Executive Summary

ES.1 Introduction

The Rio Grande Headwaters Restoration Project (RGHRP) was conducted by the Montgomery Watson Harza Americas, Inc. (MWH) Project Team under the guidance of the San Luis Valley Water Conservancy District's Rio Grande Restoration Project Enterprise Technical Advisory Committee (TAC). The Project was undertaken to analyze and prescribe a plan to restore historical functions of the river. An interactive approach with the general public, landowners, Project beneficiaries and governmental agencies was used to develop the analysis and recommendations contained herein. Funding was provided by the Colorado Water Conservation Board (CWCB).

The primary purposes of this Project were to analyze and develop a restoration master plan for the Rio Grande from the upstream corporate limit of the Town of South Fork, Colorado to the Alamosa-Conejos County line. The study assesses and presents a plan to enhance the adequacy of the Rio Grande to fulfill the following historical functions:

- Maintenance of channel capacity and overbank capacity.
- Protection of channel and floodplain from damage by flooding.
- Maintenance of riparian habitat.
- Delivery of Rio Grande Compact commitments.
- Access to river for water diversion.

ES.1.1 Consulting Team

The RGHRP project team consisted of:

- MWH Americas, Inc. (Project Management, Hydrology, Hydraulics, Floodplains, Compact Issues)
- Agro Engineering, Inc. (River Inventory, GIS Mapping, Irrigation Diversions, Local Coordination)
- Lidstone and Associates (Geomorphology, Irrigation Diversions)
- SWCA, Inc. (Vegetation, Habitat, Wildlife)

ES.1.2 Technical Advisory Committee

The Technical Advisory Committee (TAC) provided assistance, guidance and review of the work. The input and guidance from the TAC was key to a successful project. The RGHRP TAC was comprised of the following individuals:

- Mike Blakeman, U.S. Forest Service, Landowner
- Mike Blenden, U.S. Fish and Wildlife Service
- Doug Davie, Silva Ditch, Landowner
- Allen Davey, Davis Engineering

- Kate Booth Doyle, San Luis Valley Ecosystem Council/Rio Bravo Coalition
- Brian Hyde, Colorado Water Conservation Board
- Dennis Felmlee, San Luis Valley Water Conservancy District
- Robert Felmlee, San Luis Valley Water Conservancy District
- Jeff Johnson, Colorado Division of Wildlife
- Pete Magee, SLV GIS/GPS Authority
- Scott Miller, U.S. Fish and Wildlife Service
- D.H. McFadden, Geological Consultant, Retired Division Engineer
- Doug Messick, San Luis Valley Water Conservancy District
- Randall Palmgren, San Luis Valley Water Conservancy District
- Steve Russell, Natural Resources Conservation Service
- Doug Shriver, Centennial Ditch
- Steve Vandiver, Division Engineer
- Ray Wright, Rio Grande Water Conservation District

The work was guided by the TAC, the San Luis Valley Water Conservancy District (SLVWCD) and the Colorado Water Conservation Board (CWCB). The TAC met to review and discuss intermediate Project deliverables at key Project milestones and participated in making strategic planning decisions. Two public meetings were held to guide the data collection effort and develop a final restoration plan.

ES.2 Study Area Description and Data Collection

The Rio Grande Headwaters Restoration Project study area is located along the Rio Grande within the San Luis Valley of Colorado. This is shown in **Figure ES-1**. The San Luis Valley is a large intermountain basin located in the south-central portion of the state. The study area includes the Rio Grande from the upstream town limits of South Fork to the Alamosa/Conejos county line and encompasses the river corridor in all of Alamosa County and most of Rio Grande County. The study area includes approximately 91 miles of the river. The study reach includes South Fork, Del Norte, Monte Vista and Alamosa, portions of the Rio Grande and Higel State Wildlife Areas and portions of the Alamosa National Wildlife Refuge. The river within the study reach is primarily used for irrigation diversions, wildlife habitat, ranching and recreation.

The data collection portion of the project was undertaken to understand historical and current events which may have affected the river corridor, gather data necessary to perform a technical analysis of the five key areas as described above, and understand limitations to the restoration effort. Data collected included current and historical aerial photography, hydrology data (daily flows, peak discharges, and Rio Grande Compact requirements), floodplain reports and maps, bridge inspection reports, and existing geographic information system (GIS) coverages for land use, soil type, vegetation characteristics, property ownership, and topography. Meetings were also held with key stakeholders in an effort to gather knowledge not necessarily available in written form. As part of the GIS mapping tasks, the river corridor was flown to develop low resolution and high resolution aerial photos.

A GIS-based river corridor inventory was prepared as part of the data collection effort. The inventory documented irrigation structures, bridges, banks, channel bed, vegetation and other features in the corridor. The river was “floated” from the upstream study limits near South Fork to the downstream study limits. A full video inventory of river conditions was taken and developed into a GIS coverage. Key river locations were visited and studied by members of the technical team to collect field data such as channel geometry, bank conditions, floodplain vegetation conditions, and irrigation diversion structure conditions. Portions of the data collected during these visits are also available through GIS coverages.

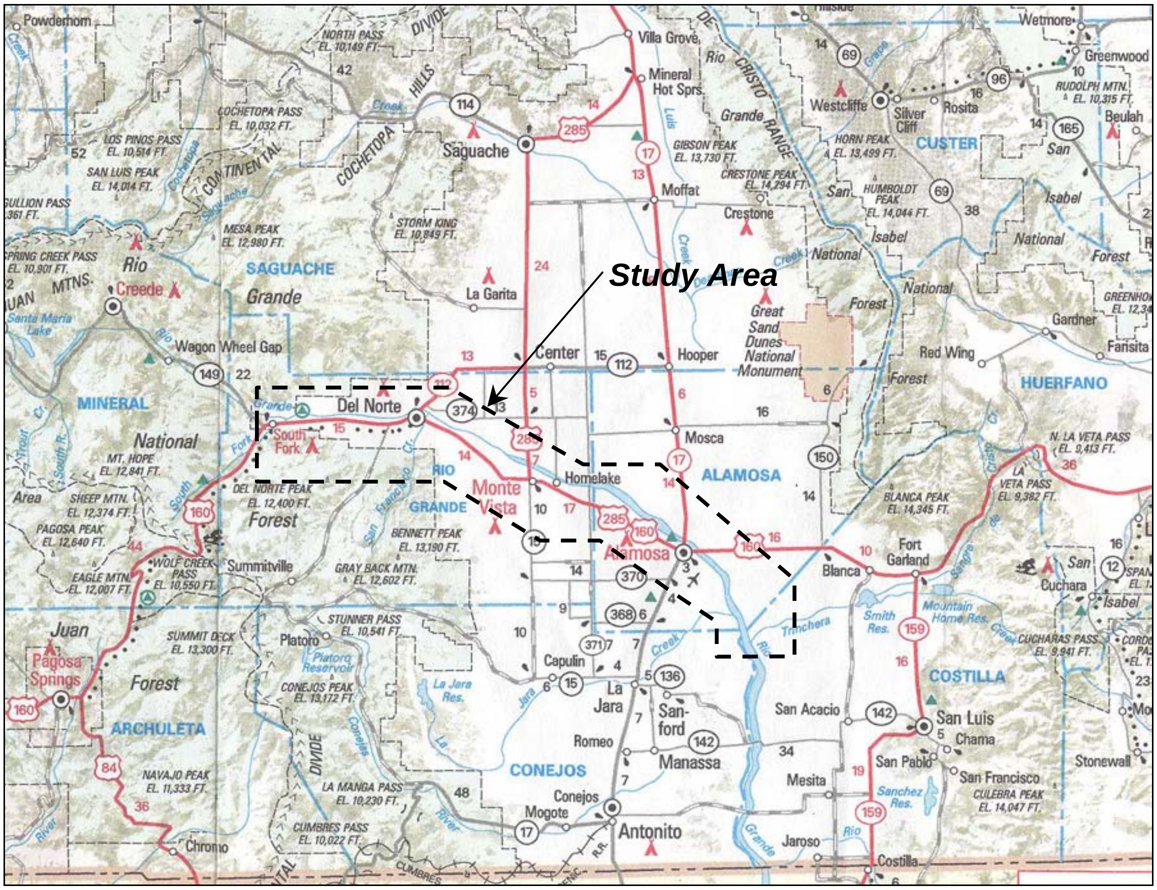

Figure ES-1. RGHRP Study Area and San Luis Valley Map

In order to provide a base level for further examination, the study area was divided into several reaches. The division of these reaches was based on homogeneous characteristics related to hydrology, floodplain width, river geomorphology and vegetative conditions. These reaches are defined in **Table ES-1**. A profile of the study reach is presented in **Figure ES-2**.

