Chapter 3

Affected Environment

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This chapter describes the resources of the study area that could be affected by the proposed action, its alternatives, and other proposed management actions. Study area resources are numerous and complex. Therefore, the descriptions focus on various resource *indicators*. A resource indicator is a particular measure of a resource used to assess impacts on the overall resource. The effects of the alternatives on the selected resource indicators are evaluated in chapter 4. These analyses are considered adequate to address all potentially significant effects on each resource. Potentially affected resources are water resources; water quality; agricultural soil and land resources; biological resources, including special status species; regional economy; recreation; cultural resources; Indian trust and treaty assets (ITA); and environmental justice.

Section 1 of this chapter describes the study area setting, section 2 discusses irrigation districts, and the remaining sections describe each of the potentially affected resources.

1. Study Area Setting

This section briefly describes the study area's general setting. The study area extends from Santa Rosa Reservoir in Guadalupe County through De Baca, Chaves, and Eddy Counties to the New Mexico-Texas State line at the southern end of Eddy County. Larger communities in the study area include Santa Rosa, Fort Sumner, Roswell, and Carlsbad (map 1.1).

Pecos River Facts

Headwaters: North of Pecos, New Mexico, in the Sangre de Cristo Mountains

Terminus: Discharges to the Rio Grande between Comstock and Langtry, about 38 miles northwest of Del Rio, Texas

Length: Approximately 900 miles

Total drainage area: Approximately 33,000 square miles

General flow direction: South/southeast

The Pecos River originates in the Sangre de Cristo Mountains of northern New Mexico. From its headwaters, it meanders across 500 river miles (about 330 straight-line miles) as it flows south across eastern New Mexico, until it crosses into Texas south of Carlsbad, New Mexico. It flows another 400 river miles to its confluence with the Rio Grande near Langtry, Texas. The total drainage area at its confluence with the Rio Grande is approximately 33,000 square miles, with 19,000 square miles within New Mexico. In addition to the mountains at the northern end of the Pecos River basin (outside the study area), the basin is bordered by the Capitan and Sacramento Mountains to the west, and the Guadalupe Mountains to the southwest.

At the northern end of the study area, the climate is typical of the southern High Plains, transitioning to upper Chihuahuan Desert at the southern end. The land-surface elevation varies greatly throughout the basin, and the region is considered semi-arid, with average rainfall across the basin ranging from 11-15 inches annually. Precipitation in the study area exhibits a distinct seasonality. In late fall and winter, precipitation is typically associated with frontal storms entering the study area from the west and northwest. In contrast to the generally lower-intensity precipitation associated with the frontal storms, from July through August, scattered high-intensity thunderstorms occur nearly daily across the study area, triggered by convective heating of a moisture-laden atmosphere. The moisture during this summertime "monsoon" season results from atmospheric circulation from the Gulfs of Mexico and California to the south.   Relative humidity, which affects evaporation, ranges from an average of near 65 percent around sunrise to near 30 percent in midafternoon; however, afternoon humidity in warmer months is often less than 20 percent and occasionally may go as low as 4 percent (Western Regional Climate Center, 2005). In the northern portion of the study area, average air temperatures vary from the low 50s to low 20s (degrees Fahrenheit [°F]) in the middle of winter and from the low 90s to the low 60s in the middle of summer. In the southern portions of the basin, average temperatures vary from the high 50s to high 20s in the middle of winter and from the low 100s to the high 60s in the middle of summer. In addition to humidity and temperature, winds can be moderate to extreme and can greatly affect potential evaporation and, ultimately, water resources in the Pecos River basin. Measured wind velocities in the study area have exceeded 70 miles per hour; with springtime being the most consistently windy period.

Selected USGS Stream Gages on the Mainstem of the Pecos River in New Mexico

- Near Pecos
- Near Anton Chico
- Above Santa Rosa Lake
- Below Santa Rosa Dam
- Near Puerto De Luna
- Below Sumner Dam
- Below Taiban Creek Near Fort Sumner
- Near Dunlap
- Near Acme
- Near Artesia
- Kaiser Channel Near Lakewood
- Below Brantley Dam Near Carlsbad
- Below Avalon Dam
- Below Dark Canyon At Carlsbad
- Near Malaga
- At Red Bluff

The Pecos River system in New Mexico includes three major reservoirs: Santa Rosa Reservoir, Sumner Lake, and Brantley Reservoir; a fourth smaller reservoir (Avalon) just south of Brantley Reservoir is used by the Carlsbad Irrigation District (CID) for staging and diverting Brantley Reservoir releases (map 1.1).

Selected U.S. Geological Survey (USGS) stream gages (map 2.1) on the mainstem of the Pecos River in New Mexico are listed in the sidebar.

From Santa Rosa Dam to Sumner Lake, the Pecos River flood plain mostly is incised into bedrock canyons of varying width and up to 300 feet deep. In the subreach from Santa Rosa to Puerto de Luna, agricultural fields irrigated by river diversions and riparian vegetation, both native (e.g., cottonwoods and willows) and non-native (e.g., Russian olive and tamarisk, commonly known as salt cedar), occupy the flood plain. From Sumner Dam to Brantley Reservoir is a broad valley that was a relatively treeless, dry flood plain before the 1900s (Hufstetler and Johnson, 1993). Today, the lower valley, from the Near Acme gage to Brantley Reservoir, is covered by farm fields, and the entire flood plain is clogged with invasive trees. In recent years, however, the Bureau of Reclamation (Reclamation), CID, and the State of New Mexico have made great strides in eradicating the non-native invasive species. Major tributaries include the Arroyo del Macho, Rio Hondo, Rio Felix, Rio Penasco, South Seven Rivers, Black River, and Delaware River from the west, along with Long Draw, Alamagordo Creek, and Taiban Creek from the east. These tributaries are predominantly ephemeral.

Evidence shows that the river channel currently is narrower than it was historically. Channel narrowing is attributable to several factors, including the following:

- Decrease in the frequency and magnitude of the channel-forming discharge because of flow regulation (Tetra Tech, Inc., 2000a).

- Decrease in sediment load from sediment trapping and storage in reservoirs (Tetra Tech, Inc., 2000a).

- Encroachment by non-native vegetation, such as salt cedar, which has armored the streambanks in many places. Armored streambanks contribute to channel narrowing and restrict the river's ability to migrate and meander across its flood plain (Tetra Tech, Inc., 2000a).

- Direct human manipulations of the channel and flood plain, such as bridges, levees, dikes, channelization, and meander cutoffs (Tetra Tech Inc., 2000a).

- Declining ground water level because of human activities (e.g., lower water yields from high elevation watersheds, and ground water diversion).

The water supply in the Pecos River basin is derived from three sources: snowmelt from the northern mountains, runoff from summer storms across the basin, and ground water base inflows. The snowmelt and runoff sources are highly variable from year to year. Ground water inflows along the reaches from the Below Santa Rosa Dam gage to the Near Puerto de Luna gage, from the Near

Acme gage to the Near Artesia gage, and directly into Brantley Reservoir from Major Johnson Springs generally are more consistent over time and less affected by the varying climatic conditions.

2. Irrigation Districts

Farming along the river is very important to the regional economy and is mostly concentrated in three major irrigation districts. Fort Sumner Irrigation District (FSID) is located just downstream from Sumner Dam, on the east side of the river. FSID irrigates approximately 6,000 acres out of 10,000 authorized by its diversion right, which is a direct flow right of the natural riverflows up to 100 cubic feet per second (cfs). The Pecos Valley Artesian Conservancy District (PVACD) relies on ground water and irrigates approximately 100,000 acres of land west of the river from Roswell to south of Artesia. The Hagerman Canal (owned by Hagerman Irrigation Company [HIC]) supplies water to approximately 9,000 acres in the PVACD area using a combination of surface water diverted from the Rio Hondo and ground water pumped from the Roswell basin.

Carlsbad Project Facts

Reservoirs for Storage: Santa Rosa, Sumner, Brantley, Avalon

Irrigated Acreage: 25,055 acres

Project Owner: Bureau of Reclamation

Project Operator: Carlsbad Irrigation District

Conservation Storage: Storage of water in individual reservoirs for later release for stipulated project uses, in contrast with reservoir storage capacity used for flood control. (Conservation storage capacities for each of the reservoirs used by the project are provided in table 3.1.)

Project Storage: Sum of storage in all reservoirs (Santa Rosa, Sumner, Brantley, and Avalon) cannot exceed project storage of 176,500 acre-feet.

A key water project in the study area is the Carlsbad Project. Reclamation owns the Carlsbad Project dams, which CID operates under contract. CID owns the Carlsbad Project irrigation facilities. Carlsbad Project water is stored in Santa Rosa Reservoir, Sumner Lake, Brantley Reservoir, and Avalon Reservoir to provide irrigation water to about 25,000 acres within CID, located near the city of Carlsbad. Because of fallowing, rotation, and permanent improvements, CID annually irrigates approximately 20,000 acres of the 25,055 authorized by the Carlsbad Project.

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3. Water Resources

This section describes the water resources indicators in detail. To provide additional context for these indicators, this section also describes several topics related to existing water resources in the study area: reservoir storage, evaporation, and seepage; operational priorities; water operations; streamflows; and ground water. (Appendix 3, "Hydrologic and Water Resources," provides additional information.)

3.1 Resource Indicators

The following indicators were selected to evaluate water resources:

- Flow frequency at the Near Acme gage
- Additional water needed (AWN) to meet target flows
- Carlsbad Project water supply
- Pecos River flows at the New Mexico-Texas State line
- Pecos River Compact (Compact) delivery obligation
- Base inflows in the Acme to Artesia reach of the Pecos River
- Carlsbad Project water acquisition option efficiencies

3.1.1 Flow Frequency at the Near Acme Gage

The primary goal of the proposed actions is to augment flows in critical habitat for the Pecos bluntnose shiner (shiner), while conserving the Carlsbad Project water supply. The alternatives are named for the prescribed target flows in the vicinity of the upper critical habitat for the shiner; thus, resulting flows in the habitat for the shiner are clearly an important indicator for each alternative. Flow exceedance curves provided the information needed to analyze flow augmentation. The focus was on flows at the Near Acme gage, located just downstream from the upper critical habitat. The Near Acme gage is located in a stretch of the river that undergoes complete drying, so flow frequency at this location is also a good indicator of intermittency (or flow of 0 cfs). Several other gages along the Pecos River were examined; however, the Near Acme gage proved the most useful in demonstrating the impacts of the alternatives.

The results of the analysis of flow exceedance curves also were used to determine the frequency of intermittency and to compare the number of days of intermittency under the alternatives and the pre-1991 baseline.

3.1.2 Additional Water Needed to Meet Target Flows

Bypassing available flows above FSID's diversion right through Sumner Dam often would be insufficient to meet an alternative's identified target flows. Because augmenting flows to meet specified targets in critical habitat for the shiner is the primary goal of each alternative, additional water needed to always meet these targets was computed and adopted as a resource indicator. The acquisition and management of this water would likely include, but is not limited to, a fish conservation pool (FCP) in Santa Rosa Reservoir and/or Sumner Lake.

3.1.3 Carlsbad Project Water Supply

One of the key goals of the proposed actions is to conserve the Carlsbad Project water supply. Operations of Sumner Dam (and, more recently, Santa Rosa Dam) on the Pecos River historically were set to deliver water to CID as efficiently as possible. Even for the most efficient operation, depletions occur. Water is stored and eventually conveyed to the main CID diversion at Avalon Dam. Some of that water is depleted because of evaporation at the reservoirs. Conveyance losses are also substantial because of evaporation from the water surface, along with seepage and losses to transpiration from riparian vegetation. The Pecos River RiverWare surface water model simulates the effects of all of these processes.

Depletions would differ among the alternatives, but all of the proposed alternatives would cause higher depletions than the pre-1991 baseline, primarily because of the lower efficiency of bypassing flows compared to diverting that water to storage and releasing it later in more efficient block releases.

3.1.4 Pecos River Flows at the New Mexico-Texas State Line

Under the Pecos River Compact, the State of New Mexico is obligated to deliver flows to the New Mexico-Texas State line, measured at the Red Bluff gage (i.e., its "delivery obligation.") While New Mexico may obtain a credit for overdelivery, it is not allowed to incur a debt; therefore, the impact of the proposed actions on flows at the State line is another key water resources indicator. Changes in surface water delivery to CID affect return flows to the Carlsbad ground water basin and also may cause changes in the supplemental (irrigation) well pumping schedules in CID. Both of these hydrologic components affect base inflows to the Pecos River downstream from Avalon Dam. These changes in the Carlsbad basin, plus changes in spills at Avalon Dam, may substantially impact the State of New Mexico's ability to meet its delivery obligation under the Compact. Similar to the calculation of net depletions to the Carlsbad Project water supply, net depletions to State-line flows were computed as the difference between modeled State-line flows under each alternative and modeled flows under the pre-1991 baseline. Another aspect of the Compact that may be affected by actions contemplated in this environmental impact statement (EIS) is New Mexico's delivery obligation, which depends, in part, on releases from Sumner Dam.

3.1.5 Pecos River Compact Delivery Obligation

The 1988 *Texas* v. *New Mexico* U.S. Supreme Court Amended Decree (Amended Decree) provides a methodology for computing New Mexico's delivery obligation. The delivery obligation is computed from an inflow-outflow relationship that is based on Sumner Dam releases, plus three sets of derived flood inflows between Sumner Dam and the State line. These inflows are applied to an empirically-derived relationship in order to compute New Mexico's delivery obligation. To reduce the impact of short-term variability in riverflows, the inflow-outflow relationship and resulting delivery obligation is based on a 3-year running average of inflows and deliveries as established by the approved methodology. While the resource indicator "Pecos River Flows at the New Mexico-Texas State Line" addresses potential effects of the proposed actions on actual delivery of water to the State line, determination of the obligation itself may be affected by changing operations at Sumner Dam. Changes in total volume of water released from Sumner Dam, as a result of flow target operations via bypasses or fish conservation pool operations, plus any additional water acquisitions (AWA) upstream of Lake Sumner may affect the long-term average releases from Sumner Dam and, subsequently, the delivery obligation.

3.1.6 Base Inflows in the Acme to Artesia Reach of the Pecos River

The Carlsbad Project water supply includes a substantial contribution from base inflows from the Roswell ground water basin along the reach from the Near Acme gage to the Near Artesia gage. Historically, the contribution of base inflows to the Carlsbad Project water supply has been about 20,000 to 35,000 acre-feet per year. Any actions that would affect these base inflows would directly affect the Carlsbad Project water supply. The alternatives do not include prescribed changes in ground water pumping operations in the Roswell basin; however, two Carlsbad Project water acquisition (CPWA) options (following paragraph) do involve ground water retirement and/or ground water pumping in the Roswell basin. These options would impact base inflows to the river from the Roswell basin; thus, base inflows along the reach from the Near Acme gage to the Near Artesia gage were included as a water resource indicator.

3.1.7 Carlsbad Project Water Acquisition

Net depletions to the Carlsbad Project water supply were initially determined for each alternative with bypass flows only and no water acquisition options. As previously described, to mitigate for net depletions to the chronically short Carlsbad Project water supply, Reclamation would acquire water from one or more potential sources; these potential sources are referred to as Carlsbad Project water acquisition or CPWA options. Recognizing that some options may more effectively mitigate depletions than others, a CPWA option efficiency resource indicator was defined. The efficiency is the percent of the water acquired at the source that effectively offsets net depletions to the Carlsbad Project water supply; this efficiency was computed from model results. These efficiencies also were used to determine the *amount* of water that would need to be acquired from the available sources to mitigate net depletions to the Carlsbad Project water supply.

3.2 Impact Area

The actions evaluated in this EIS would affect both the hydrological systems in the Pecos River basin (specifically the Pecos River from Sumner Lake to the New Mexico-Texas State line and the two major ground water basins, Roswell and Carlsbad) and associated water users.

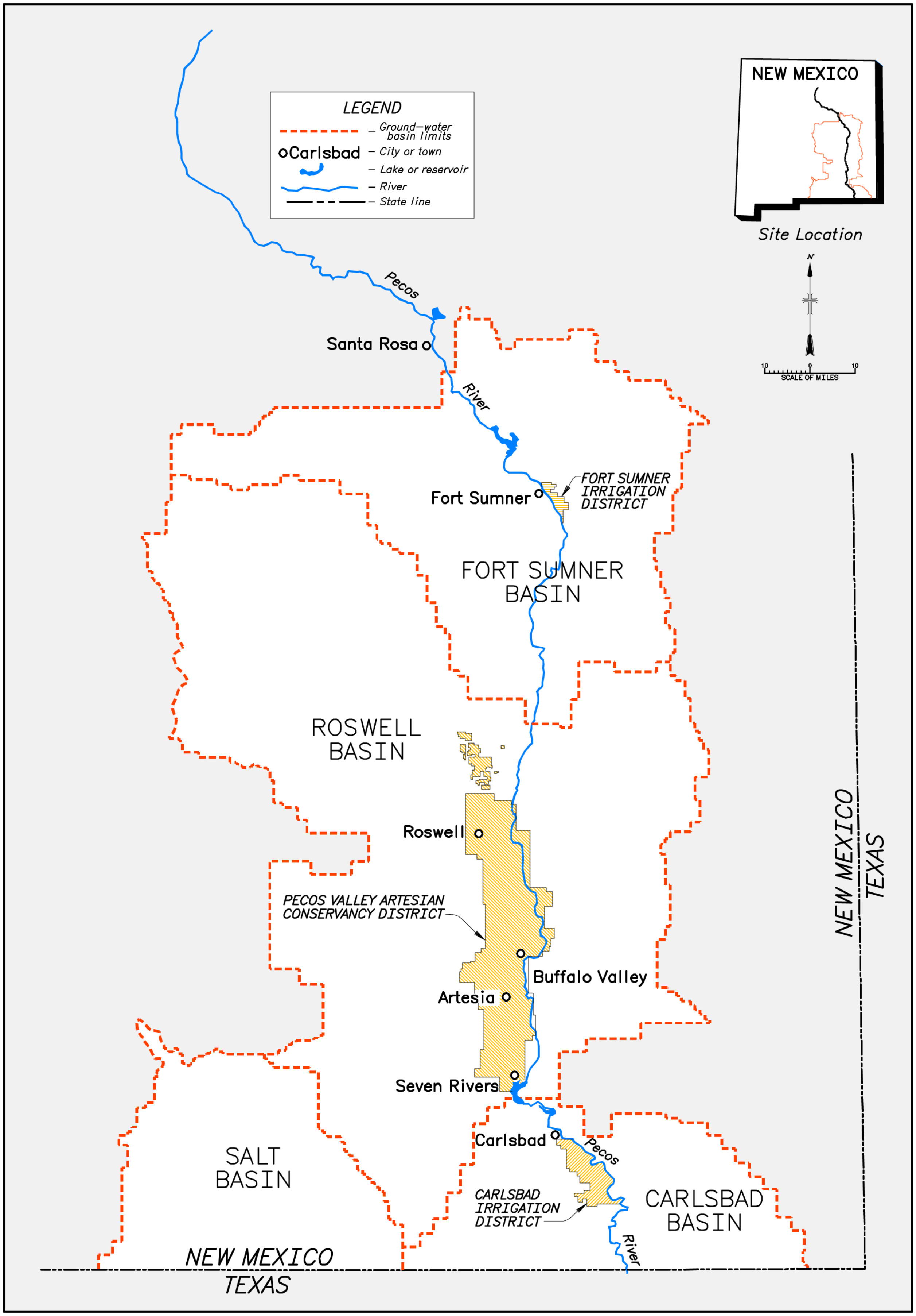
As discussed in Section 1, “Study Area Setting,” the water supply in the Pecos River basin is derived from three sources: snowmelt from the northern mountains, runoff from summer rainstorms (monsoon season) across the basin, and base inflows from connected ground water basins. Surface water flows in the Pecos River also are strongly affected by reservoir operations, as well as ground water pumping in the Roswell basin. (See Section 3.9, “Ground Water,” for a discussion of ground water basins in the study area; map 3.1 shows ground water basins in the study area.)

The runoff from snowmelt and monsoon season rainfall is highly variable from year to year. Land-surface elevations in the headwaters are almost 13,000 feet in the headwater streams of the study area, and these watersheds can receive heavy snowfall. An average snowfall of 156 inches has been reported for Harvey’s Upper Ranch in the Sangre de Cristo Mountains, at an elevation of 9400 feet. Average annual runoff to Santa Rosa Reservoir, from snowmelt, rainfall, and base inflows in the headwaters, on the basis of the Above Santa Rosa and Below Santa Rosa gages for the period 1929-2002, is 87,000 acre-feet, with a maximum of 547,000 acre-feet in 1940 and a minimum of less than 16,000 acre-feet in 2002 (USGS, 2002).

Runoff from precipitation downstream from Santa Rosa Reservoir also is highly variable. On the basis of historical streamflow data collected since 1940, the average annual volume of ungaged storm inflows to the river between Santa Rosa Reservoir and Avalon Dam has been estimated to be 77,000 acre-feet, with a gaged maximum and minimum of 798,000 and 14,800 acre-feet, respectively (USGS, 1999; Tetra Tech, Inc., 2000a; Tetra Tech, Inc., 2001).

In addition to runoff from snowmelt and rainfall, ground water inflows also affect flows in the river. While ground water inflows vary in response to climatic conditions and ground water pumping, they tend to exhibit much less variability than the surface-water inflows. Ground water inflows add a net of approximately 80,000 acre-feet to the river annually in the Fort Sumner and Roswell basins in the reach between Santa Rosa Reservoir and Brantley Dam. Ground water inflows also occur south of Brantley Dam in the Carlsbad basin. Ground water inflow trends are discussed in greater detail in Section 3.9.1, “Ground Water Accretions to the River.”

The primary users of surface water in the study area are FSID, CID, and HIC, but diversions also occur at the Puerto de Luna and Anton Chico acequias. River pumpers between the Near Acme and Near Artesia gages also divert directly from



Map 3.1 Ground water basins in the study area

the Pecos River to support agricultural lands. Diversions by CID and FSID, along with the subsequent return flows, directly affect flows in the Pecos River.

Thus, flows in the lower Pecos River (downstream from Santa Rosa Reservoir) are primarily a function of monsoon season rainfall and seasonal ground water inflow, as well as reservoir operations set by CID, FSID, U.S. Army Corps of Engineers (Corps), and New Mexico Office of the State Engineer (NMOSE). The primary factors governing scheduling of deliveries for the Carlsbad Project are the need to meet irrigation demands and the need to deliver water efficiently. (Delivery efficiency is discussed in Section 3.6, "Operational Priorities," and Section 3.7, "Water Operations.")

3.3 Reservoir Storage

The total annual allowable entitlement storage for the Carlsbad Project, as defined by the Pecos River Compact, in Santa Rosa Reservoir, Sumner Lake, Brantley Reservoir, and Avalon Reservoir combined is 176,500 acre-feet. The maximum allowable entitlement or "conservation storage" limit is the amount of water that the Carlsbad Project can store for irrigation. Each reservoir also is constrained by its own conservation storage limit. The portion of conservation storage allocated for the Carlsbad Project in Santa Rosa Reservoir, for example, is approximately 100,000 acre-feet, although the entire storage is approximately 500,000 acre-feet. Only that amount allocated for the Carlsbad Project is termed conservation storage or "project storage." The conservation storage limit in Santa Rosa Reservoir and Sumner Lake changes each year, on the basis of estimated sediment deposition since the last survey. The conservation pool elevation in Avalon Reservoir cannot exceed 3177.4 feet (elevation measurement based on the National Geodetic Vertical Datum of 1929 [NGVD 29]), which corresponds to 4,466 acre-feet of storage, on the basis of the 1996 survey. The conservation pool elevation in Sumner Lake cannot exceed 4261 feet (NGVD 29) from May 1 to September 30, which corresponds to 42,898 acre-feet of storage, on the basis of the 2001 survey. From October 1 to April 30, the Carlsbad Project is entitled to store an additional 20,000 acre-feet above the allowable conservation storage space in any reservoir, providing total reservoir storage in all the reservoirs does not exceed 176,500 acre-feet, but this water must be evacuated by April 30 every year. Brantley Reservoir has a constant conservation storage limit of 40,000 acre-feet in addition to the 2,000-acre-foot minimum pool and sediment deposition; thus, the elevation of the conservation pool increases as sediment accumulates. The conservation pool in Santa Rosa Reservoir is equal to 176,500 acre-feet (the total allowable entitlement storage) less the sum of the individual conservation storage limits determined each year for Sumner Lake, Brantley Reservoir, and Avalon Reservoir. The conservation storage limit and corresponding elevation in Santa Rosa Reservoir change every year, on the basis of sediment accumulation in Sumner Lake and Avalon Reservoir. On the basis of the most recent surveys of Sumner Lake (2001) and Avalon Reservoir (1996), the conservation storage limit at Santa Rosa Reservoir is 92,236 acre-feet.

Table 3.1 presents data about Pecos River reservoirs, including purpose, ownership, completion date, allowable conservation storage space, and total storage capacity. Sumner Lake and Brantley Reservoir were last surveyed in 2001. Avalon and Santa Rosa Reservoirs were last surveyed in 1996. Of the three major reservoirs on the river, Brantley Reservoir exhibits the highest bank-storage capacity because of its direct connection to the Major Johnson Springs aquifer.

