from Cochiti Reservoir then are needed to inundate the modified areas. While these habitat restoration projects generally are unable to shift the broader geomorphic trends, they have created localized enhancements to aquatic habitat and have resulted in a significant increase in the availability of overbank habitat during most spring snowmelt runoff periods.

The Rio Grande is and will continue to be a highly managed system. Similarly, silvery minnow populations have been managed by a variety of activities ranging from the habitat restoration projects described above to population augmentation with fish reared in hatcheries. Unlike the silvery minnow, which currently only exists in,[20] and must complete its entire life cycle within, the MRG, the flycatcher is mainly dependant on the project area and other similar areas in the Southwest for breeding and rearing of young and completes other portions of its life cycle elsewhere. Flycatcher populations are dependent on riparian conditions within their breeding area. Within the United States, the species occurs in southern California, Arizona, New Mexico, southern portions of Nevada and Utah, and possibly southwestern Colorado. The species is likely extirpated from west Texas. Rangewide, changes in hydrology and active management of and development in river corridors have reduced the availability of suitable habitat for the flycatcher and contributed to population decline.

Because of the above factors, active management and persistence of habitat for both species is important for maintaining viable populations.

5.2 Climate

Climate varies across the Rio Grande Basin in both time and space. Most of the basin is arid or semiarid, generally receiving less than 10 inches of precipitation per year. In contrast, some of the high mountain headwater areas receive an average of over 40 inches of precipitation per year. Climatic conditions in the basin are highly variable, as is indicated by the previously mentioned order of magnitude variability in the annual unregulated flow volumes at Rio Grande stream gages.

Annual variations in timing and volume of streamflow are strongly influenced by ocean circulation patterns, such as the El Nino-southern oscillation, which affects annual variability, and the Pacific Decadal Oscillation (PDO), which affects climate and streamflow on a multiyear to multidecade basis. These oceanic patterns modulate seasonal cycles of temperature and precipitation and affect snow accumulation and melting (JISAO, 2012). Particular combinations of these

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[20] Viability of the reintroduced population in the Big Bend Reach is currently not established.

ocean circulation patterns also can result in extended drought or wet periods. An extended period of below average precipitation occurred in New Mexico from the 1940s through the mid 1970s, correlating with a negative/cool phase of the PDO; above average precipitation then prevailed from 1981 through the mid-1990s, correlating with a positive/warm phase of the PDO. Drought returned in the late 1990s through 2004, along with the negative phase of the PDO (JISAO 2012, Corps et al. 2007).

Over the course of the 20th century, the Rio Grande Basin has become warmer. As is shown by the blue dots on figure 11, which represent a moving average, the basin average temperature has increased by 1–2 °F over the course of the 20th century. This warming of the Rio Grande Basin has not been steady in time. The basin's average temperature increased steadily from roughly the 1910s to the mid-1940s and then declined slightly until the 1970s before increasing steadily through the end of the century. This temporal pattern of warming is consistent with findings for other basins within the region. In northern New Mexico, recent annual average temperatures have been more than 2.0 ºF (1.1 ºC) above mid-20th century values (D'Antonio 2006, Rangwala and Miller 2010). The San Juan Mountains, the headwaters of the Rio Grande, have experienced a 1 ºC increase from 1895–2005, with most of the warming occurring during 1990–2005.

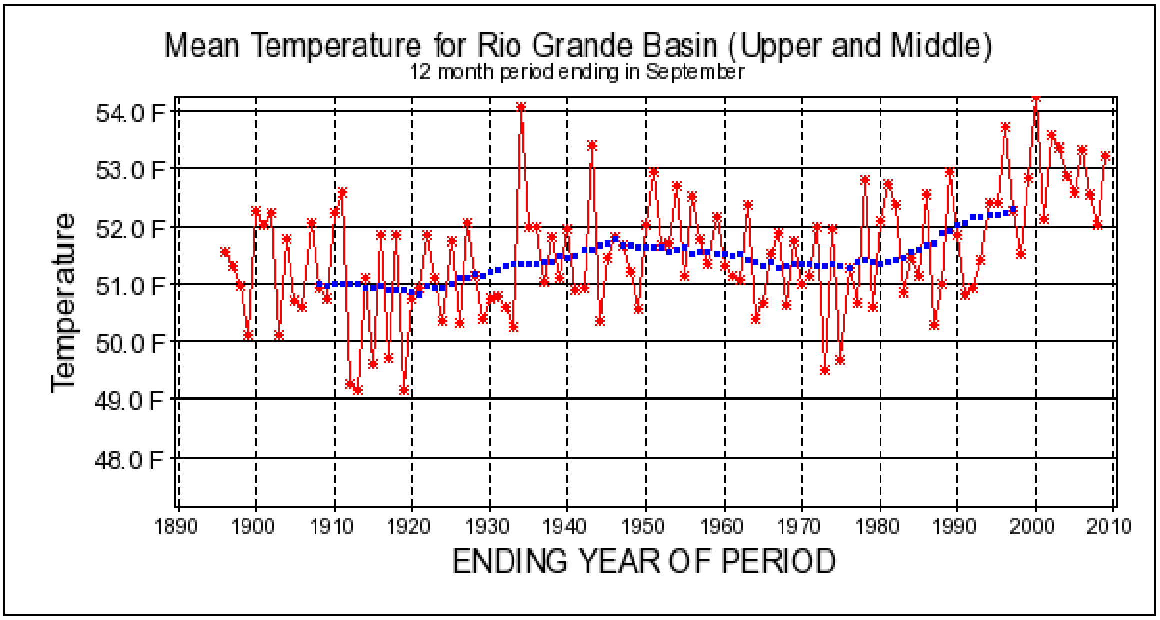

Figure 11. Observed annual temperature, averaged over the Rio Grande Basin above Elephant Butte.

A slight increase in basin precipitation is evident over the past century (figure 12); however, this apparent change in precipitation is subtle relative to annual variability.

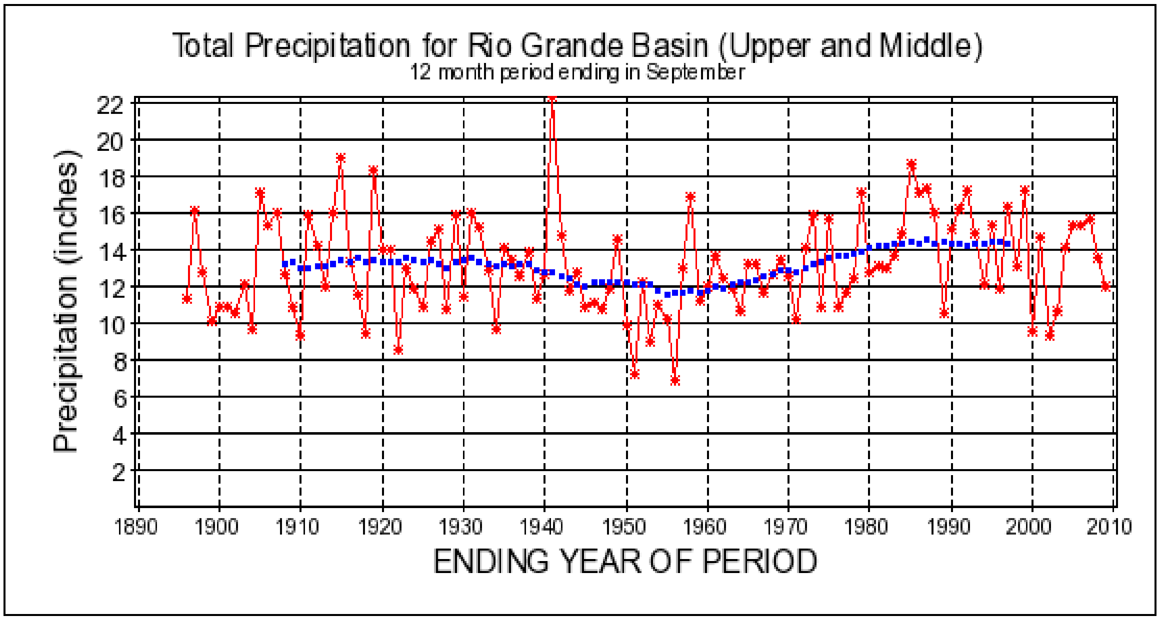

Figure 12. Observed annual precipitation, averaged over the Rio Grande Basin above Elephant Butte.

Source: Western Climate Mapping Initiative (WestMap) available at: http://www.cefa.dri.edu/Westmap/. Red line indicates annual time series for the given geographic region. Blue line indicates 25-year moving annual mean.

Peak snowmelt runoff across northern New Mexico occurred, on average, 7 days earlier over the past half century than during the first half of the 20th century (Stewart et al. 2005, Enquist et al. 2006). In addition, streamflow in the winter months of January, February, and March has increased over the last quarter century relative to the century as a whole (Passell et al. 2004; Woodhouse, Lukas, and Meko 2007).

5.3 Status of Listed Species

This section is a summary of status and monitoring activities for listed species covering approximately the past decade within the Proposed Action area. Summary information of all baseline activities that affect listed species including hydrology, channel conditions, and management activities are reviewed in section 5.7.

The information presented in section 5.3.1, discussing the Rio Grande silvery minnow, reflects to a great extent the analyses done in the annual reports from the contractors carrying out the Collaborative Program's Population Monitoring and Population Estimation Program and related studies.[21] This approach endeavors to document the status of the silvery minnow population and its annual reproductive success through efforts to measure the year-to-year abundance, density, and distribution of individuals of the species at 20 locations in the Middle Rio Grande. The primary stated objective of the monitoring program has been to document temporal trends in silvery minnow abundance at these 20 sites, with secondary objectives of documenting population monitoring correlations with discharge patterns, documenting mesohabitat usage patterns, documenting changes in relative abundance among fish species over time, and determining site-specific sampling variation.[22]

The efforts of recent Collaborative Program studies within the program's workgroup have undertaken a thorough analysis of the population monitoring data. Initial results indicate that silvery minnow population viability in the MRG should incorporate measures of minnow resilience and density dependence in the population dynamics, in addition to measures of abundance, and should attempt to discern the responses of the population to different environmental conditions in terms of minnow reproduction, survival, and recruitment. Since the minnow can exhibit extreme population volatility from year to year, it is to be expected that distribution and abundance results from a given point in time, or trends inferred from year to year, may be less relevant for determining viability than measures of environmental and management conditions that a PVA analyses reveals as the most important factors to maintain the species' persistence.[23]

The PVA Workgroup has worked to compile existing minnow population monitoring data sets and to reach scientific consensus as to the quality, integrity, and completeness of these data. This consensus data set will be used in the end PVA products that the Collaborative Program will use to inform the updated description of species status and population viability. Further data and analyses may be supplied during the course of the consultation, and extension of the consultation to obtain and analyze outstanding data may be appropriate.[24]

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[21] See the Middle Rio Grande Endangered Species Act Collaborative Program Interim Monitoring Plan (September 22, 2006, Draft), Appendix A, Rio Grande Fish Community Monitoring ("2006 Fish Monitoring Plan").

[22] See, e.g., Rio Grande Silvery Minnow Population Monitoring Program Results from September 2009 to October 2010.

[23] See 16 United States Code § 1536(a)(2) (requiring the use of the "best scientific and commercial data available" by Federal agencies in fulfilling their ESA Section 7 consultation requirements); *Consolidated Salmonid Cases*, 791 F.Supp.2d 802, 825-27 (E.D. Cal. 2011) (requiring the National Marine Fishery Service to "apply generally recognized and accepted biostatistical principles, which constituted best available science").

[24] See Federal Register 50 CFR Ch IV (October 1, 2008, Edition) Sec. 402.14:

5.3.1 Rio Grande Silvery Minnow

5.3.1.1 Population Monitoring Activities

There are several ongoing activities that are performed to monitor the current status of silvery minnow in the project area. Reclamation, through the Collaborative Program, funds silvery minnow population monitoring that occurs each month except for January and March using seines and collects catch per unit effort (CPUE) data on the small bodied fish community of the Rio Grande. Similar methods have been used since 1993. Principal objectives of this study are to provide timely monitoring of the temporal trends for silvery minnow within the Rio Grande.

The PVA work group determined that this set of data was also credible for estimating relative brood strength, and annual cohort survival for years 1 and 2 (D. Goodman power point presentation, March 27, 2011).[25] October surveys are assumed to be the best available indicator of annual population status and annual recruitment due to the generally stable base flow conditions and warm water temperatures (Collaborative Program Appendix A, 2006) leading to lower sampling variability (SWCA 2010, Task 1). An additional study using repeated sampling occurred at all sites in November 2009 and 2010 (4 days in a row) to investigate the level of sampling variation for this type of sampling, results showed that variation within that timeframe is low and consistent for studies in 2009 and 2010 (Dudley and Platania 2011).

A gear evaluation study is underway to examine the strengths and weaknesses of various sampling methodologies. Initial findings indicate that large numbers of samples are needed to detect small population changes with the current methodology (SWCA 2010, Task 1) especially when population numbers are low. The study also indicates that the mean size of minnows captured by seining may be smaller than with fyke nets, especially during spring sampling in overbank habitats (SWCA 2011). As far as community monitoring, seines captured the highest number of species when compared with fyke nets and electrofishing. As with all fish sampling techniques, this study has indicated that gear suitability is dependent on study objectives, methods used, target species, and logistical and budgetary constraints (SWCA 2011).

In addition to population monitoring, population estimation has been conducted in October since 2006. The population estimate uses a closed sampling method, utilizing cages and electrofishing within mapped sections of the river. There

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(d) "…The Federal agency requesting formal consultation shall provide the Service with the best scientific and commercial data available or which can be obtained during the course of the consultation for an adequate review…"
(f) "…When the Service determines that additional data would provide a better information base from which to formulate a biological opinion, the Director may request an extension of formal consultation and request that the Federal agency obtain additional data…"

[25] D. Goodman PowerPoint presentation, March 27, 2011.

appears to be a close relationship between the 2008–2010 population trends obtained from the population estimation program and population monitoring (Dudley et al. 2011); however, there is a divergence between the two datasets in 2011. There are not enough data points currently to establish if there is a relationship between the two studies. The riverwide population estimate has ranged from a high of 1.4 million in 2009 to a low of 267,000 in 2010.

Each spring, egg drift is monitored within the river channel and canals annually during spring run-off. This monitoring is a requirement of the 2003 Biological Opinion and provides information on the timing and magnitude of spawning in the MRG. The number of monitoring stations has varied among years but has been at least two within the river at standard locations. These stations are deployed within the river, and the number of eggs per volume is calculated on a daily basis. Hourly catch rates also are recorded by crews collecting eggs for propagation purposes.

Project specific monitoring also occurs for habitat restoration and river maintenance projects. These will be discussed more specifically in section 5.6.

5.3.1.2 Status of Silvery Minnow in the MRG

Egg monitoring has shown a large variation in the number of eggs that are detected in the river on an annual basis. Timing of spawning appears to be related to a combination of discharge and water temperature conditions. Though the total numbers of eggs collected in low flow years is generally higher than in high flow years, when adjusted for total volume of water, the number of eggs transported in high flow years is still substantial (several million eggs) (Dudley and Platania 2010). Small numbers of eggs annually are collected in irrigation canals. Improvements in the way diversions have been managed have minimized the number of eggs that are entrained. Temperature monitoring during egg monitoring indicates that, while mean daily temperatures across years are similar during spawning events, temperatures during high flow years are more constant and experience less diel variation (Platania and Dudley 2006). It is unknown how this temperature fluctuation affects spawning or larval development.

Silvery minnow spawning has been detected each year that monitoring was conducted. As can be seen in figure 13, there is no significant correlation of the catch rate of eggs at the two monitoring sites with October CPUE ($R = 0.708$, $p = 0.352$). Silvery minnow have a large possible reproductive output (> 2,000 eggs per female) (Platania and Altenbach 1996). It is difficult to infer a measure of annual recruitment success from the number of eggs detected in the drift. Recruitment from egg to post-larval stages may be a more important dynamic and is dependent on habitat quantity and quality. Upcoming analysis by PVA modelers may provide further information of what the most important population limiting factors are for silvery minnow.

Population dynamics of silvery minnow have been highly variable (figure 14). Since 1993, catch rates of silvery minnow bounced back in a short time period from a low in 2003 and were at the highest level recorded in 2005. Population monitoring indicates that from 2001–2010, 4 years (2002, 2003, 2006, and 2010)

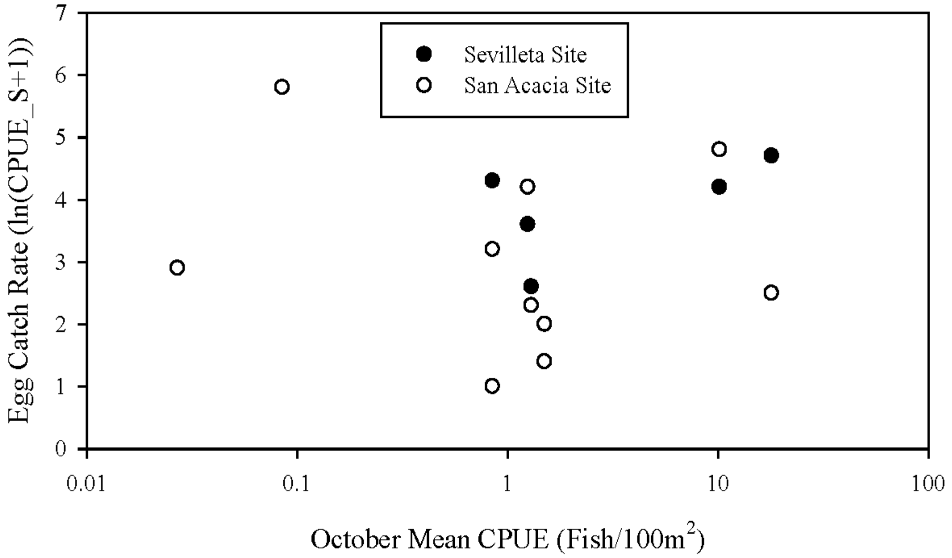

Figure 13. Scatter diagram of egg catch rate for Sevilleta (2006–2011) and San Acacia (2002–2004, 2006–2011) sites (Dudley and Platania 2011) with October CPUE data (population monitoring data).

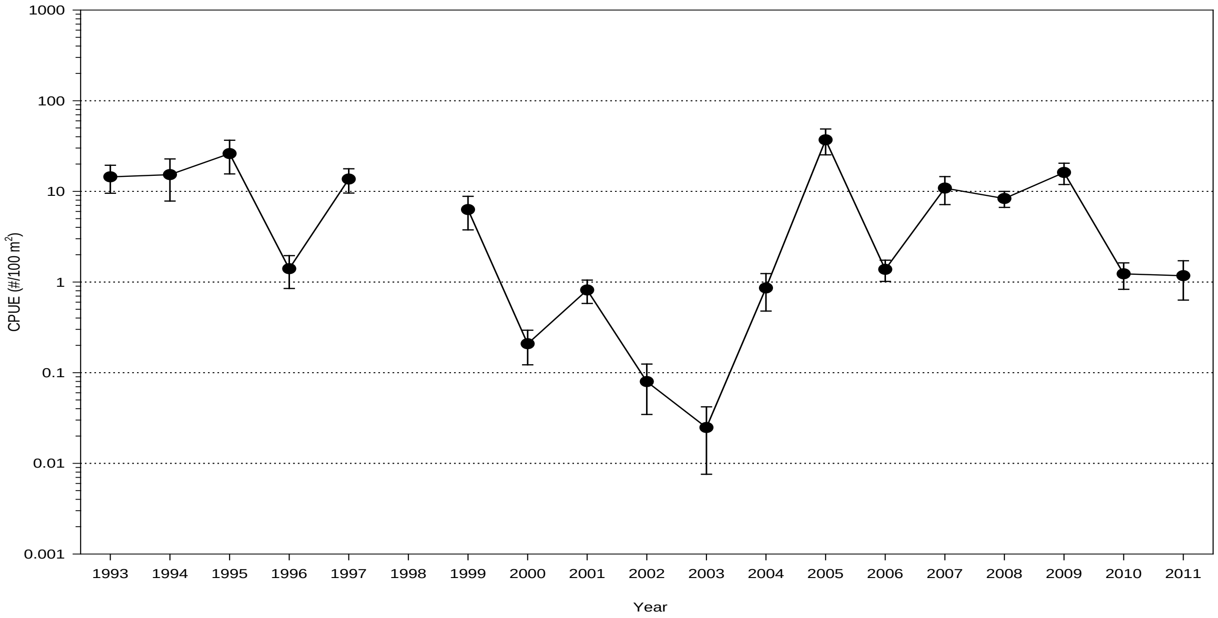

Figure 14. Rio Grande silvery minnow densities (CPUE) during October, at all sampling sites, by sampling year (1993–1997, 1999–2011). Solid circles indicate means, and error bars represent the standard error. Note log scale for y axis (population monitoring data, ASIR).

did not have a strong recruitment (meaning the fall catch rates were less than the prespawn levels) (figure 15). All of these years, except 2010, were years with little to no spring run-off (figure 44, shown later in this report). Population estimation modeling from 2008–2010 also shows a substantial decline in silvery minnow populations in 2010 in all reaches (Dudley et al. 2011). Estimates for of the 2010 population was 67–90% lower than 2008 and 2009 estimates depending on the reach and method used. It is uncertain what circumstances caused population decline in 2010. Initial findings of the 2011 draft data analysis indicate that the October catch rates are similar between 2010 and 2011.

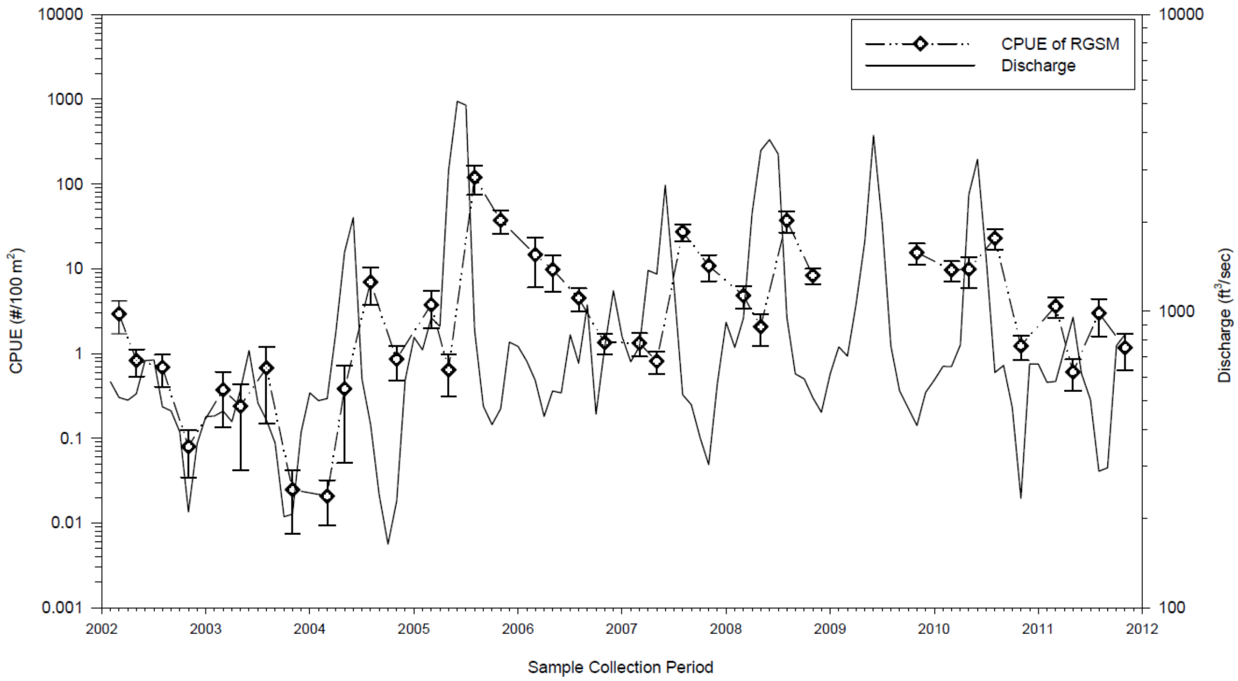

Figure 15. Time sequence of quarterly Rio Grande silvery minnow densities of the past decade (2001–2010) at population monitoring program collection sites and mean monthly discharge at USGS Gage #08330000 (Rio Grande at Albuquerque, New Mexico). Diamonds indicated sample means for each survey, and capped bars represent standard error (from Dudley and Platania, 2012).

Analysis of the population monitoring data indicates a strong positive relationship with spring flow and mean October densities (figure 16, Dudley and Platania 2011). Further analysis of this data by the Collaborative Program PVA group has demonstrated that one of the most important variables is spring flow, which sets the carrying capacity for reproductive output.[26] Dr. Goodman's presentation did

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[26] D. Goodman PowerPoint presentation March 27, 2011.

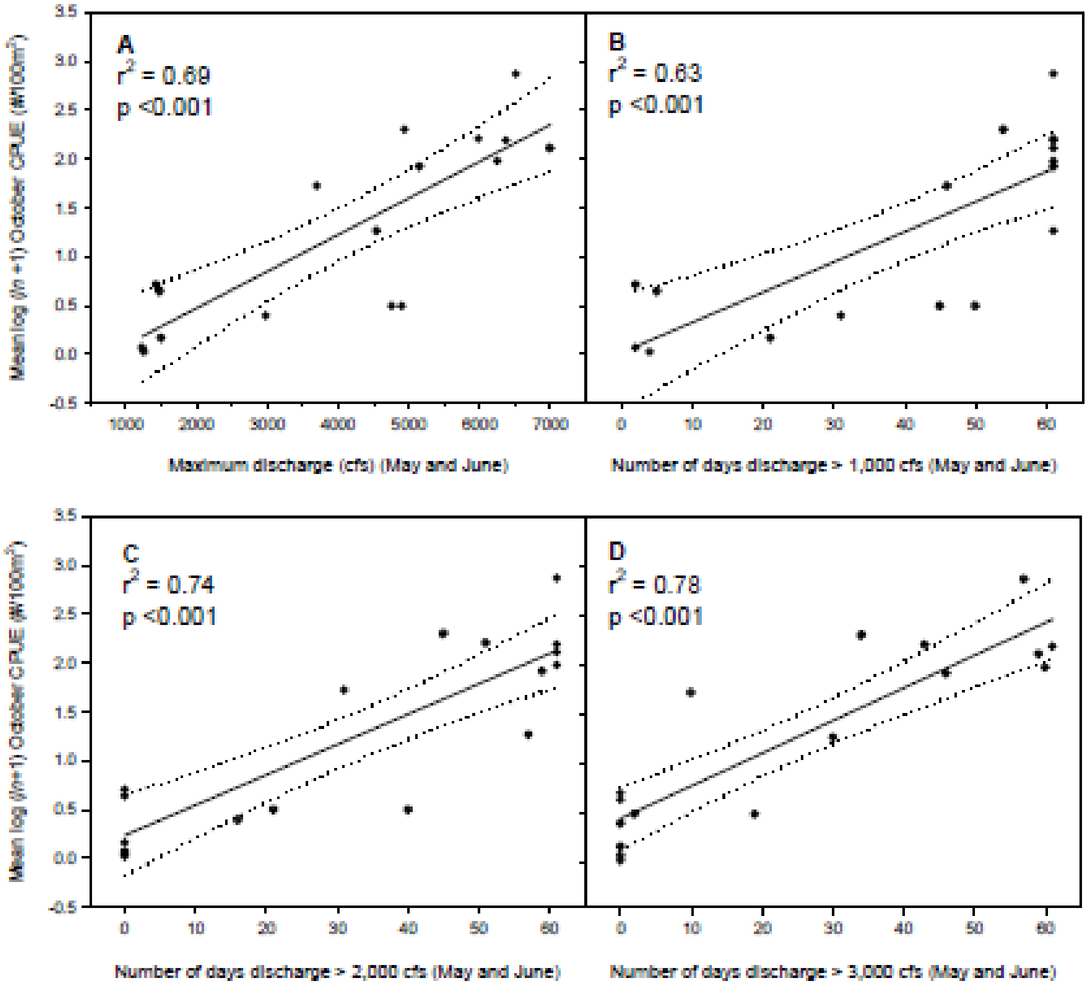


Figure 16. Regression analysis of Rio Grande silvery minnow log-transformed mean October densities (1993–1997,1999–2010) and select hydraulic variables (during May and June) for USGS Gage #08330000 (Rio Grande at Albuquerque, New Mexico). Graph shows regression line (solid) and 95% confidence intervals (dotted). From Dudley and Platania 2010).

not indicate that summer flows enhance survival through the summer using mean summer CPUE (July–September). However, the regression analysis of October CPUE by Dudley and Platania indicated that silvery minnow CPUE increased significantly with delayed onset of low flows and increased mean daily discharge (as measured at the San Marcial gage) (figure 17). There were also significant negative relationships between October silvery minnow densities and number of days with discharge below threshold values (i.e., less than [<] 200 and < 100 cfs) (Dudley and Platania 2011).

The current silvery minnow population in the MRG has been annually augmented with hatchery produced fish. The program began stocking a few fish in 2001; large numbers of fish were stocked starting in 2003 (Remshardt 2010). The

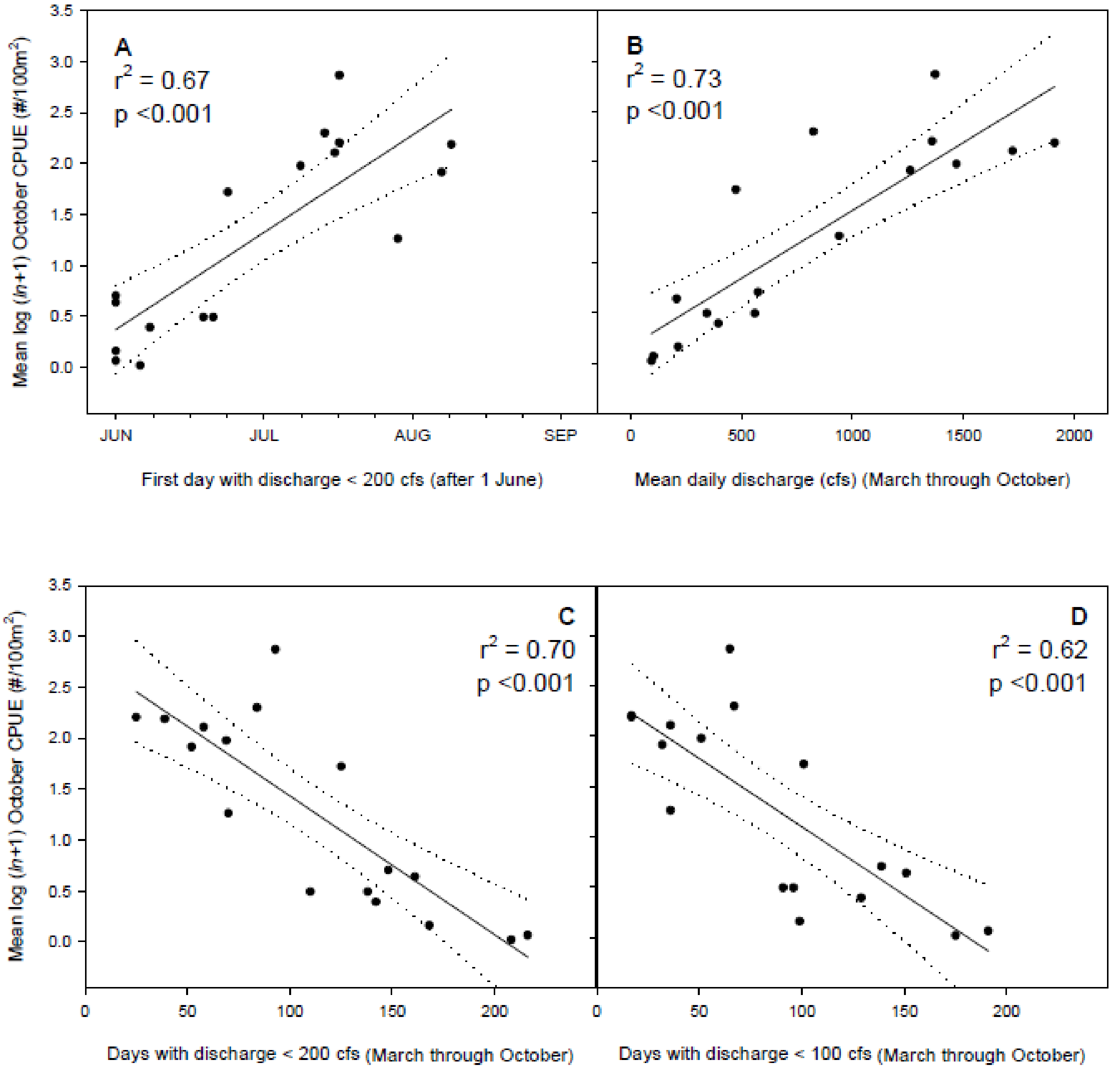


Figure 17. Regression analysis of Rio Grande silvery minnow log-transformed mean October densities (1993–1997, 1999–2010) and different hydraulic variables for USGS Gage #08358400 (Rio Grande Floodway at San Marcial, New Mexico). Graph shows regression line (solid) and 95% confidence intervals (dotted) (from Dudley and Platania, 2011).

numbers of fish stocked annually is based on a formula to achieve an overall density 10 minnows per 100 square meters as determined by fall monitoring results (Remshardt 2012). All stocked silvery minnow are marked with visible implant elastomer tags.

Generally, low numbers of hatchery fish are captured in monitoring efforts (< 3% of the total catch). Riverwide, the only year that a substantial number of marked fish were collected during population monitoring was during 2003, when approximately 10% of the total numbers of silvery minnow collected were hatchery fish, 20% in the Angostura Reach. The only fish stocked in the

Angostura Reach since 2008 have been those fish implanted with PIT tags to study use of the fish passage built around the Albuquerque drinking water diversion. Though few hatchery fish are recaptured, it appears that the augmentation program has had an effect on maintenance of genetic diversity within the three reaches. This is discussed further in the next section.

The propagation program also provides security against catastrophic failure of the species within the MRG since it is currently the only established population of silvery minnow. Silvery minnow also are salvaged from isolated pools in sections of the river that are prone to drying. The initial salvage program moved fish to upstream reaches. Since 2007, salvaged silvery minnow are only moved within a reach. Salvage and propagation activities are discussed more fully in section 5.6.3.

From 2001–2010, there was variation in the community composition of fishes in the Rio Grande. Silvery minnow comprised a higher fraction of the total ichthyofaunal community from 2005–2009 than from 2000–2004 (Dudley and Platania 2011). Seining surveys most often captured flathead chub, longnose dace, and white sucker in the Angostura Reach. Red shiner, common carp, silvery minnow, fathead minnow, river carpsucker, channel catfish, and western mosquitofish were most common in the Isleta Reach. Silvery minnow was more common in the Isleta and San Acacia Reaches as compared to the Angostura Reach. Reclamation has annually electrofished portions of the river in February. These surveys most often captured channel catfish, common carp, and river carp sucker in the Angostura Reach, while silvery minnow were the most common species captured in the Isleta and San Acacia Reaches for the past 5 years (Reclamation 2010, Reclamation 2012).

5.3.1.3 Genetics Monitoring

Genetic monitoring has been conducted on silvery minnow since 1999. Historically, population bottlenecks have occurred that likely caused the loss of rare alleles and limited the allelic diversity of the population. Genetic variation and heterozygosity are often maintained unless the bottleneck is very severe and lasts for several generations (Nei et al. 1975). Heterozygosity provides a good measure of the capability of a population to respond to selection immediately following a bottleneck. However, the number of alleles remaining is important for the long-term response to selection and survival of populations and species (Allendorf 1986). It is important to maintain a species genetic diversity for long-term population persistence to allow species the ability to adapt and respond to environmental changes.

The current genetic monitoring measures a variety of diversity metrics based on microsatellite and mitochondrial DNA markers. Prior to augmentation, there was considerable variation in diversity measures. Since the initiation of augmentation, diversity statistics have stabilized (figure 18), indicating that alleles frequencies

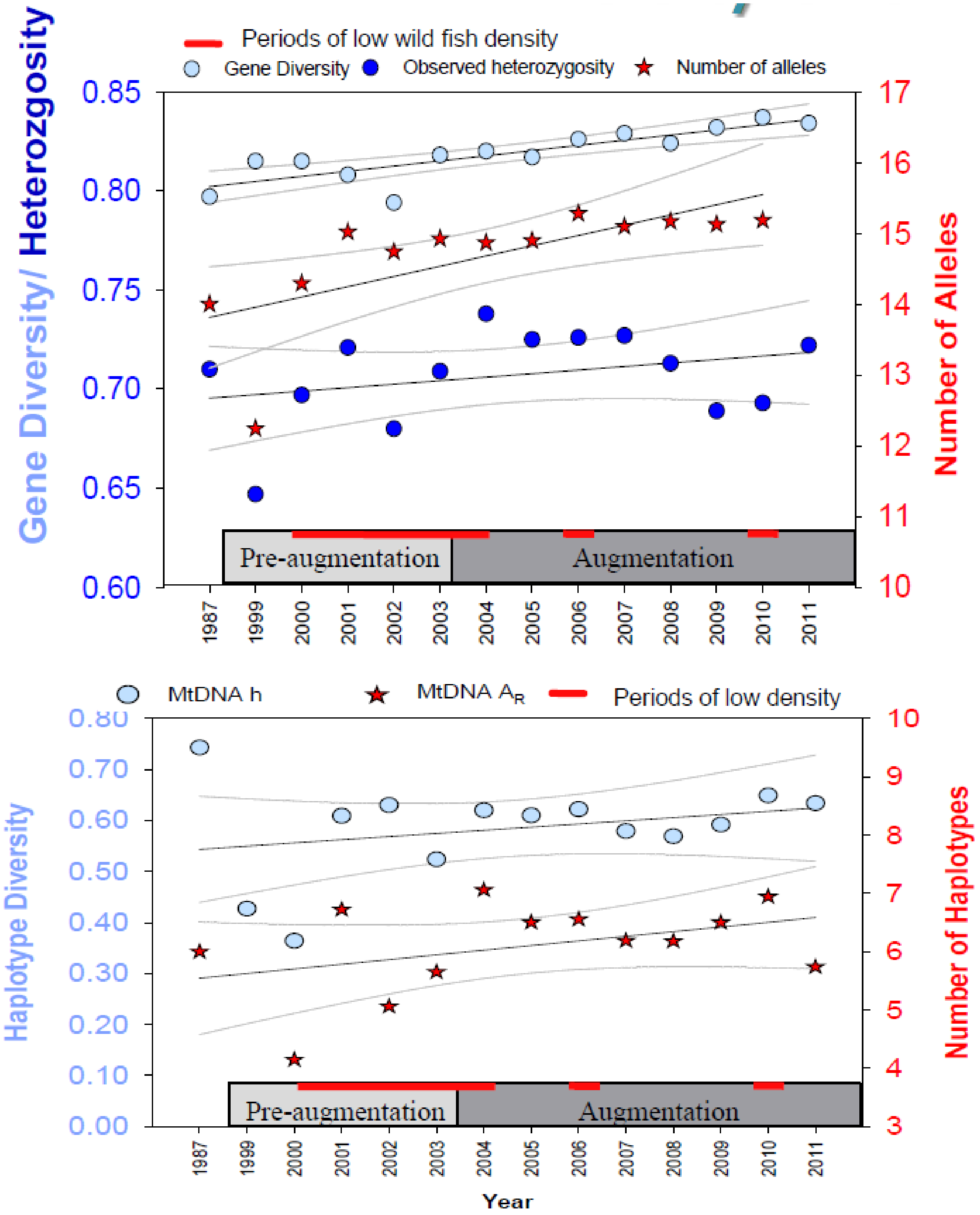


Figure 18. Diversity metrics of Rio Grande silvery minnow from genetic monitoring program from Osborne and Turner (PowerPoint presentation to Collaborative Program 2011).

are maintaining within the population. Heterozygosity has continued to be variable (Osborne et al. 2012). The investigation of the genes of the immune response, major histocompatiblilty complex, indicates that the silvery minnow shows similar variation to other cyprinid fishes studied (Osborne and Turner 2011).

Generally, recovery plans for rare species often reference a goal of attaining a minimum effective population size of 500 (Frankel and Soulé 1981). This number was derived using theoretical numbers based calculations for “ideal” populations without regard to the actual genetic diversity within the population. Temporal estimates of “genetic” effective population (N_e) size using various genetic methods have found that actual N_e of most wild populations is much lower than would be calculated using population size estimates (Palsta and Ruzzante 2008). Many fish species with type III survivorship curves (high fecundity, high early mortality) show a very low ratio of $N_{e/}N$ (adult census size). Factors that contribute to this include fluctuating population size, biased sex ratios, variance in reproductive success between individuals, and metapopulation dynamics (Turner et al. 2002).

The revised recovery plan (Service 2010) states that the effective population size of silvery minnow is estimated to be around 100. There are several ways to estimate genetic effective size. Each type of estimator has biases associated with it. In variable populations, there is not generally correlation between variance effective size (NeV) and inbreeding effective size (NeI). NeV measures the variance in allele frequencies between two time points. NeI measures the probability of identity by descent. In a declining population, NeI > NeV. In a growing population, NeI < NeV. Depending on the method used, the variance effective size has been in the range from 200–400 in the last decade (PBS&J 2011). Inbreeding effective size estimates are higher, ranging from 500 to infinity, but the variability is heavily influenced by sample size (Osborne and Turner 2011 PowerPoint). Though the estimates of variance effective size are small, they have stabilized and show a slightly increasing trend (Osborne et al. 2012).

The current silvery minnow population is confined to a limited area and does not have the possibility of occasional immigration from a disconnected population. In addition, gene flow between subsets of the population is limited to a downstream direction due to the presence of migration barriers. There is no correlation between CPUE levels and effective population size. For silvery minnow, there are likely several factors that influence genetic effective size beyond population size including augmentation of the population by captive stocks. Generally, captive stocks from wild caught origins have higher variance effective size than those that are produced from hatchery broodstock. The availability of wild caught eggs for broodstock has been variable, and most recent stockings have been from captive spawning. Large numbers of eggs were collected in 2011, which should add to the genetic diversity of the hatchery stocks. Though low numbers of hatchery fish are captured in monitoring efforts, generally, it appears that augmentation has positive effects for maintaining genetic diversity of the population, especially during low population years.

