DRAFT

GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

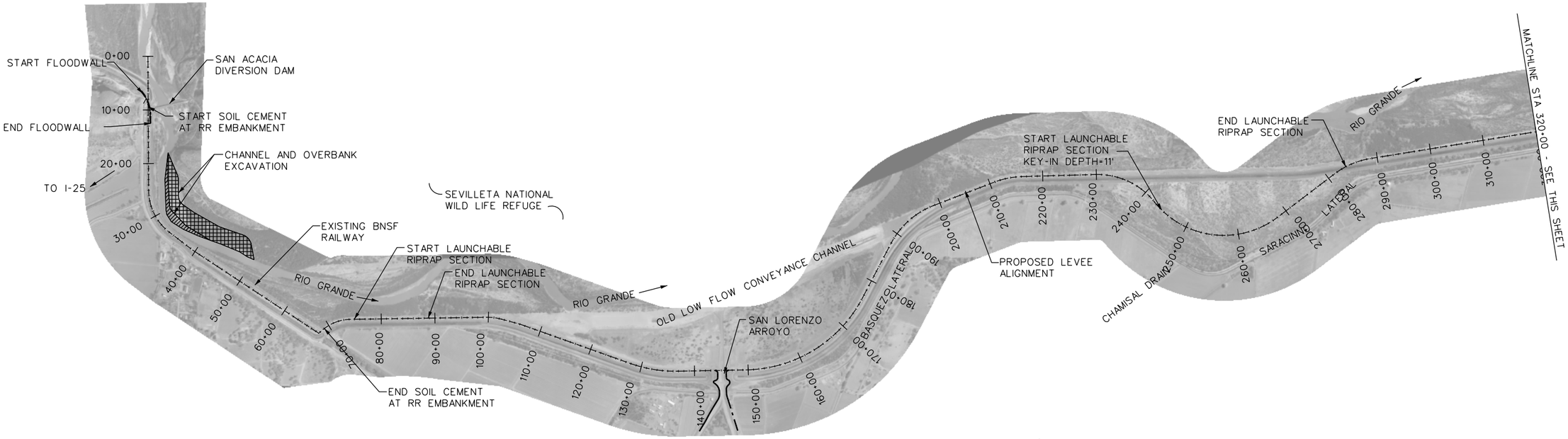
RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-1

Civil Engineering



PLAN - STA. 0+00 TO STA. 320+00

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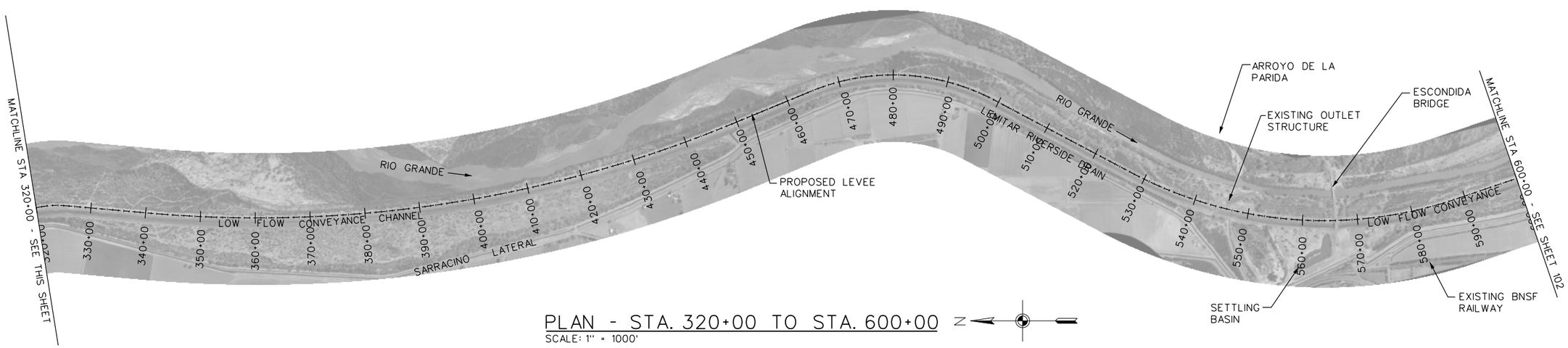

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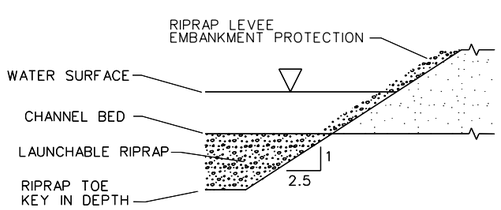

TYPICAL LAUNCHABLE RIPRAP SECTION

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PRELIMINARY

1" = 1000' 0 500' 1000' 2000' 3000'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: sn01c-101.dgn
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Plot Date: AUGUST 2006
CWIS NO.: 074778
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REVIEWED BY: B. ALANIS