Table 3.1 Pecos River reservoirs

Reservoir	Purpose(s)	Ownership	Year completed	Allowable conservation storage space[1] (acre-feet)	Total storage capacity[2] (acre-feet)	Minimum pool (acre-feet)
Santa Rosa	Flood control and irrigation	Corps	1980	92,236	438,364	0
Sumner	Irrigation and flood control	Reclamation	1937	40,398	93,828	2,500
Brantley	Irrigation and flood control	Reclamation	1988	40,000	414,466	2,000
Avalon	Irrigation	Reclamation	1907	3,866	4,466	600

[1] Excludes minimum pool.
[2] Top of flood pool; accounts for sedimentation using latest surveys; does not include flood surcharge space.

3.4 Reservoir Evaporation

Evaporation from the reservoirs in the study area is quite high because of the semi-arid climate. Evaporation not only affects the water supply in the basin it also directly affects how water is stored for later use. CID generally keeps water in Santa Rosa Reservoir and Sumner Lake as much as possible. Average annual reported evaporation losses from Brantley Reservoir and Sumner Lake are 89 inches and 84 inches per unit area, respectively (Corps, 1979, 1991a, 1991b, and 1995). The Corps' Los Esteros (Santa Rosa) Water Control Manual pre-project estimates of evaporation at Santa Rosa Reservoir were very similar to those for Sumner Lake (Corps, 1979). However, actual reservoir evaporation values at Santa Rosa Reservoir for the period 1991-97 were closer to 68 inches per year (Corps, 1999; Tetra Tech Inc., 2003a), which indicates a lower specific (per unit area) evaporation rate than Sumner Lake, because of the combination of higher elevation, slightly lower mean annual temperature, and the generally greater depth of Santa Rosa Reservoir. (This issue is discussed in the following paragraph.)

Another important concept regarding reservoir evaporation is the amount of surface area compared to the amount of stored water. Reservoirs that are shallow and more spread out, such as Sumner Lake, tend to have greater evaporation loss per volume stored than reservoirs that are deeper and less spread out, such as Santa Rosa Reservoir. Similarly, Brantley Reservoir's efficient capacity-surface area relationship is largely attributable to the large amount of bank storage included in its capacity. While the specific (per unit area) evaporation rates are similar at Sumner Lake and Santa Rosa Reservoir because of their proximity, Santa Rosa Reservoir is deeper and generally experiences less evaporation because less surface area is exposed to the atmosphere because of its topography. Conversely, Sumner Lake, with a per unit area potential evaporation of 84 inches and a surface area of approximately 2,800 acres at its conservation storage limit of 42,898 acre-feet (a ratio of nearly 15 acre-feet stored to 1 acre of exposed water surface) actually is more adversely affected by evaporation than Santa Rosa or Brantley Reservoirs (because of the bank storage effect at Brantley Reservoir). Considering the additional water in the banks at the conservation limit of 42,000 acre-feet, total storage at Brantley Reservoir is estimated to be closer to 63,000 acre-feet at the conservation limit including bank storage. With an area of 3,400 acres at the conservation limit, Brantley Reservoir has a higher capacity-to-area ratio at the conservation limit of nearly 19 acre-feet stored for every acre of exposed water surface.

3.5 Reservoir Seepage

Seepage losses are evident at Avalon Reservoir. These losses can be large and are directly related to the reservoir pool elevation. The annual loss for typical Avalon reservoir pool elevations is about 10,000 acre-feet (Tetra Tech, Inc., 2000a, 2000b, 2003b; Natural Resources Planning Board, 1942; Engineering Advisory Committee of the Pecos River Compact Commission, 1949; Anderson et al., 1960; Pecos River Master’s Manual, 2003). Brantley Reservoir also loses water to seepage but, in addition, picks up inflows from Major Johnson Springs. The net rate of gain over time from the combination of inflows from Major Johnson Springs and seepage losses in Brantley Reservoir is about 3 cfs (approximately 2,172 acre-feet per year). The connection with the Major Johnson aquifer also results in a bank storage effect at Brantley Reservoir. As the pool elevation changes, water moves in or out of bank storage, and the rate of inflow from Major Johnson Springs varies (Tetra Tech, Inc., 2000a, 2002, 2003b; Hydrosphere Resource Consultants [HRC], 2003a). Seepage losses from Santa Rosa Reservoir and Sumner Lake are negligible (Tetra Tech, 2000a).

3.6 Operational Priorities

The Carlsbad Project is one of the most senior storage water right holders on the Pecos River. Typically, CID stores most of the water in Santa Rosa Reservoir and Sumner Lake to maintain available capacity in Brantley Reservoir to capture runoff from monsoon season rainfall in the lower portions of the basin. When CID needs water for irrigation, water is moved to Brantley Reservoir. For efficiency, water is moved as block releases, which are large-volume releases made over a number of days to transmit water downstream for irrigators. Large-volume block releases to Brantley Reservoir have greater delivery efficiency (also referred to as transmission efficiency) than lower flow releases. On the basis of historic data, the average magnitude of block releases is about 1,060 cfs, and the historic average volume per release is 33,500 acre-feet. The average duration of these releases is 16 days but may vary considerably depending on other factors affecting the storage in Brantley Reservoir. The travel time for block releases from Sumner Dam to Brantley Reservoir is about 5 days. The main CID diversion, at Avalon Dam, is located approximately 10 river miles downstream from Brantley Dam.

FSID holds one of the most senior direct diversion rights on the Pecos River. Although CID's priority date is prior to FSID's priority date—1896 versus 1903, respectively—the Hope Decree, which was settled in 1933, declares that FSID's diversion right is superior to CID's diversion right, but in priority claims with irrigation districts or diverters other than CID, FSID's original priority date takes precedence (U.S. District Court for the District of New Mexico, 1925). FSID is essentially entitled to divert the natural inflows to Santa Rosa Reservoir plus the inflows between Santa Rosa Dam and Sumner Lake up to a maximum of 100 cfs. In addition to its right to divert during the irrigation season, FSID also has the right to divert for two 8-day periods during the nonirrigation season.

Another issue related to the Pecos River surface water resources is flows at the New Mexico-Texas State line, an important resource indicator. On the basis of the Compact and the Amended Decree, the State of New Mexico is obligated to deliver a portion of the surface water resources to the State line, on the basis of the calculations as described in the Pecos River Master's Manual (Pecos River Master's Manual, 2003). The primary sources of water at the State line are spills from Carlsbad Project storage, CID return flows, Carlsbad basin inflows, and side inflows entering the Pecos River downstream from Avalon Dam. As stated in the Amended Decree, New Mexico cannot accrue a debit of water to Texas and may be required to implement a priority call (a shutoff of junior water users) to mitigate any such debit that might occur as soon as it happens. However, because the junior water users are primarily ground water pumpers in the Roswell basin, a curtailment of these rights will not lead to immediate increases Pecos River flows; thus, surface water users, including CID, likely would be cut off.

3.7 Water Operations

The highest priority factor affecting water operations of the Pecos River system is flood control. However, because conditions rarely require flood operations, reservoir releases generally are not affected by flood operations. If a reservoir's designated conservation pool elevation is exceeded, flood operations are initiated. Flood operations are set up to release water as quickly as possible without exceeding channel flow limits, which are delineated in the Water Control Manuals for each dam (Corps, 1979, 1991, 1991a, 1991b, 1995). The designated river channel flow restrictions are 13,000 cfs at the Near Puerto de Luna gage, 8,500 cfs at the Near Artesia gage, and 20,000 cfs at the Below Dark Canyon gage.

When conservation storage limits are exceeded, inflows are essentially bypassed to keep the pool elevation at that limit, while ensuring that downstream flow restrictions are not exceeded. This situation is often referred to as a conservation spill.

Most of the time, agricultural demand drives water operations. The irrigation season for areas along the Pecos River typically extends from March 1 through October 31. At the beginning of each irrigation season, CID sets an allotment for irrigators in the district on the basis of the water in storage, which is updated monthly, with consideration for delivery efficiencies to the farm gates.

In the spring, CID determines if enough water is available in Brantley Reservoir for irrigators and if the water quality is acceptable. If additional water is needed or if water quality is poor and water is available upstream in Santa Rosa Reservoir and Sumner Lake, a block release is initiated from Sumner Dam to add upstream water to Brantley Reservoir. Runoff from monsoon season rainfall events can greatly affect flows downstream from Sumner Dam and the need for a block release. CID makes block releases during the irrigation season, as needed, but it attempts to end the irrigation season with the contents in Brantley Reservoir relatively low to provide storage for side inflows that may occur over the winter. Brantley Reservoir picks up inflows during the winter that are primarily from ground water inflows along the reach of the Pecos River from the Near Acme gage to the Near Artesia gage and from delayed FSID return flows.

During periods in the irrigation season when block releases are not made and no releases are made from Santa Rosa Dam, then bypasses from Sumner Dam are set to the FSID diversion right. Releases from Brantley Dam are set to the CID diversion demand at Avalon Dam. Little storage capacity exists behind Avalon Dam, and it primarily serves as a diversion structure. In addition to irrigation releases, a minimum release of 20 cfs is maintained at Brantley Dam to mitigate for the inundation of Major Johnson Springs by Brantley Reservoir. Typically, downstream releases are made from Avalon Dam only if conservation storage limits are exceeded, although since the 1990s, releases from Avalon Dam have also occurred to convey New Mexico Interstate Stream Commission's (NMISC) leased water to the State line for Compact compliance. Historically, during the nonirrigation season, only the 20 cfs has been released from Brantley Dam and all other reservoir outflows have been shut off. Current operations include bypasses of water during the nonirrigation season to benefit the shiner.

Since the listing of the shiner as a federally threatened fish species in 1987 and the beginning of Brantley Reservoir operations in 1989, water operations on the Pecos River can be separated into four distinct periods. From 1989 to 1991, operations continued much as they had before the species was listed. From 1991 to November 1997, test operations were conducted to facilitate data collection for development of the water operations RiverWare model and studies regarding the needs of the shiner. From November 1997 to May 2003, Reclamation's changed operations at Sumner Dam included bypasses of inflows above FSID's diversion right through Sumner Dam to augment flows for the shiner, with target flows of 35 cfs at the Near Acme gage. CPWA options also were introduced at this time to acquire additional water supplies to improve the Carlsbad Project's chronically short water supply. Block release operations were also modified during this time period to protect the shiner, with an effort made to generally limit the duration of the operations to no more than 15 days. The U.S. Fish and Wildlife Service (Service) issued the Final Biological Opinion for the Bureau of Reclamation's Proposed Pecos River Dam Operations, March 1, 2003, through February 28, 2006, dated June 18, 2003 (BO) (Service, 2003). The 2003-2006 BO essentially recommends target flows, on the basis of irrigation season and hydrologic condition, as reasonable and prudent alternatives (RPAs). The No Action Alternative is based on the operational rules prescribed in the BO.

> **Reading Flow Exceedance Curves**
>
> Flow exceedance curves depict the percent of time that flows are exceeded at a particular location. Curves can be developed using flows before and after a specific action or change in operations to determine how that change may affect the occurrence of different flows.
>
> The curves can be interpreted in two different ways: (1) percentage of time that flows have exceeded a given flow in the river or (2) a flow in the river that has been exceeded a given percentage of time over the historical flow record. To determine percentage of time a flow has been exceeded for a given riverflow, look up the riverflow on the y-axis and trace a horizontal line to the flow exceedance curve. From that intersection, trace a vertical line to the x-axis. This is the percentage of time over the period of record (60 years for this study) that all riverflows equal or exceed the lookup riverflow. If the goal is to determine the amount of flow in the river corresponding to a certain percentage, look up the given percentage on the x-axis and trace a vertical line to the flow exceedance curve. From that intersection, trace a horizontal line to the flow on the y-axis. This is the flow that is exceeded by the lookup percentage of time.

As previously discussed, block releases are made to transmit water to Brantley Reservoir more efficiently, with the efficiency defined as the volume of water that reaches Brantley Reservoir divided by the total volume of water released from Sumner Lake. Historically, CID has used a 25-percent reduction in volume to account for transit losses between Sumner Lake and Brantley Reservoir in a block release. Analysis of flow data shows a similar result, with an average efficiency of 70 percent in the reach from Sumner Dam to the Kaiser Channel for typical block releases not affected by tributary flood inflows. Bypasses to meet target flows in critical habitat for the shiner are less efficient than block releases because of the smaller overall volume of bypasses. Although the efficiency of a bypass from Sumner Dam to the Kaiser Channel is heavily dependent on its duration and magnitude, bypasses result in additional depletions to the Carlsbad Project water supply because the water is moved less efficiently.

3.8 Streamflows

As discussed previously, runoff from monsoon season rainfall is an important component of streamflow in the entire study area. The magnitude of these storm inflows varies greatly. Inflows from individual storms may be a few hundred to thousands of cubic feet per second. The average annual volume of inflows between Santa Rosa Dam and Avalon Reservoir, which are predominantly from runoff from these storms, has been estimated to be 77,000 acre-feet per year.

In addition to rainfall runoff, the two primary sources for inflows upstream of Sumner Dam are snowmelt runoff and ground water inflows along the reach of the river from the Near Acme gage to the Near Artesia gage. Snowmelt runoff from the northern mountains is captured in Santa Rosa Reservoir, and ground water inflows are captured in Sumner Lake. Flows in the Pecos River downstream from Sumner Dam are predominantly a function of reservoir operations, FSID bypasses for irrigation and subsequent return flows, and bypasses for the shiner. During the summer, if no specific measures are taken to augment flows in critical habitats for the shiner, resulting flows at the Near Acme gage may be intermittent if return flows from FSID are completely lost to seepage and evapotranspiration. The other primary factor affecting flows downstream from Sumner Dam is ground water inflows along the reach from the Near Acme gage to the Near Artesia gage. These inflows are a function of climatic factors and pumping in the Roswell basin, and they typically range from 40 to 80 cfs, on the basis of recent pumping rates (HRC, 2004).

Flows downstream from Brantley Dam are primarily a function of Brantley Dam block releases of water for CID. Flows downstream from Avalon Dam are primarily a function of CID irrigation return flows, ground water inflows from Carlsbad Springs, storm inflows, seepage, and spills. Figure 3.1 shows flow duration, or the percentage of time, flow was historically at or above a certain rate, as measured at the Near Puerto de Luna, Near Acme, Near Artesia, and Red Bluff gages.

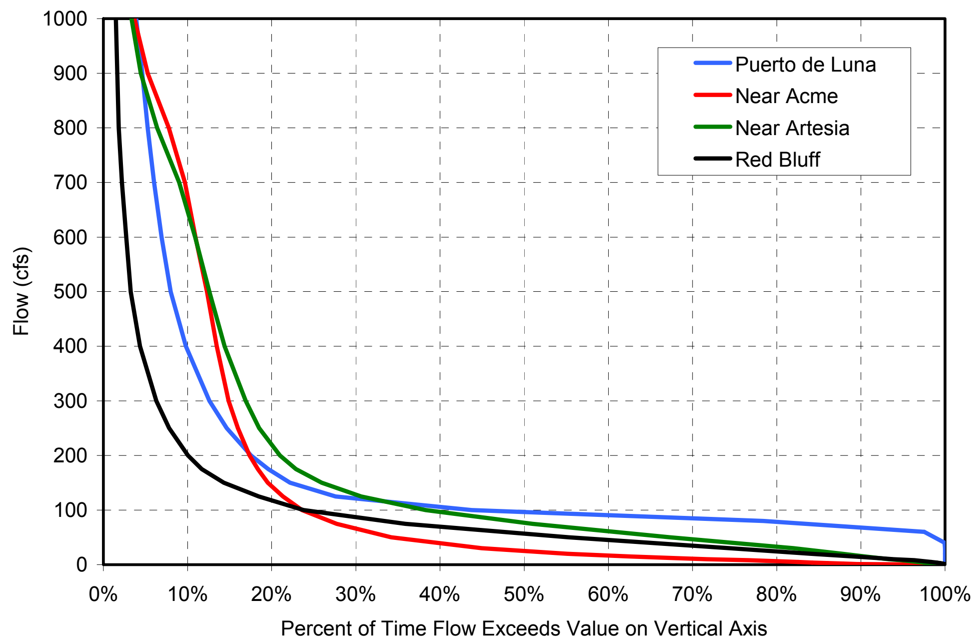


Figure 3.1 Flow duration at Near Puerto de Luna, Near Acme, Near Artesia, and Red Bluff gages (1938-2002).

Flow at the Near Acme gage is an important resource indicator for the shiner because it is the first gage downstream from its upper critical habitat. The gage continuously measures flow, and USGS posts both 15-minute and daily averages of this value. The Near Acme gage has gone dry, or "intermittent," 11 percent of the time since 1938.

3.8.1 Floods: Magnitude and Frequency

Flood magnitudes and frequencies in the study area have changed in the past century because of flow regulation. The construction of both Sumner Dam (completed in 1937) and Santa Rosa Dam (completed in 1980) reduced the peak flow events in the study area. Records do not extend back far enough in time to evaluate the effects of Sumner Dam at the Near Acme gage, but the post-Santa Rosa Dam flood magnitude at the Near Acme gage decreased considerably. The effects of Sumner Dam on flood frequency at the Near Artesia gage are evident. With Sumner Dam in place, the 100-year and 2-year storm discharges at the Near Artesia gage are computed to be 28,300 and 2,860 cfs, respectively, while the corresponding floods without Sumner Dam in place are 73,700 and 10,200 cfs, respectively. The destruction to Avalon Dam in 1893 and 1904 provides evidence of floods on the order of 73,700 cfs at the Near Artesia gage before upstream regulation. Flood frequency at the Red Bluff gage also decreased greatly following the construction of Santa Rosa Dam. Again, the gage at Red Bluff was not established early enough to consider the effects of Sumner Dam.

3.8.2 Surface Water Diversions from the Pecos River

FSID and CID rely on surface water, while HIC relies on both surface and ground water. Many farmers in CID have supplemental irrigation wells that they use when surface water supplies fall short of crop irrigation demands. FSID and CID have average annual diversions of 37,500 and 77,100 acre-feet, respectively. The potential irrigated areas for FSID and CID are 10,000 and 25,055 acres, respectively. HIC currently irrigates approximately 8,300 acres with a combination of surface water from the Rio Hondo and tributary springs to the Pecos River and ground water, which is pumped into the HIC canal. The HIC water supply for the accounting years 1997-2001 was approximately 32,000 acre-feet per year, of which about 22 percent came from surface water and 78 percent came from ground water. Major crops grown by all of the irrigation districts are alfalfa, cotton, and sorghum.

The FSID Diversion Dam is located approximately 14 river miles downstream from Sumner Dam. FSID diversions typically range from 80 to 100 cfs. The FSID diversion rate is based on a 2-week formula developed and implemented by NMOSE (NMOSE, 1980). The computed diversion rate applies to the upcoming 2 weeks and is a function of the natural inflows into Santa Rosa Reservoir and Sumner Lake over the previous 2 weeks. The calculation does not adjust for evaporation while the water is detained for 2 weeks in the reservoirs. In other words, the diversions for the coming 2 weeks are set to the average of the natural inflows for the previous 2 weeks or 100 cfs, whichever is less.

Irrigation return flows from FSID are conveyed back to the river by two main drainage canals and seepage through the alluvial ground water system. These drainage canal returns give FSID a means to control the flow in the system if there is a rainfall event or if irrigation demand decreases. These return flow paths are often used at night when irrigation demand is lower. Return flows are primarily a function of the diversion rate, but they also are influenced by temperature, rainfall, antecedent moisture conditions, humidity, ground water levels, and other factors that affect evapotranspiration, infiltration, and soil moisture.

FSID irrigation return flow is occasionally reused within the system via a pump-back operation that diverts around 10 cfs back to the fields from a drainage canal.

CID's diversion schedule exhibits some trends from year to year. Diversions are typically continuous throughout the irrigation season, but peak diversion times correlate with typical crop demands considering the climate and the growing season in the Carlsbad area. The first diversions typically begin in mid-March for the first irrigation of alfalfa and for preplanting cotton. The bulk of the next diversions usually occur in mid-May for the second irrigation of alfalfa. In June, diversions peak again for the first irrigation of cotton and third irrigation of alfalfa. During July and August, diversions are at peak levels for the irrigation of all crops. During early September, watering of new alfalfa and winter cover crops begins. The diversion gradually decreases through October and stops when the irrigation season ends on October 31.

Water is diverted to CID via the main canal on the southeast side of Avalon Dam. Currently, most of CID's water delivery system is lined with concrete and is gaged in numerous locations. CID diversion rates vary, depending on allotments, and range from 100 to 375 cfs. The Carlsbad Project water supply in any given year is estimated by the sum of storage in all of the reservoirs. Because transmission losses are incurred as water is delivered from upstream reservoirs, the total storage is measured using reduction factors for the water stored in upstream reservoirs. CID typically sets the initial annual irrigation allotment in March on the basis of the amount of water in storage, with a current maximum allotment of 3.7 acre-feet per acre (from 1994-2004, 3.5 acre-feet per acre was considered a maximum allotment; before 1994, 3.0 acre-feet per acre was considered a maximum allotment; Davis, 2005). The allotment is incrementally adjusted at the monthly board meetings as water supply in storage changes. Historical annual allotments set by CID are presented in table 3.2 (Davis, 1998, 1999, 2003). The allotments were lower during the 1960s and 1970s because of several years with below-average water supply. No allotment data are available for 1959 and 1961: in 1959, the reservoirs were spilling on February 10; in 1961, canal work was being completed. CID is limited to a total diversion of 125,200 acre-feet and a storage allotment of 176,500 acre-feet in the reservoir system. The historical average annual diversion over the period from 1940 to 2002 was 77,100 acre-feet.

Table 3.2 Historical total annual CID allotments, on the basis of CID allowable acreage of 25,055 acres

Year	Annual allotment (acre-feet/acre)	Year	Annual allotment (acre-feet/acre)	Year	Annual allotment (acre-feet/acre)
1952	0.9	**1969**	2.4	**1986**	3.0
1953	0.4	**1970**	2.5	**1987**	3.0
1954	0.8	**1971**	1.5	**1988**	3.0
1955	3.0	**1972**	3.0	**1989**	2.9
1956	2.8	**1973**	3.0	**1990**	2.8
1957	2.0	**1974**	2.0	**1991**	3.0
1958	3.0	**1975**	1.7	**1992**	3.0
1959	-	**1976**	0.9	**1993**	3.0
1960	3.0	**1977**	0.6	**1994**	3.0
1961	-	**1978**	1.6	**1995**	3.5
1962	3.0	**1979**	2.0	**1996**	3.5
1963	1.9	**1980**	2.6	**1997**	3.5
1964	1.1	**1981**	1.5	**1998**	3.5
1965	1.3	**1982**	2.7	**1999**	3.5
1966	1.6	**1983**	3.0	**2000**	3.1
1967	2.1	**1984**	3.0	**2001**	2.3
1968	1.9	**1985**	3.0	**2002**	1.3

Additional users of surface water are river pumpers, who divert directly from the river for agricultural purposes. River pumpers generally prefer to divert when riverflows are higher or during a block release when water quality is better, but irrigation demand is the primary factor affecting when diversions are made. Annual river pumper diversions from 1956-91 in the reach of the Pecos River from the Above Acme gage to the Near Artesia gage averaged 11,300 acre-feet per year. In the early 1990s, NMISC began purchasing river pumper rights to help meet Compact deliveries.

Following NMISC’s buy-up, 10 river pumpers remained with an aggregate diversion right of 5,014 acre-feet per year. Of those 10 remaining pumpers, one right for 229 acre-feet per year is essentially inactive, leaving 4,785 acre-feet per year for the remaining 9 active pumpers. Of those nine, six—with diversion rights totaling 4,425 acre-feet per year—are currently leased by Reclamation to supplement the Carlsbad Project water supply because of depletions associated with recent bypasses to augment flows in the critical habitat for the shiner. The average diversions for the period 1992-98 for the nine remaining active pumpers were 4,215 acre-feet per year, and the average diversions for the same period for those three that are not currently leased by Reclamation were 499 acre-feet per year (with a consumptive use of 360 acre-feet). Most river pumper diversions are located in the reach between the Hagerman and Lake Arthur stream gages.

3.8.3 Depletions to Riverflows

Depletions from the river are most evident in the reach from Sumner Dam to the Near Acme gage. Most depletions in this reach are believed to be the result of direct evaporation, transpiration, and percolation into the shallow aquifer (which can easily be transpired back out) and do not serve to recharge the local ground water aquifer. For low-flow periods, losses along this reach can equal 100 percent of the flows observed at the Taiban gage.

The reach of the Pecos River between the gages at Near Artesia and the Kaiser Channel can vary between losing and gaining, depending on flow conditions, while the reach from the Kaiser Channel downstream to Brantley Reservoir is generally a losing reach. Losses from the subreach contained within the upstream and downstream limits of the Kaiser Channel are substantial. The Kaiser Channel was built from October 1948 to April 1949; it was originally a 4-mile channel that served to bypass flows through the immense delta that had formed on Lake McMillan, which was located immediately upstream of Brantley Reservoir. The channel was built to reduce transpiration losses from salt cedar that grew on the delta and presently still proliferate. Because of the construction of Brantley Reservoir and the breach of the old McMillan Dam, the Kaiser Channel is now closer to 13 miles long and extends from the start of the old Lake McMillan delta to Brantley Reservoir.