5.3.1.4 Water Quality and Fish Health Monitoring

There are two general types of water quality concerns in the Rio Grande. Point source discharges generally occur near water treatment facilities or storm water discharges that can cause fish kills. These have been documented occasionally within the Rio Grande within the Angostura Reach. New Mexico Game and Fish or New Mexico Environment Department investigate any reports of fish kills and try to determine a cause. There is not a coordinated effort for a long-term record keeping process for these fish kills. In the last few years, fish kills have been documented from various causes including ash flows from forest fire areas, low oxygen events from storm water, and high chlorine levels in wastewater treatment effluent. In New Mexico, storm water-related issues are led by the New Mexico Environment Department and local governments. Currently, the city of Albuquerque has a program to improve the effectiveness of the storm drainage system within the city of Albuquerque and to safeguard the quality of the storm water runoff discharging into the Rio Grande. Currently, substances that enter the storm drain system flow directly to the Rio Grande, usually via neighborhood arroyos. New Mexico has not assumed the National Pollutant Discharge Elimination System (NPDES) storm water program, and Environmental Protection Agency (EPA) implements the NPDES program in New Mexico. The New Mexico Department of Transportation, the city of Albuquerque, the Albuquerque Metropolitan Arroyo Flood Control Authority, and the Southern Sandoval County Arroyo Flood Control Authority produced the Storm Water Management Guidelines for Construction and Industrial Activities manual in 2003.

In addition to these short-term issues, there is concern about long-term, chronic conditions that may affect fishes through long-term exposure and cause reproductive effects, health issues, or death. Sublethal impacts of various chemicals contribute to the overall conditions of environmental stress in the MRG, which could lead to declines in the population of silvery minnow and other aquatic life. A risk assessment was conducted using data available through 2003. This assessment's primary conclusion was that there is no clear "smoking gun" chemical that can be singled out as an agent likely to have produced significant riverwide historical impacts to silvery minnow. Nor can any chemical be specifically targeted as currently impairing the recovery of silvery minnow within the MRG (Tetra Tech 2005).

A study, conducted by the New Mexico Environment Department from 2006–2008 (NMED 2009), identified only a few water quality issues—notably elevated *E coli*, one sample with an ammonia concentration of 9.12 milligrams per liter (mg/L)—five times the acute criteria, low dissolved oxygen (DO) during brief periods of time, and some samples elevated in metals such as aluminum, copper, and chromium. Temperature exceedences of their 32.2 °C criterion were few, and the magnitude of exceedence was never greater than 3 °C. For pH, no exceedences of the 6.6 to 9.9 standard units criterion were documented from deployed data loggers at any locations except for one sample in 2007 at NM Highway 550 Bridge. Buhl (2008) established several preliminary parameters specific to silvery minnow: Water temps > 36 °C acutely lethal, DO < 0.6 mg/L acutely lethal.

There were several instances of dissolved oxygen readings that were lower than the 5 mg/L standard within the Angostura Reach. NMED states in their report that these will be investigated more fully in the current monitoring period (2010–2012). In their draft 2006–2008 silvery minnow health study, the Service (2012) found that many of these low dissolved oxygen readings may be associated with storm events.

Fish tissue-based testing was conducted in 2007 within the Angostura Reach using a variety of species from the MRG. Four sites were sampled: below North Albuquerque Metro Area Flood Control Authority (AMAFCA), Albuquerque South Side Water Reclamation Plant (which included the Rio Grande below South AMAFCA).

These fish showed levels of zinc, and DDT higher than levels established by the United States Department of Agriculture Forest Service BEST Program as potentially having toxic effects on various fish species (NMED 2008). Fish collected in this survey contained several chemicals above method detection limits but below toxic levels. The only contaminants not detected were lead and selenium for all samples and cadmium at two of the four sites. The sampling that took place near the Highway 550 site contained the highest concentration of cadmium and arsenic. Sampling near the Rio Rancho Waste Water Treatment Plant (WWTP) contained the highest concentrations of mercury. The Albuquerque WWTP sample contained the highest concentrations of zinc.

The service draft fish health study of the wild silvery minnow population found no pathonogenic viruses present in fish of the MRG. There was no obvious pattern of parasitic infections at various sites; however, bacterial infections were more prevalent during warm temperatures. Many species exhibited shortened opercula, including silvery minnow. It is unknown if water quality issues influence this defect.

Buhl (2011) conducted in situ experiments in the water from an irrigation waste way drain to inform the feasibility of creating refugial habitat with this water during dry periods. There were no significant differences in survival, total length, weight, or condition factor of fish across sites, but absolute weight loss and relative reduction in condition factor were significantly greater in fish at the site just below the drain (wetted in stream habitat site) compared to those at a nearby river site. Some of these differences may have been related to the depth of the site and not directly attributable to the water quality.

A 2003 survey of various pharmaceutically active compounds did not detect estrogenic hormones within the Rio Grande. Antibiotic concentrations in the Rio Grande were minimal with only sulfamethoxazole being detected (Brown 2006). Currently USGS is conducting a study of estrogenic biomarkers and the effects of these compounds on Rio Grande silvery minnow.

Water quality criteria were established for salvage of silvery minnow from isolated pools based on a series of survival tests (Caldwell et al. 2010). Fish in isolated pools are often very stressed from crowding, suboptimal water quality, and temperature fluctuations that cause them to be more susceptible to parasites and bacterial diseases. Thus, survival of these stressed fish is low. For a pool to be considered for salvage, a pool must meet the following conditions: (1) water temperature < 34 °C, (2) dissolved oxygen > 2.0 mg/L, (3) pH < 9.0 (4) no observable dead fish, (5) no moribund fish as indicated by lethargy, and (6) no fish exhibiting hemorrhagic lesions. If any of these secondary criteria are not met, the pool is not rescued.

5.3.1.5 Other Information

In addition to the monitoring activities, there are several studies supported by Reclamation and the Collaborative Program that have been (or are currently) conducted to inform future management. Bixby and Burdett (2011) investigated the correlation of nutrient availability and periphyton growth in the MRG from 2007–2010. They found that periphyton distribution is highly influenced by variation in turbidity and nutrients. In the summer months, high turbidity from tributaries creates a light-limited environment where primary production is limited to a littoral zone “bathtub ring.” Additionally, there is a gradient of nutrient inputs as the river flows through urban landscapes as concentrations of phosphate and nitrates vary.

There were similar findings of Valdez et al. in review, who studied food availability within the MRG in 2005 and 2006. In addition to the large allochthonous load of organic matter, there was also significant autochthonous production along shallow shorelines where there was sufficient light penetration for photosynthesis and where velocity was low with little scour so that macroinvertebrate and aufwuchs communities could establish. Mesohabitats that support autochthonous production and the greatest food sources for fish comprise relatively small wetted areas of the channel, which coincide with low-velocity mesohabitats used by silvery minnow. They concluded that the abundance and diversity of food resources available during their study did not suggest a food limitation for Rio Grande silvery minnow.

Fragmentation of rivers has been documented as one of the leading causes of extirpation of many species of pelagic spawning fishes (Perkin and Gido 2011). Much debate has surrounded the fish passage conservation measure for silvery minnow, the potential effects of providing fish passage at the diversion dams at Angostura, Isleta, and San Acacia. A peer review of the science surrounding the need for fish passage found that there was much uncertainty surrounding what the goals for fish passage are, and how many fish would need to use it to accomplish these goals (PBS&J 2011).

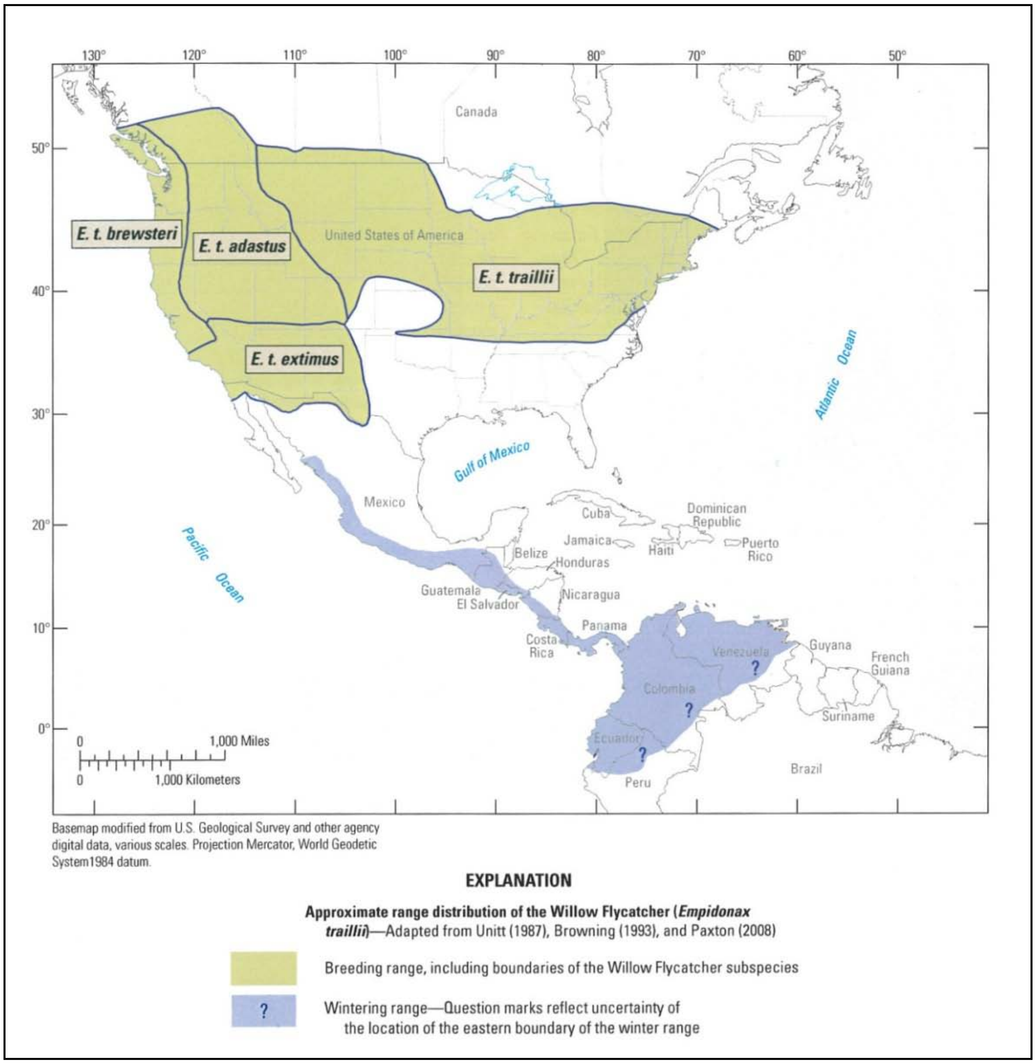
5.3.2 Southwestern Willow Flycatcher

5.3.2.1 Species Status

The current range of the flycatcher (figure 19) is very similar to the historical range; however, suitable habitat within that range has diminished considerably due to habitat loss or modification via dams and reservoirs, diversions and ground water pumping, channelization and bank stabilization, phreatophyte control, livestock grazing, recreation, fire, agricultural development, and/or urbanization (Service 2002). Brood parasitism by cowbirds also has been a contributing factor in flycatcher population decline. Prior to the listing of the flycatcher, relatively little was known about the natural history of this subspecies. Estimates of overall territory numbers rangewide in 1993 were approximately 140 distributed among 41 known sites (Durst et al. 2008).

As of 2007, the population of flycatchers rangewide increased to approximately 1,299 territories distributed among 288 sites (Durst et al. 2008; figure 20). Large populations are located along the Gila River and Rio Grande in New Mexico; the Kern, Owens, San Luis Rey, Santa Ana, and Santa Margarita Rivers in California; and the Gila, San Pedro, and Salt River drainages in Arizona (Durst et al. 2008). Currently, the Elephant Butte Reservoir (classified as south of river mile 62 for purposes of this analysis) population is the largest group of flycatchers within New Mexico, and the population within the BDANWR is the second largest along the Rio Grande (New Mexico Flycatcher Database).

A total of approximately 415 flycatcher territories were found within the entire Rio Grande Basin of New Mexico during the 2011 breeding season. Occupied sites were scattered from the Orilla Verde Recreation Area near Taos, downstream to Radium Springs near Las Cruces. During the 2011 breeding season, most suitable habitat within the main stem of the Rio Grande was surveyed, and it is highly unlikely that any large populations of flycatchers have gone undetected; however, sites supporting a few undetected territories may exist in some isolated patches of habitat throughout the Rio Grande Basin.



Basemap modified from U.S. Geological Survey and other agency digital data, various scales. Projection Mercator, World Geodetic System1984 datum.

Figure 19. Breeding ranges of the willow flycatcher subspecies (from Sogge et al. 2010).

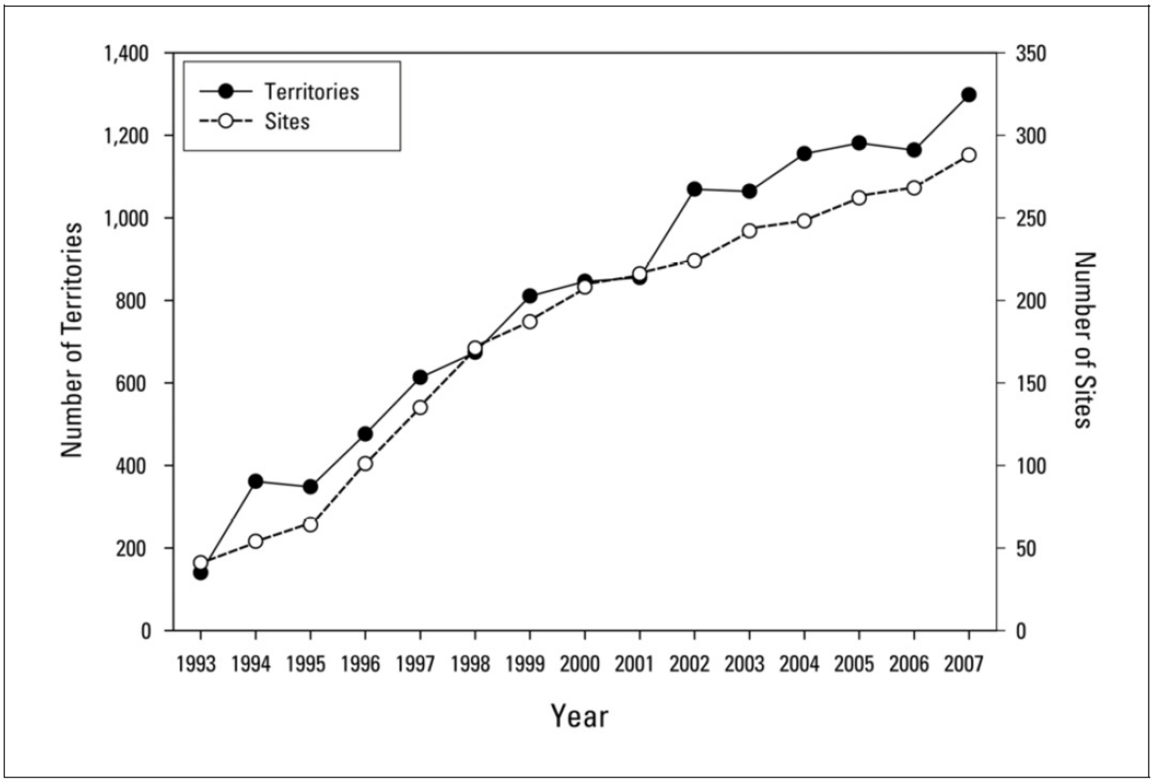


Figure 20. Estimated number of flycatcher territories and sites rangewide from 1993–2007 (from Durst et al. 2008).

Since 1993, flycatchers have been reported from 19 sites within the Rio Grande Basin; however, several of these sites no longer support flycatchers. The majority of currently occupied sites within the entire Rio Grande Basin support isolated populations of fewer than six territories. Sites such as Tierra Azul, Ohkay Owingeh, and Selden Canyon/Radium Springs have been fairly consistent in territory numbers since 1993, which is indicative of somewhat stable populations within these sites.

The Elephant Butte Reservoir population was first recorded in 1993 when four flycatcher territories were found. The population has steadily increased to 314 in 2011. Approximately 75% of the total known territories found within the Rio Grande Basin during the 2011 season were within the conservation pool of Elephant Butte Reservoir that is south of both the currently designated Middle Rio Grande Management Unit critical habitat as well as the project action area.

A total of 84 flycatcher territories were detected during the 2011 survey season along the MRG. This also includes populations from the Stateline to Otowi Bridge, a portion of which is outside the action area. Territory numbers generally have increased since surveys began in 1993 (table 2).

Table 2. Flycatcher territory[1] totals along MRG. This also includes populations from the Stateline to Otowi Bridge, a portion of which is outside the action area.

River Reach	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Rio Chama Stateline to Confluence	2	4	2	5	4	3	NS	NS	4	NS	NS	1	NS	NS	NS	0	NS	NS	NS
Stateline to Otowi Bridge	5	6	11	20	17	2	2	18	1	0	1	12	12	13	12	18	34	21	23
Otowi Bridge to Cochiti Dam	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1	1	NS	2
Cochiti Dam to Angostura Diversion Dam	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Angostura Diversion Dam to Isleta Diversion Dam	NS	3	4	3	NS	NS	NS	14	NS	NS	4	7	6	9	12	16	0	0	0
Isleta Diversion Dam to Rio Puerco	NS	NS	NS	NS	NS	NS	NS	NS	0	2	1	0	4	1	8	1	3	6	10
Rio Puerco to San Acacia Diversion Dam	NS	NS	NS	NS	NS	NS	4	7	11	11	16	17	18	21	14	31	18	13	9
San Acacia Diversion Dam to Arroyo de las Cañas	NS	NS	NS	NS	0	0	0	0	0	2	0	0	0	0	0	3	1	1	1
Arroyo de las Cañas to San Antonio Bridge	NS	NS	NS	NS	NS	0	0	0	0	1	0	0	0	1	0	0	0	3	7
San Antonio Bridge to River Mile 78	NS	NS	NS	NS	NS	0	0	0	0	4	0	1	0	2	5	5	19	37	44
River Mile 78 to River Mile 62	0	11	6	7	0	2	5	4	3	7	7	16	3	14	9	8	9	7	11
Total	5	20	21	30	17	4	11	43	15	27	29	53	43	61	60	83	85	88	84

[1] Territories: A single male or pair of flycatchers detected throughout the breeding season.
Note: Data collected from NM Rangewide Database 1993- NS: Not Surveyed. UN: Unknown.

The only two areas within the action area that have shown significant population changes over the past decade are located in the Rio Puerco to San Acacia Reach (near Sevilleta NWR/La Joya SWA) and the San Antonio to River Mile 78 Reach (near BDANWR). The population along the Rio Grande within the Sevilleta NWR and La Joya SWA was first detected in 1999.

Formal surveys were initiated in 2000, and seven territories were detected. The population increased to 17 in 2004 and remained relatively stable until 2008 when approximately 31 territories were detected. In 2011, the population declined to nine territories. Conversely, the population within the BDANWR has been increasing in numbers and distribution areas over the last 6 years. In 2009 with a population of 19, this area became one of the most highly occupied reaches along the MRG and was again in 2010 and 2011 when the population more than doubled to 37 and 44, respectively.

5.3.2.2 Flycatcher Breeding Habitat Characteristics

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

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

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

Habitat patches comprised of native vegetation account for approximately half (44%) of the known flycatcher territories in the Southwest. As of the 2007 breeding season, rangewide, 50% of breeding territories occurred in mixed patches and 4% in patches > 90% exotic (Durst et al. 2008). In many cases, exotics are contributing significantly to the habitat structure by providing the dense lower-strata vegetation that flycatchers prefer (Sogge et al. 2002).

Data collected and analyzed on nest substrate and surrounding habitat patch communities in the MRG (from Reclamation nest monitoring activities from Velarde to Elephant Butte, primarily nests from areas: Sevilleta/La Joya, BDANWR and San Marcial) indicate that flycatchers may key in on areas dominated by native vegetation but often select exotic vegetation, particularly saltcedar as a nest substrate. Saltcedar actually may be the flycatchers' substrate of choice due to its dense and vertical twig structure. From 1999–2010, approximately 40% of 1,690 nests located in these river reaches were physically constructed on exotic plants (Russian olive [*Elaeagnus angustifolia*] 2.2% and saltcedar [*Tamarix* spp.] 38.0%) (Moore and Ahlers 2011). A very large percentage given that, in the MRG, between 1999–2010, 74 nests (4.4%) with known outcomes were in saltcedar-dominated territories; 1,283 (75.9 %) were in willow (*Salix*)-dominated territories; and 333 (19.7 %) were in mixed-dominance territories (Moore and Ahlers 2011).

The saltcedar leaf beetle (*Diorhabda* spp.)(beetle) was released in field cages in six States (California, Nevada, Utah, Texas, Colorado, and Wyoming) in 1999 and field released in 2001 (DeLoach et al. 2003). The beetles defoliate saltcedar during the growing season, which corresponds to the flycatcher breeding season, and take multiple years of continuous defoliation to eventually kill saltcedar (Paxton et al. 2011). The abundance of beetles may provide a temporary food source for flycatchers, however, once defoliation takes place it is likely that other foliage feeding insects would disperse (Paxton et al. 2011). With reduced canopy cover as well as food source, flycatchers occupying habitat composed of mainly saltcedar would be at a disadvantage.

At this time, the beetle has been observed as close as Highway 313 just north of Albuquerque. Within the MRG, flycatchers use saltcedar as a nesting substrate at a disproportionate rate, which is a concern due to the inevitable expansion of the beetle. However, the vast majority of flycatcher territories are in native-dominated stands, and the defoliation or mortality of a few saltcedar trees within those stands likely will not reduce overall habitat quality (Moore and Ahlers 2011).

5.3.2.3 General Habitat Description/Condition

Suitable and flycatcher occupied riparian habitat within the MRG from the Stateline to river mile 62 include dense stands of willows and other woody riparian plants adjacent to or near the river. Some areas along that same stretch of the MRG support local areas of suitable willow flycatcher habitat (using Hink and Ohmart vegetation classification), however no birds have been observed establishing territories—thus, indicating that suitable habitat is not a limiting factor.

For the purposes of this flycatcher baseline, the area from the Stateline to river mile 62 has been divided into reaches as follows: Rio Chama (Stateline to Confluence), Stateline to Otowi Bridge (a portion of which is outside the action area above Velarde); Cochiti Dam to Angostura Diversion Dam; Angostura Diversion Dam to Isleta Diversion Dam; Isleta Diversion Dam to Rio Puerco; Rio Puerco to San Acacia Diversion Dam; San Acacia Diversion Dam to Arroyo de las Cañus; Arroyo de las Cañus to San Antonio Bridge; San Antonio Bridge to River Mile 78; and River Mile 78 to River Mile 62.

In general, the bosque in the Stateline to Otowi Bridge and Cochiti Dam through Isleta Reaches contain mainly single-aged stands of older cottonwoods (*Populus* spp.) and lack the diversity of a healthy, multiaged riparian forest. Exotic vegetation such as Russian olive and Siberian elm also has become established. In many areas, significant channel narrowing and degradation have significantly limited overbank flooding and reduced the potential for recruitment of native riparian vegetation, especially cottonwoods and willows. There are some areas within this stretch that currently do have suitable habitat in the form of lower terraces with backchannels, native willows, and marsh like conditions.

Known flycatcher habitat in the Rio Puerco area (reaches from Isleta Diversion Dam through San Acacia Diversion Dam) occurs adjacent to the river and is dominated by coyote willow (*Salix exigua*), saltcedar, and Russian olive. The trend of channel narrowing and degradation reduces the amount of overbank flooding and the potential to enhance existing sites or establish new native vegetation.

From San Acacia to River Mile 78, habitat varies greatly from deep, incised channels with dry, high terraces consisting of mainly saltcedar vegetation to areas that experience overbank flooding in high flow events with cottonwood galleries and young native patches of vegetation. The vegetation is very mixed in this large area that typically is not occupied by flycatchers (with the exception of the area within the BDANWR) and also consists of mesquite, Russian olive, saltbush, quailbush, New Mexico olive, and a variety of other species.

Within the BDANWR, habitat varies from dense monotypic saltcedar to mature cottonwood galleries. Mature coyote willow and Russian olive also typically line the banks, which is where large populations of flycatchers have established territories within the past couple breeding season.

South of the BDANWR to river mile 62 consists of mainly saltcedar and Russian olive with mature cottonwoods interspersed. In areas south of the railroad trestle, habitat contains less saltcedar and Russian olive and contains larger quantities of mature cottonwood and willows. However, in recent years, these areas have become very dry; and the mature cottonwoods have been very susceptible to mistletoe (*Viscum album)*. Foliage in the canopy is now very sparse.

5.3.2.4 Suitable Habitat Classification

Development of a Geographic Information System- (GIS) based flycatcher habitat suitability model was initiated in 1998 for the MRG Basin and continues to be refined based on changes in hydrology and updated vegetation maps. Riparian vegetation in the MRG Basin between San Acacia Diversion Dam and Elephant Butte Reservoir had been classified using the Hink and Ohmart (1984) classification system through a cooperative effort with the U.S. Forest Service. This system identifies vegetation polygons based on dominant species and structure. Plant community types are classified according to the dominant and/or codominant species in the canopy and shrub layers.

During the summer and fall of 2002, as part of the Collaborative Program, Reclamation personnel updated vegetation maps from Belen to San Marcial using a combination of ground truthing and aerial photo analysis. During the summer of 2004, the conservation pool of Elephant Butte Reservoir was again aerially photographed (true color), and vegetation heights were remotely sensed using Light Detection and Ranging (LIDAR) methods. The area was ground truthed again during the summer of 2005. In 2008, the conservation pool of Elephant Butte Reservoir again was reviewed; and habitat mapping was updated based on ground-truthing and aerial photography flown in late summer of 2007. These areas are continually being reviewed as vegetation matures and develops in new areas so that components of the flycatcher habitat suitability model remain current.

In 2008, breeding habitat suitability was refined by identifying all areas that were within 50 meters of existing watercourses, ponded water, or in the zone of peak inundation. Using the vegetation maps and the flycatcher territories detected from 2006–2009, guidelines for categorizing each vegetation type into habitat suitability classes were established based on structure and density of vegetation. Factors used in making these determinations are explained below.

Suitable – Suitable habitat included vegetation in which a high percentage of flycatcher territories was detected. Areas with a significant structural component—primarily intermediate-sized trees (15-40 ft) with or without understory or stands with dense shrubby growth (5–15 ft)—also were considered suitable if a high percentage of territories occurred within the vegetation type. Other qualifying vegetation types were those that included a combination of important plant species, especially tree willows, coyote willows (particularly in the canopy layer), Russian olive, and saltcedar (however, not monotypic saltcedar) and also vegetation classes with a “d” qualifier, which indicated > 50% aerial vegetation cover.

Moderately Suitable – Moderately suitable habitat included vegetation in which a fairly high percentage of territories occurred from 2006–2009. Areas that provided a good structural component (primarily the same community types as described in suitable habitat) and occasionally community type 1, which consisted of tall/mature trees with well developed canopy (> 40 ft) also could be considered moderately suitable. This category required an adequate combination of vegetation species with at least 50% of the species composition made up of the more desirable plant species (those listed under “Suitable” habitat).

Unsuitable – Unsuitable habitat included vegetation in community types with tall/mature trees with or without understory (> 40 ft) or communities with very young and low growth. These were habitats in which vegetation was either too sparse or too mature, or the majority of the polygon consisted of the lower priority plant species. If fourwing saltbush (*Atriplex canescens*), honey mesquite (*Prosopis glandulosa*), screwbean mesquite (*Prosopis pubescens*), creosote (*Larrea tridentata*), or New Mexico olive (*Forestiera pubescens*) were a component of the classification, then the vegetation type was determined to be unsuitable.

Nonhabitat – Nonhabitat for SWFLs included five classifications, which were open areas with no woody overstory (e.g., open water or marsh) and human developments (e.g., roads and railroads).

Results from the study, entitled Southwestern Willow Flycatcher Habitat Suitability 2008, Highway 60 Downstream to Elephant Butte Reservoir, NM, indicated that tree willow was the most important plant species for providing flycatcher habitat. Over 20% of flycatcher territories from 2006–2009 were found in two habitat classifications: TW/TW-CW3 (tree willow overstory with a relatively dense understory comprised of tree willow and coyote willow) and TW/CW-SC3 (tree willow overstory with a relatively dense understory comprised of coyote willow and saltcedar); 78% of the vegetation types surrounding territories had a tree willow component.

Although saltcedar and Russian olive are invasive and often considered undesirable plant species, they do provide suitable habitat for flycatchers in the study area. Of all the territories, 43% had a saltcedar component, and saltcedar was the dominant species within 6% of the vegetation types in which territories were found. Russian olive was a component in 9% of flycatcher territories and dominated vegetation types in 5% of the territories.

Cottonwood was a component in 11% of the vegetation types that included flycatcher territories and was the dominant species in 6% of these vegetation types. Cottonwood and saltcedar were the dominant species in an equal percentage of the vegetation in which flycatcher territories were detected.

Although not within the action area, the vast majority of suitable habitat and flycatcher territories were found within the conservation pool of Elephant Butte Reservoir, which was a vital component in determining habitat suitability composition. There were 4,208 acres of suitable and moderately suitable flycatcher habitat mapped within this area, far beyond any of the other reaches. Areas near Sevilleta NWR/La Joya SWA provided the next highest amount of suitable and moderately suitable habitat with 796 acres. The development of such high quality habitat in the conservation pool of Elephant Butte Reservoir can be attributed to a decline in the reservoir levels, which exposed soils and provided moist sites for willow to establish. The suitability of this habitat for flycatchers was substantiated by the occurrence of 893 territories documented from 2006–2009, again far more than in any of the other reaches in the study area. The Sevilleta NWR/La Joya SWA area had 97 flycatcher territories from 2006–2009, which was second in territory numbers (Ahlers et al. 2010). Ultimately, the structure and density of flycatcher habitat are likely what are most attractive, rather than the plant species composition (Moore and Ahlers 2008, 2009)

Flycatchers (and many other species of neotropical migrant landbirds) use the Rio Grande riparian corridor as stopover habitat during migration. Studies have shown that, during the spring and fall migration, flycatchers more commonly are found in willow habitats than in other riparian vegetation types, including the narrow band of coyote willows that line the LFCC (Finch and Yong 1997). Presence/absence surveys during May have detected migrating flycatchers throughout the project area in vegetation types that would be classified as "unsuitable" for breeding habitat (Ahlers and White 1997).

5.3.2.5 Development and Status of Suitable Southwestern Willow Flycatcher Breeding Habitat Within the MRG

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

The Rio Grande and associated riparian areas historically have been a very dynamic system in constant change; without this change, the diversity and productivity decreases. Sediment deposition, scouring flows, inundation, and irregular flows are natural dynamic processes that occurred frequently enough in concert to shape the characteristics of the Rio Grande channel and flood plain. Flycatcher habitat historically has developed in conjunction with this hydrologically dynamic system where habitat was created and destroyed in a relatively short period of time. It is this type of dynamic, successional system that flycatchers depend on for the establishment and development of their breeding habitat. Through the development of dams, irrigation systems, and controlled flows, the dynamics of the river system have been eliminated except for localized areas such as within reservoirs where water storage levels frequently change with releases and inflows. It is no coincidence that flycatchers have expanded and dispersed within the delta of the Elephant Butte Reservoir. In previous years, this has been the only large scale area with this dynamic process in favor of flycatcher habitat expansion in the form of changing reservoir elevations. Cottonwoods and willows are aggressive colonizers of disturbed sites in a variety of ecological situations (Reichenbacher 1984).

The interaction of river discharge (timing and magnitude), river channel morphology, and flood plain characteristics are vital components that can favor the establishment of native vegetation and enhance the development of suitable willow flycatcher breeding habitat within the MRG. To recreate these dynamic processes in a very static river system, manmade procedures have been developed and implemented such as mechanical disturbance, herbicide treatments, prescribed fire, channel realignment, operational flows, avulsions, and river realignment. These manmade processes manipulate the river and flood plain in an attempt to restore the diversity of a healthy river system.

Successful cottonwood and willow recruitment has been shown to coincide with the descending limb of the spring runoff hydrograph. The timing and rate of decline of receding flood flows such as those that occur at the conservation pool of Elephant Butte have been documented as important factors affecting seedling survival (Sprenger et al. 2002). Newly scoured area of the river channel or flood plain and areas where sediment has been deposited also provide conditions for regeneration of native species and can stimulate vegetation health. An example of this was the sediment plug in the BDANWR in 2008 and the response to that event by the large increase in suitable habitat and flycatcher territories.

Habitat modeling throughout the MRG (including areas south of the action area) has shown that there currently is suitable unoccupied habitat, thus indicating that habitat availability is presently not a limiting factor to this population. The reason that flycatchers do not expand into all areas of suitable habitat is possibly a result of their relatively strong site fidelity. However, the availability of suitable habitat is likely to decline over the next few years, particularly within the conservation pool of Elephant Butte Reservoir due to natural succession, extended flooding from the LFCC, and channel degradation in the Rio Grande. The distribution of flycatcher territories within the MRG has shifted and will continue to shift in response to these habitat changes.

5.3.3 Pecos Sunflower

In the Middle Rio Grande, the main Pecos sunflower population presently exists within the La Joya SWA, a unit of the Ladd S. Gordon Waterfowl Complex. This is one of the largest populations of *H. paradoxus*, consisting of 100,000 to 1,000,000 plants. This property is owned by the New Mexico State Game Commission. It is managed by the NMDGF for migratory waterfowl habitat, which is compatible with preservation of wetlands for *H. paradoxus*.

This site was first discovered in 2004 and has been found to be occupied every year since then. It represents one of the largest populations of *Helianthus paradoxus* in the range of the species (Hirsch 2006). The site contains all of the PCEs in the appropriate spatial arrangement and quantity but is threatened by encroachment of nonnative vegetation.

First discovered in 2004, this population is located in an area distinct from any other population in the range of the species. As such, it may contain genetic variation not found anywhere else in the range of the species. The La Joya SWA was excluded from the critical habitat designation for *H. paradoxus* due to the development of a habitat management plan that adequately protects the species (NMDGF 2007). The management plan is to support conservation of the species on the La Joya SWA by: (1) annually controlling invasive species, (2) protecting the natural spring in Unit 5 from motorized vehicles and heavy equipment, (3) monitoring core populations by digitizing these areas annually, (4) conserving *H. paradoxus* by adjusting invasive species treatment area boundaries, and (5) restoring native habitat through re-vegetation.

In accordance with the management plan, NMDGF maps core sunflower population areas annually (table 3). Areas that contain a mix of Pecos and annual sunflower are not mapped. Conservation measures include avoiding herbicide use within delineated core population areas. In 2008, seeds from the La Joya population were used to establish a new population on a private land area. Initial surveys of this area indicate that the population has established itself.

Table 3. Acreage of core Pecos sunflower population on La Joya SWA

Year	Acres Mapped
2004	66
2005	143
2006	159
2007	160
2008	209
2009	262
2010	262
2011	224

Source: J. Hirsh NMDGF Records.

Additionally, in 2010, a ditch that delivers water from Pond 3 to Pond 4 on La Joya SWA was cleared of salt cedar. Part of the cleared area was seeded with a mix of Pecos sunflower and annual sunflower. In 2011, Pecos sunflower and annual sunflower re-colonized the disturbed ground. Most of these areas are located adjacent to the La Joya Ponds.

5.3.4 Interior Least Tern

As previously mentioned in the Status and Distribution section of this analysis, the interior least tern can be considered a vagrant on the MRG and no interior least tern nesting has been recently documented (Service 1995). According to the recovery plan from the Service in 1990, the only documented breeding along the Rio Grande takes place in Texas, and the only documented breeding within the state of New Mexico can be found on the Pecos River (Service 1990), similar conclusions are drawn in the complete rangewide survey collected in 2005 (Lott 2006). Due to the low potential for occurrence and that the interior least tern likely only would be present infrequently and/or temporarily (i.e., during migration), the interior least tern would likely not be affected by the project; and no further analysis will be completed on behalf of the species.

5.4 Hydrologic Regime

This section provides the hydrologic setting of the MRG and shows the following:

- The water supply to the MRG is limited and highly variable.
- Modifications have been made to the timing, distribution, and magnitude of flows in the MRG for purposes of flood control and maximization of the beneficial use of water, and include.
    - Suppression of large, channel-forming flows by flood-control dams.
    - Redistribution of flows by water storage reservoirs, so that water is available for water supplies and, consequently, for river flows during the irrigation season.
    - Diversion of surface water and drain flows for irrigation, which decreases the flow in the river.
    - Pumping of ground water, so that significant ground water drawdowns have developed, and the ground water system now draws water from the river.

The hydrologic changes documented in this section are interconnected with the other changes that have occurred in this system, primarily geomorphic changes to the river channel, as discussed in the following section. Because of these geomorphic changes, the current hydrology is not sufficient to provide overbank flows in the upstream portions of the MRG. In the Angostura Reach, significant overbank flows begin to occur at flows above 6,500 cfs (figure 21). However, the maximum releases from Cochiti under its flood control rules are 7,000 cfs. Therefore, the available hydrologic operations have a very limited ability to provide significant overbank flows, which are important to the life cycle of the silvery minnow.

In the more downstream reaches, potential for overbank flows is more widespread, but diversions from the river decrease the flows that are conveyed to these reaches, and perching of the river channel makes it less likely that this channel will be able to maintain the flows that it receives from upstream. Frequent drying of the more downstream reaches of the MRG after the snowmelt runoff limits the degree to which they can support the postspawn survival of the silvery minnow.

This subsection begins with a discussion of the water and river operations over the past decade, organized geographically from north to south, and concludes with the current hydrologic conditions.

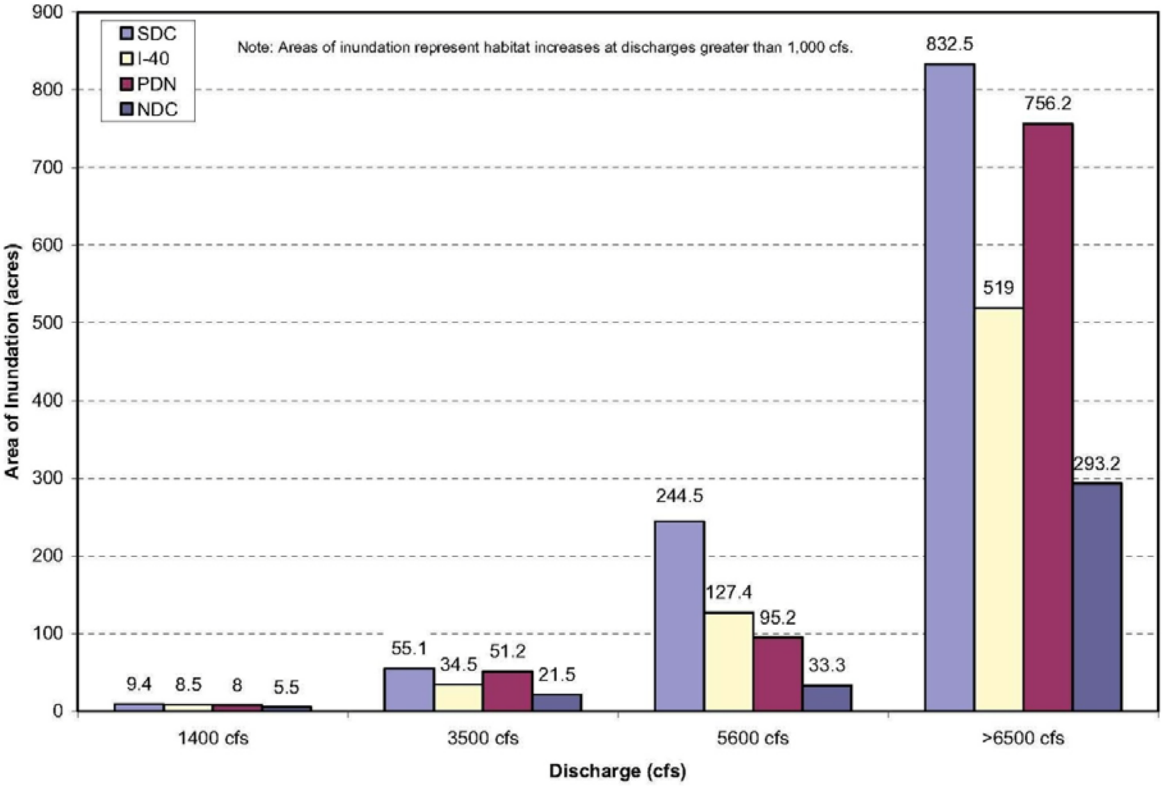


Figure 21. Bar graph showing area of overbank inundation in four subreaches of the Albuquerque Reach (the South Diversion Channel (SDC); Interstate 40 (I-40); Paseo del Norte (PDN), and North Diversion Channel (NDC) subreaches) prior to habitat restoration efforts by the Collaborative Program (Mussetter Engineering, Inc. 2006).

5.4.1 Baseline Water Operations

The term “water operations” describes the human operations of dams and diversions and activities that put water to beneficial use. Five types of water operations are implemented, often simultaneously, within the MRG system: 1) flood control; 2) irrigation; 3) municipal and industrial diversion, use, and return flow; 4) environmental operations; and 5) recreational/rafting.

5.4.1.1 An Overview of MRG Water Management Facilities and Operations

The MRG is an engineered system. River flow and water movement throughout the Rio Chama and MRG are constrained by the physical capabilities and existing authorities associated with the system’s water management facilities, operations, and policies. The MRG is affected by Colorado State line Compact deliveries, Rio Chama and other tributary inputs, imported SJC Project waters, the Corps’ flood control reservoirs along the Rio Chama and Rio Grande, and the MRG Project, all of which contribute to or regulate flows along the Rio Chama and the MRG.

Figure 22 is a schematic representation of the Rio Chama and Rio Grande that shows the major facilities and/or entities that impact flows in the MRG—from Heron Reservoir operations at the top to the Bosque Del Apache Wildlife Refuge at the bottom.

