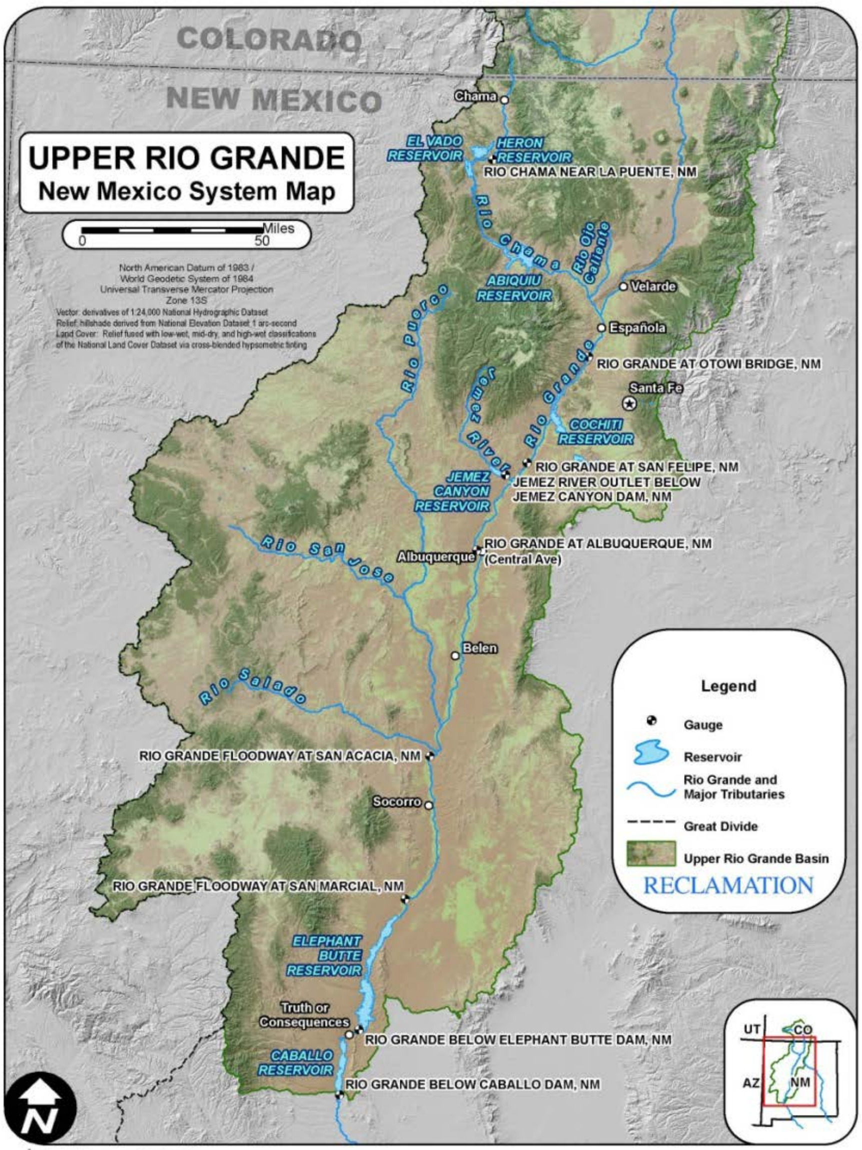
# Appendix A
# Upper Rio Grande System and Operations

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**U.S. Department of the Interior**
**Bureau of Reclamation**
**Upper Colorado Region**
**Albuquerque Area Office**


**December 2013**

# Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The U.S. Army Corps of Engineers Mission is to deliver vital public and military engineering services; partnering in peace and war to strengthen our Nation's security, energize the economy and reduce risks from disasters.

Sandia Laboratory Climate Security program works to understand and prepare the nation for the national security implications of climate change.

# Acronyms and Abbreviations

| | |
|---|---|
| ABCWUA | Albuquerque Bernalillo County Water Utility Authority |
| Buckman Project | Buckman Direct Diversion Project |
| CEC | Categorical Exclusion |
| cfs | cubic feet per second |
| EA | Environmental Assessment |
| EIS | Environmental Impact Statement |
| EPA | Environmental Protection Agency |
| ESA | Endangered Species Act |
| FONSI | Finding of No Significant Impact |
| LFCC | Low Flow Conveyance Channel |
| MRGAA | Middle Rio Grande Administrative Area |
| MRGCD | Middle Rio Grande Conservancy District |
| NEPA | National Environmental Policy Act |
| NWR | National Wildlife Refuge |
| RPM | reasonable and prudent measures |
| USACE | U.S. Army Corps of Engineers |

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# I. Basin History

Largely due to the limited water supply and the highly variable stream flows 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. Pueblo oral histories convey and the archaeological record shows that pueblo peoples had developed systems of irrigated agriculture long before the coming of Europeans. Beginning with the reestablishment of Spanish settlement (after the Pueblo revolt) in the late 17$^{th}$ century, expanded irrigation activities began to affect the flows in the Rio Grande system. The subsequent agricultural practices and administration of the river, as well as the intensive use of non-irrigated lands within the Rio Grande Basin, during 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.

From the 1930s through the present, dam and levee construction, construction of irrigation and drain system, changing land use patterns, and river channelization, as well as groundwater pumping, has significant altered flows in the Rio Grande, and the relationship between surface water and groundwater throughout the Upper Rio Grande. Operation of the flood control and water storage dams alters 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 stream flows that have resulted in cycles of drought on the Upper Rio Grande also have influenced vegetation changes on the Upper Rio Grande.

For this analysis, “Upper Rio Grande” Basin encompasses the headwaters of the Rio Grande in Colorado to the Caballo Reservoir in New Mexico, about 100 miles north of Mexico. Nine dams (Platoro, 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 Española have been constructed on the Upper Rio Grande or its tributaries over the past century by the U.S. Army Corps of Engineers (USACE), Reclamation, and the Middle Rio Grande Conservancy District (MRGCD), and in cooperation with other non-Federal partners. These dams and diversion structures affect the flow and sediment distribution in the Upper Rio Grande. 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. These 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.

Ground water use has exceeded 170,000 acre-feet per year in the Albuquerque Basin and has caused groundwater level declines of up to 160 feet (McAda and Barrol 2002). Ultimately, the water pumped from the aquifer will be replaced by seepage from the river into the groundwater system.

Prior to documented development of water resources, the Upper Rio Grande 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 floodplain and avulsed[1] to create new active watercourses. This process led to aggradation of the floodplain. When 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 was remobilized during subsequent large floods, which would re-establish a wider active channel. This process caused sediment to build up fairly uniformly across the floodplain. This active channel and floodplain 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 the endangered Southwestern Willow Flycatcher.

Today, the Upper Rio Grande through much of its reach is a single–thread channel. This is 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) (U.S. Fish and Wildlife Service [FWS] 2005). Changes on the Upper Rio Grande 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 from 1935 through1989 shows a 49 percent reduction of river channel habitat from 22,023 acres (8,916 hectares) to 10,736 acres (4,347 hectares) (Crawford et al. 1993). The Upper Rio Grande 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 Upper Rio Grande is deeper and swifter and more isolated from the surrounding floodplain. The abandonment of the floodplain in these reaches and the establishment of exotic (i.e., invasive) species in the bosque (Spanish word for "riparian forest"), such as Russian olive

[1] Avulsed. Rapid abandonment of a river channel and the formation of a new river channel.

and salt cedar, 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 Upper Rio Grande, below San Acacia Diversion Dam, currently has an upstream incised channel isolated from the historical floodplain and a downstream perched river, in which the riverbed is elevated around the surrounding floodplain. In much of the downstream river, the Low Flow Conveyance Channel (LFCC; which currently functions like a riverside drain) serves as the low point in the valley in many areas. River flow is lost to the surrounding floodplain, drains, and groundwater 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.

# II. Upper Rio Grande Water Supply and Demand

## II.A. Hydrologic Setting and Historical Conditions

### II.A.1. Native Water Supply

The Rio Grande Basin is located in the Southwestern U.S., and runs through a semi-arid region along the western edge of the Great Plains. From its headwaters in the San Juan Mountains of Southern Colorado, the Rio Grande flows southward through New Mexico, and then southeastward as it forms the international boundary between Texas and Mexico, before ultimately flowing into the Gulf of Mexico. The Rio Grande is one of the longest rivers in the United States, with a total river length of 1,896 miles (3,051 kilometers) and a drainage area of approximately 182,200 square miles (472,000 square kilometers). Basin topography varies from the mountains and gorges of the headwaters to the bosque and high desert of central New Mexico, to deserts and subtropical terrain along the boundary between Texas and Mexico. The Rio Grande serves as the primary source of water for agriculture throughout the Rio Grande Valley, as well as for municipal use by the major municipalities along the river corridor (including the cities of Albuquerque and Las Cruces, New Mexico; El Paso, Texas; and Cuidad Juarez, Mexico), and environmental and recreational uses in the states of Colorado, New Mexico and Texas, as well as in Mexico. The river also supports unique fisheries and riparian ecosystems along much of its length.

Flows in the Upper Rio Grande are derived from two primary native sources of inflow (the mainstem Rio Grande and the Rio Chama) and one source of imported water (the San-Juan Chama Project), as well as inputs from local precipitation and groundwater inflow. Combined, these sources, provide a highly variable and finite supply of water to a water-short region. The native inflow sources include the headwaters of the Rio Grande in the southern Rocky Mountains and the San Luis Valley of southwestern Colorado (approximately 75 percent of the native inflow), and the Rio Chama in the San Juan Mountains of southwestern Colorado and in northwestern New Mexico (about 25 percent of the native inflow). The native inflow, as measured at the Otowi gage upstream of Cochiti Reservoir, currently averages about 1.1 million acre-feet per year (S.S. Papadopulos and Associates 2000), of which New Mexico can consume a maximum of 405,000 acre-feet per year under the terms of the Rio Grande Compact (Colorado et al. 1938). The imported water is the San Juan-Chama Project water, which constitutes a portion of New Mexico's allocation under the Upper Colorado River Compact. This water is derived from tributaries to the San Juan River in Colorado, and provides a firm yield of 96,200 acre-feet/year, all of which must be consumed within the Upper Rio Grande. Additional water that is contributed to the river locally, from tributary inflows and from groundwater, was estimated in 2000 (S.S. Papadopulos and Associates 2000) to be approximately 180,000 acre-feet per year. This water is not subject to delivery requirements under the Rio Grande Compact, and may be fully consumed within the Upper Rio Grande.

Snowmelt processes result in Upper Rio Grande streamflows from the mainstem Rio Grande, and to a lesser degree from the Rio Chama, that peak in the late spring and early summer and diminish rapidly by mid-summer. Peak snowmelt runoff from the Rio Chama tends to be earlier in time and smaller in magnitude than that from the mainstem of the Rio Grande. Local precipitation primarily occurs in the summertime, from thunderstorms that characterize the region's summer monsoons, and feeds the Upper Rio Grande directly. These monsoons can produce additional peak flows in the river. However, these flows are usually smaller in volume than the snowmelt peaks and also of much shorter duration. While the peak runoff period typically occurs from April through June, the highest evapotranspiration and irrigation demands along the Rio Grande occur from June through mid-September.

Figure 1 depicts the average distribution in time of native flows over the last century at several gages in the Middle Rio Grande or its tributaries. This figure shows that about 75 percent of the natural runoff volume in the mainstem gage Rio Grande at Otowi Bridge, as indicated by the Otowi Index Supply, occurs during April, May, and June, and represents snowmelt runoff. Similarly, along the Rio Chama, about 80 percent of the natural annual flow occurs during April, May, and June, and is attributable to snowmelt runoff. In contrast, the Rio Puerco, which originates along the Sierra Nacimiento east of Cuba, in Sandoval County, New Mexico and enters the Rio Grande near Bernardo, runs strongest in response

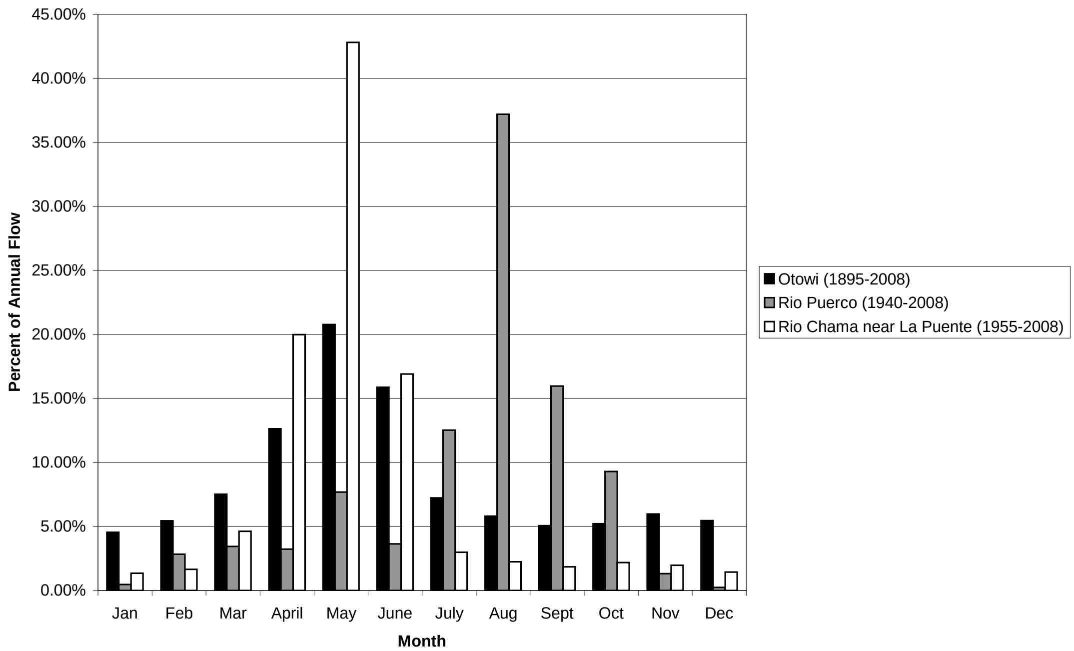


**Figure 1.—Average monthly distribution of native runoff at various gages.**

to monsoon precipitation events. Nearly 80 percent of the recorded annual flow in the Rio Puerco occurs between July 1 and October 31, with nearly 40 percent occurring during August alone (USACE, 2007). These flows are primarily attributable to summer thunderstorms.