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

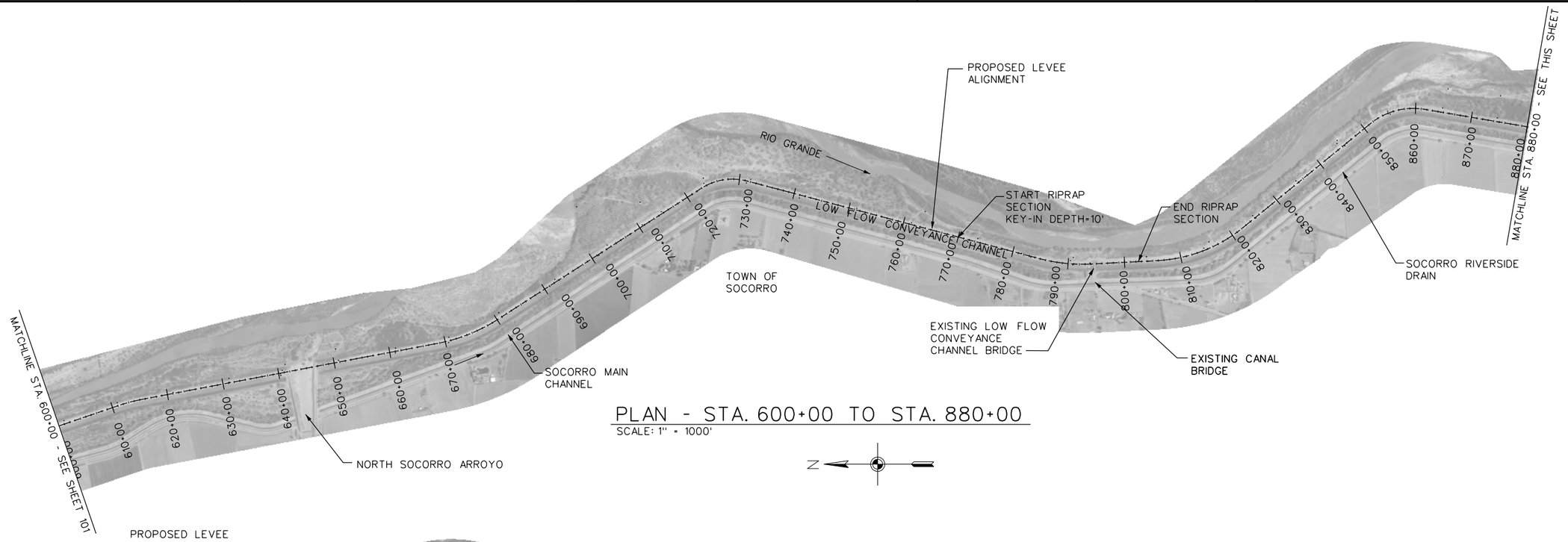
CHIEF, GENERAL ENGINEERING SECTION
DATE:

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
LIMITED RE-EVALUATION REPORT

PLAN - STA. 0+00 TO STA. 600+00

SHEET NO.
C-101
X OF X

SEQUENCE NO.
1



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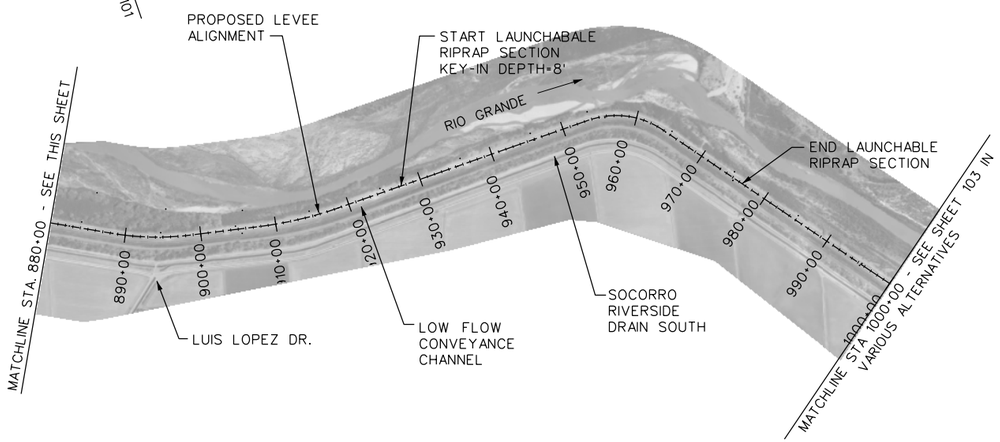

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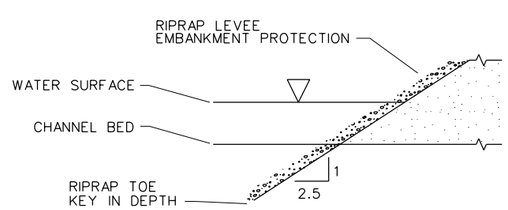