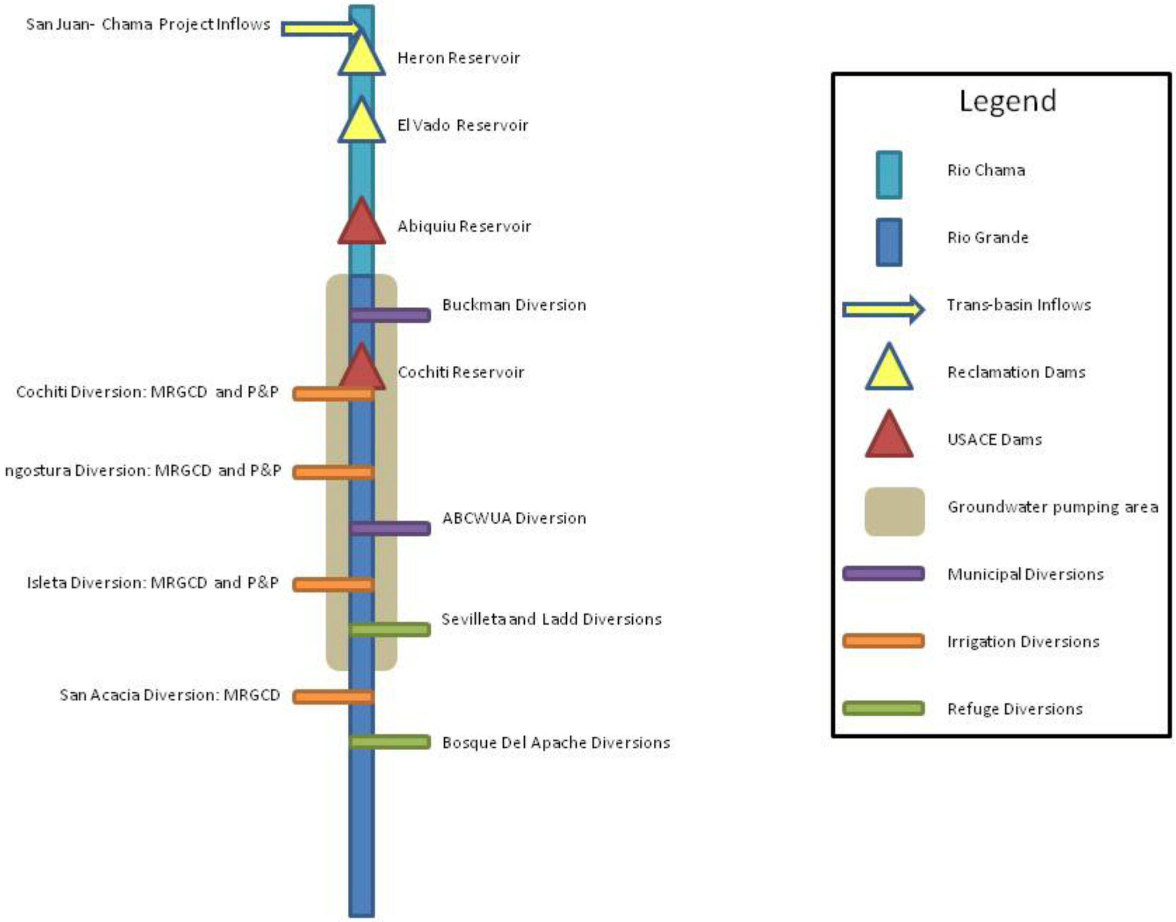


Figure 22. Schematic representation of major water facilities impacting river flows in the Middle Rio Grande.

The major Federal reservoir facilities within the action area include the following:

- Rio Chama
    - Heron Dam Reservoir (owned and operated by Reclamation as part of the SJC Project)
    - El Vado Dam Reservoir (owned and operated by Reclamation as part of the MRG Project)
    - Abiquiu Dam and Reservoir (owned and operated by the Corps for flood control and SJC Project storage)

- Rio Grande
  - Cochiti Dam and Lake (owned and operated by the Corps for flood control)
- Off-Channel
  - Jemez Canyon Reservoir (owned and operated by the Corps for flood control)
  - Galisteo Dam (owned and operated by the Corps for flood control)

Heron Dam and Reservoir are located on Willow Creek, a tributary of the Rio Chama. Reclamation operates Heron Reservoir to manage imported SJC Project waters and passes all native Rio Grande flows. Reclamation operates El Vado Reservoir to store native Rio Grande water, when allowed by the Compact, for use in the MRG Project service area by non-Indian farmers and the Six MRG Pueblos. Reclamation stores native Rio Grande waters for prior and paramount water needs pursuant to the 1981 Agreement and discussed below. When space is available, El Vado also may store SJC Project water. Abiquiu Reservoir is authorized for flood control, sediment control, and storage of both SJC Project and native Rio Grande waters. However, storage of native Rio Grande water in Abiquiu is rare.

Very little native Rio Grande flow is actually captured and stored in the major reservoirs in this system. On average, only 100,000 AF of native Rio Grande water (less than 10% of annual average flow at Otowi gage) is historically stored (even temporarily) upstream of Elephant Butte Reservoir. The vast majority of combined storage in Heron, El Vado, Abiquiu, and Cochiti Reservoirs is imported SJC Project water (Flanigan, et al. 2007).

Rio Grande flows at Otowi gage, which is located just downstream from the confluence of the Rio Chama, consist of unregulated main stem Rio Grande flows crossing the border from Colorado and discharges from reservoirs along the Rio Chama, including both native Rio Grande watershed inputs and imported SJC Project waters. Cochiti Reservoir is the sole main stem reservoir capable of regulating these native Rio Grande flood flows. Native Rio Grande spring runoff from April–June typically is allowed to pass through Cochiti Dam unregulated, with the exception of peak flows that exceed safe channel capacity. Abiquiu Reservoir is the primary flood control reservoir along the Rio Chama, and the Jemez Canyon and Galisteo provide flood control on the Jemez and Galisteo Rivers, respectively—tributaries that discharge to the MRG. Releases from the other water supply reservoirs along the Rio Chama (i.e., Heron and El Vado Reservoirs) typically occur later in the year, from May—October, depending on irrigation demand and the need for available Supplemental Water to meet environmental flow requirements.

Water management reaches differ slightly from river maintenance geomorphic reach designations and are primarily defined by locations of mainstream irrigation diversion dams (figure 23). The upper reaches are similar to the river maintenance designations. The Cochiti Reach extends from Cochiti Dam to Angostura Diversion Dam. The reach from Angostura Diversion Dam to Isleta Diversion Dam is called the Angostura Reach (this reach is interchangeably known as the Albuquerque Reach). The Isleta Reach is bounded upstream by Isleta Diversion Dam and downstream by San Acacia Diversion Dam. Water management defines only one reach below San Acacia Diversion Dam to the full reservoir pool of Elephant Butte Reservoir, known as the San Acacia Reach whereas there are several geomorphic designations within this reach.

The Low Flow Conveyance Channel is a 54-mile long riprap-lined channel that parallels the Rio Grande on the west side and originally extended from San Acacia Diversion Dam to the narrows of Elephant Butte Reservoir but now ends approximately at river mile 60. The LFCC was constructed to aid delivery of Compact water and sediment to Elephant Butte Reservoir and serves to improve drainage of irrigated lands and provide additional water for irrigation by collecting water draining from farmland. The LFCC is owned, operated, and maintained by Reclamation.

New Mexico water law follows the Doctrine of Prior Appropriation, which gives senior water users a better right than junior water users in times of shortage. Under the doctrine, priority of water rights is determined through a stream system adjudication in a court of law. Water rights in the MRG have not yet been adjudicated to determine their nature and extent, and the waters of the MRG are fully appropriated.

5.4.1.2 San Juan-Chama Water Operations

The SJC Project operations augment the Rio Grande water supplies through transbasin diversion of Colorado River water. SJC Project water must be consumptively used in New Mexico and cannot be used for deliveries under the Compact.

Figure 24 provides a summary of annual SJC Project diversions, which enter to the Rio Grande system via the Azotea Tunnel, annual inflows of SJC Project water to El Vado Reservoir, and annual amounts of water conveyed at the Otowi gage for consumption in the MRG.

During the 11-year period shown in figure 24, an annual average of about 61,550 AF of SJC Project water passed the Otowi gage in response to downstream demand by SJC Project contractor requests and Reclamation Supplemental Water Program releases. The remainder of SJC Project water remained stored in MRG reservoirs, especially El Vado and Abiquiu, as shown in figure 25.

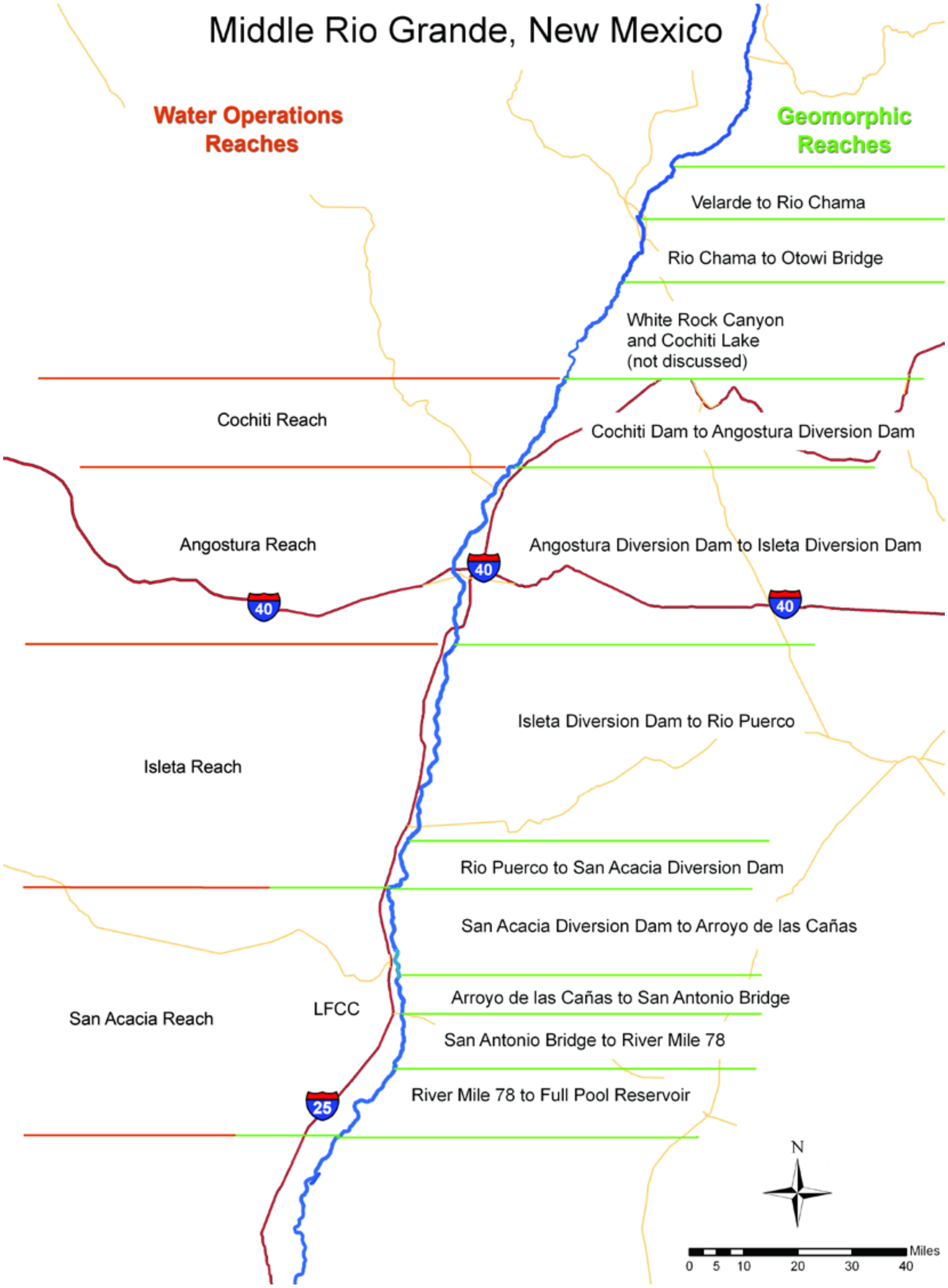


Figure 23. Geomorphic reach designation.

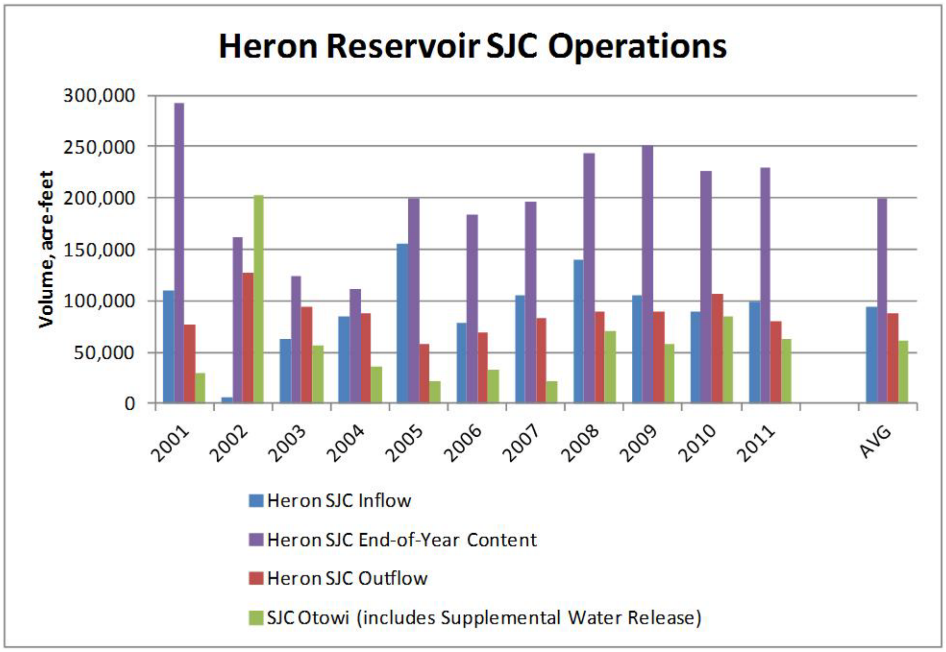


Figure 24. Summary of annual Heron Reservoir operations under the San Juan-Chama Project, including inflows, outflows, and storage of SJC Project water and annual amounts of San Juan-Chama Project water crossing the Otowi gage for consumption within the MRG.

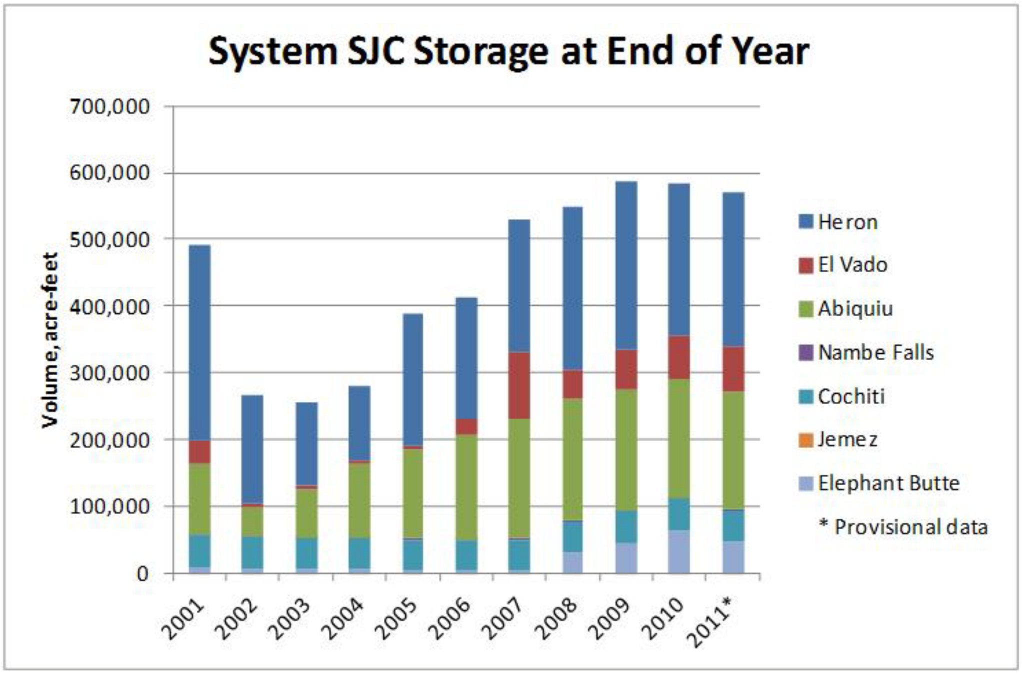


Figure 25. Summary of end-of-year storage of SJC Project water in Middle Rio Grande reservoirs.

5.4.1.3 El Vado Storage and Release Operations

Water storage dams, such as El Vado Dam, are managed to store and release water in a way that alters the spring hydrograph by scalping the peaks off the hydrographs and providing water when natural flows are lower and water needs are higher—times when the natural flows might not otherwise provide sufficient water to meet all the water needs.

Figure 26 presents a summary of storage and release activities at El Vado Reservoir over the past 11 years and visually shows the ways that El Vado Dam operations have affected the Rio Chama hydrograph. When Article VII storage restrictions under the Compact (as discussed in section 5.4.1.1) are not in effect, the peak inflows to El Vado Reservoir, shown in blue, tend to be larger than, and occur before, the peak outflows from the reservoir. In the summertime, the outflows from storage tend to exceed the inflows to the reservoir. This outflow from storage may be evident even when Article VII restrictions are in effect, due to releases of water stored earlier, when storage restrictions were not in place. Heron Dam outflows are also shown on figure 26. These flows represent San Juan-Chama water, the non-native portion of the flow that passes through El Vado.

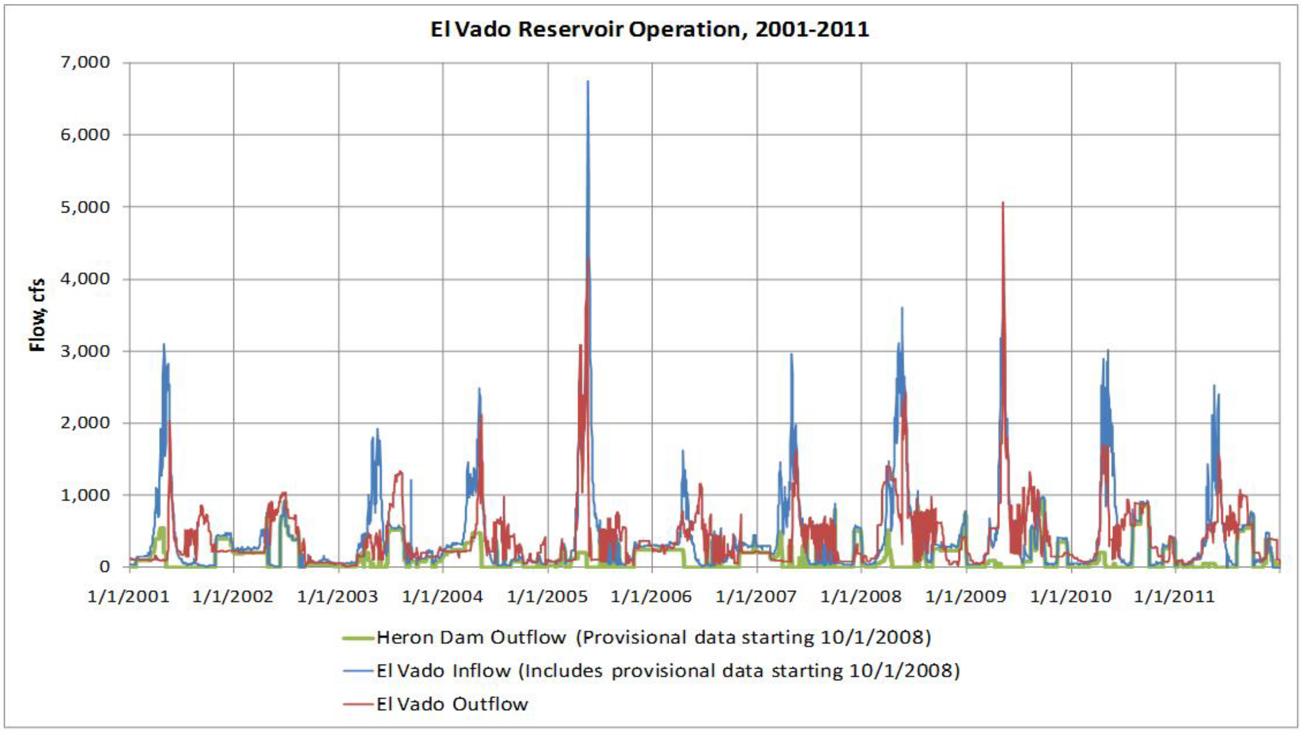


Figure 26. Hydrograph depicting El Vado Reservoir operations, 2001–2011, including a comparison of Heron Dam outflow, El Vado Reservoir inflow, and El Vado Dam outflow.

These relationships can be seen more clearly for the annual hydrograph, for 2007, an example year with a typically-shaped spring hydrograph, shown in figure 27. The difference between the Heron Dam outflow (green line) and the El Vado Reservoir inflow (blue line) represents the native inflow from the Rio Chama. The difference between the El Vado Reservoir inflow (blue line) and the El Vado Dam outflow (red line) shows the ways in which the operation of El Vado Dam affected the hydrograph of the Rio Chama.

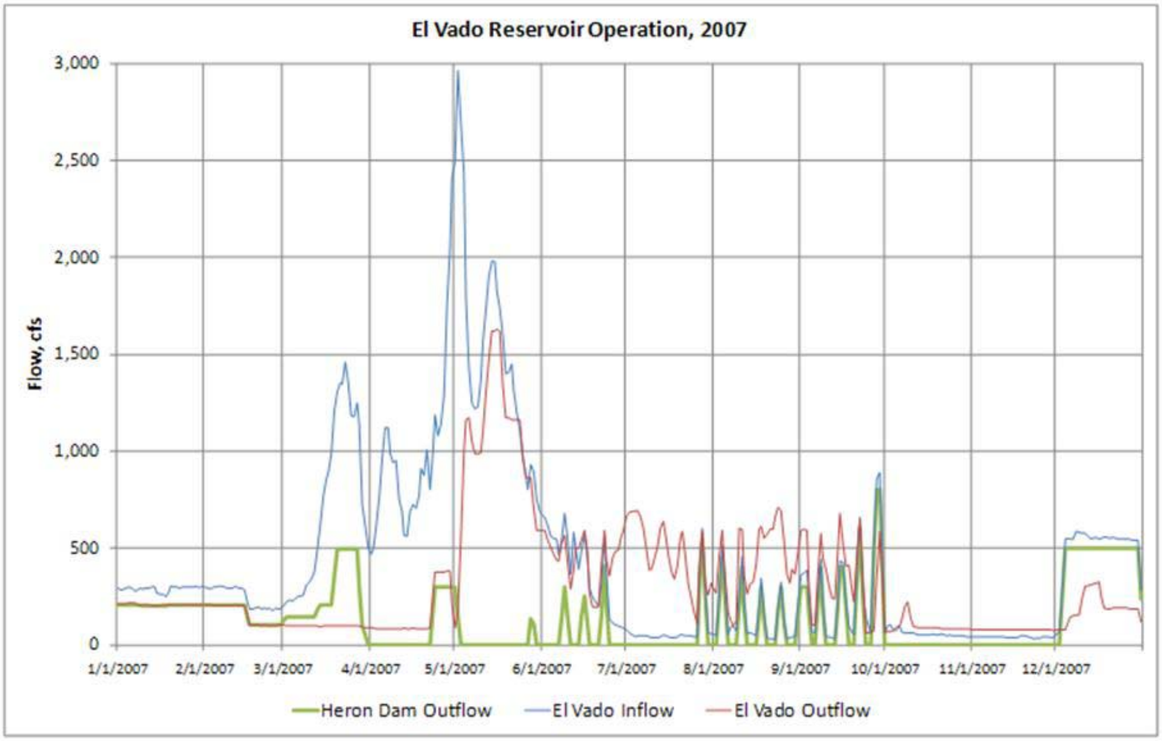


Figure 27. Comparison of Heron Dam outflow, El Vado inflow, and El Vado outflow, 2007.

Releases of stored water from El Vado are made at the request of the MRGCD, as needed to meet MRG irrigation demand, or, when the MRGCD is under shortage operations, by the Bureau of Indian Affairs as needed to meet the irrigation demand of the lands of the Six Middle Rio Grande Pueblos with prior and paramount water rights. MRGCD operations are described in more detail section 5.4.2.9 below.

5.4.1.4 Flood Control Operations

The Corps owns and operates Abiquiu and Cochiti Dams, which are primarily used for flood control, and is consulting separately on the effects of its actions. Flood control dams affect flows in the river by storing and releasing water in a manner that decreases flood peaks but does not cause significant changes in the shape of the hydrograph or in the annual total flow volume (Corps et al. 2007). The flood control dams in the Middle Rio Grande system are operated to pass all inflows except those that exceed a designated safe channel capacity downstream from the dam, currently 1,800 cfs below Abiquiu Dam and 7,000 cfs below Cochiti Dam.

Figure 28, below, displays the inflow to and outflow from Cochiti Reservoir over the past decade. The general character of each annual hydrograph is similar, indicating that the dam operations do not fundamentally change the character of the hydrograph, except in removing flows that exceed 7,000 cfs, the designated safe channel capacity in the Middle Rio Grande. When inflow exceeds this designated safe channel capacity, releases are cut to below 7,000 cfs, and the duration of the high flow event is extended until the floodwaters have been released. Such an operation can be seen in 2005 during the snowmelt runoff, but at no other time during the past decade.

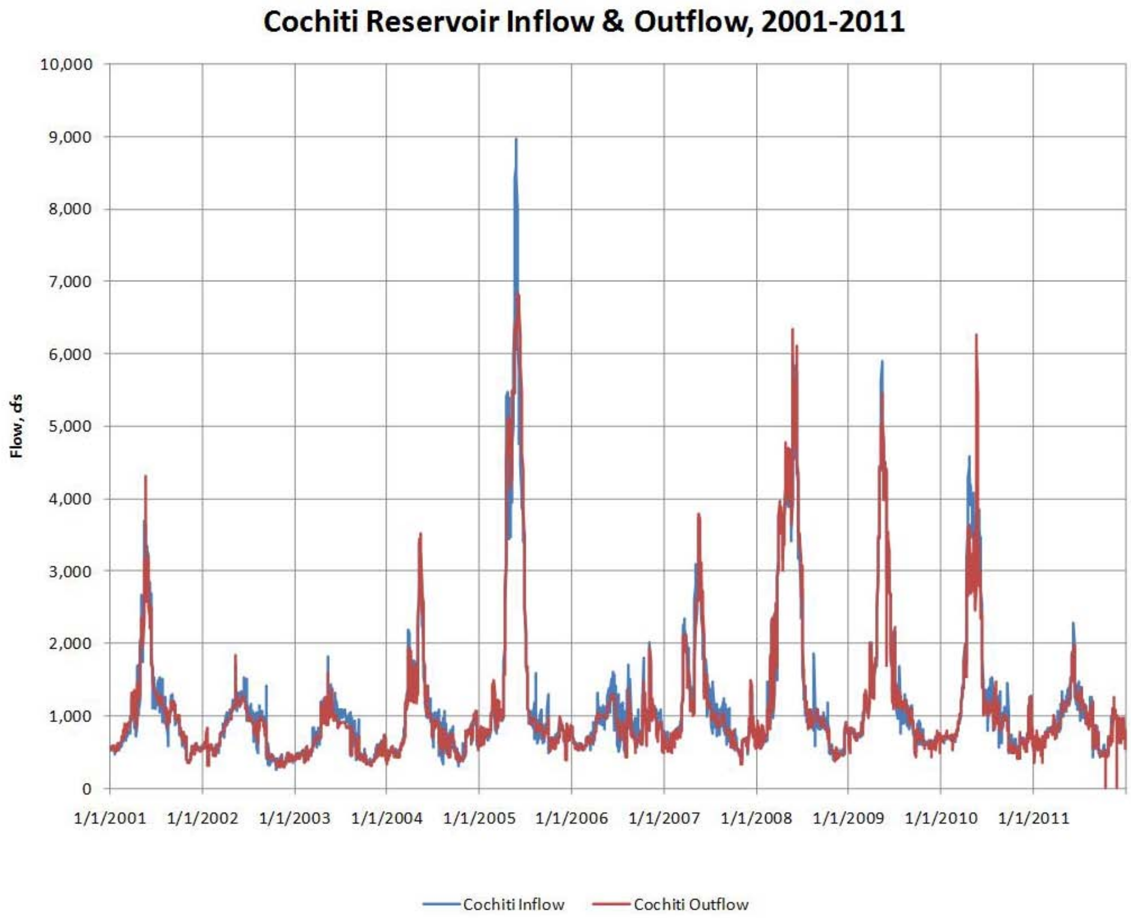


Figure 28. Comparison of inflow to and outflow from Cochiti Reservoir, 2001–2011, showing flood control operations in 2005.

Figure 29 presents a comparison of inflow and outflow hydrographs for Cochiti Reservoir for 2005 only. This comparison provides detail on the changes to the hydrograph caused by the spring 2005 flood control operations.

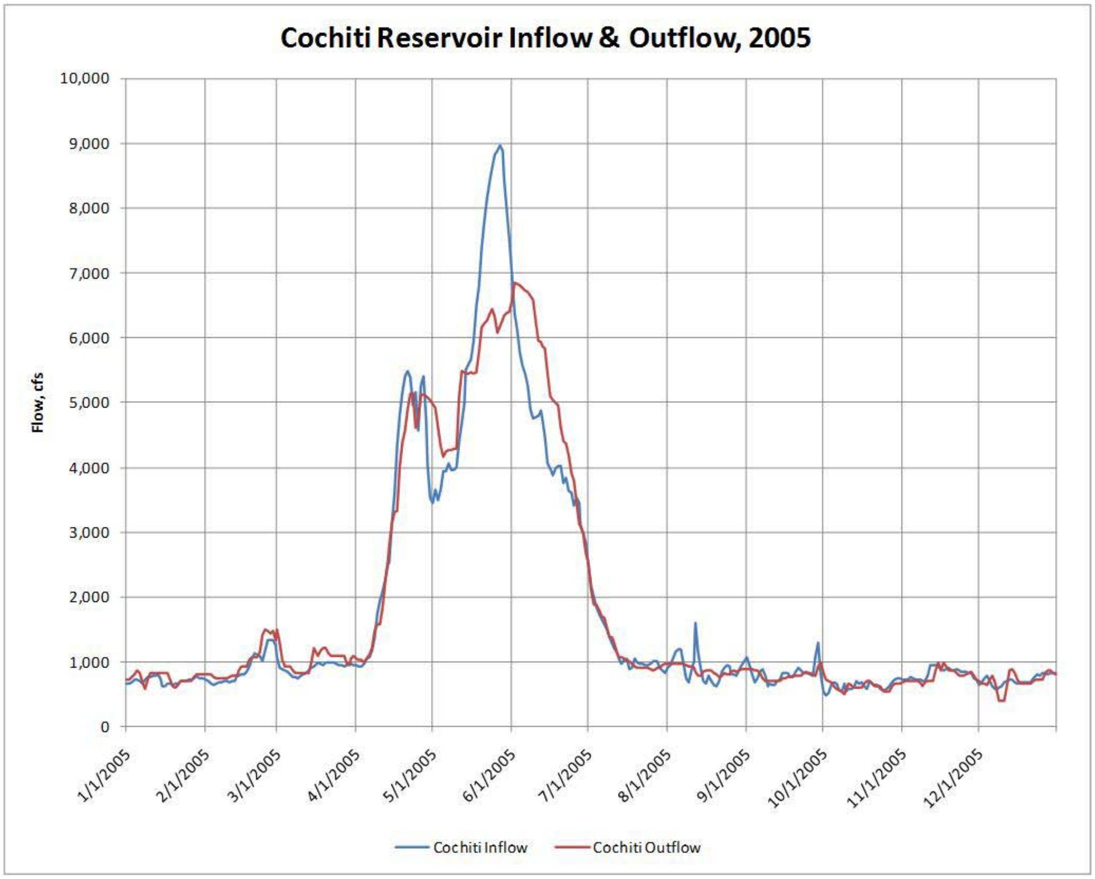


Figure 29. Comparison of inflow to and outflow from Cochiti Reservoir, 2005, showing flood control operations.

Figure 30 shows the inflow to and outflow from Abiquiu Reservoir over the past decade. The designated safe channel capacity below Abiquiu Dam is only 1,500–1,800 cfs, due to capacity restrictions in the reach directly below the dam, as well as the presence of numerous rock and brush diversions in the vicinity of Chamita (Corps 1996 [Water Control Manual]). The effects of flood operations, therefore, are more apparent on the hydrograph, and can be seen in 2001, 2004, 2005, 2008, 2009, and 2010. These flood control operations prevent the flows on the Rio Chama from significantly contributing to overbank or recruitment flows in the MRG.

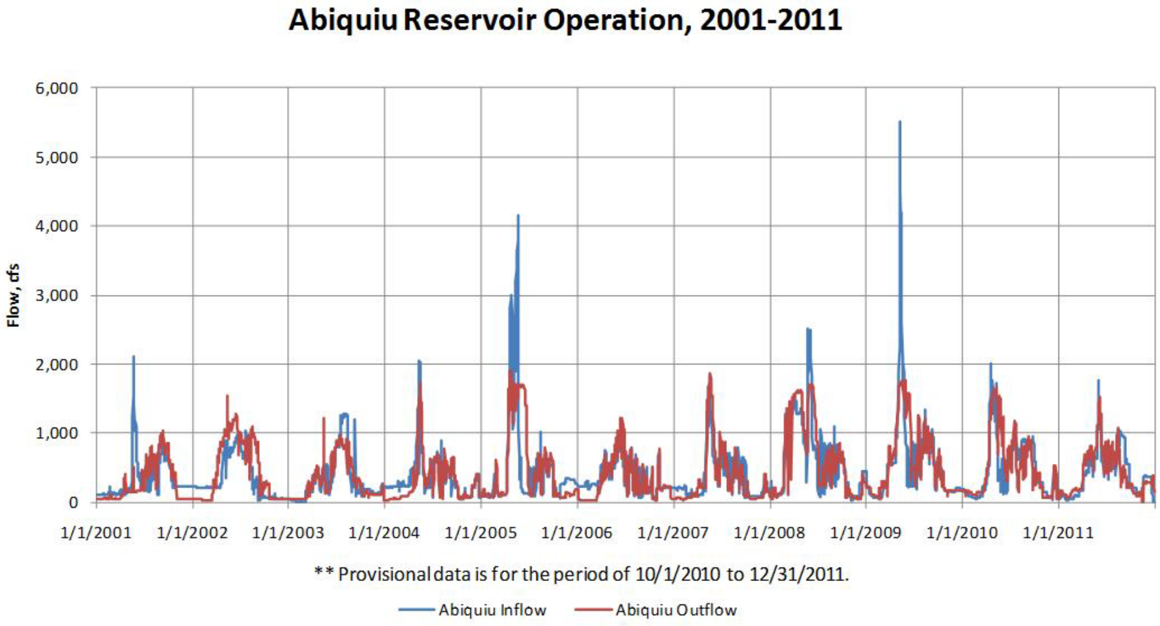


Figure 30. Comparison of inflow to and outflow from Abiquiu Reservoir, 2001–2011, showing flood control operations in 2001, 2004, 2005, 2008, 2009, and 2010.

5.4.1.5 Santa Fe's Buckman Direct Diversion

The city and county of Santa Fe use their SJC Project allotments and native Rio Grande water to support their water supply utilities through the Buckman Direct Diversion Project (Buckman Project). The Santa Fe National Forest, in concert with the city and county of Santé Fe, consulted with the Service (Consultation #22420-2006-F-0045) on the construction and operation of this project. The Service identified reasonable and prudent measures (RPM) that would minimize the incidental take resulting from this project and determined that this action, along with the proponents' environmental commitments and the Service's Reasonable and Prudent Measures, likely would not jeopardize the continued existence of the silvery minnow and will not adversely modify its designated critical habitat (Service 2007c).

The city and county of Santa Fe have initiated, under the Buckman Project, direct use of their 5,605 AFY allocation of SJC Project and native Rio Grande water to supplement their other water supplies. The partners have been diverting water to the Buckman Project from the Rio Grande since January 2011. Performance and acceptance testing was performed in April 2011, and operation was turned over from the design and construction contractor to the city, as the current project manager, for full operations in May 2011.

The current Record of Decision from the Buckman Project Environmental Impact Statement allows the Buckman Project to divert an annual average diversion of 12.06 cfs, which includes 7.75 cfs of SJC Project water and 4.31 cfs of native Rio Grande water. The Buckman Project's peak day capacity is 28.2 cfs. Additionally, up to 4 cfs of carriage water is diverted and is returned to the river, along with diverted river sediment, immediately downstream from the diversion structure. The Buckman Project is intended to divert water year-round.

Consistent with the terms of the ESA consultation, the Buckman Project will curtail diversions of native water at times when the native Rio Grande flow at Otowi gage is less than 325 cfs and will cut off all diversions of native water if the native Rio Grande flow at Otowi gage is less than 200 cfs. Curtailment when Otowi flows are between 200 and 325 cfs will be scaled by linear interpolation. Under these conditions, the project still can divert its allocation of SJC Project water. When Abiquiu Reservoir is under flood operations, the Buckman Project will not call for release of its SJC water from upstream reservoirs and instead use either native Rio Grande water or exchange and divert SJC water stored in Elephant Butte. Additional environmental commitments associated with the construction and operation of this project, which include restoration, maintenance, and monitoring of riparian and riverine habitat, are spelled out in the Record of Decision for the project, found at http://www/bddproject.org/reports.htm.

5.4.1.6 Cochiti Deviations

In 2007, the Rio Grande Compact Commission approved deviations from the Corps' normal reservoir operation schedule (as specified in its Water Control Manual) to support minnow spawning and recruitment. Such deviations from normal operations were implemented in 2007 and 2010, in coordination with the Service and Federal and non-Federal water management agencies. Such deviations from normal operations of Cochiti Dam to support overbank or recruitment flows have been approved by the Corps and, therefore, may be implemented as deemed appropriate, through 2011, with the option of a 2-year extension to 2013. The Corps has completed consultation with the Service under Section 7 of the ESA for Cochiti deviations and is operating pursuant to its biological opinion.

During a "Cochiti deviation," waters on the ascending limb of the spring runoff hydrograph are held back and temporarily stored in Cochiti Lake in an amount sufficient to allow the desired discharge volume and duration during peak flows when these waters are released. In this way, the Corps is authorized to temporarily store up to 10,000 AF of water in Cochiti Reservoir.

A deviation was implemented in 2007 to create a minnow spawning and recruitment flow of over 3,000 cfs, as measured at the Central Avenue (Albuquerque) gage, for a period of 7–10 days. The deviation operations produced an extended peak runoff flow resulting in 26 days above 2,500 cfs and

10 days above 3,000 cfs at Albuquerque. In 2010, a deviation was implemented to achieve an overbank flow of 5,800 cfs at the Central Avenue gage for 5 days. However, only a 2-day overbank flow of this magnitude was achieved. Annual hydrographs displaying the effects of the 2007 and 2010 Cochiti deviations are presented in figures 31 and 32.

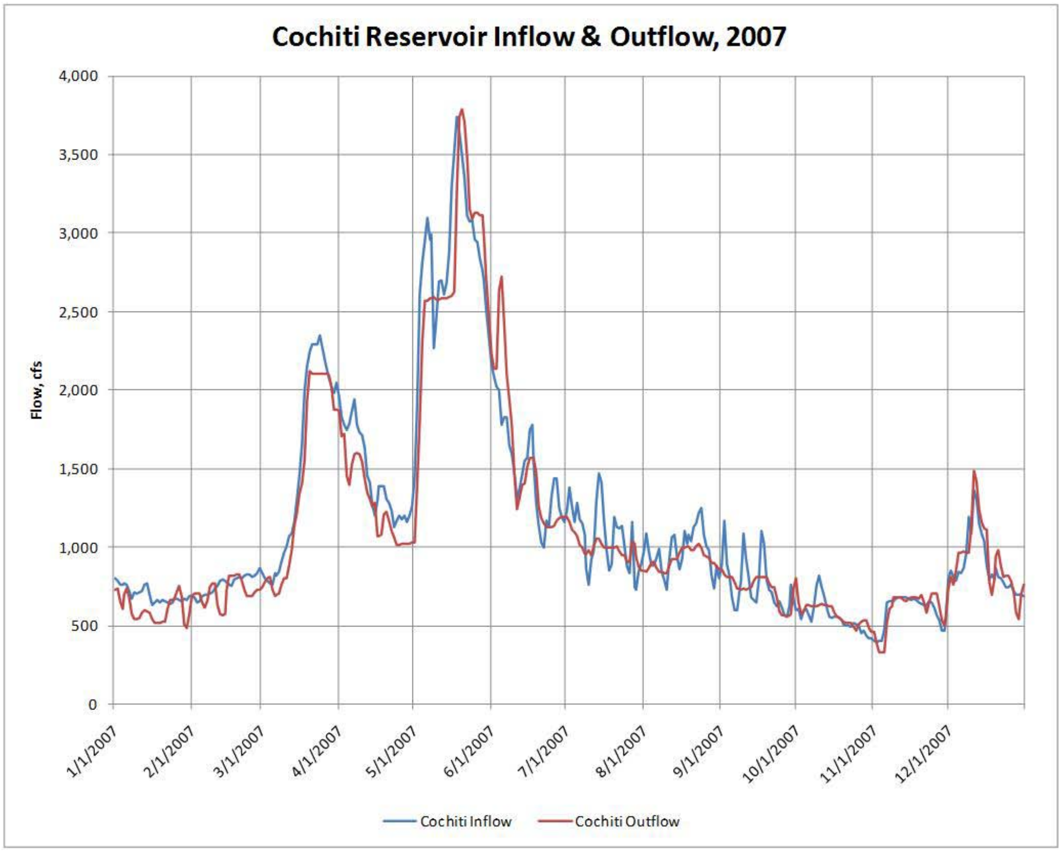


Figure 31. Comparison of inflow to and outflow from Cochiti Reservoir, 2007, showing the effects of “Cochiti deviation” operations.