Table ES-1. Description of RGHRP Reaches

Reach Name	Beginning Location	Ending Location
Reach A	Upstream Study Limits	Beginning of Split Flow Channel at Del Norte
Reach B1	Beginning of Split Flow Channel at Del Norte (North Channel)	End of Split Flow Channel
Reach B2	Beginning of Split Flow Channel at Del Norte (South Channel)	End of Split Flow Channel
Reach C	End of Split Flow Channel	Consolidated Slough
Reach D	Consolidated Slough	Rio Grande/Alamosa County Line
Reach E	Rio Grande/Alamosa County Line	Upstream end of Alamosa Levees
Reach F	Upstream end of Alamosa Levees	Chicago Ditch Diversion
Reach G	Chicago Ditch Diversion	Downstream Study Limits

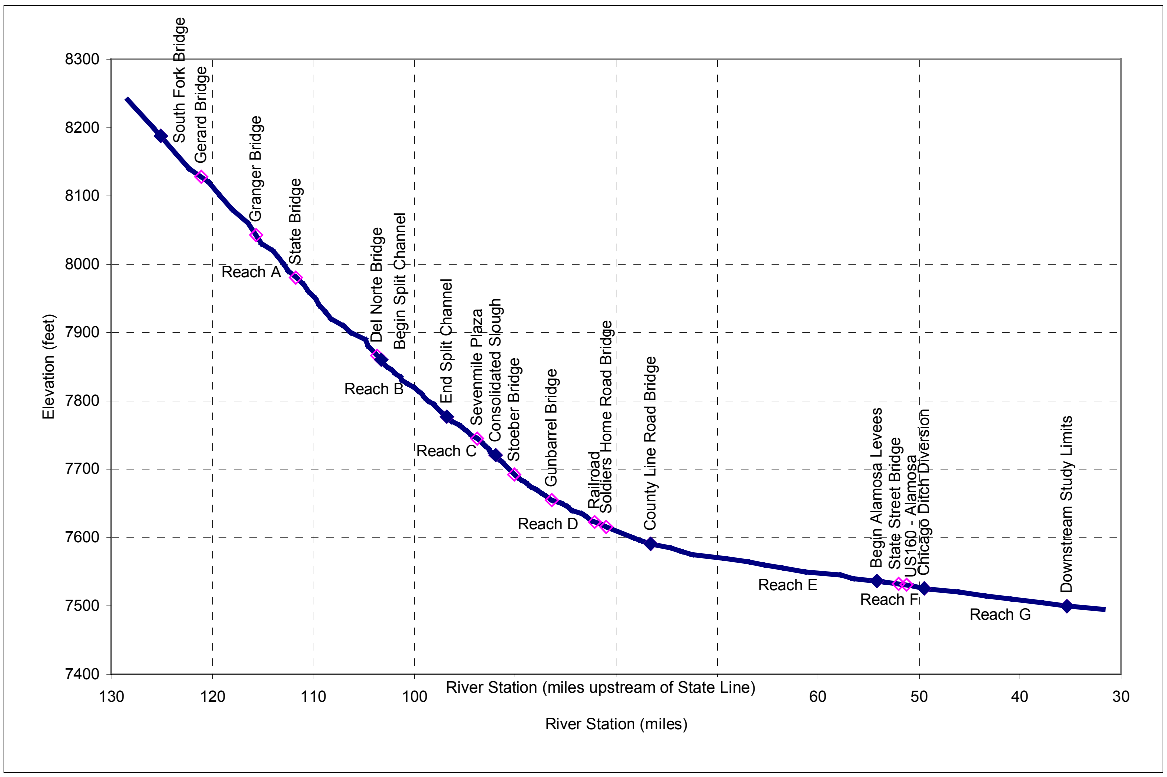

Figure ES-2. Rio Grande Channel Profile

Reach A is the steepest and most entrenched of the reaches. Through several portions of this reach, channel banks are experiencing cut banks, sloughing and undercutting. Floodplains are typically confined to the channel or lands immediately adjacent to the channel. However, there are many homesites located in or very near the 100-year floodplain. Vegetation primarily consists of dense cottonwoods with an understory of willow and bluegrasses.

Reach B includes the north and south split flow channels downstream of Del Norte. The north channel is primarily used to convey water to the Farmers Union Canal diversion just upstream of the north/south channel confluence. Flows in the north channel tend to be fairly uniform with no flood flows, while the south channel receives less base flow and most of the flood flows. Bank erosion is much less prominent in the north channel than in the south channel. The floodplain generally includes most of the area between the channels. However, except for the town of Del Norte, there is little development within the 100-year floodplain. Vegetation includes cottonwoods, willows and grasses.

Reach C includes the area between the Del Norte split flow convergence and the Consolidated Slough. The channel slope remains moderately steep, however there are locations of depositional areas. The reach is particularly active, with lateral channel migration and meander cutoffs. There are few structures within the 100-year floodplain, which is primarily contained within the river corridor. Channel bank vegetation includes old growth cottonwoods, willows and grasses.

Reach D transitions from the steeper upstream channel slopes to the flatter downstream channel slopes, causing the channel to transition from being erosional to depositional. The system is dominated by a single active channel surrounded by a network of inactive channels and oxbows. However, due to the numerous older channels and oxbows, the channel can easily migrate and cause new channels to form. The floodplain occurs on either side of the main channel. Development in the 100-year floodplain is moderate, with scattered farm sites; the area north and west of Monte Vista contains the most development. Vegetation consists of mature cottonwoods with some regeneration, willows and grasses.

Reach E is a relatively flat reach that tends to be highly depositional. Bank slopes are steep and channel capacity is limited in several areas. Out-of-bank flood events cause damage to structures within the floodplain, and may have the potential to bypass the Alamosa levee system. There are several reaches of decadent cottonwoods, with some willow and grass understory.

Reach F includes the river through the Alamosa levee system. The slope remains flat, causing deposition of sediment and loss of channel capacity. There are very few structures within the floodplain, primarily limited to the golf course north of the river. Vegetation is primarily limited to young willows on sediment bars within the river channel or on the levee banks.

Reach G primarily consists of area on the Alamosa Wildlife Refuge. The channel slope is very flat resulting in a highly depositional reach. The floodplain is very wide and helps reduce peak flows during flooding events. However, there is little development within the floodplain downstream of Alamosa. Vegetation primarily consists of grasses and willows, with scattered cottonwood stands.

ES.3 Analysis of Specific River Issues

The analysis of specific river issues was required to develop a technical understanding of existing river conditions and to develop an overall classification and prioritization of the study reach. Based upon similarities in the technical issues, the primary river reaches were further divided into sub-reaches. This allowed a more discrete breakdown of the study reach for analysis, provided a means for aggregation of technical evaluations, and allowed TAC input to river condition evaluations and alternative selection. **Table ES-2** presents the upstream and downstream boundaries and a description of the 30 sub-reaches.

ES.3.1 Hydrologic Analysis

Historical streamflow records were analyzed for the following Rio Grande gages: Thirtymile Bridge, Wagon Wheel Gap, Del Norte, Monte Vista, Alamosa, and Lasauses. Mean annual discharges are shown in **Figure ES-3**. This figure demonstrates the impact of irrigation diversions on reducing channel flows downstream of Del Norte.

Flood-frequency analyses were performed for peak discharge data at the six Rio Grande gages. Results are shown in **Figure ES-4**. Peak discharges for the higher probability events (1.5-year and 5-year) are highest at the Del Norte gage. This is primarily because during these events, a significant portion of the flood flows is purposely diverted into irrigation canals downstream of Del Norte. However, peak discharges for the lower probability events (such as the 100-year flood) increase to Alamosa, then are dissipated at Lasauses. The increase to Alamosa occurs because flows are too high for diversion to irrigation canals to make a significant difference.

ES.3.2. River Hydraulics, Capacity and Floodplain Analysis

The analysis shows that bank-full capacities ranged from less than 500 cfs in the lower portions of the river to more than 8,000 cfs. The return periods for exceedence of bank-full capacities ranged from less than 1 year at 6 of the cross-sections to approximately 11 years. All of the bank-full capacities were less than the required Compact delivery rates established by the State Engineer's Office. The effects of bank-full capacity being exceeded are felt primarily in the South Fork, Del Norte and Monte Vista areas, where 130, 159 and 74 structures are inundated by the 100-year floodplain, respectively. **Figure ES-5** shows the structures within the floodplain for each sub-reach. Potential damages in the South Fork and Monte Vista areas are made worse by the increased velocity and depths of flows within the floodplain. Delivery of Compact flows also results in some potential inundation at these areas, and could create structure inundation primarily at South Fork and Del Norte. The high flow velocity and depth also creates potential danger for persons in those same areas, where the product of depth and velocity meets or exceeds the recommended value for personal safety of 6. The Alamosa levee capacity is exceeded at the upstream end, resulting in inundation of the golf course area during even minor flood events and Compact deliveries.

Table ES-2. Sub-Reach Definition

Sub-Reach	Start Sta.	End Sta.	Length (miles)	Description
A1	125.90	123.96	1.94	South Fork - Upstream of Confluence with South Fork
A2	123.96	119.40	4.56	South Fork - to 2 miles d/s of Anaconda Ditch diversion
A3	119.40	114.00	5.40	Upstream and downstream of Minor and Meadow Glen diversions
A4	114.00	109.93	4.07	Upstream and downstream of State Bridge
A5	109.93	105.05	4.88	Upstream and downstream of Park Green diversion
A6	105.05	103.30	1.75	Del Norte - upstream of spilt including Rio Grande Canal diversion
BA1	103.30	98.16	5.14	Upstream reach of North Channel
BA2	98.16	96.30	1.86	Downstream reach of North Channel
BB1	103.30	99.39	3.91	Upstream reach of South Channel
BB2	99.39	96.30	3.09	Downstream reach of South Channel

