BIOLOGICAL ASSESSMENT

RIO GRANDE RESTORATION AT SANTA ANA PUEBLO
TERRESTRIAL HABITAT ENHANCEMENT PLAN

RIO GRANDE SILVERY MINNOW

SOUTHWESTERN WILLOW FLYCATCHER

BALD EAGLE

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U.S. Department of the Interior
Bureau of Reclamation
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This Biological Assessment analyzes the potential effects of the Rio Grande Rehabilitation through the Santa Ana Reach on the Rio Grande silvery minnow (*Hybognathus amarus*), (minnow), the southwestern willow flycatcher (*Empidonax trailii extimus*), (flycatcher), and the Bald Eagle (*Haliaeetus leucocephalus*). The river restoration work is detailed in the Project Description (attachment 1).

I. INTRODUCTION

History (Taken in part from Baird (1996), based on Crawford et. al. (1993), on the Rio Grande.)

For the last 22,000 years the Rio Grande has carried high sediment loads causing the channel to aggrade. Over a period of time, this aggradation would cause the river to seek a new course over lower elevations across the valley floor confined only by valley terraces and bedrock outcroppings (Ritter, 1986). The shifting sand substrate generally caused the river to be braided.

Historical discharges are no longer a part of the Rio Grande's hydrograph. Twenty-one annual peak discharges[1] greater than or equal to the 9,770 cubic feet per second (cfs) occurred within the first half of the century (1895-1950) and only three discharges of this magnitude have occurred within the last half of the century (1950-1995).

Channelization work on the Rio Grande occurred from 1953 to 1972. A series of levees were established along the Rio Grande to provide protection from high flows and to facilitate irrigation delivery systems to those croplands. During that time a marked decrease in sinuosity occurred as a result of channelization and reduced peak flows. When Cochiti Dam was constructed in 1975, for the purpose of flow and sediment control, the channel began to degrade, narrowing and deepening, becoming more sinuous and developing a coarser bed substrate size as a result of reduced sediment loads.

These impacts on the fluvial system have altered the processes controlling water and sediment transport. The altered sediment and flow regimes have resulted in the transformation from a wide, braided sand bed system to a single channel, incised gravel bed system through this reach. The following changes in morphologic and hydraulic characteristics summarize the channel

[1] A discharge of 9,770 cfs (the two-year return interval discharge) measured at the Otowi Gage is representative of the historic channel forming discharge.

transformation through the Santa Ana reach of the Rio Grande (Angostura Diversion Dam to Highway 44 bridge):

C Average channel slope has decreased from 0.002 to 0.00096
C Average channel top width has decreased from 1150 to 330 ft
C Average channel depth has increased from 1.6 to 3.5 ft
C Width/Depth ratio has decreased from 710 to 95
C Average channel velocities increased from 3.2 to 4.4 ft/sec
C Mean bed material size increase from 0.3 mm to >20 mm

In its current state, the Santa Ana Reach of the Rio Grande is an entrenched, slightly meandering, gravel-dominated, riffle/pool channel without a well-developed floodplain. The reach has a gentle gradient of 0.00096 with a width/depth ratio of 95. Reach averaged channel top width and flow depth are 330 and 3.5 feet, respectively at 5,000 cfs. The river banks are generally composed of unconsolidated, heterogeneous, non-cohesive, alluvial material that are finer than the gravel dominated bed material. The reach-averaged channel velocity is approximately 4.4 feet/sec. If no work is done, the river is estimated to decrease to a top width of about 250 feet with a slope of about 0.00086.

The river reduces its slope by a combination of down cutting (degradation) and lengthening (increased meandering). The river will reduce its slope until its ability to transport sediment and the sediment available are at equilibrium. The channel degradation and lengthening of this reach of the Rio Grande has resulted in a narrower, deeper channel that is disconnected with any appreciable floodplain and which threatens riverside structures.

In 1994, the Bureau of Reclamation (Reclamation) officials observed at the Santa Ana site that bank erosion was threatening the levee. Failure of the levee would lead to destruction of farm land and the main residential and commercial areas within the Santa Ana Pueblo. It would also breach the adjoining canal used for irrigation. This would cause interruption of irrigation service to the Albuquerque Division of the Middle Rio Grande Conservancy District (MRGCD). Emergency repairs were completed in 1995. Riprap was also placed on the levee slopes such that it would "launch" into the scour hole and protect the levee toe if necessary. However, before the project could be completed, safety concerns dealing with on-site procedures and equipment stopped the construction. Now, erosion has concentrated on an area downstream of the original placement, and second set of emergency repairs were made in 1998.

In 1997, a geomorphic analysis and reach wide restoration effort was undertaken. This effort addressed the degradation of historical aquatic and terrestrial habitats, channel incision, and the threatened riverside facilities. This effort, with input and coordination with the US Fish and Wildlife Service (Service), Santa Ana Pueblo (Pueblo), US Army Corps of Engineers (Corps), MRGCD, Tetra Tech ISG-FLO Engineering (FLO Engineering), Inc. and Ayres and Associates, resulted in the proposed project as described in the Project Description and Terrestrial Habitat plan. The rehabilitation of riverine habitats favorable to the minnow and a riparian Bosque connected to the river's hydrology were the primary objectives. Meeting these objectives also accomplishes the protection of riverside facilities and would allow natural fluvial processes to shape the system.

II. SPECIES DESCRIPTION

Rio Grande Silvery Minnow

Status and Distribution

The Rio Grande silvery minnow was formerly one of the most widespread and abundant species in the Rio Grande basin of New Mexico, Texas, and Mexico. Historical populations were known to have occurred in the Rio Grande upstream from present day Cochiti Reservoir; in the downstream portions of the Chama and Jemez Rivers; throughout the middle and lower Rio Grande to the Gulf of Mexico; and in the mainstem of the Pecos River from Sumner Reservoir downstream to the confluence with the Rio Grande (Bestgen and Platania 1991, Pflieger 1980)

By the 1960's, data from a number of collection efforts began to suggest that the silvery minnow had been extirpated from much of its original range. Currently, the silvery minnow occupies less than 10 percent of its historic range and is restricted to the reach from Cochiti Dam to the headwaters of Elephant Butte (Platania and Bestgen 1988; Platania 1991; Platania 1993a; Platania 1993b). The Federal Register (1993a) lists the dewatering of portions of the middle Rio Grande below Cochiti Dam through water regulation activities, the construction of main stream dams, the introduction of non-native competitor/predator species, and the degradation of water quality as possible causes for declines in silvery minnow abundance.

The silvery minnow is currently listed as endangered (Group II) on the New Mexico state list of endangered species, having first been listed May 25, 1979 as an endangered endemic population of the Mississippi silvery minnow (*Hybognathus nuchalis*) (New Mexico Department of Game and Fish 1988). On July 20, 1994, the Service published a final rule to list the silvery minnow as an endangered species with proposed critical habitat (Federal Register 1994). Proposed critical habitat was identified as the reach of the Rio Grande from the downstream side of State Highway 22 bridge crossing to the Atchison Topeka and Santa Fe Railroad bridge crossing, approximately 163 miles.

Life History and Ecology

The taxonomic status of Rio Grande silvery minnow was confirmed by Bestgen and Propst (1996). Spawning appears to occur over about a 1-month period in the late spring-early summer (May-June). Reproductive activities coincide with spring runoff. The majority of spawning individuals are Age 1 fish (1-year old); older and larger Age 2 fish normally constitute less than 10% of the spawning population. Reproductively mature females are typically larger than males; each female produces several clutches of eggs during spawning. Age 2 females are more fecund than the smaller Age 1 fish and may ultimately release up to 6,000 eggs. Following fertilization, the minnow's semi-buoyant, non-adhesive eggs drift with the current. Egg hatching time is temperature-dependent and appears to occur in 24-48 hours (more quickly in warmer water). Recently hatched larval fish are about 3.7 mm in length and attempt to remain part of the drift in the river by swimming vertically in the water column. Larvae continue to drift for a day or so after hatching, but soon move to low-velocity habitats where food (mainly phyto- and zooplankton) is abundant and predators are scarce (Platania 1995a). In low velocity habitats, e.g., backwaters and embayments, growth is rapid; silvery minnow may attain lengths of over 50 mm by December.

Spawning exerts high mortality on silvery minnow as very few adults are found in late summer. By December, the large majority (>98%) of individuals are Age 0. This ratio does not change appreciably between January and June, as Age 1 fish usually constitute over 95% of the population just prior to spawning. Generally, the population consists of only two age classes. Silvery minnow continue to grow through the winter months, albeit less rapidly than during the warmer periods of the year. Maximum size attained by this species is about 87 mm. Maximum longevity is about 25 months, but very few fish survive more than 13 months. Ongoing research should help further quantify many of these physiological characteristics.

Habitat use of silvery minnow was studied from July 1994 to June 1996 at two sites in the middle Rio Grande, i.e., Rio Rancho and Socorro (Dudley and Platania 1997). Depth, velocity and substrate measurements were collected to characterize habitat use and availability. The majority of all fish collected during this study came from the Socorro site. Silvery minnow, red shiner, western mosquitofish, flathead chub, fathead minnow, longnose dace and white sucker were relatively abundant at both sites.

Low water velocity habitats with silt/sand substrate was the most used mesohabitat type by all of the fishes collected. Habitat use was similar between the two sampling localities. Both juvenile and adult silvery minnow used mesohabitats with moderate depths (15-40cm), low water velocities (4-9 cm/sec) and silt/sand substrate. Young of year fish were generally found in shallower and lower velocity habitats than adult individuals. Seasonal changes in habitat use was most prevalent during winter months. To conserve energy while water temperatures approach freezing, silvery minnow become less active and seek habitats with cover, e.g., debris piles, and low water velocities.

Although silvery minnow are rarely collected in high-velocity conditions (associated with mid-channel areas), this is likely where spawning activities by adults take place during the spring runoff period. Silvery minnow use of overbank habitats (flooded riparian vegetation) at high discharges during seasonal flooding has not been clearly defined but this habitat could provide important rearing areas for young-of-year fish. Silvery minnow generally are not found associated with cool water temperatures, gravel or cobble substrates, strong currents, high salinity, narrow reaches, or areas where extended periods of channel drying have recently occurred.

Bestgen and Platania (1991) reported that silvery minnow may move upstream to seek refuge during periods of deteriorating habitat conditions. These fish appear to redistribute during periods of higher flow. Because of their spawning strategy, it is believed that the floating eggs replenish populations downstream.

Southwestern Willow Flycatcher

Status and Distribution

A final rule was published in the February 27, 1995 Federal Register to list the flycatcher as an endangered species under the ESA. The flycatcher is also classified as endangered (Group 1) by the State of New Mexico. It currently occurs in southern California, Arizona, New Mexico, southern portions of Nevada and Utah, western Texas, and possibly southwestern Colorado (Federal Register 1995a).

In New Mexico, the species has been observed in the Rio Grande, Rio Chama, Zuni, San Francisco, and Gila River drainages. Available habitat and overall numbers of flycatchers have declined statewide. In recent years, breeding pairs have been found within the Middle Rio Grande Project area above Elephant Butte Reservoir and between Espanola and Velarde, NM. There have been no sightings in the Cochiti and Angostura Reaches.

Life History and Ecology

The flycatcher is a late spring/summer breeder that builds nests and lays eggs in late May and early June and fledges young in late June or early July (Sogge et al. 1993, Tibbitts et al. 1994). Birds may be present in breeding territories as early as the beginning of May and as late as August.

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

Nesting habitat for the flycatcher varies greatly by site and includes species such as cottonwood, willow, tamarisk, box elder, and Russian olive. Species composition, however, appears less important than plant and twig structure. Slender stems and twigs are important for nest attachment. Nest placement is highly variable. Nest sites in New Mexico are nearly always over or adjacent to water. In rare cases in Arizona, birds have nested up to 100 meters (about 300 feet) from water. Nests have been observed at heights ranging from 0.6 m to 18 m and generally occur adjacent to or over water (Sogge et al. 1997).

Bald Eagle

Status and Distribution

The Service has reclassified the bald eagle from endangered to threatened in the lower 48 States. However, this action does not alter those conservation measures already in force to protect the species and its habitat. The bald eagle also occurs in Alaska and Canada, where it is not at risk and is not protected under the ESA. Bald eagles in Mexico are also not listed at this time.