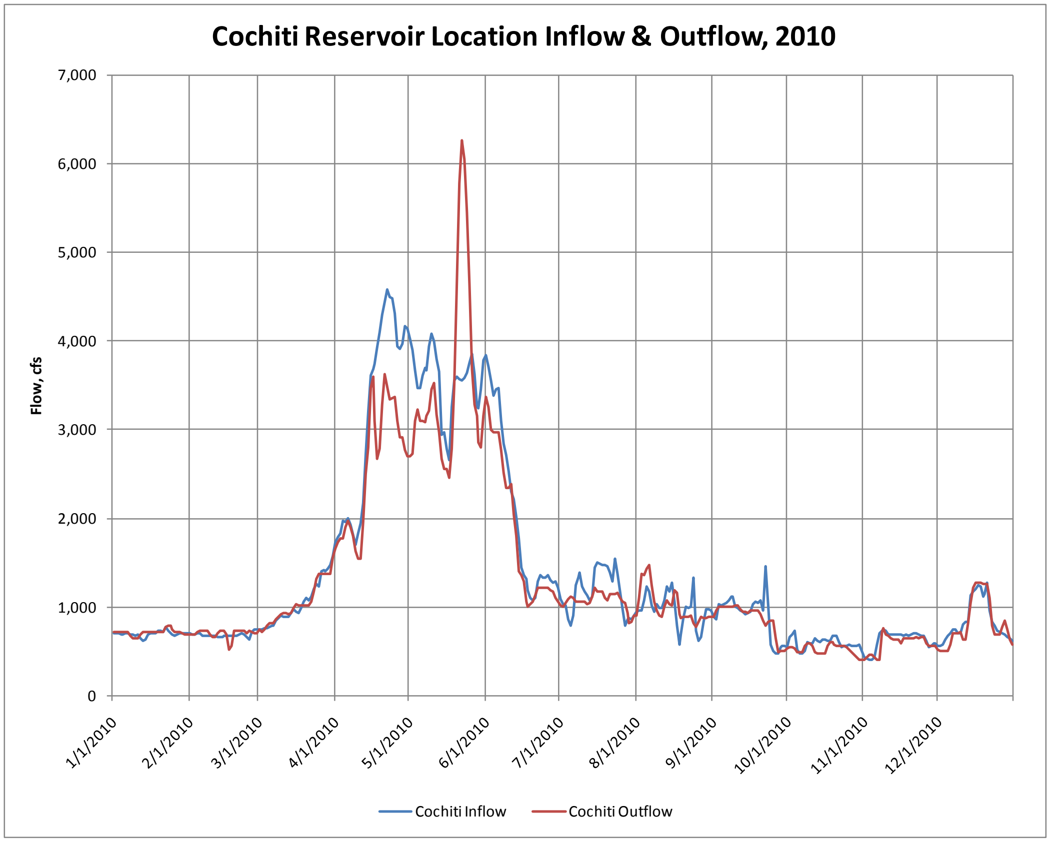


Figure 32. Comparison of inflow to and outflow from Cochiti Reservoir, 2010, showing the effects of "Cochiti deviation" operations.

5.4.1.7 Ground Water

Since the 1940s, population growth, combined with technological improvements in well drilling and pumping, have led to dramatic increases in ground water pumping in the MRG, primarily for domestic, municipal, and industrial use (McAda and Barroll 2002). As of 1999, it was estimated (Bartolini and Cole 2002, after MRG Water Assembly, 1999) that 170,000 acre-feet per year are pumped from the river-connected aquifer in the MRG, up to 110,000 of which were pumped by the ABCWUA for use in Albuquerque and Bernalillo County (ABCWUA 2010 [accessed March 2011]), although ABCWUA has now cut back that pumping to near half that amount, as it phases in use of its SJC Project water. This pumping has caused ground water drawdowns of up to 160 feet in some areas of Albuquerque (McAda and Barroll 2002). Ultimately, the water pumped is made up for by seepage from the river into the ground water system. Recharge from the river to the aquifer through the MRG was estimated in 1999 to total 295,000 acre-feet per year.

The NMOSE has calculated the depletions caused to the river by ground water pumping, and requires that the entities who do the pumping replace the water volume to the system, including the river and other affected users, through return flows, the purchase of water rights, or repayment of the water from upstream storage using SJC Project water.

The NMOSE provides Reclamation with letters describing, for each pumper, the time period of depletions from the river, the volume of water depleted from the river, and a deadline for the pumpers to release SJC Project water to replace that which was lost from the river and was not offset through the purchase of water rights or through return flows to the river. The depletions are described by the NMOSE as cumulative effects on Elephant Butte Reservoir (and, therefore, to New Mexico's deliveries under the Compact) due to depletions above and/or below the Otowi gage and cumulative effects on the Rio Grande in the MRG above and/or below the Otowi gage. Depletions that occur during the irrigation season are considered effects on the MRG and are replenished by releases to the MRGCD, which has the right to divert that flow. Depletions that occur outside of the irrigation season are considered effects on Elephant Butte Reservoir and are replenished to the Rio Grande.

The replacement SJC Project water requested by the NMOSE is released from reservoirs on the Rio Chama. If the depletion is deemed to have affected the MRGCD, the MRGCD can request to have the water stored or released to the Rio Grande for use in irrigation. If the depletion is deemed to have affected Elephant Butte Reservoir, the water is released to the Rio Grande, to be delivered to Elephant Butte Reservoir. Reclamation has received letters from the NMOSE requesting releases to replace water depleted over the current, previous, and sometimes 3 previous years. The depletions occur gradually and are replaced by an equivalent volume over a short period, typically 1–10 days. These short duration replacements typically occur months to years after the depletion. Total volumes of the depletions made up through "letter-water" deliveries of SJC Project water over the 2001–2010 period ranged from 1,000–7,000 AFY. At the end of 2010, the State Engineer requested releases for the following contractors to offset 2009 depletions: 93 AF for the city of Espanola, 161 AF for the village of Los Lunas, 13 AF for the town of Taos, 6 AF for village of Taos Ski Valley, 47 AF for the city of Belen, and 2,024 AF for the ABCWUA.

5.4.1.8 Water Right Transfers

As discussed in section 3, the NMOSE has jurisdiction over water rights administration in New Mexico, and water rights are alienable private property rights that can be conveyed like other property rights. The majority of water rights sold in the MRG have been purchased by large corporate entities, such as developers or the cities of Rio Rancho and Albuquerque. Other purchasers include some primary income farmers who purchase water rights or additional agricultural land to expand operations, as well as private entities involved in water intensive activities, such as residential developers, utilities, and technology. The transfer of land and water from agricultural to urban uses in the MRG was modeled by Sandia National Laboratory in November 2004 (Sandia Report 2004). Analyzing trends in water rights transfers is difficult because data is not readily available, accurate or up to date (Sandia Report 2004).

The aquifer in the MRG, consisting of Santa Fe Group and younger alluvial deposits, is known to be hydrologically connected to the Rio Grande surface water system. Since ground water diversions from aquifers hydrologically connected to the Rio Grande affect the fully appropriated surface flow, the NMOSE conjunctively manages the water resources within the MRG Basin. On September 13, 2000, the NMOSE established guidelines for the Middle Rio Grande Administrative Area (MRGAA);(NMOSE 2000) to ensure compliance with the Compact, to prevent impairment to existing rights, to limit the rate of decline of ground water levels so that the life of the aquifer is extended, and to minimize land subsidence.

The guidelines embody NMOSE’s existing practice for evaluating applications for permits for ground water use in the MRGAA and recognize that offsetting the effects of ground water diversions is critical to the conjunctive management of water resources within the MRG stream system. Accordingly, the guidelines provide that permitted ground water diversions shall be limited to the amount of valid consumptive use surface water rights held and designated for offset purposes by the permittee plus any NMOSE-approved flow returned directly to the Rio Grande. As mentioned above, the use of offsets or return flows replaced the depleted surface water in volume but does not restore the timing of flows in the river.

5.4.1.9 Water Management to Meet the Needs of the Six Middle Rio Grande Pueblos

The Six MRG Pueblos (Cochiti, Santo Domingo, San Felipe, Santa Ana, Sandia, and Isleta) hold aboriginal, time immemorial, reserved, and, in some instances, contract water rights that are recognized and protected under Federal law. A certain portion of their water rights is statutorily recognized under the 1928 Act and the Act of 1935, 49 Stat. 887 (1935 Act). Water rights have been statutorily recognized for 20,242.25 acres, comprised of 8,847 acres of prior and paramount lands, 11,074.4 acres of newly reclaimed lands, and 320.65 acres of lands purchased by the United States pursuant to the Pueblo Lands Act of 1924 (43 Stat. 636). The 1928 Act also recognizes a prior and paramount right to water for domestic and stock purposes. These Acts of Congress do not establish the full extent of the water to which these Pueblos are entitled, and references to the Pueblos’ “prior and paramount” rights under these Acts are not intended to suggest that the Pueblos do not have other water rights in the MRG or tributaries that are senior to other water uses in the system.

Reclamation engages in water operations to serve the water rights of the Six MRG Pueblos recognized by the 1928 Act and the 1935 Act. Each year over the past three decades, Reclamation has stored water in El Vado Reservoir to ensure an adequate supply of prior and paramount water for the Six MRG Pueblos pursuant to the 1981 Agreement. The BIA Designated Engineer and Reclamation have calculated the quantity of water to be stored at El Vado Reservoir for prior and paramount irrigation needs, based on the gap between the forecasted demand for the 8,847 acres of lands and the anticipated available supply of the river. The Coalition of the Six MRG Pueblos has then directed the Designated Engineer to request that Reclamation release the stored water according to the schedule provided by the Pueblos. This stored water has been, or is intended to be, delivered to the Pueblos by the MRGCD through downstream diversions.

A summary of the water stored for the prior and paramount rights and released annually since 2002 is provided on figure 33. During a number of the years in the past decade, water was stored for prior and paramount uses during years with Article VII storage restrictions in place under the Rio Grande Compact. Unused prior and paramount water in El Vado that was stored when Rio Grande Compact Article VII restrictions were in place was released for delivery to Elephant Butte Reservoir after the irrigation season, usually in November or December. This water is shown as released to Elephant Butte Reservoir in figure 33. Unused prior and paramount water stored in El Vado outside of Article VII storage restrictions was retagged as native Rio Grande water and is shown in figure 33 as being released to the Rio Grande account. Water shown as released to the MRGCD is water released for irrigation beyond the requirements of the prior and paramount rights.

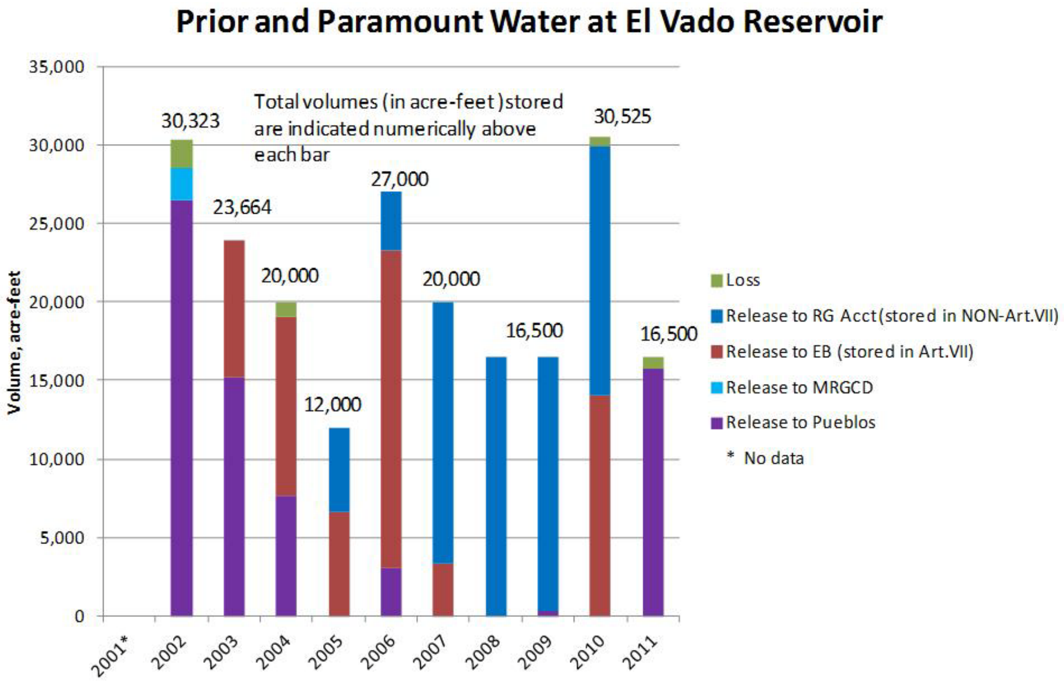


Figure 33. Summary of prior and paramount water stored in and released from El Vado Reservoir for irrigation of lands.

5.4.1.10 MRGCD Operations

Early in the decade, an extensive effort was undertaken by the NMISC, the New Mexico Water Trust Board, Reclamation, and the MRGCD to increase the MRGCD's water management efficiency and decrease the MRGCD's irrigation diversions, especially during water-short periods. Progress was made through infrastructure and metering improvements and through improvements in irrigation-system operations, such as the implementation of rotational water delivery and the development of a Decision Support System to model demand within the network and develop efficient water delivery schedules. The following figure 34 shows the effects of these improvements. Total MRGCD diversions during the 1990s were approximately 600,000 AF; but after 2001, typical total MRGCD diversions ranged from 300,000 to 400,000 AF.

These operational improvements have the effect of leaving more water in the river during periods of high native flow on the main stem. They also have the effect of extending the irrigation season during dry years by extending the availability of stored water in El Vado Reservoir. During dry times, water released from El Vado Reservoir for Middle Rio Grande irrigation supports river flows throughout the MRG, especially in the Albuquerque Reach. Therefore, extending the length of the irrigation season measurably decreases the Supplemental Water required to meet MRG ESA flow targets.

Figure 35 breaks down the diversions by MRGCD division. This breakdown shows that the largest diversions occur at the Isleta diversion structure for the Isleta division of the MRGCD. These diversions at Isleta also support the San Acacia division, which receives the tailwater from the Isleta division.

These diversions are made primarily during the summer months. The monthly average of diversions over the past decade is shown on figure 36.

MRGCD return flows are also an important part of the irrigation system and river operations. District management of return flows provides regularly wetted conditions downstream from the outlets of wasteways. MRGCD return flows can strategically release water to key reaches during low flow or drying periods in the Albuquerque or Isleta Reaches (the return flows in the San Acacia Reach return to the LFCC rather than to the river).

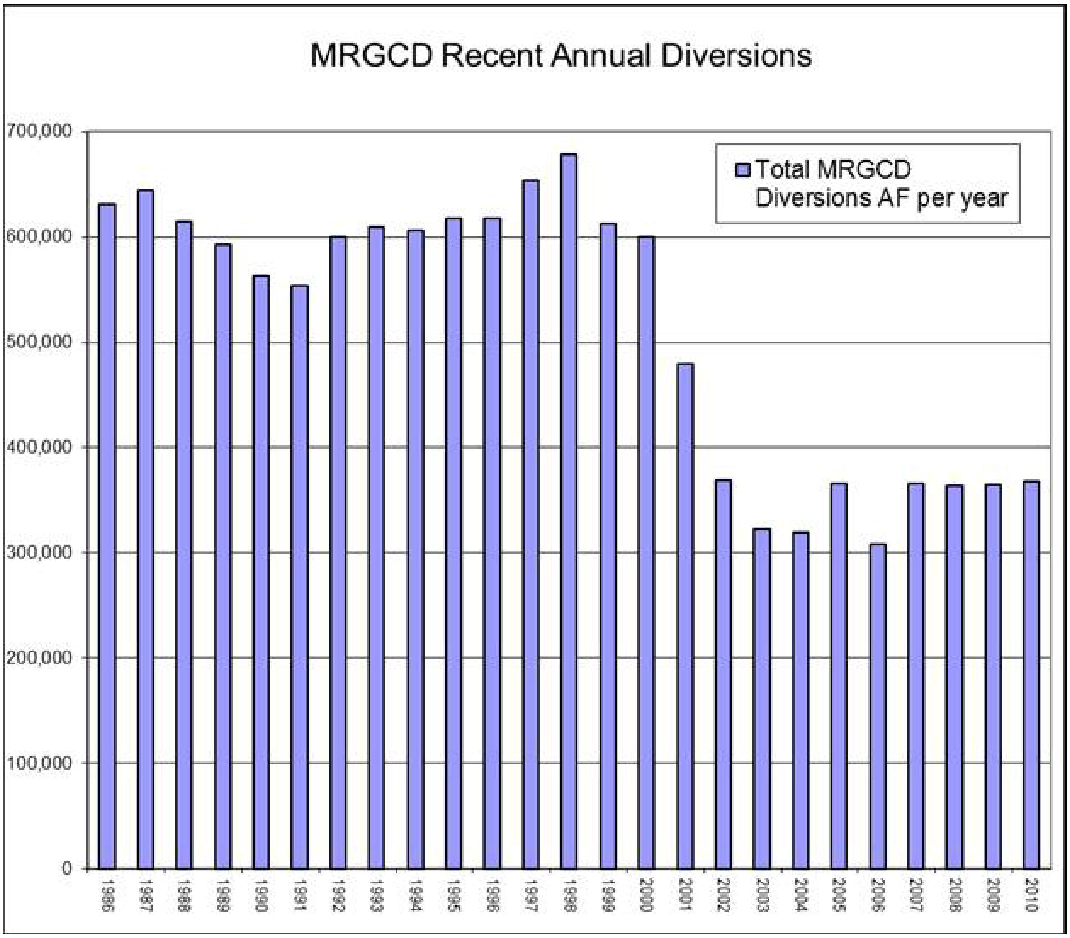


Figure 34. Summary of total water diversions by the MRGCD, 1996–2010.

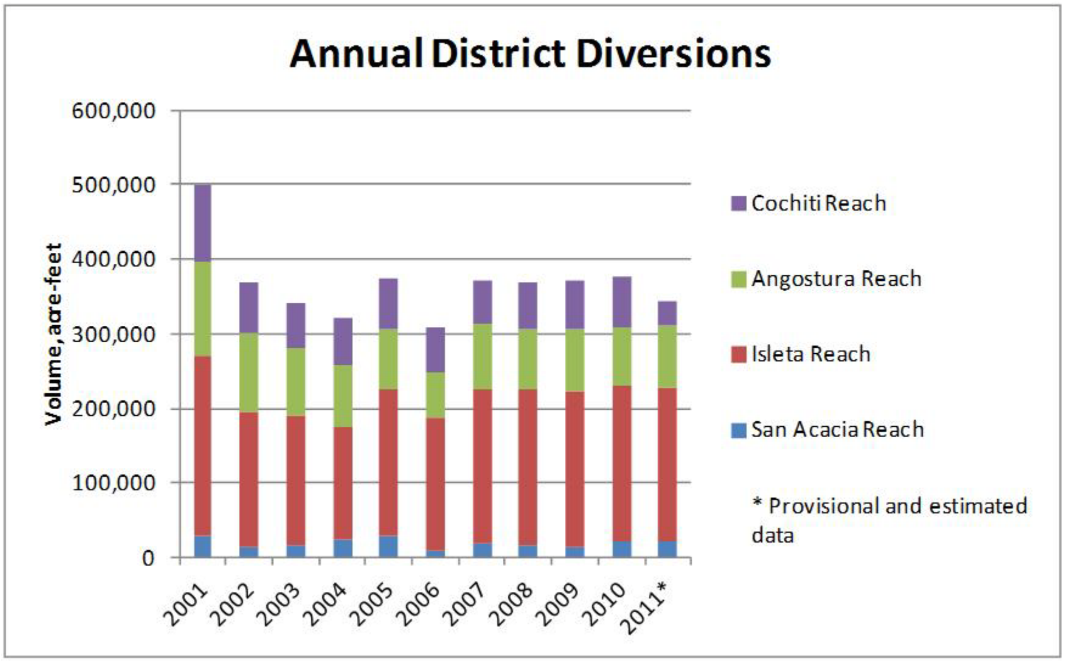


Figure 35. Summary of annual diversions from the Rio Grande to the MRGCD at the four MRG diversions structures.

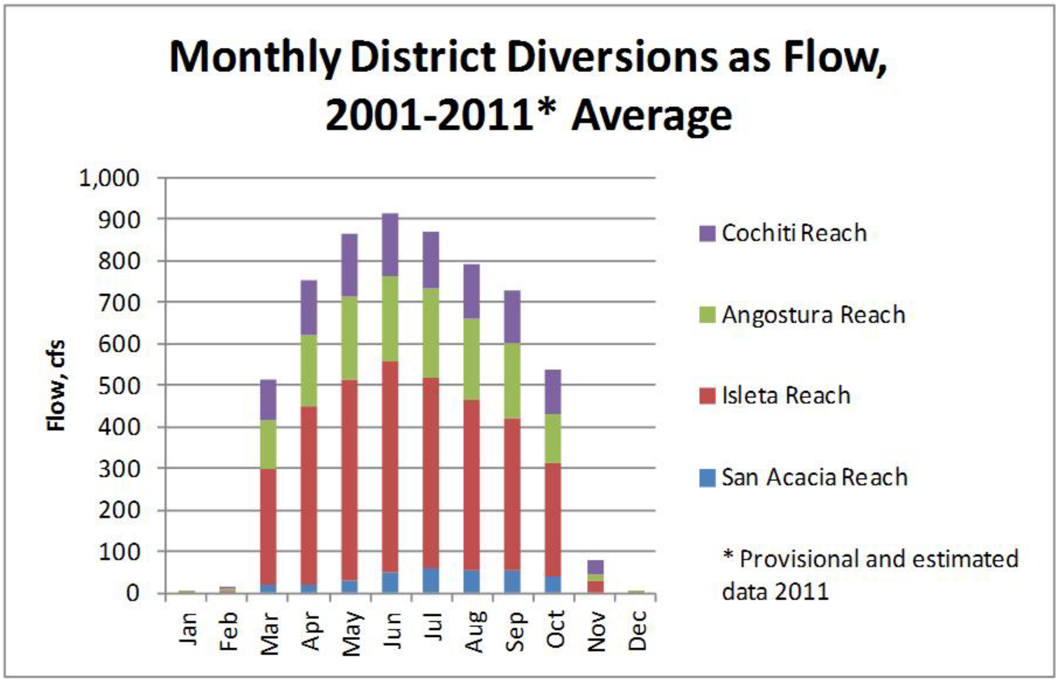


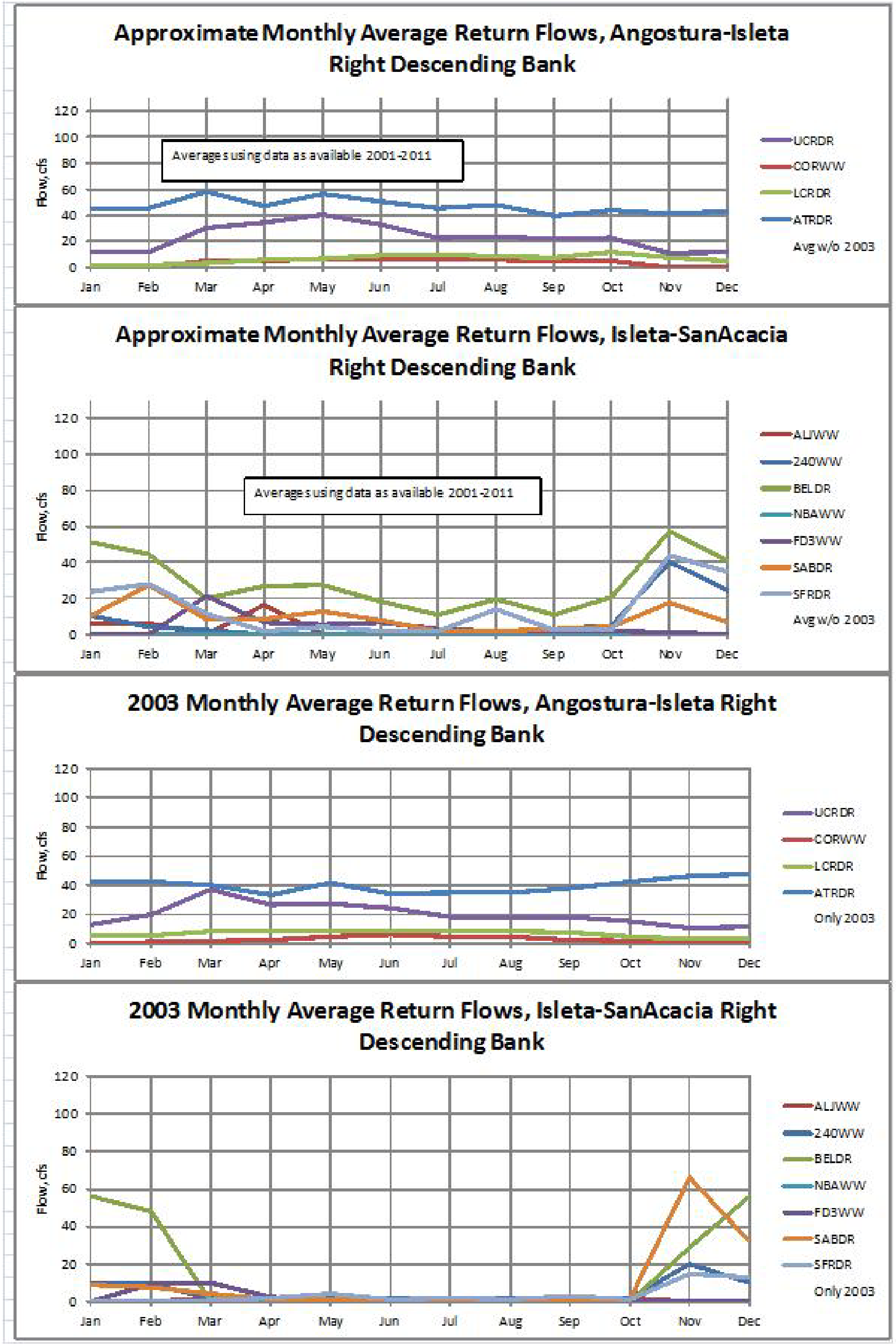
Figure 36. Monthly breakdown of average annual diversions to the MRGCD at the four MRG diversion structures, 2001–2011.

The following figures, figures 37 and 38, show the monthly average return flows from wasteways in the Albuquerque and Isleta Reaches, which enter the river from the left side (left descending bank, which is the right side as you look at a map with north at the top) or the right side (right descending bank, which is the left side as you look at a map with north at the top). It can be seen on these figures that some wasteways release water from drains, which collect ground water that is used both to supplement irrigation supplies and to return water to the river. These wasteways have higher discharge rates in the winter and lower discharge rates in the summer. Other wasteways discharge water from canals that collect tailwater from irrigation. Returns from these wasteways are lower in the winter and higher during the irrigation season.

The first graphs in each set present average wasteway and drain returns for the baseline period without 2003. The later graphs in each set present 2003 alone. 2003 stands out as the year during which the MRGCD most fully applied rotational water delivery to the laterals within its system. The difference between the graphs showing 2003 releases and those showing average releases during the other years highlights the tradeoffs between MRGCD operational efficiency, as is apparent in 2003, and the incidental benefits provided by less efficient system operation, including wasteway returns that support flows in critical reaches.

Legend for figures 37 and 38

240WW	340 Feeder Wasteway		LP1DR	Lower Peralta Drain Outfall #1
ALJWW	Alejandro Wasteway		LP2DR	Lower Peralta Drain Outfall #2
ARSDR	Albuquerque Drain Outfall		LSJDR	Lower San Juan Drain Outfall
ATRDR	Atrisco Drain Outfall		PERWW	Peralta Wasteway
BELDR	Belen Drain Outfall		SABDR	Sabinal Drain Outfall
CENWW	Central Avenue Wasteway		SANWW	Sandia Lakes Wasteway
CORWW	Corrales Wasteay		SFRDR	San Francisco Drain Outfall
FD3WW	Feeder 3 Wasteway		SILWW	Sile Main Wasteway
HAYWW	Haynes Wasteway		STYWW	Storey Wasteway
LCRDR	Lower Corrales Drain Outfall		UCRDR	Upper Corrales Drain Outfall
LJYDR	La Joya Drain Outfall		UN7WW	Unit 7 Wasteway


Approximate Monthly Average Return Flows, Angostura-Isleta Right Descending Bank

Approximate Monthly Average Return Flows, Isleta-SanAcacia Right Descending Bank

2003 Monthly Average Return Flows, Angostura-Isleta Right Descending Bank

2003 Monthly Average Return Flows, Isleta-SanAcacia Right Descending Bank

Figure 37. Summary of average district drain and tailwater returns to the Rio Grande, by month, 2001–2011, right descending bank.

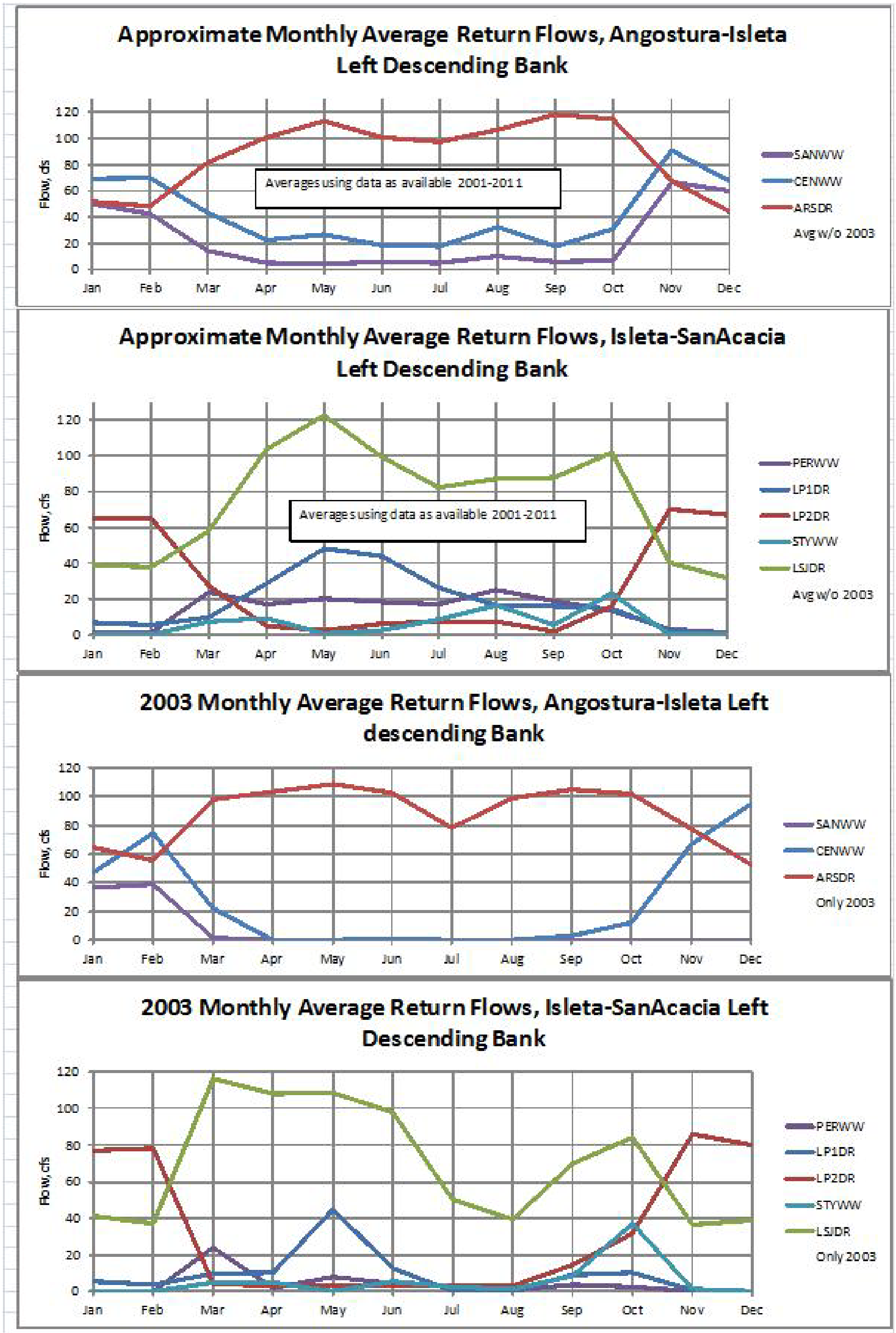


Figure 38. Summary of average district drain and tailwater returns to the Rio Grande, by month, 2001–2011, left descending bank.

5.4.1.11 Albuquerque Bernalillo County Water Utility Authority Drinking Water Project

The ABCWUA's primary use of SJC Project water is to support its Drinking Water Project in Albuquerque. After taking delivery of its SJC Project water from Heron Reservoir, the ABCWUA manages the majority (approximately 94%) of the 180,000 AF that can be stored at Abiquiu Reservoir for this water.

In 2004, Reclamation, in concert with ABCWUA, consulted with the Service under ESA, Section 7, on this project (Consultation #2-22-03-F-0146). The Service determined that this action, along with the proponent's environmental commitments and the RPM associated with the consultation, likely would not jeopardize the continued existence of the silvery minnow and would not adversely modify its designated critical habitat (Service 2004).

Until 2008, the city of Albuquerque's and Bernalillo County's potable water supplies were provided exclusively from ground water, which was pumped from the alluvial and colluvial aquifer filling the Albuquerque basin. The impact on the river of this extensive ground water pumping has been made up to the MRGCD and to New Mexico's delivery of water to Elephant Butte under the Compact through annual "letter-water" releases from Albuquerque's allotment of SJC Project water, as described generally above. Furthermore, the ground water pumping that is foreseen as a component of ABCWUA's Drinking Water Project is covered under the consultation for the Drinking Water Project described above.

The now-combined municipal supplier, ABCWUA recently has initiated use of its allocation of SJC Project water for urban uses and drinking water supply through implementation of its Drinking Water Project. Over the past 4 years, ABCWUA has been phasing in the diversion of surface water for municipal supply and the diversion of nonpotable water from a collection gallery beneath the river. The intent is for ABCWUA to conjunctively use ground water and surface water for its future municipal supply, and for its SJC Project allocation to make up the majority of the consumed water, which is typically about half of the total amount of water pumped or diverted. Figure 39 shows the total drinking water supply to the city and county, the total nonpotable supply over the past 10 years, and its distribution between ground water and surface water. It can be seen on this figure that the total potable water supply to the city is typically between 100,000 and 110,000 AFY. The figure further shows that use of the SJC Project water as a portion of that supply began at a testing level in 2008 and increased to over 40,000 AFY by 2010. Diversion of SJC Project water to the nonpotable water system began in 2003 and continued through the decade at up to 2,500 AFY.

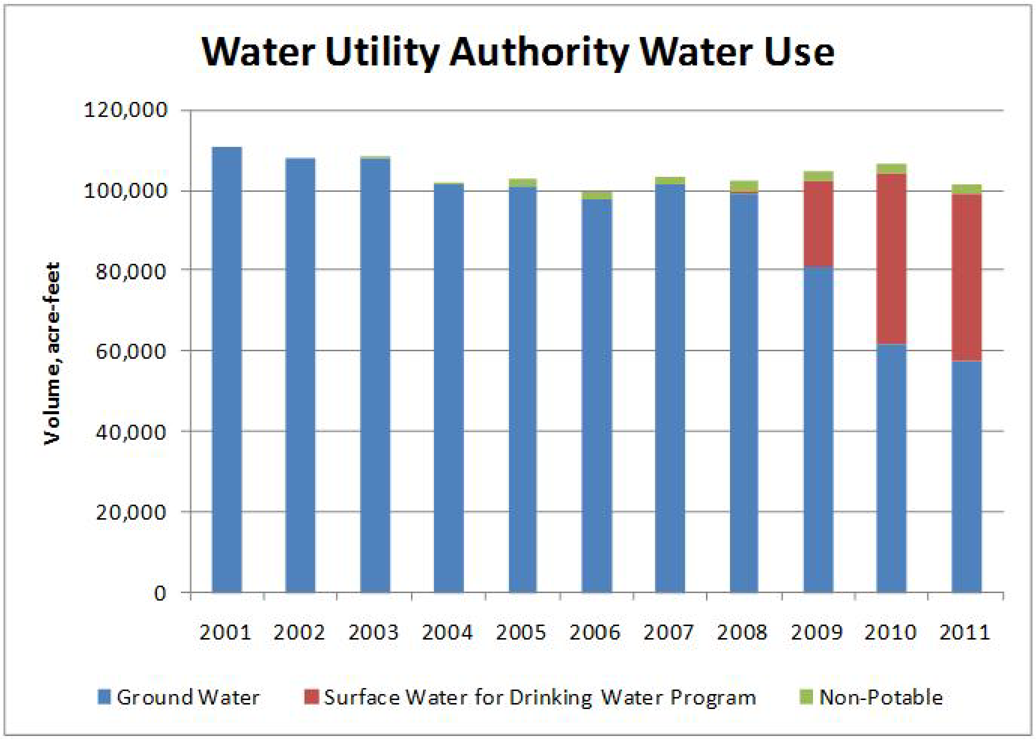


Figure 39. Gross municipal supply, including ground water and surface water contributions to the drinking water supply and nonpotable supply, to ABCWUA, 2001–2011.

Since the ABCWUA began diverting its SJC Project allotment from the Rio Grande, release of this SJC Project water from upstream storage has supplemented river flows on the Rio Chama and the Rio Grande from the Rio Chama confluence downstream to the ABCWUA's diversion structure between the Alameda Boulevard and Paseo del Norte crossings in Albuquerque. The city's diversion includes its SJC Project water allotment plus an approximately equal amount of native water, which is returned to the river downstream, at the outflow from the Albuquerque Wastewater Treatment Plant. The total amount of water returned to the river at the Albuquerque Wastewater Treatment Plant outfall, 16 river miles downstream, is summarized on figure 40.

ABCWUA's diversion of native water along with its SJC Project water decreases flows in the 16-mile reach from the diversion downstream to the wastewater treatment plant return flow. This reach includes the Albuquerque/Central Avenue gage, a key flow target location in the 2003 BiOp; therefore, operation of the drinking water project has the potential to affect how flow targets are met at this gage. For this reason, ABCWUA committed, through its ESA consultation, to curtail its diversions when native flows in the Rio Grande at the point of diversion drop below 195 cfs, and suspend diversions completely when these flows drop below 130 cfs, or when the flow at the Albuquerque gage (Central Avenue) drops below 122 cfs.

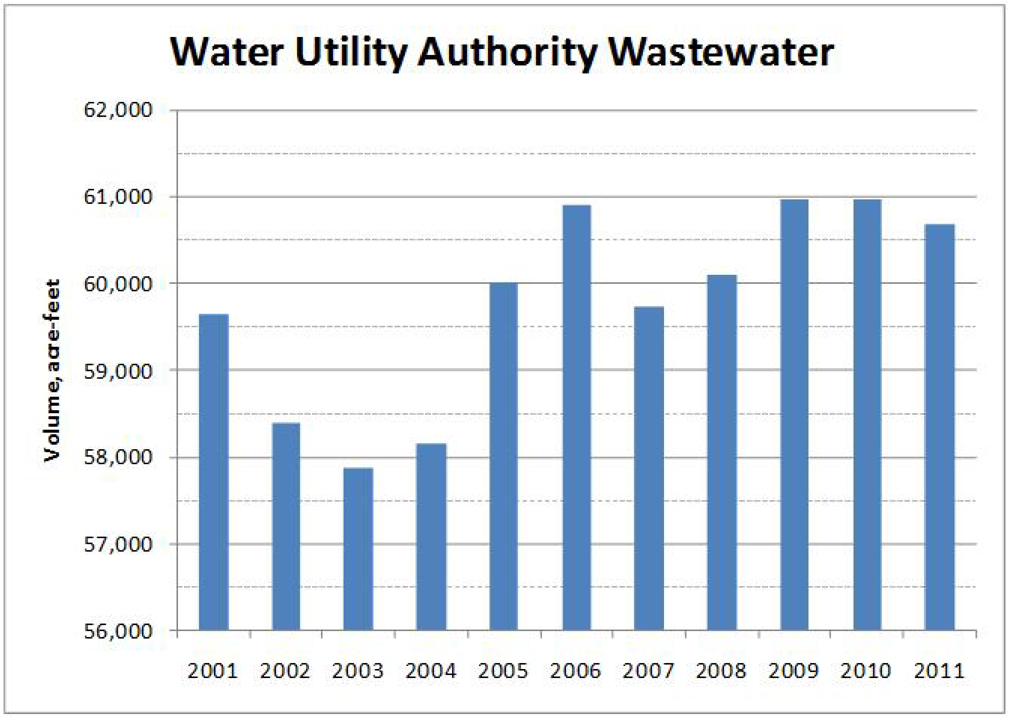


Figure 40. Summary of return flows from the Albuquerque Wastewater Treatment Plant, 2001–2011.

ABCWUA also curtails its diversions during high flows, when the turbidity gets high. As previously noted, the use of Albuquerque's supply of SJC Project water for urban uses and drinking water decreases the supply of water available to Reclamation for its Supplemental Water Program.

ABCWUA's obligation to make up for the effects on the river of past ground water pumping (discussed in section 5.4.2.6 above) continues, even if the majority of the current demand is met with surface water. For this reason, ABCWUA must continue to provide a portion of its SJC Project allotment, or native water for which it has rights, to the river for use by the MRGCD or for delivery to Elephant Butte under the Compact.

5.4.1.12 Bosque del Apache National Wildlife Refuge Operations

The Service manages the Bosque del Apache National Wildlife Refuge and is operating pursuant to a completed internal ESA consultation (Service 2001). The Service possesses approximately 10,000 AFY of senior surface water rights to support its irrigation and wildlife (mainly bird) management activities in the lower portion of the San Acacia Reach. A portion of this water is obtained during the irrigation season from tailwater from the MRGCD irrigation network. The majority of the BDANWR's supply is from direct diversions from the LFCC at the north boundary of the refuge and at a second point in the middle of the refuge.

These diversions can decrease the availability of water to Reclamation’s LFCC pumping program.

Water use for irrigation occurs mainly during the summer months. Irrigation on the refuge uses water from both MRGCD tailwater and LFCC diversions. The refuge differs from most other water users in the Middle Rio Grande Valley in that a significant portion of its diversions occurs in the winter to support ponded habitat. The water source available for these purposes in the winter is the refuges diversions from the LFCC.

Figure 41 summarizes the water consumption of the BDANWR, broken down by year and by season. The refuge also passes substantial amounts of water through its water distribution network that is returned at the south boundary of the refuge. This water is not portrayed in these consumption tallies.