A key characteristic of the Rio Grande system is the order of magnitude variability of streamflow on an inter-annual basis. Unregulated annual streamflow volumes at the upstream-most Rio Grande streamflow gage near Del Norte, Colorado, vary from less than 100,000 acre-feet up to well over 1,000,000 acre-feet. This high variability is evident in Figure 2, which depicts nearly five hundred years of Rio Grande streamflow near Del Norte reconstructed from tree-ring analysis. This reconstruction illustrates that the period of recorded stream flow, roughly 100 years, does not fully represent the historic range of extremes. For example, neither the recent drought years from 2001 through 2005 nor the 1950s drought—the most severe drought in our collective memory—match the severity of 5 previous drought episodes within this reconstructed record (Hurd and Coonrod 2007). Some anthropologists speculate that droughts prior to the reconstructed period were severe enough in this region to cause the collapse of early pre-Columbian civilizations in the region (Plog 1997). At the other end of the spectrum, the series of wet years in the mid-1980s and 1990s register as one of the five wettest periods in this reconstructed record.

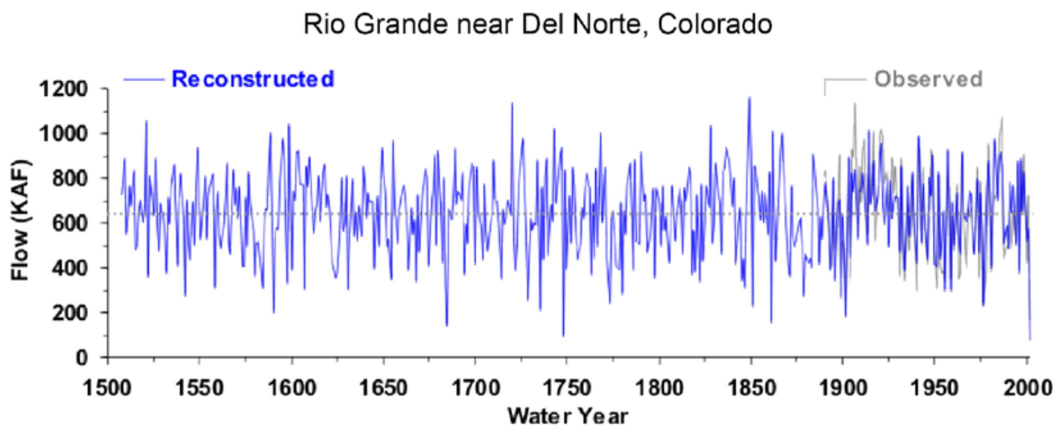


**Figure 2.—Long-run tree-ring reconstructed streamflow of the Rio Grande near Del Norte.(Lukas 2008).**

A reconstructed record for Rio Grande streamflow at Otowi (1450 through 2002) is shown in Figure 3. The blue line indicates the reconstructed record of the 10-year running averages from 1536 to 1999; the orange line indicates the 10-year running average of the actual gage record for Otowi over approximately the last century (since 1920). It can be seen on this plot that the long-term median reconstructed unregulated flow from 1450 through 2002 is about 1,800,000 acre-feet. The record shows that, before 1900, there is greater year-to-year variability, and there are more extreme and longer-duration periods of low flows (Lukas 2008).

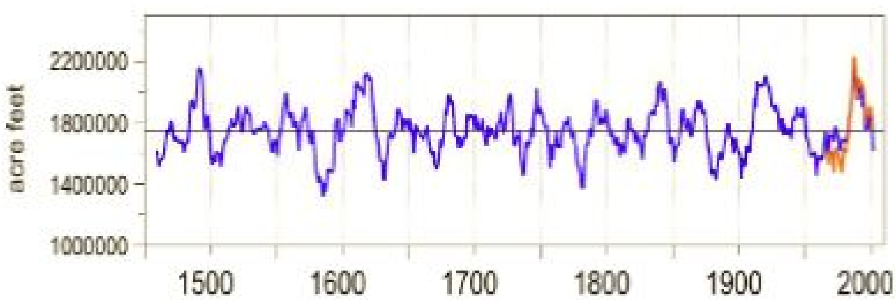


**Figure 3.—Rio Grande, Otowi reconstructed natural streamflow water year 1450 through 2002 and natural flow estimate for gage, 1958 through 2007 (10-year moving average).**

From analysis of the reconstructed record, the 1950s drought is the sixth driest record, whereas the more recent period from 1978 through 1987 is the wettest decade from 1450 through 2002 (Table 1).

**Table 1.—Driest and Wettest Decades**

| 5 Driest Decades | 5 Wettest Decades |
|---|---|
| 1576-1585 | 1978-1987 |
| 1772-1781 | 1482-1491 |
| 1623-1632 | 1610-1619 |
| 1874-1883 | 1912-1921 |
| 1893-1902 | 1831-1840 |
| 1950-1959 | |

Source: Lukas 2008.

A box and whisker plot of the Otowi natural flow reconstruction distributed for annual flows in each century (Figure 4) shows the median, 25 through 75th percentiles and the relatively extreme variability at the 5 and 95th percentiles. The plot shows that the 1900s have been slightly less extreme, and wetter on average than the previous four centuries (Lukas 2008). This indicates that annual flows measured in the 20th century may not be good indicators of the full range of historic variability.

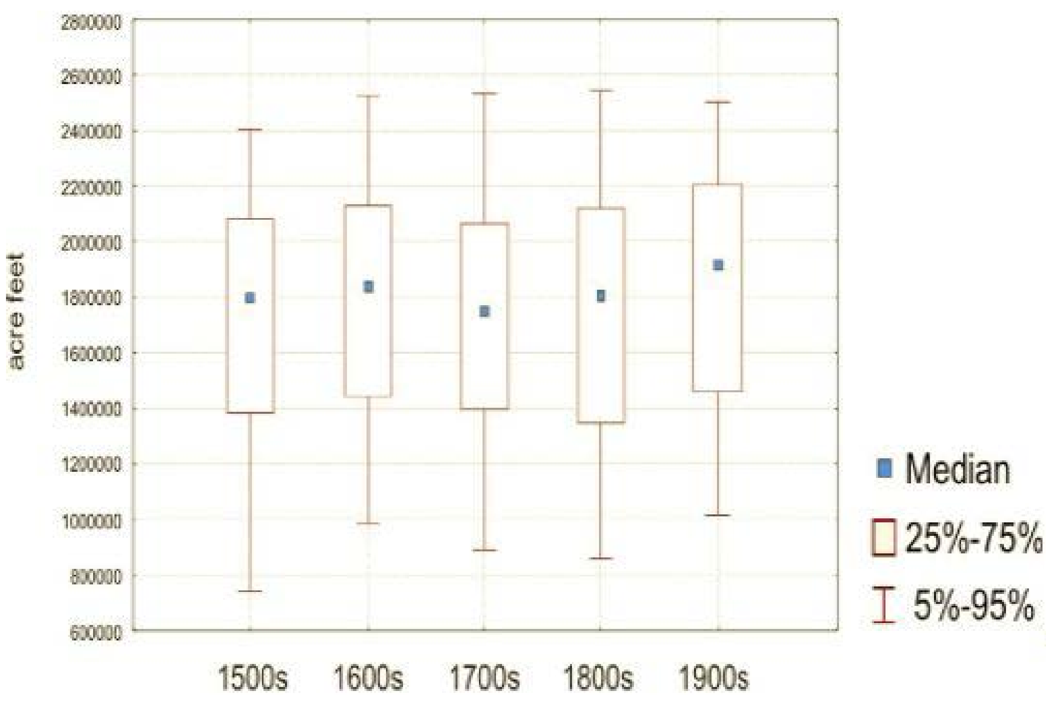


**Figure 4.—Box and whiskers plot of reconstructed Otowi natural flow.**
(Source Lukas 2008).

Droughts, defined as a year or more with annual flows less than the long-term median (i.e., less than 1,800,000 acre-feet unregulated flow at the Otowi Gage), are common in the historical record, with several mega-drought events lasting longer than 20 years. The 20$^{th}$ century record (1900 through 2000) includes only one period with a long-duration drought, within which were 16 years with available water below the long-term median. An additional dry period straddled the two centuries, extending from 1996 to 2004.

### II.A.2. Non-Native Supply (San Juan-Chama Project)

Reclamation's San Juan-Chama Project consists of a trans-basin diversion that takes water from the Navajo, Little Navajo, and Blanco rivers, upper tributaries of the San Juan River (of the Colorado River Basin), for use in the Upper Rio Grande Basin in New Mexico. The San Juan-Chama Project was authorized in 1962 under Public Law 87-483, which amended the Colorado River Storage Project Act of 1956 (Public Law 84-485) to allow diversion of a portion of New Mexico's allocation of Colorado River Basin water into the Rio Grande Basin of New Mexico. A limit of the San Juan-Chama Project water is that it must be beneficially consumptively used in New Mexico.

The firm yield of the San Juan-Chama Project is 96,200 acre-feet per year, which provides Supplemental Water supplies for various communities and irrigation districts. Reclamation maintains this water in a San Juan-Chama Project pool at Heron Reservoir. Depending upon the available supply, Reclamation allocates the water to contractors on January 1 of each year. Until 2013, Reclamation has had sufficient water in the project to provide the contractors with this full yield on January 1 of each year.

## II.B. Groundwater Supply

Between 1940 and 1957, groundwater use, especially along the Albuquerque reach, increased considerably, which led the State Engineer in 1957 to declare the Rio Grande Underground Water Basin, which authorized the State Engineer to control groundwater uses within the basin. In that year, the State Engineer began to impose conditions on new groundwater uses that required that groundwater users to purchase equal surface-water rights to each new appropriation of groundwater, and to retire those rights when the impact of the associated groundwater pumping is felt on the river.

Since that time, groundwater development has exploded, primarily to support municipal and industrial development. In 2000, the Office of the State Engineer estimated that groundwater pumping from the Albuquerque basin totaled 156,800 acre-feet per year; in that year, the State Engineer also closed the Albuquerque Basin to future development for which offset rights were not already purchased and transferred. Groundwater uses have been offset through the retiring surface-water rights, primarily from agriculture, and through replacing the impact of the groundwater pumping on the river with contracted water from the San Juan Chama project. Still, groundwater pumping has had considerable impact on the continuity of river flows. In 1956, the State Engineer estimated that the Rio Grande between the Colorado state line and the mouth of the Red River in Texas gained 93,000 acre-feet per year; In 2002, the Middle Rio Grande alone was estimated to lose 95,000 acre-feet per year (Bartolini and Cole 2002, Jones 2002).

## II.C. Upper Rio Grande Discharge Characteristics

While the Upper Rio Grande has become a regulated river system, the annual hydrograph still bears the general character and shape of the pre-development hydrograph. For example, the annual flows at the Otowi gage still vary over an order of magnitude, from 250,000 to 2.25 million acre-feet, with the majority of that flow occurring in the months of April through June. Figure 5 displays the mean monthly discharge (in cubic feet per second [cfs]) of the Rio Grande at three locations on the mainstem of the Rio Grande based on U.S. Geological Survey (USGS) river gage data from 1975 through 2008. It should be emphasized that maximum (peak spring runoff and summer rain events) and minimum (low/zero flow during dry periods) discharges are masked in this presentation through monthly averaging.

Figure 5 reveals that the Rio Grande hydrographs have a relatively low discharge from August through February and a higher discharge associated with spring runoff from mid-March through mid-July. The difference between the Cochiti release and the flow of the Rio Grande at Albuquerque gage is a result of channel losses and diversions (Figure 6). The hydrograph shows that these channel losses and diversions total approximately 300 cfs on average during the month of May. Maximum (peak spring runoff and summer rain events) and minimum (low/zero flow during dry periods) discharges are masked by the monthly averaging. Figure 7 displays the mean monthly discharge (cfs ± one standard deviation) of the Rio Grande at Otowi gage based on USGS data from 1895 through 1999. Again, note that maximum and minimum discharges are masked by the monthly averaging.

Figure 7 reveals the general characteristics of the Rio Grande hydrograph at Otowi gage as having a relatively low discharge from about August through February and a significantly higher discharge associated with spring snowmelt runoff from mid-March through mid-July. Summer irrigation demands can be over 900 cfs; native Rio Grande flows are typically insufficient to meet these needs (Flanigan 2004).