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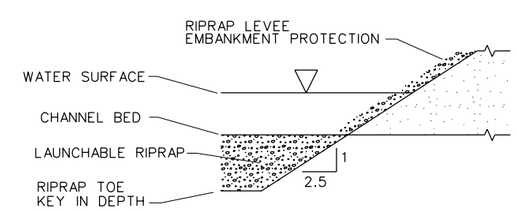

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PRELIMINARY

1" = 1000' 0 500' 1000' 2000' 3000'

US Army Corps of Engineers
Albuquerque District

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REVIEWED BY: C. CHAVEZ

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

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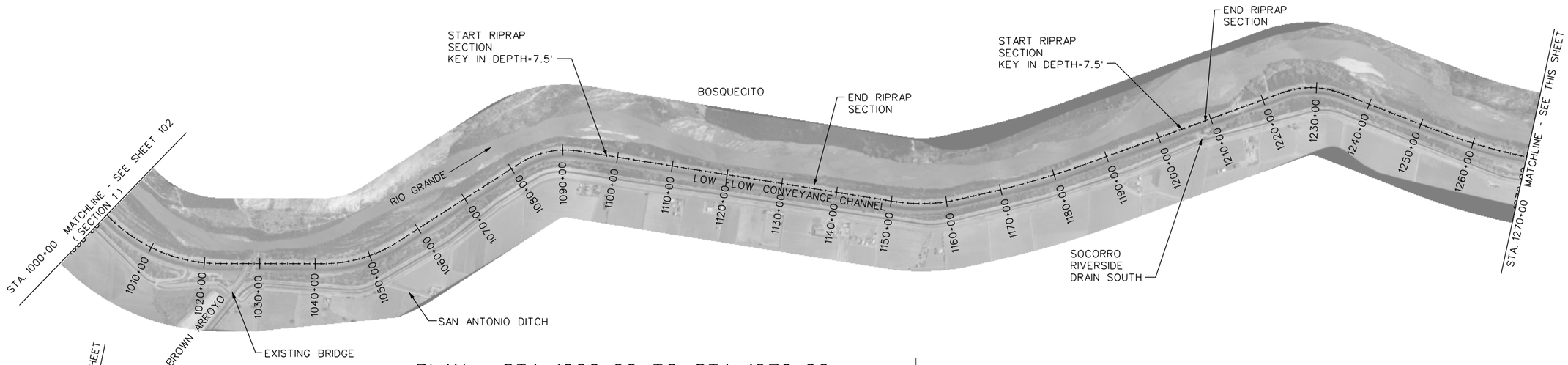
DATE:

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
LIMITED RE-EVALUATION REPORT

PLAN-STA. 600+00 TO STA. 1000+00

SHEET NO.
C-102
X OF X

SEQUENCE NO.
2



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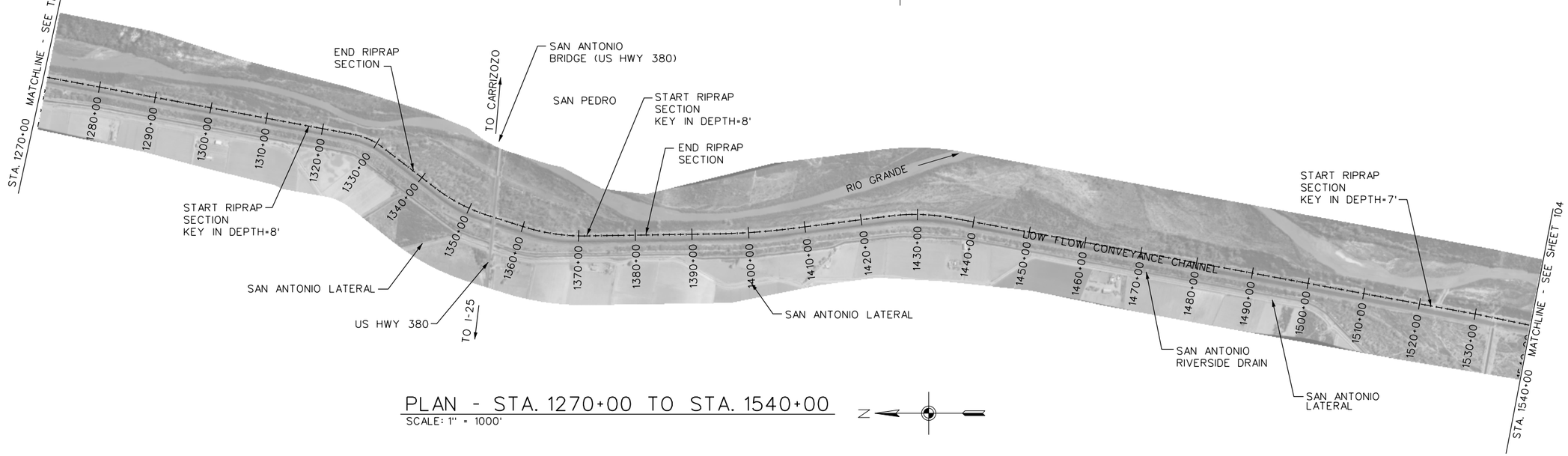
SCALE: 1" = 1000'