Bald eagles in the middle Rio Grande (Albuquerque to Rio Chama confluence) and Rio Chama have been intensively monitored by the Corps since 1988 through two annual winter surveys. Table 2 displays results of survey counts for 1988 through 1996 from January aerial flight surveys for each year. Some years have additional flights from February, but data here are limited to January surveys for comparison across years. The mean annual sightings from 1988 to 1996 is 64. The largest number of bald eagles were sighted during 1993 with a total of 88. The final two years' of these surveys resulted in exactly the same number of sightings: 62.

Life History and Ecology

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

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

III. CURRENT MANAGEMENT DIRECTION

Rio Grande Silvery Minnow

Critical habitat for the minnow was designated on June 25, 1999. Requirements for the recovery and/or protection of the minnow are as outlined in the **Draft**, minnow Recovery Plan (1998). The goals of the recovery plan are to: 1) stabilize and enhance the minnow and its habitat in the middle Rio Grande valley and 2) re-establish the minnow in at least three other areas of its historic range.

Southwestern Willow Flycatcher

Critical habitat for the Southwestern willow flycatcher was proposed, but no final critical habitat was designated on the Rio Grande or Rio Chama. Currently, there is no recovery plan for the flycatcher. Data collection on the flycatcher along the Rio Grande (Ahlers and White, 1999), is presently ongoing, and an interdisciplinary team has been formed to develop a recovery plan. Description of habitats the flycatcher utilizes during the summer and winter seasons is ongoing, and are being refined as new information is available.

Bald Eagle

Requirements for the recovery and/or protection of the Bald Eagle are as outlined in the Southwestern Bald Eagle Recovery Plan (1982). In 1995, the prime objectives of this plan were achieved and the Bald eagle was reclassified to threatened (Federal Register 1995b), though recently, the Bald eagle was proposed for delisting (Federal Register 1999).

IV. CONSULTATION-TO-DATE

In September 1997, a multi-agency interdisciplinary team headed by Reclamation, which included federal, state, and tribal agencies was created to develop a programmatic approach to water operations and river maintenance on the Rio Grande. The area of consideration extends from Velarde, New Mexico to the headwaters of Elephant Butte. The objectives of the project were to: 1) protect river side facilities, 2) establish environmental goals, and 3) define a program of work.

At the same time, Reclamation, along with the Corps, the Service, the Pueblo, and the MRGCD, had initiated the first scoping meeting to discuss the need for bank reconstruction and protection of the levee on the Rio Grande at the Pueblo. During this meeting, the Pueblo and the Service proposed a long-term solution by suggesting that Reclamation investigate excavating a new alignment for the river channel. As a result of this scoping meeting, Reclamation initiated a reach-wide geomorphic and river mechanics analysis. This effort addressed the degradation of historical aquatic and terrestrial habitats, channel incision, and the threatened riverside facilities.

On February 20, 1998, contact was made with the Service regarding the portion of the levee at the Pueblo site. Emergency repairs were needed. In March 1998, Reclamation submitted an Emergency Consultation Request, No. 2-22-98-E-168, for Emergency Reconstruction and Bank Stabilization of a Protection Levee along the Rio Grande in Santa Ana Pueblo. An analysis of the situation was included to describe the existing conditions and the effects of this project on the minnow.

In a letter to Reclamation, dated April 3, 1998, the Service acknowledged and supported the Emergency Reconstruction and Bank Stabilization work. The Service agreed with Reclamation's determination that the Emergency work would:

> "not affect the southwestern willow flycatcher"
> "may affect, but is not likely to adversely affect the Rio Grande silvery minnow,"

citing that "the determination was base on absence of habitat for the southwestern willow flycatcher and very poor habitat for the Rio Grande silvery minnow." The Service encouraged Reclamation to seek a more long-term solution which would result in "...channel stability and benefits to fish and wildlife habitat."

A series of coordination, planning and analysis meetings with the Service, the Pueblo, the Corps, MRGCD, FLO Engineering, and Ayres and Associates have been held since initiation of the geomorphic analysis. These meetings provided a forum for all participants to input suggestions and ideas during the project development. All aspects of the project, as briefly described later in this BA and in detail in the Project Description, were discussed and conceptually agreed upon. The Service and the Pueblo were integrally involved in all aspects of the project, including the fish passage analysis, aquatic/terrestrial habitat availability analysis, and terrestrial revegetation plan.

The purpose of this project is to implement an action based on the recommendations of this coordination effort. The project description presents a design which outlines the proper dimensions, patterns, and profiles, including channel realignment, Gradient Restoration Facilities, terrestrial revegetation and vegetative bank stabilization to provide conditions suitable for minnow habitat and to reconnect the main channel with the floodplain to enhance flycatcher and Bald eagle habitats. The purpose of the BA is to re-establish contact with the Service for informal consultation on this project and to evaluate the short- and long-term effects of the project on the listed fish and wildlife species of this area.

V. EXISTING ENVIRONMENT

Rio Grande Silvery Minnow

Habitat conditions for the minnow immediately below the Cochiti Dam have changed considerably since completion of the dam in 1973. The flows from the dam are generally more clear and cool and the sediment load is greatly reduced. Substrate below the dam is mostly armored cobble, with very few depositional areas. The morphologic and hydrologic characteristics summarized in the introduction detail the changes.

Immediately upstream from the confluence of the Jemez River several side channels develop. As the river flows past the Jemez confluence it flows to the river right (looking downstream) and makes a slow left turn toward the levee. The substrate is mostly gravel and sand in this area. As the river flows toward the area where the levee is threatened (project curve) there is a pool zone. Upstream and to the river right of the project curve, large abandon terraces are present along the right bank (figure 1). At the project curve the river cuts into the eastern channel bank and is turned south, southwest. No minnows have been observed in this section of the river.

Figure 1. Looking upstream from the project curve. High flows cut into levee eroding the bank. Large gravelbar on opposite bank. Overbank flooding of bar occurs at 13,000 cfs.

The river at this point has cut a steep and deep path along the outside bend next to the levee. The sand from the failing bank (figure 2) has filled in along some of the shoreline making the depth from about three to eight feet in some places. Jetty Jacks and rock that historically helped to stabilize part of the bank have also fallen into the channel on the left side. Data describing the area downstream of the project curve, from about river mile 207.5 to 207.7, identifies a large gravel bar (river left), gradually sloping into a deep, high velocity channel or mid-channel run.

Figure 2. Looking downstream from the project curve. Bank has receded as lateral scouring flows have cut away at the levee. Brush line shows where bank once was. Jetty Jacks, sticking up in foreground, fallen in along channel bank.

Below the project curve, the river turns more to the southwest. In this section of the river the channel becomes wide and split as the thread of the stream moves back to the right bank. The middle of the channel may be as shallow as two feet and the substrate is mostly sand. Minnows have been observed here, but their presents is tenuous at best. As the channel widens, a mid-channel gravel riffle forms. The channel then becomes narrower and deeper as it passes beyond the curve, down toward the power lines. Since 1992, the river directly below the Project Curve is becoming more sinuous. Aerial photos show the river moving away from the eastern bank and returning again at river mile 207.4

Southwestern Willow Flycatcher

Since the turn of the century, a good portion of the Rio Grande's native riparian plant species has been gradually replaced by Saltcedar (*Tamarix ramosissima*), an exotic, deciduous shrub from central Asia. This plant is an aggressive species much to the detriment of more preferred native species of flycatcher habitat such as willows and cottonwoods. Additionally, Russian olive (*Elaeagnus angustifolia*) and Siberian elm (*Ulmus pumila*), commonly referred to as Chinese elm, have become established along portions or banks of the Rio Grande through this reach.

Banks along the Rio Grande in the Santa Ana reach were composite banks, made up of noncohesive materials and subject to mass wasting. Inside bends result in large gravel bars two to six feet high with no vegetation (figure 1). The channel is often incised with steep banks, especially on the outside bends become vertical or steeply graded, six to 20 feet high in some places. Where vegetation is prevalent the bank is usually lined with saltcedar and/or Russian olive.

The right bank just below the Jemez River is a 20 foot high bank heavily lined with mature Russian olive and saltcedar. As the river turns back to the southeast, this upper terrace drops about 10 feet abruptly down onto a lower terrace. Before the Cochiti Dam was built, this was an active floodplain. The reduction of flows and sediments as a result of the dams placement has caused the channel to become incised. Flows of 13,000 cfs would be necessary for overbank flooding to occur on this terrace. As seen in figures 1 and 2, the terrace slopes down toward the Rio Grande forming a large point bar as the river butts up against the levee and turns back south southwest.

This lower terrace shows signs of old secondary gravel channels running downstream, one, up against the escarpment, then the second about half way onto the bar, as the river moved away from the right bank. This point bar is sparsely vegetated, mostly with younger saltcedar regeneration and offers no suitable habitat for the flycatcher. As the river reaches the lower end of the point bar, it reconnects with the old upper terrace, again 20 feet above the water surface.

The left bank just below the Jemez River is a low terrace, with gentle five foot sloping banks. The terrace forms a large point bar which is heavily vegetated at the top of the bar with mature saltcedar and Russian olive, but is sparsely vegetated on the lower end. As the river moves back against the levee at the project curve, cottonwood trees line the bank for about 300 feet. At the lower end of the project curve, two jetties occur. The river flows southwest away from the levee forming another smaller unvegetated point bar to the left. Directly below the jetties mature saltcedar lines the levee banks.

Bald Eagle

Wintering habitat for the bald eagle occurs almost statewide in New Mexico, though most of its wintering habitat is found in the North and West parts of the state. It is also a common winter resident at Santa Rosa Reservoir. These sites have large numbers of waterfowl from November to March and fisheries supported by reservoirs that provide the prey base to support foraging eagles. Winter and migrant populations seem to have increased in New Mexico, apparently as the result of reservoir construction and the expansion of fish and waterfowl populations. This species is found occasionally elsewhere in New Mexico, in the summer (New Mexico Department of Game and Fish 1988). In recent years, there have been two active bald eagle nests in New Mexico, one each in Colfax and Sierra counties (Williams 1994).

VI. CURRENT SURVEYS

Rio Grande Silvery Minnow

Within its current range, the minnow has experienced wide fluctuations in abundance. Santo Domingo and San Felipe Pueblos within the Cochiti Division were sampled during 1994. Twenty-two silvery minnow were taken among the almost 7,000 specimens collected. Recent sampling efforts have been concentrated in the reach downstream of Angostura Diversion Dam due to upstream access difficulties. Population monitoring has been conducted quarterly since 1993 at 16 sites distributed in the Albuquerque, Belen, and Socorro Divisions. The majority of minnows are collected in the Socorro Division. The Albuquerque and Belen Divisions each yield about 10 to 15 percent of the total minnows sampled (unpublished data). Minnow populations become sporadic above the Highway 44 bridge at Bernalillo, New Mexico.

The change in habitat as a result of the Cochiti Dam has also created a change in the fish species community. It now supports more cool-water species of minnows and suckers, as well as several piscivorous non-native fish species. The minnow has been monitored in the Santa Ana Reach of the river since 1992. Minnows were first sampled in this reach in 1994 (Dudley & Platania, 1997).

The Santa Ana Reach, where the proposed action is to occur, is the second reach in this stretch below the Cochiti Dam. The minnow is very rare in this reach from the Angostura diversion structure downstream and remains uncommon to the Highway 44 bridge. The distribution of the minnows throughout the rest of the reach from the bridge downstream to Isletta, fluctuates both seasonally and annually, dependent upon flow conditions.

Part of the Santa Ana reach of the Rio Grande from river mile 209.5, just below Angostura Diversion Dam, downstream to a point bar about river mile 206.6 has been monitored for the minnow by Reclamation biologists since September 1995. Conditions within these habitats may be temporary, however. As the channel moves and responds to seasonal high and low flows, habitats change. The minnow have occasionally been collected throughout this section of river (Tables 1 & 2), but is seen most specifically in habitat types as described by Dudley and Platania (1997). The last sighting of the minnow in this section of the river was in 1997.

Table 1 - Number of Rio Grande silvery minnows caught by electrofishing.

	Project Curve		
Sample Period/Year	Above	At	Below
September 1995	0	0	0
October 1995	0	0	0
December 1995	0	0	0
August 1996	5	0	1
December 1996	0	0	1
August 1997	4	0	16
February 1998	0	0	0
February 1999	0	0	0

Table 2 - Number of Rio Grande silvery minnows caught by Seine.