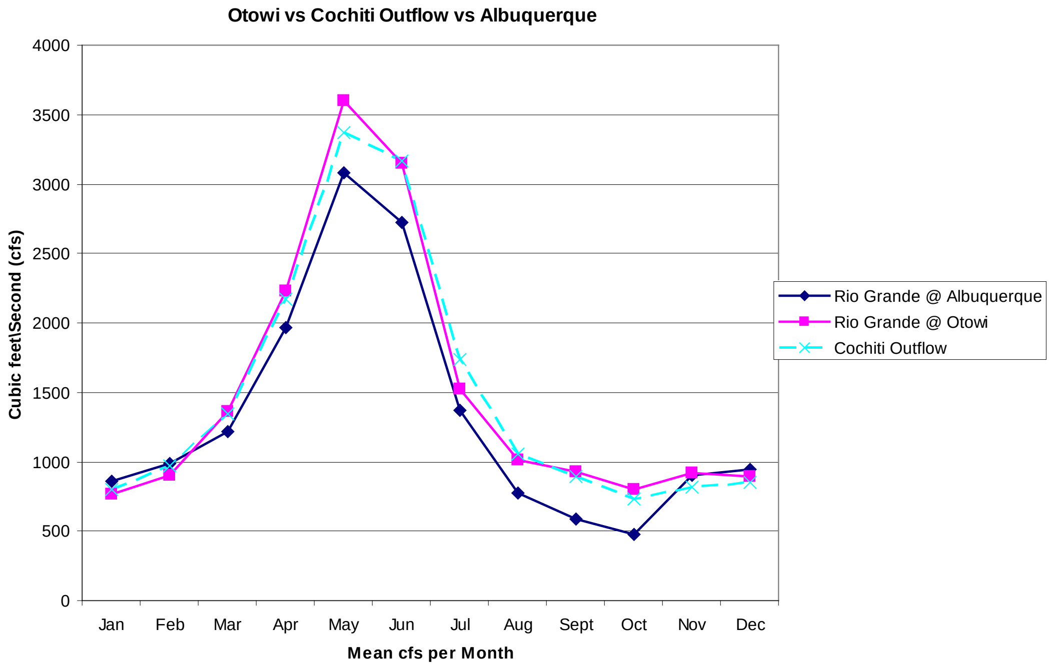


**Figure 5.—Mean monthly discharge (cfs) of the Rio Grande at Otowi gage, Albuquerque gage, and Cochiti Outflow, 1975 through 2008.**

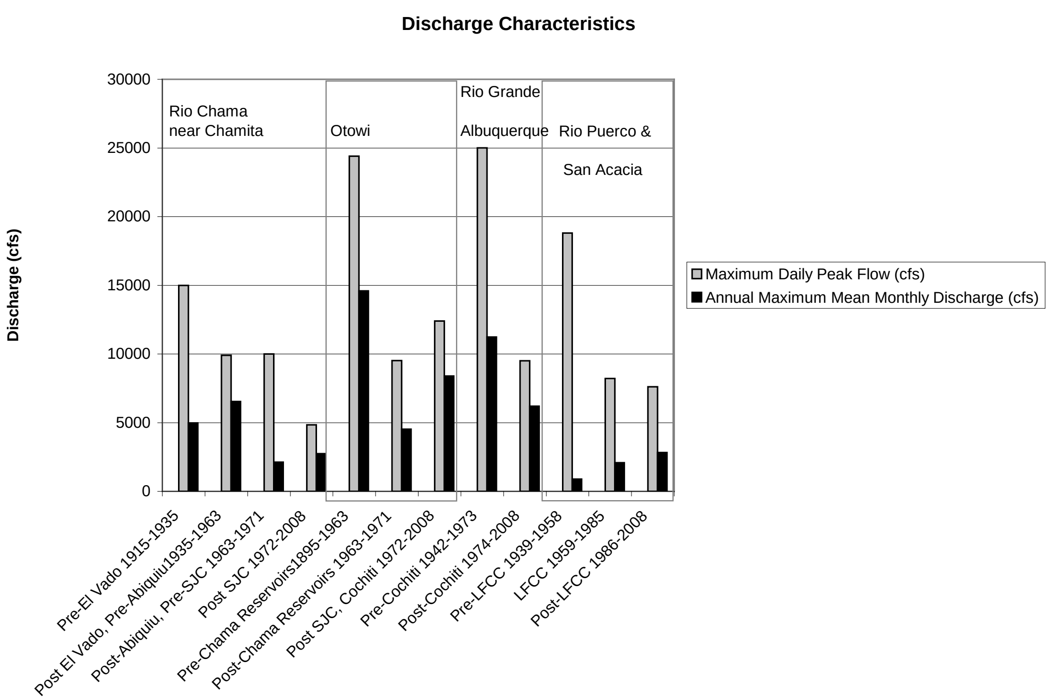


**Figure 6.—Impact of flood control and other structures on Rio Grande discharge.**

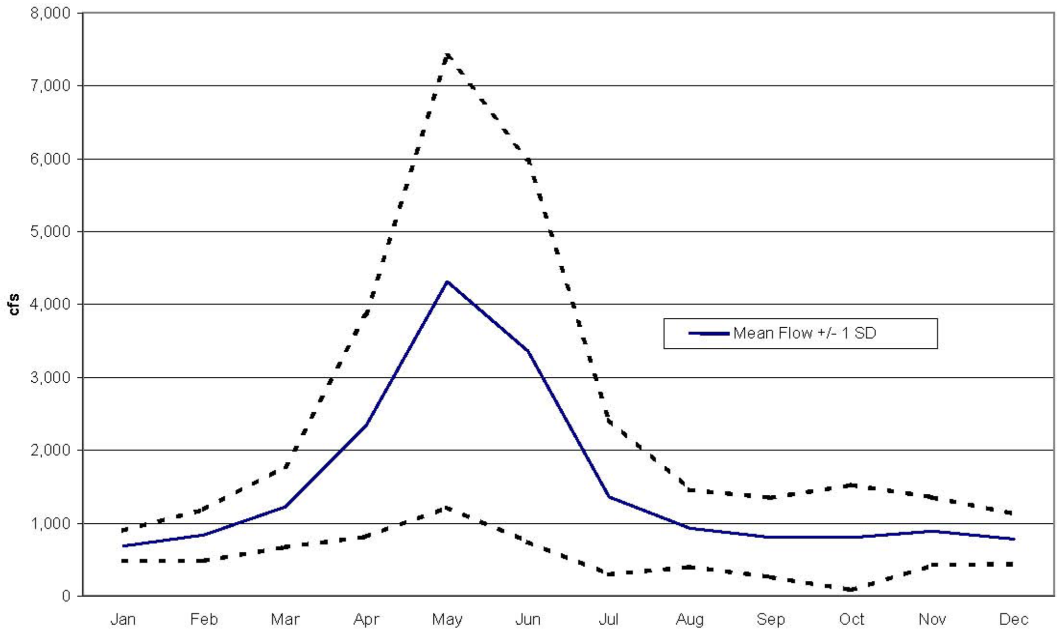


**Figure 7.—Mean monthly discharge (cfs; ± one standard deviation) of the Rio Grande at the Otowi Gauge. (U. S. Geological Survey data, 1895 through 1999).**

A more recent representation of median flows at Otowi gage from 1971 through 2007 is shown in Figure 8, broken down by the probability of occurrence of the distribution of flows. These hydrographs reflect hydrologic and water management conditions since the start of the San Juan-Chama Project and construction and operation of Cochiti Dam. The time period in the hydrographs also includes the historically wet period in the early to mid-1980s. Flows in the Rio Grande basin are skewed toward more frequent lower flows, and larger variation in the upper flows, such that mean monthly discharges, especially during the months of spring runoff, are significantly higher than median flows. Median flows are the 50th percentile flows (i.e. where half the discharges are higher and half are lower). Median spring peak flows are less than 3,500 cfs and occur in late May.

Increasing urban populations are increasing the amount of return flows provided from wastewater treatment plants and stormwater management facilities. Population increases in the basin that may affect flows along the mainstem Rio Grande include growing numbers of domestic wells in the Albuquerque basin, water rights transfers within and outside the Albuquerque basin, and decreases in irrigated lands resulting from housing development in the valley floor.

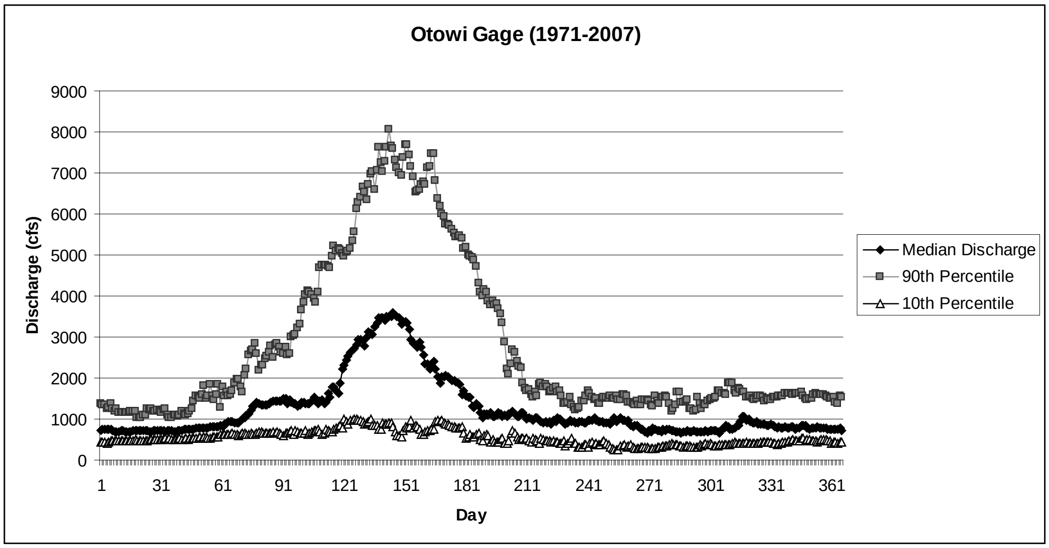


**Figure 8.—Discharge of the Rio Grande at Otowi Gage (1971 through 2007).**
Reference: USGS data 1971 through 2007.

The City and County of Santa Fe are also initiating, under their Buckman Direct Diversion project, direct use of their 5,605 acre-foot per year allocation of San Juan-Chama Project water to supplement their municipal supply. The city has been diverting water to the Buckman Direct Diversion project from the Rio Grande since January 2011.

## II.D. Changes to Size and Duration of Peak Flows and Reservoir Storage

Reservoirs are managed to store and release water in a way that scalps the peaks off the hydrographs, and provides water during lower-water and higher-use times that might not otherwise have sufficient water available. Major reservoirs on the Upper Rio Grande are listed, in upstream to downstream order, in Table 2. Please note that Galisteo Dam does not have an associated reservoir.

Construction and operation of flood control and water storage dams (Heron, El Vado, Abiquiu, Cochiti, Platoro, and Elephant Butte), as well as irrigation diversion dams (Buckman, Angostura, Isleta, and San Acacia), have modified the natural flow of the river. Mainstem dams store spring runoff and summer inflow, which would normally cause flooding, and release this water back into the river channel over a prolonged period of time. USACE normally will pass inflow, as it occurs, up to the channel capacity of the river reach below the dam.

**Table 2.—Major Reservoirs in the Upper Rio Grande.**

| Reservoir | Capacity (acre-feet) | Primary Manager | Primary Purposes |
|---|---|---|---|
| Heron | 401,300 | Reclamation | Storage |
| El Vado | 195,440 | Reclamation | Storage |
| Abiquiu | 1,198,500 | USACE | Flood Control and Storage |
| Nichols and McClure | 3,940 | City of Santa Fe | Storage |
| Cochiti | 589,159 | USACE | Flood Control |
| Platoro | 60,000 | Reclamation | Flood Control and Storage |
| Jemez | 262,473 | USACE | Flood and Sediment Control |
| Elephant Butte | 2,023,400 | Reclamation | Storage |
| Caballo | 326,670 | Reclamation | Reregulation |

At the tail end of the spring snowmelt runoff, PL 86-645 may affect USACE floodwater evacuation at Abiquiu and Cochiti dams. USACE is directed by PL 86-645 to hold (carry-over) floodwater in Abiquiu or Cochiti Reservoirs after July 1 when the natural flow at Otowi gage falls below 1,500 cfs. This water must subsequently be released between the following November 1 and March 31. While carryover storage is not a common occurrence, USACE does have discretion as to how this water is evacuated. These releases are made during the winter months, when low-flows would normally occur.

With operation of the Albuquerque Bernalillo County Water Utility Authority (ABCWUA) Drinking Water Project, regular releases of San Juan-Chama Project waters are reducing the likelihood of future river drying as far downstream as the Project’s inflatable dam and diversion structure near the Paseo del Norte bridge in Albuquerque. ABCWUA’s permit (which is currently under litigation) allows the ABCWUA to divert as long as:

- Native Rio Grande flows are available above curtailment thresholds specified in the New Mexico Office of the State Engineer permit, and

- Flood flows will not cause damage to structures or adversely affect water quality.

ABCWUA is required by its permit to return at least the volume of the native Rio Grande flows diverted at its wastewater treatment plant outfall south of Albuquerque. ABCWUA project, when operating, is expected to reduce flows across Isleta Diversion Dam by up to 12 cfs in June through August. Operations of the dam for the ABCWUA Drinking Water Project have impacted the consistency of water availability at Isleta Dam.

Similar operations by the Buckman Direct Diversion Project near Santa Fe include diversion of an additional 10 cfs in June and July. As a result, flows across Isleta Diversion Dam may, under certain conditions, decrease by 8 to 11 cfs from June through October, with less of an impact at other times of the year (U. S. Fish & Wildlife Service, 2007).