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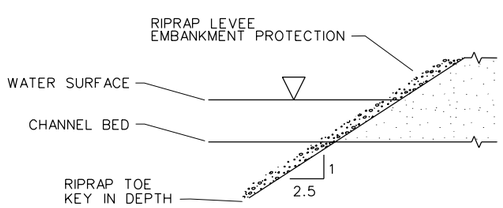
SCALE: 1" = 1000'



TYPICAL RIPRAP SECTION

SCALE: 1" = 10'

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PRELIMINARY

1" = 1000' 0 500' 1000' 2000' 3000'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SNOtc-103.dgn
Plot Scale: 1:2000
Plot Date: AUGUST 2006
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ALBUQUERQUE, NEW MEXICO

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RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
LIMITED RE-EVALUATION REPORT

PLAN-STA. 1000+00 TO STA. 1540+00

SHEET NO.
C-103
X OF X

SEQUENCE NO.
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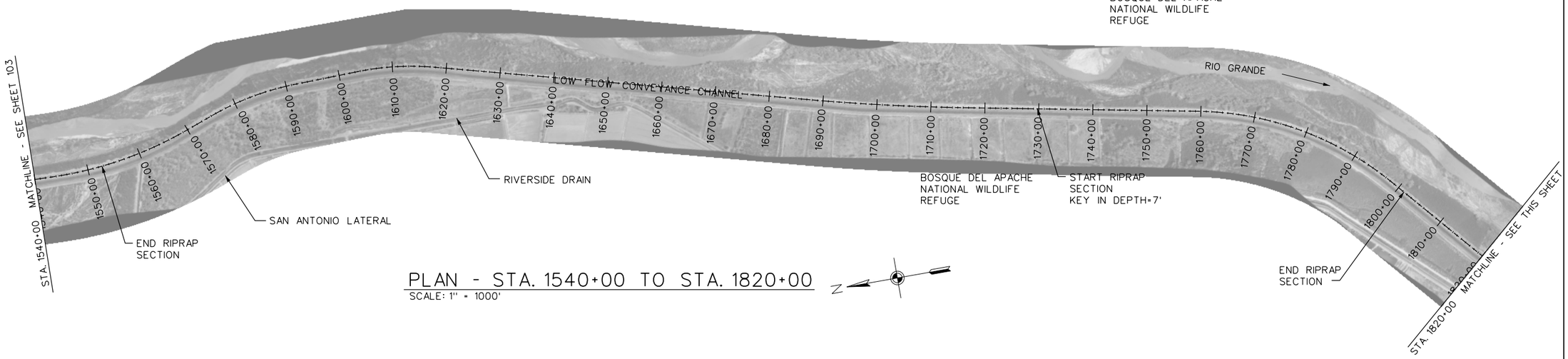
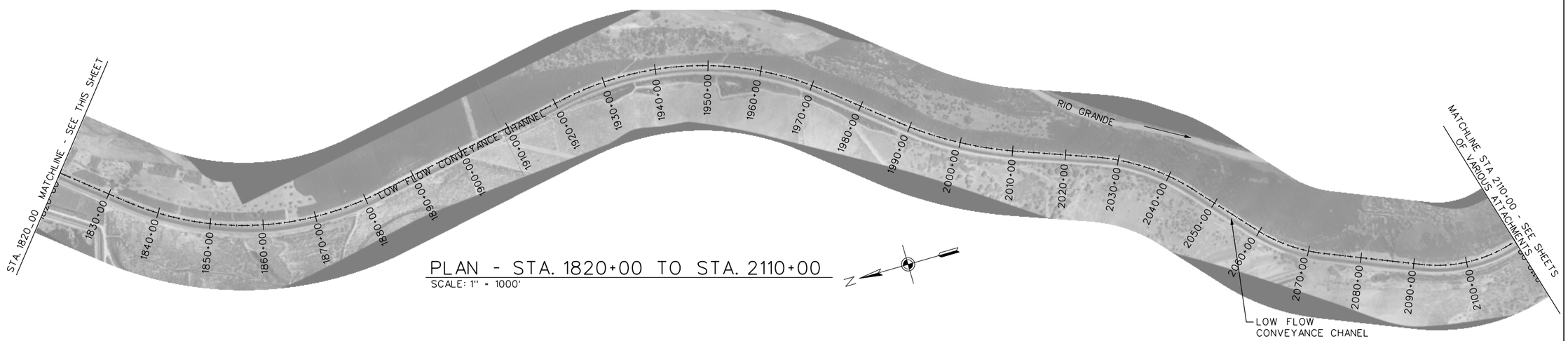