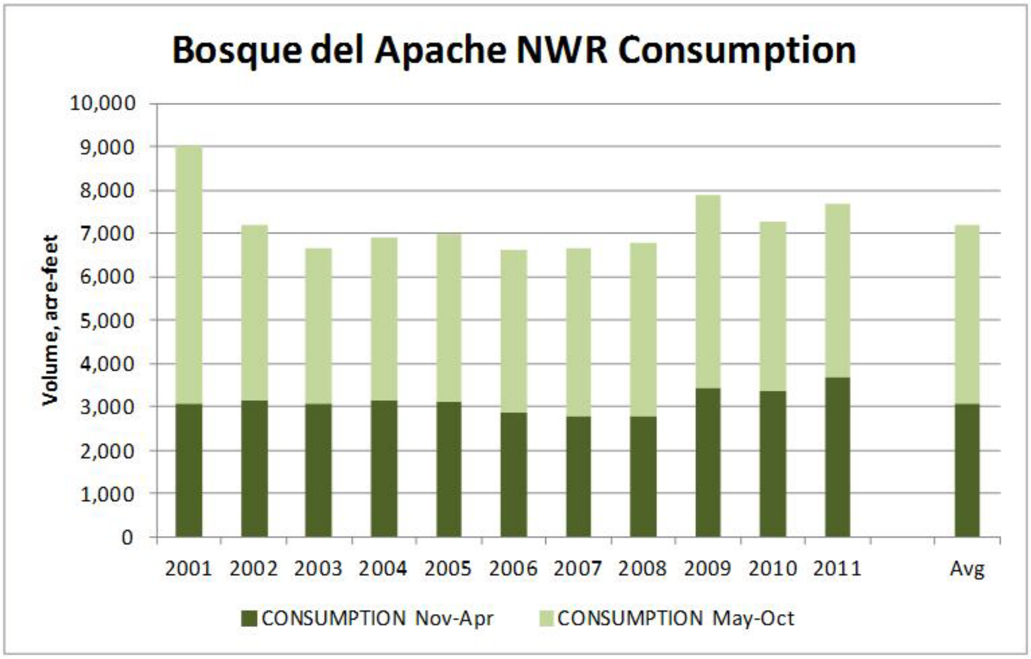


Figure 41. Seasonal breakdown of water consumption within the Bosque del Apache National Wildlife Refuge.

When water supplies are short, water from the LFCC cannot fully meet the needs of both the refuge diversion and LFCC pumping under Reclamation’s Supplemental Water Program, In its ESA consultation (Service 2001), the refuge concluded that it could contribute up to 10% of its water supply to support endangered species needs. In a few instances during the time period of operations under the 2003 BiOp in which such actions would not significantly impair refuge operations and in which river conditions were in danger of violation of the flow targets in the 2003 BiOp, the refuge has decreased its diversions from the

LFCC to allow more water to be available to Reclamation's Supplemental Water Program to avoid violating the continuous flow requirements of the 2003 BiOp.

5.4.2 Current Hydrologic Conditions

This section summarizes the hydrologic and administrative (i.e., Article VII restrictions under the Compact) conditions over the past decade.

5.4.2.1 Article VII Status and Credits under the Rio Grande Compact

As described in the previous section, Article VII of the Compact restricts storage in upstream reservoirs constructed after 1929 if there is less than 400,000 AF of usable storage for the Rio Grande Project in Elephant Butte and Caballo Reservoirs. Article VII storage restrictions were in place for a majority of the period covered by the 2003 BiOp. These storage restrictions helped Reclamation achieve flow requirements since, as described above, years are classified as "dry" under the 2003 BiOp if the Article VII storage restrictions are in place at the beginning of the spring snowmelt runoff (April 1). Years classified as "dry" under the 2003 BiOp had lower flow requirements and a longer period in which drying is permitted than was authorized for years with "average" or "wet" classifications. The recent recurring periods when storage restrictions per Article VII were in place came after a long period, from 1978–2002, in which storage restrictions were never in effect. Figure 42, below, shows New Mexico's Article VII status from 1978–2010.

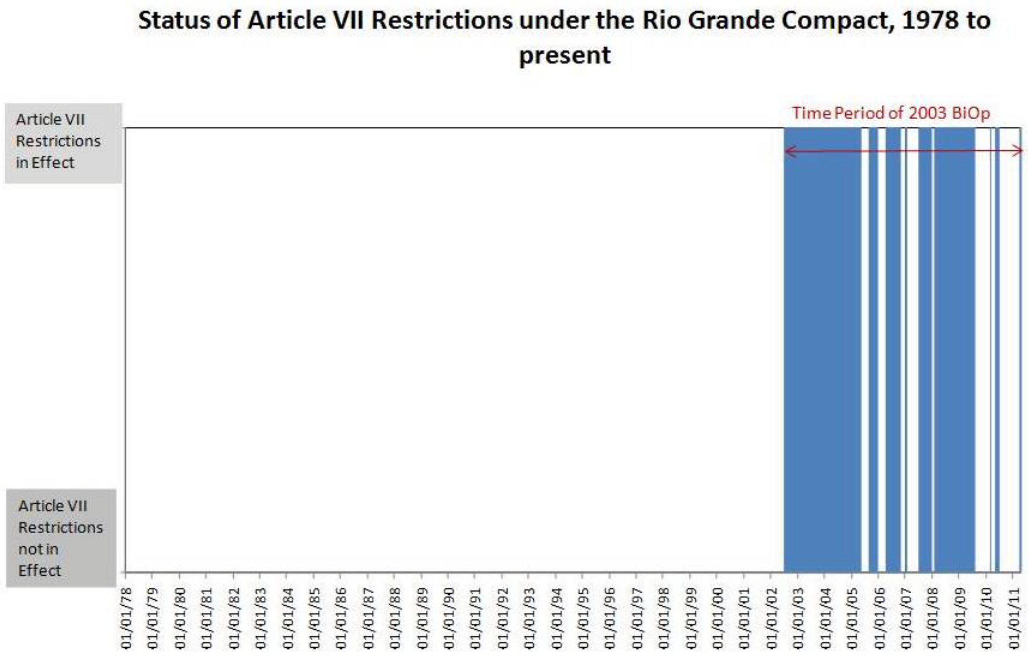


Figure 42. Article VII status under the Rio Grande Compact, 1978–2011.

During the period covered by the 2003 BiOp, New Mexico regularly accrued credits under the Compact, because this period did not include any very wet years, and also likely due to channel construction by Reclamation and the State of New Mexico in the headwaters of Elephant Butte Reservoir. In addition, it is possible that Supplemental Water released by Reclamation for ESA purposes, which has been exchanged with a like amount of native water so that it can be passed downstream, contributes to this accrual. New Mexico has relinquished credits several times during this period and has made a portion of this relinquished water available to Reclamation's Supplemental Water Program under the Conservation Water Agreement and the Emergency Drought Water Agreement.

5.4.2.2 Water Year Designation

The 2003 BiOp flow requirements are based on an annual year type designation of "dry," "average," or "wet." The following are the specifications for each of the 3 year-type designations, as described in the 2003 BiOp. "Dry years" are those for which the NRCS April 1 streamflow forecast for the Otowi gage is less than 80% of average, with average determined based on the streamflow at Otowi gage over the 30-year period from 1971–2000. "Dry year" flow requirements also can be invoked for years in which Article VII storage restrictions under the Compact are in effect on April 1. "Average years" are those for which the NRCS April 1 streamflow forecast for the Otowi gage is between 80–120% of average, and Article VII storage restrictions are not in effect. "Wet years" are those for which the NRCS April 1 streamflow forecast for the Otowi gage is greater than 120% of average, and Article VII storage restrictions are not in effect.

These designations are determined based on a combination of the April 1 hydrologic forecast for that year and the administrative conditions—specifically, whether Article VII restrictions under the Compact are in place on April 1. If Article VII storage restrictions are in effect on April 1 in a given year, that year is designated as a "dry" year regardless of the hydrologic conditions. Article VII status determined that 2003, 2004, 2005, 2006, 2007, and 2010 would be dry years, regardless of hydrologic conditions.

Figure 43, below, presents the Article VII status at the beginning of the spring runoff for each of the years in the past decade, and the corresponding water year designation. Since 2001 and 2002 were prior to the 2003 BiOp, they were not classified (another classification was in place under the 2001 BiOp). "Dry year" flow targets were in effect from 2003–2007 due to a combination of dry hydrologic conditions and Article VII Compact restrictions. The highest flow volume of the decade passed the Otowi gage in 2005; but since Article VII restrictions were in effect as a result of low reservoir levels at the end of the drought period, the less stringent "dry year" flow requirements were in place. It was not until 2008 that Article VII Compact restrictions were lifted. Therefore, the more stringent "wet year" flow requirements were in place for that year, but that was the only year in the decade for which they were. "Average year" flow requirements were in place in 2009, and Article VII restrictions returned in 2010, so "dry year" flow requirements were observed. The year 2011 was designated as a dry year based on both Article VII Compact restrictions and an extremely low snowmelt-runoff.

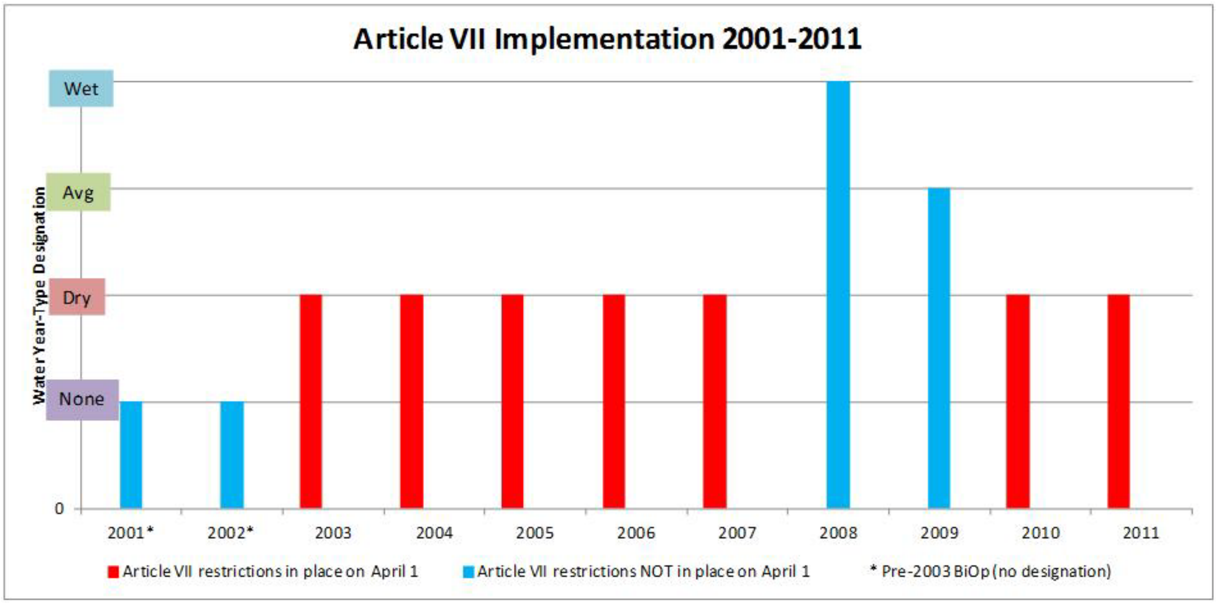


Figure 43. Article VII status under the Compact on April 1 of each year and water year-type designations under the 2003 BiOp, 2003–2011 (not applicable for 2001 and 2002).

5.4.2.3 Hydrologic Conditions Over the Baseline Period.

The first decade of the 21st century began with high reservoir levels at Elephant Butte Reservoir due to a number of high water years in the 1980s and 1990s. The first half of the decade (2000–2004) was characterized by record drought, which diminished those reservoir levels. Beginning in 2005, hydrologic conditions became wetter; however, Article VII storage restrictions, resulting from low Elephant Butte Reservoir levels due to the drought, persisted until 2006 and then recurred several times through the remainder of the decade.

For purposes of this analysis, we have divided the past decade into high volume years and low volume years, based on the total flow passing the Otowi gage that year. The high volume years are defined as those with a total flow past Otowi gage of 800,000 AF or more and include 2005, 2007, 2008, 2009, and 2010. Figure 44, which presents the hydrographs at Otowi gage for these years, reveals a pattern of snowmelt driven hydrographs, with spring pulses between April and June, which are typically bimodal, representing the smaller runoff from the Rio Chama followed by the larger runoff from the Rio Grande main stem, These hydrographs also are characterized by low summertime flows, interspersed with occasional monsoonal spikes.

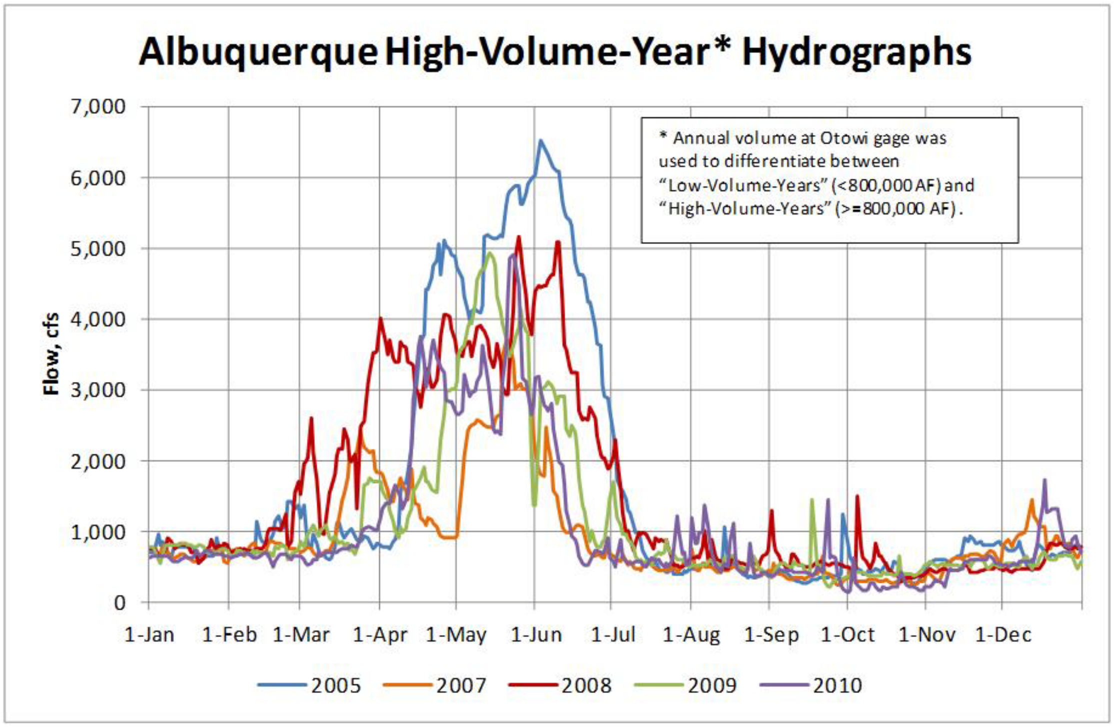


Figure 44. Hydrographs of flows at Otowi gage for the higher volume years during the past decade (2001–2011).

The highest-volume year of the decade was 2005. That year had a very large and long duration spring snowmelt runoff. Starting in mid-July, it had similar flows to the other years and, therefore, would have required significant quantities of Supplemental Waters if it had been designated as a wet year under the 2003 BiOp. However, it was designated as a dry year, since Article VII restrictions under the Compact were in place at the start of the runoff. The years 2008, 2009, and 2010 also had flows in Albuquerque of over 3,000 cfs for a significant period of time. The year 2008 was designated as wet year, and significant Supplemental Water was released to maintain higher summer flows in the Isleta and San Acacia Reaches. In 2007 and 2010, authorized deviations from normal Cochiti Dam operations were used to engineer flow spikes. In 2007, a flow spike of over 3,500 cfs was created in late May. In 2010, a flow spike of 5,800 cfs out of Cochiti Reservoir was created but maintained for only 2 days.

Figure 45 presents the hydrographs at Otowi gage for the lower volume years of the past decade, those years with a total flow past Otowi gage of less than 800,000 AE. These years include 2001, 2002, 2003, 2004, 2006, and 2011. Among these lower volume years, 2006 stands out, both for its lack of a spring runoff (springtime flows never exceeded 800 cfs) and for its significant monsoon flows, including numerous spikes with daily-average flows over 1,000 cfs. These conditions led to a considerable accumulation of New Mexico credits under the Compact. The years 2002 and 2003 were dry throughout the year, with poor snowmelt runoffs and low volume monsoons. The other years shown, 2001, 2004, and 2011 exhibit more traditional hydrographs, with bimodal spring snowmelt runoffs (representing the Rio Chama runoff followed by the main stem runoff), and low summertime flows, punctuated by occasional monsoon spikes.

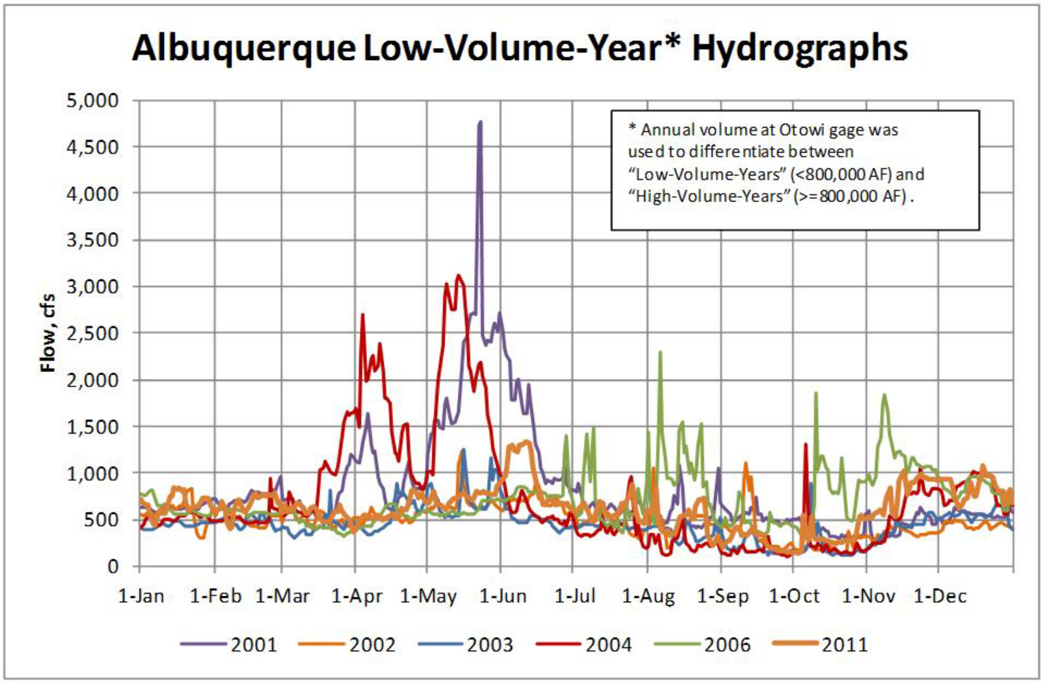


Figure 45. Hydrographs of flows at Otowi gage for the lower volume years during the past decade (2001–2011).

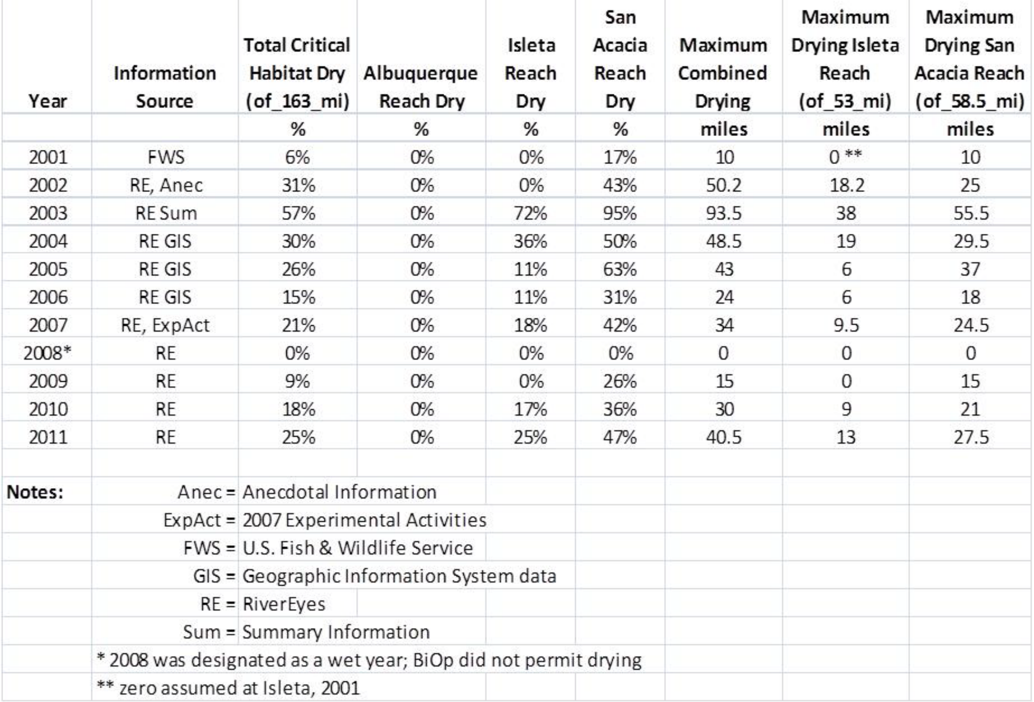
Dry years and, to some degree, the years following dry years tend to exhibit higher losses from the river to the ground water system and to evapotranspiration. This, in turn, affects river drying, as described in the following section.

5.4.2.4 River Drying

As discussed in the Water Operations section in section 2, RiverEyes data have been used to deduce trends in river drying, and threshold flows below which river intermittency should be expected. For example, river observations suggest that whenever gaged flows drop below 150 cfs at the Bosque Farms or below 200 cfs at the San Acacia gage, downstream drying is likely. The timing of drying is highly variable, affected in part by antecedent hydrologic conditions (whether the previous year was wet or dry), local weather (which affects the rates of evaporation and evapotranspiration), the degree and nature of the wetted sands, the magnitude of local return flows, the timing and nature of tributary inflows from the Rio Puerco and Rio Salado, and the degree of flood plain connectivity.

As can be seen in table 4, since implementation of the 2003 BiOp flow targets, river conditions have ranged from the rather extreme drying that occurred in 2003 to a continuous flowing river throughout 2008. The extreme river drying in 2003 occurred in response to low snowmelt runoff and a poor monsoon season that year, in combination with extremely dry antecedent conditions, which resulted in lower reservoir levels and high loss rates from the river. The MRGCD storage in El Vado was depleted, and, therefore, non-Indian irrigators were in "run-of-the-river" operations from late August through the end of the irrigation season. Therefore, irrigation water released from storage for delivery to downstream irrigation structures was not available to supplement river flow. Over 72% of the Isleta Reach and 95% of the San Acacia Reach experienced river drying, and an estimated 57% of total silvery minnow critical habitat dried in 2003. The 2006 spring runoff was also well below average because of lower than normal snowpack. In May 2006, year-to-date precipitation was well below average; and the snow pack was at 20% of average in the Rio Grande Basin. Fortunately, a strong monsoon season led to the wettest July and August within our period of monitoring. Consequently, only 26.5 miles of river dried in the summer of 2006 in the Isleta and San Acacia Reach. Fortunately, a succession of higher runoff years followed. In 2008, the river was continuous throughout the entire year. In 2011, however, dry conditions returned to the MRG, with total drying in the Isleta and San Acacia Reaches of over 40 miles.

Table 4. River drying by reach and by percent of critical habitat that dried (2001–2011)



Year	Information Source	Total Critical Habitat Dry (of_163_mi)	Albuquerque Reach Dry	Isleta Reach Dry	San Acacia Reach Dry	Maximum Combined Drying	Maximum Drying Isleta Reach (of_53_mi)	Maximum Drying San Acacia Reach (of_58.5_mi)
		%	%	%	%	miles	miles	miles
2001	FWS	6%	0%	0%	17%	10	0 **	10
2002	RE, Anec	31%	0%	0%	43%	50.2	18.2	25
2003	RE Sum	57%	0%	72%	95%	93.5	38	55.5
2004	RE GIS	30%	0%	36%	50%	48.5	19	29.5
2005	RE GIS	26%	0%	11%	63%	43	6	37
2006	RE GIS	15%	0%	11%	31%	24	6	18
2007	RE, ExpAct	21%	0%	18%	42%	34	9.5	24.5
2008*	RE	0%	0%	0%	0%	0	0	0
2009	RE	9%	0%	0%	26%	15	0	15
2010	RE	18%	0%	17%	36%	30	9	21
2011	RE	25%	0%	25%	47%	40.5	13	27.5

Notes:
Anec = Anecdotal Information
ExpAct = 2007 Experimental Activities
FWS = U.S. Fish & Wildlife Service
GIS = Geographic Information System data
RE = RiverEyes
Sum = Summary Information
* 2008 was designated as a wet year; BiOp did not permit drying
** zero assumed at Isleta, 2001

Figures 46 and 47 summarize the extent of river drying over the past decade, in terms of both the total number of river miles dried each year and in terms of the days of drying per year in the Isleta and San Acacia Reaches.

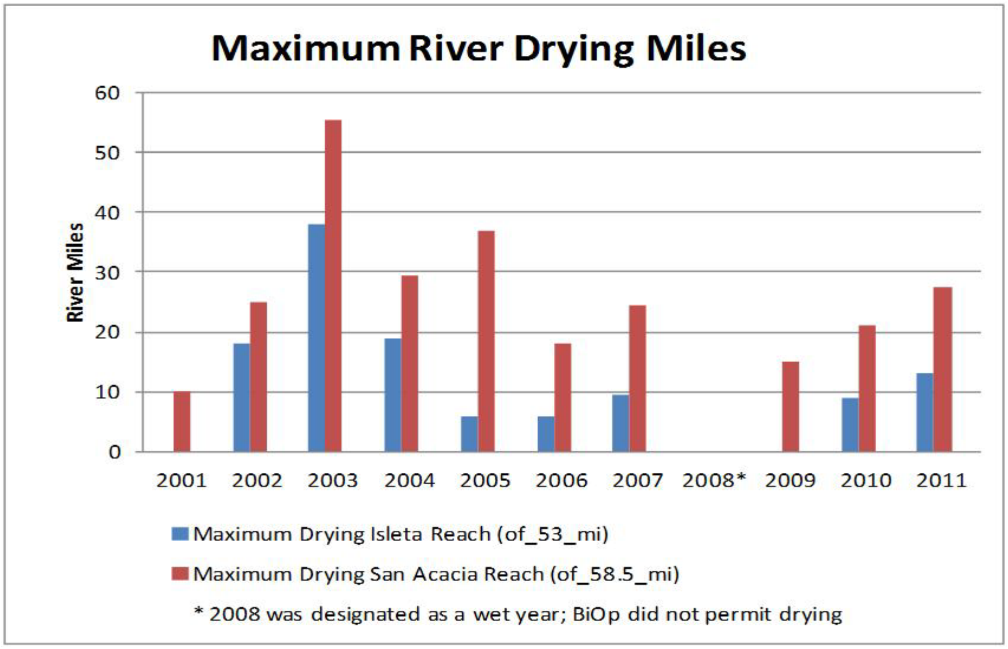


Figure 46. Summary of river miles that dried in the Isleta and San Acacia Reaches. (2001–2011).

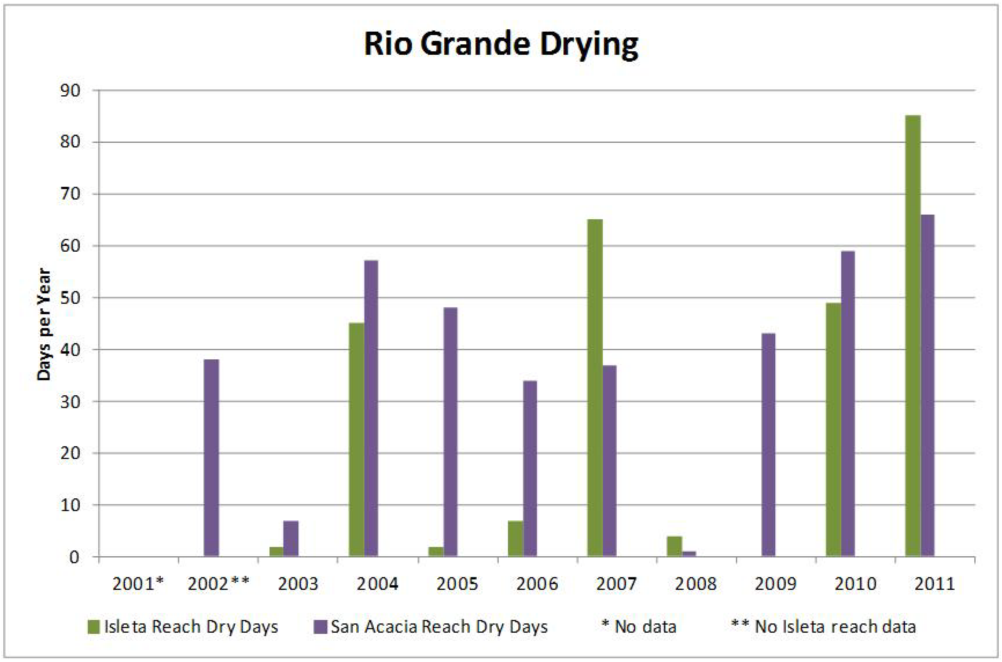


Figure 47. Number of days per year of river drying in the Isleta and San Acacia Reaches, 2001–2011.

Drying did not occur in the Cochiti Dam and Albuquerque Reaches during this time period. River operations in 2001 and 2002 were subject to different criteria, drying restrictions, and flow targets than were the years covered by the 2003 BiOp.

Figures 48 and 49 depict the timing of this river drying from 2001–2011, in the Isleta and San Acacia Reaches, by depicting the first and last day of reported drying in each reach. The years 2002, 2006, and 2011 are noteworthy for experiencing drying in the San Acacia Reach prior to June 15.

5.4.2.5 Meeting the 2003 BiOp Flow Targets

Reclamation consistently achieved compliance with flow targets established in the 2001 and 2003 BiOps due to a combination of factors:

- High reservoir levels in the drier years and low reservoir levels in the wetter years.
- A sequence of hydrologic years that was favorable under the flow target calculations.
- Lease agreements with SJC Project contractors who had not yet developed the capacity to use that water for its intended purpose.
- Agreements for water with the State of New Mexico (the Conservation Water Agreement and the Emergency Drought Water Agreement).

Because conditions were dry during the first half of the decade and became significantly wetter during the second half of the decade, Article VII restrictions under the Compact were put in place early in the decade and remained in place, or returned, for several of the later, wetter years. The Article VII storage restrictions allowed the later, wetter years to have “dry year” flow targets under the 2003 BiOp; so the water requirements to meet those targets were lower than they otherwise would have been.

Additionally, a larger amount of water has been available for Reclamation’s Supplemental Water Program than Reclamation can rely on in the future. Direct diversion projects for municipal use of SJC Project water by the city and county of Santa Fe and ABCWUA have decreased the amount of SJC Project water available for lease to Reclamation. Also, Reclamation has had the benefit of leased water from the State under the Emergency Drought Water Agreement (EDWA)/Conservation Water Agreement (CWA), which it cannot count on in the future. It is estimated that gains to Elephant Butte Reservoir were fairly high in recent years as compared to historical conditions, partially due to the lower reservoir level during much of the period but also due to extensive river maintenance activities in the Elephant Butte delta. The resulting gains in

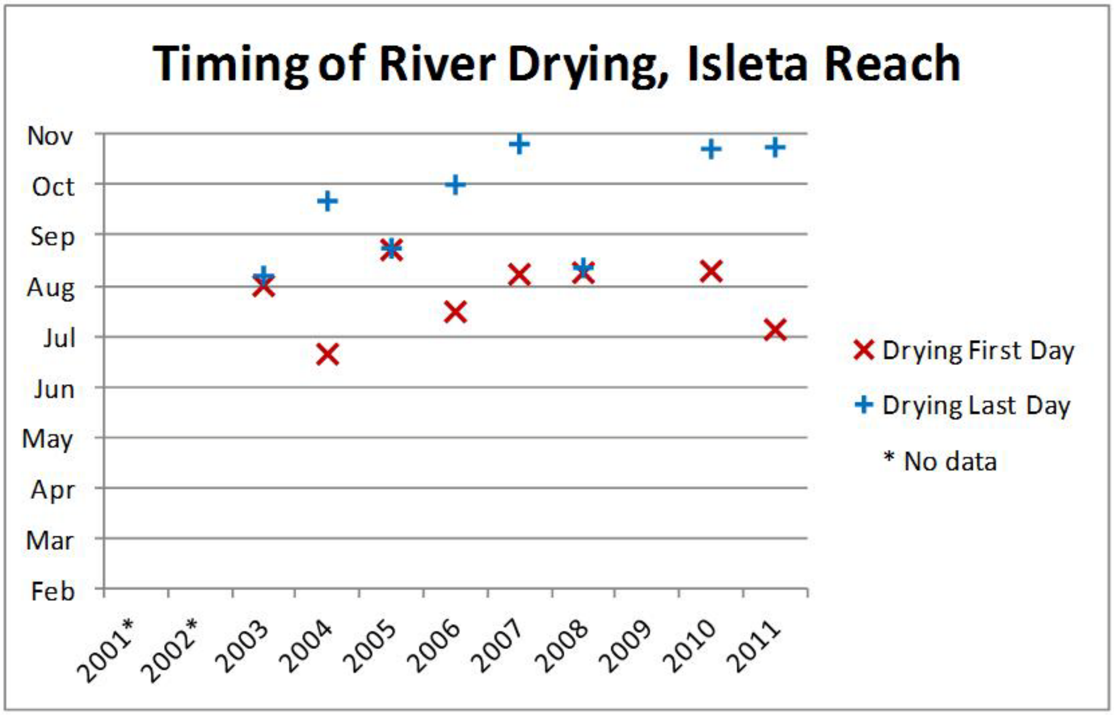


Figure 48. First and last calendar days of river drying in the Isleta Reach, 2001–2011.

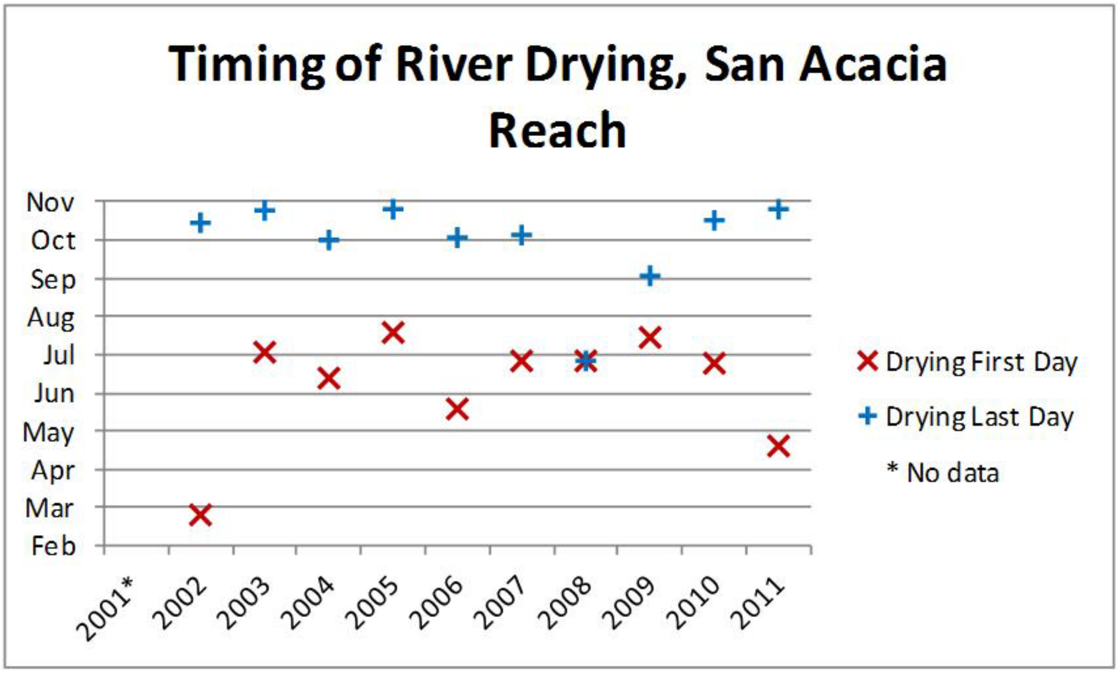


Figure 49. First and last calendar days of river drying in the San Acacia Reach, 2001–2011.

Elephant Butte deliveries resulted in greater Compact credits for New Mexico. The State was then able to relinquish an appreciable quantity of Compact credits and subsequently allow for Emergency Drought Water to be stored at El Vado Reservoir and be used for meeting the flow targets of the 2003 BiOp.

5.5 Channel Conditions and Dynamics

The following discussion is summarized from the 2012 report titled Channel Conditions and Dynamics of the Middle Rio Grande by Makar and AuBuchon. The channel conditions of a river are the integrated outcome of physical processes such as weathering, erosion, transport, and deposition of sediment and the natural and anthropogenic influences on those processes. Knowledge of the history of changes, both natural and anthropogenic, and the adjustment sequence within the alluvial watershed and channel provides a better understanding of this complexity to help interpret significant trends and estimate future conditions (Schumm et al. 1984, Kondolf and Piegay 2003).. The interrelationship between the flow of water, the movement of sediment, and the variable character and composition of the channel boundaries over time and space essentially determines the current channel morphology that is observed (Schumm 1977, Leopold et al. 1964). This channel morphology can be constantly changing as the river seeks to balance the movement of sediment (sediment supply) with the power available from the flow of water (sediment transport capacity) (Schumm et al. 1984, Reclamation 2005c). It is the imbalance between sediment transport capacity and sediment supply which is a key cause of most channel and flood plain adjustments (Lane 1955, Schumm 1977, Biedenharn et al. 2008).

Climatic changes, flood and sediment control, regulation of flows for irrigation, land use, vegetation changes, and channelization have altered the water and sediment supplied to the MRG over time. Factors affecting the imbalance between sediment transport capacity and sediment supply can be categorized as drivers of adjustment and controls on adjustment. Both drivers and controls can be modified through natural or anthropogenic means.

Important drivers on the MRG include flow frequency, magnitude and duration, and sediment supply. Changes in these drivers that have resulted in recent geomorphic channel changes on the MRG include decreased flow peaks, increased low flows of longer durations, and decreased sediment supply. Decreased peak flows result in the existing channel not being reworked on as large a scale as it was historically. Increased low flows of longer durations provide more water during dry periods. The flows can sustain vegetation but also aid encroachment of vegetation into the active channel that narrows it. Increased low flows of longer durations occur as a result of anthropogenic regulation of the flows in the water system. This includes holding back flood flows that naturally would occur during the snow melt runoff and monsoonal events and releasing that water during nonflood periods, such as during the summer and winter months. Increased low flows of longer durations also occur as a result of moving water, beyond the native flow, to keep the river wet and to facilitate the transfer of water downstream. Decreases in sediment supply, such as those due to land use changes in the watershed or the storage of sediment behind dams and diversion structures or stabilized banks and bars, can cause an increase in the likelihood of channel erosion.

There are several factors that can limit or control the effects of the drivers on channel adjustment and the observed reach characteristics. Controls of channel adjustment such as bank stability, bed stability, base level, flood plain lateral confinement, and flood plain connectivity influence the extent of effect that the drivers have on the observed characteristics of a reach. Bank stability can be affected by natural (e.g., riparian vegetation) or mechanical (e.g., riprap) means. Similarly, bed stability can come from channel armoring through bed material coarsening or from cross channel facilities. An example of a base level control is a change in pool elevation of a reservoir. The change can result in an upstream channel response, such as channel degradation or aggradation. Levees and geologic outcrops can create lateral confinement of the flood plain and limit channel migration. A well-connected flood plain dissipates the energy of flood flows, reducing the sediment transport capacity.

The fact that many changes, both natural and anthropogenic, occurred contemporaneously on the MRG greatly complicates interpreting the drivers and controls of the observed trends of channel and flood plain adjustments and also the prediction of future trends. Figure 10, in the introduction of this section, Environmental Baseline, illustrates the timing of many of these events and dates of significant floods. A more detailed history of events affecting the morphology of the MRG can be found in the report, titled Channel Conditions and Dynamics of the Middle Rio Grande (Makar and AuBuchon, 2012).

5.5.1 MRG Reach Geomorphic Parameters and Current Trends

The field of geomorphology uses certain parameters to better understand the observed trends and to help predict how a river self-adjusts to move toward a balance between sediment transport capacity and sediment supply. These geomorphic parameters help identify and document changes in the drivers and controls of channel adjustment. Geomorphic parameters currently evaluated on the MRG, from both direct measurement and/or analysis, include the following:

- Discharge magnitude and frequency
- Sediment supply
- Channel width
- Channel planform and location

- Slope
- Sinuosity
- Bed material size and type
- Channel and floodway topography

These parameters and their applicability to the MRG are further described in the report titled Channel Conditions and Dynamics of the Middle Rio Grande (Makar and AuBuchon 2012). For the ensuing discussions, reach designations follow geomorphic breaks described in the same report. Most of the discussion in this document focuses on the reaches between Cochiti Dam to the Elephant Butte Full Pool Reservoir. The majority of Reclamation's investigations have been in this historically more geomorphically active reach and, thus, more data is available. This area also corresponds to the section of the river occupied by silvery minnow.

The first two geomorphic parameters, discharge magnitude and frequency and sediment supply are geomorphic drivers. Changes in flow and sediment supply continue to impact the morphology of the MRG. The decreased annual peak flows, which are now typically less than 5000 cfs, and the reduced sediment supply are documented changes in the drivers that are correlated in time with observations of channel narrowing, vegetation encroachment, and incision; which in turn influence bank height, bed material size and generally lead to a more uniform channel. These observations are much more noticeable upstream of Albuquerque, where significant changes to the drivers have occurred. South of Albuquerque, especially south of the Rio Puerco, the effects of the changes to the drivers is less consequential because of the influence on the morphology from the tributary flows and sediment supply. These less-altered tributaries allow for a higher variability in both flow and sediment supply, which dampens the effects of the upstream changes to the drivers. These tributaries can also bring in coarser material that influences bed stability at lower flows.

The next six parameters (channel width, channel planform and location, slope, sinuosity, bed material size and type, and channel and floodway topography) are characteristics that help describe conditions of a reach. Controls on channel adjustment such as bank stability, bed stability, base level, flood plain lateral confinement, and flood plain connectivity interact with the drivers and influence the extent of effect that the drivers have on the observed characteristics of a reach. A lower bank and bed stability may have the potential to add to the sediment supply, whereas increases in the stability (bed and/or bank) or flood plain connectivity (which may cause lower velocity areas) can reduce the sediment supply.