Increases in flows in November and December are attributed to the curtailment of irrigation diversions, a decrease in riparian evapotranspiration, a significant reduction in open water evaporation rates, the release of held-over flood waters following wet runoff years, releases of unused prior and paramount water, and an emphasis on New Mexico deliveries under the Rio Grande Compact during the colder winter seasons to minimize depletions and carriage losses. Winter flows tend to be near 500 cfs even during dryer years.

## II.E. Low Flow Conditions and Historic River Drying (1956 through 2000)

A database was assembled for the 2003 Biological Assessment (U.S. Fish and Wildlife Service, 2003) that contains historical daily river flows measured at Albuquerque (Central Avenue gage), San Acacia, and San Marcial over the 45-year period from 1956 through 2000. The database was used to calculate the percentage of days with zero-flow at the noted gage locations. It must be noted that these percentages represent actual historic zero flow occurrences under river management practices that existed at the time that the measurements were made. River management practices that were employed at various times from 1956 through 2000 included:

- Active and complete diversion of the Rio Grande into the LFCC at San Acacia
- Diversion into Middle Rio Grande Project facilities and irrigation of Indian and non-Indian land within the MRGCD
- Active operation of all existing reservoirs for storage and release
- San Juan-Chama Project water releases
- Actions specifically targeted to benefit endangered species

The years in this record were ranked based on the total annual flow recorded at the Embudo gage on the Rio Grande mainstem and the La Puente gage on the Chama, upstream of the reservoirs. According to this measure, the driest year within this record occurred in 1977, with a total annual combined flow at Embudo and La Puente of 256,256 acre-feet. The wettest year within this record occurred in 1985, when the combined Embudo and La Puente flow was 1,872,072 acre-feet. The average of the flows recorded at Embudo and La Puente over the entire 45-year period was 853,141 acre-feet.

The ranked 45-year record was then divided into equal thirds, designated to represent "dry years," "average years," and "wet years" (Table 3). The number of zero-flow days (agreed for this analysis to include all days with measured daily average flow less than 1 cfs) was summed by month for Albuquerque (Central Avenue), San Acacia, and San Marcial gages. This analysis is summarized in Table 3 for "dry years" and "average years" in terms of percentage of days with zero flow for the months of May through October. Current water management practices have significantly reduced the number of days with zero flow.

**Table 3.—Historic Percentage of Days with Zero Flow (1956 through 2000)**

| Location | May | June | July | August | Sept. | Oct. |
|---|---|---|---|---|---|---|
| **Historic Percentage of Days with Zero Flow – "Dry Years"** | | | | | | |
| Albuquerque | 3% | 12% | 17% | 9% | 6% | 20% |
| San Acacia | 0% | 13% | 31% | 11% | 24% | 13% |
| San Marcial | 65% | 73% | 62% | 44% | 45% | 54% |
| **Historic Percentage of Days with Zero Flow – "Average Years"** | | | | | | |
| Albuquerque | 0% | 0% | 0% | 0% | 5% | 9% |
| San Acacia | 0% | 3% | 3% | 8% | 8% | 3% |
| San Marcial | 11% | 30% | 54% | 38% | 45% | 54% |

# III. Water-Management Infrastructure, Operations and Water Demand

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 Upper Rio Grande system:

1) Flood control

2) Irrigation

3) Municipal and industrial diversion, use, and return flow

4) Environmental operations

5) Recreational/rafting

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

Figure 9 is a schematic representation of the Rio Chama and Rio Grande that shows the major facilities and/or entities that impact flows in the Upper Rio Grande—from Heron Reservoir operations at the top to the Bosque Del Apache Wildlife Refuge at the bottom.

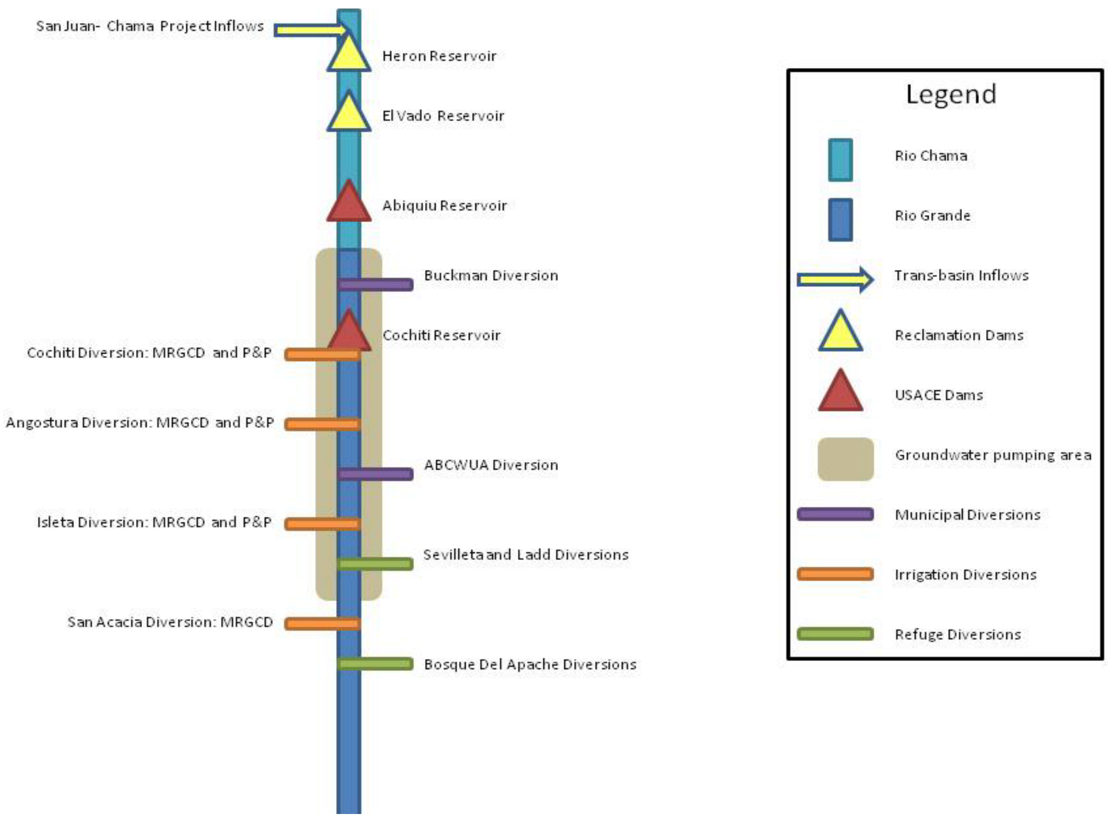


**Figure 9.—Schematic representation of major water facilities impacting river flows in the Middle Rio Grande.**

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 San Juan-Chama Project)
  - El Vado Dam Reservoir (owned and operated by Reclamation as part of the Upper Rio Grande Project)
  - Abiquiu Dam and Reservoir (owned and operated by USACE for flood control and San Juan-Chama Project storage)
- Rio Grande
  - Cochiti Dam and Reservoir (owned and operated by USACE for flood control)
- Off-Channel
  - Jemez Canyon Reservoir (owned and operated by USACE for flood control)
  - Galisteo Dam (owned and operated by USACE for flood control)

Heron Dam and Reservoir are on Willow Creek, a tributary of the Rio Chama. Reclamation operates Heron Reservoir to manage imported San Juan-Chama Project waters and passes all native Rio Grande flows. Reclamation operates El Vado Reservoir to store native Rio Grande water, when allowed by the Rio Grande Compact, for use in the Upper Rio Grande Project service area by non-Indian farmers and the six Pueblos. Reclamation stores native Rio Grande waters for prior and paramount water needs pursuant to a 1981 interagency agreement. When space is available, El Vado also may store San Juan-Chama Project water. Abiquiu Reservoir is authorized for flood control, sediment control, and storage of both San Juan-Chama 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 acre-feet of native Rio Grande water (less than 10 percent 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 San Juan-Chama Project water (Flanigan, 2007).

Rio Grande flows at Otowi gage, which is located just downstream from the confluence of the Rio Chama, consist of unregulated mainstem 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

San Juan-Chama 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 through 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 Upper Rio Grande. 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 through October, depending on irrigation demand and the need for available Supplemental Water to meet environmental flow requirements.

The Low Flow Conveyance Channel (LFCC) 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 Rio Grande 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 Upper Rio Grande have not yet been adjudicated to determine their nature and extent, and the waters of the Upper Rio Grande are fully appropriated.

## III.A. San Juan-Chama Water Operations

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

Figure 10 provides a summary of annual San Juan-Chama Project diversions, which enter to the Rio Grande system via the Azotea Tunnel, annual inflows of San Juan-Chama Project water to El Vado Reservoir, and annual amounts of water conveyed at the Otowi gage for consumption in the Upper Rio Grande.

During the 11-year period shown in Figure 10, an annual average of about 61,550 acre-feet of San Juan-Chama Project water passed the Otowi gage in response to downstream demand by San Juan-Chama Project contractor requests and Reclamation Supplemental Water Program releases. The remainder of San Juan-Chama Project water remained stored in Upper Rio Grande reservoirs, especially El Vado and Abiquiu, as shown in Figure 11.

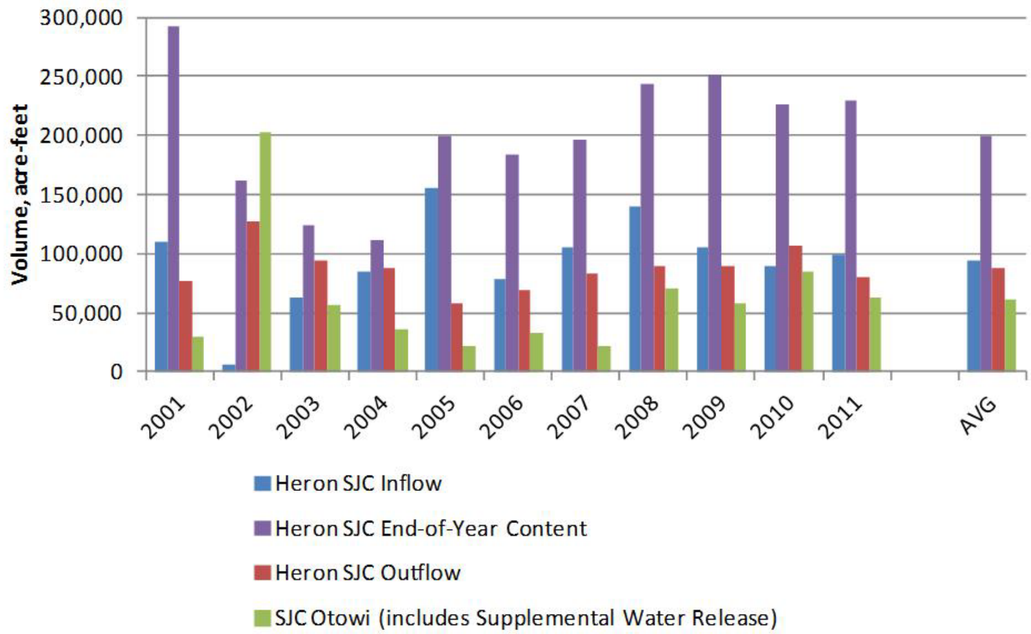


**Figure 10.—Summary of annual Heron Reservoir operations under the San Juan-Chama Project, including inflows, outflows, and storage of San Juan-Chama Project water and annual amounts of San Juan-Chama Project water crossing the Otowi gage for consumption within the Upper Rio Grande.**

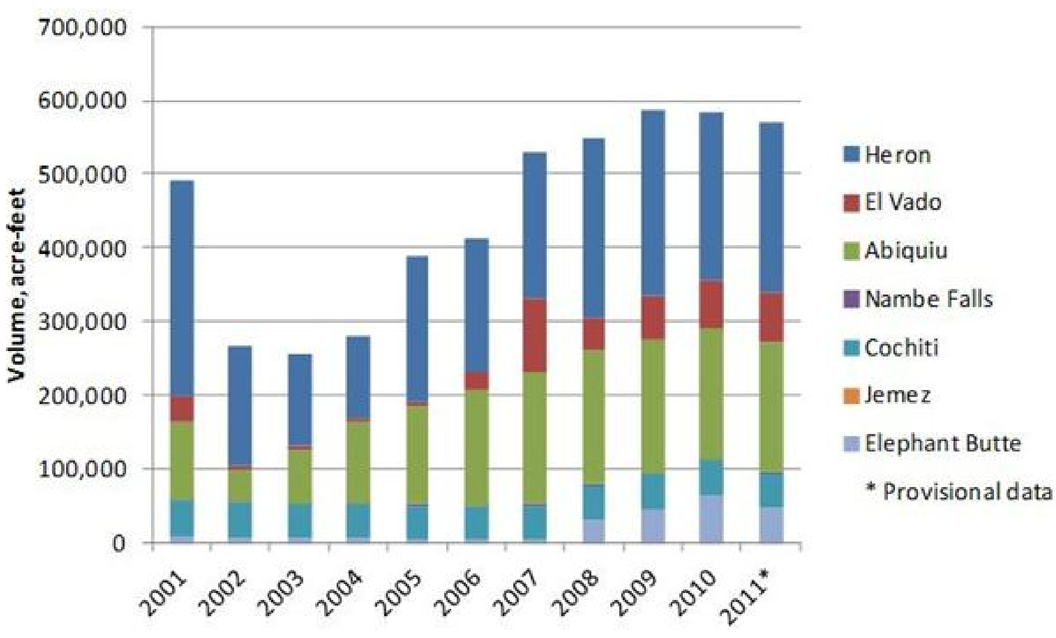


**Figure 11.—Summary of end-of-year storage of San Juan-Chama Project water in Middle Rio Grande reservoirs.**

## III.B. Platoro Dam

Platoro Dam is on the Conejos River, a tributary to the Rio Grande in southern Colorado. The dam is located high (9,911 feet) in the San Juan Mountains and is about 80 miles upstream from the Conejos/Rio Grande confluence. Congressional authority for the construction of Platoro Dam is contained in the Interior Appropriation Act of 1941. The dam was completed in 1951 by Reclamation as a multi-purpose facility for irrigation storage and flood control. The operation and maintenance responsibility has been transferred to the Conejos Water Conservancy District. USACE is responsible for administering the flood control regulation pursuant to Section 7 of the Flood Control Act of 1944.