3.9 Ground Water

Ground water and surface water in the Pecos River basin are linked. Important resource indicators for ground water interactions with surface water in the Pecos River basin include ground water inflows accruing to the Pecos River in the reach between the Near Acme and Near Artesia gages and aquifer storage levels in the Roswell basin. Inflows from the Roswell basin aquifer are important because they are a major contribution to the Carlsbad Project water supply. Aquifer storage levels serve as an indicator for the long-term status of water supplies in the basin.

The study area includes two geologically distinct ground water basins: the Roswell basin and the Carlsbad basin. Both of these basins contain two major water-bearing features: a shallow alluvial aquifer and a deep artesian carbonate aquifer. The Fort Sumner ground water basin also is included in the study area, but this declared basin contains only a shallow alluvial aquifer that is highly connected with the Pecos River.

Throughout most of the Roswell basin, the shallow and carbonate aquifers are separated by a semi-confining layer (figure 3.2). Both aquifers, however, are connected in the northwestern part of the ground water basin where the carbonate aquifer rises structurally to meet the shallow aquifer. The deep artesian aquifer is associated with the San Andres Formation and is confined on the east side and unconfined on the west. The shallow alluvial aquifer is unconfined throughout the basin, and in the southern part of the basin it contains the Major Johnson Springs aquifer. Both of the aquifers were developed for irrigation water supplies beginning in the late 19th century.

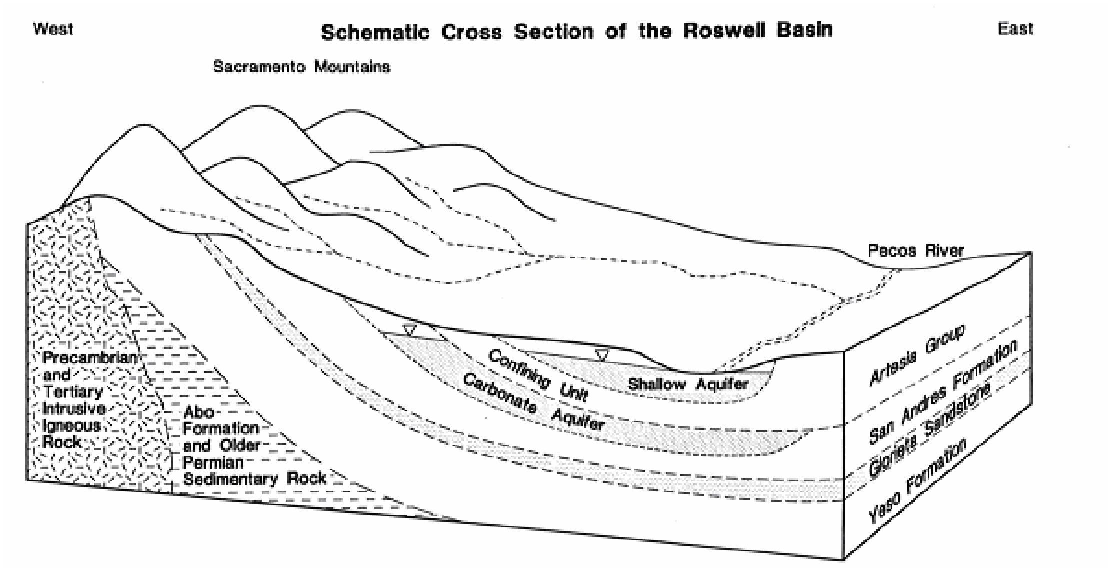


Figure 3.2 Conceptual block diagram showing the interactions between the aquifers and river (from Daniel B. Stephens & Associates [DBS&A], 1995).

The Carlsbad basin also contains a shallow alluvial aquifer and a deeper aquifer known as the Capitan Reef Complex. The Capitan Reef Complex is a large, arc-shaped aquifer that bends through the southeastern corner of New Mexico, with ends stretching into west Texas. The Pecos River, the alluvial aquifer, and the Capitan Reef aquifer are all interconnected. Just north of Carlsbad, the reef aquifer is believed to have the strongest connection to flows in the Pecos River (Robson and Banta, 1995; Barroll et al., 2004). Wells associated with the city of Carlsbad, agricultural operations in southeastern New Mexico, and agricultural operations in west Texas withdraw water from the Capitan Reef Complex. The USGS Ground Water Atlas (Robson and Banta, 1995) indicates that in 1985, more than 0.61 acre-foot of water per day was extracted from the Capitan Reef Complex; 81 percent of it was used for agriculture.

The connectivity and relationships between ground water levels in the aquifers and base inflows in the reach of the Pecos River from the Near Acme gage to the Near Artesia gage (which includes part of shiner critical habitat) are well known (e.g., DBS&A, 1995). These interactions are considered in detail in the following sections.

3.9.1 Ground Water Accretions to the River

Large ground water accretions (water gains to the river from aquifer leakage) resulting from natural springs are known to occur in the reaches between the Below Santa Rosa Dam and Near Puerto de Luna gages. Ground water inflows in the reach between the Below Sumner Dam and the Taiban gages are primarily return flows from FSID. Base inflows along the reach between the Near Acme to Near Artesia gages are from the Roswell basin aquifers; in the reach from Avalon Dam to the New Mexico State line, base inflows are from the Carlsbad basin aquifers.

The intensive development of the ground water resources for irrigation supplies in the Roswell basin has significantly reduced base inflows compared to predevelopment levels.

From the late 1980s into the 1990s, base inflows in the Roswell basin varied between 20,000 and 40,000 acre-feet per year. By the late 1990s, base inflows stabilized somewhat to around 30,000 acre-feet per year (S.S. Papadopulos & Associates, 2004). The magnitude of the base inflows has been linked to precipitation and pumping rates in the Roswell basin. On the basis of recent pumping rates, the base inflows have generally varied seasonally from 40 to 80 cfs. However, because of drought, flows dropped below 5 cfs at the Near Artesia gage during the 2003 irrigation season. The Roswell Artesian Basin Ground Water (RABGW) model was calibrated to historical observed base inflows, and for this EIS, model results provide estimates of changes in ground water base inflows to the river associated with the changes in Carlsbad Project operations (chapter 4).

3.9.1.1 Below Santa Rosa Dam to Near Puerto de Luna

In the reach between the Below Santa Rosa Dam and the Near Puerto de Luna gages, there are very consistent base inflows from springs. Base inflows that appear in this reach come from springs around the town of Santa Rosa, such as "The Blue Hole." The magnitude of these spring inflows varies seasonally and typically ranges from 66 to 85 cfs (131 to 169 acre-feet per day; Tetra Tech, 2003b). Streamflow data indicate that these spring inflows have been very consistent over time. In addition, there is no evidence that construction of Santa Rosa Dam affected the base inflows in this region. The average annual volume of base inflow contributions to the Pecos River is approximately 54,000 acre-feet in this reach.

3.9.1.2 Below Sumner Dam to Taiban

In the reach between the Below Sumner Dam and Taiban gages (just downstream from FSID), streamflow data indicate that the magnitude of ground water inflows as a result of FSID return flows generally exceed 15 cfs. This accretion is strongly dependent on FSID diversions and crop irrigation efficiency. These inflows are very consistent, but it usually takes months for the water applied to the field to reach the river. As a result, flows at Taiban exceed 15 cfs for much of the winter. These lagged returns contribute to base inflows in the river downstream from Sumner Dam.

3.9.1.3 Near Acme Gage to Near Artesia Gage

In the reach between the Near Acme and Near Artesia gages, the Roswell basin provides unique conditions yielding large base inflows to the Pecos River. These base inflows are dependent on hydrologic factors and ground water pumping from both the shallow alluvial and San Andres artesian aquifers in the Roswell basin. Ground water in the Roswell basin flows from the western recharge areas, through the deep artesian aquifer, up into the shallow alluvial aquifer, and, ultimately, into the Pecos River. Base inflow gains to the Pecos River from the late 1800s to the early 1930s have been estimated to range from 40,000 to 120,000 acre-feet per year (McAda and Morrison, 1993; DBS&A, 1995). From the early 1930s to the early 1960s, annual base inflow gains in the reach of the Pecos River between the Above Acme and Near Artesia gages decreased to an average of about 20,000 acre-feet. Most of this decline is attributed to the ground water development for irrigation water supplies, during which time artesian wells were allowed to flow year round; in addition, reduced watershed yield may also be a contributing factor. By 1967, all wells were metered and artesian wells no longer flowed all year. Base inflows from the early 1960s to the mid-1980s stayed constant at about 20,000 acre-feet per year. The conservation imposed by metering also caused a noticeable decrease in base inflows in the reach of the Pecos River between the Near Acme and Near Artesia gages because of a decrease in return flows to the shallow aquifer from croplands irrigated by deep artesian wells (DBS&A, 1995).

3.9.1.4 Major Johnson Springs

At the southern end of the Roswell basin, flow from Major Johnson Springs results in a large accretion to surface flows as the springs discharge directly into the river (and into Brantley Reservoir since 1989). Discharges from the Major Johnson aquifer can range from 8 to 45 cfs (Haskett, 1984). The construction of Brantley Dam inundated the springs, but gains from Major Johnson Springs are still evident. Reservoir storage and streamflow data indicate that Brantley Reservoir accrues a net gain of approximately 3 cfs (2,172 acre-feet per year) from the combined effects of Major Johnson Springs, ungaged losses between the Kaiser Channel and the McMillan Breach, and seepage from the reservoir.

3.9.1.5 Carlsbad Basin

Base inflows in the Carlsbad basin area are derived from two sources: return flows from CID and flows from Carlsbad Springs. Return flows from CID are directly dependent on surface water diversion amounts, supplemental pumping primarily from the shallow alluvial aquifer, crop irrigation efficiency, and precipitation in the Carlsbad area. Flows from Carlsbad Springs are believed to be the result of seepage from Avalon Reservoir into the geological formation known as the Tansill Formation, which is a fossil-rich limestone formed in a back reef environment (USGS, 1996a). Water from Avalon Reservoir moves through this formation and interacts with the Capitan Reef Complex and later resurfaces as Carlsbad Springs flows (USGS, 1996a).

3.9.2 Depth to Ground Water

The USGS Ground Water Atlas (Robson and Banta, 1995) indicates that in 1975, the artesian aquifer in the Roswell basin had a potentiometric surface that sloped gently to the southeast and ranged from 3550 to 3250 feet above sea level. The atlas also indicates that in 1926, when the first ground water studies of the Roswell basin were conducted, the potentiometric surface of the carbonate rock aquifer near the river was as much as 100 feet above the land surface. By 1950, water levels had declined 10 to 30 feet below the ground surface in the eastern part of the aquifer.

The shallow aquifer in some locations in the Roswell basin also experienced declines in water levels from 1950-75. Water levels declined almost 40 feet in some locations during that period, while in the center of the basin, a cone of depression as great as 80 feet below the ground surface was noted (Robson and Banta, 1995). Areas with large declines in the carbonate aquifer do not coincide with areas of decline in the alluvial aquifer (Robson and Banta, 1995). By 1975, the carbonate aquifer’s decline was so great that the gradient, which typically exhibited upward flow from the carbonate to the shallow aquifer, was reversed in some areas (Robson and Banta, 1995).

Base inflows in the reach of the Pecos River between the Near Acme and Near Artesia gages and more recent well data indicate that the water levels have been rising since 1967. These recoveries are attributed to the metering of wells by NMOSE in 1967 (which led to a decrease in pumping), NMISC’s retirement of many of the wells in the Roswell basin, and PVACD’s water conservation program that included the plugging of artesian wells that were previously allowed to flow year round. Because of the current drought, however, the water table has declined again to levels similar to those in the 1970s (HRC, 2005a).

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4. Water Quality

4.1 Introduction

The following indicators were selected to evaluate water quality:

- Total dissolved solids (TDS)
- Specific electrical conductance (EC)

TDS and EC are important indicators of water quality for several reasons. In general, the factors that are responsible for water quality impairment are fishery related and generally would not be affected by changes in Carlsbad Project operations. The most extensive data available are for EC. While there is no water quality standard for EC, EC can be used to estimate TDS, which is a major concern for irrigators in CID. The TDS standard is well above a concentration that would cause either a reduction in yield or complete loss of even tolerant crops. (Appendix 4, "Water Quality," provides additional information.)

4.2 Clean Water Act

Section 305(b) of the Clean Water Act requires each State to assess the quality of its waters in a report to the U.S. Environmental Protection Agency every 2 years. River reaches and reservoirs are considered impaired under the act if they are not fully supportive of their designated uses. The 2004 review showed five river reaches as impaired. The Carlsbad Project reservoirs (Sumner Lake and Santa Rosa, Brantley, and Avalon Reservoirs) also are shown as impaired. Table 3.3 summarizes the 2004 listing of impaired waters (section 303(d) list) in the mainstem of the Pecos River within the study area.

All of the river reaches, except for the reach downstream from Avalon Dam (dry), are listed as not fully supportive of a warmwater fishery, primarily because of siltation of the riverbed, which inhibits food production. The probable sources of the siltation, as shown in table 3.3, are primarily runoff from roads, parking lots, and grazing lands in the upper part of the Pecos River, with stream alterations increasing in importance farther downstream (New Mexico Water Quality Control Commission [NMWQCC], 2004a). Each of the reservoirs is also listed for mercury in fish tissue, but the source of the mercury is atmospheric deposition. The causes of siltation in Santa Rosa Reservoir and Sumner Lake are also shown as the causes of excessive nutrient loadings and eutrophication (NMWQCC, 2004b). None of these factors should be affected by the proposed action.

4.3 Pecos River

The data for most water quality measures are somewhat limited in the Pecos River basin. As mentioned previously, the best data are for EC, but there is no water quality standard for EC. There are water quality standards for TDS in the Pecos River basin, although none are exceeded. TDS is usually about two-thirds of EC.

Table 3.3 Summary of the 2004 303(d) listings of impaired waters, mainstem of the Pecos River within the study area

Pecos River reach or reservoir	Use(s) not supported	Probable cause(s)	Probable source(s)
1. Santa Rosa Reservoir to Tecolote Creek	Limited warmwater fishery	Sedimentation/siltation	Flow alterations from diversions Natural sources Grazing (unmanaged pasture)
2. Santa Rosa Reservoir	Limited warmwater fishery	Mercury in fish tissue, nutrient/eutrophication, sedimentation/siltation	Highway/road/bridge runoff (nonconstruction) Impervious surface/parking lot runoff Grazing (unmanaged pasture)
3. Santa Rosa Reservoir to Sumner Lake	Limited warmwater fishery	Sedimentation/siltation	Flow alterations from diversions Rangeland (unmanaged pasture)
4. Sumner Lake	Limited warmwater fishery	Mercury in fish tissue, nutrient/eutrophication, sedimentation/siltation	Atmospheric deposition: toxics Loss of riparian habitat Other recreational pollution sources
5. Brantley Reservoir	Limited warmwater fishery	Mercury in fish tissue	Atmospheric deposition: toxics
6. Black River to Tansil Lake	Warmwater fishery	Sedimentation/siltation	Irrigated crop production Loss of riparian habitat Grazing (unmanaged pasture) Source unknown Streambank modifications
7. Tansil Lake to Avalon Reservoir	Warmwater fishery	Usually dry	Low flow Alterations/diversions
8. Avalon Reservoir		Mercury in fish tissue	Atmospheric deposition: toxics
9. Texas border to Black River	Warmwater fishery	Sedimentation/siltation	Flow alterations from diversions Habitat modification Loss of riparian habitat Natural sources Grazing (unmanaged pasture)

Source: NMWQCC, 2004a.

Figure 3.3 shows the median EC at the major gages on the Pecos River. EC shows a general increase from upstream to downstream. The exception occurs between the Near Artesia and Below Brantley Dam gages, where EC declines rather dramatically. EC declines further in the reach between the Below Brantley Dam and the Below Dark Canyon gages. However, there is also a large spike in EC from a median of 2,680 microSiemens per centimeter (µS/cm) to

7,100 µS/cm between the Near Acme and Near Artesia gages. Subsequent dilution by mixing of less dilute high flows with more concentrated low flows in Brantley Reservoir and inflows from Dark Canyon reduce the EC at the Below Dark Canyon gage to a value somewhat closer to the EC at the Near Acme gage. The median EC then increases between the Below Dark Canyon and Near Malaga gages and between the Near Malaga and At Red Bluff gages. Each of those increases amounts to about 3,000 µS/cm, and the total change is from a median of about 3,700 µS/cm to more than 9,000 µS/cm. The median EC subsequently decreases from about 10,500 µS/cm At Red Bluff to about 9,900 µS/cm at Orla, Texas (figure 3.3).

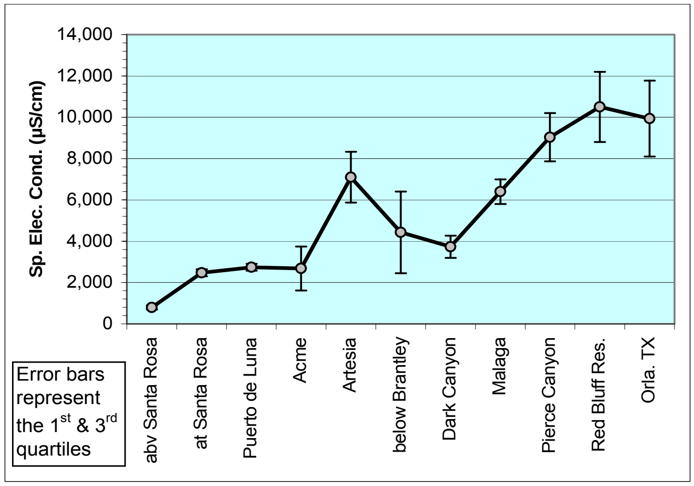

Figure 3.3 Median EC of the mainstem of the Pecos River from Above Santa Rosa Reservoir to Orla, Texas.

Although there are no water quality standards for EC anywhere in the Pecos River basin, beginning with the Near Puerto de Luna gage and continuing to Orla (with the lone exception of the Brantley Reservoir release), there are standards for TDS, chloride, and sulfate (NMWQCC, 2002a), each of which relates to EC. None of the standards for TDS, chloride, or sulfate is exceeded. Although the concentrations of each constituent are high in the mainstem of the Pecos River and generally increase in a downstream direction, the standards also are high and increase downstream. Standards increase because high concentrations are considered natural and part of the background. The Clean Water Act recognizes that such natural conditions exist and makes an exception in the water quality standards to accommodate such conditions.

4.4 Pecos River Basin Reservoirs

Table 3.4 presents a summary of selected water quality data for Pecos River basin reservoirs. As shown in table 3.3, Santa Rosa Reservoir is listed as being impaired for eutrophication (defined as the overenrichment of a lake or other water body with nutrients, resulting in excessive growth of organisms and depletion of oxygen). This eutrophication is illustrated by data in table 3.4 that show that dissolved oxygen (DO) in the bottom waters of the reservoir is depressed nearly all of the time (compared with the surface DO). However, data indicate that surface DO also can be depressed at times. This phenomenon is illustrated by the minimum surface DO shown for Santa Rosa Reservoir; at 4.76 milligrams per liter (mg/L), the DO concentration is about 70 percent of saturation.

Table 3.4 Summary of selected water quality data for Pecos River basin reservoirs (EC in µS/cm; DO in mg/L)

Reservoir	Water quality measure-ment	Minimum	Median	Maximum	Number of observa-tions
Santa Rosa	Inflow EC	120	790.5	4,350	96
	Outflow EC	340	2,125	3,710	100
	Surface EC	—	—	—	0
	Bottom EC	—	—	—	0
	Surface DO	4.76	7.38	10.38	10
	Bottom DO	0.06	2.13	4.67	10
Sumner	Inflow EC	297	2,630	4,100	319
	Outflow EC	231	1,845	3,730	1,896
	Surface EC	880	1,873	2,760	257
	Bottom EC	—	—	—	0
	Surface DO	1.9	8.5	12.4	257
	Bottom DO	—	—	—	0
Brantley	Inflow EC	921	5,390	11,496	298
	Outflow EC	1,516	4,675	7,465	298
	Surface EC	1,548	3,768	6,679	198
	Bottom EC	1,772	5,179	7,696	198
	Surface DO	5.95	8.74	12.70	197
	Bottom DO	0.11	4.44	11.94	197

On the basis of median EC, there is an apparent increase through the reservoir. The median EC of the outflow is about three times that of the inflow. Such an increase is unusual. In most Western reservoirs, the outflow has a lower EC than the inflow. The majority of the inflow is from either storm water runoff or snowmelt, each of which has a relatively low EC. The lower EC inflows tend to dilute the higher EC low flows during the remainder of the year. Unfortunately, there are no EC data for the reservoir itself to evaluate this finding further.

Sumner Lake is also listed as being impaired for eutrophication. No bottom DO data are available for Sumner Lake, but the surface measurements shown in table 3.4 were made by the New Mexico Department of Game and Fish (NMDGF) from May 2001 and May 2002 (Denny, 2003). The minimum DO in table 3.4 for Sumner Lake is very low for a surface measurement and is less than 40 percent of saturation, which indicates that respiration exceeded photosynthesis at the time. The surface DO was low at the time in several areas of the lake. Such a condition would be indicative of eutrophication.

The median outflow EC at Sumner Lake is lower than that of the inflow and similar to the surface EC (table 3.4). This result indicates that the previously described mixing effect predominates in the reservoir. However, there were many more outflow EC measurements than surface or inflow measurements. Furthermore, the periods of record for the measurements do not coincide. Both the inflow and outflow EC records began in September 1959. Measurements downstream from the dam ceased in 1988, while those for inflow continue. As noted previously, NMDGF only made lake surface measurements for one year. Because of all of the preceding differences, the data sets may not represent the same hydrologic conditions.

Brantley Reservoir also shows DO depression in both the surface and bottom waters, but much more so in the deeper water, as would be expected. The New Mexico DO standard for all categories of warmwater fisheries is 5 mg/L (NMWQCC, 2002a). The median DO in Brantley Reservoir is less than the standard; the standard is met less than half of the time. However, when the low DO is attributable to natural causes or the reasonable operation of irrigation or flood control facilities, the DO standard does not apply (NMWQCC, 2002a). In the case of Santa Rosa Reservoir, the bottom DO was below the standard in the 10 profiles measured during the period 1999-2001. Furthermore, the minimum surface DO concentrations in both Santa Rosa Reservoir and Sumner Lake (table 3.4) were below the standard. These results indicate that low DO is a significant environmental problem in all three of the mainstem reservoirs in the study area. Low DO restricts the access of fish to the deeper waters of a reservoir and favors a bottom fauna predominated by tolerant organisms such as *Tubifex* worms at the expense of less tolerant organisms such as insect larvae.

The median EC of the outflow from Brantley Reservoir is more than 700 µS/cm lower than that of the median inflow. The periods of record for the two data sets are the same. These data indicate dilution within the reservoir by the higher flow-lower EC water. However, the median EC of the surface water is more than 1,400 µS/cm lower than that of the bottom water, indicating that mixing is not occurring all of the time, and some form of salinity gradient is present in the reservoir most of the time. Because the EC of the bottom water is somewhat greater than the EC of the outflow, this indicates that some of the mixing is attributable to the withdrawal. In other words, the outflow does not consist solely of water siphoned off the bottom of the reservoir but, rather, a mix of that water and withdrawals from overlying, more dilute layer of water.

4.5 Ground Water

Figure 3.4 shows the EC of the ground water in the predominant aquifers of FSID, PVACD, the intervening area between FSID and PVACD, and CID. The data included on figure 3.4 consist of EC measurements made by the Roswell District of NMOSE between 1927 and 1999. Just as the EC in the Pecos River increases from the Near Acme gage to the Near Artesia gage (figure 3.3), the EC of the alluvial ground water increases downstream from FSID to PVACD, and it decreases downstream from Brantley Reservoir to CID (figure 3.4). The EC of the ground water in the Artesia Group shows a similar pattern. The EC of the ground water in the alluvial aquifer and the Artesia Group is similar in the area upstream of Brantley Reservoir. In the Roswell basin, the alluvial sediments and Artesia Group are generally grouped together as the shallow aquifer.

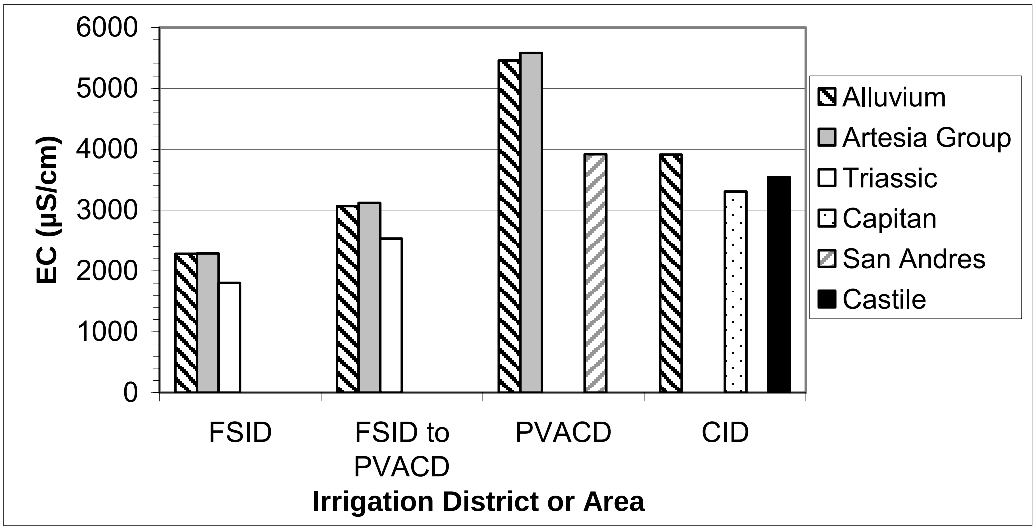

Figure 3.4 Median EC of ground water in various aquifers along the Pecos River.