Table ES-2. Sub-Reach Definition

Sub-Reach	Start Sta.	End Sta.	Length (miles)	Description
C1	96.30	93.10	3.20	Confluence of Flow Split through Sevenmile Plaza Bridge
C2	93.10	92.77	0.33	Prairie Ditch Diversion Area
C3	92.77	92.02	0.75	Monte Vista / Piedra diversion area
D1	92.02	89.75	2.27	Consolidated Slough diversion area
D2	89.75	87.40	2.35	Butler Ditch diversion area
D3	87.40	85.17	2.23	Monte Vista - Upsteram and downstream of Gunbarrel Road
D4	85.17	81.12	4.05	Monte Vista - Empire / Billings diversion area
D5	81.12	79.80	1.32	Homelake Area including San Luis Valley Canal diversion
D6	79.80	77.00	2.80	Upstream of Rio Grande / Alamosa County Line including Centennial Ditch diversion
D7	77.00	76.01	0.99	Straightened Reach U/S and D/S of County Line including Excelsior diversion
E1	76.01	74.32	1.69	Dowstream of Excelsior diversion
E2	74.32	68.63	5.69	Upstream of Costilla Ditch diversion
E3	68.63	65.89	2.74	Costilla Ditch diversion
E4	65.89	60.26	5.63	Downstream of Costilla Ditch diversion
E5	60.26	55.62	4.64	Upstream of Alamosa levees - Independent Ditch diversion
F1	55.62	52.12	3.50	Alamosa Levees - Upstream of State Street bridge
F2	52.12	49.54	2.58	Alamosa Levees - State Street bridge to Chicago Ditch diversion
G1	49.54	45.20	4.34	Immediately downstream of Alamosa Levees
G2	45.20	39.27	5.93	Rock Creek confluence area
G3	39.27	35.35	3.92	La Jara Creek confluence area

In areas outside the urban communities, overbank flows to a certain extent can be beneficial. Riparian areas benefit from some overbank flow to establish and irrigate new seedlings. However, overbank flows which occur frequently or occur at higher depths and velocities can result in damage to riparian areas, channel instability, damage to agricultural land, damage to grazing land and structural damage. Sub-reaches which show exceedence of bank-full capacity equal to or less than 1 year and have high depth*velocity relationships will may result in excessively damage. This occurs in areas between South Fork and Del Norte and areas near Monte Vista. Areas immediately upstream and downstream of Alamosa, which have frequent inundation but low depth*velocity ratios and few structures in the floodplain, may benefit from overbank flow to support vegetation.

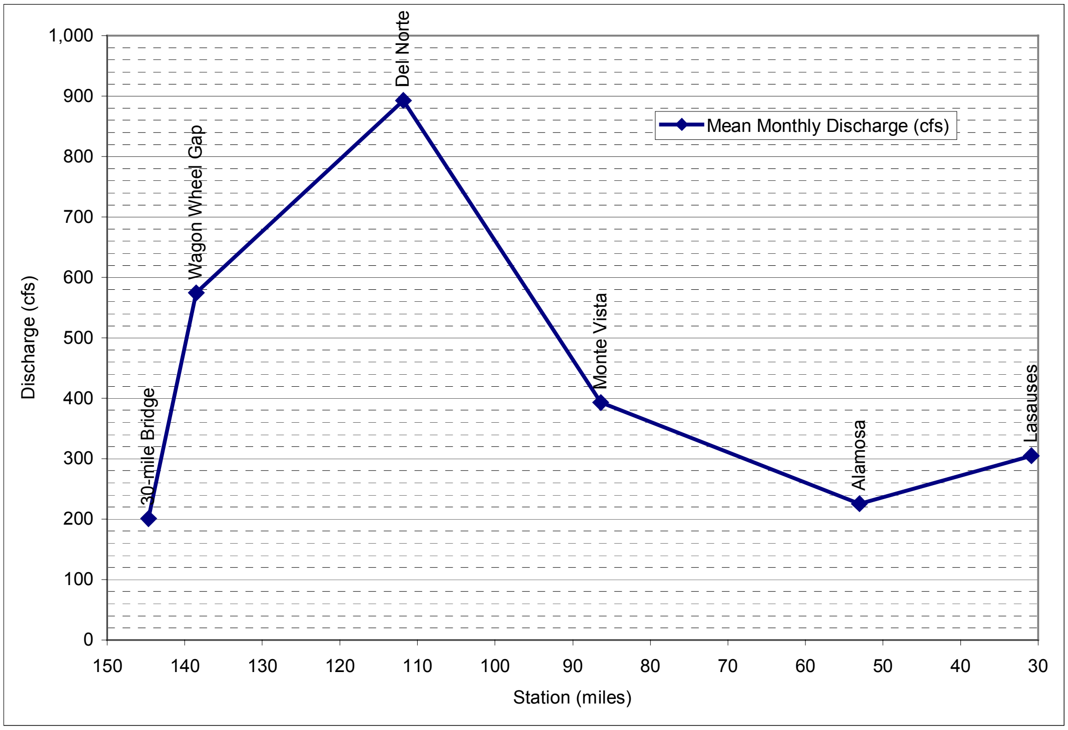

Figure ES-3. Rio Grande Mean Annual Flow, All Gages (Period-of-Record)

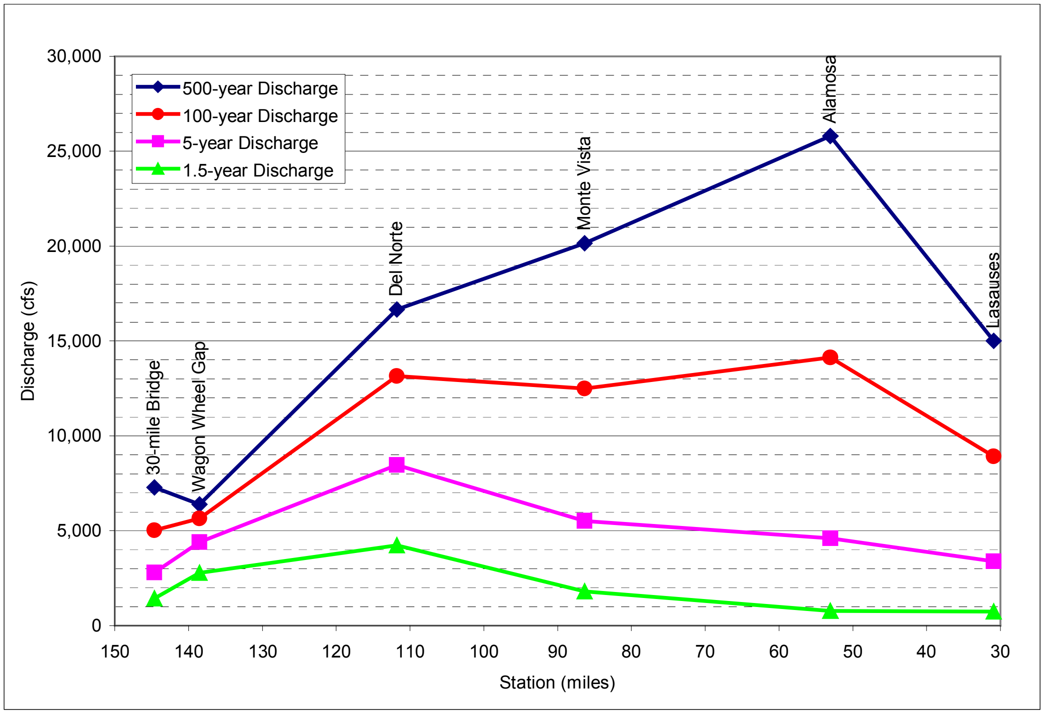

Figure ES-4. Peak Discharges Along the Rio Grande

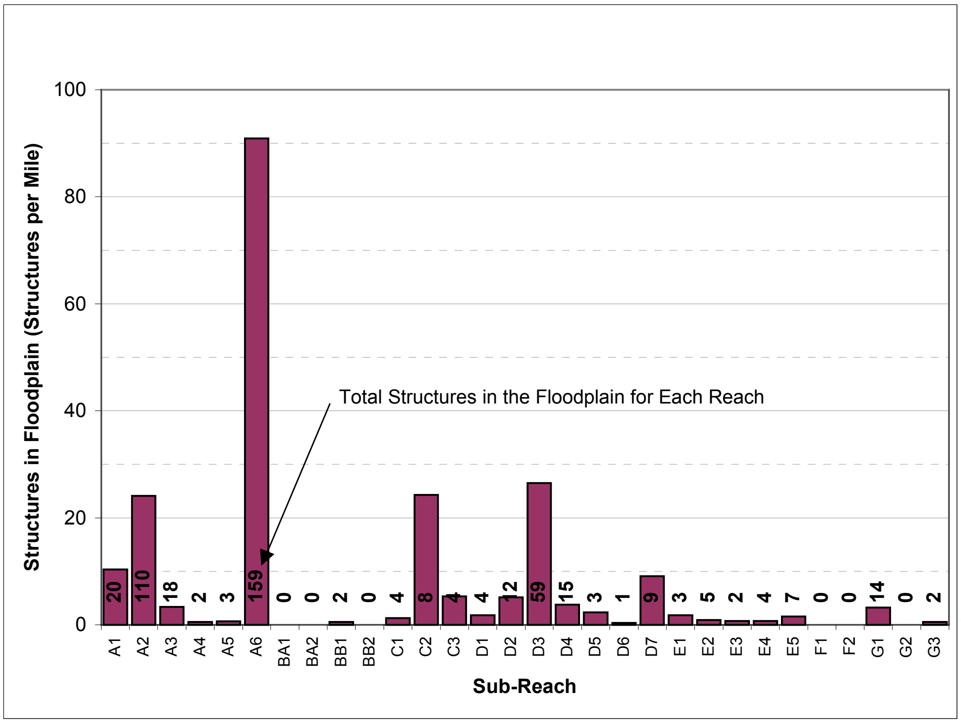

Figure ES-5. Structures within the Floodplain

The evaluation of existing hydraulic capacity and floodplain issues has identified several key problems to be addressed by the RGRHP. These are summarized below.