PLAN - STA. 1540+00 TO STA. 1820+00

SCALE: 1" = 1000'

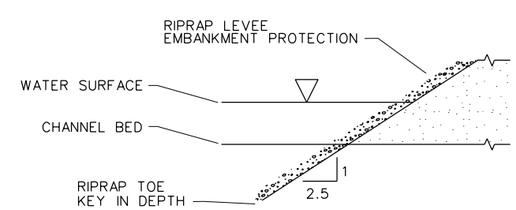


PLAN - STA. 1820+00 TO STA. 2110+00

SCALE: 1" = 1000'

GENERAL NOTES

1. ORTHOGRAPHY PHOTOGRAHY PROVIDED BY INTERGRAPH SERVICES COMPANY (ISC) COLLECTED ON FEBRUARY 2007 FOR THE US ARMY CORP OF ENGINEERS DEVELOPED USING DIGITAL ORTHOGRAPHY, NEW MEXICO CENTRAL PLANE, NAD 83.
2. A LEVEE HEIGHT OF 12' OR LESS WILL REQUIRE THE SLOPE ON THE NEW LEVEE TO BE 1 VERTICAL TO 2.5 HORIZONTAL. A LEVEE HEIGHT OVER 12' WILL REQUIRE THE SLOPE TO BE 1 VERTICAL TO 3 HORIZONTAL.



TYPICAL RIPRAP SECTION

SCALE: 1" = 10'

PRELIMINARY

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SNOtc-104.dgn
Plot Scale: 1:2000
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REVIEWED BY: B. ALANIS

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ALBUQUERQUE, NEW MEXICO

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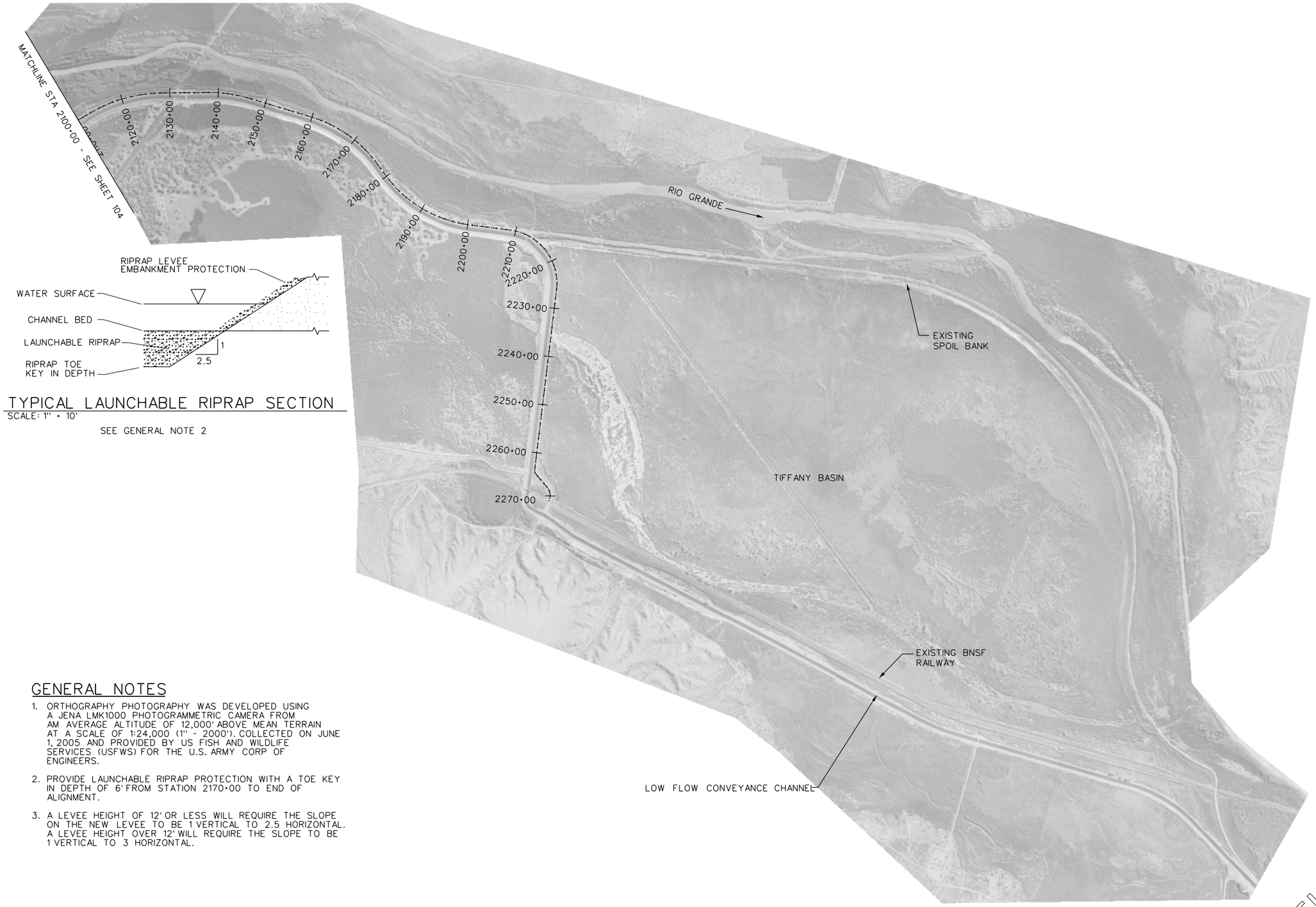
DATE:

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
LIMITED RE-EVALUATION REPORT

PLAN-STA. 1540+00 TO STA. 2110+00

SHEET NO.
C-104
X OF X

SEQUENCE NO.
4



TYPICAL LAUNCHABLE RIPRAP SECTION

SCALE: 1" = 10'

SEE GENERAL NOTE 2

GENERAL NOTES

1. ORTHOGRAPHY PHOTOGRAPHY WAS DEVELOPED USING A JENA LMK1000 PHOTOGRAMMETRIC CAMERA FROM AM AVERAGE ALTITUDE OF 12,000' ABOVE MEAN TERRAIN AT A SCALE OF 1:24,000 (1" - 2000'). COLLECTED ON JUNE 1, 2005 AND PROVIDED BY US FISH AND WILDLIFE SERVICES (USFWS) FOR THE U.S. ARMY CORP OF ENGINEERS.
2. PROVIDE LAUNCHABLE RIPRAP PROTECTION WITH A TOE KEY IN DEPTH OF 6' FROM STATION 2170+00 TO END OF ALIGNMENT.
3. A LEVEE HEIGHT OF 12' OR LESS WILL REQUIRE THE SLOPE ON THE NEW LEVEE TO BE 1 VERTICAL TO 2.5 HORIZONTAL. A LEVEE HEIGHT OVER 12' WILL REQUIRE THE SLOPE TO BE 1 VERTICAL TO 3 HORIZONTAL.

PLAN - STA. 2100+00 TO STA. 2270+00

SCALE: 1" = 1000'

N

PRELIMINARY

1" = 1000' 0 500' 1000' 2000' 3000'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SNOtc-105.dgn
Plot Scale: 1:2000
Plot Date: AUGUST 2006
CWIS NO.: 074778
P2 NO.: 104542
Zero Accidents Zero Tolerance

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ALBUQUERQUE, NEW MEXICO

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: B. ALANIS

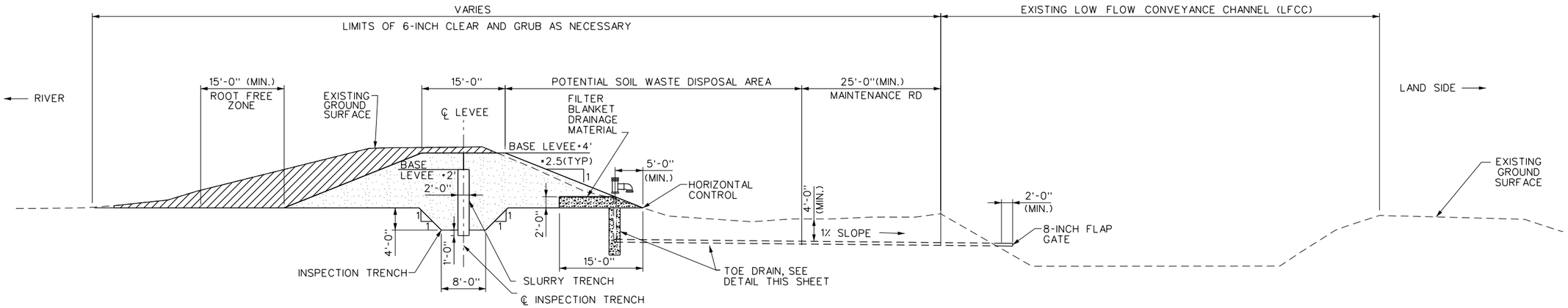
CHIEF, GENERAL ENGINEERING SECTION
DATE:

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
LIMITED RE-EVALUATION REPORT