Aquifers other than the alluvium and the Artesia Group differ in the four areas shown on figure 3.4. In the more northerly areas of FSID and the area to the immediate south, the next most commonly sampled wells were in the Triassic Chinle and Santa Rosa Formations. The EC of the Triassic aquifers is slightly lower than the EC of the alluvium and the Artesia Group wells. The most commonly sampled wells in PVACD were in the San Andres Formation, which was not sampled in any of the other three areas shown on figure 3.4. The San Andres Formation constitutes the artesian aquifer; the Artesia Group of strata forms the cap on the artesian aquifer (Barroll and Shomaker, 2003). The EC of the San Andres ground water is much lower than that of the overlying aquifers.

The geology changes just north of CID. Where to the north there are shelf deposits, the Delaware Basin lies to the south. The Delaware Basin is rimmed by the Capitan Reef (or Capitan Limestone) Complex, the most commonly sampled aquifer after the alluvium in CID (Barroll and Shomaker, 2003). The EC of the Capitan Reef is low to the west, near its recharge area in the Guadalupe Mountains, but it increases to the east because of mixing of poorer quality water from the bedrock aquifers in the Pecos River basin and seepage from Avalon Reservoir (Barroll and Shomaker, 2003). Where the Capitan Reef is absent, the alluvial aquifer is directly underlain by the Permian Castile and Salado Formations, which together comprise up to 2,500 feet of evaporite beds (Barroll, 2002).

5. Agricultural Soil and Land Resources

5.1 Introduction

The following indicators were selected to evaluate agricultural soil and land resources:

Soil resources

- Erosion potential (mainly wind erosion)
- Quality (mainly soil salinity)

Land resources

- Quality, as measured by the acres of lands meeting criteria for national prime farmland (PF) and the acres of lands meeting criteria for farmland of Statewide importance (FSI)
- Acres of land infested with noxious weeds and plants (mainly salt cedar)

What is Prime Farmland?

Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion, as determined by the Secretary of Agriculture (NRCS, 2005).

These indicators of agricultural soil and land resources are important because they affect soil and land productivity and the long-term food security of our Nation.

In addition to the two indicators of agricultural soil resources, this section describes soil sodicity (the presence of excess sodium) and drainage (soil wetness). Also, in addition to the two indicators of agricultural land resources, this section describes irrigated acreage, cropping patterns and trends, crop yields, water use efficiency, fallowing, land retirement, land development, and flooding damage. Conditions for the period 2002-04 are described.

5.2 Evaluation Area

The Pecos River has long provided irrigation water for valuable food and fiber crops, as well as cattle feed for the local livestock industry (Cummins, 1892). The State of New Mexico and Reclamation consider the irrigated land along the Pecos River to be a valuable resource, and the Federal Farmland Protection Policy Act requires an impact evaluation of prime and unique farmlands. According to this act, “the Department of Agriculture and other Federal agencies should take steps to assure that the actions of the Federal Government do not cause United States farmland to be irreversibly converted to nonagricultural uses in cases in which other national interests do not override the importance of the protection of farmland nor otherwise outweigh the benefits of maintaining farmland resources."

According to the Natural Resources Conservation Service (NRCS), many soil series comprising about 83,000 acres in the study area are considered to be PF when irrigated (Brummer, 2001). This analysis considers all irrigated lands to be valuable farmlands worthy of evaluation.

The waters of the Pecos River downstream from Santa Rosa Dam are marginal for irrigation because of their high salt content; thus, any changes in water quality or quantity or in the timing of deliveries could significantly affect irrigated agriculture (Brummer, 2001). The evaluation area includes the Pecos River basin from Guadalupe County to the Texas border; however, this evaluation focuses on CID because the historic release schedule is designed to maximize water quality and quantity for this district. Because some CPWA options could affect other irrigation districts, these other districts also are described. Other irrigated areas along the Pecos River include artesian basin area irrigators (mostly ground water), private river pumpers, wildlife areas, FSID, and Puerto de Luna and a number of other small irrigated areas upstream of Sumner Lake.

Soils in the evaluation area include flood plain, recent alluvial terrace, older terrace, and upland soils. The alluvial soils are best suited for irrigation, although large areas of old terraces (underlain by caliche) and upland soils (underlain by limestone or gypsum beds) are irrigated.

5.3 Soil Quality

Soil quality refers to organic matter content, nutrient and water-holding capacity, soil tilth (the physical condition of the soil with respect to its fitness for the growth of a specific crop), structure, and internal drainage. The soils in the study area tend to be high in calcium carbonate and gypsum. The high amounts of residual calcium carbonate tend to maintain an acceptable surface soil structure (Brummer, 2001). Soil organic matter is rather low. Irrigation tends to maintain or increase organic matter in the surface soil because irrigation usually results in the increased incorporation of crop residues into the soil. Soil salinity and sodicity are considered very important components of soil quality and are discussed separately.

5.4 Soil Salinity

The lands along the Pecos River tend to be somewhat saline. Soil salinity has increased as a result of irrigation. Comparisons of current data with 1948 data indicate that salinity has stabilized in most fields and that the lands are in equilibrium with the irrigation water. Table 3.5 lists the average percent salinity of more than 30 CID sites in 1948, 1993, and 1997 (Brummer, 2001).

In areas of restricted drainage, soil salinity tends to increase until the lands can no longer be farmed profitably. Sensitive crops can be affected by 0.1 percent salts.

(U.S. Department of Agriculture [USDA], 1954). Many areas of farmland along the lower Pecos River, as well as unharvested fields left for wildlife use, have been abandoned because of excess soil salinity in combination with chronic water shortage. Control of soil salinity is especially critical during the spring because excess salt on the planting beds greatly inhibits germination and emergence of seedlings. Areas invaded by salt cedar tend to be very high in salts. Salt cedar tends to concentrate salts in surface soils because the leaf fall contains a considerable amount of salt. For land to meet PF criteria, soil salinity, as measured by specific electrical conductance of the saturation extract (ECe) should be less than 4 deciSiemens in the top meter of soil. Soil salinity levels on many irrigated prime farmlands in the Pecos River basin currently are approaching the 4 deciSiemens per meter (dS/m) ECe threshold level. Any increase in irrigation water salinity would decrease the acreages of land qualifying for PF in the Pecos River basin.

Table 3.5 Average salinity of lands along the Pecos River

Year	Average percent salt (root zone)
1948	0.28
1993	0.27
1997	0.26

5.5 Wind Erosion Potential

The lands in the Pecos River basin are subject to moderate-to-high wind erosion potential. Keeping lands in crop rotations tends to reduce wind erosion, while exposed, fallowed lands tend to have greater damage from wind erosion. Lands retired from irrigation should be reseeded with native grasses to reduce wind erosion damage. State-controlled land retirement programs call for reseeding and erosion control measures. Many lands that are otherwise eligible for PF designation are excluded from this category because of the elevated wind erosion hazard (Smith, 2004). The general soils map from the Eddy Area, New Mexico, soil survey indicates that more than 50 percent of the irrigable lands are subject to moderate to severe wind or water erosion; wind erosion is the major hazard.

5.6 Water Erosion Potential

Rainfall in the study area tends to come in intense thunderstorms during the summer. These storms have the potential to erode exposed soils. Water erosion potential generally increases with increasing slope length and steepness. Most of the irrigated lands along the Pecos River are nearly level to gently undulating or sloping; however, some water erosion has occurred. Irrigation-induced erosion occurs when excess flow and velocity of irrigation water move soil from the upper end of a field to the lower end. Reducing the flow in the furrows with methods such as surge valve irrigation can reduce erosion incidental to irrigation. Many of the irrigated lands along the Pecos River have been bench-leveled (nearly level terraces) to facilitate efficient irrigation (Marshall, 2003). The only water erosion noted on these lands was erosion of the berms between the benched fields. Water erosion is a minor problem in the study area because current land management has helped to reduce this hazard.

The Pecos River has sandy and unstable banks. Erosion of unstable banks once allowed the river to move back and forth across the flood plain. Controlled releases from dams have probably reduced streambank erosion. Any alternative that leads to increased overbank flooding would increase the natural process of streambank erosion.

The soils of the Pecos River basin are somewhat susceptible to water erosion. Generally, only lands with slopes of 0 to 3 percent slope are included in PF inventories. Slopes of FSI in the Pecos River basin can range up to 10 percent but are commonly less than 6 percent (NRCS, 1986).

5.7 Soil Sodicity

Excess sodium causes dispersion of soil particles, resulting in reduced infiltration of irrigation water and precipitation. As a result, it may be difficult to replace soil water for crop use and crop yields may be reduced. To qualify for PF designation, the exchangeable sodium percentage level should not exceed 15 percent in the top meter of soil (National Archives and Records Administration [NARA], 2005).

5.8 Drainage

Some farmers along the lower Pecos River have poorly drained soils. Most of these poorly drained soils are the result of canal seepage or irrigation deep percolation perching on underlying gypsum beds or impermeable calcium carbonate layers. This situation creates perched, saline water tables that impede land productivity. As productivity declines, the farmer has less and less income to remedy the situation by installing drains. CID reports that impaired drainage is a major problem in the district. About 5,000 acres in CID are adversely affected by shallow ground water and soil wetness. CID’s existing drainage system consists of 30 miles of open drains and 2 miles of closed drains. Further drain construction and canal lining are needed to improve productivity in portions of CID.

Poor drainage is also a problem in the ground water basin. As ground water pumping has decreased in recent years, drainage problems have increased. These drainage problems have led to reactivation of some regional drainage districts, and some new drains have been constructed by growers to relieve soil wetness. Some FSID lands also are adversely affected by shallow ground water.

5.9 Important Farmlands

As discussed previously, important farmland in the study area consists of PF and FSI. PF has the soil quality, growing season, and moisture supply needed for the soil to economically produce sustained high yields of food, fiber, forage, and oilseed crops when properly managed. Of the several types of important farmland, only PF is based on national criteria. (The Farmland Protection Policy

Act requires evaluation of PF.) Some of the criteria (NARA, 2005) that relate most directly to this evaluation include the following:

- Lands are irrigated
- Soil reaction pH is between 4.5 and 8.4
- Lands are not adversely affected by shallow ground water
- Soil salinity in the top meter is less than ECe 4 dS/m
- Exchangeable sodium percentage is less than 15 in the top meter of soil
- Lands are not subject to frequent flooding
- Surface soil erodibility does not present a serious erosion hazard when local climatic factors are considered

In some areas, land that does not meet the criteria for prime or unique farmland has been determined to be FSI by State or local officials in cooperation with the State Office of NRCS because it is the best land available in the region (NRCS, 2005). Generally, these areas produce excellent yields but require more intensive conservation treatments to ensure sustained yields relative to PF. Irrigated farmlands must be classed as at least irrigated capability class IV to qualify for the FSI designation based on New Mexico NRCS criteria. The NRCS capability class IV lands have very severe limitations that reduce the choice of plants, require very careful management, or both. Land and water right purchases during recent years have reduced the acreages of important farmlands along the Pecos River.

NRCS websites provide lists of soil series, mapping units, and associations that qualify as important farmland (NRCS, 2005). Lands must be irrigated in order to qualify as PF or FSI. Table 3.6 presents the number of soil types in the study area, their acreage by county, and the dates of the listings.

Table 3.6 Number of soil types in study area

County	PF[1]	FSI[2]	Date of listing
Eddy	5 (74,000 acres)	15	3/25/2002
Chaves south	0	20	1/17/2002
Chaves north	1 (1,200 acres)	11	1/27/2002
De Baca	4 (7,400 acres)	21	3/25/2002
Guadalupe	1 (no data on acres)	Not available	2/01/2002

[1] Only irrigated lands qualify for PF in the Pecos River area because of the dry climate and the need for irrigation. Many soil series that would otherwise qualify for PF if irrigated were removed from the PF category a few years ago, based on the severe wind erosion hazards in the area (Smith, 2004).
[2] No FSI listings are available. Series and associations with an irrigated capability class of IV or higher were placed in this category based on soil survey information.
Source: NRCS, 2005.

As table 3.6 shows, the Pecos River basin contains extensive areas of important farmlands. (Supporting data include the listings of important farmland soil mapping units by county.) On the basis of a preliminary examination of soil surveys, it appears that more than 50 percent of the irrigated lands in CID are designated as PF. The percentage of PF irrigated in upstream areas is much lower; however, nearly all irrigated lands in the Pecos River Valley currently meet the criteria for FSI.

5.10 Noxious Weeds

Salt cedar invasion is considered a major problem on the Pecos River. Salt cedar consumes large amounts of water along the river corridor; reduces the usability of lands for range; and has invaded many irrigated farmlands, rangeland, and valuable wildlife habitat lands along the river. Estimated costs (Brummer, 2003) to control this plant with herbicides range from $89 to $141 per acre, while mechanical control costs are higher (about $600 per acre). Salt cedar is spread by seeds in floodwaters, and flooding in late summer and autumn tends to facilitate its spread. Nearly all water lost to seepage along the Pecos River is eventually transpired by the salt cedar and is permanently lost from the local water supply. The extent of the salt cedar invasion prior to control operations was estimated at more than 60,000 acres.

Lands invaded by salt cedar tend to be highly saline because of salts extruded by the salt cedar leaves, which eventually fall to the soil. Salt cedar can contribute to flood damage because dense stands will back up floodwaters; however, salt cedar can reduce streambank erosion.

Salt cedar control operations usually result in a mixed stand of perennial grasses, broom snakeweed, mesquite, and four-wing salt bush. Coyote willow and seep willow will colonize some of the wetter areas. Replacing salt cedar with vegetation dominated by perennial grasses is estimated to conserve about 1 acre-foot per acre per year of water because of transpiration differences (Reclamation, 1997).

Reclamation, soil and water conservation districts, and other State and local government agencies have dedicated abundant resources to the salt cedar eradication (water salvage) program begun in 1965. Over the past several years, large acreages of salt cedar have been sprayed with the herbicide imazapyr. These programs have reduced the acreage of salt cedar infestation to an estimated 25,000 acres, with less than 10,000 acres of dense stands (Brummer, 2003).

Federal Executive Order 13112 (Invasive Species) and the State Noxious Weed Control Act (sections 76-7-1 to 76-7-22 New Mexico Statutes Annotated [NMSA] 1978) may be applicable to weed control.

5.11 Irrigated Acreage

The total irrigated acreage in the study area averaged about 160,000 acres from 1980-85 (including tributary and ground water irrigation). This acreage has decreased in recent years because of land retirement for water rights, as well as some land abandonment because of excess salt and seepage. The general trend in the Pecos River Valley is a gradual decline in irrigated acreage.

Reclamation records indicate that CID irrigated 16,500 acres in 1917; an average of 24,592 acres from 1921-33; and an average of 20,000 acres from 1934-40. By 1993, CID irrigated a total of 18,813 acres. Private pumpers along the Pecos River irrigated nearly 20,000 acres at one time, but this acreage has been reduced to about 3,000 acres currently. FSID currently irrigates about 6,000 acres, and PVACD irrigates more than 100,000 acres.

5.12 Cropping Patterns and Trends

CID is best suited for salt-tolerant crops. The soils are too saline for maximum yields of some climatically adapted crops, such as chili peppers and pecans, although these crops are grown successfully in upstream areas north of CID. In the early 1900s, some deciduous fruit was grown in the valley (Means and Gardner, 1900). However, none has been reported in CID crop reports since about 1970. There has been a long-term trend toward increased alfalfa production and decreased cotton production in CID. Alfalfa acreage increased from about 4,300 acres in 1925 to about 12,000 acres in 1992 (Reclamation, 1992). Apples formerly were an important crop in the Roswell and Fort Sumner areas; however, no commercial apple orchards were observed in current field inspections. Recent trends in the Roswell area include large increases in corn and small grain acreage for nearby dairies. Upstream areas, such as FSID, grow about 75 percent alfalfa. The other lands are mostly used for rotation crops between alfalfa plantings, such as small grains and forage mixes. Cropping patterns are based on Reclamation’s 1992 crop report for CID and are presented in table 3.7 (Reclamation, 1992).

5.13 Crop Yields

New irrigation technology and crop improvements have led to general increases in crop yields over the past 30 years. These improvements have not been fully realized in the Pecos River Valley, especially in areas affected by excess salt.

Yields presented in table 3.7 are much lower than potential yields based on the climate of the area, despite irrigation water deliveries of 3.9 acre-feet per acre in 1992.

Table 3.7 CID cropping patterns (1992)

Crops	Acres	Percent of irrigated	Yield per acre
Alfalfa	11,755	65	6 tons acre
Cotton	4,243	24	0.85 bales
Irrigated pasture	633	3	8.3 animal unit months
Peppers	785	4	1,800 pounds
Pecans	229	1	1,400 pounds
Other crops	508	3	
Total irrigated cropland	18,153		

5.14 Water Use Efficiency

An important measure of water use efficiency is the comparison between crop yield and the volume of water used to produce the crops. Water use efficiency appears to be increasing slightly in CID because crop yield per acre has gradually increased over the years, while crop water deliveries per acre have been stable.

5.15 Fallowing

Fallowed acreage has fluctuated over the past 25 years. CID crop reports indicate nearly 6,000 acres were fallowed in 1992 and 1993. While fallowing for crop rotation, soil building, or moisture storage is considered beneficial, long-term fallowing can be detrimental to land productivity. Buildup of noxious weeds and, in some cases, salt, can occur on lands that are idle for long periods. Currently, some CID landowners can fallow their land for a crop year and receive a payment for the water supply.

5.16 Land Retirement

Irrigated lands are currently being purchased and retired on the basis of a settlement among NMISC, CID, and PVACD to ensure long-term compliance with the Pecos River Compact and the Amended Decree. Other lands have been retired from irrigation because of a water table buildup or a soil salinity increase. Still other lands have been retired because of high costs to pump ground water or other economic factors. Lands in the area of the artesian ground water basin are being retired, and the ground water is being transferred to urban use.

5.17 Land Development

Little new land development is occurring in the Pecos River Valley because available water supplies are inadequate to fully irrigate existing lands. NRCS has been improving the infrastructure of existing irrigated lands under the Environmental Quality Incentives Program, which may cost share up to 75 percent of the costs of certain conservation practices.

5.18 Flooding Damage to Lands

The lands along the Pecos River and its tributaries are subject to infrequent flooding from heavy spring and summer storms. This flooding has damaged irrigation structures, fences, and other properties of agricultural landowners on the flood plain. Flooding has also physically eroded valuable soils in farm and range lands. Upstream reservoirs have helped control flood damage; however, flooding is still a problem because of intense localized summer storms downstream from the dams. Prime farmland cannot be subject to frequent flooding.

6. Biological Resources

6.1 Introduction

This section identifies biological resources that may be affected by one or more of the alternatives. The affected environment for consideration of biological resources includes approximately 350 river miles of the Pecos River and the four reservoirs. Biological resources were evaluated within the following defined area:

- The Pecos River and adjacent flood plain between the Below Santa Rosa Dam and At Red Bluff gages, upstream of the New Mexico/Texas State line.

- Santa Rosa Reservoir, Sumner Lake, Brantley Reservoir, and Avalon Reservoir.

The following indicators were selected to evaluate the effects of the alternatives on biological resources:

Terrestrial and flood plain ecosystem components (including wetlands, riparian vegetation, and wildlife)

- Increased potential for overbank flows and erosion of riverbanks containing riparian, wetland, and terrestrial habitats.

- Increased potential for inundation of habitats used by nesting shorebirds, including interior least tern, terrestrial wildlife species, and wetland aquatic species.

Riverine aquatic ecosystem components

- Changes in frequency, extent, and duration of intermittency at the Near Acme gage that would cause direct mortality of aquatic organisms and loss of aquatic habitat.

- Changes in frequency of extreme low flows (less than 3 to 5 cfs) at the Near Acme gage that could result in rapid development of channel intermittency and loss of aquatic habitat.

- Change in frequency, magnitude, or duration of managed or natural peak flows at the Near Acme gage that could impact aquatic habitat or spawning activities.

Reservoir aquatic ecosystem components

- Changes in availability of sport fish spawning habitat and adult habitat in response to reservoir elevation changes.

Special status species that occur within the study area

- For each species, see the indicators listed previously for the ecosystem that contains its habitat (e.g., riverine aquatic for Pecos bluntnose shiner and terrestrial for interior least tern)

Critical habitat within the study area

- For each designated critical habitat, refer to the indicators listed previously for appropriate ecosystem type (e.g., riverine aquatic for Pecos bluntnose shiner critical habitat).

The importance of each of these indicators is described in the following sections.

6.2 Terrestrial and Flood Plain Ecosystem Components

Hildebrandt and Ohmart (1982) characterized riparian vegetation communities along the Pecos River from approximately Santa Rosa, New Mexico, to near Garvin, Texas. They identified seven major riparian vegetation community types and found woody riparian vegetation to be most abundant. Communities dominated by salt cedar (*Tamarix parviflora*) accounted for about 93 percent of the woody riparian vegetation, while communities dominated by cottonwood (*Populus* spp.) accounted for about 7 percent. Vegetation in the vicinity of the abandoned McMillan Reservoir delta accounted for almost half of the salt cedar-dominated vegetation community, and an extensive community of salt cedar also was found at Bitter Lake National Wildlife Refuge (BLNWR); outside of these areas, salt cedar typically occurred within narrow fringes along the riverbanks. Many of these areas have recently been sprayed to remove salt cedar. (See Section 5.10, “Noxious Weeds” in “Agricultural Soil and Land Resources.”)

Plains forested wetlands occur through much of the Pecos River basin and account for most of the vegetation in the study area. These wetlands occur on bars and terraces of wide flood plains at elevations ranging from 3500 to 4800 feet above mean sea level. Common plant species associated with these wetlands are Fremont cottonwood (*Populus fremontii*), salt cedar, willow (*Salix* spp.), and seepwillow (*Baccharis salicifolia*). Additional wetland types occur in patches throughout the study area. These wetland communities include southwest forested wetlands; southwest scrub-shrub wetlands; plains persistent-emergent wetlands; and warm temperate, southwest persistent-emergent wetlands. Within these wetland areas, populations of special status aquatic invertebrates (table 3.8) and other wetland dependent species occur in spring/seep habitats. In addition, upland vegetation includes plains dry steppe and shrub habitat and Chihuahuan desertscrub habitat. Typical vegetation includes short bunch grasses (e.g., buffalograss and blue grama), juniper, mesquite, and creosote bush.

Hildebrandt and Ohmart (1982) censused wildlife along vegetation community transects within the Pecos River basin. The bird community was the most diverse and abundant of all wildlife types, with 310 species recorded. At least 285 of those species (USGS, 2003) have been observed or may occur at BLNWR, an important resting and wintering area for migratory and resident bird species. The herptile (amphibian and reptile) community in the study area consisted of 40 species and was dominated by terrestrial reptiles. Predators and large mammals identified along these transects included beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), porcupine (*Erethizon dorsatum*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus ocythous*), ringtail (*Bassariscus astutus fulvescens*), raccoon (*Procyon lotor hirtus*), long-tailed weasel (*Mustela frenata*), badger (*Taxidea taxus*), striped skunk (*Mephitis mephitis hudsonica*), hog-nosed skunk (*Spilogale* sp.), bobcat (*Felis rufus pallescens*), mule deer (*Odocoileus hemionus hemionus*), and pronghorn (*Antilocapra americana americana*). Small mammal communities consisted of various species of ground squirrels (*Spermaphilus* spp.), mice, and rats (*Cricetidae* and *Muridae*).

The first indicator selected to evaluate the effects of the alternatives on terrestrial ecosystem components is the increased potential for overbank flows and erosion of riverbanks containing riparian and terrestrial habitats. Increased frequency of these overbank flow events could change the character of the stream channel and surrounding riparian vegetation. These changes to the vegetation would affect the diversity and abundance of local terrestrial wildlife.

The second indicator is the increased potential for inundation of habitats used by nesting shorebirds, including interior least tern, wildlife species, and wetland dependent species, including the special status invertebrate and fish species in the Roswell area. Inundation of these areas could change the character of the habitats and could displace individuals to unsuitable habitats.

6.3 Riverine Aquatic Ecosystem Components

More than 50 warmwater and coldwater species of fish have been documented in the study area between Santa Rosa Reservoir and the New Mexico-Texas State line (Sublette et al., 1990). Many of these species are specially adapted to live in the shifting sand and silt substrates that dominate the river between Fort Sumner and Brantley Reservoir. Generally, small-bodied fishes dominate the riverine fish community and have received much of the research attention in the system, because of the presence of the small-bodied Pecos bluntnose shiner (*Notropis simus pecosensis)*, a federally threatened fish species. Aquatic species, including reptiles and amphibians dependent upon Pecos River flows, have been well documented in the basin. Numerous studies related to the shiner have provided much of the known information regarding the aquatic ecosystem.

The first indicator selected to evaluate the effects of the alternatives on riverine aquatic ecosystem components is a change in the frequency, extent, or duration of intermittency (defined as flows of 0 cfs) at the Near Acme gage. A period of intermittency would result in mortality for aquatic organisms, including fish, reptiles and amphibians, invertebrates, macrophytes, and algae. The Near Acme gage is located between the upper and lower critical habitats on the Pecos River. Though this stretch of river was not designated as critical habitat, the habitat is high quality and supports good numbers of shiners and other fish species. Studies and monitoring of the habitat and shiner in this stretch have occurred over the last 12 years and are presently ongoing.