- Urban development in the Rio Grande corridor over the past 120 years has encroached into the 100-year floodplain, putting infrastructure and the public at risk. This has occurred primarily in South Fork (new development on streambanks and in the floodplain); Del Norte (old development in the floodplain); the unincorporated Rio Grande County area near Monte Vista; and other isolated areas like the old low-lying development upstream of Sevenmile Plaza. The plan should include approaches for mitigating flood hazards in these areas.
- Several existing bridges act as obstacles to flood flows either because of channel changes or poor designs, and need to be modified. These include Gunbarrel Road, the old Sevenmile bridge, the railroad bridge and the Rio Grande / Alamosa County Line bridge.
- The Alamosa Levees no longer have their original design capacity due to sedimentation and vegetation growth, and cause backwater flooding at the golf course at their upstream end even during low flows. Capacity within the levees needs to be restored and flooding at lows must be prevented.
- Channel instability between Monte Vista and Alamosa creates the potential for the Rio Grande channel to shift to the north during a severe flood event, bypassing the Alamosa Levees. This would cause significant damage in Alamosa and should be prevented.
- Land development (urban and agricultural) combined with loss of channel capacity through sedimentation and other factors has created flooding

problems during periods when Compact deliveries are being moved through the system. These problems occur primarily at South Fork, Del Norte, agricultural lands between Monte Vista and Alamosa, and the golf course in Alamosa. A plan for delivering Compact flows without causing damage in these areas is needed.

- The safety of individuals within the floodplain is threatened during flood flows in the upper portions of the river where recreational uses are highest. Plans should be developed for evacuation in case of high water

ES.3.3 Geomorphology Analysis

The project team obtained aerial photographs of the study area for the years 1941, 1963 and 1998. Aerial photos were georectified utilizing USGS quadrangle maps and landmarks on the aerial photos. Using the USGS quad and rectified air photo composite, a quantitative evaluation of the changes in river planform from 1941 through 1998 was completed. Such changes include channel length and channel sinuosity. In order to provide some understanding of the historical changes in bed elevation and its relationship to adjustments in planform, CDOT bridge analysis inspection data was incorporated into the geomorphic analysis. The bridge data provided bed elevation changes at a fixed point (i.e., the bridge) over the last 10 to 15 years. Finally, rating tables at the Del Norte, Monte Vista and Alamosa stream gages were incorporated into the geomorphic analysis. Gage data, like the bridge data, allow a review of bed elevation changes at a fixed point. Unlike the bridge data, the period of record for the individual gages is significantly longer and is directly comparable to the air photo record.

The Rio Grande is a sediment-dominated system. This means that the channel changes seen in the field and identified as channel instability issues are a response to changes in sediment discharge and to a lesser extent, water discharge. The river is “hydraulically efficient” as it enters South Fork and remains so through the upper sub-reaches of Reach A. As such the river is capable of transporting its water and sediment load without major erosion or sedimentation. There has been little change in channel bed elevation and minor changes in channel length or sinuosity over the analysis period.

From river station 103.6 through river station 76.6 (Reaches B, C and D), there has been a net decrease in channel length between 1941 and 1998. Each reach within this river segment has exhibited channel shortening via meander cutoffs. Historically the greatest period of meander cutoffs seems to have occurred during the period from 1941 to 1963. This was also the period of significantly higher and more frequently occurring peak flows. As the channel length decreases, the channel slope and sediment transport capacity increases. Bed material transported through the straightened reach will be deposited downstream. In several cases, the period from 1963 to 1998 indicated an increase in channel length immediately below a straightened upper reach. Channel length will increase as the downstream reach accommodates the recently deposited sediment; bar development will increase meandering and decrease channel slope. Sinuosity will increase.

River station 76.6 to river station 36.6 shows a net increase in channel length from 1941 to 1998. Analysis of stage rating curves, bridge data and field reconnaissance indicate that bed aggradation, loss of flood capacity and sedimentation at irrigation headgates is the dominant problem. On a regional scale, bed material generated from the upper reaches has been transported to the lower reaches. Diversion dams, low natural stream gradients, accumulation of debris in a low capacity channel, and a 30-year period of lower peak flows impact the sediment transport capacity of this river reach.

The following key stream geomorphology problems and issues must be addressed in the RGHRP plan.

- Eroding banks in and downstream of South Fork are threatening existing and proposed development, adversely impacting valuable aquatic and wildlife habitat, and contributing sediment to the lower river reaches where sediment deposition is a problem.
- Isolated severely eroding banks between South Fork and Del Norte could be stabilized to minimize sediment production to downstream areas, as well as to protect adjacent land.
- The South Channel downstream of the Del Norte flow split has stability problems due to the unnatural flow regime (no low flows, only high flows), that also make this a high sediment producing area.
- Erosion and deposition problems in the vicinity of the Sevenmile Plaza area need to be addressed.
- Approaches are needed to mitigate – or live with – the highly depositional nature of reaches D and E between Monte Vista and Alamosa. Sediment deposition causes loss of capacity and channel meandering evidenced by bank erosion. Measures are needed to balance the rate and volume of sediment transported into these reaches with the sediment transport and storage capacities in the reaches themselves.
- Sediment deposition downstream of Monte Vista is responsible for loss of channel conveyance, leading to flooding problems during high flows and, in some cases, even during normal Compact deliveries. Short leveed sections of this reach have had limited effectiveness and have largely shifted problems to upstream and downstream areas. A plan for enhancing channel capacity while improving geomorphic stability is needed.
- Sediment transport through the Alamosa Levee reach (Reach F) has been adversely impacted in part by the obstruction created by the Westside Ditch diversion dam. Sediment transport capacity in the leveed area needs to be increased.
- Bank erosion occurs downstream of the Alamosa Levees and on the Alamosa National Wildlife Refuge because this reach is sediment deficient. Critical banks needs to be stabilized and/or sediment delivery from upstream reaches needs to be increased.
- Channel instability has adversely impacted the effectiveness of numerous diversion structures throughout the study area through bank migration and sediment deposition.
- The numerous abandoned channel cutoffs and oxbows in the Rio Grande floodplain, particularly downstream of Monte Vista, provide important

opportunities for improving the flow and sediment transport and storage capabilities in the study area.

- Increased sediment production from the watershed upstream of South Fork may play a role in the oversupply of sediment found in the reach downstream of Monte Vista. This deserves further investigation beyond this study effort.

ES.3.4 Riparian Habitat Analysis

The analysis of existing riparian habitat in the Rio Grande corridor was based on three components: Riparian Vegetation, Riparian Wildlife, and Fisheries. This project included an investigation of the following: current vegetation composition and a comparison to historic conditions; terrestrial wildlife habitat analysis; aquatic wildlife habitat analysis; and identification of issues pertaining to the improvement of riparian and aquatic habitat conditions.

The Rio Grande riparian and stream ecosystem is uniquely rich in productivity and is important to wildlife as well as human populations. Riparian zones are an interface between terrestrial and aquatic environments and serve many functions including the filtering of pollutants before they reach the aquatic environment. In the western states, especially in the more arid areas such as the San Luis Valley, riparian systems offer a rare source of lush vegetation that is typically more biologically diverse than surrounding areas. Benefits of stream and riparian habitat include: control of flooding and sediment transport; enhancement of water quality; fish and wildlife habitat; and socioeconomic values.

Riparian Vegetation

Key vegetation communities in the study area consist of narrowleaf cottonwood and willow. Cottonwood is the dominant vegetation upstream of Monte Vista, and willow is the dominant vegetation downstream of Alamosa. Between Monte Vista and Alamosa both species are prevalent.

Health of the cottonwood community varies along the corridor from excellent to fair. Most of the cottonwood forest is comprised of a mature age class; regeneration rates are not keeping up with aging of older trees. Factors adversely affecting cottonwood communities are lack of periodic flooding to promote natural regeneration, encroachment by agricultural and urban land uses, and, more recently, beaver. Willow communities appear to be generally healthy, with most adverse impacts being associated with land clearing and channel maintenance.

Review of historical aerial photographs documented a considerable loss of riparian vegetation extent and density between 1941 and present. This was due to agricultural clearing, urban development, and channel migration. Photographs also showed that in areas of channel or floodplain scour, natural regeneration processes were successful.

Fallen cottonwood trees, either due to decadence, stream bank erosion or beaver activity, create serious debris obstructions at bridges and irrigation diversion dams that result in increased flooding problems in the Rio Grande corridor.

Riparian Wildlife

Wildlife habitat assessments were based on field reconnaissance and analysis of published and anectodal information. Key indicator species were selected to be representative of response of wildlife to habitat changes. These included: bald eagle, southwestern willow flycatcher, whooping crane, mule deer, beaver, waterfowl, sandhill crane, heron, shorebirds, raptors, upland gamebirds, songbirds, tiger salamander, Woodhouse's toad, and northern leopard frog. These indicator species have a broad variety of habitat preferences, all of which can be found in the study area in varying degrees. In general it was found that areas with high quality riparian vegetation communities provided high quality habitat for most of the key indicator species. Adverse impacts on riparian vegetation have similar impacts on wildlife communities.

It is important that the Rio Grande corridor provide a diversity of habitats – e.g., mudflats, ponds, riffles, cottonwood galleries, willow thickets – to support a diversity of native wildlife. Two of the key indicator species may receive special consideration in the RGHRP.

- The southwest willow flycatcher is listed as endangered by the U.S. Fish and Wildlife Service, and a Recovery Plan is currently being prepared that will probably affect portions of the study area. Preferred habitat consists of thickets of willow or other shrubs with an overstory of scattered larger trees adjacent to surface water or saturated soil.
- Beaver returned to the study area in the mid 1980s, and have caused problems by damming sloughs and oxbows and felling cottonwood trees.

Fisheries

A cold-water fishery extends from South Fork to Monte Vista, below which a transition occurs to a warm-water fishery. The reach from South Fork to the Farmer's Union Canal is a Gold Medal trout fishery (rainbow and brown trout), as designated by the Colorado Division of Wildlife. Although habitat is good in this reach, it could be improved by protection the riparian zone, creating more riffle-pool complexes, and preventing bank erosion and flooding. The highest potential for habitat improvement exists between South Fork and Del Norte, although some improvements could also be made between Del Norte and Monte Vista.