Total storage in Platoro Reservoir is approximately 60,000 acre-feet, of which 6,000 acre-feet is reserved solely for flood control and the remainder is jointly used for flood control and irrigation storage. The maximum rate of release from the dam is 920 cfs. In order to preserve fish and wildlife habitat below the dam, the Conejos Water Conservancy District maintains minimum instream flows of 7 cfs during October through April, and 40 cfs (or natural inflow, if less) during May through September. Flood control and irrigation storage operations at Platoro Dam have minimal effect on flows in the Rio Grande.

## III.C. 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 12 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.

Releases of stored water from El Vado are made at the request of the MRGCD, as needed to meet Upper Rio Grande 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.

When Article VII storage restrictions under the Rio Compact 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 12. These flows represent San Juan-Chama water, the non-native portion of the flow that passes through El Vado.

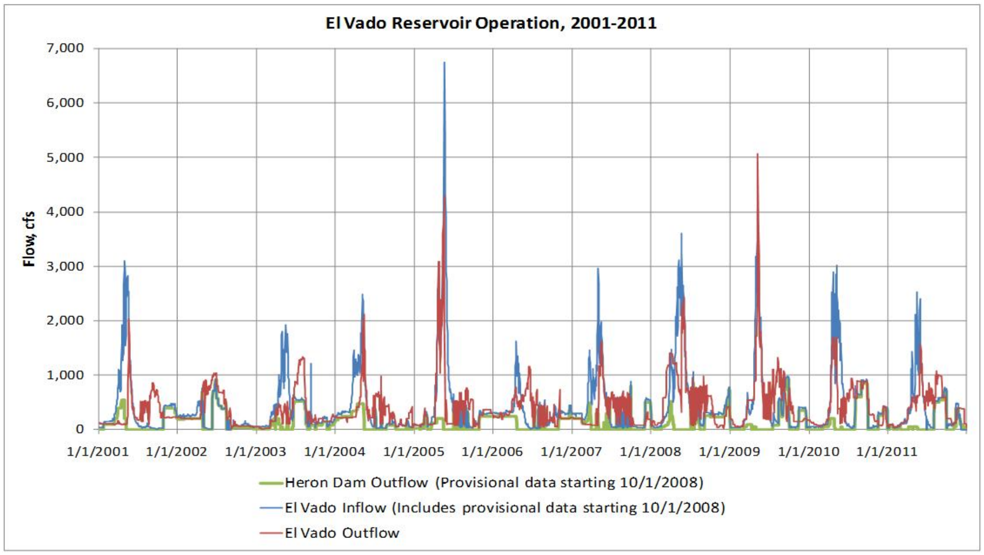


**Figure 12.—Hydrograph depicting El Vado Reservoir operations, 2001 through 2011, including a comparison of Heron Dam outflow, El Vado Reservoir inflow and El Vado Dam outflow.**

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 13. 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.

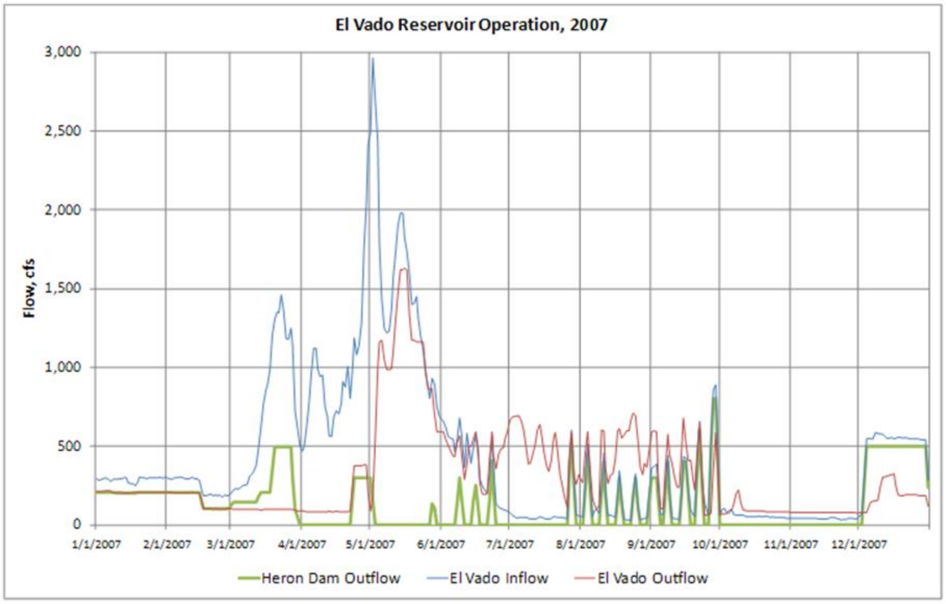


**Figure 13.—Comparison of Heron Dam outflow, El Vado inflow, and El Vado outflow, 2007.**

# III.D. Flood Control Operations

USACE owns and operates Abiquiu and Cochiti Dams, which are primarily used for flood control. 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 (USACE 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 14 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 (USACE 1995 [Water Control Manual, Appendix A]). 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 Upper Rio Grande.

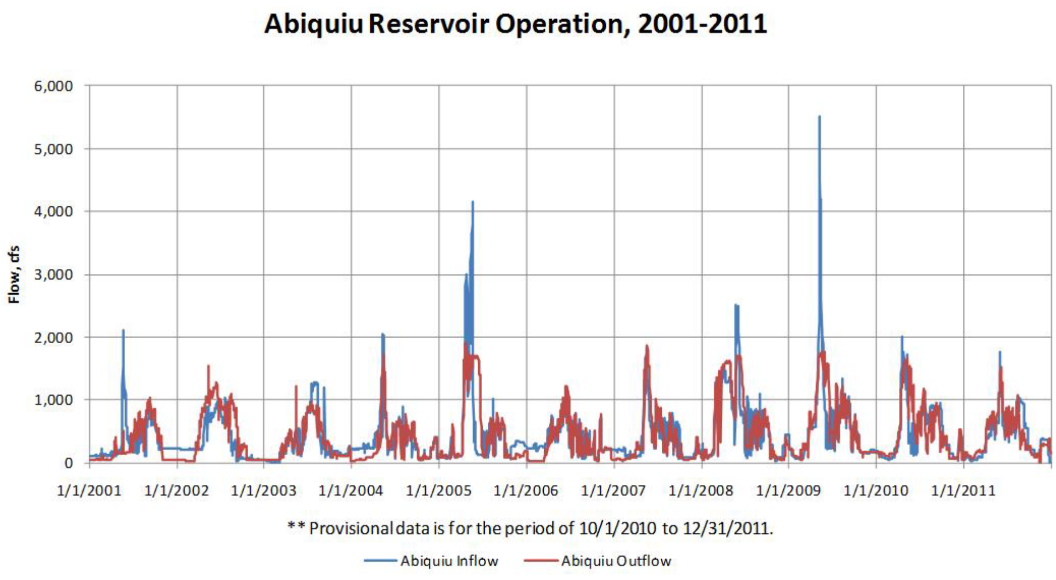


**Figure 14.—Comparison of inflow to and outflow from Abiquiu Reservoir, 2001 through 2011, showing flood control operations in 2001, 2004, 2005, 2008, 2009, and 2010.**

Figure 15displays 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

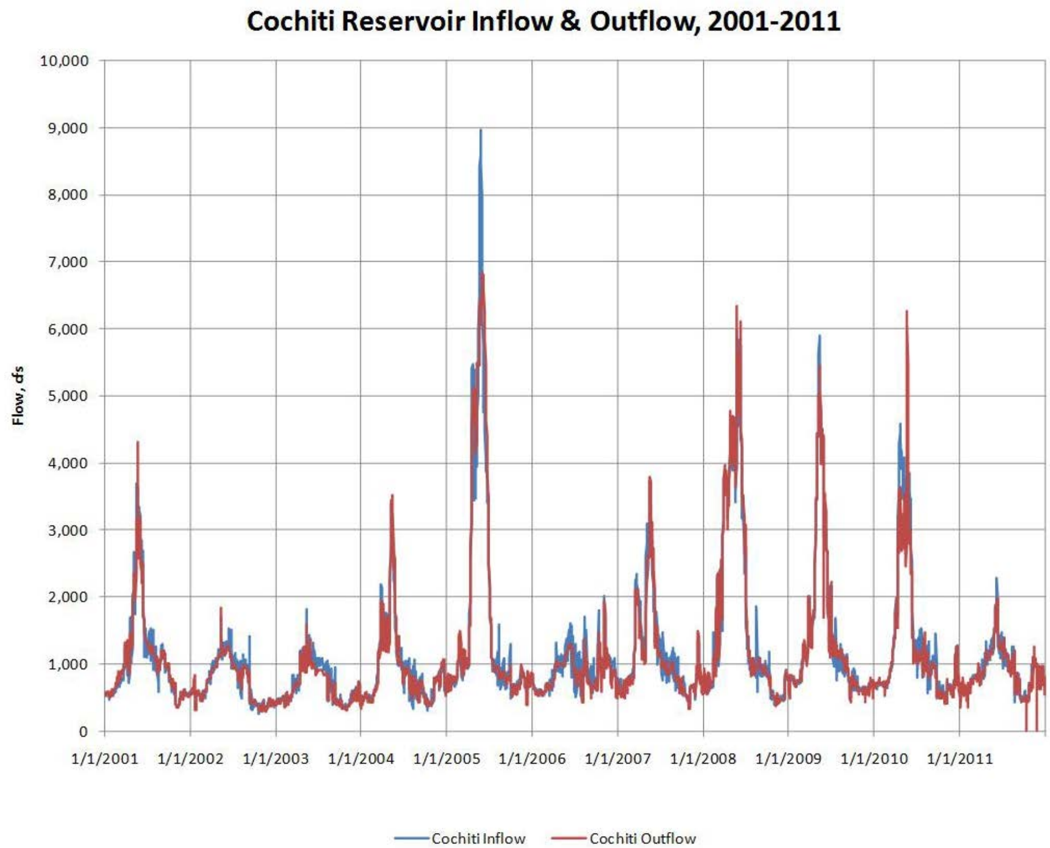


**Figure 15.—Inflow and outflow hydrographs for Cochiti Reservoir, 2001 through 2012.**

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 decade.

## III.E. Cochiti Deviations

In 2007, the Rio Grande Compact Commission and the Corps of Engineers approved deviations from the Corps' normal reservoir operation schedule (as specified in its Water Control Manual; U.S. Army Engineer District, Albuquerque, Corps of Engineers, 1996) to support minnow spawning and recruitment. 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, USACE is authorized to temporarily store up to 10,000 acre-feet of water in Cochiti Reservoir.

Such deviations from normal operations were implemented in 2007 and 2010, in coordination with the FWS 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 USACE and, therefore, were implemented as feasible and deemed appropriate, through 2013.

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 to 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 Figure 16 and Figure 17.

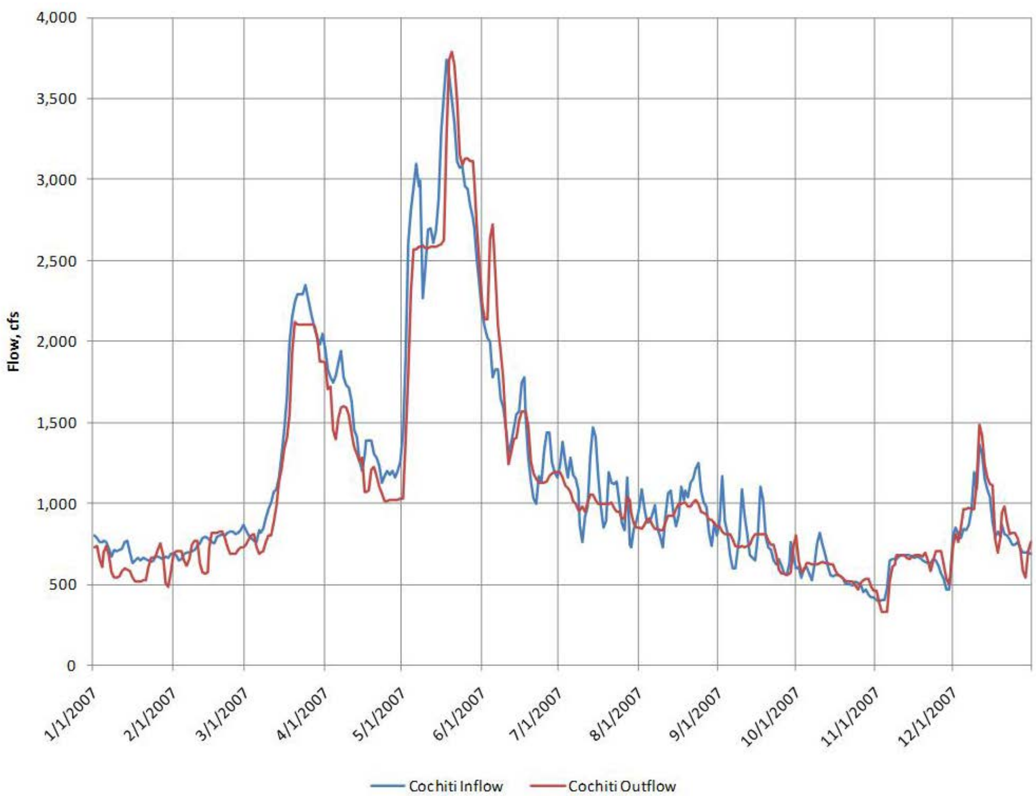


**Figure 16.—Comparison of inflow to and outflow from Cochiti Reservoir, 2007, showing the effects of "Cochiti deviation" operations.**