The influence of drivers and controls along the MRG is variable, but commonalities have been identified. It is the commonalities in the river's responses to drivers and controls present that help identify and separate the MRG

Table 5. Reach geomorphic parameters

Water Operations Reaches	Geomorphic Reaches	River Miles (RM)	Average Width (feet)	Planform	Slope	Sinuosity	Bed Material Type	Current Observations of -Channel and Floodway Topographical Changes	Currently Relevant Trends
Velarde	**Velarde to Rio Chama** (sediment transport capacity greater than (>) sediment supply)	285 to 272	190 [a]	Low sinuosity, single channel.	0.00224 [d]	N/A	Gravel and small cobble	Horizontal alignment fairly stable. Tributary sediment deposition can induce bank erosion. A few migrating bends, but dense vegetation has limited the extent. Low/moderate channel incision. Minor amount of narrowing where riparian vegetation is encroaching on the active channel.	Channel narrowing Vegetation encroachment Bank erosion Coarsening of bed material Increased channel uniformity
Espanola	**Rio Chama to Otowi Bridge** (sediment transport capacity > sediment supply)	272 to 257.6	310 [a]	Low sinuosity, single channel, some split channels.	0.00162 [d]	N/A	Gravel and coarse sand	Local increase in bank height and incision or channel bed degradation. Horizontal alignment fairly stable. Moderate channel incision. A few migrating bends—river bed below the riparian root zone in some areas. Minor amount of narrowing where riparian vegetation is encroaching on the active channel.	Channel narrowing Vegetation encroachment Bank erosion Coarsening of bed material Increased channel uniformity
Cochiti	**Cochiti Dam to Angostura Diversion Dam** (sediment transport capacity > sediment supply)	232.6 to 209.7	220 [b]	Moderate sinuosity, single channel, with islands/bars. Constrained channel width less than (<) calculated meander belt width.	0.00123 [e]	1.15 [g]	Gravel and small cobble dominated, with some sand	Channel disconnection with floodway due to high historic incision. Bank heights are very high. Bars are becoming stabilized with vegetation, and some are continuing to increase in size. Vertical stability is fairly stable due to gravel dominated bed, but there can be degradation locally. Some tributaries bring in coarse materials that act as local grade control.	Channel narrowing Vegetation encroachment Bank erosion Coarsening of bed material Increased channel uniformity
Albuquerque	**Angostura Diversion Dam to Isleta Diversion Dam** (sediment transport capacity > sediment supply)	209.7 to 169.3	390 [b]	Transition from wide braided to single channel.	0.00091 [e]	1.16 [g]	Sand changing to gravel dominated in upper portion, sand bed in lower portion	Channel disconnection with floodway due to high historic incision in upper portion of reach. Banks and bed in lower portion have been relatively stable. There is potential for additional incision and bend migration. Narrowing where riparian vegetation is encroaching on the active channel. Bar formation and stabilization. Vertical and lateral accretion of bars. Complexity within the braided planform and active flood plain in lower portion. Significant amount of floodway modifications to reconnect channel with floodway. Moderate incision—greater upstream.	Channel narrowing Vegetation encroachment Increased bank height Incision or channel bed degradation Bank erosion Coarsening of bed material Increased channel uniformity
Isleta	**Isleta Diversion Dam to Rio Puerco** (sediment transport capacity > sediment supply)	169.3 to 127	350 [b]	Narrowing through island and bar development, becoming single thread.	0.00077 [f]	1.08 [g]	Sand, a few gravel deposits forming	Narrowing through vegetation growth stabilizing islands and bars. Bank height increasing due to sediment deposition (vertical accretion). The channel cross section is becoming more uniform. Potential for channel incision as the channel continues to narrow. Horizontal alignments have been fairly stable (little bend migration) as the banks are densely vegetated. Low incision, increasing to high downstream. Bed elevation and channel slope have been relatively stable.	Channel narrowing Vegetation encroachment Increased bank height Coarsening of bed material Increased channel uniformity
	Rio Puerco to San Acacia Diversion Dam (sediment transport capacity > sediment supply)	127 to 116.2	250 [b]	Single thread with islands, narrowing.	0.00069[f]	1.10 [g]	Bimodal gravel and sand	Localized channel incision, and bend migration in the downstream area. Entrenched with low bank height due to inset flood plains. Coarse Rio Salado deposits acting as bed control.	Channel narrowing Vegetation encroachment Increased bank height Incision or channel bed degradation Coarsening of bed material Increased channel uniformity

Table 4. Reach geomorphic parameters (continued)

Water Operations Reaches	Geomorphic Reaches	River Miles (RM)	Average Width (feet)	Planform	Slope	Sinuosity	Bed Material Type	Current Observations of -Channel and floodway topographical changes	Currently Relevant Trends
San Acacia	**San Acacia Diversion Dam to Arroyo de las Cañas** (sediment transport capacity greater than [>] sediment supply)	116.2 to 95	270 [b]	Single channel—low to moderate sinuosity.	0.00078 [f]	1.11 [g]	Bimodal gravel and sand	High incision, decreasing downstream Bend migration threatening riverside infrastructure. Active channel area and width has decreased through 2001 but currently stable. Point bar growth is present where the banks migrate. Tributary reconnections may increase sediment supply.	Vegetation encroachment Increased bank height Incision or channel bed degradation Bank erosion Coarsening of bed material Increased channel uniformity
	Arroyo de las Cañas to San Antonio Bridge (sediment transport capacity less than [<] sediment supply)	95 to 87.1	320 [b]	Becoming single thread and narrowing, slightly meandering thalweg is beginning to form.	0.00076 [f]	1.11 [g]	Sand	Horizontal and vertical stability historically and in short term. Channel filling with sediment; in the downstream portion, sediment plugs may be possible. Transition between upstream degradation and downstream aggradation. Vegetation growth causing local narrowing and increasing channel uniformity. Low potential for general bend migration however it may occur locally. Recent aggradation increasing downstream; Elephant Butte pool elevation may have low level effect. Tributary reconnections may increase sediment supply .	Channel narrowing Vegetation encroachment Aggradation Increased channel uniformity
Bosque del Apache[j]	**San Antonio Bridge to River Mile 78** (sediment transport capacity < sediment supply [m])	87.1 to 78	230 [b]	Becoming single thread and narrowing, potential for avulsions.	0.00071 [k]	1.12 [g]	Sand	Previously slightly aggrading, recently highly aggrading. Bank heights low; flood plain connectivity high except very downstream section. Increasing loss of sediment transport capacity except very downstream section. Prone to sediment plugs. Vegetation growth is narrowing the channel. Bed elevation influenced by large variations in the water surface elevation of Elephant Butte Reservoir.	Channel narrowing Vegetation encroachment Aggradation Channel plugging with sediment Perched channel conditions Increased channel uniformity
San Marcial	**River Mile 78 to Elephant Butte full pool** (sediment transport capacity < sediment supply[m])	78 to ~60	130 [c]	Narrow single thread.	0.00058 [k]	1.16 [g]	Sand	Normally aggrading, recently degrading. Area between the levees is perched above the historical flood plain, but recent channel degradation has reduced the main channel bed elevation. Historical loss of channel capacity and sediment plug formation. Bed elevation influenced by large variations in the water surface elevation of Elephant Butte Reservoir. Flood plain disconnection in lower portion of this reach. A few migrating bends—river bed below the riparian root zone in some areas. Some island and bar formation. San Marcial Railroad Bridge narrows active flood plain.	Channel narrowing Vegetation encroachment Increased bank height Incision or channel bed degradation Bank erosion Coarsening of bed material Increased channel uniformity

[a] 2002 photography. [b] 2008 photography. [c] 2007 photography. [d] 2000 data. [e] 2002 data. [f] 2007 data. [g] 2006 photography. [h] 2009 data N/A – data not available. [i] Elephant Butte Dam to Palomas Creek. [j] Water Operation reach extends from the north (~RM 84) to south (~RM 74) boundary of the BDANWR. [k] 2010 data. [m] This is the historically most common condition. The sediment balance may change to the condition of sediment transport capacity is > sediment supply in portions of these reaches, depending upon the extent of the base level lowering of the Elephant Butte Reservoir, the duration that the reservoir pool is down, and the incoming sediment supply.

into reaches with similar trends. The analysis of the geomorphic parameters, beyond identifying current trends on the MRG, also provides a summary of traits or characteristics for these reaches and a trajectory of expected changes. A summary of these six geomorphic parameters that influence the drivers and currently observed trends is provided in table 5. Additional information and discussions on reach specific details are provided in the report titled Channel Conditions and Dynamics of the Middle Rio Grande (Makar and AuBuchon 2012).

The major current trends observed on the MRG, although not every trend on every reach, are listed below.

- Channel narrowing
- Vegetation encroachment
- Increased bank height
- Incision or channel bed degradation
- Bank erosion
- Coarsening of bed material
- Aggradation (river bed rising due to sediment accumulation)
- Channel plugging with sediment
- Perched channel conditions (river channel higher than adjoining riparian areas in the floodway or land outside the levee)
- Increased channel uniformity

These trends and their applicability to the MRG are discussed in the sections below. The relationship between sediment transport capacity and sediment supply is also identified for each trend. This relationship is key to anticipating future changes in reach trends and the direction of river responses, which helps determine potentially more sustainable corrective actions. Additional details supporting these trends and the relationship between sediment transport capacity and sediment supply are provided in the report titled Channel Conditions and Dynamics of the Middle Rio Grande (Makar and AuBuchon 2012).

5.5.1.1 Channel Narrowing (Sediment Transport Capacity Can Be Either Greater or Less than Sediment Supply)

The channel narrowing that has occurred since 1949 is likely the result of some combination of decreased peak flows, increased low flows of longer duration, decreased sediment supply, increased bank stability, increased flood plain lateral confinement, and decreased flood plain connectivity. The particular combination is dependent on reach-specific conditions.

When sediment transport capacity is greater than sediment supply, bed degradation or channel incision can occur. More bed degradation occurs in the channel thalweg (deepest area of the channel) than in shallower areas resulting in channel narrowing. For the case where the sediment transport capacity is less than the sediment supply, channel narrowing can occur as a result of sediment deposition in the form of medial or bank attached bars during high flows (lateral accretion). When subsequent flows are lower, these bars may not remobilize and so result in channel narrowing. Based on historical accounts and survey data, the MRG has narrowed significantly over the last century (Makar et al. 2006). For both cases, the resulting more confined, uniform sections offer little diversity of instream habitats for silvery minnow and low flood plain connectivity. Narrow, confined channels have less low velocity habitats for silvery minnow and often require higher flows to inundate riparian vegetation, which is important for flycatcher.

5.5.1.2 Vegetation Encroachment (Sediment Transport Capacity Can Be Either Greater or Less than Sediment Supply)

Significant vegetation encroachment into the active channel has occurred historically and again during the recent drought cycle as documented by historical photography and in Scurlock (1998), Lagasse, (1980) Makar et al. (2006), and Makar (2010). This is likely the result of decreased peak flows and increased low flows of longer duration. Increased low flows of longer duration provide water more consistently and encourage vegetation growth near the channel. At the same time, the decreased peak flows have insufficient shear stresses to uproot the established vegetation. Existing hydrology and flood control operations for safe channel capacity make an event large enough to destabilize the current vegetation extremely unlikely on the MRG. Thus, it is likely that, on a reach scale, bank erosion and subsequent bank migration will be restricted, provided the bed elevation does not degrade below the root zone of established riparian vegetation. These channel resetting events maintained a diversity of habitats, backwaters, and side channels within the river channel for silvery minnow and a variety of successional stages of vegetation with riparian zone for flycatchers.

Conditions where the sediment transport capacity is greater than the sediment supply can lead to bed degradation or channel incision, as described above in the section on channel narrowing. The channel incises more along the thalweg than in other portions of the river bed; therefore, adjoining, higher areas of the river bed are inundated and mobilized less frequently, which creates a condition conducive to vegetation growth. This vegetation growth then reduces the width of the active channel.

Conditions in which the sediment transport capacity is less than the sediment supply can result in sediment deposition. These deposits can become vegetated if they are not remobilized by high flows, thereby narrowing the channel. These more confined, uniform sections offer little diversity of instream habitats for silvery minnow and low flood plain connectivity. The mature vegetation associated with this encroachment is valuable habitat for flycatchers but has a limited lifespan of suitability. Habitat diversity both in the riparian zone and within the channel has decreased due to lack of channel resetting events.

5.5.1.3 Increased Bank Height (Sediment Transport Capacity Can Be Either Greater or Less than Sediment Supply):

The increase in bank height that has occurred is likely the result of some combination of decreased sediment supply, increased bank stability, low bed stability, lowered base level (e.g. Elephant Butte reservoir pool elevation), increased flood plain lateral confinement, and flood plain connectivity (lower velocities in flood plain cause sediment to settle and result in vertical accretion in flood plain). The particular combination is dependent on reach-specific conditions.

If the sediment transport capacity is greater than the sediment supply, bank height increases can occur as a consequence of channel degradation or incision, which can reduce flood plain connectivity as well. When sediment transport capacity is less than sediment supply, bank height can increase due to sediment deposition in the flood plain (vertical accretion). This is primarily due to the lower sediment transport capacity of the flood plain when flows go overbank. An example of vertical accretion on the MRG is the observation of surface deposits during the high flows in the spring of 2005 on vegetated bars and islands within the Albuquerque area (Meyer and Hepler 2007). Similarly after the 2005 spring runoff ended, field observations indicated significant vertical accretion occurred on the bars, islands, and flood plains in the Isleta to Rio Puerco Reach, especially near areas of flowing water (Bauer 2007). These higher features subsequently require larger magnitude runoff events to inundate. These more confined, uniform sections offer little diversity of instream habitats for silvery minnow and low flood plain connectivity.

5.5.1.4 Incision or Channel Bed Degradation (Sediment Transport Capacity Is Greater than Sediment Supply)

When banks are more resistant than the bed, the river seeks to increase its sediment supply by transporting additional sediment from the bed. The incision that has occurred is likely the result of some combination of decreased sediment supply, increased bank stability, low bed stability, lowered base level (e.g., Elephant Butte Reservoir pool elevation), increased flood plain lateral confinement, and decreased flood plain connectivity. The last three factors all contribute to higher flow energy, which adds to the river’s need to self-adjust through channel bed degradation. The particular combination of factors is dependent on reach-specific conditions.

Incision on the MRG between Cochiti and Isleta has been impacted most strongly by construction of Cochiti and Jemez Canyon Dams, and these effects appear to be continuing to extend downstream. The lack of upstream sediment supply exacerbated the combined effects from the placed jetty fields of the more efficient channel and the reduction of bank material as a sediment source and resulted in degradation of the river channel and disconnection from the adjacent flood plain. Another example of this trend in the lower reaches of the MRG is due to the recent low elevation of Elephant Butte Reservoir. The low reservoir elevation is one of the causes of erosion of the upstream channel and delta deposits that has led to channel degradation from the southern BDANWR to the pool. Due to these changes, the channel has become disconnected from the surrounding flood plain in some areas. The extent (depth and length) of degradation depends on the extent of the base level lowering and the duration that the reservoir pool is lower.

The incision throughout the MRG also has the effect of lowering the water table in the vicinity of the active channel, which diminishes the ability of the river to recharge perennial and ephemeral wetland areas. These more confined, uniform sections offer little diversity of instream habitats for silvery minnow and low flood plain connectivity.

5.5.1.5 Bank Erosion (Sediment Transport Capacity Is Greater than Sediment Supply):

The bank erosion that has occurred is likely the result of some combination of decreased sediment supply, low bank stability, higher bed stability, lowered base level (e.g., Elephant Butte Reservoir pool elevation), increased flood plain lateral confinement, and decreased flood plain connectivity. The last three all contribute to higher flow energy that adds to the river’s ability to self-adjust through bank erosion. The particular combination of factors contributing to bank erosion is dependent on reach-specific conditions. When the bank stability is less than the bed stability, the channel responds to unmet sediment transport capacity by bank erosion and lengthening of the channel, thereby increasing sinuosity. An overly-lengthened channel may reduce sinuosity when a more hydraulically efficient cutoff channel develops and straightens that bend. These dynamic processes can form side channels and other features that may contribute to habitat diversity within the reach. Higher sinuosity areas are more likely to contain features such as backwaters and low velocity side channels that are important to all life stages of silvery minnow and overbank wetted vegetation used by flycatchers. It should be noted, however, that on the reach scale, the MRG is classified as having low sinuosity.

Bed material coarsening (discussed below) can make the bed more resistant to erosion than the banks. Channel degradation or incision leads to taller banks that are often less stable, again resulting in bank erosion. At present, the bank heights in several reaches of the MRG are generally tall enough for the river’s thalweg to intersect the banks beneath the root zone of the riparian vegetation, creating conditions in which the banks are more easily eroded. This, coupled with a single-channel planform and a thalweg that alternates between the banks, has led to the development of a series of migrating bends in those reaches.

5.5.1.6 Coarsening Bed Material (Sediment Transport Capacity Is Greater than Sediment Supply

As the channel bed degrades or incises, bed sediment of finer sizes, which are more easily transported, are removed from the bed while coarser sizes remain. Figure 50 presents the median size of the bed material over time in the MRG and shows the coarsening trend. Coarsening of bed material is likely the result of some combination of decreased sediment supply, increased bank stability, low bed stability that allows transport of finer bed particles, lowered base level (e.g., Elephant Butte Reservoir pool elevation), increased flood plain lateral confinement, and decreased flood plain connectivity. The first three factors may contribute to channel narrowing, which may lead to or be coupled with channel bed degradation. The last three of these factors all contribute to higher flow energy, which adds to the river's ability to move bed material. Under all of these conditions, the bed material may potentially coarsen further. Since the amount of energy to move a particle is proportional to its size, only the very coarsest materials remain. The particular combination of factors contributing to coarsening of bed material is dependent on reach-specific conditions.

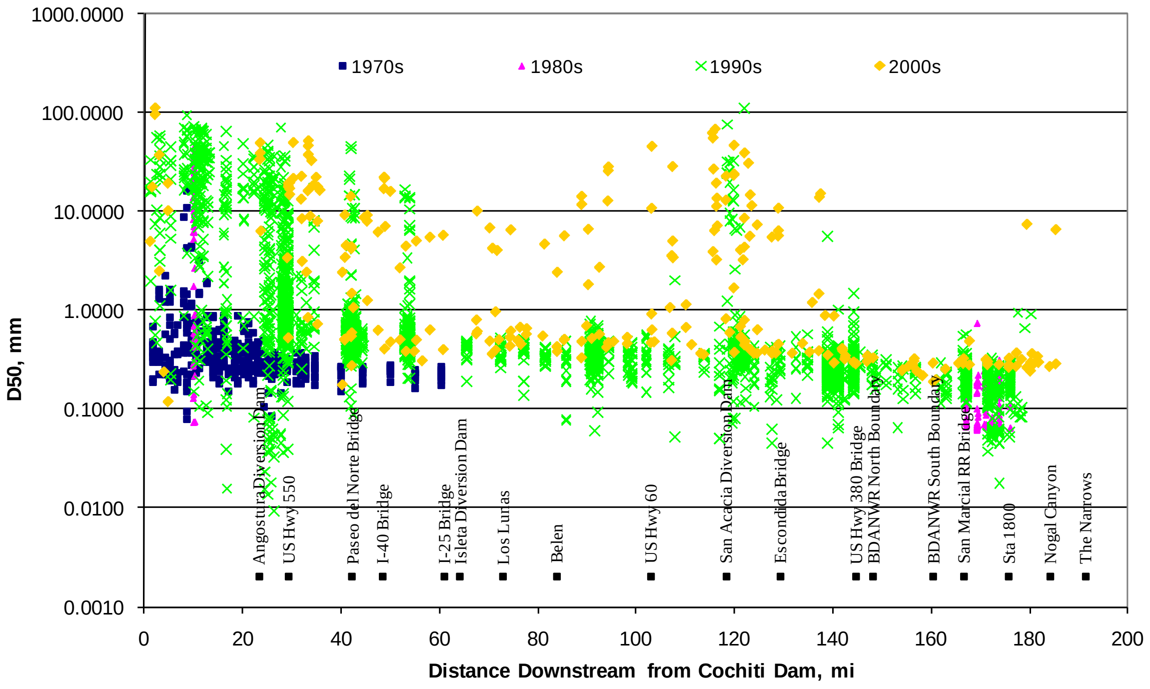


Figure 50. Median bed material size on the MRG over time (Bauer 2009).

5.5.1.7 Aggradation (River Bed Rising Due to Sediment Accumulation – Sediment Transport Capacity Is Less than Sediment Supply)

Aggradation is likely the result of some combination of high sediment supply, increased bank stability, higher base level (e.g., Elephant Butte Reservoir pool elevation rising that causes flatter slopes and increased flow resistance upstream, which tend to decrease the channel's sediment transport capacity), increased flood plain lateral confinement (which causes increased aggradation, due to limitation of the available area for deposition), and increased flood plain connectivity. The particular combination of factors contributing to aggradation is dependent on reach-specific conditions.

When sediment deposition occurs, it raises the bed elevation in both the main channel and the adjoining riparian zone. The extents and amounts are dependent upon the magnitude of the sediment transport imbalance; the greater the imbalance, the greater the deposition. The aggradation rate in the San Marcial area has been historically greater than any other reach. From 1900–1937, the riverbed aggraded more than 16 feet at the San Marcial Railroad Bridge. It has aggraded almost 13 more feet through 1999 (Makar 2009). The railroad bridge has been raised three times for a total of 22 feet (Van Citters 2000). Aggradation is currently a significant long-term concern from San Antonio south. There is some mild aggradation upstream of San Antonio. These reaches are strongly influenced by the pool elevation of Elephant Butte Reservoir (Elephant Butte Dam was closed in 1916) as well as sediment and water discharge magnitude, duration, and frequency (Levish 2010). During wetter periods with a full reservoir, these reaches continue to experience high levels of aggradation, alternating with degradation influenced by recession of the reservoir during drier periods and lower incoming sediment load.

The aggradation of the active channel provides water to a broader area of riparian vegetation that is used by flycatchers as well as lower velocity habitats for silvery minnow.

5.5.1.8 Channel Plugging with Sediment (Sediment Transport Capacity Is Less than Sediment Supply)

Channel plugging is likely the result of some combination of high sediment supply, increased bank stability, higher base level (e.g., Elephant Butte Reservoir pool elevation), increased flood plain lateral confinement, and increased flood plain connectivity. A higher base level and an increase in flood plain connectivity can reduce the sediment transport capacity of the river, which over time builds conditions that support the formation of sediment plugs. The particular combination of factors that lead to plugs is dependent on reach-specific conditions.

As sediment deposits in the main channel, flow from the top of the water column can go overbank at lower discharges. Because there is a lower concentration of sediment being transported at the top of the column, the overbank flow removes a higher percentage of water volume than sediment load. As a result, the main channel sediment transport capacity is reduced, but the sediment supply decreases by a smaller percentage. This results in additional deposition in the main channel. Continued overbank flows with sediment accumulation in the main channel further reduces main channel flow capacity. This process can continue until sediment completely fills the main channel. The River Mile 78 to River Mile 62 Reach has a history of sediment plug formation near RM 70, approximately 1.5 miles upstream of the San Marcial Railroad Bridge. Three plugs have formed at this location in the last 20 years, in 1991, 1995, and 2005. The 1991 plug caused a breach of the Tiffany Levee on the west side of the river. The 1995 plug grew to a length of approximately 5 miles, and the 2005 plug grew to a length of approximately 3 miles. During the 2008 spring runoff, a sediment plug formed in the main channel of the river within the San Antonio Bridge to River Mile 78 Reach, just downstream from RM 81. The main channel was completely plugged with sediment for a length of a half mile and partially plugged upstream of that for a distance of over 1 mile.

The plugging of the active channel provides water to a broader area of riparian vegetation that is used by flycatchers as well as lower velocity habitats for silvery minnow. A connected flood plain provides important larval and rearing habitats for silvery minnow as well as inundated riparian vegetation for flycatcher.

5.5.1.9 Perched Channel Conditions (River Channel Higher than Adjoining Riparian Areas in the Floodway or Land Outside the Levee – Sediment Transport Capacity Is Less than Sediment Supply)

Perched channel conditions are likely the result of some combination of high sediment supply, increased bank stability, higher base level (e.g., Elephant Butte Reservoir pool elevation), increased floodway lateral confinement, and increased flood plain connectivity.

As a riverbed raises and sediment-laden waters flow overbank into the riparian zone, flow velocity decreases, which causes sediment deposition that, in turn, raises the river bank height. Continued bed raising and overbank deposition results in a channel bed, bordered by natural levees, which is significantly higher than the adjoining areas between manmade levees or geologic formations. This condition is known as a perched channel. A river corridor also can become higher than land areas outside the levee when sediment deposition occurs across the entire flood plain between the levees. The historical valley flood plain accessible by the MRG has been significantly reduced by levees paralleling much of the river. Subsequent aggradation between the levees has rendered that area higher than the adjoining valley for most of the MRG between Angostura Diversion Dam and Elephant Butte Dam. This process is most pronounced on the Rio Grande downstream from San Antonio. Perched channel conditions can be a factor in channel plugging.

The perching of the active channel provides water at a larger variety of flows to a broader area of riparian vegetation that is used by flycatchers as well as lower velocity habitats for silvery minnow. A connected flood plain provides important larval and rearing habitats for silvery minnow as well as inundated riparian vegetation for flycatcher.

5.5.1.10 Increased Channel Uniformity (Sediment Transport Capacity Can Be Either Greater or Lesser than Sediment Supply)

On a reach scale in the MRG, morphological features (width, depth, velocity, flood plain connection, backwater features, etc.) that were once significantly variable are becoming more uniform. This increase in channel uniformity results primarily from a decreased variability in flows and sediment supply. This decreased variability is a result of flow control, which causes lower peaks and more constant low flows. Lower peaks mean less energy is available to rework the channel and flood plain. The channel banks and flood plain do not erode as much, and sediment remains stored in the banks. More constant low flow means vegetation can grow more easily (see vegetation encroachment section above), further reinforcing the existing bank line and perhaps storing even more sediment.

In the MRG, storage of sediment behind dams in both the main stem and tributaries, less watershed erosion due to land use changes, and bank and bed stabilization have so reduced the sediment supply that, even with lower peaks, the sediment transport capacity is greater than the sediment supply for most of the MRG. SWCA (2010b) found that after the 1930s the channel dynamics in the Angostura to Isleta Reach of the MRG were diminished to the point that the riparian environment diversity became static and no longer changed as it once did.

Conditions in which the sediment transport capacity is greater than the sediment supply lead to river bed degradation or channel incision, as previously described. As the channel incises and narrows, the active channel planform moves from a wide braided channel with extensive mobile bars to a narrow single channel with few mobile bars. The wetted channel at higher flows changes from being wide and shallow with significant topographic and hydraulic variations, to narrow and deep with limited space for topography and hydraulic variations. These changes contribute to increased channel uniformity locally and also on a reach basis as the irregularities of the natural channel become more and more alike. The end result is a channel with more uniform slope and width, high, steep banks, lower suspended sediment load, and coarser bed material.

Conditions in which the sediment transport capacity is less than the sediment supply lead to channel aggradation, as previously described. Since the majority of the MRG has lateral constraints, as the channel aggrades, the space between the constraints becomes elevated. This, in turn, raises the bed elevation of the main channel, creating greater opportunities for flooding and diminishing the topographical elevation variations between the main channel and the flood plain.

Vegetation growth, as described in the section on vegetation encroachment, is encouraged by the smaller in-channel forces created by lower peak flows and the greater connectivity between the main channel and the flood plain. Bars often attach to the bank as the channels fill in, decreasing bar mobility. Under these conditions, the active channel planform moves towards a narrow active channel with a more consistent width and limited sediment mobility.

Figure 51 illustrates one aspect of channel uniformity, the variability of the channel width within a reach. The narrowing of the gap between the maximum and minimum measured widths and the decrease in the standard deviation are an indication that widths are becoming increasingly uniform.

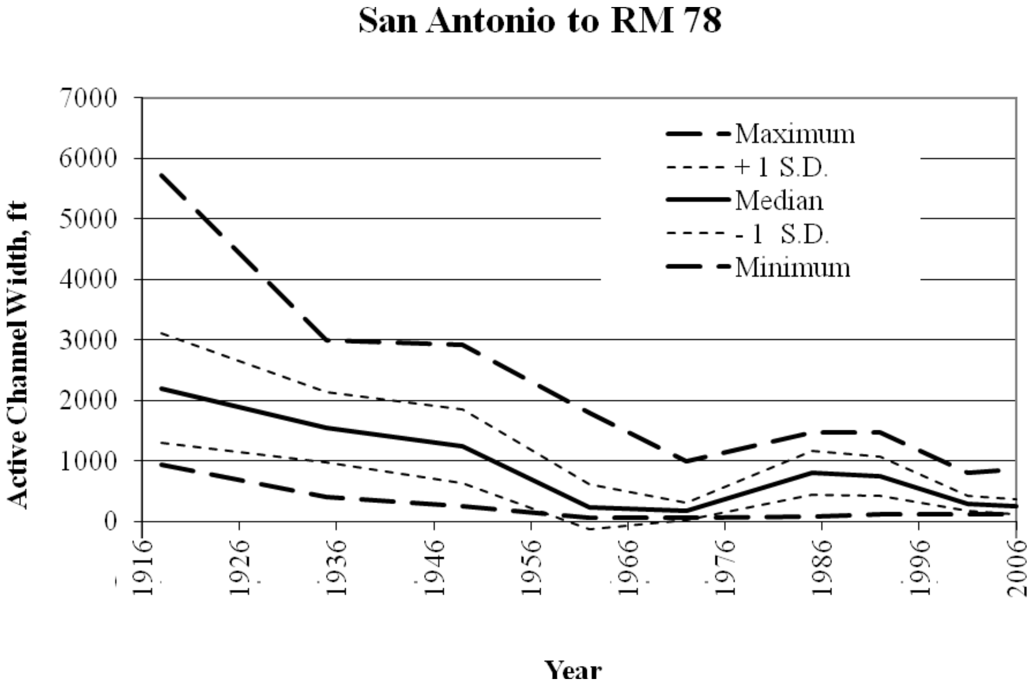


Figure 51. Channel mean width change over time with standard deviation for San Antonio (RM 87.1 to RM 78).

5.6 Actions to Avoid, Minimize, or Mitigate

This environmental baseline is also affected by many ongoing activities that the Service prescribed in biological opinions issued over the last 10 years, as well as other activities that have had positive effects on the status and knowledge of the species. Many of these activities have been carried out by the Collaborative Program, which focuses on improving the status of the listed endangered species in the MRG including the silvery minnow and the flycatcher. These activities serve as a tool to conserve listed species, assist with species recovery, and help protect critical habitat.

The following is a brief discussion of the activities carried out, including elements in the RPA, RPM, and conservation recommendations in the 2003 BiOp as well as other measures that may improve the status and knowledge of the species.

5.6.1 Environmental Water Management

Over the past decade, Federal, State and local agencies have engaged in efforts to coordinate water and river operations to improve system operations and achieve ESA compliance. Environmental water operations are triggered by 2003 BiOp flow criteria. RPA Element C mandates that reconnaissance of portions of the Middle Rio Grande be performed to:

1. Provide current information on river flows that allow Reclamation and the other agencies to react quickly to rapidly changing conditions on the river,
2. Facilitate coordination among the agencies to prevent unexpected drying.
3. Prepare for silvery minnow rescues.

Daily coordination of water operations between Federal and non-Federal partners has been especially critical during periods of limited water availability and river drying. For example, coordination with the MRGCD allowed the maintenance of short lengths of wet river during extremely dry periods through small, targeted return flows from irrigation system drains, outfalls, and wasteways. Also, coordination of the RiverEyes program with the Service’s minnow salvage program allowed targeting of salvage efforts to the locations at which they would be most effective. Information provided by the RiverEyes program also allowed optimal use of pumping from the LFCC to the river as needed to limit the extent of drying, manage recession and avoid excessive stranding, and to support silvery minnow rescue operations.

Many of the RPA elements (A to O, RPMs 1.1, 3.1, and 3.2) involve water management thresholds, targets, and requirements. Element A calls for a spike release to induce silvery minnow spawning. A natural spike flow occurred in 2003 and was followed in 2009 by a spike flow resulting from an experimental deviation in the operation of Cochiti Reservoir. A deviation of Cochiti Reservoir operations also occurred in 2010, but that deviation resulted in a rapid decrease in flows following the flow spike, which may have disrupted the development of silvery minnow eggs and larvae.

Supplemental water releases have aided in maintaining the flow targets and slowing the rate of recession, which helps both minnow and flycatcher habitat (Elements A to O, RPM 3.1, 3.2). Supplemental water generally has only been used to manage the recession of spring runoff and not to augment spring peaks.

The flow requirement increases between average and wet years in the 2003 BiOp may not significantly change the condition of the river but can result in a significant increase in the required water.

As part of the Supplemental Water Program (Element O, RPM 4.1), in the San Acacia Reach, pumping from the LFCC to the river is done at four locations. The use of this water to manage river recession has been successful and has allowed many of the fish to move with the receding river. Pumping for flycatchers has not been done directly and should be assessed on a case-by-case basis where appropriate; during very dry years, it is theorized that pumping may attract predators to areas where flycatchers are nesting. In recent years, pumps have run continuously at the south boundary of BDANWR during low flow conditions though not required by the 2003 BiOp. There has been no assessment of the effectiveness of pumping to benefit the species or how effective the pumped water is at maintaining river connectivity.

5.6.1.1 Reclamation's Supplemental Water Program

Reclamation initiated its Supplemental Water Program in 1996 to support water needs of the ESA-listed species in the MRG. The program originally included acquisition, storage in upstream reservoirs, and release of water to support river flows. Since 2001, it also has included operation of a pumping network in the San Acacia Reach to pump water from the LFCC to the river. Reclamation has enhanced the flexibility of its program of leases of annual allotments of SJC Project water with a program of waivers of release dates from Heron Reservoir of contracted water. This program of release waivers has served to further enhance water releases for environmental and recreational purposes on the Rio Chama.

Through these methods, Reclamation has acquired a supply of Supplemental Water over the past decade and used this water to support river flows and manage recession to meet the needs of the endangered species and the terms of the BiOps. Since 2003, Reclamation has released an average of 28,568 AFY of Supplemental Water in the manner deemed to provide the most benefit to the listed species. An updated NEPA analysis of the current Program was completed in 2011, and a finding of no significant impact was issued.

The Program has included the following elements:

- Lease from contractors and storage of SJC Project water
- Heron Reservoir release waiver
- Acquisition and storage of relinquished credit water from the State of New Mexico;

- Release of Supplemental Water to meet the needs of listed species
- Pumping of water from the LFCC to the San Acacia Reach of the Rio Grande

These elements of the program are described in more detail in the following subsections.

5.6.1.1.1 San Juan-Chama Project Water Acquisition and Storage

Since 1997, Reclamation has acquired most of its Supplemental Water Program water by entering into temporary lease agreements with SJC Project contractors. The amounts and sources of these leases each year are summarized in table 6.

Since 2003, Reclamation has leased an average of 24,664 AF of water from SJC Project contractors annually.

Figure 52 presents a summary of the water obtained for Reclamation's Supplemental Water Program from willing SJC Project contractors since 2001. The primary source of SJC Project water to the program has been the ABCWUA. However, as previously described, ABCWUA has brought online its drinking water diversion, through which it plans to use its allocation of SJC Project water for urban supply. Therefore, the availability of this water to Reclamation's Supplemental Water Program has been significantly reduced.

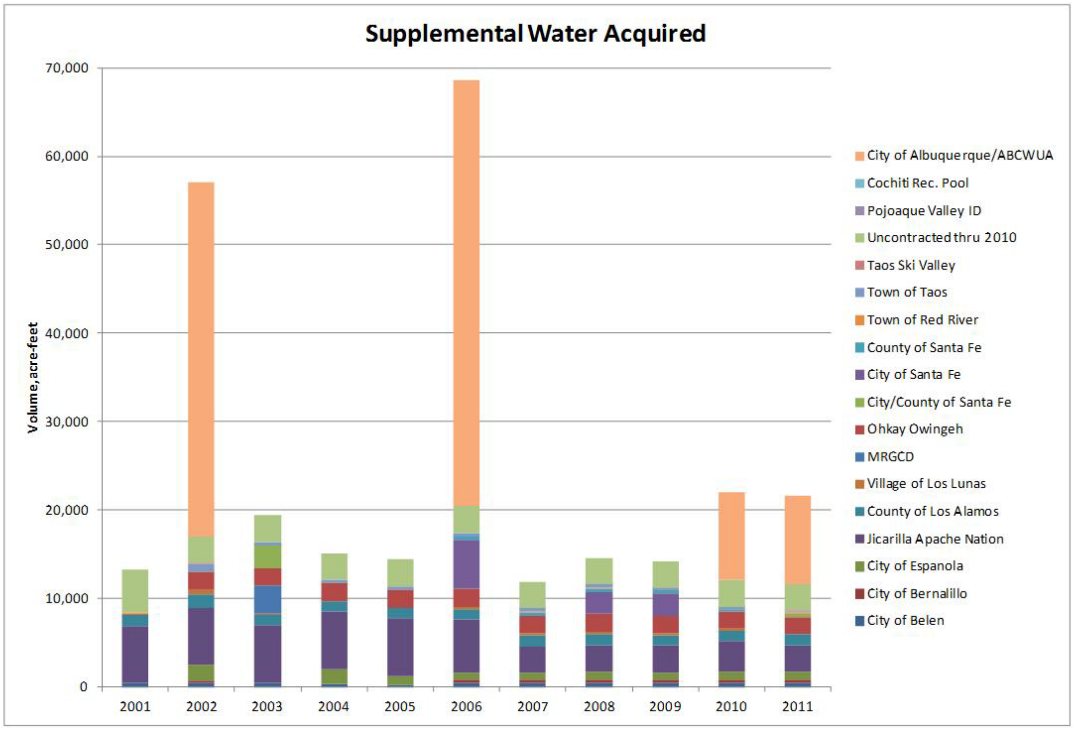


Figure 52. Summary of San Juan-Chama Project water leased to Reclamation's Supplemental Water Program.

Table 6. Leased supplemental San Juan-Chama Project water (1997–2011)

CONTRACTOR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Albuquerque	10,000	10,000	10,000	64,500		40,000				48,200				10,000	10,000	202,700
City of Belen			800	700	400	470	504	354	242	450	470	470	400	450	450	6,160
City of Bernalillo						300				400	320	400	400	400	400	2,620
City of Espanola		2,000	2,000	5,000		1,687		1,650	1,000	800	856	850	850	850	900	18,443
Jicarilla Apache Nation			6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,000	2,948	3,000	3,000	3,500	3,000	66,948
County of Los Alamos		3,650	3,600	5,000	1,200	1,529	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	25,779
Village of Los Lunas		500	500	300	200	500	100			256	293	331	200	200		3,380
MRGCD							3,132									3,132
Ohkay Owingeh						2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	20,000
City of Santa Fe		10,000	10,000	10,000			2,500			5,500		2,500	2,500		375	43,375
County of Santa Fe										375	375	375	375	175		1,675
Town of Red River			60	60	60	60	60	60	60	60	60	60	60	60	60	780
Town of Taos			400	400		937	419	400	400	400	400	400	200	245	225	4,826
Taos Ski Valley			50	50		53					15	15	15	8	8	214
Uncontracted		4,990	4,990	4,990	4,990	2,990	2,990	2,990	2,990	2,990	2,990	2,990	2,990	2,990	2,990	49,860
Total	10,000	31,140	38,900	97,500	13,350	57,026	19,405	15,154	14,392	68,631	11,927	14,591	14,190	22,078	21,608	**449,892**

Reclamation has entered into agreements with the MRGCD and ABCWUA to store the leased SJC Project water that Reclamation acquires for the Program. Under an MRGCD storage agreement, which expired at the end of 2009, Reclamation stored up to 30,000 AF of SJC Project water in El Vado Reservoir. The ABCWUA storage agreement authorizes Reclamation to store 10,000 AFY of SJC Project water in Abiquiu Reservoir through 2012, with options to extend.

5.6.1.1.2 Heron Reservoir Release Waivers

As discussed above, SJC Project contractors must take delivery of their annual allocation of SJC Project water prior to December 31 of each year; otherwise their water reverts to the SJC Project pool at Heron Reservoir. However, Reclamation regularly authorizes extension of that date, in cases for which such an extension benefits the United States. Waivers generally allow SJC Project water to remain in Heron Reservoir through April 30 of the year following the one in which the water was allocated to the contractor. Reclamation has authorized waivers even later in the year, but only under unusual circumstances.

Reclamation has authorized waivers at times when maintaining water in Heron will allow use of such water at a later date to facilitate downstream storage or when changes to the timing of deliveries help maintain fishery flows and support recreation on the Rio Chama. Reclamation also has authorized waivers to contractors who have agreed to lease their allocated water to Reclamation's Supplemental Water Program.

From 2003–2011, Reclamation acquired over 201,601 AF of San Juan-Chama Supplemental Water at a cost of approximately $17,679,696.

5.6.1.1.3 Conservation Water Agreement and Emergency Drought Water Agreement

Reclamation also includes in its Supplemental Water supplies water leased from the State of New Mexico of water obtained through relinquishment of New Mexico credits under the Rio Grande Compact. Lease of this water to Reclamation's Supplemental Water Program was made possible through the Emergency Drought Water Agreement[27] and the Conservation Water Agreement (CWA) with the State of New Mexico. CWA and EDWA water has been stored, and made available to Reclamation, consistent with the relevant interstate compacts and with State and Federal law as a conservation pool upstream of Elephant Butte Reservoir. Pursuant to the amended EDWA agreement (2003–2013), Reclamation may release up to 20,000 AF of its allocated water in any one calendar year. This water is authorized for storage while Article VII storage

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[27] In 2003, Reclamation, the MRGCD, the Service, BIA, and the Corps entered into the Emergency Drought Water Management Agreement to coordinate the use of EDWA water, to provide an additional source of stored water for routine MRGCD operations, and to manage EDWA water in a manner that optimizes operations for meeting needs of both irrigators and species as set out in the 2003 BiOp.

restrictions under the Compact are in effect; and, therefore, this supply has significantly contributed to the availability of Supplemental Water during low-water years.