Sample Period/Year	Site A	Site B	Project Site
September 1995	2	7	*
October 1995	0	0	*
December 1995	0	0	*
August 1996	0	0	*
December 1996	0	0	*
August 1997	0	0	*
February 1998	0	0	*
February 1999	0	0	*

* Unable to sample by seine.

Reclamation has conducted a semi-annual, presence/absence surveys for the past five years in areas of active river maintenance to assess the potential effects of maintenance activities on the aquatic environment. The standard monitoring method has been to use a raft outfitted with electrofishing equipment for main channel sampling and a 4 X 1.5 m seine with 0.6 cm mesh for sampling side channel, backwater, and shallow riffle habitats. The entire reach is monitored by electrofishing equipment and two sites, as described below, are sampled by seining methods.

Figure 3. Site A - Reclamation biologists seine for silvery minnows in a backwater located on the Santa Ana Pueblo, directly below Angostura Diversion Dam.

There are two sites where the minnow is sampled for by seine: Site A (about river mile 209.5)(figure 3), directly below Angostura Diversion Dam, and Site B (about river mile 208.7), immediately above the mouth of the Jemez River. Both sites are above the project curve, located one-half mile downstream from the Jemez River. Site A is a main channel run over gravel/cobble. Depending on the discharge at the time of sampling, there are several riffle areas within this section of river. In the middle of the channel at the top of the run there is a woody debris aggregate.

Site B, is a multibraided portion of the river that flows back into a single channel at the mouth of the Jemez River. Also depending on the discharge the side channels may be flowing or backwaters. The backwaters are usually sand/silt and the flowing side channels are gravel/sand substrates.

A review of the survey data thus far shows that no minnows were found in the project curve location, (about river mile 207.7). Preferred habitat availability within the project curve area appears tenuous at best. Habitat depth less than two feet has been extremely rare. At the curve, as recorded on June 30, 1995, only one habitat at the site was less than two feet in depth (61cm), however the velocity exceeded two feet per second (ft/s) or 70 centimeters per second (cm/s). Dudley and Platania (1999) reported that "It was uncommon at either site (Socorro or Rio Rancho) to collect fish in depths <10 or in depths >50 cm,"and "Few individuals from either site selected higher water velocity (>40 cm/s) areas."

Few minnows are found in the upper range of higher flows. Dudley and Platania (1999) showed that the minnow was most prevalently found (86.5 %) in these lower flows of less than 0.33 feet/sec. and occasionally found (11 %) in flows of 0.33 to 0.98 feet/sec., but rarely (0.8 %) in flows greater than 1.31 feet/sec (>40 cm/s). The fish community in general utilized flows greater than 0.33 feet/sec., more in the summer than in the winter. Dispersal flows for the minnow have not been defined.

The minnow was first observed below the project curve area in August 1996, again in December 1996 and finally, the largest population, in August 1997. In August 1997, 16 minnows were collected along an east bank point bar located at river mile 207.1, just upstream from the proposed Gradient Restoration Facility #1, (GRF1). No minnows were found in sampling efforts of February 1998 or 1999 (Tables 1 & 2). Biannual sampling is scheduled again for August 1999.

Southwestern Willow Flycatcher

Presence/absence and nest monitoring surveys along the Rio Grande have been conducted since 1993. In 1994, eleven willow flycatcher territories were detected in the San Marcial area, all above the railroad bridge (Mehlhop and Tonne 1994). In 1995, willow flycatchers were observed on the west bank of the Rio Grande south of Isleta Marsh within the Belen Division and in the lower portion of the Socorro Division, both above and below the San Marcial railroad bridge. Also in 1995, several individuals were observed along the river near Velarde, NM and nesting willow flycatchers were located on the San Juan Pueblo. In 1996, willow flycatchers were again detected during the breeding season below the San Marcial railroad bridge and in the Española valley (Ahlers and White 1996). Nesting attempts were documented at three sites in the Española valley and one site in the San Marcial area (Johnson et al. 1996).

Surveys for presence/absence and habitat suitability along the Rio Chama below Abiquiu Dam in 1994 identified no willow flycatchers and found only small areas of potential habitat (Eagle Ecological Services 1994). However, a Service biologist did record an unidentified *Empidonax* about a quarter-mile from the Rio Chama near Chili, New Mexico (Eagle Ecological Services 1994). These data indicate the lower Rio Chama may be used by flycatchers to a limited extent. Several willow flycatcher territories have been identified each breeding season from 1993-1995 in the Rio Chama drainage near Parkview, above Heron Reservoir (New Mexico Department of Game and Fish 1995). However, suitable willow flycatcher habitat along the Rio Chama is very limited, resulting in few occurrences of the species in this drainage.

Virtually no suitable habitat exists at this time for the flycatcher throughout the Cochiti and Santa Ana reaches. An annual report (Ahlers and White, 1996) showed there were no flycatchers sited along this stretch of river. The Site Description identified the habitat as having mature cottonwoods, often bordered or mixed with saltcedar and Russian olive. Willows that were seen along the high flow channels were in small patches and provided only marginal habitat at best. Point bars had sparse riparian regeneration and there was evidence of occasional overbank flooding. Ahlers and White (1996) reported that "Most of the mature riparian vegetation lacked understory structure and density and is unsuitable habitat." At this project site the high bars are very sparsely vegetated flycatcher habitat and are only inundated at about 13,000 cfs and there is no suitable habitat.

Bald Eagle

Annual Bald eagle counts are generally conducted during the second week in January. Table 3 below shows that most of the Bald eagle sightings were above the Jemez River. Infact, almost all of the sightings from the Jemez River to Cochiti Dam occurred in the upper stretch of the Cochiti Reach nearer the dam. Bald eagles generally find roosting habitat in the White Rock Canyon area during winter periods (Ahlers and White, personal communication).

Table 3. Results of winter bald eagle flight surveys during January from 1988 to 1996 on the Rio Grande and Rio Chama by the U.S. Army Corps of Engineers. Data include sightings for both adult and immature birds.

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

Very few of the sightings occurred into the Santa Ana Reach. Bald eagles are seen occasionally in summer near the Cochiti Reservoir, but have not been seen nesting below the dam.

VII. DESCRIPTION OF THE PROPOSED ACTION

The Project Description and Terrestrial Revegetation sections describe a multi-phased program.

Descriptions of each are given below.

Project Description

The Santa Ana River Rectification Project (Project) will encompass approximately 6,500 feet of the Rio Grande. The Project will consist of three phases being constructed over a three to five year time period. Phase 1, which will occur during the first year, will consist of the installation of a gradient restoration facility (GRF) and accompanying fish passage apron, the excavation of a 25-foot pilot channel, installation of river dikes to block off the existing river channel and excavation of trenches along the estimated bankline position to install bioengineering. A coffer dam will be established around the GRF construction. A sheet pile wall may be placed between the active river channel and the bio-engineering trenches to allow planting and a six inch stone toe placement. Dewatering will occur at both activities.

The bankline bioengineering will consist of planting willows along the bankline and toe protection of six-inch rock along the toe of the bank (see <u>Terrestrial Revegetation</u> section). The six inch rock is wrapped in bio-degradable coir fabric. The coir fabric will keep the rock in place until vegetation is established on the bankline. The rock is sized such that it will move during a five year flood event. The bankline will also have rootballs and footer logs installed.

The widening of the river may take longer than one year, depending on the years runoff. Excavation of some of the floodplain will occur during this phase also. Phase 2 will begin after the pilot channel has widened into the new river channel. This phase will consist of excavating the remaining floodplain areas, the planting of these areas and the installation of the bendway weirs. The bendway weirs may be constructed in Phase 3 if the channel is continuing to adjust to the new alignment during Phase 2. Phase 3 will consist of the installation of the second GRF and revegetation efforts. It should be noted that the second GRF installation is dependent upon funding from other sources. Below are the specifics of each phase.

Specific details of each phase are outlined in the Project Description.

<u>Terrestrial Revegetation</u>

Flexibility with the vegetation design and planting schedule is a must. Adaptive management will be utilized to determine vegetation planting locations, perform terracing, timing and extent of planting, etc. The revegetation enhancement feature of this project would encompass about 45 acres of land adjacent to the Rio Grande, beginning at River Mile 207 and continuing upstream to River Mile 208, near the confluence of the Jemez River. Monitoring of the hydrologic/geomorphic conditions that result from the river restoration effort will help determine the timing, location, and extent of planting for the project. The bankline revegetation area will be flooded at 5,000 cfs (6" deep); overbank flooding on the excavated terraced floodplain shall occur from 5,000-7,000 cfs.

A variable surface and terracing will be created on the excavated floodplain. Biologists will work with the construction personnel to achieve this goal. Prior to planting, soil electroconductivities

(EC) shall be determined for planting suitability of the various types of vegetation selected for a particular area. Revegetation efforts will occur in four zones: 1) the GRF bankline, 2) the bankline, 3) the backwater, and 4) the floodplain. Sustainable restoration is the goal. A combination of planting poles and natural establishment are part of the overall plan. All poles, i.e., cottonwoods/blackwillow will be caged with a minimum of four foot (4') cages to prevent potential beaver and/or rodent damage.

Both backwater areas shall be densely planted with willows. Blackwillow and cottonwood poles will also be planted to achieve an overstory canopy in these areas. No planting will occur in the area where the staging/access areas will be located for installation of GRF2. Planting will occur after the GRF2 has been installed. Santa Ana Pueblo will exclude livestock from the area.

Phases

The river revegetation work will be performed in two phases as briefly described below. In Phase 1, soil salinities (EC) and groundwater levels would be determined prior to planting. Minimal planting would occur during this phase. The primary planting that will be performed will occur within two excavated trenches located on bends near or at the confluence of the Jemez River and along the GRF1 side slopes. Some willows will also be planted along the estimated bankline where bioengineering efforts will take place.

During Phases 2 and 3, planting in the excavated floodplain and backwater zones (explained below) will occur. Live staking and brush mattressing with coyote willows will be planted along the banks between the rootballs that have been installed. After all Phase 2 work is completed, the two abandoned channels or backwater areas would be planted. All planting should occur during the December to March timeframe.

Planting methods will vary for coyote willow. In addition to mattressing and live staking, other methods may be used, such as live fascines, brush layering and joint planting. Consideration for each method is based on method type, type of embankment, slope and elevation of the visible high water mark on the newly created banks. These methods will be used to some extent with planting of cottonwoods and blackwillow poles.

Regeneration Zones

There will be four revegetation zones: 1) the GRF bankline, 2) the bankline, 3) the backwater, and 4) the floodplain.

In the GRF bankline zone, coyote willow and blackwillow/cottonwood poles will be planted in the GRF side slopes. Cottonwood and blackwillow poles will be planted on the upstream and downstream revetments.

Coyote willow, utilizing live staking and brush mattressing techniques, would be planted along the bankline of the river bend’s outside banks. Coir and/or burlap fabric would be utilized in this planting process to help stabilize the soil. These plants would be planted above the five year return interval. Plantings would serve to provide toe protection and stability. Plantings would be placed between the rootballs.

In the backwater areas, "bands" of vegetation would be created using containerized stock and/or cutting stock which would include New Mexico olive and coyote willow. The first band located near the edge of the backwater would include coyote willow and New Mexico olive. Plantings located outside of this first band would include blackwillow and cottonwood poles which are a part of the excavated floodplain zone plantings. Two, one-acre patches of dense willows will be planted between the backwater areas and main channel to establish potential flycatcher habitat.

Cottonwood and blackwillow poles would be planted at moderate densities in the floodplain zone to "jump-start" revegetation efforts. Natural regeneration, to some extent, is expected in this area.

Monitoring

The monitoring of the river restoration and revegetation project is essential to determine what adaptive management strategies will be pursued. The timing and extent of vegetation planting are dependent on the results of the monitoring of 1) Vegetation, 2) Groundwater well measurements, and 3) Hydrologic/geomorphic conditions that result from the project.

Vegetative sampling will occur one to two times per season. A three year program will be established to uantitatively measure species composition, percent cover, planting success, vegetative measurements (height, crown width, DBH, condition).

Reclamation will install five monitoring wells in the project work area. Wells will be monitored during the various construction phases and for three years thereafter.

The hydrologic/geomorphic conditions are important in determining the timing, location, and extent of vegetation planting.