The warm-water fishery below Monte Vista supports a variety of non-native fish, including northern pike, largemouth bass, yellow perch, black bullhead, channel catfish, green sunfish, mosquitofish, carp and trench. The native Rio Grande sucker is no longer found in the channel (only in major tributaries), but the river does support native populations of brook stickleback, longnose dace, Rio Grande chub, fathead minnow, red shiner, and white sucker. Lack of flow due to upstream diversions is the primary habitat threat for these species.

Riparian Habitat Restoration Issues

The following issues were considered important to the riparian habitat component of the RGHRP project.

- Protection of the riparian corridor against further encroachment by agricultural and urban land uses
- Grazing management to protect the health of the existing riparian vegetation
- Allowable periodic flooding of cottonwood and willow communities to promote natural regeneration
- Management of the irrigation diversion system to prevent excessive dewatering of the stream and remove as many barriers to fish passage as possible
- Management of beaver populations
- Measures to reduce debris problems associated with fallen cottonwoods during high flows
- Enhancement of trout habitat, particularly in the reach from South Fork to Del Norte
- Possible protection of southwest willow flycatcher habitat

ES.3.5 Diversion Structures Analysis

A qualitative and quantitative analysis of the numerous diversions within the study reach was completed. An inventory of diversion structures is provided in **Table ES-3**.

Several factors control the effectiveness and stability of each point of diversion and conveyance structure. These include wasteways, debris problems, sedimentation, river migration and river access. Most of the ditches within the study reach are not equipped with wasteways. Wasteways assist in preventing the buildup of sediment within the canal and allow better regulation of the diversion by allowing sediment continuity and by returning a portion of water and sediment to the river downstream of the diversion structure. Debris problems, sedimentation, river migration, and river access are factors that address the ability of the structure to function as designed. Specifically, debris problems include downed timber and associated trash; sedimentation manifests itself as the buildup of sediment within the diversion; river migration addresses river movement away from and toward the diversion as well as the potential for the river to cut around and bypass the diversion entirely; and river access is defined as the diversion's ability to divert water. Each diversion and the factors which control its effectiveness are discussed in the text. **Table ES-3** lists the qualitative rating of each diversion structure (i.e. good, fair, poor).

Table ES-3. Diversion Structure Capacity and Overall Rating

ID	Diversion Name	Location (river mile)	Sub Reach	Est. Capacity (cfs)	Dec. Capacity (cfs)	Overall Rating
7022	RIVIERE ESTATES AUG PLAN	123.1	A2	no records	no records	Good
511	ANACONDA D	121.4	A2	40	38.76	Fair
752	MINOR D	118.1	A3	70	39.48	Fair
742	MEADOW GLEN D	117.5	A3	50	46.86	Good
787	PFEIFFER D	116.8	A3	15	10.67	Fair
681	INDEPENDENT D 2	114.4	A3	40	67.23	Fair
614	EHROWITZ D	113.8	A3	15	12.35	Fair
528	BAUER D	112.4	A4	15	15.25	Fair

Table ES-3. Diversion Structure Capacity and Overall Rating

ID	Diversion Name	Location (river mile)	Sub Reach	Est. Capacity (cfs)	Dec. Capacity (cfs)	Overall Rating
965	ATKINS D	109.9	A4	2	1.05	Poor
782	PARK GREEN D	108.2	A5	10	5.2	Poor
611	DYER D	106.1	A5	5	4	Fair
812	RIO GRANDE CHANNEL	104.7	A6	1900	1648.5	Good
833	SCHUCH SCHMIDT	104.7	A6	6	4.4	Good
747	MIDLAND D	103.7	A6	40	60	Poor
815	RIO GRANDE D 4	103.6	A6	4	1.2	Fair
810	RIO GRANDE D 1	103.3	A6	18	36	Fair
737	MCINTOSH ARROYO D	98	BB2	8	4	Poor
846	SILVA D	95.2	C1	25	18.8551	Good
518	ATENCIO D2	95.2	C1	6	4	Fair
736	MCDONALD D	93.8	C1	20	14.4	Fair
798	PRAIRIE D	93.4	C2	380	367.02	Good
753	MONTE VISTA CHANNEL	92.6	C3	380	340.77	Good
811	RIO GRANDE PIEDRA VALLEY D	92.6	C3	96	94.48	Fair
781	PACE D	91.6	D1	4	1.4	Poor
0	CONSOLIDATED SLOUGH	91.9	D1			Poor
556	BUTLER D	90.7	D1	10	6.8	Poor
636	FISH D	87.8	D2	10	9.3	Poor
775	NICHOL D	87.2	D2	10	11.2	Poor
623	EMPIRE CNL	84.6	D4	550	505.92	Fair
546	BILLINGS D	83.2	D4	40	34.94	Poor
829	SAN LUIS VALLEY CHANNEL	79.9	D5	400	500.98	Poor
566	CENTENNIAL D	79.1	D6	100	82.4	Fair
627	EXCELSIOR D	76.1	D7	120	89.7	Fair
587	COSTILLA D	65.6	E3	110	103.3	Poor
680	INDEPENDENT D	57.7	E5	20	11.2	Fair
903	WESTSIDE D	50.9	F2	47	35.8	Poor
575	CHICAGO D	49.5	F2	120	66.4	Good
773	NEW DITCH	42.6	G2	120	30.43	Fair
901	WEISS D	103.3	BA1	4	1.34	Good
552	BREY D	103.3	BA1	5	4.8	Good
814	RIO GRANDE D 2	103.3	BA1	8	4.2	Good
699	KANE CALLAN D	103.3	BA1	24	24	Good
513	ANNA RABER D	103.3	BA1	5	3.8	Good
777	OFF D	103.3	BA1	10	5	Good
801	RABER D	103.3	BA1	4	3.8	Good
966	HALL-VOSS D	103.3	BA2	4	1.95	Good
582	COCHRAN PIONEER D	103.3	BA2	5	3	Good
631	FARMERS UNION CHANNEL	103.3	BA2	910	801.45	Good

The following points summarize the findings of the diversion structure assessment and indicate key stream diversion problems and issues that must be addressed in the RGHRP plan.

- The 6 major diversions on the river (those with a decreed capacity of more than 300 cfs, including Rio Grande Canal, Prairie Ditch, Farmers Union Canal, Monte Vista Canal, Empire Canal and San Luis Valley Canal) comprise 80 percent of the total decreed diversions within the study reach. Of those, four diversions (Rio Grande Canal, Farmers Union Canal, Prairie Ditch and Monte Vista Canal), which represent 61 percent of the total decreed diversions within the study reach, are in good condition.

- Channel conditions at diversions in the upper end of the system near South Fork are fairly stable. Some debris buildup is evident at the diversions.
- Sedimentation in diversions along the steeper portions of the channel upstream of Del Norte is a major problem. Few of the structures have wasteway channels to allow sluicing of sediments. Channel instability also becomes a problem in this area. Diversion density is fairly high in this area at an average of 0.8 diversions per mile. Therefore, diversion consolidation should be considered.
- Only one diversion (McIntosh Arroyo Ditch) is contained in the South Channel. Relocation of the diversion structure to allow other project objectives to be maximized in the South Channel should be considered.
- Diversions from the North Channel are all in fair to good condition, and no major restoration efforts on the North Channel are required for diversion purposes.
- Diversions between the Del Norte split flow confluence and the Consolidated Slough (Reach C) are generally in good condition. The exception is McDonald Ditch, which utilizes the old Sevenmile Bridge structure as a diversion and was given a fair rating. The density of diversions within Reach C is the highest in the study reach at an average of 2 diversions per mile of stream length. However, because the river and diversions are in good condition, consolidation is not necessarily recommended.
- Channel instability is a major problem for diversions from the Consolidated Slough downstream through the Westside Diversion. All diversions were given fair to poor ratings. Channel avulsion, lack of channel capacity, sedimentation, and debris accumulation are all problems at these diversions.
- The density of diversions between the Consolidated Slough and Centennial Ditch is fairly high at 0.6 diversions per mile. Diversion consolidation should be considered at several locations to maximize diversion efforts at fewer diversion locations.
- The Westside Diversion Dam is in poor condition, and is causing capacity problems within the Alamosa levees. The dam should be removed and the diversion consolidated or redesigned to significantly reduce or eliminate its impacts on the Alamosa levees.
- The New Ditch diversion on the Alamosa National Wildlife Refuge has inadequate capacity and obstructs river flows.

ES.3.6 Local Planning Issues

A review of existing floodplain management and comprehensive land use plans as they relate to the RGHRP objectives was conducted. Emphasis was on floodplain management, zoning and land development regulations that affect potential development in the river corridor.

Floodplain management is a tool available to local communities to assure that development in flood-prone areas meets minimum public safety standards and is consistent with local land use objectives. Locally adopted floodplain management regulations currently allow governmental bodies in the Rio Grande corridor to exercise a certain amount of control over the nature of development in the floodplain areas in the corridor. All of the entities along the Rio Grande within the study reach currently have floodplain ordinances that include requirements for floodproofing or setting finished floor elevations at or above the base (100-year) flood elevation, and establish limitations on increases in the base flood elevation within the floodway. However, patterns of recent development indicate that these regulations are not uniformly or aggressively enforced in all areas. In addition, new structures and access roads in floodplains have been elevated on fill (consistent with floodplain regulations) for protection, but have in turn caused flooding problems in upstream areas by blocking flows in the floodplain.