In 2003, New Mexico offered to relinquish up to 217,500 AF of accrued credit waters in Elephant Butte Reservoir. In April 2003, New Mexico relinquished 122,500 AF of credit water held in Elephant Butte Reservoir, and Texas accepted that water in project storage. It was further agreed that Texas would accept the balance of 95,000 AF if available. In 2004, Texas accepted an additional 53,000 AF. These agreements allowed Reclamation to store in El Vado Reservoir a maximum of 169,448 of the 175,500 AF relinquished to date while under Article VII restrictions. Approximately one-third of the relinquishment storage could be used by Reclamation on behalf of federally listed endangered species, while two-thirds of the relinquishment was assigned to the MRGCD supplies. Releases related to the EDWA storage for endangered species compliance averaged 7,620 AF over the 6-year period from 2003–2008. Credit relinquishments for 125,000 AF in 2008 enabled Article VII restrictions to be lifted. Approximately 62,500 AF of water was allocated for species needs, but EDWA waters were not actually stored in 2008. An unallocated balance of 62,500 AF of water was reserved for future as yet undefined needs. As of the end of 2011, there was 19,196 AF of EDWA water in storage at El Vado, and Reclamation has an additional unused allocation of 19,500 AF.

Reclamation also sought to maximize storage for Supplemental Water obtained either from EDWA or SJC Project water leases. Storage agreements for conservation water storage at Abiquiu Reservoir were secured, contingent on the availability of space. In 2005 and 2006, 20,000 AF of storage at Abiquiu was designated for conservation storage. A new agreement signed in 2007 identified 10,000 AF of conservation storage space. Since ABCWUA has brought its SJC Drinking Water Project online, the amount of potentially available conservation storage space available at Abiquiu is increasing and is expected to ultimately increase to about 30,000 AF.

From 2003–2011, Reclamation acquired over 64,509 AF of Supplemental Water under the Emergency Drought Water Agreement at a cost of approximately $6,450,900.

5.6.1.1.4 Release of Supplemental Water

Supplemental water acquired as described in the sections above has been released from storage by Reclamation as needed to meet the needs of listed species. Since SJC Project waters are not authorized to be used for delivery compliance under the Compact, Reclamation has exchanged the leased SJC Project water with MRGCD for native Rio Grande flows. The SJC Project water leased each year by Reclamation has, therefore, been used beneficially in New Mexico for irrigation, while native waters have augmented stream flow and provided benefits to the listed species. The MRGCD has used the exchanged Supplemental Water for irrigation once it has passed the downstream-most flow target.

The following figure 53 shows the total water released under the Supplemental Water Program for ESA purposes over the past decade. It is evident from this figure that CWA and EDWA water were a significant source of water released to benefit listed species during the drought years of the early part of the past decade. Please note that in 2001 and 2002, water was released according to different criteria and flow targets than in the years covered by the 2003 BiOp. In 2000, 171,000 AF was released that was related to a court order to keep the Rio Grande wet pending re-consultation with the Service over the minnow. This process resulted in the 2001 BiOp. In 2002, 73,000 AF was released under the 2001BiOp.

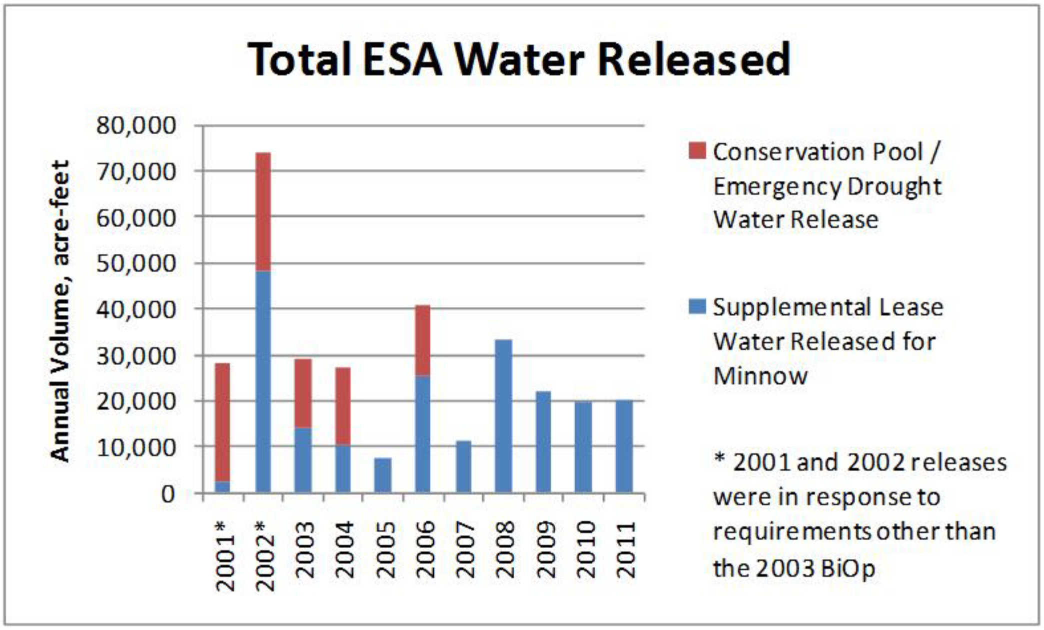

Figure 53. Summary of water released annually to meet the needs of listed species under Reclamation's Supplemental Water Program.

A new Biological Opinion was implemented as of March 13, 2003, and the remaining releases were made to meet the requirements of that BiOp. The annual average release of water for ESA purposes under the 2003 BiOp was 28.568 AF, of which 19,593 AF was leased SJC water, and 8,975 AF was conservation pool/emergency drought water.

About one-third of Supplemental Water released was used to support continuous flow requirements, spring spawning and recruitment flows, and to manage recession (March–June) while the remaining two-thirds of Supplemental Water supplies were released to meet late season flow targets (July–October) or manage recession after rewetting.

The date of first release of Supplemental Water has varied widely, from early March to early August. These variations, which are graphed in figures 54 and 55, are dependent on hydrologic conditions (the earliest dates are from the drought years of 2002–2004) and BiOp requirements for a given year. The last release date for Supplemental Water each year was in October, the last month of the irrigation season for non-Pueblo irrigators, except in 2006, in which it was in early November, during the final period of Pueblo irrigation. In figures 54 and 55, these dates of ESA water release are compared to the dates of reported river drying in the Isleta Reach and the San Acacia Reach. As can be seen on these graphs, ESA water release typically has been initiated in anticipation of river drying in these reaches.

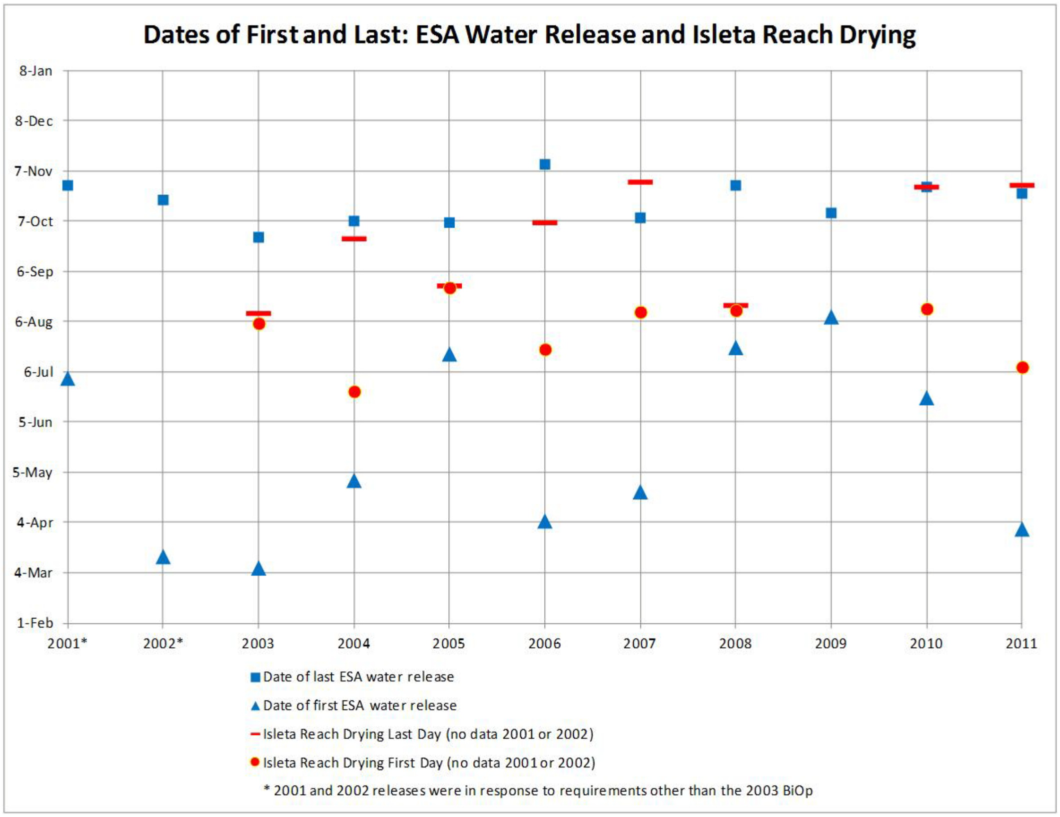

Figure 54. Comparison of dates of first and last release of water from Reclamation's Supplemental Water Program to dates of reported river drying in the Isleta Reach, 2001–2011.

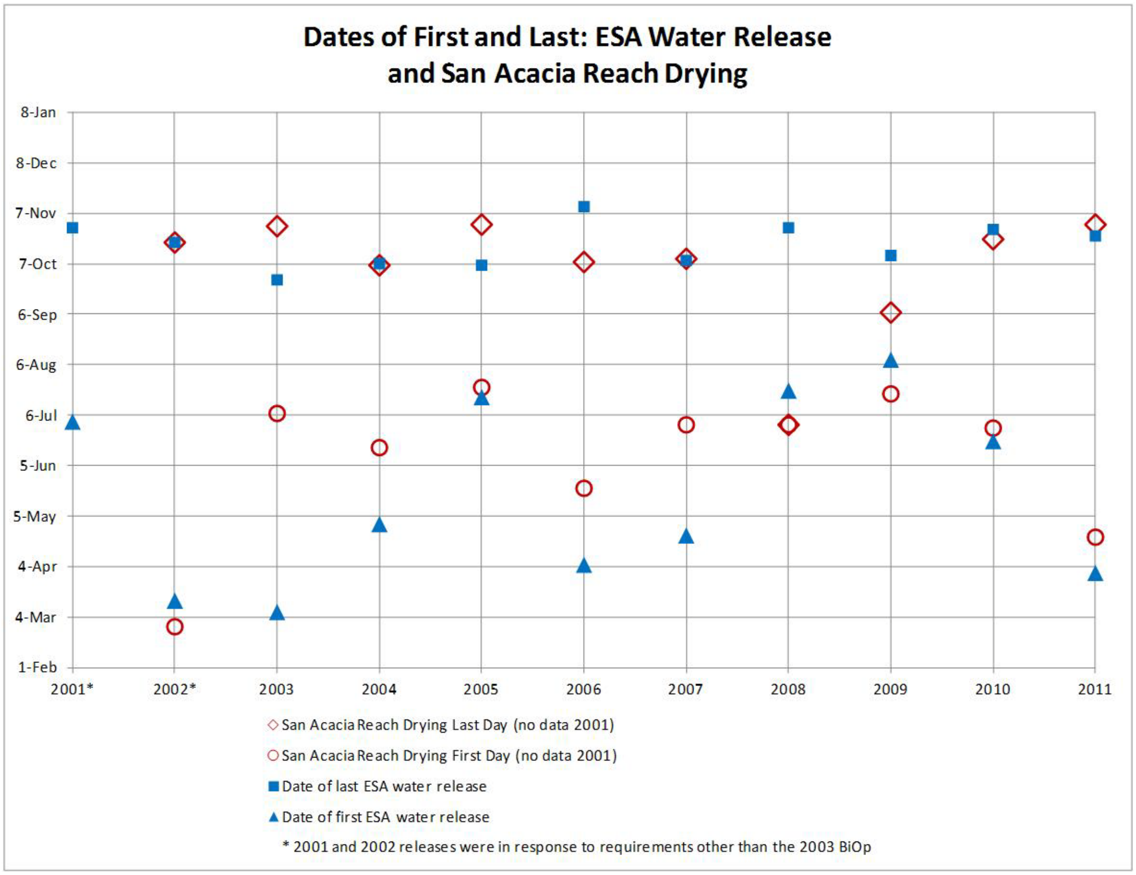

Figure 55. Comparison of dates of first and last release of water from Reclamation's Supplemental Water Program to dates of reported river drying in the San Acacia Reach, 2001–2011.

The data presented demonstrate that Reclamation has met the flow requirements of the 2001 and 2003 BiOps over the past decade, but that Reclamation's ability to do so was dependent on the following conditions and events:

- The availability of water to be leased to Reclamation's Supplemental Water Program, including both SJC Project water leased from willing sellers and water relinquished and leased to Reclamation by the State of New Mexico.

- Conservations measures and other helpful water management actions performed by Reclamation's water management partners, including the Corps, the Service /BDA National Wildlife Refuge, the State of New Mexico, and the MRGCD.

- No years with small, early snowmelt runoffs, such that Supplemental Water is required to maintain continuous flow throughout the MRG.

5.6.1.1.5 Pumping from the Low Flow Conveyance Channel

Due to the long travel times for Supplemental Water stored in Rio Chama reservoirs, various types of diversion and river losses, and difficulties in meeting downstream flow targets during dry periods, Reclamation implemented a local water management alternative in the reach below San Acacia Diversion Dam, in which water, collected from seepage into the LFCC, is pumped from LFCC to the river. From 2001–2010, pumping of water from the LFCC to the river in the San Acacia Reach has been used to limit the extent of river drying from Neil Cupp south to Fort Craig and to assist in managing river recession and silvery minnow rescue. LFCC pumping was identified in the 2003 BiOp as a beneficial action that helps sustain habitat for both the silvery minnow and Southwestern willow flycatcher. Accordingly, Reclamation has performed this action as part of its Supplemental Water Program. As such, it does not preclude river drying when drying is allowed under the 2003 BiOp.

In 2000, Reclamation installed and operated temporary pumps at Neil Cupp, Mid-Bosque, South Boundary, and Ft. Craig to alleviate drying in the Rio Grande to benefit the RGSM and SWWF. Subsequently, Reclamation relocated the Mid-Bosque pumps to North Boundary. In June 2005 Reclamation produced an appraisal design study on installing permanent, electrically operated pumps at the four historical sites. Due to monetary concerns, the permanent-pump alternative was not pursued. At present, sites are located at both the northern and southern boundaries of Bosque del Apache Wildlife Refuge (North Boundary, South Boundary), Neil Cupp and Fort Craig.

Although not required by the 2003 BiOp, Reclamation has continuously pumped water from the LFCC to the river at South Boundary during each of the summer drying seasons except 2008, to maintain river flows south of BDANWR for the benefit of the minnow. Other stations are used as needed and, as water is available, to assist in managing river recession (generally before the end of June) and to support RGSM salvage and rescue operations. The pumps at North Boundary and at Neil Cupp have been operated intermittently, primarily due to the need to balance the use of the available water in the LFCC between the Supplemental Water Program, the MRGCD (which has an LFCC diversion structure at Neil Cupp) and the BDANWR (which has an LFCC diversion structure at the north boundary of the refuge).

Figure 56 shows the total amount of pumping from all of the LFCC pump stations since 2001 on an annual basis. LFCC pumping volumes ranged from 30 (2008) to 32,481 (2002) AFY. As this figure shows, total pumping was highest during the early 21st century drought years and has declined considerably since. A typical distribution of volume pumped at each site is given in figure 57, which was representative of the 2006 pumping season.

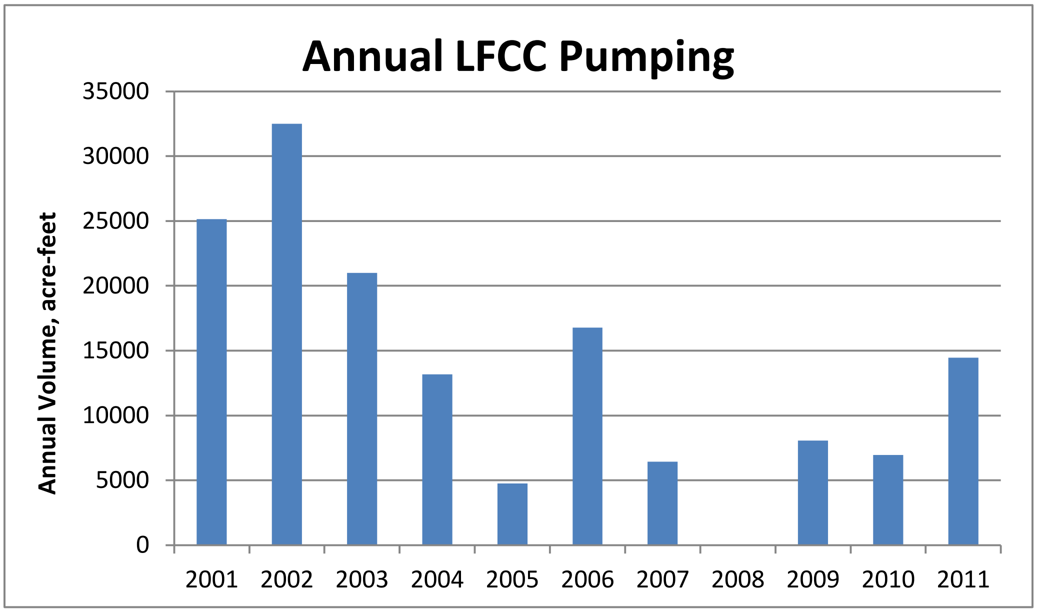

Figure 56. Summary of water pumped annually from the LFCC to the San Acacia Reach of the Rio Grande, as part of Reclamation's Supplemental Water Program.

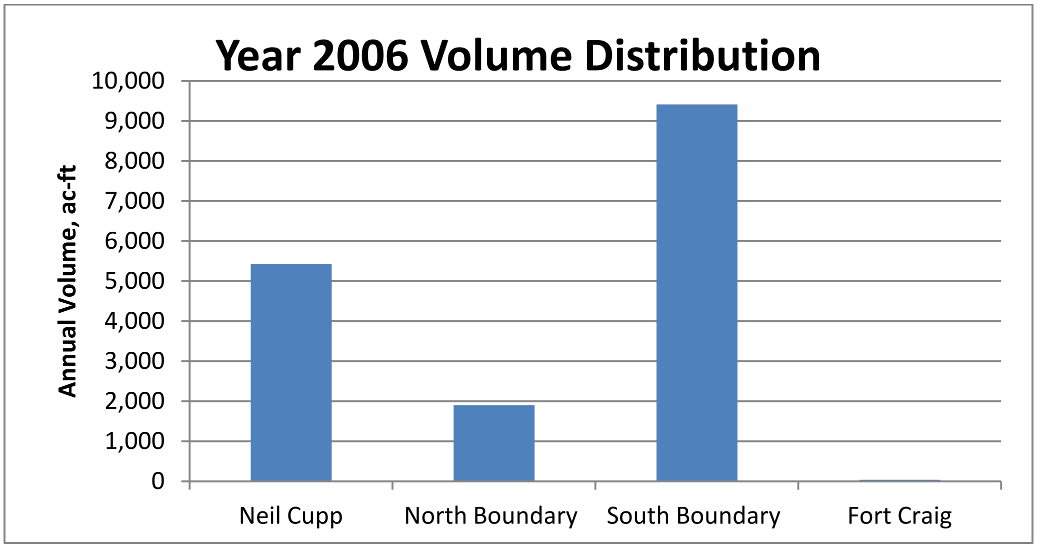

Figure 57. 2006 distribution of annual volume pumped from the LFCC across the four pumping sites used during the baseline period.

Figure 58 provides a comparison of the time period during each calendar year in which Reclamation has pumped water from the LFCC to the San Acacia Reach of the river to the time period in which drying was reported in this reach. In most of these years, pumping has been initiated in anticipation of river drying and has helped to ameliorate the effects of that drying on the species by providing refugial wetted habitat at key locations.

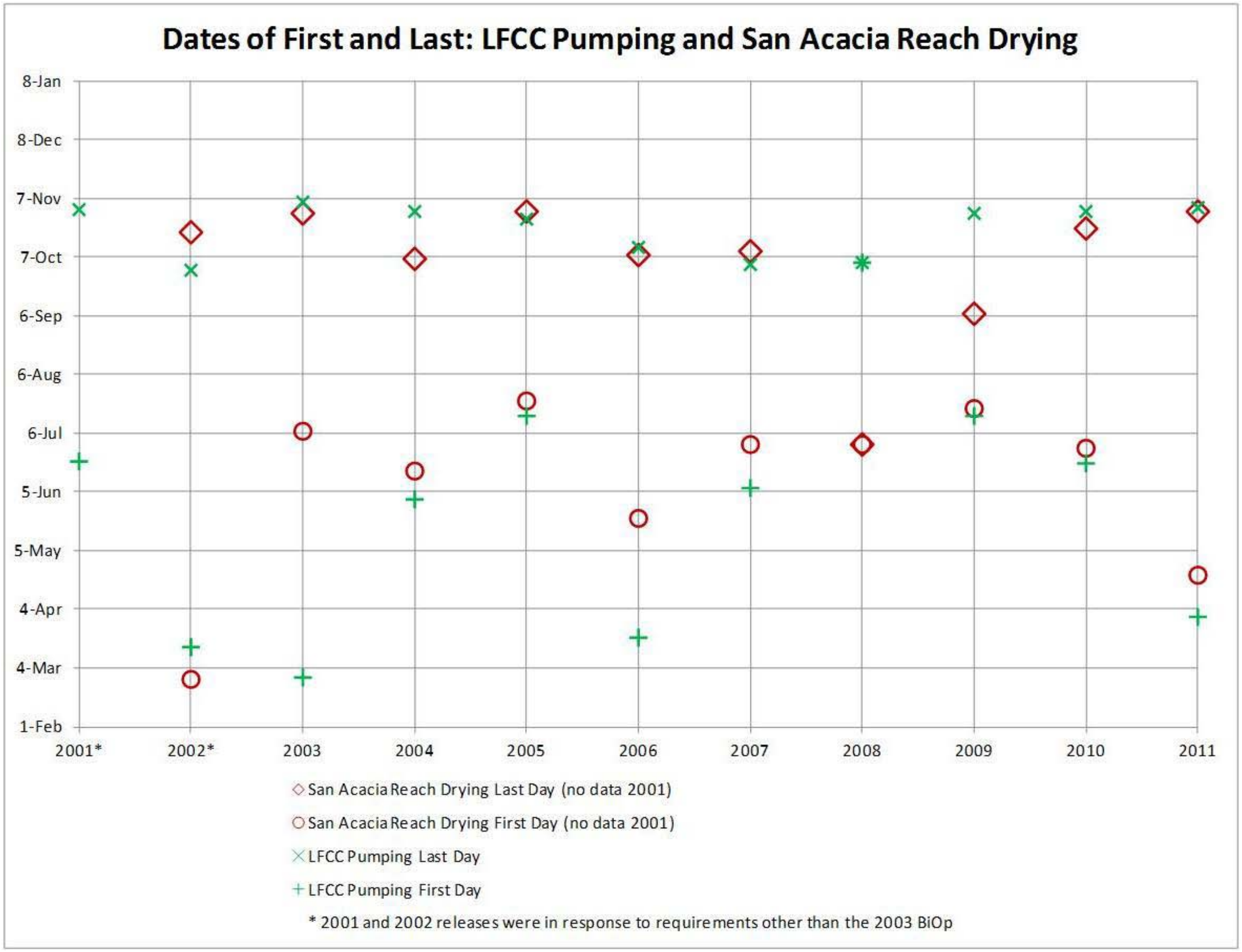

Figure 58. Comparison of the calendar days of supplemental water release to the calendar days of pumping from the Low Flow Conveyance Channel.

5.6.1.2 MRGCD's Conservation Activities.

The MRGCD takes the below-described measures to support listed species. Additionally, the MRGCD participates in and shares the cost of the Collaborative Program/RIP, and funds PVA model development (full funding for one of the two models under development).

5.6.1.2.1 MRGCD's Enhanced Coordination for Environmental Water Operations

The MRGCD's enhanced coordination for environmental water operations have included the following timeframe:

- Participation in the regular management of water operations throughout the MRG, in conjunction with Reclamation, the Corps, NMISC, the ABCWUA, and the Service with the goal of providing efficient water management, meeting the needs of all State of New Mexico permitted water uses, remaining in compliance with the Compact, and benefitting the species to the greatest extent practical.

- Provision of access to MRGCD managed lands for operational and scientific purposes involving species (including guides, keys, etc.), including activities related to habitat restoration projects, fish monitoring, and fish salvage.

- Operation and maintenance of measurement stations, telemetry equipment, computer processing, and data exchange networks to collect and distribute information on MRGCD water operations to other water management entities and the general public.

- Expansion and refinement, with funding and cooperation from the State of New Mexico, Reclamation, and the Program, of the network of MRGCD measurement stations to contribute to a more thorough scientific understanding of water movement, distribution, and use throughout the MRG.

- Support for efforts by Reclamation and NMISC to fully understand Rio Grande depletions from all sources through participation in river measurements made by various entities.

- Support for management of Supplemental Water by Reclamation, and species salvage by the Service, through participation in river measurements during critical periods.

5.6.1.2.2 MRGCD Operations to Support Instream Habitat and Flow Management

The primary purpose of the MRGCD's operational measures described below has been to benefit listed species.

- MRGCD requested that Reclamation release from El Vado only the amount of irrigation water necessary to sufficiently augment native supplies to meet agricultural demands. This operational efficiency has the goal of increasing annual carryover of stored water, minimizing both Reclamation's need for Supplemental Water for the species and impacts of subsequent storage operations on flows. This allowed the MRGCD to minimize the rate of diversion at the Diversion Dams during critical times, most significantly Angostura Diversion Dam, and to continue to use the layout of the four MRGCD divisions to efficiently re-use return flows.

- The MRGCD has managed releases of return flows from drain outfalls and wasteways to better meet the needs of RGSM. These releases, which have been coordinated with Reclamation's Supplemental Water Program, have increased the consistency of return flows and have provided discrete wetted sections that have served as refugia for RGSM, with possible SWFL benefit. On occasion, the MRGCD managed these releases to assist the Service with its RGSM rescue efforts.

- The MRGCD has exchanged Reclamation's Supplemental Water, as necessary, for an equal amount of native water. This exchange has ensured that all SJC Project water that was released under the Supplemental Water Program was beneficially consumed within the MRG.

- The MRGCD has borne all losses to Reclamation Supplemental Water through Cochiti Dam and Albuquerque Reaches. As a result, Supplemental Water has been conveyed through the Cochiti and Albuquerque Reaches without incurring any loss. In exchange, the MRGCD has diverted the remaining Supplemental Water once it has passed the downsteam-most flow target specified in the 2003 BiOp.

- During periods with a continuous flow requirement through the MRG, the MRGCD has borne a variable portion of losses to Reclamations' Supplemental Water, to ensure that 50% of the Supplemental Water arriving at Isleta Diversion Dam is passed through the Isleta Reach to the San Acacia Diversion Dam.

- During its shortage/conservation operations in the fall of 2011, the MRGCD reduced diversions at Angostura Diversion Dam to the minimum practical rate of flow required to meet irrigation demand within the Albuquerque division.

- The MRGCD has exchanged water with Reclamation's Supplemental Water Program to allow the program to achieve intended rates of flow below diversion dams without accounting for travel time between the reservoir from which the water was released and the river reach of concern (that is, when Reclamation has begun releasing Supplemental Water, the MRGCD has bypassed water through its diversion dams to support critical reaches downstream, even though the Supplemental Water had not yet reached the diversion dam). The MRGCD has taken actions to avoid the sealing of gates in the Isleta Diversion Dam, such that the normal gate leakage of approximately 8 cfs is maintained throughout the irrigation season. This water has provided critical refugial habitat for the minnow downstream from the dam.

- The MRGCD has taken actions to avoid the sealing of gates in the San Acacia Diversion Dam, such that the normal gate leakage of a approximately 8 cfs is maintained throughout the irrigation season. This water has provided critical refugial habitat for the minnow downstream from the dam.

5.6.1.2.3 The MRGCD's Operation to Support Spring Peak Flows

- The MRGCD has minimized or temporarily suspended diversions during periods of peak silvery minnow egg production to minimize incidental entrainment of eggs and larvae into irrigation canals; this action has been subject to rates of flow, agricultural needs, and coordination with the Service.

- The MRGCD has coordinated its storage requests with Reclamation, NMISC, and the Corps with the goal of maximizing peak discharge and/or duration of the spring runoff through the MRG to benefit the species.

5.6.2 Habitat Improvement

Habitat restoration elements in the 2003 BiOp include various components meant to benefit the species. Some elements are basically coordination efforts to utilize the best available methods to minimize take. For example, any project that may potentially affect flycatcher or minnow habitat is coordinated with the Service including maintenance of LFCC pumps (Element P). This includes vegetation clearing and other activities that surround the pump sites. Water is a key element within the Rio Grande, and many gages in the river and within MRGCD (Element Q) have helped to ascertain the accurate accounting of water use. Other elements are more specific to improving conditions for endangered species and may be specifically tied to the recovery plan.

5.6.2.1 Fish Passage

Fish passage (Element R) has been delayed due to needed additional assessments. An external peer review process, initiated through the Collaborative Program, was completed in 2011. This peer review of the science surrounding the need for fish passage found that there was much uncertainty surrounding what the goals for fish passage are, and how many silvery minnow would need to use it to accomplish these goals (PBS&J 2011). The peer review panel recommended that more research into the relationship between genetic diversity and dam fragmentation as well as the influence of habitat mitigation within reaches on movement, growth, survival, and reproductive success of the silvery minnow be conducted before fish passage at San Acacia Diversion Dam is attempted.

5.6.2.2 Habitat Restoration

Habitat improvement projects (Elements S, T, and X) and efforts by other parties in coordination with the Collaborative Program, yielded over 2,500 acres of habitat restoration work in the MRG at a cost of $16,487,092. This amount includes Reclamation and Collaborative Program amounts for actual construction. Additional funding was provided for planning, design, and monitoring costs (not included in the $16.4 million).

The initial focus of these restoration efforts was in the more degraded upstream reaches between Cochiti Dam and Isleta Diversion Dam. However, more recently the emphasis has expanded to include significant restoration efforts in the Isleta Reach. Funded through the Collaborative Program, the Corps, Reclamation, the Service’s Management of Exotics for Recovery of Endangered Species program, ABCWUA, the Pueblos, city of Albuquerque, and others have provided localized changes to improve riverine and riparian conditions along the MRG.

The projects have used techniques including creating/opening secondary high flow channels, lowering/clearing bank lines, islands, and adjacent bars, creating overbank flooded habitat, clearing non-native vegetation, planting native vegetation, building gradient reduction facilities, widening the river channel, placing large woody debris, building embayments and backwater areas, and removing lateral constraints. Further descriptions of the methods, the most likely geomorphic and biological response, as well as habitat characteristics of the habitat restoration techniques commonly used on the MRG over the last decade is included in appendix 1. Because the MRG is actively self-regulating to balance its sediment transport capacity and sediment supply, exact geomorphic and biological responses to a particular method after implementation are more difficult than for rivers that are closer to a sediment balance. Caveats on the use of the geomorphic responses are described in the Channel Conditions and Dynamics section.

The objective of many of the projects has been to provide additional low velocity habitats during high flows and increase retention of eggs and larvae within the upper reaches of the river when inundation targets are met for these projects. Habitat restoration techniques that have been used for improving habitat at lower flow conditions include creation of refugial habitat at drains and placement of cottonwood snags or large woody debris that create pool habitat. Specific projects for flycatchers also have been completed, which replace monotypic stands of saltcedar with dense native vegetation and provide greater flood plain connectivity.

Monitoring is ongoing to evaluate if restoration is producing positive results for minnows and flycatchers and to evaluate effectiveness of techniques used. Generally, most projects have had positive results and use by minnow. For silvery minnow, it is considered to be a success if more low velocity habitat is available at the sites than was available prior to restoration. Large numbers of silvery minnow have been collected on inundated sites (Collaborative Program 2011, SWCA 2010a&b). Creation of suitable flycatcher habitat is predicted to take several years postconstruction for mature vegetation to establish. No suitable habitat was identified in the 2008 flycatcher habitat suitability model. At this time, no flycatcher nesting has been verified on any program habitat restoration sites.

Hydrologic monitoring on NMISC restoration sites indicates that these sites provide fish habitat that is lower velocity and shallower than the adjacent river channel. Monitoring efforts also have been analyzed to understand the potential differences in hydrological conditions produced by different general restoration techniques. For this effort, four broad categories of habitat restoration techniques were used: high flow channels, backwaters, and lowering of bank shelves and islands (table 7). While all techniques produced hydrologic habitat conditions that fall within the suitable habitat range, backwaters generally produced the lowest velocity and the second highest depths. High-flow channels resulted in both the highest depth and highest velocity conditions. Shelves and islands were the only two techniques that had conditions within the suitable habitat range recorded in each measured transect (ISC 2011 DRAFT).

The amount of restored habitats that inundate annually varies depending on discharge. Most features have been designed to inundate at flows between 1,500 and 3,500 cfs at the site location. The amount of restored acreage that inundates annually increases with the amount of flow, though all features do not function equally at flows greater than their designed inundation level. For example, a feature designed to inundate at 1,500 cfs may not provide low velocity habitat at 3,500cfs. Since the year 2000, 4 years had spring discharge levels that fully inundated restored sites in the Albuquerque Reach (> 3,500 cfs) for more than 10 days, while 5 years failed to inundate any sites designed for 1,500 cfs or more for at least 10 days (table 8). Available data for the Bosque Farms and 346 Bridge Gage show that the inundation targets for restoration sites in the Isleta Reach are met less often. Table 9 provides a brief description of habitat restoration projects and the listed acreage of that work. Information was compiled from three sources: The Middle Rio Grande Endangered Species Collaborative Program's (MRGESCP) annual reports and Reclamation's annual Biological Opinion Accomplishment Reports sent to the Service.

Table 7. Average depth and velocity conditions on categorized habitat restoration sites (ISC 2011 Draft)

Technique Categories	Sample Number (n)	Mean Depth (ft)	Mean Velocity (ft/sec)
High Flow Channels	24	1.23	1.24
Backwaters	15	1.18	0.23
Bank Shelves	33	0.76	0.35
Island	24	0.67	0.32

Table 8. Maximum consecutive days of discharge exceeding habitat restoration inundation targets at Albuquerque Gage from 2000–2011 (USGS8330000), Bosque Farms Gage from 2006–2011 (USGS 08331160), and Highway 346 Gage from 2006–2011 (USGS 08331510). Dark shading indicates no days with average discharge greater than inundation targets. Lighter shading indicates inundation less than 10 consecutive days.

Albuquerque Reach				Isleta Reach			
Albuquerque Gage	**Inundation Targets (cfs)**			**Bosque Farms Gage**	**Inundation Targets (cfs)**		
Year	**3,500**	**2,500**	**1,500**	**Year**	**3,500**	**2,500**	**1,500**
2000	▨	▨	▨	2006	▨	1	2
2001	2	6	37	2007	▨	4	28
2002	▨	▨	▨	2008	11	27	92
2003	▨	▨	▨	2009	13	28	35
2004	▨	1	13	2010	4	6	31
2005	71	78	88	2011	▨	▨	▨
2006	▨	▨	1	**346 Bridge**			
2007	3	15	37	2006	▨	▨	▨
2008	22	92	103	2007	▨	4	27
2009	20	34	47	2008	12	26	93
2010	12	31	62	2009	15	33	35
2011	▨	▨	▨	2010	5	7	32
				2011	▨	▨	▨

Table 9. Summary of habitat restoration activity on the Rio Grande, sorted by geomorphic reach

Year	Type of Work	Project Lead/ Project Name	Total Work Done
	Rio Chama to Otowi Bridge		
2004	Non-native vegetation removal and native vegetation planting	Ohkay Owingeh Pueblo	40 acres vegetative removal,75 acres native planted
	Removal of approximately 40 acres of Russian olive and other exotic vegetation. In addition, willows and native wetland plants were planted in two areas.	Ohkay Owingeh Pueblo	75 acres
2005	SWFL habitat created at Ohkay Owingeh Pueblo creation of high flow channels, removal of non-native trees, and planting of native tree species	Ohkay Owingeh Pueblo	10 acres
2007	Ohkay Owingeh Pueblo installed habitat within restored bosque, also included exotic vegetation removal	Ohkay Owingeh Pueblo	10 acres
2007	Buried Bendway weirs at San Ildefonso	Reclamation	
2008	Ohkay Owingeh Pueblo installed habitat within restored bosque, also included exotic vegetation removal	Ohkay Owingeh Pueblo	38 acres removed, replanted
2010	Ohkay Owingeh Pueblo invasive species removal and native vegetation planting• 15,000 herbaceous wetland plants, 3500 coyote and Gooding’s willows, and 148 box elder.	Ohkay Owingeh Pueblo	279 acres replanted
	Total Rio Chama to Otowi		**487 acres of habitat work**
	Cochiti Dam Reach		
2005	Bank lowering at Santa Fe River confluence1.6 acres re-connected to river and planted with native vegetation	Reclamation	1.6 acres reconnected
2006	Modification of side channel to connect with main stem, creation of embayments and backwater, non-native vegetation removal.	Santo Domingo	114 acres non-native removed, 2 acres side channel, embayment
2007	Santo Domingo Pueblo reconnected an old oxbow to the main channel, created embayments, and installed large woody debris to the main channel	Santo Domingo	23 acres, oxbow recreation
2008	Removal of non-native vegetation at San Felipe Pueblo	San Felipe Pueblo	10 acres non-native removed
2008	Riparian and backwater area creation; bioengineering at the Pueblo de Cochiti	Reclamation	7 acres backwater
2009	Santo Domingo Pueblo - removal of invasive species and channel restoration over three areas	Santo Domingo	58 acres combined non-native removal and channel
2010	Santo Domingo Endangered Species Habitat Improvement Project Phase IV– reconstruction of a historic side channel	Santo Domingo	9 acres historic side channel
2011	Revegetation and construction at two Santo Domingo sites	Santo Domingo	30 acres
	Vegetation clearing, riparian and backwater area creation, bioengineering at the Pueblo of San Felipe	Reclamation	18 acres of non-native vegetation removal, 5 acres of habitat restoration; bioengineering planted with native vegetation
	Total Cochiti to Angostura		**272.6 acres habitat work**
	Angostura Reach		

Table 9. Summary of habitat restoration activity on the Rio Grande, sorted by geomorphic reach

2003	Habitat restoration at the Pueblo of Sandia	Sandia Pueblo	40 acres restored
2003	Clearing non-native vegetation, installation of willow swales and Gradient Restoration Facilities.	Santa Ana	Cleared 500 acres of bosque, 100 acres of willow swale, 4 GRFs
2003-2004	Perennial pools created using cottonwood large woody debris through Albuquerque reach	MRGCD	3 Cottonwood Snags
2004	Willow swale installation at Santa Ana Pueblo	Santa Ana Pueblo	10 acres willow swale
2004	Wetland creation and bosque restoration at Tingley Beach	City of Albuquerque	48 acres restoration, wetland creation (Tingley)
2005	Island and bank destabilization through the Albuquerque reach	ISC/Reclamation	12 acres bar destabilization
2005	Pond reconstruction, bosque restoration, and wetland creation at Tingley Beach	City of Albuquerque	9 acres wetlands construction, 15 acres pond reconstruction
2005	Removal of non-native vegetation throughout the Albuquerque reach		200 acres non-native removal and replanting
2006	ISC performed bank lowering, island lowering, and ephemeral channel excavation north of Alameda bridge through the Albuquerque reach	ISC	74 acres, bank, island lowering
2006	Habitat creation at the Rio Grande Nature Center	Corps/Rio Grande Nature Center	15 acres various riparian
2006	Flood plain lowering and formation of riparian habitat near Bernalillo	ISC	6 acres high flow channel
2007	Excavation of ephemeral channels and removed non-native vegetation at the Rio Bravo south site	City of Albuquerque	26 acres non-native removal near channel
2007	U.S. Highway 550, Paseo del Norte to Montano Road, in the vicinity of the I-40 bridge and in the vicinity of the South Diversion Channel. Restoration techniques included vegetated island modification, bar habitat modification, placement of large woody debris, bank scouring, bank lowering, and the establishment of ephemeral channels.	ISC	87 acres, various methods
2007	Riparian and variable flow aquatic habitat created on the Pueblo of Sandia , construction of bendway weirs and placement of rootwads	Reclamation	35 acres, mostly riparian near aquatic
2008	Habitat restoration at north Rio Bravo site	City of Albuquerque	1.3 acre Rio Bravo
2008	Rio Grande Nature Center bosque reconnection with the Rio Grande	Corps/Rio Grande Nature Center	10 acres non-native, 3 acres high flow channel
2009	Bank lowering project/habitat restoration	Corps	27 acres of habitat restored, 62 acres of banks and islands were lowered
2009	Construction of backwater and other bank lowering activities	City of Albuquerque	20 acres of bank and bar lowering; 5 acres of habitat was created by the backwater construction
2009	Removal of jetty jacks and created habitat north of Rio Bravo by reshaping of the bank	City of Albuquerque	140 jetty jacks, re-treated 20 acres of re-sprouting non-native vegetation, and planted 40 cottonwoods, 250 black willows, and 4,000 sedges and rushes. 58.3 acres of habitat were created .
2009	Route 66 bosque restoration, 121 acres of riparian restoration, 5 willow swales, and 3 high-flow channels	Corps	121 acres of habitat restored
2009	Sediment spoil pile removal	Santa Ana/ Reclamation	20 acres of overbank improved
2009	Construction of a 5-acre backwater and refugial habitat	ISC	25 Acres

Table 9. Summary of habitat restoration activity on the Rio Grande, sorted by geomorphic reach

	at an old irrigation diversion structure, named the Atrisco Diversion. Also, 20 acres of river bankline, islands, and bank-attached bars were modified by lowering and sculpting to create new flood plain habitats that inundate during spring runoff		
2009	Re-connection of flood plain at the Pueblo of Santa Ana	Pueblo of Santa Ana/Corps	62 acres of bank-lowering to increase the extent and frequency of inundation in the Pueblo's reach of the Rio Grande
2010	Project features include island and bar vegetation removal and destabilization, bank lowering, and backwater embayments	Sandia Pueblo	24 acres bar lowering, backwater
2011	Project features include island and bar vegetation removal and destabilization, bank lowering, and backwater embayments	Sandia Pueblo	30 acres, backwaters, destabilization
	Total Angostura Diversion Dam to Isleta Diversion Dam		**1,530 acres habitat work**
	Isleta Reach		
2003	Riverbank was lowered and bank features constructed at Los Lunas Habitat Restoration Project	Reclamation	50 acres bank lowering, etc.
2005	Pole planting of native vegetation at 2002 Los Lunas restoration site	Reclamation	16 acres replanted
2007	MRGCD, Reclamation, and Habitech collaborated in the anchoring of enhancement structures comprised of large cottonwood snags in the Middle Rio Grande channel at the outfalls of the three drains located upstream of Highway 308 near Belen, New Mexico in the Isleta Reach	MRGCD	Structures installed on three drains.
2008	Isleta Pueblo – Island destabilization project funded by New Mexico Water Trust Board.	Isleta Pueblo	
2009	Modification along banklines, islands, and bank-attached bars to create new flood plain habitat. The new habitat features include a large off-channel backwater in a low-lying area of the Bosque.	ISC/Isleta Phase I	24 acres, island modification and bank lowering, 5.8 acre backwater
2010	Habitat modification includes nonnative species removal, high flow channels, and bank lowering.	ISC-Reclamation/ Isleta Phase II	56 acres, various techniques
2011	Habitat modification includes nonnative species removal, high flow channels, and bank lowering.	ISC-Reclamation/ Isleta Phase II	45 acres, various
	Total Isleta Reach		**196.8 acres habitat work**
	San Acacia Reach		
2003	Helicopter spraying of dense saltcedar groves south of Socorro.		230 acres sprayed, vegetation control
2005	Setback of lateral constraints around RM 113/114	Reclamation	187 acres to readjust
2005	Removal of monotypic saltcedar and the mechanical control of non-native vegetation river bars and jetty jacks removal.	BDANWR	51 acres non-native removal
2006	Removal of monotypic saltcedar and the mechanical control of non-native vegetation river bars and jetty jacks removal.	BDANWR	76 acres non-native removal
2009	Setback of lateral constraints around RM 111, additional space provided for river to self adjust	Reclamation	59 acres setback
	Total San Acacia Reach		603 acres habitat work
	Total habitat work (all reaches)		**3,089 acres**

5.6.2.3 Railroad Bridge Relocation

The relocation of the railroad bridge at San Marcial (Element U) has not been implemented due to cost and lack of agency authorization. With the steady lowering of Elephant Butte Reservoir levels since 2001, the headcut that has resulted has contributed to increasing the flow capability under the bridge, which was the original reason for the relocation.