Saltcedar Control

Saltcedar will most certainly try to establish itself on the floodplain and within newly disturbed areas. Utilizing a low-impact, selective herbicide application of Garlon 4 (Triclopyr), saltcedar will be best controlled in its early stages. A 25% mixture of the herbicide is necessary to achieve satisfactory control and this mixture can be obtained by adding one quart or part of the herbicide formulation plus three quarts or parts of JLB Oil Plus. JLB Oil Plus is a 100% blend of natural oils plus limonene penetrants.

Young saltcedar will be treated, as necessary, for three years after revegetation work has been completed, i.e., 3 years/phase.

VIII. ANALYSIS OF THE EFFECTS OF THE PROPOSED ACTION

The rehabilitation effort was developed to establish long-term resolution of bank stability and habitat improvement to this Pueblo site. Designed into this plan are special features which address the needs of the minnow and the flycatcher.

The project decreases the average channel velocity by 22 percent down to 3.4 ft/s, decreases channel depths by 10 percent to 3.8 ft, increases average channel width by 25 percent up to 360 ft, and increases W/D ratio by 28 percent to 105. The floodplain excavation and development adds 45 acres of floodplain which is available for potential habitat. The floodplain will be planted with cottonwood, black willow, coyote willow, NM olive, and Baccharis (see above Terrestrial Revegetation section). The revegetation plan was developed by participants from Reclamation, the Pueblo, and the Service.

To accommodate the various species to be planted on the floodplain, the floodplain elevation will vary to provide depths to the water table that are adequate for species survival. The floodplain elevations will vary from two-feet above the low groundwater elevation to four to six feet above the groundwater elevation. Various floodplain characteristics will be developed by gently sloping the ground surface, developing terraces, and providing individual areas of higher ground.

The decreases in channel velocities and channel depths and increase in average channel width improve the habitat characteristics to the benefit of the minnow. The floodplain lowering and backwater areas will provide low velocity habitats. The floodplain lowering and revegetation will establish a Bosque connected with the systems hydrology.

Gradient Restoration Facility

The project as described in phase 1 of the plan calls for the channel to be realigned, moving flows away from the present deteriorating levee bank. The project design includes a GRF. The primary purpose of the GRF is to halt continued channel incision and reduce upstream velocities. The height of the GRF will be two feet above the natural river bed with a downstream apron designated to mimic the hydraulic characteristics of natural riffles in the reach. This may provide better fish passage opportunities at the appropriate dispersal flow. As described in the project description, the apron will extend 500 feet downstream of the facility at a slope of 0.004 ft/ft. An apron slope of 0.004 was the approximate average slope of the riffles measured in this area over flow conditions ranging from 550 to 2,000 cfs. This apron design will allow the minnow and other aquatic species to move upstream and over the GRF.

Depths and velocities in existing natural riffles were measured at different discharges. At 700 cfs, the mean depth and velocity for riffles were calculated at 0.9 feet and 3.2 feet/sec. respectively. The calculated mean depth and velocity for the GRF apron at the same discharge would be 1.4 feet and 1.5 feet/sec. respectively. Average depths and velocity for the riffles at 1,500 cfs were 1.3 feet and

3.4 feet/sec. and again for the GRF apron, calculated mean depths and velocity were 2.8 feet and 1.5 feet/sec., respectively.

Though dispersal flows are not yet known for the minnow, flows calculated for the GRF apron's at 700 cfs and 1,500 cfs, are only slightly higher than the upper range of flows in which the minnow is normally found. Sustained and burst speeds for the minnow may be sufficient to negotiate these GRF's even at these flows. The calculated hydraulic conditions related to the GRF appear to be more favorable to the minnow than the existing natural riffles.

The placement of the GRF not only halts future channel degradation, but creates an upstream flow-through backwater. This backwater will result in sediment deposition, reduced velocities, shallower depths and increased water surface elevations which will inundate the adjacent floodplain. These aspects of the project provide flow conditions that are believed to be more favorable to the minnow and Bosque rehabilitation.

Oxbow Backwater Habitats

By backfilling and blocking off specific areas in the existing channel, oxbow type backwaters will be created. The new alignment will reconnect with the lower end of these backwaters. There will be no measurable flow through these backwaters. Ground water and the open lower end of the oxbows will provide sufficient water to these habitats.

The minnow is not typically found in this type of habitat. The consensus of the project participants, including those representing the U.S. Fish and Wildlife Service, was to keep these side channel areas open to provide slack water areas fringed with vegetation. These two oxbow backwater areas will be planted as described in the Terrestrial revegetation section which was developed by Reclamation, Pueblo and Service collaboration.

In addition to the backwater fringe vegetation, two densely vegetation patch areas of willows will be planted between the backwaters and the main channel. These one-acre willow patch areas are being established in the floodplain to provide variability in the terrestrial vegetation and to increase potential willow flycatcher nesting habitat.

Sedimentation

Sediment loads in the Rio Grande are among the highest of any of the rivers of the world. From the 1950's to the mid 1960's, the average annual sediment inflow into Elephant Butte reservoir reached 24,000 milligrams per liter (mg/l). Since the mid 1960's this figure has diminished considerably to its present concentration of about 5,000 mg/l.

For a similar period in time, 1956-1961, concentrations of sediment from the Rio Puerco into the Rio Grande, just upstream from Elephant Butte, contributed about 152,000 mg/l. At present, it still contributes about 50 % of the sediment to the middle Rio Grande, a total of approximately 50,000 mg/l. The concentrations of sediment in this portion of the Rio Grande far exceed the concentrations seen in the Angostura reach by 10 times the present amount. This area still remains one of the strong holds for the minnow, though populations were affected by river drying in 1996.

Three "identifiable changes in sediment load" have been observed at the combined Albuquerque/Bernalillo gages since 1958 as a result of construction activities (Bureau of Reclamation, 1999). Average sediment concentrations were at 2150 mg/l from 1956 to 1958 and decreased to 1340 mg/l by 1973. With the completion of the Cochiti Dam, the average sediment concentrations diminished to about 272 mg/l. Bureau of Reclamation, (1999) concluded that even with average sediment concentrations from the mid 1950's, a total of 1070 mg/l of suspended sediments could be added to the system without surpassing the historical load.

Short term affects of increased suspended sediment concentrations (SSC), stemming from construction activities would be limited to less than 1,000 feet downstream. SSC's from erosion of the pilot channel and excavated material will range slightly higher than 109 mg/l, the rate of the fill activity, but not higher than the bar excavation activity, calculated at 138 m/gl. The heavier portion of these sediments will fall out immediately below the construction site and the smaller, lighter sediments will dissipate to a more acceptable level within 1,000 feet of the construction site. Sediment concentrations from the river dike construction will fall within this range too.

Though little is known about SSC's for the minnow, a great deal of study has been done on salmonids and other aquatic organisms (Marcus, 1990). Though not comparable, salmonids have a low tolerance for SSC and would provide the low end level of protection for a majority of fish. *Fish Hatchery Management*, by the U.S. Fish and Wildlife Service (1983) stated that "Turbidities in excess of 100,000 parts per million[2] do not affect fish directly and most natural waters have far lower concentrations than this."

Since minnows evolved in these highly sedimented systems, SSC's should be considerably higher for the minnow. Monitoring efforts in the project description would not only provide regular checks on SSC's, but would additionally provide a baseline for the minnow. Again, the most affected area of the highest SSC's would be limited to within 1,000 feet downstream of the construction site and for the time of construction only.

Terrestrial Habitat Enhancement

The primary purpose of the terrestrial habitat enhancement is threefold: 1) to help stabilize the newly formed banks of the realignment, 2) to establish native vegetation on the floodplain, and 3) to establish native vegetation around the oxbow backwaters and in patches to increase potential flycatcher habitat areas. Establishing a riparian component during the first phases of the project is important to the structural stability of the outside banks of the realigned channel. Roots of willows and cottonwoods develop quickly. Willows, especially the Coyote Willow (*Salix exigua*), are a pioneering or early seral species and tend to be a particular favorite type of habitat of the flycatcher

[2] one part per million (1 ppm) is equal to one milligram per liter (1 mg/l).

during migration stopovers (USDA Forest Service, 1998). They are especially adept at stabilizing soils of disturbed areas. This willow is a prolific sprouter and can re-establish itself quickly following light to moderate disturbances. Cottonwoods are also a pioneering species and quickly establish disturbed soils. They are long lived and provide additional stability over time.

Initially, no type of habitat will exist after the river reforms the channel and banks. Stabilizing the banks are only a part of the beneficial effects that will be derived. Based on the successful vegetation of the banks and over time, these plants can provide a density that will offer thermal, hiding, nesting and foraging habitat for many terrestrial species, as well as birds and insects. Insects, associated with these willow stands, appear to be an important part of flycatcher's diet (USDA Forest Service, 1998).

Ahlers and White (1999) identified that "...(1) mature cottonwood stands with at lease some willow plants in a dense understory, and (2) mid-aged and young stands of dense riparian shrubs at least 5 m high and at least partially composed of willow" were high suitable habitats for the flycatcher. "...stands of very young, sparse riparian plants on river bars that could develop into stands of willows and adequate structure through growth and/or additional recruitment,..." such as the plan (Attachment 2) is calling for, is considered as "Potential Vegetation with Future Growth", a highly desirable condition. Low on the suitability list were "...species that lack the structural density to support breeding flycatchers," especially vegetation types composed of understory entirely of saltcedar and/or Russian olive.

IX. DETERMINATION

Reclamation's proposed realignment and restoration on the Rio Grande at the Santa Ana Pueblo is a long-term solution to the operation and maintenance of the existing levee. This proposal incorporates environmental goals with sound structural technology to achieve a prolonged and stable situation for this section of the Rio Grande. Additionally, the design components of the realignment provide beneficial attributes which not only serve to facilitate endangered and threatened species, but all species within this area.

Rio Grande Silvery Minnow

The minnow has been found within the project area, but its record of appearance is spotty. Sampling efforts have not found it in this area for the last two years. Though construction of this site will obviously have an affect on any individuals within the area, the affects are not expected to be long lasting nor will they present unavoidable and life threatening conditions for an extended period downstream. The minnow, as well as other fish will have the availability to move downstream to safer and less stressful areas.

Though these activities may affect minnows for a short time, they are not expected to have adverse results. Habitats will be modified in this process, but will be improved by (1) realigning the channel for greater stability, (2) lessening the impacts of levee erosion (and the need for additional maintenance), and (3) improving the opportunity for upstream dispersal. Therefore, the proposed action may affect, but is not likely to adversely affect the Rio Grande silvery minnow and will not destroy or adversely modify its critical habitat.

Southwestern Willow Flycatcher

Since no flycatchers have been located within the reach and no habitat exists in the project area, it is highly unlikely that the species or its habitat will be harmed by activities of the proposed realignment and habitat enhancement activities. It is possible that individual migrating flycatchers could be displaced up- or downstream from the construction area during the time of activity, but should not be further affected.

Overall, the opportunity for potential vegetation with future growth is a very positive aspect of this project. The development of (1) backwater habitats, (2) (future) overhanging vegetation in the proper proportions, and (3) channel stability, promotes the type of suitable habitat that flycatcher's prefer. Therefore, the proposed action may affect, but is not likely to adversely affect the Southwestern willow flycatcher and will not destroy or adversely modify any present usable habitat.

Bald Eagle

Since few Bald eagles have been seen within the reach and no nesting habitat exists in the project area at present, it is also highly unlikely that the species or its usable habitat will be harmed by activities of the proposed realignment and habitat enhancement project. It is possible that individual migrating Bald eagles could be displaced up- or downstream from the construction area during the time of activity, but should not be further affected.

Like the habitats being developed for the flycatcher, potential habitats, such as backwaters and cottonwood stands offer future areas for the Bald eagle to utilize. Therefore, the proposed action may affect, but is not likely to adversely affect the Bald eagle and will not destroy or adversely modify any present usable habitat.