The second indicator is a change in the frequency of extreme low flows (less than 3 to 5 cfs) at the Near Acme gage. This indicator is important because these low flows could result in the rapid development of channel intermittency and endanger local aquatic organisms and their habitat.

The third indicator is a change in the frequency, magnitude, or duration of managed peak flows at the Near Acme gage. This indicator is important because changes may affect the frequency and timing of fish spawning, the survival of eggs and juvenile fish, and the availability of habitat for juvenile and adult fish.

6.3.1 Santa Rosa Reservoir to Sumner Lake

In this reach, the river meanders through a fairly narrow valley. Small pockets of wetlands form in backwater areas and along slow-moving sections of the river. Generally, small-bodied fishes dominate the riverine fish community. Numerous populations of aquatic invertebrates occur throughout the study area in riverine and spring/seep habitats.

6.3.2 Sumner Lake to Brantley Reservoir

Approximately 30 river miles downstream from Sumner Dam, the Pecos River enters a broad alluvial plain. Between Fort Sumner and Roswell, the river is more typical of a Plains stream, with a relatively wide channel and a shifting sand substrate. Shallow runs and braided channels are prevalent, and there are small wetlands along the river and in oxbows. This reach provides the necessary habitat components for the shiner and other aquatic species.

Intermittency sometimes occurs for as much as 20-25 miles upstream of the Near Acme gage when base inflows are diverted. The river downstream from the Near Acme gage is generally wetter than it is upstream because of irrigation returns and spring inflows. However, the channel narrows and the geomorphic and hydrologic conditions necessary to provide adequate habitat for the shiner and other fish species are often lacking. Between Artesia and Brantley Reservoir, through the Kaiser Channel, the river is very narrow and incised.

6.3.3 Brantley Dam to New Mexico-Texas State Line

Downstream from Brantley Dam, the channel is incised in limestone, which creates riffles and pools in the river. The salinity of the Pecos River increases as the river approaches the Texas border (Service, 1998). As in the other reaches, small-bodied fishes generally dominate the riverine fish community with a few large bodied species, including the blue sucker (table 3.8). This reach has been affected by numerous fish kills caused by golden algae (*Prymnesium parvum*). Little is known about why golden algae blooms occur.

6.4 Reservoir Aquatic Ecosystem Components

Sport fish stocked for recreation purposes dominate reservoir fisheries. Stocking records, creel censuses, and sport fish management activities have provided information on reservoir fisheries (Denny, 2004).

Santa Rosa Reservoir is a popular sport-fishery for catfish, largemouth and smallmouth bass, crappie, and walleye. Sumner Lake provides warmwater fishing, with several varieties of bass, crappie, pike, bluegill, carp, and catfish. Detritivores, including shad, carp, and warmwater suckers, may be important to trophic (food chain level) dynamics in Sumner Lake, because they have been found to accumulate large biomasses and influence food availability there (Cole et al., 1991). The Sumner Lake stilling basin contains catfish and trout. NMDGF stocks the stilling basin with rainbow trout from November through March.

Brantley Reservoir provides year-round fishing for white bass, catfish, largemouth bass, walleye, and crappie. In the last several years, Brantley Reservoir has been stocked with crappie, Florida strain largemouth bass, and catfish. Golden algae blooms are possible in Brantley Reservoir.

The indicator selected to evaluate the effects of the alternatives on the reservoir aquatic ecosystem is a change in reservoir elevations that might lead to changes in spawning, adult, or rearing habitat for sport fish.

6.5 Special Status Species

Special status species are those listed as threatened or endangered under provisions of the Federal Endangered Species Act of 1973, as amended (ESA); those proposed or considered as candidates for such listing; and those considered as rare or species of concern by the Service, NMDGF, and New Mexico Energy, Minerals and Natural Resources Department, Forestry Division.[1]

Not all special status species fall under Federal or State statutes concerning threatened and endangered species. Generally, species designated as threatened or endangered receive protection under the designating agency's applicable statutes, and species considered to be rare or species of concern do not receive protection under these statutes. Species considered by the Service as candidates for threatened or endangered status are not provided protection under ESA. However, Federal agencies are required to confer with the Service on actions likely to jeopardize the continued existence of a candidate species or to result in

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[1] Although the New Mexico Energy, Minerals and Natural Resources Department, Forestry Division, has statutory authority for establishing a list of New Mexico endangered plant species, the list is maintained by the nongovernmental New Mexico Rare Plant Technical Council (NMRPTC, 1999).

> **What are Special Status Species?**
>
> ***Special status species*** are rare animal and plant species that have been identified by Federal or State agencies as needing protective measures. Special status species as defined and used in this document include the following:
>
> - Plant and animal species **listed** as **Federal threatened or endangered** under provisions of the Endangered Species Act of 1973, as amended (ESA).
> - Plant and animal species **proposed** for listing as Federal threatened or endangered under ESA with the proposed listing published in the *Federal Register.*
> - Animal species listed as **State endangered or threatened** under provisions of New Mexico Statutory Chapter 17, Article 2:17-17-2-37 through 17-2-46.
> - Plant species listed as **State endangered** under provisions of New Mexico Statutory Chapter 75, Article 6: 17-6-1.
> - Species designated as **sensitive** or **species of concern** by State and/or Federal management agencies.

the destruction or adverse modification of proposed critical habitat. Species not receiving protection under statutes specifically related to threatened and endangered species may receive some protection under other State and/or Federal statutes.

Information on the occurrence and potential for occurrence of special status species within the study area was obtained from lists maintained by the Service, NMDGF, and New Mexico Rare Plant Technical Council (NMRPTC). A total of 45 special status species were identified as occurring in Guadalupe, DeBaca, Chaves, and Eddy Counties (New Mexico counties in the study area; table 3.8).

Many of the 45 species typically occupy habitats not occurring in the study area, are unlikely to be affected by the proposed action and, thus, were eliminated from detailed analysis. These species are not discussed in detail in this chapter or in Chapter 4, "Environmental Consequences." Species not eliminated require a more detailed analysis to determine if effects are possible. The two species requiring a more detailed analysis, Pecos bluntnose shiner and interior least tern, are discussed in the following sections.

Indicators from the appropriate ecosystem component are used to evaluate the effects of the alternatives on special concern species (i.e., riverine aquatic for Pecos bluntnose shiner and terrestrial for interior least tern). These indicators reflect changes in the availability of breeding and adult habitat. Both habitats are necessary for survival and reproduction, elements vital to maintaining a viable population.

6.5.1 Pecos Bluntnose Shiner (Notropis simus pecosensis)

The Pecos bluntnose shiner (family *Cyprinidae)* is a federally threatened species and a New Mexico threatened species. It is a small fish that is native to the Pecos River in New Mexico. The shiner (*Notropis simus)* was first collected in 1874 in the Rio Grande of New Mexico (Federal Register 52(34): 5295-5303).

Two subspecies were recognized: the Rio Grande bluntnose shiner (*N. s. simus*) and the Pecos bluntnose shiner (*N. s. pecosensis*) (Chernoff et al., 1982)

The Service designated the Pecos bluntnose shiner as a federally threatened species, with critical habitat, in 1987 under ESA. The upper critical habitat extends approximately from the Taiban Creek confluence to Crockett Draw (map 3.2). The lower critical habitat extends from approximately Hagerman to Artesia. At the time of listing, the Service identified the "most important factors in the species' decline as reduced flow in the main channel of the river because of water storage, irrigation, and water diversion" (Federal Register 52(34): 5295-5303).

The State of New Mexico listed the shiner as endangered, group II, in 1976 (first listed under the name silverband shiner [*N.* cf. *shumardi*]; Sublette et al., 1990). Group II species were defined by the State as those whose prospects for survival or recruitment in New Mexico are likely to be in jeopardy within the foreseeable future (Service, 1987). In the September 2000 NMDGF Biennial Review and Recommendations, the species was listed as threatened with no change in status recommended (NMDGF, 2000, 2002a).

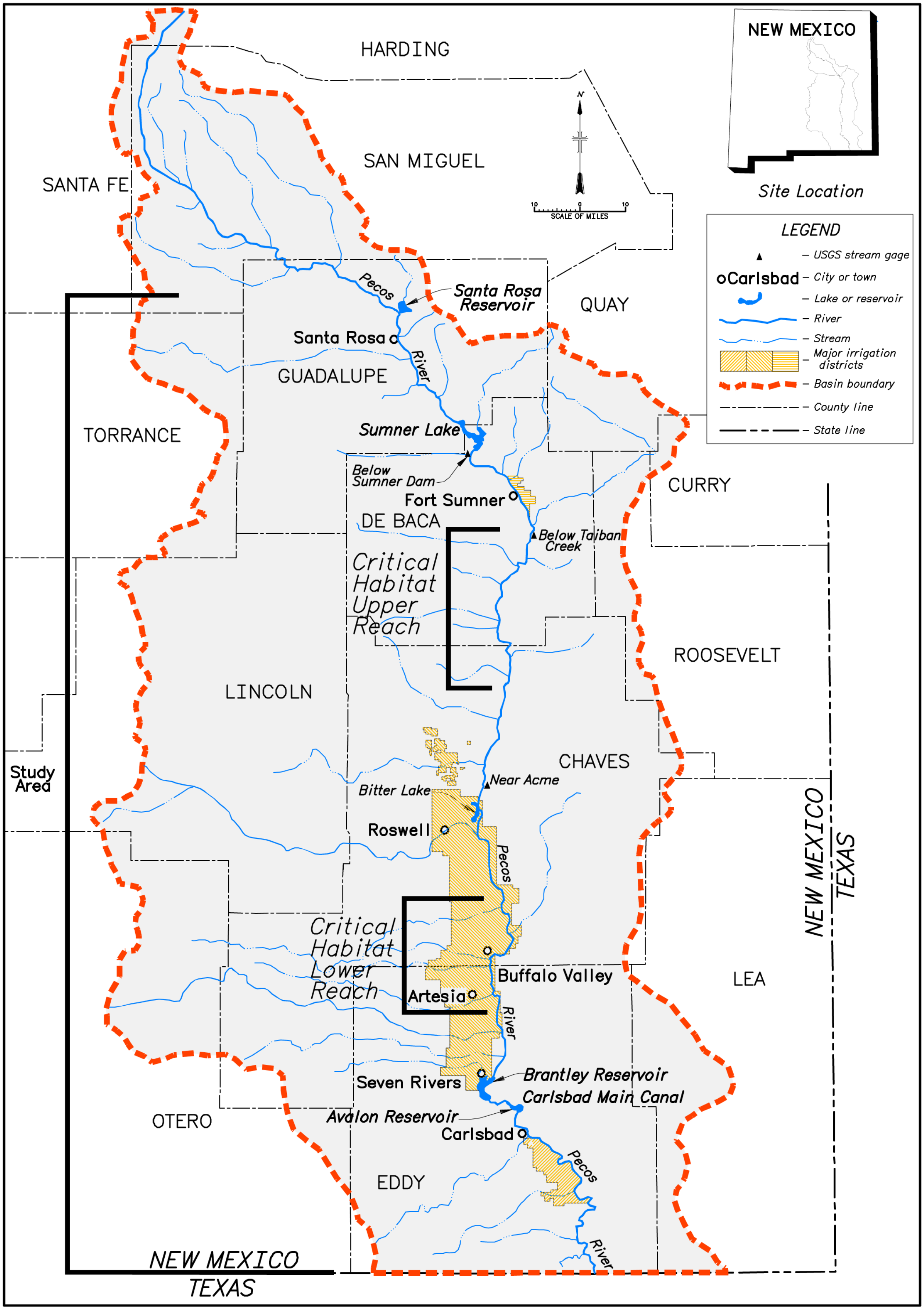
The shiner has been characterized as carnivorous-omnivorous, based on the shape of the digestive tract (Sublette et al., 1990). Bestgen and Platania (1987) found that organic matter, filamentous algae, and terrestrial plant matter (including seeds, seed coatings, and small woody debris) comprised 52 percent of all identified food items from the gut of 14 Rio Grande shiners. Terrestrial and aquatic invertebrates comprised the other 48 percent of the identified food items. Terrestrial plant organic matter and terrestrial invertebrates made up 75 percent or more of the contents in 43 percent of the guts examined. Platania (1993) examined 655 Pecos bluntnose shiner stomachs and found terrestrial invertebrates (ants and wasps), aquatic invertebrates, larval fish, and plant seeds.

Individual shiners may live up to 3 years, but most individuals live about 2 years. The fish mature after their first year of life (age 1). Age 1 females produce up to 500 eggs per spawn; age 2 females produce up to 1,000 eggs, but few survive to spawn at age 3. Platania (1993) and Platania and Altenbach (1998) described the shiner as pelagic (open water), broadcast spawners that produce nonadhesive, semibuoyant eggs that are approximately 1 millimeter in diameter at expulsion and harden in water to about 3 millimeters. Platania (1995a) reported a positive correlation between reproduction of Pecos River broadcast-spawning species (including the shiner) and increases in river discharge between early June and late September. Hatch et al. (1985) reported that the shiner has a prolonged spawning season lasting into September. Platania (1993) reported the 1992 spawning season occurred between June and August. Elevated flows (irrigation releases, spring runoff, and rainstorm events) appear to be an environmental cue to initiate spawning (Platania and Altenbach, 1998). Females release eggs in the mid-water column, where males immediately fertilize them. After fertilization, the eggs incubate as they drift with the river current, and the larvae hatch in about 24 hours. The tiny protolarvae (about 5 millimeters long) continue to drift with the current for 3 to 4 days and then actively forage and select low-velocity habitats.

Platania (1995b) summarized historic collections of the shiner. Based on collections made from 1902 to 1949, the confirmed pre-1950 range of the shiner was from near the city of Santa Rosa, downstream to the vicinity of Major Johnson Springs, near Carlsbad. However, there is no reason to believe that the shiner did not historically occupy the Pecos River as far downstream as the Texas border. On the basis of collections made since 1982, the current range of the shiner is believed to be approximately 186 miles from near the Taiban Creek confluence, DeBaca County, downstream to Brantley Reservoir (Hoagstrom, 2003). Recently, eight juvenile shiners were collected downstream from Brantley Reservoir (NMDGF, 2004), presumably after being flushed through the reservoir during an irrigation release. All age classes of the shiner occupy the upper critical habitat section; primarily larval and juvenile forms occupy the lower critical habitat section with few adults collected (Hoagstrom, 2003).

The shiner has been collected only from the mainstem Pecos River or at the mouths of its major tributaries (Service, 1992; Platania, 1995b). There is a 1986 collection record for the species in the Rio Felix of Chaves County, approximately 1 mile upstream of the Rio Felix/Pecos River confluence, but Platania (1995b) considers this record aberrant. Hatch et al. (1985) found the species in every major habitat within its range, except stagnant pools, and found it most often in water 17 to 41 centimeters (6.7 to 16 inches) deep with smooth, nonturbulent flow and sandy substrate.

In research conducted in flows that ranged from 15 to 300 cfs, Hoagstrom (2003) found the shiner in all habitats sampled, although 94.4 percent of the total catch was from water less than 1.3 meters (4.3 feet) deep and flowing at a velocity of 0.84 meter per second (2.7 feet per second). Hoagstrom further concluded that of a total catch of 684, about 69 percent came from areas 0.12 to 0.25 meters (4.7 to 9.8 inches) deep with a flow of 0.04 to 0.42 meters per second (0.13 to 1.4 feet per second), and about 18 percent were collected from areas of 0.29 to 0.39 meter (11.4 to 15.3 inches) deep and with a flow of 0.04 to 0.42 meter per second (0.13 to 1.4 feet per second); there were no important differences in depth of water occupied by different size classes, but there was a difference in velocity, with age 0 fish occupying lower velocities. The shiner showed a preference for depths greater than 0.5 meter and velocities ranging from 0 to 0.7 meter per second (Hoagstrom, 2003).



Map 3.2 Pecos bluntnose shiner critical habitat

Kehmeier et al. (2004) documented that between flows of 2 cfs and 81 cfs, water depth and velocities overlapped considerably for habitats used by small-bodied minnows in the Pecos River, including the Pecos bluntnose shiner, and were unsuitable when analyzed independently for development of habitat-to-flow relationships. Rather, Pecos River fishes use discrete mesohabitat types, which are generally described as habitat types that provided suitable combinations of features such as depth, velocity, substrate, turbulence, cover, and food. The shiner and other small-bodied cyprinids strongly selected perpendicular and parallel plunge habitats with average depths of 24 centimeters (0.78 feet) and average velocities of 0.18 meter per second (0.60 feet per second). These habitats were characterized by sudden increases in depth and reduced velocity, often with vertical recirculation or an eddy effect that have the potential to provide areas for resting, food entrainment, and adjacent cover for escape from predators. More than 60 percent of shiners were collected in these plunge habitats, which comprised a very small percentage of all available habitats at all flows.

6.5.2 Interior Least Tern (Sterna antillarum athalassos)

The interior least tern is a federally endangered species and a New Mexico endangered species. Severe declines of interior least tern populations were due to habitat loss from river channelization, dam construction, and regulated flows. In New Mexico, this species is at the extreme southern and western periphery of its range. The first recorded sightings of interior least tern in New Mexico occurred in 1949 at BLNWR (Jungemann, 1988). A small population of least terns has used this area for the past 51 years; the number of terns sighted at BLNWR during peak abundance fluctuates annually. There is no designated critical habitat for this species.

The interior least tern is the smallest member of the tern subfamily (Sternidae), measuring about 21 to 24 centimeters in length with a 51-centimeter wingspan. Sexes are alike, with a characteristic black-capped crown and white forehead. The back and dorsal wing surface are grayish, with white breast, belly, and underwings. Legs are shades of orange or yellow, and the bill, which is black tipped, also varies from yellow to yellow-orange in color. Immature least terns have darker plumage than adults, a dark bill, and a dark eye stripe. Least terns lay two to three eggs beginning in late May, with incubation lasting approximately 20 to 25 days. Tern chicks are capable of mobility but remain at the nest and are fed by parents. They gradually wander away from the nesting territory as they mature. Fledging occurs at about 3 weeks, with parental attention continuing until migration.

Interior least terns may use areas within the Pecos River basin for both nesting and feeding. Throughout the interior least tern’s range, the nesting period begins in mid-May and may last through August. Interior least terns typically nest in colonies on broad, unvegetated sandbars and flats. The nest is scraped in sand and/or gravel and is normally unlined. An important factor for successful interior least tern nesting is the adequacy of the food base. Interior least terns feed exclusively on small fish (Kingery, 1998), indicating that an adequate food base for both adult and young-of-the-year is common in the Pecos River.

Tern use of reservoir storage space has been documented outside of the study area (Kingery, 1998). However, it has been documented that nesting success within reservoir pools is less successful than nesting on islands and sandbars (Kingery, 1998). In 2004, several nesting pairs of interior least terns were sighted within the conservation storage space of Brantley Reservoir (between the 3240- and 3245-foot elevation contours). There is currently no knowledge of whether suitable habitat for the tern occurs at other elevations within the reservoir. Therefore, the known elevation was used as a benchmark to evaluate potential impacts to the species. In 2005, monitoring of the shoreline and adjacent areas of Brantley Lake began the second week of May and continued through July at approximately 2-week intervals. Terns were observed, but no evidence of nesting was found during the summer months.

6.5.3 Other Special Status Species

Table 3.8 presents the other special status species listed within the study area, describes their requisite habitat components, and portrays whether the species is further analyzed in chapter 4. For those species not requiring further analysis, impacts to the species are included in analysis of impacts to their habitats encompassed by each resource area (e.g., Pecos assiminea snail habitat covered by the terrestrial and flood plain ecosystem components).

Table 3.8 Special status species list, including Federal endangered species - status of wildlife and plants listed within the study area: T = threatened, E = endangered, P = proposed, CH = critical habitat, SC = species of concern

Common name	Scientific name	Life requisite	FWS Status	NM Status	Resource area coverage	Further analysis
Plants						
Gypsum wild buckwheat	*Eriogonum gypsophylum*	The species has been recorded in one location within the study area of the Pecos River basin (Hildebrandt & Ohmart, 1982; Martin & Hutchins, 1980, 1981), on some rocky hillsides near Seven Rivers, but not within riparian areas. It does not grow in sandy or loamy conditions.	T	E	Terrestrial ecosystem	No
Kuenzler hedgehog cactus	*Echinocereus fendleri var. Kuenzleri*	The species is xerophytic and occurs primarily on gentle, well-drained, gravelly-to-rocky slopes and benches on limestone or limey sandstone in upland habitat types. Resource inventory reports do not show this cactus growing within the study area.	E	E	Terrestrial ecosystem	No
Lee pincushion cactus	*Coryphantha sneedii* var. *leei*	This species grows primarily in cracks in limestone in areas of broken terrain and steep slopes of Chihuahuan desert scrub. In New Mexico, the species grows on rocky slopes or limestone ledges above 4000-foot elevation. No findings of this cactus have been reported within the riparian areas of the Pecos River basin.	T	E	Terrestrial ecosystem	No

Table 3.8 Special status species list, including Federal endangered species - status of wildlife and plants listed within the study area: T = threatened, E = endangered, P = proposed, CH = critical habitat, SC = species of concern

Common name	Scientific name	Life requisite	FWS Status	NM Status	Resource area coverage	Further analysis
Puzzel (Pecos) sunflower	*Helianthus paradoxus*	This species is common to desert wetlands, such as springs and seeps, as well as along margins of streams and impoundments. It is found in permanently saturated soils. It is found within study area on BLNWR and at the Dexter National Fish Hatchery near Dexter, New Mexico.	T	E	Terrestrial and flood plain ecosystem	No
Invertebrates						
Pecos assiminea snail	*Assiminea pecos*	This species is a terrestrial snail, inhabiting moist substrates adjacent to flowing water. It needs a humid microclimate (NMDGF, 1988). It has been observed underwater (NMDGF, 1996), but it is not known if this is typical behavior or an accidental occurrence. CH has been proposed for this species.	E	E	Terrestrial and flood plain ecosystem	No
Noel's amphipod	*Gammarus desperatus*	This species inhabits brackish to freshwater springs associated with Permian marine sediments (Cole, 1985). Two populations have been extirpated since the 1950s. Loss of habitat and decreases in existing populations indicate that the species' persistence is precarious (NMDGF, 2002a). It is endemic to southeastern New Mexico; it is known only from springs at the Roswell Country Club, Lander Springbrook, and BLNWR (Cole et al., 1991). CH has been proposed for this species.	E	E	Terrestrial and flood plain ecosystem	No
Texas hornshell	*Popenaias popeii*	This species, also referred to as "Pope's mussel," occurs on soft or rocky substrates in larger streams. Texas hornshell populations in New Mexico are marginal at best. Current distribution in New Mexico is confined to approximately a 14-kilometer reach of the Middle Black River in Eddy County (NMDGF, 2002a).	--	E	Terrestrial and flood plain ecosystem	No
Roswell pyrg [springsnail]	*Pyrgulopsis roswellensis*	The Roswell pyrg is endemic to south-western New Mexico, with populations occurring only at the Roswell Country Club and BLNWR. These populations are thought to be stable under current conditions (NMDGF, 2002a). Preferred habitat appears to be limestone rubble in swift spring outflows (Noel, 1954). The species can survive in small seepage areas as long as flow persists, but population densities decrease with decreasing current velocity (NMDGF, 1988). CH has been proposed for this species.	E	E	Terrestrial and flood plain ecosystem	No
Koster's springsnail	*Tryonia kosteri*	This species is strictly aquatic and occurs in slow-velocity water or off-spring habitats and streams. It occurs mainly on soft substrates, such as mud and organic debris, but it may attach to pebbles and vegetation. It occurs at Roswell Country Club and BLNWR; these populations are considered stable. Proposed CH is on BLNWR.	E	E	Terrestrial and flood plain ecosystem	No

Table 3.8 Special status species list, including Federal endangered species - status of wildlife and plants listed within the study area: T = threatened, E = endangered, P = proposed, CH = critical habitat, SC = species of concern

Common name	Scientific name	Life requisite	FWS Status	NM Status	Resource area coverage	Further analysis
Fishes						
Blue sucker	*Cycleptus elongates*	This species inhabits deep pools and channels in moderate to large rivers. Adults prefer swift water. The blue sucker spawns in riffles over bedrock and cobbles and feeds in riffle habitats over firm substrates and areas with dense algal growth. It occurs between Brantley Dam and Avalon Reservoir and occasionally downstream from Avalon Dam to the New Mexico-Texas State line.	--	E	Riverine ecosystem	No
Pecos bluntnose shiner	*Notropis simus pecosensis*	See narrative.	T/CH	T	Riverine, special status species resources	Yes
Arkansas River shiner	*Notropis girardi*	This species was introduced into the Pecos River by bait bucket. It is a pelagic, broadcast spawner that spawns from May though July. The Arkansas River shiner feeds on invertebrates and detritus.	E	--	Riverine ecosystem	No
Pecos gambusia	*Gambusia nobilis*	This species is endemic to the Pecos River. It inhabits backwaters, pools in small tributaries, and springs of off-channel sites along the Pecos River between Sumner Dam and the New Mexico State line. No populations currently exist in the mainstem Pecos River in New Mexico.	E	E	Terrestrial/ flood plain ecosystem	No
Pecos pupfish	*Cyprinodon pecosensis*	Little is known about the historic distribution and abundance of Pecos pupfish before 1950. It inhabits shallow ground water or springs associated with sinks and marsh habitat. The pupfish is present on BLNWR and Bottomless Lakes State Park areas, and it may enter the Pecos River from connected waterways.	--	T	Terrestrial/ flood plain ecosystem	No
Gray redhorse (sucker)	*Scartomyzon congestum*	The gray redhorse dwells in clear-to-moderately turbid, warm, sluggish, low-gradient streams. It occupies medium-to-large pools, with cobble, gravel, silt, or sand bottoms. At present, it is only found downstream from Brantley Dam in the Pecos River and in the lower reaches of the Black River.	--	T	Riverine ecosystems	No
Mexican tetra	*Astyanax mexicanus*	This species is associated with pool and backwater habitats in clear flowing water over gravel bottoms. It is known to occur in the Pecos River between Sumner Dam and Brantley Reservoir and on BLNWR. It also occurs at some stream and spring habitats off the Pecos River channel.	--	T	Riverine ecosystem	No