Comprehensive land use plans are or could be used by communities in the Rio Grande corridor to affect the nature and location of land use impacts on the river system. This can be done by precluding or encouraging certain types of land uses in selected areas through zoning designations, establishing special development standards to be applied to sensitive river corridor areas, and establishing special development standards to be applied to sensitive river corridor areas. None of the land use planning documents and ordinances currently being used by entities in the Rio Grande corridor provide adequate ability to protect and preserve the corridor from adverse impacts of future land development.

The following local planning issues are important to understanding existing conditions in the Rio Grande corridor and developing solutions to deal with existing problems.

- All entities have adopted floodplain regulations that meet minimum FEMA standards, but some are stricter than others.
- Floodplain regulations guide but do not prohibit development in the Rio Grande floodplain.
- Floodplain regulations have not been uniformly or aggressively enforced in the past.
- Some solutions to floodplain development meet the requirements of the regulations but cause other problems (e.g. placing access roads on fill).
- Comprehensive land use planning practices vary significantly among the entities in the study area.
- Development pressure in the river corridor is greatest in South Fork and the unincorporated areas near South Fork, Del Norte and Alamosa.
- None of the land use planning documents and ordinances currently being used by entities in the Rio Grande corridor provide adequate ability to

protect and preserve the corridor from adverse impacts of future land development.

ES.3.7 Sub-Reach Ratings

Existing river condition evaluations were determined by a ranking system which combines technical scoring of decision criteria by the technical experts and weighting of the decision criteria by the TAC. This allows the technical evaluation of each sub-reach to be combined with those attributes in the sub-reach that the TAC values as restoration objectives. A simple weighted average methodology was used for the scoring scheme, whereby all technical evaluations are normalized from 0 to 10, with 10 being the highest possible value, and multiplied by the weight given the criteria by the TAC.

The five criteria were based on the original stated project objectives. Because the channel capacity and Compact delivery objectives are not mutually exclusive, these two project objectives were combined into a single decision criterion. In addition, because channel stability was not originally stated as a project objective but is an underlying necessity of any river restoration project, it was added as a decision criterion. The technical team then assigned scores to each of the decision criteria through several technical evaluation measures. The criteria and evaluation measures are shown in **Table ES-4**.

Table ES-4. Decision Criteria and Technical Evaluation Measures

Criteria	Evaluation Measures
Channel capacity and delivery of Compact flows	Probability of bank-full exceedence Impacts on structures from delivery of compact flows
Protection from flood damage	Structural damage from flood flows Protection of personal safety during flood flows Adequacy of existing floodplain regulations Areas of special consideration
Maintenance of riparian habitat	Vegetation density Regeneration of riparian vegetation Human activity in riparian areas Agricultural disturbance of riparian areas Terrestrial wildlife habitat Aquatic habitat
Access to river for water diversion	River stability at diversion Avulsion tendency Cutoff tendency Ability to divert decreed capacity Debris problems Sedimentation at structure Existing maintenance problems Diversion access to river Planform location Adequacy of design
Channel stability	Bank stability Meander migration

Weighting of each criterion allowed the TAC to provide input on both the evaluation of existing reaches and the recommended alternatives for restoration. During the TAC meeting on February 16, 2001, an exercise was undertaken with the TAC to determine the importance of the criteria for each sub-reach. During the TAC meeting, each main reach within the study area was discussed separately. The relative importance of each criterion for each sub-reach is presented in **Table ES-5**.

Table ES-5. TAC Relative Importance of Sub-Reach Evaluation Criteria

Sub-Reach	Criteria Importance					Comments
	Channel Capacity	Floodplain	Riparian Habitat	Diversion Access	Channel Stability	
A1		1				High recreational value
A2	3		2		1	High recreational value
A3	2	1				High recreational value
A4			2		1	High recreational value
A5			1			High recreational value
A6		1				
BA1				1		
BA2				1		
BB1			1			
BB2			1		2	
C1		1		2		
C2		1				Existing development is floodprone
C3				1		Consolidate headgates
D1		1		2		Development pressure. Restore floodplains.
D2		1				Development pressure. Restore floodplains.
D3		1		2		Development pressure. Restore floodplains.
D4				2	1	Restore function floodplains.
D5			1	2	3	Restore function floodplains.
D6			1		2	Restore function floodplains.
E1	1	1	1	1	1	Restore function floodplains.
E2	1	1	1	1	1	Restore function floodplains.
E3	1	1	1	1	1	Restore function floodplains.
E4	1	1	1	1	1	Restore function floodplains.
E5	2	1				Development pressure. Restore floodplains.
F1	2	1				
F2	2	1				Fix Westside Diversion.
G1			1		2	
G2			1		2	New Ditch.
G3			1		2	

Note:
(1) Numbers represent relative importance of criteria, with 1 indicating the most important criterion.

Based on the technical scores and the TAC weighting for each of the sub-reaches, an overall score for each sub-reach was developed. The normalized technical scores for each criteria and the composite scores are shown in **Table ES-6**. The 10 sub-reaches with the overall lowest weighted scores are highlighted. The following is a summary of those reaches.

- Low scores in sub-reaches A1, A6, and D2 are driven primarily by the low scores for channel capacity and/or floodplains, and the relative importance placed on the criteria by the TAC. These areas encompass portions of South Fork, Del Norte and the outskirts of Monte Vista, respectively.
- Sub-reach D1 is primarily influenced by poor scores in diversion access, which was ranked as important by the TAC. The sub-reach contains the Pace, Consolidated Slough and Butler Ditch diversions.
- River conditions for sub-reaches D4, D5, D6 and D7 are symptomatic of the dynamic state of the river system in the area, which results in low scores for channel capacity, channel stability, diversions and riparian habitat. Increased channel stability in the area would likely result in higher scores for the other decision criteria.
- The TAC rated each of the criteria equally for sub-reach E3. The low riparian habitat and diversion access scores are the primary reasons for the low overall score for the sub-reach. In sensitivity analysis of weighting schemes, this sub-reach is the most sensitive, and could be replaced in the top ten by sub-reach BB2 or D7.
- Low scores in sub-reaches E5 and F2 are not only a function of lower floodplain and capacity scores, as rated the most important criteria by the TAC, but are also a function of poor riparian habitat and poor diversion access.

The sub-reaches with the lowest weighted scores have the highest restoration priority for achieving the project objectives, given the weights developed by the TAC. However, other projects outside these poorly rated sub-reaches may also be proposed.

Table ES-6. Weighted Sub-Reach Scores

Sub-Reach	Channel Capacity	Floodplain	Riparian Habitat	Diversion Access	Channel Stability	Weighted Score
A1	4.9	2.2	2.0	10.0	10.0	5.2
A2	4.0	2.2	8.0	7.5	9.4	7.2
A3	5.6	6.4	10.0	4.7	6.8	6.5
A4	4.5	9.3	10.0	0.8	8.8	7.6
A5	5.1	9.4	8.0	0.3	5.7	6.1
A6	0.0	0.0	4.0	6.3	9.9	3.4
BA1	10.0	9.6	4.0	7.3	10.0	8.0
BA2	10.0	9.4	0.0	7.8	10.0	7.5
BB1	6.7	9.6	6.0	10.0	6.3	7.4
BB2	9.5	9.4	4.0	4.5	6.1	6.0
C1	9.8	6.1	6.0	5.3	6.0	6.3
C2	5.2	6.0	4.0	8.8	9.0	6.5
C3	9.3	9.4	8.0	5.2	5.8	7.2
D1	4.1	9.2	6.0	0.7	5.8	5.6
D2	2.9	6.6	6.0	2.5	2.1	4.5
D3	3.8	6.9	6.0	10.0	4.5	6.9
D4	4.6	8.4	4.0	1.2	0.0	2.4
D5	4.9	6.6	4.0	3.0	9.5	5.0
D6	5.5	9.4	4.0	3.1	1.2	4.1
D7	2.4	6.3	6.0	6.1	7.7	6.0
E1	5.5	9.8	6.0	6.1	6.4	6.8
E2	4.5	9.5	4.0	10.0	9.1	7.4

Table ES-6. Weighted Sub-Reach Scores

Sub-Reach	Channel Capacity	Floodplain	Riparian Habitat	Diversion Access	Channel Stability	Weighted Score
E3	5.9	9.8	2.0	3.1	8.3	5.8
E4	6.6	7.8	6.0	10.0	7.9	7.7
E5	5.0	5.2	4.0	3.4	6.8	5.0
F1	6.3	6.5	0.0	10.0	6.5	6.1
F2	5.7	7.0	0.0	0.0	7.3	5.0
G1	3.1	8.3	4.0	10.0	8.0	6.2
G2	4.7	10.0	6.0	7.8	8.4	7.2
G3	4.5	9.7	6.0	10.0	8.1	7.3

Note: Indicates the lowest rated 10 sub-reaches.

ES.4 Enhancement and Monitoring Plan

Solutions have been proposed for each of the river sub-reaches for which unsatisfactory river conditions were identified, and for specific locations outside these sub-reaches where significant localized problems were identified. Alternatives have been developed based on accepted stream stabilization and riparian corridor management methods. Proposed projects include structural measures and non-structural measures. Projects have been prioritized based on their ability to address problems in the worst-ranked sub-reaches.

ES.4.1 High Priority Projects

High-priority structural projects were selected to address the most important problems in the study area, based on the sub-reach rankings described previously and the recommendations of the study team regarding other localized problems. High-priority structural projects and the problems they address are listed in **Table ES-7**.