PLAN-STA. 2100+00 TO STA. 2270+00

SHEET NO.
C-105
X OF X

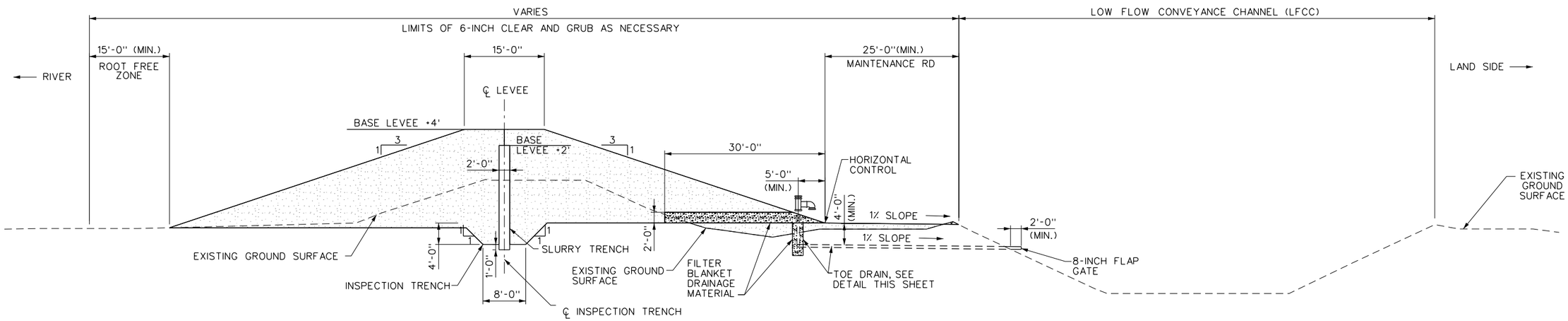
SEQUENCE NO.
5



TYPICAL LEVEE REPLACEMENT SECTION-A

SCALE: 1" = 10'

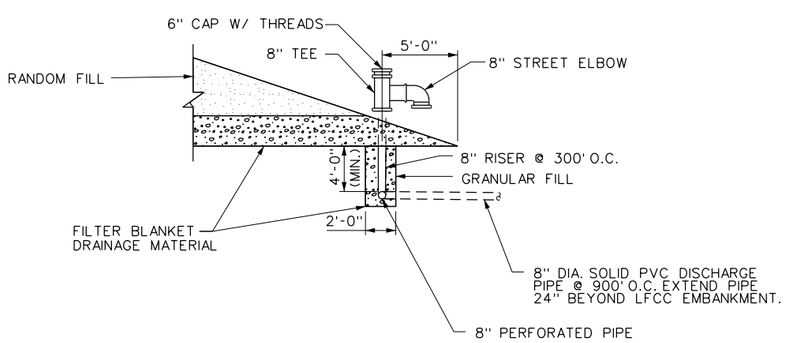
* SEE GENERAL NOTE NO. 1



TYPICAL LEVEE REPLACEMENT SECTION-B

SCALE: 1" = 10'

* SEE GENERAL NOTE NO. 1



TYPICAL TOE DRAIN DETAIL

SCALE: NOT TO SCALE

GENERAL NOTES

1. A LEVEE HEIGHT OF 12' OR LESS WILL REQUIRE THE SLOPE ON THE NEW LEVEE TO BE 1 VERTICAL TO 2.5 HORIZONTAL. A LEVEE HEIGHT OVER 12' WILL REQUIRE THE SLOPE TO BE 1 VERTICAL TO 3 HORIZONTAL.
2. DELETE TOE DRAIN, SLURRY TRENCH AND INSPECTION TRENCH WHEN HEIGHT OF LEVEE IS 5' OR LESS.
3. EXISTING SPOIL BANK WILL BE DEMOLISHED TO CONSTRUCT NEW LEVEE.
4. GRADING REQUIREMENTS ARE AS SHOWN AND DEPEND ON LEVEE HEIGHT.
5. HORIZONTAL CONTROL WILL BE SET AT THE EXISTING LAND SIDE LEVEE TOE WHEN LEVEE HEIGHT IS SMALLER OR EQUAL TO THE EXISTING LEVEE HEIGHT. HORIZONTAL CONTROL WILL SHIFT TOWARDS LFCC AS LEVEE HEIGHT INCREASES. NEW LEVEE LAND SIDE TOE WILL BE AT MINIMUM 25' FROM LFCC BANK.
6. "TYPICAL LEVEE REPLACEMENT SECTION-A" IS TYPICAL OF THE NEW LEVEE APPROXIMATELY THE SAME HEIGHT OF THE EXISTING LEVEE OR SMALLER. APPROXIMATELY STA. 80+00 (BOR 1219) TO STA. 1900+00 (BOR 1588).
7. "TYPICAL LEVEE REPLACEMENT SECTION-B" IS TYPICAL OF THE NEW LEVEE AT A HEIGHT LARGER THAN THE EXISTING LEVEE. APPROXIMATELY STA. 1900+00 (BOR 1588) TO STA. 2260+00 (BOR 1654).