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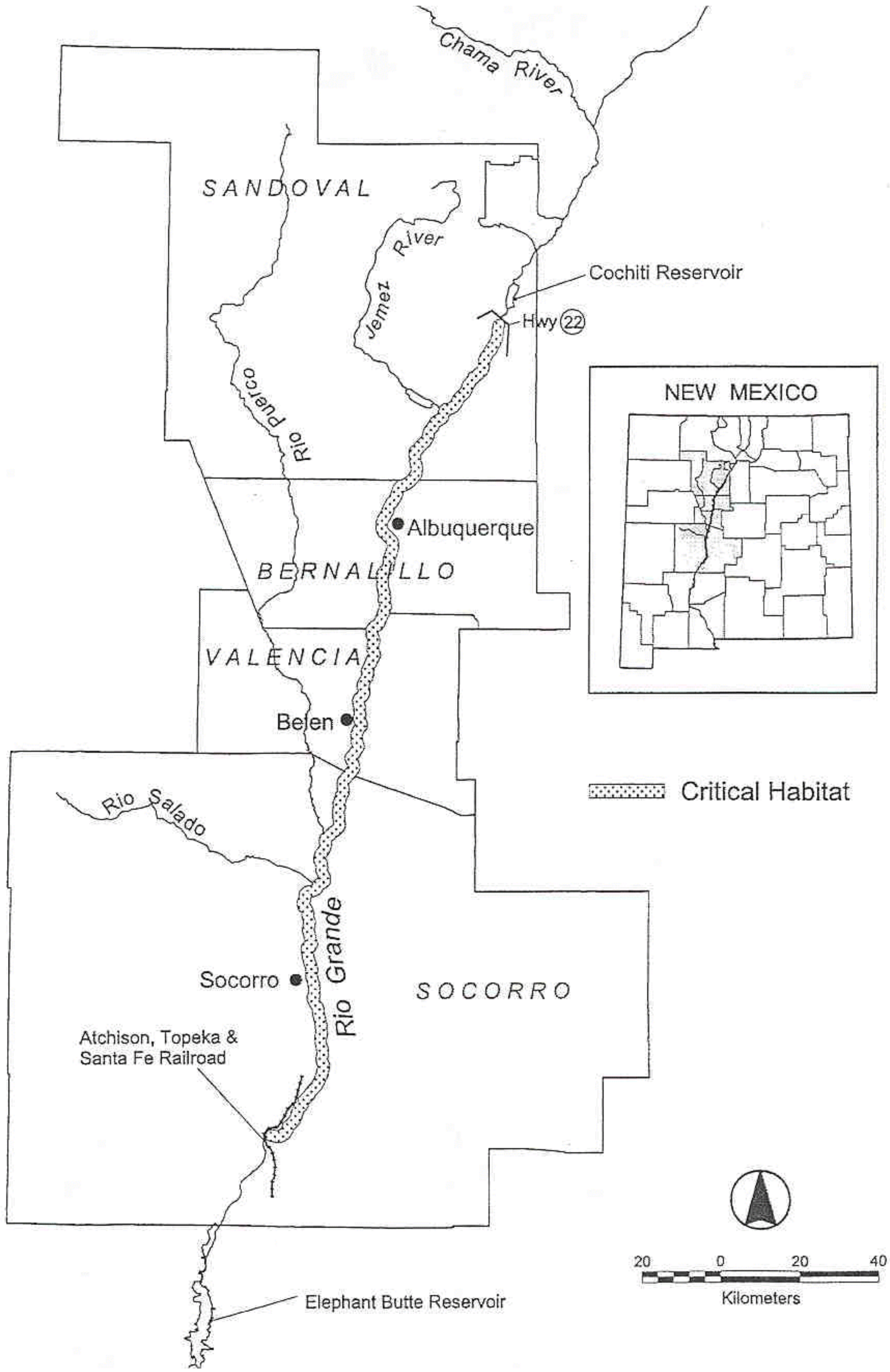
Chama River
SANDOVAL
Jemez River
Cochiti Reservoir
Hwy 22
Rio Puerco
NEW MEXICO
Albuquerque
BERNALILLO
VALENCIA
Belen
Critical Habitat
Rio Salado
Rio Grande
Socorro
SOCORRO
Atchison, Topeka &
Santa Fe Railroad
20 0 20 40
Kilometers
Elephant Butte Reservoir

Figure 4. Map of Rio Grande silvery minnow critical habitat

Attachment 1

SANTA ANA
JULY 1999
PROJECT DESCRIPTION

The Santa Ana Indian Pueblo river maintenance site is along the Rio Grande approximately eight miles downstream of the San Felipe gage (see Figure 1). At this location, the river bends sharply and cuts into the eastern bank causing severe erosion. If allowed to continue, the erosion will cause levee failure resulting in destruction to farm land and the main residential and commercial areas within the Santa Ana Pueblo. It would also breach the adjoining canal used for irrigation. This would cause interruption of irrigation service to the Albuquerque Division of the Middle Rio Grande Conservancy District.

In this study, the river's geomorphology, historical plan view, width, depth, sinuosity, and radius of curvature were analyzed for the period between 1970 and 1997. This level of analysis was needed such that the design will ultimately accomplish the project's purpose while being compatible with the geomorphic trends. The study reach was defined as beginning at the Angostura Diversion Dam (upstream of the Jemez Confluence) and continuing south and ending at the Highway 44 Bridge in Bernalillo (see figure 2). This distance is approximately four river miles.

GEOMORPHOLOGY

The geomorphic characterization of the Santa Ana Reach provides a framework within which river and resource managers can effectively communicate morphologic and hydraulic river conditions. To develop an understanding of the changing fluvial processes controlling bed and bank erosion at the Santa Ana river maintenance site, a recent historical geomorphic description is presented, which will include the recent geomorphic trends of the Santa Ana Reach of the Rio Grande. A summary of the geomorphology is presented

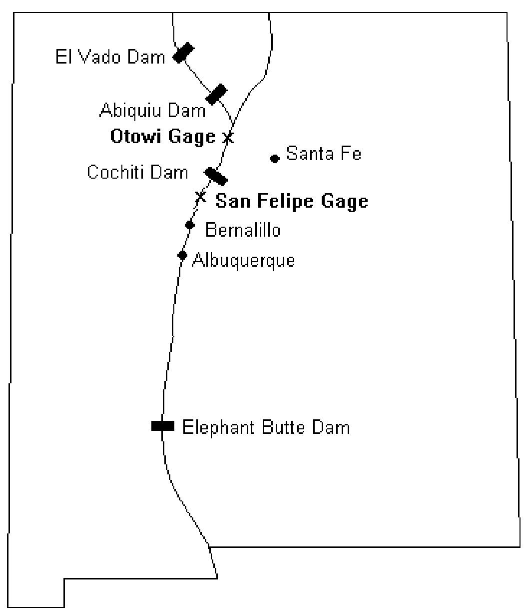

Figure 1. Location Map, Rio Grande and Rio Chama, New Mexico.

herein. More detail is included in the **Geomorphology Report** (Mosley and Boelman, 1998).

Historically the middle Rio Grande has been a braided, relatively straight or slightly sinuous, aggrading channel with a shifting sand substrate with low banks. During the last forty years, river rectification works have been constructed to improve water and sediment conveyance. More recently, the construction of Cochiti Dam has reduced peak flows downstream and trapped sediment. These impacts on the fluvial system have altered the processes controlling water and sediment transport. The altered sediment and flow regimes have resulted in the transformation from a wide, braided sand bed system to a single channel, incised gravel bed system through this reach. The following changes in morphologic and hydraulic characteristics summarize the channel transformation:

- Average channel slope has decreased from 0.002 to 0.00096
- Average channel top width has decreased from 1150 to 350 ft
- Average channel depth has increased from 1.6 to 3.5 ft
- Width/Depth ratio has decreased from 710 to 95
- Average channel velocities increased from 3.2 to 4.3 ft/sec
- Mean bed material size increase from 0.3 mm to >20 mm

The Santa Ana Reach of the Rio Grande has been classified using various characterization and classification methods. These methods failed to uniformly describe the river for each data set. Use of these classifications to provide a forum for discussion and description of this site is therefore being used only qualitatively.

In its current state, the Santa Ana Reach of the Rio Grande is an entrenched, slightly meandering, gravel-dominated, riffle/pool channel without a well-developed floodplain. The reach has a gentle gradient of 0.00096 with a width/depth ratio of 95. Reach averaged channel top width and flow depth are 330 and 3.5 feet, respectively at 5,000 cfs. The river banks are generally composed of unconsolidated, heterogeneous, non-cohesive, alluvial material that are finer than the gravel dominated bed material. The reach-averaged channel velocity is approximately 4.4 feet/sec. If no work is done, the river is estimated to decrease to a top width of about 250 feet with a slope of about 0.00086.

The geomorphic data and sediment transport analysis indicate that the Rio Grande through the study reach is an incised river that is showing a future trend of becoming more incised. Current river trends show that the channel width will continue to narrow and bed elevations will degrade while mean depths and mean channel velocities will increase. It is expected that channel sinuosity will also increase and development of meanders will continue. This is in response to the channel lengthening through degradation (bed erosion) and meandering (bank erosion) due to reduced sediment inflow.

Historical planform as shown on historical aerial photographs has been insightful as well. In 1972, the study reach was entirely braided. By 1984, the incision was well underway and the channel from CO-27 downstream to the Highway 44 bridge was still braided (see figure 2). By 1994, most of the study reach was incised. A meander pattern has been developing over this period. The incision has continued to proceed downstream since 1994. Even in the braided part of the reach, there has been channel incision. What used to be shifting middle bars are now vegetated islands. Judging by this past sequence of aerial photos, the river will continue to incise, become more sinuous and eventually become an entirely gravel bed channel.

Bank retreat and lateral migration of natural channels commonly occurs through the fluvial erosion of bank material and subsequent mass wasting of the upper bank. The bank erosion process can result from channel degradation, flow around bends, flow deflections due to local obstructions, or a combination of the above. For the case of an incising channel, exceedence of the maximum stable bank height will lead to mass failure and bankline retreat. Flow around a bend can cause erosion at the toe of the bank and subsequent bank failure due to increased shear stress on the outside of the bend.

The specific failure mechanisms at a given location are related to the characteristics of the bank material. The eroding outside bend at the Santa Ana site was found to be a composite bank, containing both cohesive and noncohesive material. The top 2.5 to 3.0 feet of bank material was found to be a cohesive clay/silt material.

The stratum below this upper cohesive layer (to a depth of approximately 10 feet) was found to be poorly graded, well-sorted noncohesive sand, with a median particle diameter of 0.54 mm.

Composite banks containing cohesive material overlaying noncohesive material are subject to fluvial removal of noncohesive material near the bank toe, resulting in mass wasting of the upper noncohesive and cohesive material. Fluvial transport removes the failed material downstream allowing for further erosion. Erosion of the noncohesive sand material at the Santa Ana site has resulted in the lateral bank migration that is threatening the levee.

The bank instability and lateral migration of the eroding Santa Ana bend is due to the susceptibility of the material to fluvial erosion and the angle of repose of the noncohesive sand material. Increased shear stresses generated by increased velocities around the bend remove bank material particles causing a steepened bank slope. This slope is steeper than the angle of repose of the bank material resulting in slumping of the upper bank material.

ALTERNATIVE ANALYSIS REVIEW

In considering the alternatives, three levels of alternative evaluation were used. They were based on land use, river geomorphology, engineering, economic aspects, environmental and practical aspects of the project. The goal of efficiently accomplishing the prescribed objectives was best achieved by spending most of the available staff time on the most acceptable alternatives. Therefore, several alternatives were eliminated during Level One and Level Two analyses. A summary of the alternative analysis is presented herein. A more detailed review of alternatives is included in the **Alternative Analysis Report** (Mosley and Boelman, 1998).

Level One analysis was designed to eliminate alternatives that for obvious reason, could not be considered. This level considered land use, available sediment load and adverse changes due to decreasing width-depth ratios.

Level Two analysis was designed to eliminate alternatives that would not help the study reach progress toward dynamic equilibrium. This analysis eliminated those alternatives that have a greater potential of causing additional large scale work at a later time as the river adjusts toward equilibrium. Adjustments toward equilibrium would be in the form of continued degradation (bed lowering), channel narrowing and increased channel length.

The Level Three analysis focused on helping the reach progress toward dynamic equilibrium or reach a new dynamic equilibrium that will provide more habitat for the Rio Grande Silvery Minnow and the southwestern Willow Flycatcher. These alternatives were considered on the basis of engineering, economics and environmental issues. The engineering issues were based on levee protection, geomorphic trends, construction feasibility and sediment transport. The construction and future maintenance costs were determined for each alternative. Environmental considerations were based on encouraging biodiversity and enhancing habitat for native species.

Three different alternatives were evaluated in the Level Three analysis. Each alternative addressed the channel geomorphology and reduced habitat concerns with different philosophies. Following is a brief summary of each.