Table ES-7. High Priority Structural Projects

Alternative	Sub-Reach Location	Channel Capacity	Floodplain	Riparian Habitat	Diversion Access	Channel Stability
Del Norte Flood Protection	A6	●	●			◎
South Channel Geomorphic / Riparian Improvements	BB1-BB2	◒		●		●
Reach C Geomorphic Improvements	C1-C3					
Consolidated Slough/Pace Headgate Improvements	D1		◒		●	◒
Other Reach D Headgate Consolidations	D2-D6		◒		●	
Monte Vista Flood Protection	D3	◒	●			
Reach D Channel Stability Improvements	D1-D5			◒	◒	●
Reach E Channel Stability Improvements	E1-E5	◒	◒	◒	◒	●

Table ES-7. High Priority Structural Projects

Alternative	Sub-Reach Location	Channel Capacity	Floodplain	Riparian Habitat	Diversion Access	Channel Stability
Reach E Floodflow Containment	D3, E4, E5	◒	●			
Reach E Diversion Consolidation	E1-E5			◒/◎	●	◒
Westside Diversion Consolidation	F2	◒	◒		●	
Alamosa Levee System Improvements	F1	●	●	◎		

Note: ● = Direct beneficial impact ◒ = Indirect beneficial impact ◎ = Indirect negative impact

Each high-priority structural project is briefly described below.

- **Del Norte Flood Protection** – Prepare a Flood Hazard Mitigation Plan for the Town of Del Norte. As a minimum, investigate non-structural measures and the concepts of a setback levee and a bypass channel. Prepare new floodplain mapping.
- **Reach B South Channel Improvements –** Change operation of North Channel headworks, establish a pilot (low-flow) channel in the South Channel corridor, install grade control structures, reconnect oxbows using spill structures and protect key structures using engineered solutions.
- **Reach C Geomorphic Improvements –** Consolidate, relocate or eliminate McDonald Ditch diversion, combine Monte Vista and Piedra headgates, utilize compound weir diversions, reconnect old meanders and utilize fish habitat structures.
- **Consolidated Slough/Pace Headgate Improvements** – Consolidate the Consolidated Slough, Pace, Monte Vista Canal, and Rio Grande Piedra diversions at the existing Monte Vista Canal headgate.
- **Other Reach D Headgate Consolidations** – Redirect or train flows near the Fish Ditch diversion, construct bendway weirs or relocate Nichols Diversion, relocate Billings Ditch diversion and improve the Centennial Ditch ditch or consolidate with Empire Canal headgates.
- **Monte Vista Flood Protection**- Prepare a Flood Hazard Mitigation Plan for Monte Vista. Investigate non-structural measures and structural projects such as constructing a short setback levee and a drainage culvert with outfall channel in the south floodplain area. Prepare new floodplain mapping.
- **Reach D Channel Stability Improvements –** Reconnect channel with floodplain using rock spill structures. Straightening and/or dredging of the river along with stream barbs to increase erosion would increase capacity, however, it would have adverse impacts on lower reaches and thus is not recommended.
- **Reach E Channel Stability Improvements –** Combine Excelsior, Costilla and Independent Ditches, possible straightening, and reconnection of channel to floodplain with spill structures. Sediment would be stored in

old oxbows providing opportunities for riparian habitat and wetlands development.

- **Reach E Floodflow Containment** – Prevent flood flows from spreading north of the river and flooding Alamosa by: (1) constructing wasteways in Billings Ditch, San Luis Valley Canal and Costilla Canal; and/or (2) constructing setback levees along existing county road right-of-ways.
- **Reach E Diversion Consolidation** – Divert the Costilla and Independent decrees at the Excelsior headgate and transfer water to these ditches where they are crossed by the Excelsior. A lateral of the Excelsior could also deliver water to the Westside Canal as a way to eliminate the Westside diversion.
- **Westside Diversion Consolidation** - Eliminate the problematic Westside Ditch diversion structure by either: (1) installing a low-head pumping station; (2) extending Excelsior Canal through an inverted siphon to deliver Westside water; (3) extending the Empire Canal to the Alamosa Ditch to deliver Westside water; (4) replacing the existing diversion dam with a more suitable diversion structure; (5) using City of Alamosa wastewater effluent; or (6) acquiring and retiring the Westside Ditch water right. A more detailed feasibility study is needed to select the best alternative.
- **Alamosa Levee System Improvements** – Prevent frequent flooding of Alamosa golf course by improving and extending the levees on the north side of the channel, installing drainage structures beneath the existing levees on the north side of the channel, and performing pro-active removal of sediment and willows prior to predicted flood events.

ES.4.2 High Priority Non-Structural Measures

Perhaps the most cost-effective alternatives for river corridor protection and enhancement consist of measures that do not require construction of large capital projects. These non-structural measures include administrative, regulatory, and policy actions, many of which could be applied throughout the study area. The TAC has been considering several policy alternatives during the course of the RGHRP study, and the consultant team has identified other non-structural approaches worthy of consideration. High-priority non-structural measures are briefly described below.

- **River Task Force** – Form a task force of agency and community representatives to assume responsibility for implementation of the RGHRP recommendations, including public outreach and technical assistance to residents.
- **Riparian Buffers** – Establish stream buffers to manage urban and agricultural land uses and activities in the riparian corridor.
- **Grazing Management** – Establish cattle exclusion guidelines and target areas in the stream corridor.
- **Land Use Planning –** Amend existing comprehensive land use plans to include special development guidelines for streamside areas.

- **Floodplain Management** – Adopt uniform, upgraded floodplain development standards for all communities in the river corridor.
- **Snag and Drag Program** – Implement a program for finding and removing fallen and unhealthy trees on streambanks, bridges and diversion structures.
- **Beaver Management** – Develop and implement a beaver management program for riparian areas where beaver populations threaten the vitality of riparian vegetation.
- **Guidelines for Ditch/Diversion Maintenance** – Adopt standard operating procedures for ditch and diversion design and maintenance that minimize impacts to the river system. Examples include: constructing permanent diversions rather than push-up dams; constructing and maintaining wasteways in each ditch; permanently removing cleared sediment and debris rather than returning it to the river.
- **Flow Management** – Investigate approaches for meeting Rio Grande Compact deliveries and satisfying the priority water rights system in ways that improve river function and avoid adverse impacts.
- **Sediment/Watershed Study** – Conduct a study of the watershed upstream of South Fork to develop mitigation plans for processes that are contributing to excessive sediment loads in the RGHRP study area.

ES.4.3 Other Specific Alternatives

Other projects were identified by the project team as being important to the overall enhancement of the Rio Grande corridor, although they did not make the high-priority list. These projects are listed below.

- South Fork Area Bank Stabilization and Fish Habitat Improvements
- South Fork Landscaping for Wildlife
- Atkins Park and Green, and Minor Ditch Diversion Improvements
- Remove Detroit Riprap
- Remove Old Sevenmile Bridge
- Del Norte to Stoeber Lane Fish Habitat Improvements
- Potential New North Canal System
- Railroad and County Line Bridge Improvements
- New Ditch Diversion Improvements
- Alamosa NWR Channel Improvements

ES.4.4 General "Handbook of Alternatives"

Generic structural and non-structural alternatives that could be used at many similar problem spots along the river were compiled in a "Handbook of Alternatives." The Handbook includes: channel stability measures, such as bendway weirs, rock barbs and bioengineering techniques; irrigation structure improvements, such as diversion dams, headgates and wasteways; riparian habitat enhancement alternatives, such as fencing and re-planting of native species; bridge improvement alternatives; and typical flood protection measures.

ES.4.5 Monitoring Plan

A monitoring plan is recommended to assess the effectiveness of the selected river enhancement measures. Design of many of the geomorphically-based improvements is as much art as science, and an "adaptive management" approach is recommended wherein project features and designs should be adjusted over time as more experience is gained with their actual performance in the Rio Grande project area.

The recommended monitoring plan has the following components, listed in order of their importance.

1. Conduct a full river corridor survey every five years based on aerial photography and computer technology. Document changes in channel conditions, vegetation conditions, and floodplain conditions.
2. As each high-priority structural project is installed, develop and implement a specific plan to document "before" and "after" conditions.
3. Inspect channel and bank enhancement projects (e.g., bendway weirs, J-hooks) and new irrigation diversion dams and headgates annually after the spring runoff and irrigation seasons have ended.
4. Establish three locations for monitoring sediment transport and deposition: (a) USGS Monte Vista stream gage; (b) County Line Road bridge; (c) US160 bridge.

The River Task Force should accept long-term responsibility for the monitoring program. There are many opportunities for involving the public in the monitoring program, and using it as a public outreach tool.

ES.5 Implementation Program

ES.5.1 Project Prioritization

High-priority structural projects were ranked to determine their relative importance in solving the key river system problems as identified by the TAC. **Table ES-8** ranks the high-priority structural projects. The TAC felt that all projects are important, and what can be done first should be done first. Factors such as cost, potential partners, construction sequencing, political preferences, etc., could influence the order in which projects are pursued.

Table ES-8. Affected Sub-Reaches and Prioritization of High Priority Structural Projects

Alternative	Sub-Reach		Average	Project
	Location	Effects	Score	Rank
Del Norte Flood Protection	A6	A6	3.4	1
South Channel Geomorphic / Riparian Improvements	BB1-BB2	BB1-BB2	6.7	10
Reach C Geomorphic Improvements	C1-C3	C1-C3	6.7	11
Consolidated Slough/Pace Headgate Improvements	D1	D1	5.4	3
Other Reach D Headgate Consolidations	D2-D6	D2-D6	4.7	2
Monte Vista Flood Protection	D3	D3	6.9	12
Reach D Channel Stability Improvements	D1-D5	D1-E5	5.7	5
Reach E Channel Stability Improvements	E1-E5	E1-E5	6.6	8
Reach E Floodflow Containment	D3, E4, E5	D3-F2	5.7	6
Reach E Diversion Consolidation	E1-E5	E1-E5	6.6	8
Westside Diversion Consolidation	F2	F1,F2	5.6	4
Alamosa Levee System Improvements	F1	F1	6.1	7

Non-structural river enhancement measures were prioritized subjectively based on the opinion of the consultant team. Because of their application throughout the study area, a quantitative prioritization based on sub-reach ranking was not possible. Non-structural measures are listed below in order of priority.