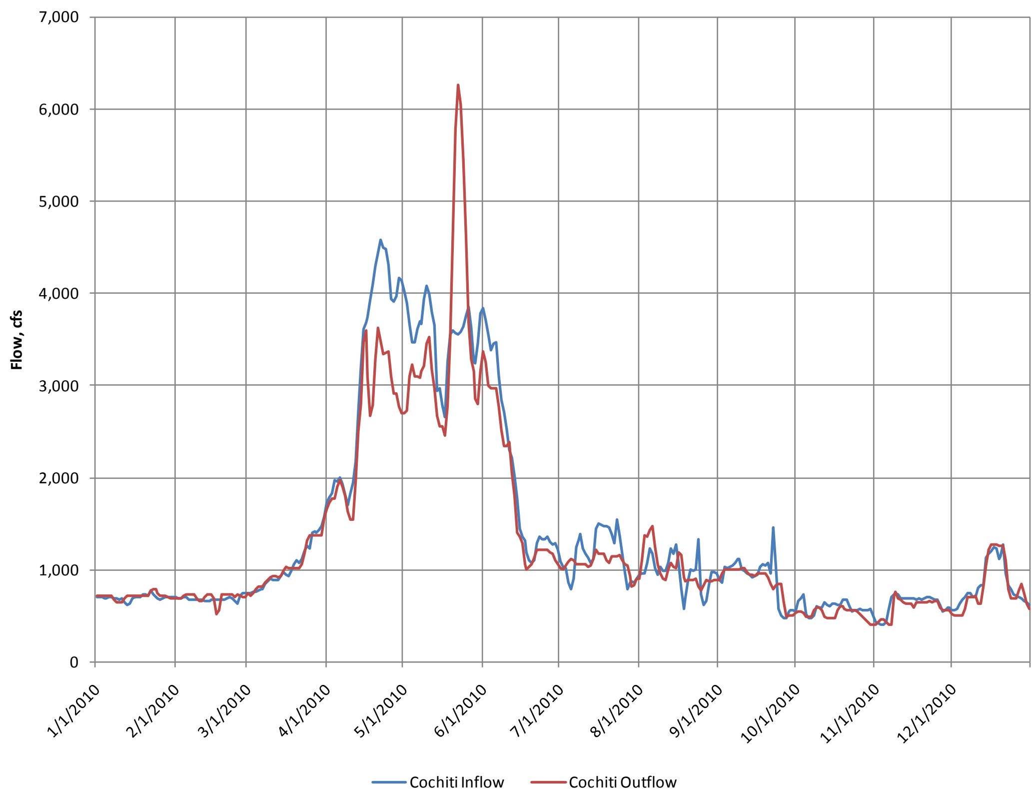


**Figure 17.—Comparison of inflow to and outflow from Cochiti Reservoir, 2010, showing the effects of "Cochiti deviation" operations.**

# III.F. Ground Water

Since the 1940s, population growth, combined with technological improvements in well drilling and pumping, have led to dramatic increases in groundwater pumping in the Upper Rio Grande, primarily for domestic, municipal, and industrial use (McAda and Barrol 2002). As of 1999, it was estimated (Bartolini and Cole 2002) that 170,000 acre-feet per year are pumped from the river-connected aquifer in the Upper Rio Grande, 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 San Juan-Chama Project water. This pumping has caused groundwater drawdowns of up to 160 feet in some areas of Albuquerque (McAda and Barrol 2002). Ultimately, the water pumped is made up for by seepage from the river into the groundwater system. Recharge from the river to the aquifer through the Upper Rio Grande was estimated in 1999 to total 295,000 acre-feet per year.

The New Mexico Office of the State Engineer has calculated the depletions caused to the river by groundwater 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 San Juan-Chama Project water.

The State Engineer 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 San Juan-Chama 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 (termed “letter water”). The depletions are described by the State Engineer as cumulative effects on Elephant Butte Reservoir (and, therefore, to New Mexico’s deliveries under the Rio Grande Compact) due to depletions above and/or below the Otowi gage and cumulative effects on the Rio Grande in the Upper Rio Grande above and/or below the Otowi gage. Depletions that occur during the irrigation season are considered effects on the Upper Rio Grande 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 San Juan-Chama Project water the State Engineer requests 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 New Mexico Office of the State Engineer 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 to 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 San Juan-Chama Project water over the 2001 through 2010 period ranged from 1,000 to 7,000 acre-feet per year. For example, at the end of 2010, the State Engineer requested releases for the following contractors to offset 2009 depletions:

- 93 acre-feet for the city of Espanola
- 161 acre-feet for the village of Los Lunas
- 13 acre-feet for the town of Taos
- 6 acre-feet for village of Taos Ski Valley
- 47 acre-feet for the city of Belen
- 2,024 acre-feet for the ABCWUA

## III.G. Water Right Transfers

As discussed in section 3, the New Mexico Office of the State Engineer 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 Upper Rio Grande 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 Upper Rio Grande was modeled by Sandia National Laboratory in November 2004 (Sandia National Laboratories 2004). Analyzing trends in water rights transfers is difficult because data are not readily available, accurate or up to date (Sandia National Laboratories 2004).

The aquifer in the Upper Rio Grande, consisting of Santa Fe Group and younger alluvial deposits, is known to be hydrologically connected to the Rio Grande surface water system. Since groundwater diversions from aquifers hydrologically connected to the Rio Grande affect the fully appropriated surface flow, the NMOSE conjunctively manages the State Engineer established guidelines (New Mexico Office of the State Engineer 2000) for the Middle Rio Grande Administrative Area (MRGAA) to ensure compliance with the Rio Grande Compact to:

- Prevent impairment to existing rights
- Limit the rate of decline of groundwater levels so that the life of the aquifer is extended
- Minimize land subsidence

The guidelines embody the State Engineer’s existing practice for evaluating applications for permits for groundwater use in the MRGAA and recognize that offsetting the effects of groundwater diversions is critical to the conjunctive management of water resources within the Upper Rio Grande stream system. Accordingly, the guidelines provide that permitted groundwater 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 State-Engineer-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.

## III.H. Water Management to Meet the Needs of the Six Middle Rio Grande Pueblos

The six 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. 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 U.S. 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 Upper Rio Grande 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 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 Pueblos pursuant to the 1981 Agreement. The Bureau of Indian Affairs 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 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 18. 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 18. 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 18 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.

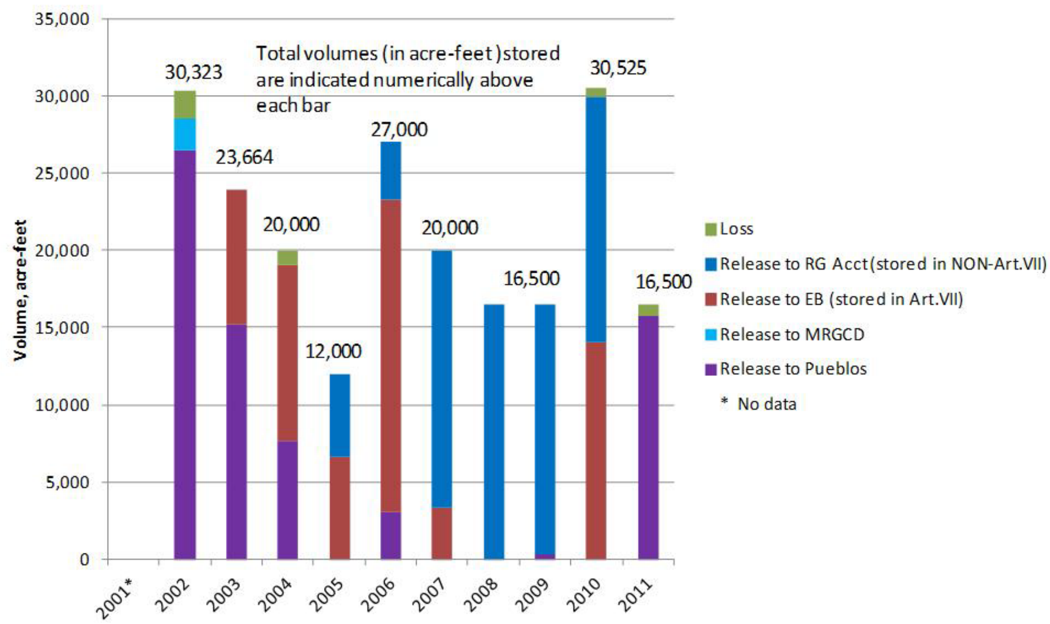


**Figure 18.—Summary of prior and paramount water stored in and released from El Vado Reservoir for irrigation of lands.**

## III.I. Middle Rio Grande Conservancy District Operations

Early in the 2000s, an extensive effort was undertaken by the New Mexico Interstate Stream Commission, 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. Figure 19 shows the effects of these improvements. Total MRGCD diversions during the 1990s were approximately 600,000 acre-feet; but after 2001, typical total MRGCD diversions ranged from 300,000 to 400,000 acre-feet.

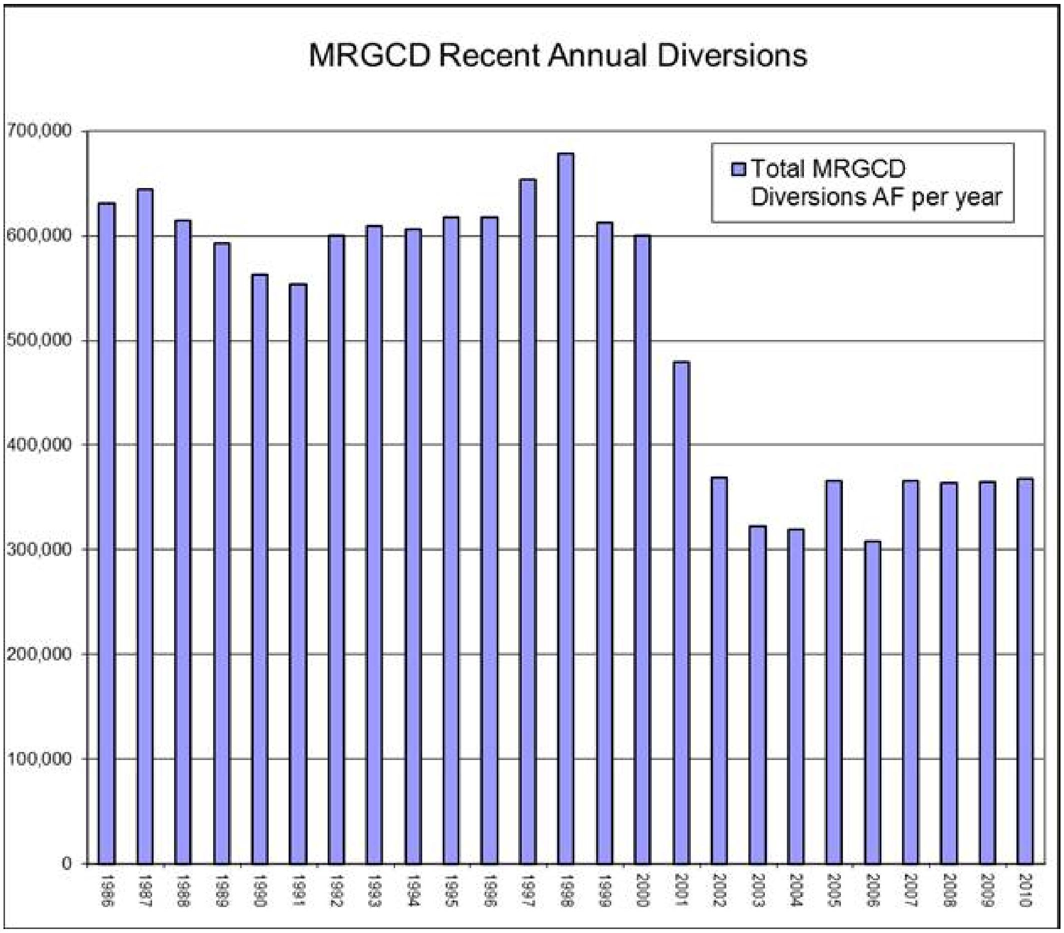


**Figure 19.—Summary of total water diversions by the MRGCD, 1996–2010.**

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 Upper Rio Grande, especially in the Albuquerque Reach. Therefore, extending the length of the irrigation season measurably decreases the Supplemental Water required to meet Upper Rio Grande ESA flow targets.

Figure 20 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.