The first alternative proposed widening the river to increase width/depth ratios, reduce velocities, and reduce sediment transport capacity. This alternative was found to increase the width/depth ratios, reduce velocities, and incorporate overbank areas into the flow regime. However, the stability of the widened channel is suspect. If the channel is widened by raising the bed with sediment material from the abandoned terraced the channel would degrade back to about the current grade. If the channel is widened by mechanically removing bank material it is anticipated that the channel would resume a narrower width.

The second alternative proposed installing a gradient restoration facility (GRF) to stabilize the bed and cause upstream aggradation. The upstream aggradation would increase width/depth ratios and reduce velocities. Low head GRF(s) were found to be ineffective in causing upstream aggradation. Grade control structures of greater height did develop upstream aggradation and increases in width/depth ratios, however fish passage and construction costs are a concern. Fish passage methodologies are available that allow for the design of suitable structures. GRF structures of lesser height than those found to promote upstream aggradation would have the ability to successfully pass minnows.

The third alternative proposed realigning the channel to increase the channel length to the equilibrium slope. Analytical, theoretical and empirical relationships were used to define appropriate values for channel slope, width, depth, velocity, and planform characteristics (meander wavelength and radius of curvature). The equilibrium channel conditions for the fluvial processes currently shaping the channel (reduced sediment supply and decreased flows) do not address the silvery minnow habitat or bosque concerns.

All three proposed alternatives have possibilities, though none is individually appropriate for stabilizing the channel bed and improving native species habitat. Several additional combinations of the above alternatives were developed that will alter the fluvial process of the reach to benefit native aquatic and terrestrial species with the current flow and sediment load and provide levee protection. The disciplines of fluvial geomorphology, river engineering, stream ecology, and biology were blended to develop a river restoration concept that maximizes the benefits to native aquatic and terrestrial species, allowing geomorphic processes to occur and provide levee protection. The ideas and suggestions of many individuals and organizations were incorporated into a list of final alternatives and consequently a preferred alternative, hopefully making the project a success for all concerned parties. The short list of the final alternatives are described below.

- **Riprap Lining** - A traditional bank stabilization design that would move the active river channel away from the threatened levee 100 feet and utilize a riprap revetment for the protection of the channel banks on the outside of each bend. Total cost was approximately $835,000. This alternative was only used for cost comparison purposes.

- **Widen the River and Install Gradient Restoration Facility (GRF) - (Veg. To Veg.)** - An alternative to widen the channel to the entire width between the left and right vegetated bankline. Total cost ranged from approximately $8.2 million to about $15.3 million.

- **Small Realignment** - An alternative to install a GRF, combined with channel widening. Total cost was approximately $2.1 million. This alternative was eliminated because flows would still be directed toward the levee at the critical location.

- **Large Realignment** - An alternative to widen and realign the river combined with either one or two GRF(s). Several different river widths were also analyzed. Total cost ranged from approximately $2.6 million to about $4.2 million.

An analysis to determine the preferred alternative that has the most environmental benefit for the least cost was developed. Table A, below, shows the results for the large realignment and the Veg. To Veg. Alternatives, including the amount of change from the current conditions. Table B shows a comparison of the lengths of effects, and costs per unit for these values.

The alternative scenarios were numerically ranked according to index number importance. The Veg. to Veg. scenario ranked first in available acreage, width - depth ratio, difference in width - depth ratio and cost per difference in width - depth ratio. However, in discussing the results, it was determined that the Veg. to Veg. scenario would be eliminated because of its high overall cost of $8.2 million, which translated to an extremely high cost per effected length and cost per wetted acreage, when compared to the remaining scenarios.

Table A

Alternative	Length of Effects	Estimated Cost	Cost/ft	Velocity, ft./sec (% Change)	Depth, ft. (%Change)	Width, ft. (% Change)	W/D (% change)
Current CO 24 to TA 261				4.4	4.2	295	75
Scenario 1 - 300 Channel	5275	$2,700,000	$510	4.0 (-9 %)	3.8 (-10 %)	345	85 (+13 %)
Scenario 1 - 400 Channel	5275	$3,000,000	$570	2.9 (-34 %)	4.4 (+5 %)	410 (+28 %)	95 (+19 %)
Scenario 2 - 360 Channel	7462	$4,200,000	$560	3.4 (-22 %)	3.8 (-10 %)	395 (+25%)	105 (+28 %)
Scenario 2 - 400 Channel	6702	$4,380,000	$655	3.7 (-16 %)	3.8 (-10 %)	430 (+32 %)	115 (+34 %)
Veg. to Veg. 1 GRF	5275	$8,240,000	$1560	4.3 (-2 %)	2.9 (-31 %)	420 (+30 %)	155 (+53 %)

Once this scenario was eliminated, the results were re-ranked as shown in Table B. SCE.1-300 ranked first in cost per length and SCE.1-400 ranked first in cost per wetted acreage. SCE.2-360 ranked first in effective length, amount of wetted acreage and available acreage for potential habitat. SCE.2- 400 ranked first in width - depth ratio, difference in width - depth ratio and cost per difference in width - depth ratio.
With no other clear eliminations, a count of first places narrowed the options to SCE.2-360 and 400. From these two, SCE2-360 was chosen because of its longer total length of effect and its overall lower cost ($4.2 million versus $4.4 million). Consensus was reached on this scenario and it was chosen as the preferred alternative.

Table B

Scenerio	Available Overbank Acreage for Potential Habitat	Length of Effect (ft)	Cost per Length of Effect	W/D	Change in W/D	Cost per Change in W/D	Wetted Acreage[a]	Cost per Wetted Acreage
SCE.1 – 300	40	5275	$510 (1)	85	10	$270,000	42	$65,000
SCE.1 – 400	35	5275	$570	95	20	$150,000	50	$60,000 (1)
SCE.2 – 360	45 (1)	7462 (1)	$560	105	30	$140,000	68 (1)	$62,000
SCE.2 –400	38	6702	$655	115 (1)	40 (1)	$110,000 (1)	66	$66,000
VEG. TO VEG.	50	5275	$1,560	155	80	$103,000	51	$162,000

[a] Includes overbank and main channel

Sce.1 - 300-foot Channel (Large Realignment)

- One 2-foot GRF located between TA 259 and CO 26.
- The channel will widen to approximately 300 feet.

Sce.1 - 400-foot Channel (Large Realignment)

- One 2-foot GRF located between TA 259 and CO 26.
- The channel will widen to approximately 300 foot, with additional excavation widening the channel to 400 foot.

Sce.2 - 360-foot Channel (Large Realignment)

- Two 2 foot GRF's, one located between TA 259 and CO 26, another located at TA 252.
- The channel will widen to approximately 360 foot.

Sce.2 - 400-foot Channel (Large Realignment)

- Two 2 foot GRF's, one located between TA 259 and CO 26, another located at TA 252.
- The channel will widen to approximately 360 foot, with additional excavation widening the channel to 400 foot.

Veg. To Veg. (Widen the river between vegetation line to vegetation line)

- A channel widened from vegetated bankline to vegetated bankline with a bed slope of 0.00096.
- One 5.6 foot GRF located at TA 261.
- A levee protected with 100 foot buffer

ACTIVITY

The Rio Grande Restoration Project at Santa Ana will encompass approximately 7,500 feet of the Rio Grande. The Project will consist of three phases being constructed over a three to five year time period. Phase 1, which will occur during the first year, will consist of the installation of a gradient restoration facility (GRF) and accompanying fish passage apron, the excavation of a 25-foot pilot channel, installation of river dikes to block off the existing river channel, excavation of trenches along the estimated bankline position to install bioengineering. The bankline bioengineering will consist of planting willows along the bankline and toe protection of six-inch rock along the toe of the bank. The rock will be encased in coir fabric or other biodegradable material. The rock is sized such that after the fabric degrades away, it will move during a five year flood event. The bankline will also have rootballs and footer logs installed. The widening of the river may take longer than one year, depending on the years runoff. Excavation of some of the floodplain will occur during this phase also. Phase 2 will begin after the pilot channel has widened into the new river channel. This phase will consist of excavating the remaining floodplain areas, the planting of these areas and the installation of the bendway weirs. The bendway weirs may be constructed in Phase 3 if the channel is continuing to adjust to the new alignment during Phase 2. Phase 3 will consist of the installation of the second GRF and revegetation efforts. It should be noted that the second GRF installation is dependent upon funding from other sources. Below are the specifics of each phase.

PHASE 1 (Fall/Winter 1999)

The work being accomplished in Phase 1 is shown in Figure 3.

GRF1 will be constructed approximately 150 feet downstream of river mile 207 (Figure 3). This structure will halt the current channel degradation trend, stabilize the channel slope, and provide upstream aggradation and channel widening. The GRF1 is comprised of five main components: the upstream and downstream sheet pile walls, the apron, the apron toe, and revetments (both upstream and downstream).

The upstream GRF sheet pile cutoff wall will be tied into the channel banks 20 feet and include upstream rock protection (Figures 4 and 5). The invert of the sheet pile wall with be two feet above the channel bed. The sheet pile wall will extend across the existing 280-feet wide channel. The sheet pile wall side slopes will be at 2H:1V, extending 11 feet above the invert up the channel banks. The sheet pile and channel bottom of GRF1 will have a transverse slope of 70H:1V. This will provide a recess in the center of the channel and diverse flow conditions along the transverse gradient. The channel recess not only provides diverse velocities and depths along the transverse gradient, but also concentrates low flows. Concentrating low flows is important to insure the flow is not thinly spread across the entire approximate 300 feet width of the structure. The recess will act as a channel thalweg.

Rock (12-inch) will be placed upstream of the sheet pile wall for additional stability. Rock will be placed at the elevation of the sheet pile in an eighteen-inch layer. The rock upstream slope will be at the natural angle of repose of the material, approximately a 2H:1V slope. Immediately downstream of the sheet pile wall, the apron begins. An eight-inch thick gravel (1.5-inch) filter will be placed below the rock layer. A geotextile fabric may be used in conjunction with the 1.5 inch gravel to further effect the filtering process. If the geotextile fabric is used, the quantity of gravel will be reduced.

An apron profile and a typical apron cross section of GRF1 are also found in figures 6 and 7, respectively. The apron will consist of an eighteen-inch thick layer of rock (12-inch) placed on a one foot layer of 1.5-inch gravel filter. River gravels excavated during construction will be placed on top of the riprap after both layers are placed. The river gravels have been found to provide stability of the rock layer and will provide a substrate on the apron that more closely resembles the existing bed substrate.

The apron slope is based on field data and hydraulic modeling of riffles that are currently found in the project reach (figure 6). It is known that the silvery minnow move through these existing riffles as they are found in the upstream channel. An apron slope of 0.004 feet/feet was the approximate average slope of the riffles over flow conditions ranging from 550 to 2,000 cubic feet per second (cfs). Flows of this range were modeled as it is believed that the silvery minnow move upstream in the late fall and early spring months. An apron slope of 0.004 was found to provide hydraulic conditions (flow depth and velocities) that are more suitable than the natural riffles over this discharge range. At a discharge of 700 cfs, the existing riffle velocity and average depth were calculated to be 3.2 feet/sec and 0.9 feet, respectively. For the same 700 cfs discharge, the calculated velocity and mean depth over the GRF apron are 1.5 feet/sec and 1.4 feet, respectively. At 700 cfs, the width and width/depth ratio are 265 feet and 290 for the existing riffles and 340 feet and 240 for the GRF apron. For a discharge of 1,500 cfs, the existing riffle average velocity and depths were 3.4 feet/sec and 1.3 feet, respectively, while the apron average velocity and depth were 1.5 feet/sec and 2.8 feet, respectively. At 1,500 cfs the width and width/depth ratio are 360 feet and 275 for the existing riffles and 355 feet and 125 for the GRF apron. An apron slope of 0.004 was found to provide velocities that are on average slower and depths that are on average deeper than that modeled for the riffle. Additionally, the GRF apron bottom is sloped towards the center of the channel in the transverse direction, creating flow depths and velocities that vary around these average values along this transverse gradient.

The apron will extend 500 feet at a slope of 0.004. The apron side slopes will be at the natural angle of repose of the material 2H:1V, extending 11 feet up the channel banks. The apron side slopes will consist of an eighteen-inch thick layer of rock (12-inch) placed on a one foot layer of 1.5-inch gravel filter, with the top four feet of the apron side slopes being an eight-inch layer of 6-inch rock. Utilizing the 6-inch rock on the upper portions of the apron side slopes where the shear stresses are less will decrease the volume of rock, transition the riprap to a smaller size, and allow easier planting of willow and cottonwood poles. The apron of GRF1 will have transverse bed slopes of 70H:1V for a distance of 145 feet from the channel invert to the toe of each side bank. This will provide a recess in the center of the channel and diverse flow conditions (e.g., depth and velocity) along the transverse gradient.