Table 3.8 Special status species list, including Federal endangered species - status of wildlife and plants listed within the study area: T = threatened, E = endangered, P = proposed, CH = critical habitat, SC = species of concern

Common name	Scientific name	Life requisite	FWS Status	NM Status	Resource area coverage	Further analysis
Greenthroat darter	*Etheostoma lepidum*	This species is associated with streams and small rivers having clear water, aquatic vegetation, and gravel-to-cobble substrates. It inhabits swift-flowing streams and springs, especially vegetated riffle areas with gravel and rubble substrates. The species is native to the Pecos River and occurs in the study area at BLNWR, Pecos River between Brantley Dam and Avalon Reservoir, including the Black River.	SC	T	Riverine ecosystem	No
Bigscale logperch	*Percina macrolepida*	This species is located in streams and rivers with deep, non-turbulent, fast flows over cobble substrate. It is also found within impoundments. It is documented in the Pecos River between Santa Rosa Dam and Sumner Lake and in the area of Carlsbad and the Black River.	--	T	Riverine ecosystem	No
		Herpetiles				
Western river cooter	*Pseudemys gorzugi*	This species prefers streams with slow-to-moderate current, firm bottoms, and abundant aquatic vegetation. It also inhabits stock tanks, ponds, large ditches, and even brackish tidal marshes. It is confined to the Pecos River drainage, including the Pecos, Black, and Delaware Rivers down stream from Brantley Dam.	--	T	Terrestrial/ flood plain ecosystems	No
Plainbelly water snake	*Nerodia erthrogaster*	This species inhabits backwaters, pools in wet woodlands, rivers, ponds, sloughs, lakes, dams, and any waterways. It is active from April to October and begins breeding soon after emergence. Its presence is known only from the lower Pecos Valley area, including along the Black and Delaware Rivers.	--	E	Terrestrial/ flood plain ecosystems	No
Western ribbon snake	*Thamnophis proximus*	This species is found along the margins of water bodies, including rivers, streams, springs, stock tanks, and irrigation canals. It prefers areas that are open and sandy, associated more with brush than forest. It is known to occur in abundance at BLNWR.	--	T	Terrestrial/ flood plain ecosystems	No
Blotched water snake	*Nerodia erythrogaster transversa*	This is a highly aquatic species; it swims and dives with ease and seeks its prey in water. It is confined to areas of permanent water in New Mexico. It is known to occur only from the lower Pecos Valley area, including along the Black and Delaware Rivers.	--	E	Terrestrial/ flood plain ecosystems	No
		Birds				
Northern aplomado falcon	*Falco femoralis septentrionalis*	This falcon is associated with open desert grasslands in scattered yuccas, mesquite, and other shrub or forested borders. The species typically nests in April and May in shrubs and trees. The last nesting pair was reported near Deming, New Mexico, in 2002.	E	--	Terrestrial ecosystem	No

Table 3.8 Special status species list, including Federal endangered species - status of wildlife and plants listed within the study area: T = threatened, E = endangered, P = proposed, CH = critical habitat, SC = species of concern

Common name	Scientific name	Life requisite	FWS Status	NM Status	Resource area coverage	Further analysis
Bald eagle	*Haliaeetus leucocephalus*	Bald eagles usually overwinter in the study area from October to April. The density of this species depends on prey, suitable perch and roost sites, weather conditions, and, sometimes, lack of human disturbance. Individuals are generally found from the headwaters of the Pecos River to just downstream from Fort Sumner.	T	--	Terrestrial ecosystem	No
Interior least tern	*Sterna antillarum athalassos*	See narrative.	E	E	Terrestrial, special status species resources	Yes
Mexican spotted owl	*Strix occidentalis lucida*	This species inhabits mountains and canyons in dense, multistoried forests with close canopies. It nests in mixed-conifer forests, typically in April. The Mexican spotted owl broods less than three young. There are no reported sightings within study area.	T	--	Terrestrial ecosystem	No
Piping plover	*Charadrius melodus circumcinctus*	This species is found on beaches with wide, sandy, cobbly material near open water. The species is sensitive to human disturbance. It is rare in New Mexico; it was last reported in 1995.	T	E	Terrestrial ecosystem	No
Common ground dove	*Columbina passerina pallescens*	This species inhabits lowland riparian and marshy areas including cultivated and abandoned fields, gardens, citrus groves, and pine and scrub oak woods. It is rare in New Mexico; the last nest sighted in New Mexico was prior to 1990.	--	E	Terrestrial ecosystem	No
Brown pelican	*Pelecanus occidentalis*	This species is transient and strictly coastal. Vagrants or misdirected juveniles have been spotted in New Mexico. It inhabits shallow water estuarine areas or offshore sandbars. It nests on the ground or on slightly elevated platforms.	--	E	Terrestrial ecosystem	No
Mammals						
Black-footed ferret	*Mustela nigripes*	This species was once common in New Mexico, but it is now extirpated. Reported sightings throughout New Mexico may have been a long-tailed weasel subspecies. The black-footed ferret is closely associated with prairie dog communities, which are also rare in New Mexico. There are no recent records of the black-footed ferret in the Pecos River basin.	E	--	Terrestrial ecosystem	No
Least shrew	*Cryptotis parva*	This species is less than 3 inches long and lives in forested areas and weedy fields. The species burrows, making nests out of leaves and grasses. It may have up to three litters per year with up to nine young per litter. It is known to occur at BLNWR.	--	T	Terrestrial ecosystem	No

Critical Habitat and ESA

Critical habitat under ESA:

- Within the **geographic area** occupied by a species as well as specific areas outside the occupied geographic area that are essential
- Contains **physical or biological features** essential to conservation of the species;
- May require **special management considerations and protection.**

Under ESA, Federal agency actions may not result in the destruction of habitat or adverse modification of designated critical habitat or habitat proposed for such designation.

6.6 Critical Habitat Occurring Within the Study Area

Two sections of the Pecos River within the study area are designated critical habitat for the Pecos bluntnose shiner: (1) an approximately 64-mile section south of Fort Sumner in DeBaca and Chaves Counties and (2) an approximately 37-mile section near the cities of Hagerman and Artesia. Constituent elements identified for this critical habitat include permanent water, a main river channel habitat with sand substrate, and a low- velocity flow.

Critical habitat has been designated for four invertebrate species (*Pecos assiminea* snail, Noel's amphipod, Roswell springsnail, and Koster's springsnail) known to occur in some nonriverine aquatic habitats within the general study area (Service, 2002a). Critical habitat for these species includes 1,127 acres of BLNWR. Primary constituent elements of critical habitat for these four species have been identified as permanent, flowing, unpolluted, fresh to moderately saline water; slow to moderate velocities of water over substrates ranging from deep organic silts to limestone cobble and gypsum substrates; presence of algae, submerged vegetation, and detritus in the substrata; water temperatures in the approximate range of 10 to 20 degrees Celsius (50 to 68 °F), with natural diurnal and seasonal variation slightly above and below that range. In addition to these primary constituent elements, *Pecos assiminea* proposed critical habitat has one additional element: moist soil at stream or spring-run margins with vegetation growing in or adapted to an aquatic or very wet environment (e.g., salt grass or sedges).

The indicators used to evaluate the riverine aquatic ecosystem also were used to evaluate the effects of the alternatives on the Pecos bluntnose shiner critical habitat. These indicators are appropriate because the critical habitat is located in a river section of the Pecos River system and numerous researchers (Hatch et al., 1995; Hoagstrom, 2003; and Kehmeier et al., 2004) identified frequency, extent and duration of peak and intermittency to be important indicators for Pecos bluntnose shiner survival.

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7. Regional Economy

7.1 Introduction

The following indicators were selected to evaluate impacts on the regional economy:

- Change in value of regional output produced in the study area
- Change in regional income
- Change in regional employment
- Change in farm acreage

These indicators and the reasons for their selection are discussed in detail in chapter 4. To provide the context for these indicators, this section describes the following aspects of the regional economy:

- Population
- Education
- Total personal and per capita income
- Earnings by industry
- Employment/unemployment
- Poverty
- Value of agricultural production
- Agricultural acreage

Appendix 5, "Estimating Regional Economic Impacts," provides additional information.

7.2 Impact Area

The study area (proceeding downstream) includes the New Mexico counties of Guadalupe, De Baca, Chaves, and Eddy (map 3.3). The larger economic impact area includes Curry and Roosevelt Counties. These two counties include regionally important cities that have strong economic ties to the four counties in the study area.

The Pecos River study area begins in northwest Guadalupe County and bisects the four counties as it flows south to the Texas border (map 3.3). Eddy County borders the west Texas panhandle and includes the towns of Artesia and Carlsbad, the county seat. Carlsbad Caverns National Park is about 16 miles southwest of Carlsbad. Roswell is the county seat of Chaves County and is also a tourism center. Fort Sumner is the county seat of De Baca County, and Santa Rosa is the county seat of Guadalupe County. The largest city in Curry County is Clovis, and the largest city in Roosevelt County is Portales. Government, services, and retail trade are the largest industry sectors of the regional economy, with agriculture important in some parts of this area. The majority of irrigated land in the study area is located in Eddy County.

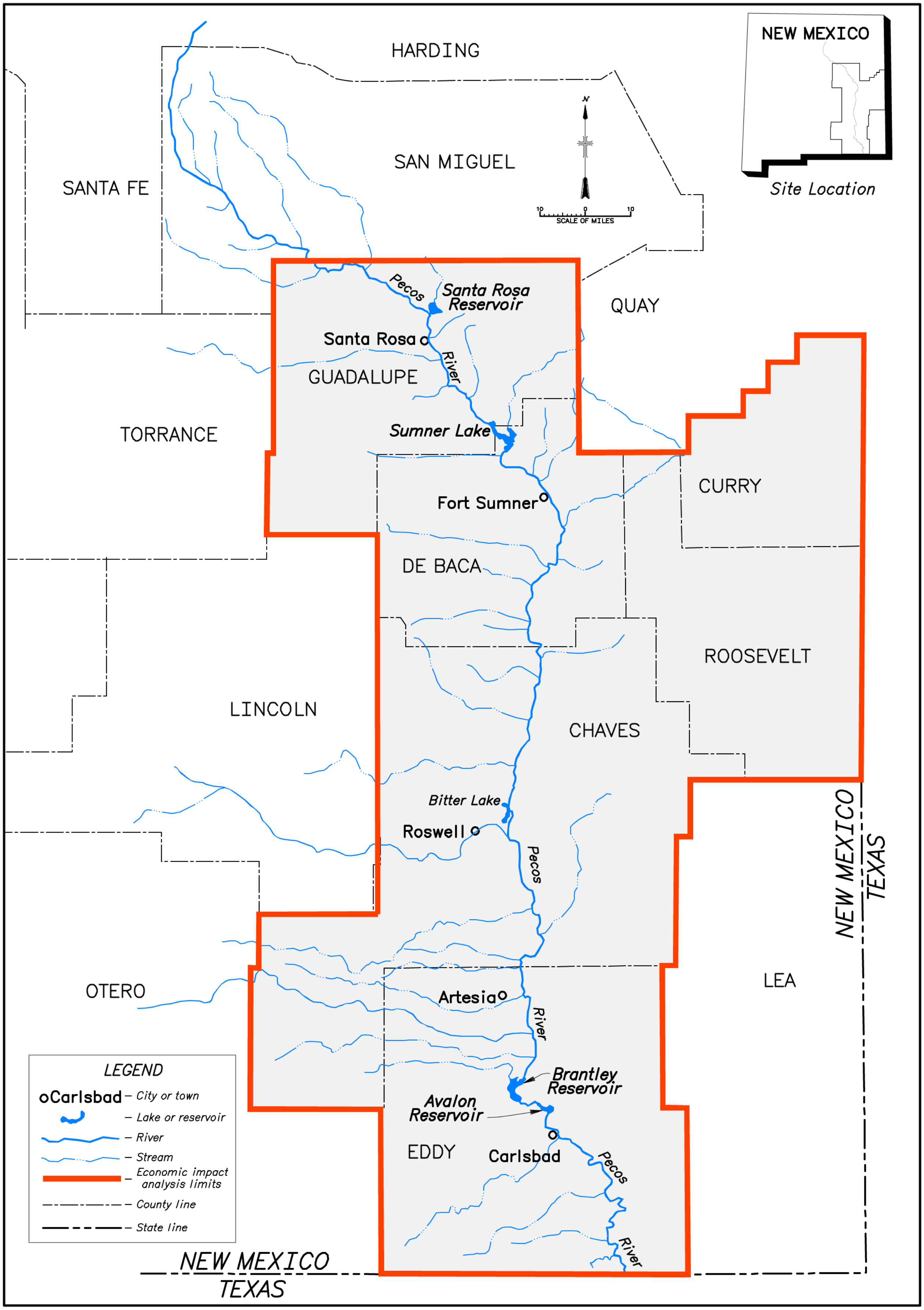
7.3 Population

The 2000 Census estimated a population of 183,022 in the impact area. The region is predominantly rural, with almost 57 percent of the population concentrated in the cities of Roswell, Carlsbad, and Clovis (table 3.9). Nearly 86 percent of the area's total population lives in Chaves, Eddy, and Curry Counties. More than one-half of each county's population resides in their respective county seats. De Baca County is the only county that experienced a population loss from 1990 to 2000 (0.5 percent). Chaves County's population increased approximately 6.1 percent from 1990 to 2000. However, the population of Chaves County actually decreased from 1995 to 2000. The same pattern of growth and decline applies to De Baca, Eddy, and Roosevelt Counties. Eddy County's population increased a net 6.3 percent from 1990 to 2000. Guadalupe County's population fell in 1995 and then rose for a net increase of 12.6 percent by 2000. The regional population increased by 11,251 people for a net 6.5 percent gain for the decade. During this same time period, the State of New Mexico's population increased by more than 20 percent.

Table 3.9 Population of the study area (1990-2000)

County/City/State	1990	1995	2000
Chaves County	57,849	61,539	61,382
Roswell	44,654	47,048	45,293
Curry County	42,207	47,464	45,044
Clovis	30,954	35,150	32,667
De Baca County	2,252	2,355	2,240
Fort Sumner	1,269	1,338	1,249
Eddy County	48,605	52,889	51,658
Carlsbad	24,952	26,822	25,625
Artesia	10,610	11,441	10,692
Guadalupe County	4,156	4,125	4,680
Santa Rosa	2,303	2,295	2,744
Roosevelt County	16,702	18,615	18,018
Portales	10,690	11,444	11,131
Study area counties	171,771	186,987	183,022
New Mexico	1,515,069	1,682,417	1,819,046

Sources: U.S. Census Bureau, 2000.
Bureau of Business and Economic Research, University of New Mexico, 2004.



Map 3.3 Economic impact analysis area

Table 3.10 presents population projections from the New Mexico Bureau of Business and Economic Research for the impact area and New Mexico. As shown, only the population growth rate for Guadalupe County is projected to keep pace with the State growth rate through 2010. The projected growth rates of the other counties are less than one-half that of the State's. From 2000 to 2030, none of the population growth rates of the counties are projected to keep pace with the State's. The percentage change in projected population from 2000 to 2010 and 2000 to 2030 is also shown in figure 3.5.

Table 3.10 Population projections for the study area (2010-2030)

County/ State	2010	2020	2030	% change 2000 to 2010	% change 2000 to 2030
Chaves	64,864	67,591	69,251	5.7	12.8
Curry	46,973	48,190	48,168	4.3	6.9
De Baca	2,289	2,296	2,296	2.2	2.5
Eddy	55,274	58,514	61,066	7.0	18.2
Guadalupe	5,304	5,748	5,989	13.3	28.0
Roosevelt	20,197	22,159	23,773	12.1	31.9
New Mexico	2,112,986	2,383,116	2,626,553	16.2	44.4

Source: Bureau of Business and Economic Research, University of New Mexico, 2004.

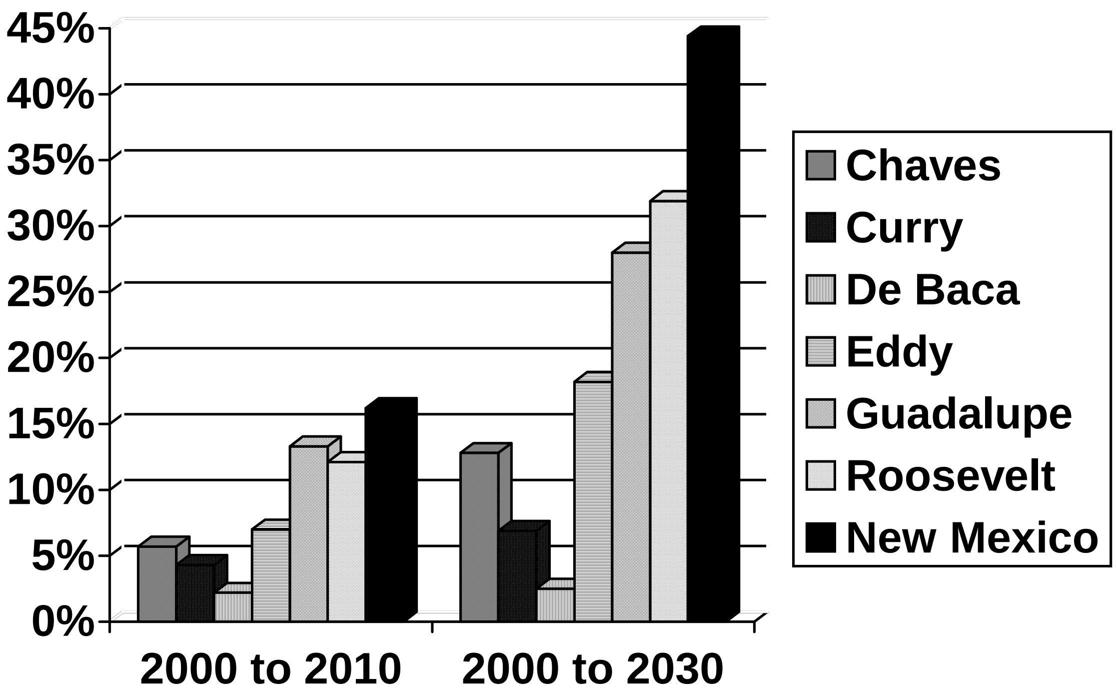


Figure 3.5 Percentage change in projected population.

7.4 Education

Table 3.11 presents the level of education in the impact area, New Mexico, and the United States in 2000. The percentage of high school graduates for the counties in the study area is less than the State and national averages. The percentage of college graduates in New Mexico and the Nation was about 24 percent, while the percentage of college graduates in the study area counties ranged from 10.3 percent to 22.6 percent. Such figures can partially explain the lower incomes and higher than average rates of unemployment and poverty discussed in the following sections.

Table 3.11 Education level 2000 data (percent of total population 25 years and older)

Area	Less than high school graduate (%)	High school graduate or higher (%)	Bachelor's degree or higher (%)	Population 25 years and older
Chaves County	27.4	72.6	16.2	37,811
Curry County	21.6	78.4	15.3	26,403
De Baca County	27.6	72.4	16.3	1,584
Eddy County	25.0	75.0	13.5	32,572
Guadalupe County	31.6	68.4	10.3	3,099
Roosevelt County	24.8	75.2	22.6	10,245
New Mexico	21.2	78.8	23.4	1,134,801
United States	19.6	80.4	24.4	182,211,639

Source: U.S. Census Bureau, 2000.

7.5 Total Personal and Per Capita Income

Table 3.12 presents the household or total personal incomes (TPI) and per capita personal incomes (PCPI) for the impact area, New Mexico, and the United States. Per capita income measures average income per person. In 2002, New Mexico's TPI was $45.9 billion, accounting for about 0.5 percent of the United States' TPI. Chaves, Curry, and Eddy Counties each had TPIs of more than $1 billion in 2002. De Baca, Guadalupe, and Roosevelt Counties each had relatively small TPIs compared to the other counties in the study area. Figure 3.6 shows a comparison of 2002 per capita income for the six study area counties, all of New Mexico, and the United States.

New Mexico's 2002 PCPI of about $24,823 was about 80 percent of the national average (nearly $30,906) and ranked New Mexico 46th in the country, just above Montana. The PCPI of each Chaves, De Baca, and Guadalupe Counties was much lower than the State and national averages in both 1989 and 2002. In 2002, the PCPI of Chaves, Curry, Eddy, and Roosevelt Counties was better than the PCPI of the other two counties; however, their PCPIs were less than the State PCPI and the national PCPI. De Baca County's 2002 PCPI was only 66 percent of the national average. Guadalupe County's 2002 PCPI was only 47 percent of the national average. These below-average PCPIs for the six counties continue the pattern observed in 1989. In a State that is near the bottom, nationally, the affected region even falls below the State average. These data indicate that residents in the six-county region are much less financially prosperous than the average individual in New Mexico and the Nation.

Table 3.12 Total personal income and per capita income

Area	1989 total personal income ($)	2002 total personal income ($)	1989 per capita personal income ($)	2002 per capita personal income ($)
Chaves County	778,247,000	1,366,968,000	13,628	22,727
Curry County	580,446,000	1,077,395,000	13,724	23,984
De Baca County	27,107,000	43,400,000	11,978	20,299
Eddy County	666,959,000	1,218,202,000	13,894	23,763
Guadalupe County	41,057,000	65,749,000	9,651	14,415
Roosevelt County	207,074,000	428,834,000	12,572	23,792
New Mexico	21,172,658,000	45,974,027,000	14,078	24,823
United States	4,571,133,000,000	8,900,007,000,000	18,520	30,906

Source: Bureau of Economic Analysis, 2004; U.S. Census Bureau, 2004.

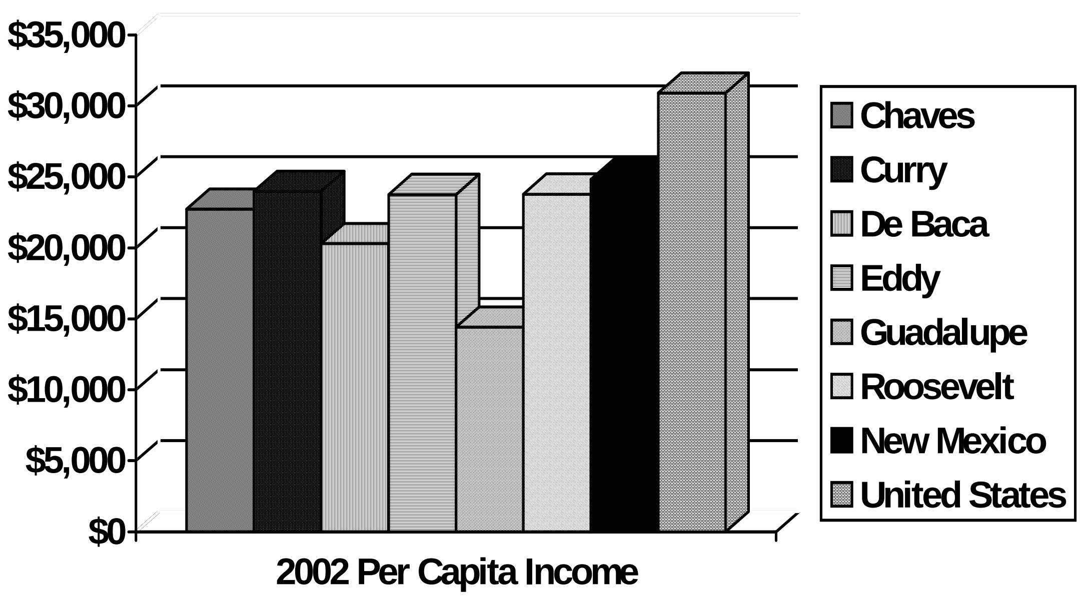


Figure 3.6 2002 per capita income in study area.

7.6 Earnings

Agriculture, government (all levels), services, and retail trade were the most important industry sectors in Chaves, Curry, De Baca, and Roosevelt Counties. These sectors accounted for at least 60 percent of total earnings in 2000 (table 3.13). Agriculture is considerably more important in De Baca and Roosevelt Counties than in the State as a whole. For New Mexico, services, closely followed by government, and, more distantly, by retail trade, accounted for more than one-half of the earnings. Mining, services, government, and transportation and public utilities were all in double figures in terms of earnings for Eddy County. The government sector accounted for about 44 percent of earnings in Curry County and 35 percent of the earnings in De Baca County. Some information is confidential because there are so few firms that it would be possible to estimate earnings for individual firms from the aggregated data. To protect privacy, these data are not presented in the Bureau of Economic Analysis tables.