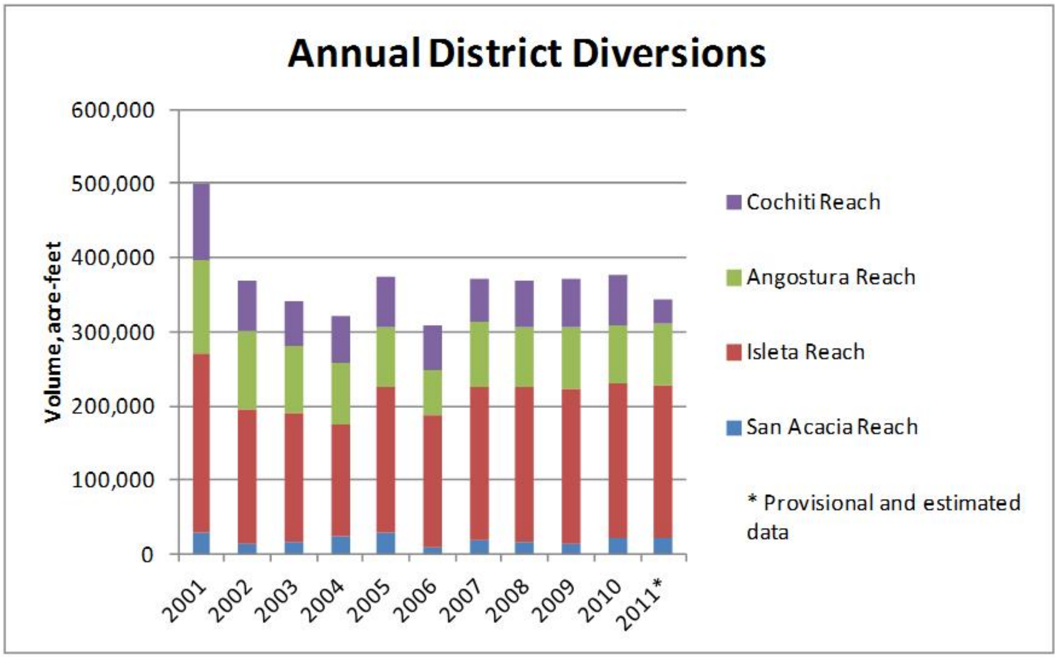


**Figure 20.—Summary of annual diversions from the Rio Grande to the MRGCD at the four Upper Rio Grande diversions structures.**

These diversions are made primarily during the summer months. The monthly average of diversions over the past decade is shown in Figure 21.

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).

The following figures, Figure 22 and Figure 23 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 groundwater 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.

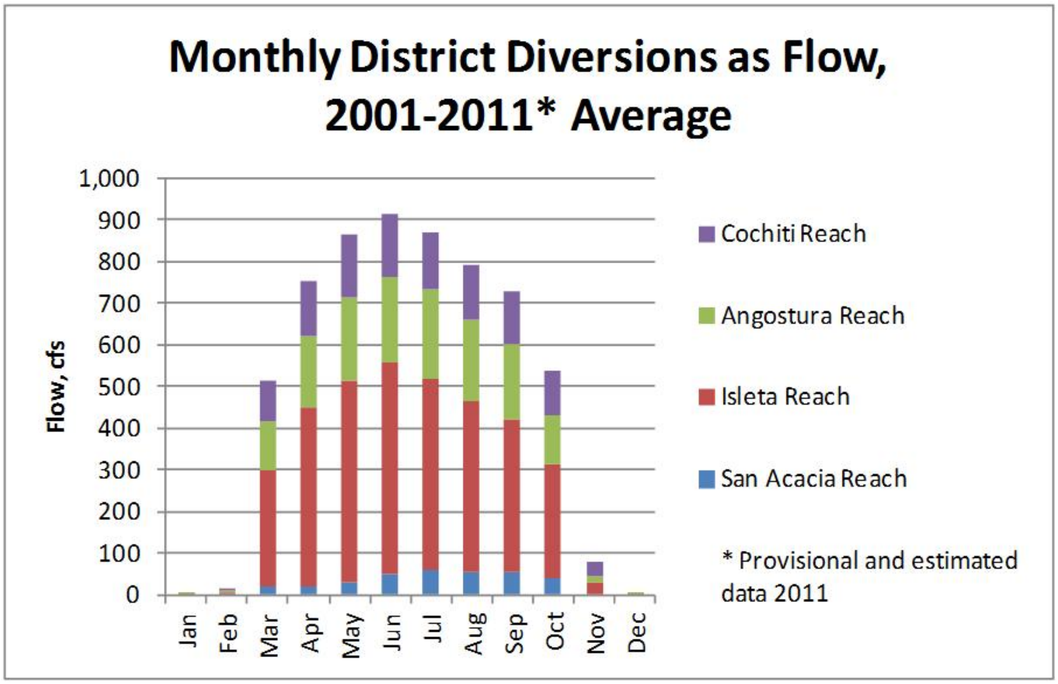


**Figure 21.—Monthly breakdown of average annual diversions to the MRGCD at the four Upper Rio Grande diversion structures, 2001–2011.**

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.

## III.J. Albuquerque Bernalillo County Water Utility Authority Drinking Water Project

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

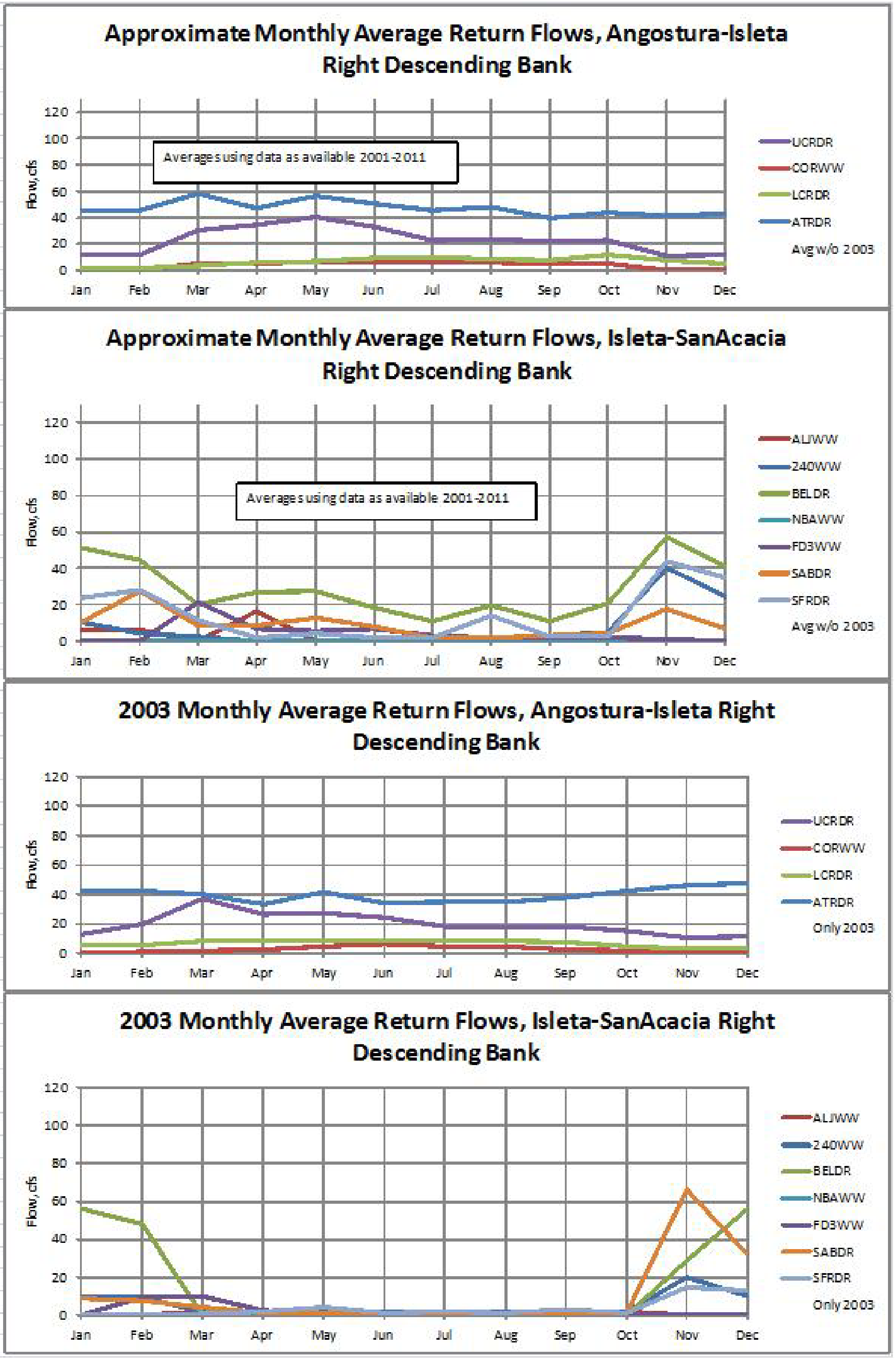


**Figure 22.—Summary of average district drain and tailwater returns to the Rio Grande, by month, 2001–2011, right descending bank.**

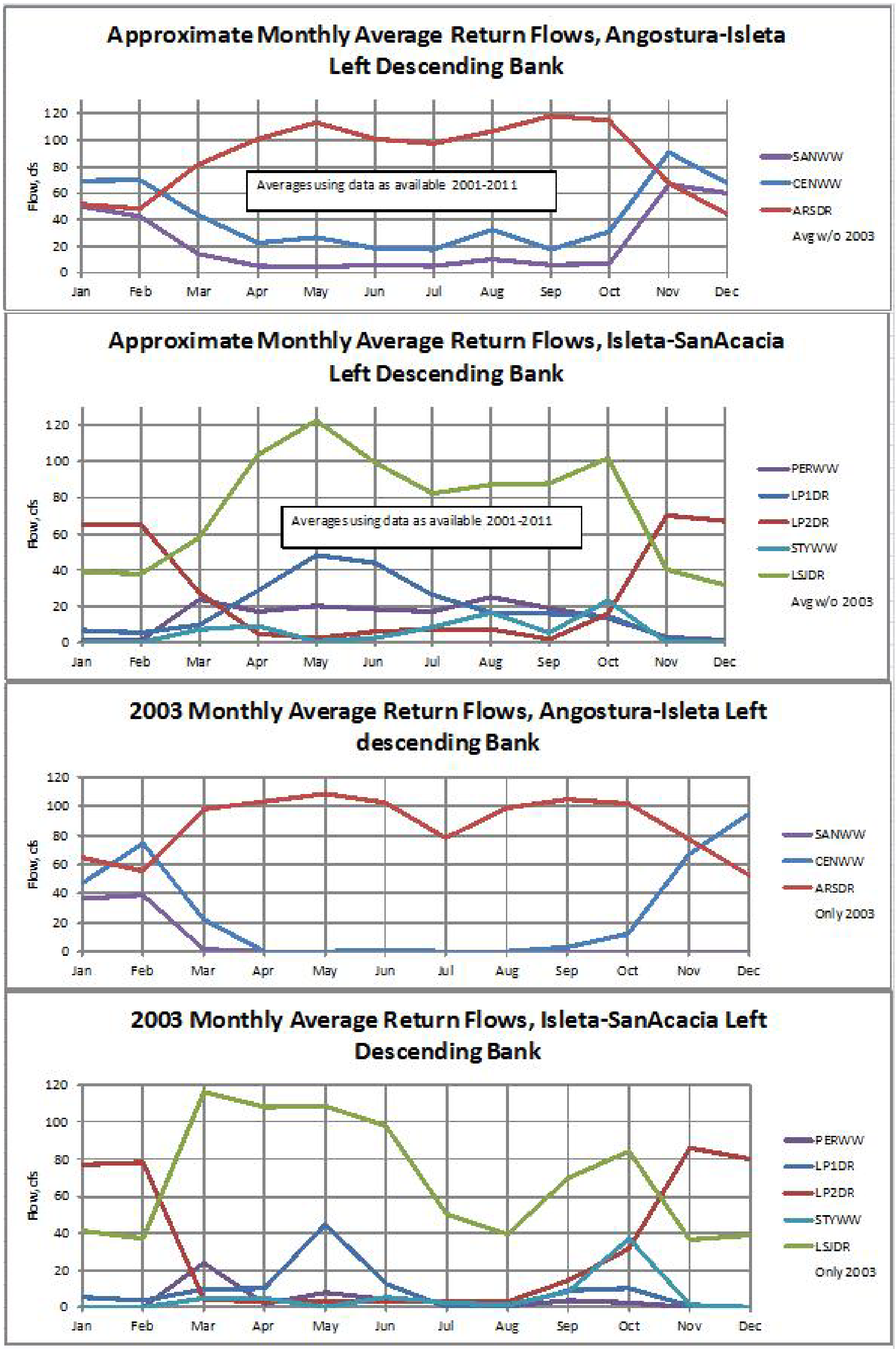


**Figure 23.—Summary of average district drain and tailwater returns to the Rio Grande, by month, 2001–2011, left descending bank.**

**Legend for Figure 22 and Figure 23**

| | | | |
|---|---|---|---|
| **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 |

In 2004, Reclamation, in concert with ABCWUA, consulted with the FWS under ESA, Section 7, on this project (Consultation #2-22-03-F-0146). The FWS 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 (US Fish & Wildlife Service 2004).

Until 2008, the City of Albuquerque’s and Bernalillo County’s potable water supplies were provided exclusively from groundwater, which was pumped from the alluvial and colluvial aquifer filling the Albuquerque basin. The impact on the river of this extensive groundwater 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 San Juan-Chama Project water, as described generally above. Furthermore, the groundwater pumping that is foreseen as a component of ABCWUA’s Drinking Water Project is covered under the consultation for the Drinking Water Project.