The GRF1 apron toe consists of a sheet pile wall and rock (figures 6 and 8). The sheet pile wall of the GRF toe is to ensure that the water surface elevations of the lower discharges stay above the apron surface. The apron toe sheet pile wall will be tied into the channel banks 20 feet. The sheet pile wall will extend across the existing channel 380 feet for GRF1. The elevation of the apron toe sheet pile wall will be one foot below the rock elevation. A riprap (12-inch) toe will extend downstream from the apron toe sheet pile three feet and have a thickness of five feet. This rock toe will be placed on a one-foot layer of 1.5-inch gravel filter. The downstream slope of the rock toe will be at the natural angle of repose of the rock, approximately 2H:1V.

Revetments will extend 100 feet upstream and 100 feet downstream from the GRF structure. The revetments will prevent flows from eroding the channel banks upstream and downstream from the structure, resulting in instability and possible structure failure. The GRF revetments consist of an eighteen-inch thick layer of rock (12-inch). The revetments will be sloped at the angle of repose of the material, approximately 2H:1V. The revetments will extend up the bank 12 feet and have a toe extending 5 feet below the bed elevation. The revetments will be keyed into the channel banks 20 feet using 12-inch rock. The keys will be covered with soil material and planted as outlined in *Vegetative Restoration Guidelines* section.

Fifteen-thousand cy of 12-inch rock, 500 cy of 6-inch rock, and 7,000 cy of filter gravel (1.5-inch) will be utilized. If the geotextile fabric is used in the filter, there will be 201,000 square feet (sf) of material used. Consequently, the amount of gravel will be reduced by 25 to 50 percent. A total of 720 linear feet of sheet pile will also be placed in the construction of GRF1. Approximately 55,000 cy of bed material will be excavated during the construction of GRF1. This material will be spread over the newly constructed apron and side slopes. This will also be placed upstream of the GRF. The material placed upstream of the GRF will be within the coffer dam built for construction. This will eliminate the placement of sediment within the flowing river.

Next, a 25-foot bottom width pilot cut will be excavated as shown in the attached drawings. The pilot channel will be excavated at a slope of 0.00095 and 2H:1V side slopes. The new channel will begin above the Jemez River confluence and will end by transitioning into the existing river channel near GRF1 on the southern end as shown in Figure 3. Excavation of about 110,000 cubic yards will be required for the 25-foot bottom-width pilot cut. It may take more than one year for the river planform to completely widen, depending on the runoff for that year. However, the excavation of approximately 250,00 cy floodplain material will occur in phases after the channel widens the 25-foot bottom width, but before it widens to the anticipated 360-foot wide channel. Once the pilot cut begins to widen, the excavated material will be dozed to the pilot cut edge and allowed to move downstream as the channel widens. With spring runoff flows being an important part of the process, the remaining floodplain excavation will occur during Phase 2. There is approximately 900 feet of backfill in the new alignment. This is needed to keep the newly aligned river from reverting into it's current channel while it is widening to the new alignment. This backfill is approximately 20,000 cubic yards. The abandoned oxbows of the existing river will not be backfilled. These areas will be left for extensive revegetation and wetland development, which may include creating additional planting edge into the existing bankline and depositing fill mounds for planting for extra habitat value. Figure 9 shows a typical cross section showing the current river and the pilot channel. The existing river will be blocked off by river dikes. The river dikes will require approximately 8,000 cy of fill material and about 4,700 cy of 16-inch riprap. Figure 10 illustrates a typical dike cross section.

Because of the soft sand material and low permissible shear stresses, short term bioengineering bank protection will be needed once the river has widened at two bends shown on figure 3. The total length of both bends is about 2,600 feet. Trenches will be excavated to the elevation of the new channel and toe protection will be installed (Figure 11). Installation of rootballs will also be completed. Toe protection is required to allow plantings to root and stabilize the bank while the new river planform is widening. The toe protection will be six-inch rock that will be erodible at 8,000 cfs, the five-year return period peak flow event. The rock will be encased in coir fabric or other biodegradable bioengineered material to give additional; bank stability until the root mas from the plantings are established. After the fabric material has degraded, the rock will become erodible. Between the rootballs, willows will be planted using the "willow mattressing" method. This method is outlined in the *Vegetative Restoration Guidelines* section. In the lower shear stress areas of the bend, fabric encapsulated soil techniques will be used. The estimated quantities for the toe protection is 1,200 cubic yards of 6-inch rock, about 33,000 sf of coir fabric or other bioengineered material and approximately 80 cottonwood rootballs with about 80 footer logs. Phase 1 ends at the beginning of Spring Runoff of year 2000.

PHASE 2 (Fall/Winter 2000)

Phase 2 will begin after the river has widened and conjunctively, at the start of the spring runoff season. It is anticipated that the river will have realigned itself and is now following its new planform. The new floodplain will be excavated 6 inches below the field determined bankfull elevation. The excavated material will be placed along the edge of the bankline such that river flows will carry it downstream. As referenced in Phase 1, the material from the floodplain (200,000 cy in Phase 2) will be dozed to the pilot cut edge and allowed to move downstream as the cut widens. Figure 12 shows the new alignment. Figure 13 shows typical cross sections of the estimated new channel. This will continue until the floodplain has reached the anticipated width and elevation. The combined Phase 1 and 2 floodplain excavation will be approximately 450,000 cy. After the excavation of the floodplain, groundwater wells will be installed as part of the revegetation planting planning and design. Data from these wells will be used by Reclamation's biologists, U.S. Fish and Wildlife's (FWS) biologists and personnel from the Santa Ana Pueblo to finalize the Vegetative Restoration Plan. Locations and depths will be planned by the above personnel.

A portion of the excavated floodplain material will be used to create extra "edge" around the ponded oxbow areas. The "edge" is defined as additional terrestrial area available for planting. The "edge" will be created by placing excavated material along the bankline to create more linear feet of edge for planting. Exact placement and configuration will be arbitrary and decided in the field by Reclamation biologists. The configuration will be look natural and will be planted for additional wildlife and wetland effect. An approximately one acre plat along the backwater areas will be planted more densely than the surrounding areas.

Sixteen-inch riprap placed during previous years emergency projects will also be removed also. This riprap will be used during the placement of the bendway weirs or other pertinent work. However, because some the riprap is in areas outside the reach of the construction equipment, not all of the rock will be able to be moved. This rock will be left in place. The amount of riprap currently in place is about 1,300 cy. Roughly 70 percent of this riprap will be removed.

Bendway weirs are to be placed along the outside bank of the river bend immediately upstream of river mile 207 (see figure 14). The weirs are required at this bend to prevent further erosion of the outer bank endangering the riverside levee and drain. Bendway weirs are low-level, upstream-angled stone sills, attached (and keyed into) the outer bank of a bend. Weirs are built in sets and are designed to act as a system to control velocities and current directions through the bend. The hydraulic effects of the weirs reduce erosion on the outer bank of the bend by reducing flow velocities near the outer bank and breaking-up the secondary currents in the bend. Bendway weirs also improve aquatic and terrestrial habitat by creating pools at the stream end, diverse velocity fields, instream cover, and depositional zones downstream and between the weirs.

Ten bendway weirs consisting of 16-inch rock spaced from 100 to 130 feet apart will be placed along 1,200 feet of the left outer bank (figure 15). The weirs will range in length from 60 to 100 feet (figure 16). Upstream angles will vary from 60 to 90 degrees measured from a line tangent to the bank (figure 16). The weir height will be approximately two feet above the bed at the river end and increase to approximately six feet at the bank (the top slope will vary from approximately 10H to 25H:1V depending on weir length). The weir top width will vary from four feet wide near the stream end to 15 feet near the bank. The wider width near the bank is to accommodate construction equipment. The side slopes of the weirs will be the angle of repose of the rock, approximately 2H:1V.

The bendway weirs will be keyed into the channel bank. Keys will be constructed of 16-inch rock and will extend to the top of bank at 2H:1V slope. The keys will be 15 feet deep and 15 feet wide. Approximately 4,200 cy of 16-inch rock will be used in the construction of the bendway weirs. The weirs and keys will be covered with soil material and planted as outlined in *Vegetative Restoration Guidelines* section.

PHASE 3 (Fall/Winter 2001)

Gradient Restoration Facilities

The second GRF (GRF2) will be installed at the beginning of the third year or when the river has reached its equilibrium width. This installation is contingent on funding opportunities currently being pursued by the Santa Ana Pueblo and Reclamation. GRF2 will be constructed approximately 700 feet upstream of river mile 208 (figure 17). The design of GRF2 is similar to GRF1. The large abandoned terrace located in the upper half of the project allows for a much wider GRF and an opportunity to allow the river channel to migrate within this width.

GRF2 will consist of a sheet pile cutoff wall tied into the channel banks 20 feet and upstream rock protection (figures 18 and 19). The invert of the sheet pile wall with be two feet above the existing channel bed. The sheet pile wall will extend across the existing channel 840 feet for GRF2. Similar to GRF1, GRF2 will have recesses in the sheet pile wall. Due to the extended length of GRF2, there will be three recesses, providing the channel multiple locations to spill over the GRF during lower flows. This will allow natural fluvial processes and meandering tendencies to remain. The transverse slopes of the sheet pile recesses will vary from 50H:1V over a distance of 100 feet to 67H:1V over a distance of 135 feet.

Twelve-inch rock will be placed upstream of the sheet pile wall for additional stability. Rock will be placed at the elevation of the sheet pile in an eighteen-inch layer. The rock upstream slope will be at the natural angle of repose of the material, approximately a 2H:1V slope. Immediately downstream of the sheet pile wall the apron begins. An eight-inch gravel (1.5-inch) filter will be placed below the rock layer. A geotextile fabric may be used, in which case, a minimum two-inch gravel filter will be used.

A typical apron cross section and apron profile view of GRF2 is found in Figures 20 and 21. The apron will consist of an eighteen-inch thick layer of rock (12-inch) placed on an eight-inch thick layer of 1.5-inch gravel. A geotextile fabric layer may be used in conjunction with the gravel filter. If so, the gravel filter will be reduced to a minimum of two inches. River gravels excavated during construction will be placed on top of the riprap after both layers are placed. Like GRF1, the apron slope of GRF2 is 0.004 and will extend 500 feet downstream. The apron side slopes will be at the natural angle of repose of the material 2H:1V, extending 11 feet up the channel banks. The apron side slopes will consist of an eighteen-inch thick layer of rock (12-inch) placed on a one foot layer of 1.5-inch gravel filter, with the top four feet of the apron side slopes being an eight-inch layer of 6-inch rock. Utilizing the 6-inch rock on the upper portions of the apron side slopes where the shear stresses are less will decrease the volume of rock, transition the riprap to a smaller size, and allow easier planting of willow and cottonwood poles. GRF2 will have recesses in the apron. Due to the extended length of GRF2, there will be three recesses, providing the channel multiple locations to flow downs

the GRF apron during lower flows. The transverse slopes of the apron recesses of GRF2 will vary from 50H:1V over a distance of 100 feet to 67H:1V over a distance of 135 feet.

The apron toe consists of a 840 feet sheet pile wall and rock (figures 21 and 22). Refer to the apron toe specifics of GRF1 for sheet pile elevation and rock description and placement. Revetments will extend 100 feet upstream and 100 feet downstream from the GRF structure. The details of the structure revetment and revetment keys are the same as GRF1. The construction of GRF2 will used 30,000 cy of 12-inch rock, 400 cy of 6-inch rock and 15,000 cy of gravel (1.5 inch). If the geotextile fabric is used in the filter, there will be 500,000 sf of material used. A total of 1,680 linear feet of sheet pile will also be placed in the construction of GRF2. Approximately 77,500 cy of bed material and terrace material will be excavated for construction of GRF2. This material will be placed on the bed and side slopes of GRF2 and upstream of GRF2. The material placed upstream of GRF2 will be the coffer dam built for construction. This will eliminate the placement of sediment into the flowing river.