Table 3.13 Percentage of total earnings by industry (2000)

Industry sector	Chaves County	Curry County	De Baca County	Eddy County	Guadalupe County	Roosevelt County	New Mexico
Farm	12.9	7.6	16.4	2.6	negative earnings	28.3	1.7
Agriculture services, forestry, fishing, and other	2.0	N/A	(D)	0.5	(D)	1.1	0.7
Mining	6.8	N/A	0.8	21.6	0.4	0.9	3.3
Construction	4.8	3.4	6.9	5.9	20.3	4.0	6.5
Manufacturing	11.0	1.8	2.7	6.2	(D)	3.6	7.6
Transportation and public utilities	4.2	11.6	(D)	12.9	24.4	9.7	6.2
Wholesale trade	3.5	2.7	(D)	2.7	(D)	2.2	4.0
Retail trade	11.3	10.4	11.7	9.0	16.3	9.5	10.4
Finance, insurance, real estate	3.6	2.9	2.7	3.0	(D)	1.9	5.2
Services	18.4	14.3	6.9	17.8	12.8	9.7	26.4
Government (Federal, State, local)	21.5	43.7	35.0	17.9	29.6	29.0	27.0
Other	NA	1.6	NA	NA	NA	NA	NA
Total earnings in 2000 ($)	777,479,000	656,193,000	20,955,000	767,881,000	44,057,000	201,686,000	29,196,377,000

(D) = not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.
Source: Bureau of Economic Analysis, 2001.

7.7 Employment/Unemployment

While agriculture provided a large portion of earned income in Chaves County, this sector accounted for less than 8 percent of the jobs in the county in 1999. Government (all levels), services, and retail trade provided more than 6 out of 10 of the total positions in the county. Agriculture was the most important source of jobs in De Baca County (nearly 3 out of 10 employment opportunities). More than 50 percent of all jobs were in the government, services, and retail trade industrial sectors. Farming employed 1.5 of every 10 workers in Guadalupe County. However, retail trade, the primary employer in Guadalupe County, employed 3 of every 10 workers. Services and government each employed approximately 2 of every 10 workers. Agriculture is a relatively important employer in the two sparsely populated counties in the affected area. For Chaves and Eddy Counties, as well as for New Mexico as a whole, agriculture is a much less important employer.

The pattern of unemployment has varied by county (table 3.14). Unemployment in New Mexico has been consistently higher than the national average. Guadalupe County has been hardest hit, with double-digit unemployment throughout the 1990s. The least populated county, De Baca, had consistently lower unemployment than the State or the Nation during this same decade. Since 1990, Eddy and Guadalupe Counties have had higher unemployment rates than the State and Nation. In 2003, Chaves, De Baca, Eddy, and Guadalupe Counties each had an unemployment rate higher than the State and national averages.

Table 3.14 Unemployment for selected years

Area	1990 (%)	1995 (%)	2000 (%)	2003 (%)
Chaves County	5.5	8.0	6.3	8.6
Curry County	5.8	5.2	3.9	3.9
De Baca County	5.0	3.0	4.5	8.7
Eddy County	6.6	7.7	6.7	6.8
Guadalupe County	11.8	11.0	8.4	8.0
Roosevelt County	6.2	5.3	3.4	3.5
New Mexico	6.5	6.3	5.0	6.4
United States	5.6	5.6	4.0	6.0

Source: Bureau of Labor Statistics, 2001, 2002a, 2002b.

7.8 Poverty

Poverty has been a problem for the region and New Mexico for a long time. Table 3.15 presents estimates of people of all ages in poverty for the impact area, New Mexico, and United States for selected years.

Table 3.15 Percentage estimates for people of all ages in poverty (selected years)

Area	1989 (%)	1999 (%)
Chaves County	22.4	21.3
Curry County	19.2	19.0
De Baca County	21.9	17.7
Eddy County	20.4	17.2
Guadalupe County	38.5	21.6
Roosevelt County	26.9	22.7
New Mexico	20.6	18.4
United States	13.1	12.4

Source: U.S. Census Bureau, 2004.

Poverty status is measured by the U.S. Census Bureau on a family basis. In other words, either everyone in the family is considered to be in poverty or no one in the family is in poverty. The family characteristics used to determine poverty status are the number of people, number of related children under 18, and whether the primary householder is over age 65. An income threshold is determined given a particular family's set of characteristics; if that family's income is below that threshold, the family is considered to be in poverty.

For example, the poverty threshold in 1999 for a four-person family with two children under the age of 18, and the householder is under age 65, is $16,895 per year. The threshold for the same family in 1989 was $12,575, and the threshold in 2004 was $19,157. The threshold changes from year to year as a result of changes in the cost of living. As table 3.15 shows, each county in the impact area has had a much higher poverty rate than the national average for all selected years. Poverty rates for the six study area counties, New Mexico, and United States are compared graphically in figure 3.7.

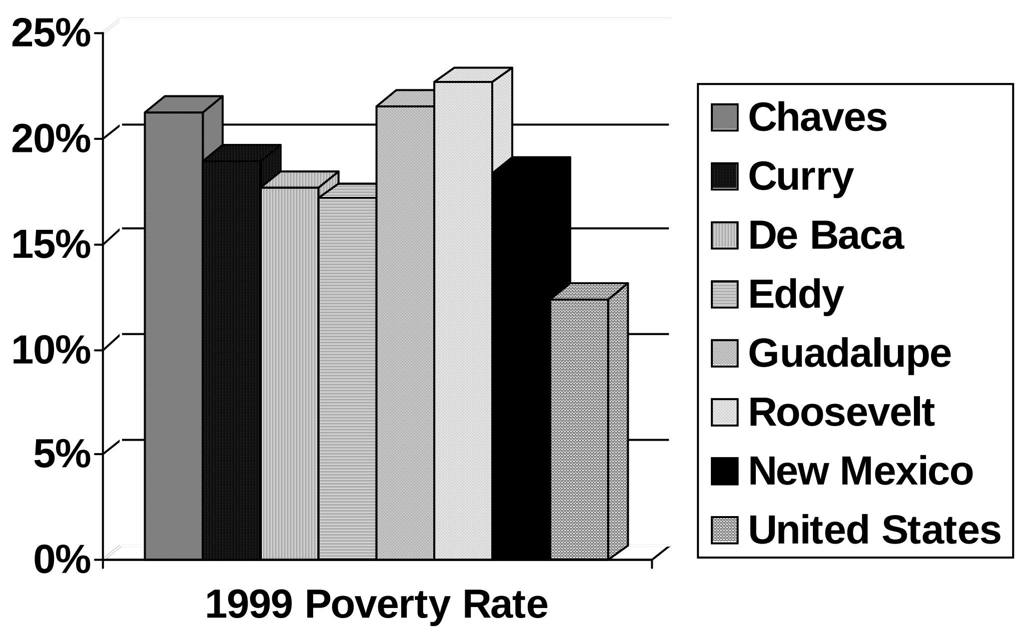


Figure 3.7 Poverty rates in study area counties.

Table 3.16 presents additional income, educational attainment, population age, occupation, and unemployment information for selected counties and towns.

Table 3.16 Socioeconomic data for counties and primary cities and towns in the affected region

2000 data	Eddy County	Artesia	Carlsbad	De Baca County	Fort Sumner	Chaves County	Roswell	Guada-lupe County	Santa Rosa
Population	51,658	10,692	25,625	2,240	1,249	61,382	45,293	4,680	2,744
Per capita income (1999 $)	15,823	13,911	16,496	14,065	13,327	14,990	14,589	11,241	11,168
Median household income (1999 $)	31,998	29,529	30,658	25,441	19,583	28,513	27,252	24,783	25,085
High school graduates or higher (%)	75.0	70.1	77.4	72.3	63.0	72.6	73.8	68.3	71.3
College graduates or higher (%)	13.5	12.1	14.5	16.2	11.8	16.2	16.9	10.3	6.7
Age of population (%)									
0 to 17 years	28.9	30.3	27.1	24.1	22.4	29.1	28.5	24.4	23.1
18 to 64 years	56.4	54.6	55.8	50.5	46.3	56.2	55.5	61.8	64.9
65 years and over	14.7	15.1	17.1	25.4	31.3	14.7	16.0	13.8	12.0
Median age (years)	36.4	35.1	37.70	43.8	45.6	35.2	35.2	37.5	36.3
Occupation (%)									
Managerial/professional	25.1	23.8	25.2	32.7	21.2	27.6	27.3	26.3	22.4
Services	17.1	15.2	19.9	17.1	26.2	16.2	17.4	30.1	35.5
Sales and office	24.9	25.3	26.0	19.3	22.2	24.9	26.3	19.3	21.6
Farming/forestry/ fisheries	2.1	3.1	0.7	6.8	4.0	4.4	2.6	1.0	0.4
Construction, extraction, and maintenance	16.4	14.7	15.5	12.8	13.6	11.1	10.7	13.1	10.7
Production, transportation, and material moving	14.4	18.0	12.5	11.3	12.8	15.8	15.7	10.1	9.3
Unemployment rate	3.9	3.6	3.8	2.9	2.5	5.0	5.2	3.6	2.9

Source: U.S. Census Bureau, 2000.

7.9 Value of Agricultural Production

The six-county impact area contained about 19.6 percent of the farms (2,988 farms) and nearly 20 percent (8,987,074 acres) of the total farm acreage (irrigated and nonirrigated) in New Mexico in 2002 (table 3.17). The 277,337 irrigated acres in the six-county area represent slightly more than 42 percent of the total irrigated cropland in New Mexico. Average-size farms in the six counties range from about 1,354 acres in Curry County to about 7,500 acres in De Baca County.

The median-size farm in each county, except Eddy County, was considerably larger than the median size of 160 acres for the State. In each county, the predominant farm size was 1,000 acres or more. Most of the harvested cropland was on farms with 260 acres or more, emphasizing the importance of large farms for agricultural production.

In 2002, farmers in the six-county region sold $815 million of agricultural products. Livestock production is the predominant agricultural activity in the region, accounting for 86.5 percent of the value of agricultural products sold in 2002 ($704,653,000) for the six-county region (table 3.18). In Guadalupe County, livestock production accounted for nearly 97 percent of the value of agricultural marketing. Livestock production in Roosevelt, Curry, and Chaves Counties ranged from 87 to 89 percent of the value of agricultural products sold. Crop production is most important in Eddy and De Baca Counties, accounting for 24 to 30 percent of the value of agricultural products sold. It should be noted that a large portion of the agricultural value in table 3.18 is not attributable to production that relies on irrigation water.

Table 3.17 Number of farms and acres (2002)

	Chaves County	Curry County	De Baca County	Eddy County	Guadalupe County	Roosevelt County
Farm (number)	604	677	188	510	208	804
Land in farms (acres)	2,515,660	916,320	1,409,434	1,183,073	1,461,766	1,500,821
Average size of farm (acres)	4,165	1,354	7,497	2,320	7,028	1,867
Median size of farm (acres)	335	490	700	161	1,200	432
Percent of harvested cropland: farm size 260 acres or more	89.6%	64.1%	N/A	88.9%	64.1%	97.7%
Percent of harvested cropland: farm size 500 acres or more	80.6%	61.6%	N/A	77.9%	47.3%	93.3%
Number of farms with harvested cropland	295	356	65	317	71	275
Harvested cropland (acres)	61,308	248,081	6,387	45,041	1,394	151,887
Irrigated acreage	59,316	88,717	6,307	43,332	1,142	78,523

N/A = not available.
Source: National Agricultural Statistics Service, 2002.

Table 3.18 Value of agricultural production (2002) in dollars

Area	Crops, including nursery and greenhouse crops	Livestock, poultry, and their products	Total market value of agricultural products sold	No. of farms	Average market value of agricultural products sold per farm
Chaves County	29,989,000	253,960,000	283,949,000	604	470,115
Curry County	26,561,000	206,039,000	232,601,000	677	343,576
De Baca County	3,598,000	11,643,000	15,241,000	188	81,069
Eddy County	24,798,000	57,413,000	82,211,000	510	161,198
Guadalupe County	344,000	10,141,000	10,485,000	208	50,407
Roosevelt County	24,627,000	165,457,000	190,083,000	804	236,422
New Mexico	397,257,000	1,302,773,000	1,700,030,000	15,170	112,065

Source: National Agricultural Statistics Service, 2002.

Farm production expenses represent a measure of the value of output demand directly tied to agricultural activity. Net cash returns from farm production measures net income generated by farming. These data are presented in table 3.19. Chaves, Curry, and Roosevelt Counties account for 86 percent of farm production expenses in the study area and 40 percent of the State total. Approximately 93 percent of the net cash return in the study area occurs in these three counties.

Table 3.19 Farm production expenses and net cash return (2002)

Area	Farm production expenses	Net cash return[1]	Net cash return per farm[1]
Chaves County	230,377,000	59,276,000	97,978
Curry County	206,114,000	43,911,000	64,861
De Baca County	13,335,000	2,381,000	12,731
Eddy County	75,696,000	7,987,000	15,630
Guadalupe County	9,705,000	1,372,000	6,627
Roosevelt County	160,738,000	42,108,000	52,569
New Mexico	1,500,021,000	294,688,000	19,373

[1] Net cash returns are equal to the total value of agricultural products sold, minus total production expenses. These figures include net cash return from agricultural sales, government payrolls, other farm-related income, direct sales, and Commodity Credit Corporation loans.

Source: National Agricultural Statistics Service, 2002.

Approximately 39 percent of all New Mexico farms had net positive revenues in 2002. The percentage of farms with net positive revenues is higher than the State average for all of the study area counties except Eddy County. Gains and losses for all of the study area counties are shown in table 3.20. The farms used to estimate gains and losses in table 3.20 include livestock operations and operations with nonirrigated crops that do not represent a high level of water demand.

Table 3.20 Farms with net gains and net losses (2002)

Area	Number of farms with net gains[1]	Average gain per farm ($)	Number of farms with net losses	Average loss per farm ($)[1]
Chaves County	304	212,582	301	(17,769)
Curry County	426	120,802	251	(30,083)
De Baca County	108	33,007	79	(14,987)
Eddy County	185	70,054	326	(15,255)
Guadalupe County	112	24,211	95	(14,103)
Roosevelt County	496	97,718	305	(20,855)
New Mexico	5,927	68,645	9,284	(12,082)

[1] Net gain refers to an operation where the value of products sold exceeds the costs of production, while a net loss occurs when the value of products sold is less than the costs of production.

Source: National Agricultural Statistics Service, 2002.

7.10 Municipal and Commercial Water Use

Municipal and commercial water use is closely tied to changes in population. Population projections for the affected area and the State are shown in table 3.10. Growth rates for the six counties are considerably below the averages for the entire State, although growth is expected to occur. This growth will translate into greater demands for municipal water. Annual average growth rates are presented in table 3.21. Future municipal and industrial water demand also could be affected by the establishment of future regional water supply systems. Improved water quality and/or reliability could result in greater household use and could attract industrial/business location in the future.

Table 3.21 New Mexico population projection annual growth rates, by county, as of July 1

County/State	2000-05	2005-10	2010-15	2015-20	2020-25	2025-30
Chaves County	0.59	0.49	0.44	0.38	0.28	0.20
Curry County	0.43	0.39	0.32	0.19	0.05	-0.06
De Baca County	0.26	0.17	0.03	0.03	-0.01	0.01
Eddy County	0.68	0.65	0.60	0.54	0.47	0.38
Guadalupe County	1.29	1.14	0.92	0.68	0.48	0.34
Roosevelt County	1.12	1.10	1.01	0.85	0.73	0.67
New Mexico	1.53	1.39	1.27	1.14	1.02	0.93

Source: Bureau of Business and Economic Research, University of New Mexico, 2004.

8. Recreation

8.1 Introduction
The following indicators were selected to evaluate recreation:

- Recreation visitation and associated expenditures at Santa Rosa Reservoir, Sumner Lake, Brantley Reservoir, and Avalon Reservoir

- Recreation along the Pecos River

These resource indicators are important because visitation is closely related to the development, operations, and maintenance of recreational facilities and to the expenditures (fiscal impacts) and economic value (benefits) of recreation. To provide a context for this indicator, this section describes each facility and its recreational uses. It then discusses current recreation visitation and associated expenditures.

8.2 Recreation Facilities

8.2.1 Santa Rosa Reservoir
In addition to its other purposes, Santa Rosa Reservoir, located on the Pecos River about 7 miles north of Santa Rosa, is a recreation use area. The Corps and the New Mexico State Division of Parks and Recreation share recreation management duties in this area. The State leases 551 acres from the Corps for Santa Rosa Reservoir State Park, which has facilities for boating, camping, fishing, hiking, picnicking, sailing, water-skiing, and wildlife viewing.

The Corps encourages fishing, hiking, and hunting on these lands. Backcountry access is by foot only. Fishing can be poor to excellent, depending on the water level; low water levels result in poor fishing success. Approximately 680 acres of land are managed by the Corps as wildlife habitat. Hunting is allowed on project lands, except within 300-yard “no shooting” zones around camping, recreational, and operational areas.

8.2.2 Sumner Lake
Sumner Lake, located on the Pecos River about 16 miles northwest of Fort Sumner, encompasses approximately 4,500 acres of water surface and 60 miles of shoreline. The New Mexico State Division of Parks and Recreation provides facilities for, and manages recreation at, Sumner Lake State Park.

Although Sumner Lake is primarily used for irrigation, recreation is also a beneficial use. Facilities are provided to support boating, camping, fishing, picnicking, sailing, water-skiing, and wildlife viewing. Visitor use during the summer is affected by extreme water levels above or below the conservation pool.

8.2.3 Brantley Reservoir

Brantley Reservoir is located on the Pecos River, 13 miles upstream of Carlsbad. The New Mexico State Division of Parks and Recreation manages recreation use at the reservoir through Brantley State Park The 3,400-acre reservoir and adjacent land provide access to and facilities for boating, camping, fishing, hiking, hunting, picnicking, water sports, and wildlife viewing.

Brantley Reservoir's importance as a water-based recreational resource is enhanced because of its location in the Chihuahuan Desert in southeastern New Mexico. Water levels fluctuate during the spring and summer because of (1) variations in releases to meet demands for irrigation by CID and (2) large variations in inflows that are primarily from block releases and monsoon season storm inflows. Water levels can fluctuate during the autumn, but generally not with as much deviation. Historic patterns of recreation use observed by Reclamation and New Mexico State Division of Parks and Recreation indicate that recreation use is primarily affected by extreme lake levels above or below the conservation pool during the spring and summer months.

Brantley Wildlife Area consists of 28,000 acres along the Pecos River and Brantley Reservoir. This area is located 15 miles north of Carlsbad and provides boating, camping, fishing, hunting, photography, trapping, and wildlife watching opportunities for the public.

8.2.4 Avalon Reservoir

Avalon Reservoir is located on the Pecos River, 3 miles north of Carlsbad. CID manages recreation under an agreement with Reclamation.

Recreational use of this reservoir is minimal, consisting mostly of day use shoreline fishing and some dispersed camping (Davis, 2002). Boating is not allowed, and there are no developed facilities to support recreation. CID does not collect or keep any records of visitor use at the reservoir. Because recreational use of the reservoir is low, there are few problems with vandalism or trash pickup.

8.2.5 Pecos River and Surrounding Area

The Pecos River from Sumner Dam to the headwaters of Brantley Reservoir is available (with limited access) for public recreation, depending upon the presence of water and rate of flow. Waterfowl hunting is popular along this reach of the river during late fall and winter.

Power Dam Lake is located one mile south of Santa Rosa and is leased by the city's department of game and fish. This 13-acre lake provides opportunities for fishing and picnicking. The water level is maintained at 38 acre-feet.

Bitter Lake National Wildlife Refuge provides more than 24,500 acres of varied habitat, including sinkholes, playa lakes, seeps, gypsum springs, alkaline wetlands, and the 9,620-acre Salt Creek Wilderness. It is an important part of the Central Flyway. This refuge is home to 350 species of birds, 57 mammal species, 50 reptile and amphibian species, and 24 fish species. It serves as the winter home for thousands of geese, lesser sandhill cranes, ducks, and other waterfowl. There is an 8-mile, self-guided auto tour and a developed wildlife viewing area. Wildlife watching and hunting are the primary recreational activities at the refuge.

The W.S. Huey Waterfowl Area encompasses 2,880 acres along both sides of the Pecos River. It is located about 6 miles east of Artesia and 5 miles north of U.S. Highway 82. This area was purchased by Reclamation to mitigate habitat changes caused by the Brantley Dam. Visitors can take a self-guided tour of the area, and waterfowl watching and upland bird hunting opportunities are offered. No boating, camping, or fishing is allowed.

Small watercraft and other flotation devices can be used on the upper reaches of the Pecos River in the spring if flows are sufficient. Fishing, however, appears to be the primary activity on the river. Fishing and other recreational activities depend on the availability of water, as well as public access. Public access below Sumner Dam is provided by the State park. Other public access is available at State and county highway bridges and across public land managed by the Bureau of Land Management (BLM). BLM does not have any developed recreation sites or river access sites along the Pecos River. The area of the river in which the greatest amount of recreational use takes place is likely directly downstream from Sumner Dam. The presence of the State park, with its camping and picnicking facilities, restrooms, and easy access, makes this a popular river recreation area.

8.3 Recreation Visitation and Associated Expenditures

A large portion of the water-oriented recreational facilities and use in the study area is associated with Santa Rosa Reservoir, Sumner Lake, and Brantley Reservoir. Streamside recreation occurs, mainly in the form of fishing, but the reservoirs are the primary water attractions in the region. Each reservoir has a State park on its shores, and these developed facilities provide additional access and encourage recreation use.

Table 3.22 presents the most recent annual visitor use at each of these reservoirs from 1999 through 2003. Most use occurs during the March through September recreation season.

Santa Rosa Reservoir State Park averaged more than 74,000 recreation visits from 1990 to 2001. Visitor use at Sumner Lake ranged from a low of less than 24,000 visits to a high of more than 127,000 visits, with an average of more than 82,000 visits each year.

Although visitation at Sumner Lake State Park has moderately decreased in recent times of drought, visitation fell drastically during 2002 and 2003. This reservoir was completely drained in 2002 for irrigation use. The lack of water and destruction of the fishery resulted in approximately 40,000 fewer visitors to Sumner Lake State Park in 2002 and an additional 40,000 fewer visitors in 2003. The 14-year average is just over 82,000 visits.

Table 3.22 Recreation use (visits per year) at State parks along the Pecos River (1999-2003)

Year	Santa Rosa Reservoir	Sumner Lake	Brantley Reservoir
1999	88,625	127,210	138,995
2000	85,823	104,285	131,192
2001	64,768	100,088	123,817
2002	50,572	61,000	97,029
2003	55,037	23,926	69,461
14-year average (1990-2003)	71,056	82,125	102,234

Source: New Mexico State Park and Recreation Division, 2002 and 2004.

Brantley Reservoir has averaged more than 102,000 visits each year. Brantley Reservoir also continued to experience low water conditions in 2002 and 2003 that substantially impeded recreational use. In 1997, Brantley State Park received more than 134,000 recreation visits, up 28 percent from 1994. Most visitors come to the park during the spring and summer (March through August) and are either local residents or from Texas.

Together, Santa Rosa, Sumner, and Brantley Reservoirs have averaged nearly 248,000 visits annually, which represent an important economic impact for the region. Table 3.23 presents expenditure data, by category, for fishing, hunting, and wildlife watching for New Mexico. The 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, conducted by the Service, only examined three activities. For the purposes of estimating recreation expenditures in the four-county area, it is assumed that expenditures for water contact activities (boating, swimming, and water-skiing) are most similar to expenditures for fishing. Camping, picnicking, sightseeing, and expenditures from other activities are assumed to be similar to those for wildlife watching (nonconsumptive activities). Total visitation is thus allocated as fishing (65 percent), hunting (10 percent), and wildlife watching (nonconsumptive use, 25 percent) to estimate recreation-related expenditures.

Table 3.24 presents the estimated recreation-based expenditures in the four-county region. Recreation at the three Pecos River reservoirs resulted in more than $11 million in annual expenditures (in 2003 dollars).

In 2001, recreation use at Sumner Lake exceeded 100,000 visits. The estimated economic impact for expenditures for food and lodging, transportation, and other items related to recreation at the park is $2.7 million. In 2003, visitation to the park dropped to about 24,000, as a result of continuing drought conditions and the draining of the lake in 2002 for irrigation use. The comparable expenditures (without adjusting for inflation and assuming the same expenditure patterns by visitors) for this lower visitation would have been about $0.8 million, an adverse economic impact of nearly $2 million. Visitors to parks located on reservoirs have adjusted to water levels fluctuating throughout the irrigation season;

however, when a lake is completely drained and its primary recreation resource is lost (the fishery), annual visitor use is drastically reduced until that lost resource is restored.

Table 3.23 Total and average per visitor day recreation expenditures for selected activities in New Mexico for 2001

Category	Fishing		Hunting		Wildlife watching	
	Total	Per day	Total	Per day	Total	Per day
Food and lodging	$35,924,000	$14.46	$25,697,000	$15.42	$92,938,000	$14.56
Transportation	29,764,000	11.98	18,916,000	11.35	52,514,000	8.23
Other	24,965,000	10.05	15,356,000	9.21	5,564,000	0.87
Equipment, etc.[1]	85,823,000	34.54	93,399,000	56.03	407,274,000	63.83
Total	$176,476,000	$71.02	$153,368,000	92.00	$558,290,000	$87.49

[1] Covers purchase of major equipment items that are durable goods (for example, boats, recreational vehicles, tents, binoculars, backpacks, etc.). These items are usually used on many separate trips and are not considered trip-specific purchases.