The now-combined municipal supplier, ABCWUA recently has initiated use of its allocation of San Juan-Chama Project water for urban uses and drinking water supply through implementation of its Drinking Water Project. Over the past four 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 groundwater and surface water for its future municipal supply, and for its San Juan-Chama 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 24 shows the total drinking water supply to the city and county, the total nonpotable supply over the past 10 years, and its distribution between groundwater 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 acre-feet per year. The figure further shows that use of the San Juan-Chama Project water as a portion of that supply began at a testing level in 2008 and increased to over 40,000 acre-feet per year by 2010. Diversion of San Juan-Chama Project water to the nonpotable water system began in 2003 and continued through the decade at up to 2,500 acre-feet per year.

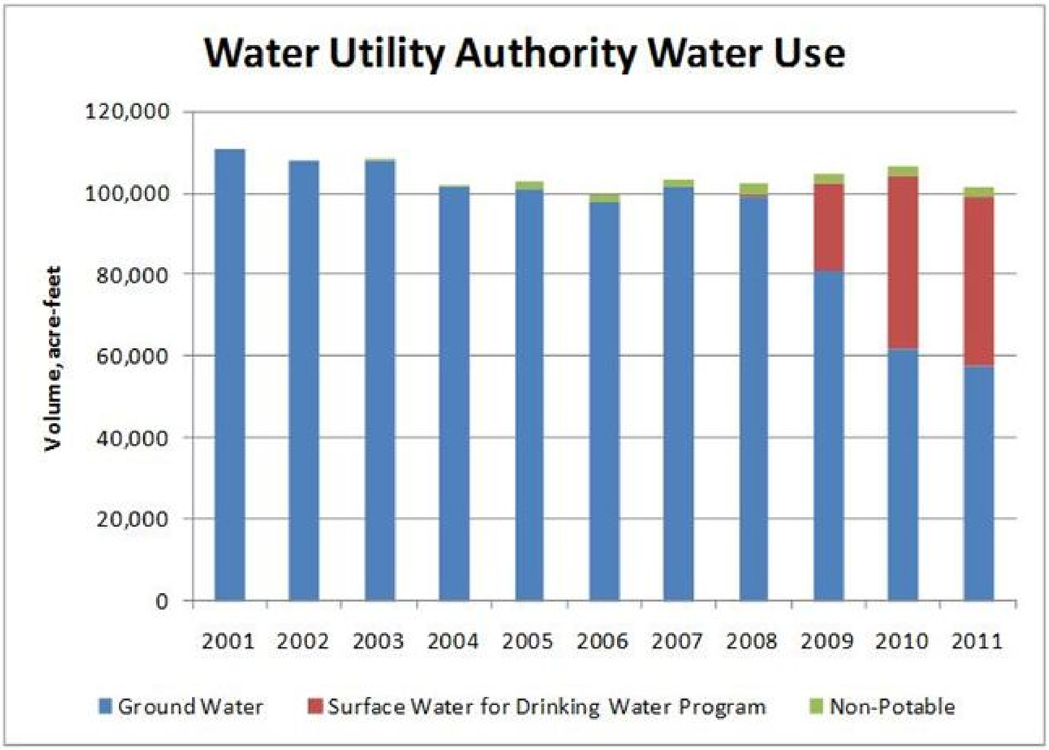


**Figure 24.—Gross municipal supply, including groundwater and surface water contributions to the drinking water supply and nonpotable supply, to ABCWUA, 2001 through 2011.**

Since the ABCWUA began diverting its San Juan-Chama Project allotment from the Rio Grande, release of this San Juan-Chama 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 San Juan-Chama 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 in Figure 25.

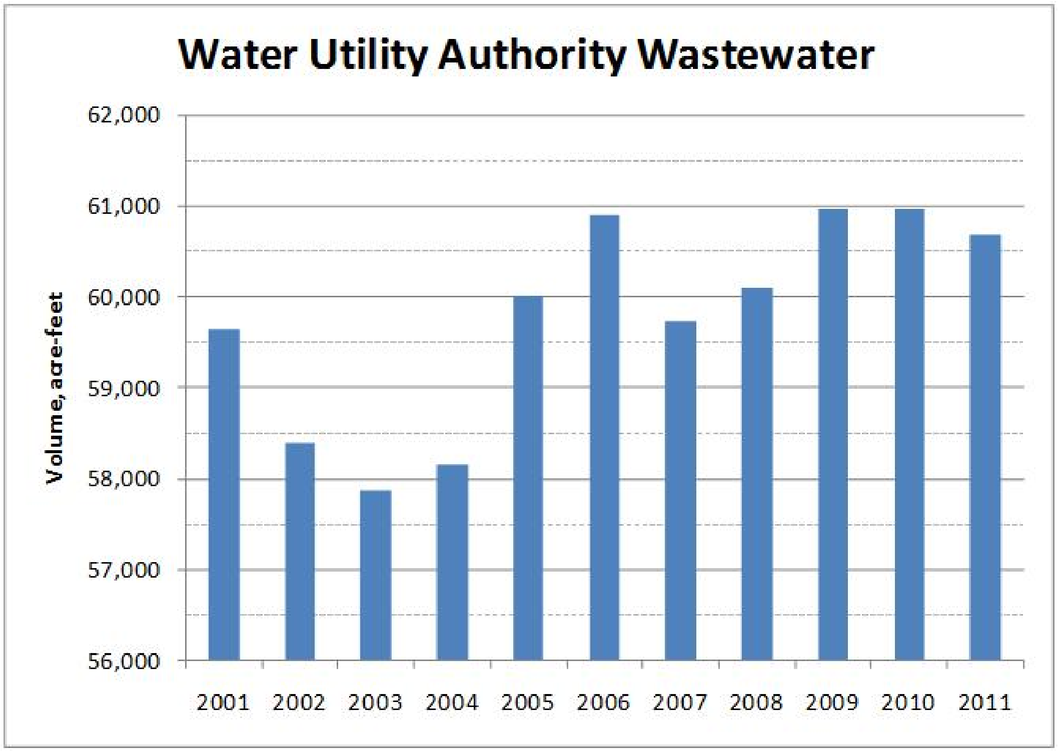


**Figure 25.—Summary of return flows from the Albuquerque Wastewater Treatment Plant, 2001 through 2011.**

ABCWUA's diversion of native water along with its San Juan-Chama 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 Biological Opinion (U. S. Fish & Wildlife Service, 2003); 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.

ABCWUA also curtails its diversions during high flows, when the turbidity gets high. As previously noted, the use of Albuquerque's supply of San Juan-Chama 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 groundwater pumping 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 San Juan-Chama Project allotment, or native water for which it has rights, to the river for MRGCD use or for delivery to Elephant Butte Reservoir under the Rio Grande Compact.

## III.K. Santa Fe's Buckman Direct Diversion

The city and county of Santa Fe use their San Juan-Chama 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 Santa Fe, consulted with the FWS (Consultation #22420-2006-F-0045) on the construction and operation of this project. FWS 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 (US Fish & Wildlife Service, 2007).

The city and county of Santa Fe have initiated, under the Buckman Project, direct use of their 5,605 acre-feet per year allocation of San Juan-Chama 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 project includes a total diversion of 17 cfs, which includes 12 cfs of San Juan-Chama Project water, and 4.25 cfs of native Rio Grande water, which is returned further downstream. An additional 5 cfs is diverted for mixing purposes and is returned to the river directly. The 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 Buckman Diversion can still divert its allocation of San Juan-Chama Project water. If Abiquiu Reservoir is under flood operations, however, the project will not call for release of its San Juan-Chama Project water, but may divert native Rio Grande water.

Consistent with the terms of the Endangered Species Act (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 San Juan-Chama Project water. When Abiquiu Reservoir is under flood operations, the Buckman Project will not call for release of its San Juan-Chama Project water from upstream reservoirs and instead use either native Rio Grande water or exchange and divert San Juan-Chama Project 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 (U.S. Forest Service and Bureau of Land Management 2007).

## III.L. Bosque del Apache National Wildlife Refuge Operations

The Service manages the Bosque del Apache National Wildlife Refuge (NWR) and is operating pursuant to a completed internal ESA consultation (US Fish & Wildlife Service, 2001). FWS possesses approximately 10,000 acre-feet per year 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 Bosque del Apache NWR’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 (Figure 26). 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 sources available for these purposes in the winter are the refuge’s diversions from the LFCC.

Figure 26 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.

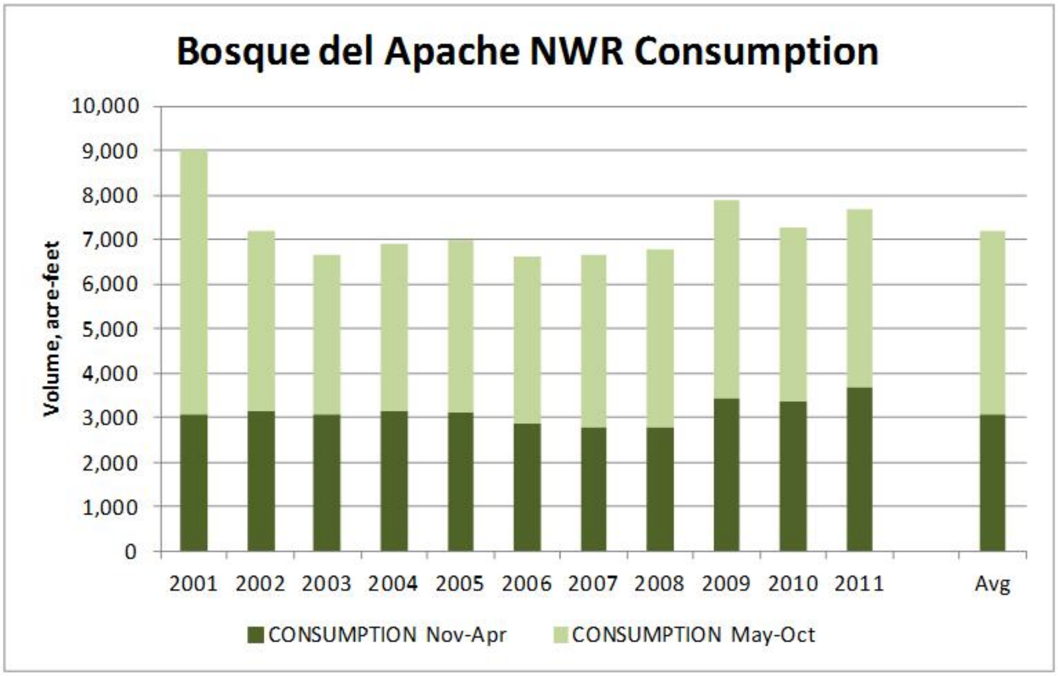


**Figure 26.—Seasonal breakdown of water consumption within the Bosque del Apache National Wildlife Refuge.**

When water supplies are short, water from the LFCC cannot fully meet the needs of both the Bosque del Apache NWR diversion and LFCC pumping under Reclamation's Supplemental Water Program, In its ESA consultation (U.S. Fish & Wildlife Service, 2001), the refuge concluded that it could contribute up to 10 percent of its water supply to support endangered species needs. In a few instances during the time period of operations under the 2003 Biological Opinion 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 Biological Opinion, 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 Biological Opinion (U.S. Fish & Wildlife Service, 2003).

# IV. Environmental / Ecological Considerations

## IV.A. NEPA

In compliance with the National Environmental Policy Act (NEPA), Reclamation's Albuquerque Area Office evaluates whether a proposed discretionary Federal action would have a significant impact on the quality of the human environment. If the proposed action clearly meets a defined exclusion category and does not individually or cumulatively have a significant effect on the human environment, a Categorical Exclusion (CEC) would be prepared. The CEC is a written checklist to document whether a proposed action meets the criteria for being categorically excluded from further NEPA documentation. If not, an Environmental Assessment (EA) is prepared. If the analysis in the EA concludes the proposed action would not have a significant impact on the quality of the human environment, then a Finding of No Significant Impact (FONSI) would be prepared. On the other hand, if the analysis in an EA concluded that the proposed action might have significant impacts on the human environment, then an Environmental Impact Statement (EIS) would be prepared. Upon completion of the NEPA compliance process, whether through a CEC, EA, or EIS, Reclamation is free to implement the proposed action.

## IV.B. Endangered Species Act

The Albuquerque Area Office operates under biological opinions on the Middle Rio Grande and Pecos Rivers in New Mexico, including a broad, overarching biological opinion on each river, and a multitude of project-specific biological opinions (Bureau of Reclamation, 2012). The broad, basin-scale biological opinion mandate specific minimum flows by reach and season and have specific requirements relative to river drying. Reclamation monitors the response of fish populations and riverine and riparian habitat to a range of hydrologic conditions, (e.g., flooding, extreme drought, and river drying) because it is critical to its ability to manage available water resources in a flexible manner that considers the needs of downstream users and the ecosystem.

Project-specific biological opinions have specific restrictions, including water quality considerations that must be met during construction. Each specific project under a biological opinion has monitoring requirements that extend for a minimum of five years after construction is completed to allow assessment of how the ecosystem has changed, improved, or suffered.

## IV.C. Clean Water Act

Reclamation complies with the Clean Water Act, Sections 404 and 401, by submitting project-specific applications. Section 404 permits are obtained from USACE. A Section 401 permit would be obtained from the designated agency overseeing the waterbody where the proposed project related work would take place, i.e., the State of New Mexico, the Environmental Protection Agency (EPA), or an approved pueblo designated with Section 401 certification. Each project must implement the permit requirements specifically applicable to the project. Also, each specific project issued a Section 404/401 permits has monitoring requirements that extend for a minimum of five years after construction is completed to allow assessment of how the ecosystem has changed, improved, or suffered.

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