1. River Task Force
2. Riparian Buffers
3. Grazing Management
4. Land Use Planning
5. Floodplain Management
6. Snag & Drag Program
7. Beaver Management
8. Guidelines for Ditch/Diversion Maintenance
9. Flow Management
10. Sediment/Watershed Study

Figure ES-6 shows the organizations that should be responsible for the various non-structural measures.

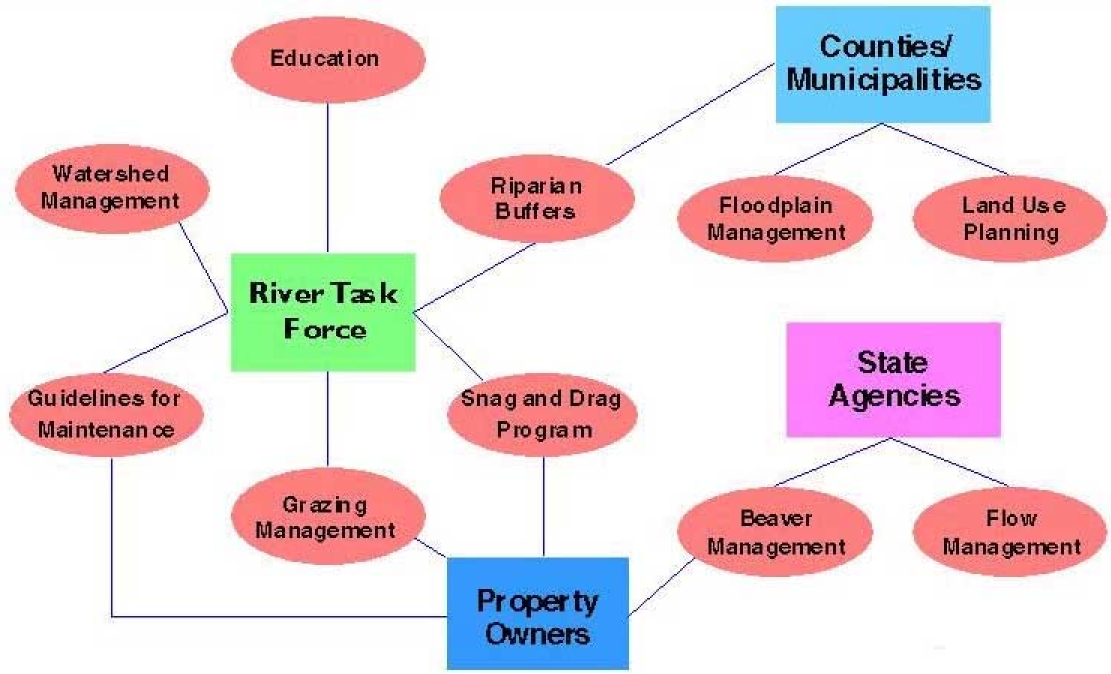

Figure ES-6. Organizations and Their Primary Responsibilities for Implementing Non-Structural Projects

ES.5.2 Cost Estimates

Planning level cost estimates for the high priority projects have been developed to provide the TAC and other decision makers with "ball-park" level information for planning purposes. A summary of these cost estimates is presented in Table ES-9. Unit cost information was taken from experience with similar projects, national cost publications and local vendors. Costs include construction costs, engineering costs, right-of-way costs and project management costs.

Costs of implementing the recommended non-structural measures could vary widely and would be different for each community or agency. These costs have not been estimated at this time.

Table ES-9. Planning Level Cost Estimates for High Priority Structural Projects

Project	Alternative (1)	Total Cost
Del Norte Flood Protection	Option 1 - Railroad Levee	$500,000
	Option 2 - Channel Levee	$900,000
	Option 3 - Bypass Channel	$6,600,000
South Channel Geomorphic / Riparian Improvements		(3)
Reach C Geomorphic Improvements		(3)
Consolidated Slough/Pace Headgate Improvements	Option 1 - North Route	$400,000
	Option 2 - South Route	$350,000
Other Reach D Headgate Consolidations		(3)
Monte Vista Flood Protection	Item 1 - Levee, Channel and Culvert	$1,000,000
Reach D Channel Stability Improvements		(3)
Reach E Channel Stability Improvements		(3)
Reach E Floodflow Containment	Item 1 - North Farm Road Levee	$1,500,000
	Item 2 - River Road Levee	$2,400,000
	Item 3 - Wasteway Structures (each)	$500,000

Table ES-9. Planning Level Cost Estimates for High Priority Structural Projects

Project	Alternative [1]	Total Cost
Reach E Diversion Consolidation	Option 1 - Without Westside Delivery Alternative	$1,100,000
	Option 2 - With Westside Delivery Alternative	$1,500,000
Westside Diversion Consolidation	Option 1 - Pumping Station [2]	$350,000
	Option 2 - Excelsior Extension	$400,000
	Option 2b - Excelsior with Small Pumps [2]	$500,000
	Option 3 - Empire Extension	$800,000
	Option 4 - Replace Diversion Structure	- Infeasible -
	Option 5 - Excelsior with Wastewater	$400,000
Alamosa Flood Protection	Item 1 - Levee	$3,600,000
	Item 2 - Drains	$100,000

Notes:

(1) The label "option" pertains to alternatives which are mutually exclusive (select only one alternative). The label "Item" pertains to those alternatives which are not mutually exclusive (apply all items).

(2) Cost does not include annual pumping costs. Estimated annual pumping costs: Option 1 - $6,000; Option 2b - $2,000.

(3) Cost does not include annual pumping costs. Estimated annual pumping costs: Option 1 - $6,000; Option 2b - $2,000.

ES.5.3 Short-Term Implementation Activities

Implementing projects in the order of the previously presented priority rankings of structural and non-structural river enhancement measures would generally address the most severe problems first. However, several other factors could influence the order in which projects are pursued, including the availability of outside funding, ability to capitalize on other related projects or partnerships, the potential for developing effective demonstration projects, and the willingness of affected private property owners to participate in recommended solutions.

With these factors in mind, it is recommended that the following implementation activities be initiated as soon as feasible.

1. Form the recommended River Task Force immediately. The River Task Force should move quickly to establish partnerships with local governments and possible funding organizations, and to focus the efforts of public and private organizations on making the RGHRP recommendations a reality. One of the first tasks of the River Task Force should be to develop and implement a public outreach program to encourage full community support for the principles of good river corridor stewardship. This program could also provide limited technical assistance to property owners wishing to implement projects based on these stewardship principles.

2. Seek formal adoption of the RGHRP report by local governments, and endorsement of the report by CWCB.

3. Begin the political lobbying process necessary to eventually have all the entities adopt stream buffer, land use, and floodplain management ordinances that will protect the river corridor from future impacts. It is anticipated that gaining approval for these ordinances could be difficult, and work in forming political alliances should begin immediately.

4. Identify any land acquisition requirements for the high-priority structural projects, and develop a property acquisition plan. Because land values in the river corridor will continue to rise, acquiring needed property as early in the implementation process as possible will minimize project costs.

5. Secure funding for specific feasibility studies that will be required to implement the key RGHRP recommendations.

6. Package preferred channel restoration projects in ways that will attract funding from outside sources. Financial assistance is primarily available for wetlands and wildlife protection and enhancement projects, so it is important to identify and quantify benefits in these categories for any proposed projects.

7. Coordinate with the NRCS, which currently has a grant for implementing bank stabilization and grazing management measures with selected willing landowners. The current and proposed NRCS river stabilization projects are generally consistent with the recommendations of the RGHRP.

8. Identify demonstration projects, like those being performed by NRCS, that can be readily implemented and serve as focal points for generating community interest in the RGHRP. Examples include establishing stream buffers on selected parcels, and consolidating selected irrigation headgates.

The River Task Force should set its own implementation priorities based on knowledge of special opportunities for partnering with other organizations and projects, for working with selected landowners, and for capitalizing on advantageous political conditions. It should be expected that priorities will shift over time as different opportunities arise.

Recommendations presented in Section 4 include a number of additional studies that will be necessary to implement the proposed structural and non-structural projects. The most important additional studies are:

- Prepare Flood Hazard Mitigation Plans for the cities of Del Norte, Monte Vista and Alamosa, that will include detailed analyses of potential flood management measures, and will be developed in close cooperation with City and County staffs.
- Prepare more detailed engineering studies of the possible approaches for combining the Reach D headgates, improving the Consolidated Slough/Pace headgates, and fixing the Westside diversion problem. The

RGRHP has identified several options in each case. Engineering feasibility, cost, and stakeholder preferences need to be evaluated for each project in order to select and then design a recommended solution.

- Perform hydrologic and hydraulic modeling studies to determine whether approaches to meeting the Rio Grande Compact deliveries can be developed that provide greater benefits for the river corridor. The Rio Grande Decision Support System model should be used in this analysis, which will have to be coordinated closely with the State Engineers Office.

ES.5.4 Potential Implementation Partners and Funding Sources

Implementation of the RGHRP recommendations will require developing partnerships with outside organizations and seeking funding assistance from public and private agencies. The following programs may be potential funding partners.

- Natural Resources Conservation Service
- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service Partners for Fish and Wildlife
- U.S. Environmental Protection Agency Regional Geographic Initiative Program
- Colorado Water Conservation Board
- Colorado Division of Wildlife
- Great Outdoors Colorado Trust Fund
- San Luis Valley Wetlands Focus Area Committee
- Rio Grande Headwaters Land Trust
- River Network
- The Nature Conservancy
- Private Organizations (Ducks Unlimited, Trout Unlimited)