Source: Service and U.S. Census Bureau, 2003.

Table 3.24 Estimated annual trip-related recreation expenditures attributable to recreational use of the three Pecos River reservoirs (2003 $)

Category	Santa Rosa Reservoir	Sumner Lake	Brantley Reservoir
Food and lodging	$2,220,659	$1,242,083	$1,545,031
Transportation	1,576,907	935,228	1,163,332
Other	1,005,977	653,380	812,741
Total	$4,803,543	$2,830,691	$3,521,103

Source: NMDGF, 2002b.

Table 3.25 presents data for the Pecos River reaches. NMDGF manages three State wildlife areas located on the Pecos River. NMDGF regulates fishing and hunting and collects some visitor use data for recreation along the Pecos River. Angler days are estimated using a mail survey.

Although recreation visitation numbers are not available for the Pecos River between Sumner Lake and Brantley Reservoir, recreation use has been observed in the reach immediately downstream from Sumner Dam and within the BLM's Roswell and Carlsbad resource areas. As at the reservoirs, extremely high or low water levels affect the recreational use of the river.

BLNWR received an average of 39,500 visitors during the years 1999 through 2001.

Table 3.25 Estimated angler days for the Pecos River

Reach	License year		
	1997-98	1998-99	1999-2000
Santa Rosa Dam to Sumner Lake	6,194	7,807	8,838
Sumner Dam to Roswell	7,540	8,045	14,516
Roswell to Brantley Reservoir	28,697	28,949	20,917
Brantley Dam to Texas border	51,987	78,648	82,612
Total for the Pecos River	94,418	123,449	126,883

Source: NMDGF, 2002b

9. Cultural Resources

9.1 Introduction

The following indicators were selected to evaluate changes to cultural resources:

- The known presence or potential for cultural resources that may be eligible for listing on the *National Register of Historic Places* (NRHP) or locations that are important to Native American or other traditional communities in areas affected by the proposed action

- Riverflow and reservoir storage levels and fluctuation resulting from changes in water operations where there is a potential for directly disturbing resources, increasing access to resources, or exposing submerged resources

- Ground-disturbing activities such as drilling, trenching, grading, or construction where resources may be present; modifications to historic water retention or conveyance infrastructure; or loss or abandonment of historic structures associated with water acquisition options

These resource indicators parallel the requirements of the National Historic Preservation Act of 1966, as amended (NHPA), and other laws, regulations, and Executive orders to take in to account the effects of government actions on significant cultural resources.

In this section, cultural resources are defined and the Area of Potential Effect (APE) is described. (The APE is the physical area where the alternatives and water acquisition options may affect cultural resources.) The regulatory background and data collection and consultation activities are outlined, followed by a summary of known cultural resources.

9.2 Definitions and Area of Potential Effect

Cultural resources are locations of human activity, occupation, or use. They include expressions of human culture and history in the physical environment, such as prehistoric or historic archaeological sites, buildings, structures, objects, districts, or other places. Cultural resources can be natural features, plants, and animals that are considered to be important to a culture, subculture, or community. Cultural resources also include traditional lifeways and practices. Identified cultural resources along the Pecos River reflect the long prehistoric use of the area; attempts to regulate riverflows and irrigate crops; historic era settlement, farming, and grazing activities; and the continuity of Hispanic and Native American cultural traditions and practices.

Cultural resources have been organized into prehistoric resources, historic resources, and traditional cultural properties. These types are not exclusive, and a single cultural resource may have multiple components.

Prehistoric cultural resources refer to any material remains, structures, and items used or modified by people before Europeans established a presence in New Mexico in the early 17th century. Examples of prehistoric cultural resources in the region include room blocks, rock art, water control features, campsites, and scatters of prehistoric artifacts, such as pottery sherds or stone tool-making debris.

Historic cultural resources include material remains and the landscape alterations that have occurred since the arrival of Europeans in the region. Examples include ranching and agricultural features, water control and conveyance features, railroad and road corridors, structural ruins, and scatters of historic artifacts.

Traditional cultural properties are places associated with the cultural practices or beliefs of a living community. These sites are rooted in the community's history and are important in maintaining cultural identity. Examples of traditional cultural properties for Native American and Hispanic communities include natural landscape features, places used for ceremonies and worship, places where plants are gathered to be used in traditional medicines and ceremonies, places where artisan materials are found, and places and features of traditional subsistence systems, such as community-maintained irrigation systems and traditionally used fields, grazing areas, and firewood-gathering sites.

The cultural setting, which is included in the supporting cultural resource technical report (Tetra Tech, Inc., 2004a), includes information from the broad study area to provide background on the regional resource base and to supplement the limited synthesis of cultural resource information from the river corridor. The APE for cultural resources for the proposed changes in water operations includes the existing water channels or active flood zones of the Pecos River corridor and the various reservoir storage pools.

Other actions contemplated in the EIS include options for acquiring and developing water sources and the consideration of conservation and habitat restoration measures. Some of these actions could affect cultural resources but are not sufficiently defined to determine an APE. These actions may result in construction, ground disturbance, changes to water storage and delivery infrastructure, and land abandonment. Additional cultural resource identification, evaluation, and effects determinations would be required as these undertakings and their locations are defined.

9.3 Regulatory Background

The identification of cultural resources and Federal agency responsibilities regarding cultural resources are addressed by a number of laws, regulations, Executive orders, programmatic agreements, and other requirements listed in the cultural resource technical report (Tetra Tech, Inc., 2004a). The principal Federal law addressing cultural resources is NHPA and its implementing regulations (36 Code of Federal Regulations [CFR] 800). Section 106 of NHPA outlines the process for identifying and evaluating historic properties; for assessing the effects of Federal actions on historic properties; and for consulting to avoid, reduce, or

Cultural Resources Compliance

The National Historic Preservation Act (NHPA) is the principal Federal law addressing cultural resources. Its implementing regulations at 36 CFR 800 require Federal agencies to review actions that are federally funded, licensed, or occur on Federal or tribal land that may affect a property eligible for listing on the **National Register of Historic Places (NRHP).** NRHP is a federally maintained register of districts, sites, buildings, structures, architecture, archeology, and traditional cultural places. Properties that meet the eligibility criteria are known as historic properties. Formal nomination and listing on the NRHP is not necessary for consideration under NHPA.

The **section 106 process** is a procedure that Federal agencies follow to identify, evaluate, assess effects, and resolve adverse effects of its actions. These actions are conducted in consultation with the **State Historic Preservation Officer (SHPO),** tribes, and other parties. The Identification and evaluation of cultural resources is accomplished by first determining an **Area of Potential Effect (APE)**. The APE is the geographic area within which a project may indirectly or directly cause changes in the character or use of historic properties, if present. Additional studies (for example, archaeological surveys or architectural inventories) are conducted to determine whether there are historic properties within the APE that may be eligible for listing on the NRHP. If historic properties are present, the potential effects of the action are assessed. If there is an adverse effect, the agency works to resolve adverse effects in consultation with the SHPO, tribes, and other consulting parties. Adverse effects are most often resolved by mutual agreement. The **Advisory Council on Historic Preservation (ACHP)** may participate in controversial or precedent-setting situations. ACHP is an independent Federal agency that oversees the section 106 process and has legal responsibility to balance historic preservation concerns with Federal project requirements.

minimize adverse effects. The term "historic properties" refers to cultural resources that meet specific criteria for eligibility for listing on NRHP. This process does not require preservation of historic properties, but it does ensure that the decisions of Federal agencies concerning the treatment of these places result from meaningful consideration of cultural and historic values and the options available to protect the properties.

NHPA is triggered when historic properties may be affected by a federally funded or licensed action or by actions on Federal or tribal land. The identification and evaluation of cultural resources for NRHP eligibility is the responsibility of the lead Federal agency (in this case, Reclamation), with the concurrence of the New Mexico State Historic Preservation Officer (SHPO). The section 106 process to identify and evaluate resources and to address any adverse effects is usually conducted in phases. First, the project APE is determined and the type and level of the identification efforts are defined with consulting parties. Methods used to identify the presence of cultural resources and to determine significance vary among the resource types. When identified, cultural resources are evaluated to determine whether the resource is eligible for listing on the NRHP or is of traditional importance to contemporary communities. Resources that are already listed, that are determined eligible for listing, or that are undetermined are afforded a level of consideration under the section 106 process. Undetermined resources are those for which eligibility cannot be determined, based on current knowledge of the resource and where further work is needed to make an evaluation. Compliance with these and other provisions of the NHPA is required as a separate process that contributes to the analysis of the proposed alternatives and options in this EIS.

9.4 Data Collection and Consultation

The water channels and active flood zones of the Pecos River corridor and the reservoirs were reviewed for the presence of previously recorded cultural resources and for cultural resources surveys. A 200-meter-wide buffer zone centered on the river corridor was researched on the Internet and in person through the Archaeological Records Management System (ARMS) of the New Mexico Historic Preservation Division in Santa Fe. (The records maintained by ARMS are accessible only to qualified researchers who register annually with the Historic Preservation Division.) A buffer zone of 100 meters around each of the reservoirs was also researched. No field work was conducted. Cultural resources and cultural resources surveys referenced are from previous compliance projects or resources discovered and recorded during the course of other activities. Cultural resource locations are generally confidential, except in the case of historic structures, and are not published, in order to prevent disturbance and unauthorized collecting. In addition to reviewing ARMS records, other data sources were inspected for identifying cultural resources, including NRHP and the New Mexico State *Register*.

The identification and significance of traditional cultural properties, traditional use areas, and sacred sites are determined primarily by consulting with the affected contemporary communities. In November 2002 and September 2005, Reclamation contacted representatives of tribal groups with historic ties to the Pecos River basin or tribal groups who had expressed interest in Reclamation activities. Reclamation contacted these groups on a government-to-government basis to identify any concerns about the potential effects of future Reclamation activities connected with this EIS on a variety of issues, including cultural resources and traditional cultural properties. In addition, Reclamation contacted various representatives and offices of the Bureau of Indian Affairs (BIA), informing them of the consultation and requesting any feedback that the agency might have regarding the project and possible environmental effects, including the potential to affect cultural resources. A copy of this correspondence and list of recipients is included in appendix 6, “Consultation Letters.” During the initial consultation, BIA’s Southern Plains Regional Office declined to offer comments, but confirmed that Reclamation had contacted the appropriate Native American communities and BIA offices. The Mescalero Apache Tribe determined that the project would not affect any objects, sites, or locations important to their traditional culture or religion. The Comanche Nation responded to the second consultation letter stating that it had “no immediate concerns or issues” but wished to be “kept informed on the project’s progress.” No other responses have been received to date.

The SHPO was consulted in September 2005 and had no comments other than expressing the need to be consulted under section 106 as options were identified and proposed. Further consultation with the SHPO and Native American groups will be conducted throughout this process. Additional cultural resource compliance actions and agreements likely would be required in order to implement some water acquisition options and conservation and habitat restoration measures.

9.5 Existing Conditions

The record search identified more than 30 surveys or other cultural resource studies that include portions of the buffer zone. There has been very little systematic archaeological survey coverage overall, with even fewer of the surveys covering large blocks of land. The exception is lands surrounding the reservoirs, where cultural resource compliance projects have been conducted. Many resources near the reservoirs have been examined on multiple occasions, and site records have been updated. With much of the land adjacent to the river in private hands and undeveloped, few surveys have been conducted along the length of the river. In many areas, dense non-native vegetation inhibits survey access and visibility. Sites in the immediate vicinity of the river or in flood zones would be subject to disturbances that would reduce the likelihood of their preservation or their visibility. Few existing studies address the built environment. Because the buffer area has not been systematically studied, any patterns of resources observed reflect survey coverage and site preservation, rather than necessarily representing the potential entire range of resources present or their distribution in the vicinity of the river. However, this record search provides the best available sample of resources likely to be present along the Pecos River and reservoirs. Additional information on the results of the record search and the cultural setting are included in the cultural resource technical report (Tetra Tech, Inc., 2004a). The record search identified 250 cultural resources in the buffer zones. Almost all of these cultural resources are archaeological sites or structural ruins, except for intact bridges and water conveyance features. Of these 250 cultural resources, 70 are prehistoric, 63 are historic, and 18 have both prehistoric and historic components. Ninety-nine resources are recorded as unknown or temporally undetermined. In most cases, these sites include artifacts or features that generally would be assigned to prehistoric sites but have not, or could not, be definitely attributed to that period because of the continuity of these artifact sets or features into the historic period. In other cases, the material remains are very ambiguous or the records are insufficient to determine temporal placement.

The most common resource types recorded include some structural remains with either multiple features, components, or artifact sets (65) or structural remains with single features, components, or limited artifact sets (64). Artifact scatters consisting of more than two artifact types represent the next largest category (36), followed by lithic (chipped stone) scatters (31), and 9 other types. The records for 20 sites have not been finalized by the researchers. For these sites, only the era and location have been registered while the site forms are being completed.

The NRHP eligibility status of 187 of these resources has not been determined in concurrence with SHPO. Forty-two resources have been determined eligible for listing on the NRHP for their scientific information potential. Four have been determined eligible without specifying a criterion, and one has been determined eligible for its association with historic events. Thirteen have been evaluated and are not eligible.

Three properties are listed on the NRHP. The Fort Sumner Railroad Bridge crosses the Pecos River 2 miles west of the village of Fort Sumner. It was listed in 1979 for its association with historic events and for its architectural and engineering significance. The ruins of Fort Sumner are adjacent to the Pecos River, west of the village. Fort Sumner was listed on the NRHP in 1974 for its association with historic events and its information potential as an archaeological site. CID facilities constructed between 1888 and 1949 as part of the Carlsbad Irrigation Project or Improvement Company are a National Historic Landmark (NHL). CID was listed in 1964 as an excellent surviving representation of a large, turn-of-the-century reclamation system. Contributing elements of the NHL are along 28 miles of the Pecos River upstream of and downstream from Carlsbad. Ownership of the distribution system and other contributing elements of the NHL were transferred in 2000 from Reclamation to CID under the terms of a memorandum of understanding, which ensures continued cultural resource protection.

No traditional cultural properties have been identified, based on the initial consultation with tribal groups. Additional consultation will continue throughout the EIS process.

10. Indian Trust and Treaty Assets

10.1 Introduction

The following indicator was selected to evaluate Indian trust and treaty assets:

- The presence or potential for Indian real property, physical assets, or intangible property rights that could be affected by the alternatives and water acquisition options

To provide a context for this indicator, this section defines ITAs and the region of influence (ROI) and describes the methods of evaluation, including regulatory background and identifying techniques.

10.2 Definition and Region of Influence

Indian trust assets are legal interests in assets held in trust by the Federal Government for federally recognized Indian tribes or nations or for individual Indians. Assets are anything owned that has monetary value. A legal interest refers to a property interest for which a legal remedy, such as compensation or injunction, may be obtained if there is improper interference. A trust has three components: the trustee, the beneficiary, and the trust asset. The beneficiary is also sometimes referred to as the beneficial owner of the trust asset. In the Indian trust relationship, the United States is the trustee and holds title to these assets for the benefit of an Indian tribe or nation or for an individual Indian.

These assets can be real property, physical assets, or intangible property rights. Examples include lands, minerals, water rights, hunting and fishing rights, other natural resources, money, or claims. They need not be owned outright, but can include other types of property interest, such as a lease or a right to use something. ITAs cannot be sold, leased, or otherwise alienated without Federal approval. While most ITAs are on Indian reservations, they can be off reservations.

ITAs do not include things in which a tribe has no legal interest. Without a treaty or act of Congress specifying otherwise, land ownership can affect the determination of whether or not a resource is an ITA. For example, off-reservation sacred sites in which a tribe has no legal property interest generally are not considered ITAs. In this case, if religious or cultural resources could be affected by the Federal action, these interests would be addressed as part of the cultural resources or social impact assessment because of the lack of legal property interest. The same resource on a reservation, trust, or ceded land may be an ITA, as determined on a case-by-case basis (Reclamation, 1993).

The ROI for ITAs is the Pecos River basin, from Santa Rosa Reservoir to the New Mexico-Texas State line. Reclamation has contacted several tribal groups and the

Bureau of Indian Affairs in the Southwest, Texas, and Oklahoma to identify any tribal trust or treaty interests in the Pecos River basin.

10.3 Regulatory Background

The Indian trust responsibility is a legal duty on the part of the United States to protect and maintain rights reserved by, or granted to, Indian tribes or individuals. Trust relationships are established through a congressional act or Executive order and through provisions identified in historical treaties. These rights have been further interpreted through court decisions and regulation. This trust responsibility requires Federal agencies, such as Reclamation, to take actions reasonably necessary to protect ITAs and to fulfill treaty obligations. Agencies must respect the inherent governmental authority of Indian tribes, which is derived from their original sovereignty and is a recognized principle in U.S. constitutional law.

The Department of Interior, Departmental Manual Part 303: Indian Trust Assets, defines general Interior policy and principles for managing ITAs. Agencies are required to protect and preserve ITAs, to ensure their use promotes the interests of the beneficial owner, to enforce leases, to promote tribal control, to manage and distribute income, to maintain good records, and to protect treaty-based fishing, hunting, gathering, and similar rights of access and resource use on traditional tribal lands (Interior, 2003).

Reclamation ITA policy states, “Reclamation will carry on its activities in a manner which protects ITAs and avoids adverse impacts to ITAs when possible. When Reclamation cannot avoid adverse impacts, it will provide appropriate mitigation or compensation.” The policy requires explicit evaluation in NEPA analyses of potential effects of proposed actions on trust assets (Reclamation, 1993).

10.4 Identification

ITAs are identified primarily through consultations with federally recognized Indian tribes on a government-to-government basis (Executive Order 13084 and the Executive Memorandum of April 29, 1994, on Government-to-Government Relations with Native American Tribal Governments). The tribal government is the primary point of contact in most cases, but BIA and the Office of American Indian Trust are also consulted. The Office of American Indian Trust helps BIA develop inventory listings for ITAs for tribes. There is no comprehensive list of all ITAs for tribes and individual Indians. If ITAs could be present at a project site, and if a proposed action could conflict with Indian lands and ITAs, there must be government–to-government consultation with the recognized tribal government having jurisdiction over the affected ITAs, BIA, and Reclamation’s solicitor to determine interests, concerns, effects, and appropriate priorities for management and mitigation. Further information on the nature of the trust asset is determined by examining government documents, such as treaties, court decisions, water rights adjudication proceedings, and proclamations establishing reservations. In some cases, the measure of impact significance on ITAs may be estimated based on the monetary value of the assets to the Indian tribe, but ITAs may have social and cultural values that need to be considered in addition to their economic value.

10.5 Existing Conditions

There are no reservations, trust, or ceded lands in the ROI. In November 2002, Reclamation contacted representatives of tribal groups with historic ties to the Pecos River basin and tribal groups who had expressed interest in Reclamation activities. Reclamation contacted these groups on a government-to-government basis to identify any concerns about the potential effects of future Reclamation activities connected with this EIS on trust assets, cultural and biological resources, or tribal health and safety. In addition, Reclamation contacted various representatives and offices of BIA, informing them of the consultation and requesting any feedback that the agency might have regarding the project and possible environmental effects, including the potential to affect ITAs or cultural resources. A copy of this correspondence and list of recipients is included in Appendix 6, "Consultation Letters." BIA's Southern Plains Regional Office declined to offer comments, but confirmed that Reclamation had contacted the appropriate Native American communities and BIA offices. The Mescalero Apache Tribe determined that the project would not affect any objects, sites, or locations important to its traditional culture or religion. No other responses have been received to date.

No ITAs have been identified on the basis of this initial consultation. Additional contacts will be made to update the tribes on the progress of the EIS, to provide information on the alternatives under consideration, and to solicit any concerns relative to trust assets, cultural or biological resources, or tribal health and safety. Consultation to identify any trust issues will continue throughout the EIS process.

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11. Environmental Justice

The following indicator was selected to evaluate environmental justice:

- The proportion of physical or economic impacts compared to the distribution of specific population characteristics

An evaluation of environmental justice impacts is mandated by Executive Order 12898 on Environmental Justice (February 11, 1994). Environmental justice addresses the fair treatment of people of all races and incomes with respect to Federal actions that affect the environment. Fair treatment implies that no group of people should bear a disproportionate share of negative impacts from an action. The impacts of an action can be considered disproportionately distributed if the percentage of total impacts imposed on a specific group is greater than the percentage of the total population represented by that group. A group can be defined by race, ethnicity, income, community, or some other grouping.

Evaluating potential environmental justice concerns requires an understanding of where the project impacts are likely to occur and where potentially affected groups are located. The analysis relies on demographic data from sources such as the U.S. Census Bureau, individual counties and municipalities, and local school districts to determine the location of different groups of people. Identifying the location of specific groups can be difficult when nonpermanent residents, such as migrant workers, are in the affected area. Demographic data are poor for these groups of people. Census data do not account for all nonpermanent residents because some cannot be contacted or some may not want to be counted. In addition, the Census has a tendency to undercount the number of people in rural areas, because of difficulties encountered with contacting residents in sparsely populated regions. However, Census data are typically the most complete and comparable demographic and economic data available for individuals and households.

Income data are presented in Section 7, “Regional Economy.” The data in table 3.12 indicate that the per capita income in the economic impact area is lower than the average for all of New Mexico and for the entire United States. The per capita income of Guadalupe County was much lower than for the rest of the study area. Therefore, any alternatives that have a disproportionate adverse effect on Guadalupe County may have environmental justice issues. Per capita income for 2002 is shown graphically in figure 3.8.

U.S. Census Bureau data based on self-reporting also are available for race and Hispanic origin. Table 3.26 presents these data. Race is considered by the U.S. Census Bureau a separate concept from Hispanic origin (ethnicity). People who identify their origin as Spanish, Hispanic, or Latino may be of any race. These data indicate that the distribution of population by race and ethnicity is similar for each of the study area counties, except for Guadalupe County, which has a very large percentage of residents who identify themselves as of “other race” and ethnically Hispanic. Chapter 4 describes any potential inter-related socioeconomic impacts to both the total affected population and to the low-income and/or minority communities of concern evaluated.

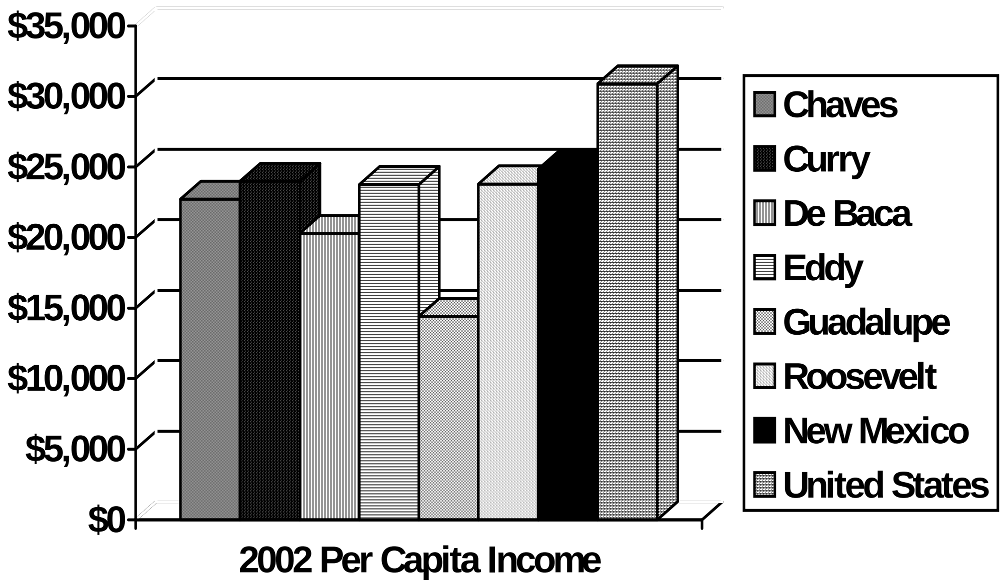

Figure 3.8. 2002 per capita income in study area.

Table 3.26 Population of study area by race and Hispanic ethnicity

Race and Hispanic origin	Chaves County		De Baca County		Eddy County		Guadalupe County		Four-county Region	
	Total	Percent of total	Total	Percent of total	Total	Percent of total	Total	Percent of total	Total	Percent of total
White	44,167	72.0	1,882	84.0	39,438	76.3	2,530	54.1	88,017	73.4
Black or African American	1,209	2.0	1	0.0	805	1.6	62	1.3	2,077	1.7
American Indian and Alaskan native	694	1.1	21	0.9	646	1.3	53	1.1	1,414	1.2
Asian	323	0.5	5	0,2	231	0.4	25	0.5	584	0.5
Native Hawaiian and other Pacific races	34	0.1	0	0,0	47	0.1	2	0.0	83	0.1
Other race	13,042	21.2	281	12.5	9,129	17.7	1,828	39.1	24,280	20.2
Two or more races	1,913	3.1	50	2.2	1,362	2.6	180	3.8	3,505	2.9
Hispanic or Latino (can be of any race)	26,904	43.8	790	35.3	20,023	38.8	3,801	81.2	51,518	42.9

Source: U.S. Census Bureau, 2005.