The final portion of the project will be the installation of some instream habitat structures. These structures will be “snags” placed in the new channel to give cover for fish. The snags will be either cabled from the bank using a “deadman”, or placed in the river with a large boulder(s) on top to hold it in place. Exact placement of these structures will be determined by Reclamation’s fisheries biologist, in conjunction with FWS and the Santa Ana Pueblo.

Summary of Quantities

Phase 1:

GRF1 - 12-inch riprap	13,000 cy	Dikes - Fill Material	8,000 cy
GRF-1 - 6-inch rock	400 cy	Dikes - 16-inch riprap	4,700 cy
GRF1 - 1.5-inch gravel filter	1,750 - 7,000 cy	Toe Protection - 6-inch rock	1,200 cy
Sheet Pile	720 LF	Rootballs	80 Each
Pilot Cut Excavation	108,000 cy	Footer logs	80 Each
Backfill	20,000 cy	GRF1 - Excavation	55,000 cy
Coir fabric for toe protection	130,000 sf	Coir fabric for willow mattressing	33,000 sf
Geotextile fabric	201,000 sf	Excavation for Bioengineering trench	
Floodplain Excavation	250,000 cy		

Phase 2:

Floodplain Excavation	200,000 cy
Riprap Excavation	about 900 cy
Bendway Weirs - 16-inch riprap	4,200 cy

Phase 3:

GRF2 - 12-inch riprap	30,000 cy
GRF2 - 6-inch rock	400 cy
GRF2 - 1.5-inch gravel rock filter	3,750 - 15,000 cy
GRF2 - Sheet Pile	1,680 LF
GRF2 Excavation	77,500 cy

Vegetative Restoration Guidelines

Approximately 45 acres of land adjacent to the Rio Grande downstream of the Jemez River will be revegetated as part the this project. Flexibility in the vegetative design is a must. Adaptive management will be utilized to determine vegetative planting methods, locations, terracing, etc. Prior to planting, soil electro- conductivities (EC) will be determined for planting suitability of the various types of vegetation selected for a particular area. Different methods will be used to some extent with planting of cottonwoods and black willow poles. Planting methods will vary for coyote willow. In addition to mattressing and live staking, other methods may be used, such as live fascines, brush layering and joint planting. Consideration for each method is based on method type, type of embankment, slope and elevation of the visible high water mark on the newly created banks. These methods may be used in conjunction with the tree planting. The tree plan will be developed by Reclamation and FWS biologist. Once this is developed, other variations of vegetative cover will be incorporated**.**

Because of the variety of plantings being used, planting periods for each species may differ and are limited to the dormant season. Figures 3, 12 and 17 show approximate locations of these techniques. A brief description of the different methods follows.

Live staking involves the insertion and tamping of live, rootable vegetative cuttings into the ground (Figure 23). The live stakes will root and grow. A system of stakes creates a living root mat that helps stabilize the soil by reinforcing and binding soil particles together and by extracting excess soil moisture. Most willow species are ideal for live staking because they root rapidly and begin to dry out a slope soon after installation. The ends of the stakes would be planted in the high water ground table.

Brush mattressing is commonly used in Europe for streambank protection. Figures 24 and 25 illustrate plan and profiles views, respectively, of this methodology. Figure 26 presents a step-wise installation schematic. It involves digging a slight depression on the bank and creating a mat or mattress from biodegradable strands of rope or cord and live, freshly cut branches from sprouting trees or shrubs. Branches up to 2.5 inches in diameter are normally cut 3 to 10 feet long and laid in criss-cross layers with the butts in alternating directions to create a uniform mattress with few voids. The mattress is then covered with rope secured with wooden stakes up to 3 feet in length. The mattress is then covered with soil and coir fabric and watered repeatedly to fill voids with soil and facilitate sprouting; however, some branches should be left partially exposed on the surface. The structure will be placed above stone toe protection, which will prevent the bank from undercutting. Brush mattresses are generally resistant to waves and currents and provide protection from the plants being dug out by animals.

Live fascines are long bundles of branch cuttings bound together into sausage-like structures. Figure 27 illustrates a side view installation of live fascines. Similar to live fascines are live bundles in which the live cuttings are bundled together in coir fabric and then installed (Figure 28). Bunch plantings (Figure 29) are similar to live fascine and live bundles, except the cut ends of the whips are bunched together and placing in a coir or burlap bag with soil. These bunches are planted along excavated trenches along the bank slope. When cut from appropriate species and properly installed, they will root and immediately begin to stabilize slopes. They should be placed in shallow contour trenches on dry slopes and at an angle on wet slopes to reduce erosion and shallow face sliding.

Brush layering consists of placing live branch cuttings in small benches excavated into the slope (Figure 30). The width of the benches can range from 2 to 3 feet. The portions of the brush that protrude from the slope face assist in retarding runoff and reducing surface erosion. Brush layering is somewhat similar to live fascine systems because both involve the cutting and placement of live branch cuttings on slopes. The two techniques differ principally in the orientation of the branches and the depth to which they are placed in the slope. In Brush layering, the cuttings are oriented more or less perpendicular to the slope contour. In live fascine systems, the cuttings are oriented more or less parallel to the slope contour. The perpendicular orientation is more effective from the point of view of earth reinforcement and mass stability of the slope.

Joint planting (or vegetated riprap) involves tamping live cuttings of rootable plant material into soil between the joints or open spaces in rocks that have previously been placed on a slope. The cuttings can be tamped into place at the same time that rock is being placed on the slope face.

Fabric encapsulated soil involves wrapping biodegradable coir fabric around soil to form a series of distinct soil lifts or terraces that are subsequently vegetated. The soil lifts can range from approximately a foot to a foot-and-a-half in height. Planting techniques associated with fabric encapsulated soil includes placing willow whip between soil lifts, seeding under the coir fabric, and planting containerized seedlings through the coir fabric on the top of each lift.

Over the course of this project, groundwater wells will be installed. Groundwater well numbers and locations will be determined by wildlife biologists and Santa Ana Pueblo personnel. The river revegetation work will be accomplished in three phases as briefly described below.

Phase 1: A 25 foot bottom width channel will be constructed during this Phase. Some groundwater wells will be installed (numbers currently undetermined; wells could be installed in backwater or other areas that are suitable and would not be destroyed over time by construction equipment/activities). Some bioengineering plantings would occur during this phase along the two new bends. EC levels would be determined during this time period. After the completion of the GRF, the side slopes will be covered with soil material and planted with willows using “joint planting”. The bankline bioengineering will consist of planting willows along the estimated bankline and toe protection of six-inch rock along the toe of the bank. The rock is sized such that it will move during a five year flood event. Bank stabilization will be in the form of rootballs with toe protection installed the previous year. Live staking and brush mattressing with coyote willows will be planted along the banks between the rootballs that have been installed. Another possible method would be to plant 2-foot live stakes into the excavated key hole, leaving about 2-4 inches exposed. A geotextile will be placed to help in stabilizing the stakes. Then the rock material for the key will be placed on top. The top of the dikes will be planted with willow also. Live cuttings will be placed in the placed fill material as live fascines with some joint planting and live staking.

Phase 2: Phase 2 will involve the finishing of the proposed floodplain. It is anticipated that the river will have realigned itself and is now following its new planform. After all Phase 2 work is completed, the floodplain areas and GRF side slopes will be planted. All planting should occur during the November to February time frame.

Phase 3: Installation of GRF 2 will occur on the north end of the project area near the confluence of the Jemez River. The GRF key will be planted as referenced above in Phase !. After the installation of the GRF is complete, any remaining areas will be planted. Backwater areas shall be densely planted with willows to create potential habitat for the southwestern willow flycatcher. Black willow and cottonwood poles will also be planted to achieve an overstory canopy in these areas. The top

of the bendway weirs will be covered in soil material and planted using “joint planting”. The top of the keys would be planted as mentioned above for the GRF.

The planted area will be flooded at 5,000 cfs (6" deep). Overbank flooding on the excavated terraced floodplain shall occur from 5,000-7,000 cfs. Slopes will vary from a flat surface to approximately 0.005. Variable surfacing and terracing will be created. Biologists will work with construction personnel in the field to achieve this goal. The floodplain will be divided into zones for revegetation. Areas nearest the water table will consist of willow plantings, both coyote and black. Cottonwood and black willow poles will be planted in a random fashion, approximately 30 feet apart. All poles will be caged with a minimum of five-foot cages to prevent potential beaver or rodent damage. Larger cottonwood trees on the east bank are recommended for protection for protection with wire caging. Beaver damage is currently severe on these trees.

MONITORING

The progression of the natural channel widening and bed changes will be monitored by Reclamation engineering staff through existing survey points and annual data collection efforts. Revegetation efforts and endangered species monitoring and coordination will be conducted by Reclamation’s Environmental and Biologist staff in coordination with the Santa Ana Pueblo Office of Natural Resources and the U.S. Fish and Wildlife Service.

WATER QUALITY PLAN

All construction work will occur during low flows in the river. Before each phase is initiated, testing will occur in the river to monitor the existence of silvery minnow in the construction reach. It is anticipated that no cottonwood trees will be removed in the construction of this project.

For the installation of the first GRF, half of the river will be blocked off and de-watered. The river will be blocked off by constructing a coffer dam around the potential work site. The coffer dam will consist of either the placement of concrete Jersey barriers lined with a geotextile membrane and backfilled with fill material, the placement of inflatable water bladders, or the installation of sheet pile. The coffer dam and de-watering will allow equipment to work in a “dry” condition and prevent disturbed material from entering the river flow. The GRF key and half of the body will be installed in the “dry” portion of the river. Once this is complete, the opposite side will be blocked and dewatered. The remainder of the body and opposite key will then be installed. After this, the river will be unblocked and flow allowed to resume over the new GRF structure.

Next the body of the pilot cut will be excavated. At points where the pilot cut intersects the existing river, three feet of the existing alignment will be left in place as a plug. Since the new alignment crosses the existing river several times, there will be several plugs. As the new channel is being excavated, material will be stockpiled for backfill purposes.

Concurrently, the short term bioengineering bank stabilization for the bends will begin. The estimated bankline in the bends will be excavated to the proper elevation. De-watering of the excavated areas may be required to allow accurate placement of the bioengineering material. The toe protection and rootballs will be installed. Possible willow whip planting may occur at this time depending on field determination.

Once the alignment, slope and bank stabilization is completed, the plugs will be removed, beginning at the downstream end. Once the plugs are removed, the river will begin to split flow into the pilot channel. The river dikes will now be installed. The installation of the dikes will also require measures to install it in the “dry”. These measures will be the same as mentioned above in the installation of the GRF. The dikes will be installed on the downstream side of the existing river intersection. The dikes will average nine feet in height. The construction of the dike will consist of two phases. The first phase will consist of placing riprap along the bed of the river as shown in figure 10. This top elevation will be the low flow water mark. The second phase of constructing the dike will consist of adding the top to the riprap base. The core of this portion of the dike will be fill material. The completed dike will measure 13 feet across the top with 2H:1V side slopes. The riverside of the dike will be stabilized with a 16-inch riprap revetment. Before the riprap is placed however, the dike fill will be pole planted with short coyote willow stakes. The stakes will be planted such that the base of the stake is in or near the existing water table. In time, as the roots establish, the willows will grow and cover the riprap, thus making it more aesthetically and environmentally pleasing.

For Phase 2, the excavation of the floodplain will occur first depending on evolution of the river channel. After the floodplains are graded, the bendway weirs will be installed. Depending on the Socorro scheduling, if it is during the dormancy period, the bank stabilization will also be planted. This will be in conjunction with the protection installed the previous year.

Phase 3 will begin with the installation of GRF2. Its installation will be as described for GRF1. After the GRF2 is installed, planting of the overbank areas will commence, depending on dormancy periods.

FUTURE RIO GRANDE

After studying the historic records of the Rio Grande as described in the Geomorphology section, it is envisioned that the Rio Grande will once again be a wide, shallow and slower velocity river, that will have periodic overbank flooding that would help in naturally regenerating the Bosque with cottonwoods and other native vegetation. With the current river planform, there is no current overbank areas. After the project is complete, there will be approximately 45 acres of habitat improvements and potential overbank flooding areas. There is currently 2,022 feet of wetted acres within the river planform now. This will increase to 6,215 feet after the project completion. With a healthier riparian zone, the area would be conducive to willow flycatchers and other wildlife species. Currently, there is no available habitat that would attract the flycatcher. The potential afterwards would be about 45 acres of habitat area around the river system. The riverine component would see the upstream migration of the silvery minnow up to Angostura Diversion Dam.