5.6.2.4 Overbank Flooding and Sediment Transport

The Corps has stored and later released floodwater to increase the number of days of flood plain inundation downstream from Cochiti Dam. With a degraded river channel and the very established vegetation along much of the river, the maximum flow allowed from Cochiti Dam (7,000 cfs) has limited ability to create new backwater habitats for silvery minnow and flycatcher within the upper reaches (Element V). Habitat restoration projects have increased the area that inundates at lower discharge levels. Increased sediment transport out of Cochiti, Jemez, and Galisteo Dams, (Element W) has not fully been implemented but is ongoing. In addition to this possible source of sediment into the overall sediment starved MRG, and indirect benefit from all the ongoing habitat restoration work is that approximately 2–3 million cubic yards of sediment have been reintroduced into the river. This number is derived from a summation of Clean Water Act 404 permits and environmental assessments submitted for the projects.

5.6.3 Salvage and Captive Propagation and Actions to Minimize Take of Silvery Minnow

Propagation of silvery minnow has been very successful; in most years, there are more minnows available at propagation facilities than are needed for MRG augmentation activities (Element Y, Z, AA). Dexter National Fish Hatchery and Technology Center has been able to supply more than enough minnows than are required annually for the MRG. Hatchery fish also are maintained in two other facilities (Albuquerque Biopark and NMISC Los Lunas Refugium). Minnows also were held at the New Mexico State University A-Mountain Facility for research purposes. That program was discontinued in 2009. Genetic testing so far indicates that the captive fish are representative of the wild population, and augmentation has aided in maintaining genetic diversity between reaches (Osborne and Turner 2012). A fourth recently constructed Minnow Sanctuary within the Angostura Reach will also eventually contribute towards minnow management. If negative impacts to minnow population occur in the river, these propagation facilities can provide minnows back to the river. Reclamation and the Collaborative Program exceeded the monetary support requirements for these propagation facilities with a total of $6,644,970 provided to the Service, the Albuquerque Biopark, the ISC Refugium, and the Minnow Sanctuary for expansion (at Dexter) and O&M to date.

The 10j experimental population in the Big Bend area (Element BB) is now in its third year, and recruitment has occurred. Hatchery produced minnows were provided for this reintroduction from MRG propagation facilities. The population needs to be monitored for several more years, but the results are encouraging. Lessons learned from this activity can be used when the next population is established (Element CC). Reclamation and the Collaborative Program exceeded the monetary support requirements for this activity with a total of $1,120,00 provided to the Service to date.

Silvery minnow have been salvaged from drying reaches each year except 2008 (RPM 1.2, 1.3). To determine the extent of drying and facilitate salvage of silvery minnow, RiverEyes contractors monitor the river daily (Element C). It has been difficult to determine how salvage benefits (RPM 1.3) the silvery minnow population, since it likely depends on the duration and magnitude of drying; but relocating fish into flowing habitat does reduce the amount of mortality due to drying. Protocols for salvage were adjusted in 2007 in an effort to increase the likelihood that salvaged fish are fit enough to survive when released (Remshardt 2010, Caldwell et al. 2010). River flows are ramped down slowly using Supplemental Water in coordination with the Service. Pumping from the LFCC aids the ramp down process.

During the spawning period for the silvery minnow, egg monitoring in irrigation canals and entrainment have been assessed, and egg monitoring and collection occurs within the river channel (RPM 2.1 and 2.2). Egg monitoring has occurred each year except 2005. The Service monitors eggs within the canals and more indepth analysis of the egg entrainment data is underway by the Service. ABCWUA also conduct egg monitoring activities upstream of the Paseo del Norte diversion, near the water intake point, to estimate and reduce the amount of silvery minnow eggs entrained in the diversion structure. Egg collection activities are coordinated between the city of Albuquerque and the Service.

5.6.4 Water Quality

Since 2001, there are many general water quality assessments and specific studies that have been completed or are in process (Element DD, EE). Much of the data collected by these studies has not been clear and definitive on the effects of various water quality parameters on the silvery minnow population. The current status of information is presented in section 5.3.1.4.

5.6.5 Monitor Cowbird Paritism

A cowbird control program was conducted along the MRG from 1996–2001. This program involved trapping and removing cowbirds in an effort to reduce brood parasitism on flycatchers. In 1998, a telemetry study was initiated to determine the daily and seasonal movements of cowbirds to evaluate the effectiveness of localized cowbird trapping efforts (Sechrist and Ahlers 2003). An Assessment of the Brown-Headed Cowbird Control Program in the Middle Rio Grande, New Mexico, was prepared in 2003 by Moore and Ahlers to monitor the success of the cowbird trapping and removal effort. To complete this assessment, a nest monitoring and point count study was conducted targeting neotropical avian species. The end result concluded that, although cowbird trapping was effective on a local level by reducing cowbird abundance and parasitism rates, it is an ineffective method for increasing overall nesting success.

In 2006, a report titled Riparian Obligate Nesting Success as Related to Cowbird Abundance and Vegetation Characteristics Along the Middle Rio Grande, New Mexico, by Dave Moore concluded that habitat quality is the most important factor to neotropical migrant nesting success. Similar to the report from 2003, it was found that when parasitism rates were locally reduced, other factors came into play (such as predation for example), that inevitably kept nesting success at the same level.

In addition to studies focused on cowbird parasitism, all nests monitored since 1999 have indicated whether or not parasitism was present. Further analysis on nest parasitism versus nesting substrate, territory dominance, and hydrology immediately under the nest is completed annually.

5.6.6 Conservation Recommendations

Many of the 25 conservation recommendations in the 2003 BiOp have been implemented and/or are ongoing studies. Results from some of the studies indicate the need for additional work or refinements of the original hypothesis. The following table 10 is a list of the conservation recommendation with their current status.

Table 10. Synopsis of activities for conservation recommendations as defined in the 2003 BiOp

	Conservation Recommendations and Studies	Studies to Date
1	Effects of turbidity and suspended sediment on silvery minnow	The Service was funded by the Collaborative Program to investigate fish health including effects of suspended sediment. This project is still ongoing; initial findings indicate that high suspended sediment may affect the amount of food available to silvery minnow (Lusk PowerPoint 2011), which concurs with findings by Magana 2009 and Bixby and Burdett 2011.
2	Effects of sediment toxicity on silvery minnow	NMED 2009 review of current information found that chemical concentrations in sediment may have some impacts to fish and aquatic life. Based on the data collected in 2006–2007, the concentrations are not at levels where fish kills would be expected due to any one chemical; however, several chemicals were found above levels where adverse effects are expected to occur only rarely.
3	Silvery minnow diet and sediment ingestion	Diet studies have been conducted on hatchery fish (Magana 2009, Watson et al. 2009) that indicate that silvery minnow are primarily algavores but may use other food items such as macroinvertebrates depending on their availability. There are upcoming projects to determine diet and habitat use of larval fish.
4	How effluents from waste water treatment plants mix with Rio Grande at various discharges	Not completed.
5	Water pollution education; effects and prevention	Not completed specifically for MRG.
6	Voluntary water quality monitoring by citizens	Not completed.
7	Agricultural water forbearance program	A water management decision support system was developed in 2007 by NMISC. MRGCD would be the lead agency to implement a forbearance program.
8	Program for conversion of high to low water use crops	ISC's Middle Rio Grande Water Plan www.waterassembly.org/waterplan.htm describes the benefits and tradeoffs associated with converting to low water use crops. Further development of these ideas would need to be developed with MRGCD, NMDA and others.

Table 10. Synopsis of activities for conservation recommendations as defined in the 2003 BiOp

9	Monitor/study silvery minnow spawning	Ongoing activity, spawning mentoring in the river and canals is funded each year by Reclamation. Studies indicate few eggs are currently entrained in canals (Service Data). River monitoring provides information on the timing and conditions surrounding spawning events in the river.
10	Develop and implement long-term plan	Ongoing in Collaborative Program
11	Annually survey and report willow flycatcher habitats to FWS	Surveys began in 1994 in a more concentrated area but have expanded to the southern boundary of Isleta Pueblo to Elephant Butte Reservoir since 2002. Areas near Velarde and Frijoles Canyon also have been surveyed periodically.
12	Fund willow flycatcher habitat requirements study	A nest monitoring effort supplies information on habitat requirements (i.e., distance to water, nest substrate species, major plant community, etc.) and compares nesting components to nest success. A nest quantification study from 2004–2006 provided insight to habitat requirements such as stem densities and percent canopy cover for example. A mapping effort and subsequent habitat suitability model was completed in 2008 from Bernardo to Elephant Butte. Previous mapping efforts took place using the modified Hink and Ohmart approach in 2002 and 2005.
13	Contingency plan for fire in willow flycatcher habitat	Not formally completed. In a recent fire within the Elephant Butte Reservoir pool, coordination among fire crew and Reclamation and Bureau of Land Management staff took place to focus on protecting occupied flycatcher habitat from destruction.
14	Study ground/surface water relationship	This study is very site specific and dependant on soil composition, vegetation composition, and other factors. A ground water model was developed by USGS. Also, a study using data loggers to document the ground water levels and comparing that information to flows in the river was initiated in the BDANWR in 2010.

Table 10. Synopsis of activities for conservation recommendations as defined in the 2003 BiOp

15	Implement water efficiencies and apply savings to silvery minnow and willow flycatcher conservation	There are many informal water conservation contributions that MRGCD has implemented. ABCWUA routinely evaluates and improves/ monitors the water conservation program.
16	Encourage adaptive management of flows and conservation of water for ESA species	A formal Adaptive Management Program is being developed for the Middle Rio Grande. This process will be more completely discussed in the conservation actions section.
17	Secure storage rights and water for ESA species	Not completed; studies needed
18	Fund habitat preference studies for silvery minnow	Habitat use studies were done by Platania in 1997 based on the population monitoring information. Studies to understand habitat availability at various flow conditions were completed at several sites by Bovee et al. 2008. Their model indicated that greater amounts of suitable habitat (as defined by the recovery plan) at discharges between 100 and 200 cfs. Additionally, the Corps is currently funding USGS to conduct a habitat availability study.
19	Study saltcedar control and ensure no impacts to willow flycatcher and seek funding for habitat restoration	A study was initiated in 2002 to analyze revegetation strategies and restoration of saltcedar infested sites. This study used mechanical treatments, growth amendments, herbicide applications, and seeding mixtures in an effort to restore the site. A final report was not completed; but upon visiting the site, it appeared that not many native species developed. Young saltcedar and kochia revegetated the area instead. Goats were released within a study plot in 2004 to study their impacts on saltcedar resprouts. After 2 years of treatment, less than 10% of saltcedar plants were killed. However, duff and leaf area index was reduced by 27% and plants were damaged/stressed. Saltcedar leaf beetles have been recently detected within the MRG. Monitoring is underway to determine the effects of this species on the MRG bosque.

Table 10. Synopsis of activities for conservation recommendations as defined in the 2003 BiOp

20	Prevent unauthorized use of silvery minnow water	River discharge is monitored at several locations. The MRGCD has an ongoing process to identify water rights and leases within their district boundaries.
21	Assess willow flycatcher population at Elephant Butte Reservoir	Multiple studies on hydrologic and vegetation parameters as well as annual surveys and nest monitoring have taken place within the Elephant Butte Reservoir and associated population of flycatchers. A flycatcher management plan is currently in place to focusing on developing suitable habitat outside of the reservoir pool.
22	Use drains for silvery minnow refugia	Low densities of silvery minnow likely persist within the permanently watered canals such as the LFCC and drains (Cowley et al. 2007, Lang and Altenbach 1994, Reclamation 2010). Buhl 2011 conducted in situ studies in drains to inform refugia development. Woody structures were installed at the outflow of several drains to provide habitat. Results of these projects have been mixed.
23	NMGF monitor silvery minnow at Angostura Reach	Not conducted routinely; Angostura monitoring is covered in Population Monitoring Program.
24	Limit encroachment into 10,000 cfs flood plain	Houses build adjacent to the bankline has already restricted flows below the Highway 550 Bridge near Bernalillo to 7,000 cfs. Isleta Reach has very limited encroachment between the levees on both sides of the river. The collaborative program San Acacia Reach group has proposed a reach assessment be accomplished in 2013.
25	Investigate effects of predation and competition on silvery minnow	There is little information on the effects of predation and competition on silvery minnow within the MRG. Discussions of extirpation of silvery minnow within the Pecos watershed cite competition with introduced plains minnow as a primary factor (Hoagstom et al. 2010).

5.7 Summary of Baseline Conditions for Listed Species

There has been a multitude of recent activities in the MRG aimed at improving the status of the currently listed species, especially the silvery minnow and flycatcher. Silvery minnow and flycatcher population levels have both increased since the initiation of the 2003 BiOp. The following evaluates the status of baseline conditions in each reach. In addition, tables are developed for each major period in the life history of the listed species presenting the current knowledge of status of each critical habitat PCE.

5.7.1 Summary of Habitat Condition, Species Status, and Restoration by Reach

The following information is a short summary of habitat conditions and habitat restoration projects on the Rio Grande, sorted by geomorphic reach, as well as information on silvery minnow and willow flycatcher status in the area.

5.7.1.1 State Line to Otowi (State Line–RM258)

Along the Rio Grande from the State Line to Otowi, 18 flycatcher territories were documented in 2000 (table 2). In 2004 and 2005, 12 territories were detected (NM Rangewide Database). In 2009, the population increased to 34 territories. Twenty-one territories were identified in 2010 (NM Rangewide Database). As of 2011, 452 acres of habitat restoration was funded for habitat restoration within this reach. These projects have targeted improving the health of the river for flycatchers, and the reach continues to be occupied by flycatcher. Flycatcher critical habitat exists in this reach from Taos Junction Bridge to the upstream boundary of Ohkay Owingeh Pueblo. The proposed critical habitat extends to Otowi Bridge. Though there are historic records of silvery minnow from this reach, it was likely never abundant (Bestgen and Platania 1991). Silvery minnow have not been documented in this reach for over 30 years; the last silvery minnow was captured near Velarde 5 years after the closing of Cochiti Dam in 1973 (Bestgen and Platania 1991).

5.7.1.2 Chama River (State Line to Confluence)

Along the Rio Chama from the State line to the confluence of the Rio Grande, flycatcher surveys have been recorded in the NM Rangewide Database since 1993 (table 2). In 1993, two flycatcher territories were observed. The largest population detected in this reach was in 1994, 1997, and 2001 with four territories. There are few early fish sampling records in the Chama. There is some historic information from tribal sources that silvery minnow may have occupied the Chama up to approximately Abiquiu (Parametrix 2010). There is no critical habitat designated in this reach of the river. No habitat restoration projects have been done on this reach for silvery minnow or flycatchers.

5.7.1.3 Otowi Bridge to Cochiti Dam (RM 258–RM 233)

Formal surveys for flycatcher were not conducted within this reach until 2008. Since that time, territory totals have ranged between one and twp territories mainly in an area just south of Frijoles Canyon. The type specimens of silvery minnow were likely collected near Otowi Bridge (Bestgen and Platania 1991). Silvery minnow have not been collected in this reach for over 40 years. The current potential to support silvery minnow in this reach (if they were repatriated) is limited by the entrenched channel and loss of flood plain connectivity, cold water temperatures, channel fragmentation, substrate size, and competition with non-native fish species. The lack of low velocity habitats for larvae and young-of-year and the lack of contiguous sections of river to allow silvery minnow to complete its lifecycle within the reach would limit the ability for the species to successfully complete its life cycle (Bunjer and Remshardt 2005). There is no critical habitat designated in this reach of the river. No habitat restoration projects have been done on this reach for silvery minnow or flycatchers.

5.7.2 Cochiti Dam Reach

5.7.2.1 Cochiti Dam to Angostura Diversion Dam (RM 233–RM 210)

This reach has not been formally surveyed for flycatcher and is not known to have any suitable habitat. Silvery minnow egg monitoring has been conducted in the Angostura Canal from 2002 to present. During this time, only three eggs have been reported (in 2003), and those were not preserved for confirmation. The lack of eggs in the Angostura Canal suggests that silvery minnow density upstream of Angostura Diversion Dam is extremely low if present (Service 2009). No publicly available surveys were conducted in the last decade. Limiting factors in this reach for silvery minnow are likely cool water conditions from the operations of Cochiti Dam, lack of low velocity habitat, and a generally degrading river channel (Service 2008). The land base encompassing the Cochiti Dam Reach is primarily tribal-owned and requires partnership with the Pueblos. Funding has been provided to Cochiti, Santo Domingo, and San Felipe Pueblos through the Collaborative Program from 2002 through present for habitat restoration and maintenance including nonnative vegetation control, bank lowering, and side channel formation. In total, over 277 acres have been restored to date (table 9).

5.7.3 Angostura Reach

5.7.3.1 Angostura Diversion Dam to Isleta Diversion Dam (RM 210-RM 169)

As shown in table 2, three to four flycatcher territories were known to occur in a small area in 1994 and 1995 within this reach (Mund et al. 1994, Mehlman et al. 1995). In 2000, surveys in all suitable nesting habitats within this reach found 14 territories (Johnson and Smith 2000). In 2003, only four territories were found (Smith and Johnson 2005). Seven territories were located in 2004 (Smith and Johnson 2005), six territories were identified in 2005 (Smith and Johnson 2006), and sixteen territories in 2008 (NM Rangewide Database). In 2009 and 2010, there were no territories located in this reach (NM Rangewide Database).

Silvery minnow have been commonly collected throughout this reach since 2004. This reach has not dried in recent years. Flood plain connectivity is minimal in many portions of this reach. Lack of habitat diversity and amount of low velocity habitats above Highway 550 likely was cited as a limiting factor for silvery minnow (SWCA 2008). A habitat mapping technical report was developed to supplement the ABCWUA ongoing conservation measures to include opportunities for additional aquatic and riparian projects in the Albuquerque Reach of the river. This report included extensive field surveys, mapping, and ranking of potential sites within the Middle Rio Grande. Field efforts for this project were conducted in cooperation with the Service during February 2002.

Several projects have taken place on the Sandia Pueblo and around the city of Albuquerque to improve riparian conditions with the assistance of Collaborative Program funding. To date, over 900 acres have been restored. Many of the restoration projects have concentrated on projects that provide a greater connectivity with the river at lower discharge levels than previous conditions. Other strategies have included creating side channels and installing woody vegetation to create pools during low flows. Initial results of monitoring silvery minnow at these sites indicate that large numbers of silvery minnow do use the created overbank habitats during inundation (Collaborative Program 2011, SWCA 2010). Initial monitoring of the installed large woody debris found that silvery minnow were present both during winter and summer sampling but higher numbers were collected during the summer (Wesche et al. 2006).

5.7.4 Isleta Reach

5.7.4.1 Isleta Diversion Dam to Rio Puerco (RM169–RM 127)

The majority of flycatchers detected within this reach are typically migratory flycatchers, late migrants, or occasional lone male territories. The first nesting pair was located just north of the Rio Puerco in 2005 (table 2). Over the last several years, this same area typically has about one to four territories detected. In 2010, this area supported four territories composed of three pairs and one additional pair about three-fourths of a mile upstream. In 2011, the population expanded to 10 territories, mainly near the Rio Puerco, but also farther north in the area from Los Lunas to Bernardo. Silvery minnow abundance is highly variable in this reach (Dudley and Platania 2010, Reclamation 2010). Prior to 2004, recruitment was low in this reach. Silvery minnow distribution and abundance patterns show the importance of base flows within the reach to maintain population numbers (Parametrix 2008).

Habitat restoration work throughout this reach has cleared vegetation and increased the potential for channel movement. Techniques include creation of backwaters, secondary channels, as well as bankline benches and terracing. Monitoring of these habitats indicates use of these habitats during inundation by adult silvery minnow and larval fishes as well as egg retention (SWCA 2010a, Collaborative Program 2011). Cottonwood snags also were installed at drain outfalls in this reach. Initial monitoring shows use by silvery minnow during inundation, but the intended purpose of scouring and maintaining wetted pools over a range of flow conditions had mixed results due to sedimentation issues (Wesche et al. 2010).

5.7.4.2 Rio Puerco to San Acacia Diversion Dam (RM127–RM116.2)

Flycatchers on the Sevilleta NWR and La Joya WMA were initially discovered in 1999 with four territories (table 2). All flycatchers within this reach have been found along the banks of the Rio Grande. Surveys have continued in this area since 1999, with seven territories detected in 2000 and eleven territories in 2001 and 2002. The highest numbers to date for this site, 31 territories, were detected in 2008. Over the last 3 years, there has been a decrease in territories. In 2009, there were 18 territories detected; in 2010, there were 13 territories detected; and 9 territories were detected in 2011.

This reach has lower propensity for drying than the upstream portions of Isleta Reach (Parametrix 2008). Increases in channel complexity could increase the habitat diversity required to maintain silvery minnow within the reach. There are some areas that have been perennially wet in this section due to return flow from the San Juan drain. This is likely important to silvery minnow within this reach. Habitat assessment of these flows was modeled by USGS (Bovee 2008). No habitat restoration projects have been done on this reach for silvery minnow or flycatchers.

5.7.5 San Acacia Reach

5.7.5.1 San Acacia Diversion Dam to Arroyo de las Cañas (RM 116.2–RM 95)

This area has been surveyed for flycatchers since 1997 and has had intermittent territory establishment through the years (table 2). There has never been a nesting flycatcher pair detected within this reach. Silvery minnow in this reach are seasonally concentrated in the spring and summer below the diversion dam where water is generally perennial (Dudley and Platania 2010). It is unknown if there is seasonal upstream movement behavior that would cause minnows to accumulate below the diversion dam, which blocks upstream movement. Rescue operations rarely occurred in this reach. Salvaged fish from other portions of the San Acacia Reach are stocked here where water is perennial (Service 2001 through 2010). Little potential for overbank flooding exists in this reach (Parmetrix 2008). There have been river maintenance projects within this reach, which have focused on moving back the levee and relocating the LFCC to allow the river greater area to migrate (Reclamation 2008).

5.7.5.1.1 Arroyo de las Cañas to San Antonio Bridge (RM 95–RM 87.1)

This reach is very similar to the San Acacia to Arroyo de las Cañas Reach and has been surveyed for flycatchers since 1998. Within the last 13 years, there have been minimal territories, with the exception of summer 2011 (table 2). During the breeding season of 2011, a total of seven territories were detected within this reach, most of which were detected within close proximity of the BDANWR. Silvery minnow densities in this reach are highly variable, October densities increased from 2006–2009 (Dudley and Platania 2010). Rescue efforts have occurred most years in portions of this reach. River pumps are installed in this reach to aid in slowing the rate of river drying using water supplied from the LFCC. No habitat restoration projects have been done on this reach for silvery minnow or flycatchers.

5.7.5.2 San Antonio Bridge to River Mile 60 (RM 87.1–RM 60)

The upper portion of the BDANWR within the active flood plain have been surveyed for flycatchers annually since 1998. From 1998–2008, there were less than five territories detected annually. In 2009, there was a large population increase to 19 territories and another large increase in 2010 with 37 territories. In 2011, the largest population in this section was recorded with a total of 44 territories.

In lower portions of the reach, from 1994–1996, the majority of detections within this reach were located between the south boundary of the BDANWR to the railroad trestle near Black Mesa. Since 1994, the population within this entire reach has increased and decreased responding to vegetation and hydrological changes. Peak years within this section include 1994 with 11 territories, 2004 with 16 territories, and 2006 with 14 territories. Since 2006, territory numbers range from 7–11, with 11 territories detected in 2011.

Silvery minnows generally are collected in surveys within this reach, and occasionally densities are high. Reclamation surveys and population monitoring surveys found high winter densities in 2010 following high 2009 October numbers (Dudley and Platania 2010, Reclamation 2010). Generally, this reach is very prone to river drying, and salvage generally occurs early in the year. River pumps from the LFCC supply water to the river from the northern and southern boundary of the refuge and near Fort Craig and aid in slowing the rate of river drying. Due to the perched condition of the channel, high flow events may go out of the channel and into the lower elevation overbank areas. There have been sediment plugs that have formed within the channel.

5.7.6 Summary of Baseline Conditions Affecting Silvery Minnow Life History and Critical Habitat Elements.

In this section, baseline biology information and status of critical habitat elements (PCEs) are described in table 11. The life history of the minnow is subdivided into spawning, egg, larval, juvenile, and adult stages; and current information on how those stages are functioning is described.

Even though there is some uncertainty surrounding the preferential spawning locations for the minnow, it is evident that the minnow likely will spawn in the spring with any slight increase in discharge in whatever habitat is available.

Table 11. Status and information of life history elements and critical habitat PCEs for silvery minnow. Grey cells indicate that life history stage is generally not present during that season or affected by the PCE.

Life History Element	Spawning	Eggs	Larval	Juvenile	Adult
Spring (April–June)	Spawning has been detected each year. Very small flow spikes are necessary for fish to spawn. Properly functioning in baseline.	The carrying capacity of recruitment is set by spring flows. Eggs and larvae that are retained upstream in low velocity habitats are more likely to recruit into the adult population. Higher spring flows allow more overbank habitats to be inundated. Recruitment success is likely the driver for genetic diversity and effective size of the population. Function is tied to spring runoff. Habitat restoration has increased available habitat at lower discharge levels in Angostura Reach.			Large numbers of adult silvery minnow are collected on overbank habitats during spring flows. It appears that population levels must be very low before the numbers of adult spawners has a detectable effect on numbers of offspring measured in next fall.
Summer (June–September)			Delayed onset of low flow conditions and increased summer flow correlates with higher October densities. Increased turbidity from various flow events may decrease the available food base. Refugial habitats may decrease take and maintain higher numbers of silvery minnows during dry periods. Refugial habitats were constructed at some return drains and may reduce the impact of drying on the population.		
Fall (September–November)				Generally steady base flows during this time period is positive for October population densities. Drying has occurred within this timeframe.	

Table 11. Status and information of life history elements and critical habitat PCEs for silvery minnow. Grey cells indicate that life history stage is generally not present during that season or affected by the PCE.

Life History Element	Spawning	Eggs	Larval	Juvenile	Adult
Winter (December–March)					Silvery minnow are known to use habitats with some type of cover. Relatively constant winter flows are positive. Habitat restoration activities have installed large woody debris in both the Angostura and Isleta Reach.
Summary of baseline population trend and indicators.	Baseline conditions 4 years of 10 had negative population growth. However, catch rates have increased substantially since the low in 2003. Discharge of at least 3000 cfs in Angostura Reach and delayed onset of low flow increase likelihood of mean October CPUE > 10 fish per 100 square meters.				
Critical Habitat PCEs					
Hydrologic Regime					
Low to moderate currents	Determined by sediment transport, reach slope, sinuosity, which all contribute to habitat complexity. Current trend is toward channel simplification. Habitat restoration has improved condition in Angostura Reach and Isleta Reach.				
Diversity of habitats for all life history stages		Egg and larval development habitat is greater when overbank habitats are inundated. Depending on river, reach occurs when spring flows are greater than 1,500 cfs. Flows reached this level at the Albuquerque gage for at least 10 days in 7 of the last 12 years. Habitat restoration activities have provided more low velocity habitats in the 1,500- to 3,500-cfs range.		Juvenile and adult silvery minnow use wetted habitats with moderate depths and low velocity during nonwinter times. Winter habitat use is concentrated in deeper areas with available cover (debris piles, tumbleweeds). Bovee et al. (2008) modeled the availability of habitat at various flow regimes. Habitat in their model was maximized at flows between 40 and 150–200 cfs depending on the availability of woody debris. Similar studies of availability are currently underway.	
Spawning trigger	Spawning has occurred each year of baseline, even in years with minimal spring flow spike.				
No increased low flow	River drying is predicted when flows drop below 100 cfs at San Acacia gage. Number of low flow days at San Acacia gage is significantly different in baseline timeframe (2003–2011) and listing timeframe (1993–2002) (t= [2.1], $p<0.05$). Mean # days <100 cfs 1993–2002=17 (SE 10), 2003–2011=52 (SE 12).				

Table 11. Status and information of life history elements and critical habitat PCEs for silvery minnow. Grey cells indicate that life history stage is generally not present during that season or affected by the PCE.

Life History Element	Spawning	Eggs	Larval	Juvenile	Adult
Constant winter flow				Irrigation seasons generally end up and down the basin. Water deliveries are often made in November and December, which may increase base flows.	
Unimpounded stretches of river with a diversity of habitats and low velocity refuge areas					
River reach length	Reach length in Middle Rio Grande has not changed since time of listing. The only new cross channel structure is the ABCWUA diversion that was mitigated with a fish passage structure. The pit tag study shows that silvery minnow do use the passage.				
Habitat "Quality" in each reach and refugial habitats.	Each reach has positive and negative habitat attributes. Channel trends throughout the MRG are towards a more simplified channel due to vegetation encroachment. Cochiti Dam and Angostura Reaches are not as susceptible to drying but have limited connection with overbank areas. Isleta Diversion Dam and San Acacia Reaches are prone to drying in areas but have low overbank thresholds and a greater diversity of meso-habitats than the upper reaches due to the more dynamic nature of the channel than the upper reaches. Habitat restoration activities have provided more low velocity habitats in the 1,500- to 3,500-cfs range. Low velocity refuge areas are important during summer drying and overwinter habitat. Channel trend throughout the MRG is towards a more simplified channel due to vegetation encroachment.				
Substrate of sand or silt					
Substrate size		Substrate size is dependent on water velocity and sediment transport within the reach. The lower reaches of the river are dominated by sand/silt substrates. Reaches that have a low sediment supply (Cochiti and Angostura) are trending towards larger substrates.			
Water quality					
Temp >1˚ - <30˚C.	Warmer temperatures speed the rate of egg development and larval growth. This is generally considered positive for fish since they spend less time in this vulnerable stage. A notable difference between water temperatures in high flow years versus low flow years is the minimization of diel variation in high flow years, thus a more constant temperature. Overbank habitat has been shown to provide warmer daytime temperatures but may also experience greater fluctuations corresponding to air temperatures then main channel habitats.		NMED monitoring has shown little evidence of temperatures exceedences within the main channel of the river. Isolated pools often exceed 30 ˚C. Pools >34 ˚C are not salvaged due to the poor condition of fish within the pools. Low temperatures have not been a concern within the occupied portion of the MRG except in extreme weather events. Ice flows were present within the channel in February 2011 following extreme low temperatures.		

Table 11. Status and information of life history elements and critical habitat PCEs for silvery minnow. Grey cells indicate that life history stage is generally not present during that season or affected by the PCE.

Life History Element	Spawning	Eggs	Larval	Juvenile	Adult
DO > 5 mg/L	There have been records of low dissolved oxygen within the main stem of the MRG. Many of these are associated with rain events and storm water entering the system. The duration of these low DO events are generally less than a few hours. There were localized conditions that deviated from the main stem conditions due to low flow conditions and isolated pools. From salvage data, it appears that many isolated pools have DO that falls below the optimal level. These pools are not considered for salvage. Additionally, low DO was detected in 2005 on inundated flood plain areas that have high levels of organic materials.				
pH (6.6-9.0)	No exceedences of the 6.6 to 9.9 (s.u.) criterion were documented from deployed data loggers at any locations except for one sample in 2007 at NM Highway 550 Bridge. Isolated pools may experience high pH levels. Pools greater than 9.0 are not considered for salvage.				
Other Contaminants	Short-term water quality issues due to chlorine releases from waste water quality treatment plants have occurred infrequently in the MRG. Initial studies of fish tissue indicate elevated levels of zinc in some samples. Other studies have not indicated specific water quality issues that may be affecting silvery minnow.				

It does appear that the spring hydrograph has a substantial influence on the recruitment of silvery minnow into the population (section 5.3.1.2). This is indicated by the relationship of fall catch rates and the spring hydrograph. Spring flows that inundate the flood plain create large amounts of low velocity habitat that aids in the retention of eggs and larvae in upstream reaches and provides an area of highly productive low velocity habitat, which promotes larval development. The lack of recruitment in 2010 provides some indication that management of recession may be an important management consideration.

The current measure of the population is based on October catch rates, which gives an indication of annual recruitment into the population. October catch rates of silvery minnow have varied widely since the inception of the monitoring program in 1993. This variation is similar to abundance measures of many species of fish that have high reproductive potential. Though there is large variation, mean catch rates from 2004–2011 are over 10 times higher than the lowest recorded catch rates in 2002 and 2003. Mean catch rates in 2005 were roughly 1,000 times the mean catch rate recorded in 2003.

Juvenile silvery minnow utilize low velocity habitats, similar to larval stages; however, they are able to actively swim at this stage. Little is known about the full range of factors that influence survival of juvenile and adult silvery minnow. Food availability is varied due to hydrology and storm events. Studies indicate that the main source of periphyton, which is one of the main foods of silvery minnow, exists in a “bathtub ring” in the shallow sections of the river. Storm events or other flow changes may affect periphyton availability by scour events, inundation which places existing colonies out of optimal light areas, or desiccation.

Drying also causes direct take of silvery minnow. Drying has occurred each year since 2003 except for 2008 in some portion of critical habitat. There is some evidence that a portion of silvery minnow are able to move with the water as the river begins to dry, and some fish can survive for long periods in the isolated pools that may persist in disconnected sections of the river. However, there is documented take of minnows that has occurred each year associated with drying. Other unquantified sources of take that occur with river drying include predation from birds and other species, as well as mortality due to poor water quality and disease that is exacerbated when fish are isolated in pools.

At least some amount of river drying is predicted when San Acacia flows drop below 100 cfs. On average, from 2003–2011, there were 52 days annually when San Acacia was below 100 cfs compared to the previous timeframe (1993–2002) when the annual average was 17 days. There is a significant negative correlation to October catch rates and the number of days with low flow conditions at the San Marcial gage (figure 17).

There is little known about winter survival of silvery minnow. Studies indicate that they are most often found in backwaters and other habitats with cover in the winter (Dudley and Platania 1996, Dudley and Platania 1997). As with other fish species, they seek out low velocity habitats that limit the amount of energy they must expend during cold water temperatures. It is hypothesized that stable water levels may be positive since stability of individual habitats is related to stability of water levels in the MRG. Generally, flow is higher early in the winter when letter water is being released as well as other activities to move stored water. Winter storm flows occur periodically.

With the current condition of the river, mechanical means are needed to substantially change geomorphology. Water management alone cannot provide flows of high enough discharge and duration to remove established vegetation and reset river banks. Habitat restoration activities since 2003 have increased the amount of habitat that inundates at lower flow levels, especially in the Angostura Reach. These areas show use by silvery minnow each year of inundation.

5.7.7 Summary Baseline Conditions Affecting Willow Flycatcher Life History and Critical Habitat Elements

The flycatcher population within the MRG has increased over the last decade. Habitat availability appears to not be a limiting factor since not all suitable habitat is occupied. High flow events and overbank flooding conditions tend to attract flycatchers and lead to new territory establishment. These localized events aid in providing the successional aged structure in riparian stands that flycatchers depend on. Suitable habitat areas are temporary because vegetation senescence occurs relatively quickly.

Temporary overbank flooding or close proximity to water also contribute to vegetation health and insect prey base abundance. This is particularly important during territory establishment to attract and retain territories. As flycatchers move through the chronology of the season and put forth an increasing amount of energy towards nesting (first territory establishment, then pairing, nest building, egg laying, incubating, feeding nestlings, and taking care of fledglings), they are less and less likely to abandon a territory. Nest success is dependent on vegetative health to provide the canopy cover required for protection from predators and other environmental stressors such as weather. Conversely, prolonged flooding prohibits seed establishment and can have a long-term negative effect on vegetative health. Nest success has remained relatively high within the MRG over the last decade with a slight decline this past summer of 2011.

The proposed critical habitat designation for flycatchers (76 CFR 50542) indicates riparian habitat in a dynamic successional environment to be used for nesting, foraging, migration, dispersal, and shelter. This habitat can include trees and shrubs such as Gooddings willow, coyote willow, tamarisk, or Russian. Vegetation must be dense, with a canopy cover of about 50–100%. Vegetation can range in height from about 6–98 feet tall depending on elevation (within the project area, vegetation height is typically about 9–26 feet tall [Moore 2007]). Patches also must include small openings of open water or marsh areas to create a variety of habitat that is not uniformly dense. Vegetation patch size can range from 0.25–175 acres.

A variety of insect prey populations are also essential for flycatchers. The abundance of insects typically associated with riparian flood plains or moist environments is likely related to the proximity of water to the habitat patch and density of vegetation within the canopy. Flooded sites provide for higher relative humidity and likely greater insect abundance (Reclamation 2009). No surveys have been done to estimate prey availability within various types of habitats within the MRG. Insects that are considered to be flycatcher prey include flying ants, wasps, and bees (Hymenoptera); dragonflies (Odonata); flies (Diptera); true bugs (Hemiptera); beetles (Coleoptera); butterflies, moths, and caterpillars (Lepidoptera); and spittlebugs (Homoptera). See table 12.

Table 12. Status and information of life history elements and critical habitat PCEs for willow flycatcher. Grey cells indicate that life history stage is generally not present during that season or affected by the PCE

Life History Element	Migration (April–June and July–September)	Arrival to Territories/ Territory Establishment/Nest Building (May–July)	Egg Laying/ Incubation/ Nestling/ Fledgling (June–August)
Breeding Season (April–September)	Flycatchers may use less suitable habitat as stopover locations (i.e., narrow vegetated areas such as LFCC or areas a greater distance from water).	Flycatchers are attracted to areas within 50 m of slow moving water, particularly flooded areas, or areas with saturated soils and dense vegetative canopy cover. Higher spring flows allow more overbank habitats to be inundated, thus attracting flycatchers, improving vegetative health, and likely increasing abundance in prey.	At this point, flycatchers are more invested in their established territories and less likely to abandon nests should conditions dry or decline in value. However, if vegetation does not have adequate water resources, canopy cover will likely decrease, and predation and/or parasitism would likely be more prevalent. Prey abundance may decrease with decreased water availability.
Summary of baseline population trend and indicators.	Baseline conditions since 1993 have indicated mainly positive population growth. The most recent increase in territory numbers within the project area can be attributed to an event within the BDANWR in which overbank flows increased in combination with the large population within Elephant Butte Reservoir beginning to disperse and defend territories in other locations.		
Critical Habitat PCEs			
Riparian Vegetation		Riparian habitat in a dynamic successional environment to be used for nesting, foraging, migration, dispersal, and shelter. Dense tree or shrub vegetation in close proximity to open water or marsh areas. The 2008 habitat suitability study mapped out suitable habitat in Isleta Diversion Dam and San Acacia Reaches. Habitat mapping occurs every 2–4 years and documents changes within the riparian area. Currently, flycatcher only occupy a portion of suitable habitats; thus, amount of habitat is not considered to be limiting factor.	
Insect Prey Populations	The abundance of insect prey populations in a given habitat patch is likely related to the proximity of the patch to riparian flood plains or moist environments. There is no data indicating that insect prey is a limiting factor within suitable habitat areas.		

5.7.8 Summary Baseline Conditions Affecting Pecos Sunflower.

Pecos sunflower (*Helianthus paradoxus)* is currently only located in two locations within the MRG action area, La Joya Wildlife Management Area and a private location. There is no designated Pecos sunflower critical habitat for the species within the action area. *Helianthus paradoxus* is an annual species that must re-establish populations of adult plants each year from seed produced during previous years' reproductive efforts. Populations tend to grow in crowded patches of dozens or even thousands of individuals. Solitary individuals may be found around the periphery of the wetland, but dense, well-defined stands within suitable habitats are more typical. NMDGF developed a habitat conservation plan to support conservation of the species on the La Joya Wildlife Management Area by:

1. Annually controlling invasive species.
2. Protecting the natural spring in Unit 5 from motorized vehicles and heavy equipment.
3. Monitoring core populations by digitizing these areas annually.
4. Conserving *H. paradoxus* by adjusting invasive species treatment area boundaries.
5. Restoring native habitat through re-vegetation.

The acreage of Pecos sunflower on La Joya has varied but has remained greater than 200 acres since 2008. Water supply for this population is provided through existing drains that supply La Joya WMA.