LEGEND

- CUT
- RANDOM FILL
- FILTER BLANKET
- EXISTING GROUND SURFACE

1" = 1000'
1" = 10'
0' 5' 10' 20' 30'

PRELIMINARY

US Army Corps of Engineers
Albuquerque District

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U.S. CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

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REVIEWED BY: SEE COVER
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SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
LIMITED RE-EVALUATION REPORT

LEVEE SECTIONS AND DETAILS

SHEET NO.
C-106
x OF x

SEQUENCE NO.
6

DRAFT

GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-2 & 3

Hydrology & Hydraulics and Sedimentation

RIO GRANDE FLOODWAY

SAN ACACIA TO BOSQUE DEL APACHE UNIT

SOCORRO COUNTY, NEW MEXICO

November 2011

Appendix F-2, F-3, Hydrology, Hydraulics, and Sedimentation

US Army Corps
of Engineers
Albuquerque District
South Pacific Division

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ATTACHMENT

Rio Grande Floodway: San Acacia to Bosque del Apache Unit, Socorro, NM, Flood Damage Reduction Project, Hydrologic Analysis, December 2004

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HYDROLOGY, HYDRAULICS, AND SEDIMENTATION

1 INTRODUCTION

1.1 PURPOSE OF HYDROLOGIC, HYDRAULIC & SEDIMENT ANALYSES

Hydrologic and hydraulic analyses of a watershed provide an estimate of the potential for flooding and the expected flood peaks, volumes, durations, and corresponding river depths and velocities associated with the flood. The study reach extends along the Rio Grande from the San Acacia Diversion Dam, located north of the city of Socorro, and near the historic community of San Acacia, downstream past the Bosque del Apache National Wildlife Refuge to the headwaters of Elephant Butte Reservoir, south of the former village of San Marcial. The 58-mile reach is located in the southern-most section of the Middle Rio Grande Valley in New Mexico. The study area watershed consists of the Rio Grande and two large ephemeral tributaries, the Rio Puerco and the Rio Salado. Historically, floods in the study area have been associated with two types of events: (1) spring snowmelt runoff from the upper Rio Grande watershed and (2) monsoonal floods primarily contributed from the Rio Puerco and Rio Salado watersheds. Sediment is provided primarily by the uncontrolled tributary flows from the Rio Puerco and the Rio Salado. Sedimentation within the study area has played an important role historically and is anticipated to do so into the foreseeable future. An evaluation of sedimentation provides insight into the episodic and long-term impact of sediment movement and deposition within the channel and floodway. Sediment movement and deposition influences river hydraulics, including flood routing and stage, and the functionality and longevity of proposed project features.

The U.S. Army Corps of Engineers (Corps), Albuquerque District, addressed the hydrology, hydraulics, and sedimentation in previous studies, most recently in the draft *Rio Grande Floodway, San Acacia to Bosque del Apache Unit, Socorro, NM, Flood Damage Reduction Project, Limited Reevaluation Study* completed in 1999. However, both new data and improved analytical techniques are available that have allowed the Corps to refine the analyses and design. The Corps revised the hydrologic and subsequent hydraulic analyses for this report based on work initiated in 2003, and updated sediment information was prepared in support of these activities. The scope of the sedimentation work focuses primarily on long-term trends in the study reach, particularly aggradation, which affects hydrograph routing behavior as well as river stage and required levee height. Additionally, the report provides supporting sediment information for bridge alternative evaluation and the development of Risk and Uncertainty Analysis parameters.

The hydrology and hydraulics analyses address existing and future without-project conditions and future with-project conditions. The Corps estimates future conditions to be the existing conditions at a time 50 years into the future, measured from the completion of project construction. Future with-project conditions include projected sedimentation. The with-project analysis includes the significant impacts of the proposed design alternatives so that specific design features can be evaluated. The differences in floodplain depth and extent between the without-project and with-project conditions support the evaluation of the benefits of the proposed project features.

1.2 WATERSHED AREA

The 58-mile study reach is located in the southern-most section of the Middle Rio Grande Valley. The Rio Grande watershed at San Acacia measures 26,770 square miles, including 2,940 square miles in a closed basin in the San Luis Valley, Colorado. Elevations range from over 14,000 feet in the Colorado mountains to 4,660 feet at San Acacia. Upstream flow on the Rio Grande is controlled by Cochiti Dam and Lake, Jemez Canyon Reservoir, Galisteo Dam, and Abiquiu Reservoir. The contributing, uncontrolled drainage area below the dams measures 3,580 square miles in the Rio Grande watershed, 7,350 square miles in the Rio Puerco watershed, and 1,395 square miles in the Rio Salado watershed. The Rio Puerco and the Rio Salado join the Rio Grande approximately 10 miles and two miles, respectively, upstream of San Acacia. The city of Albuquerque is located on the Rio Grande approximately 70 miles upstream of the study area. The Rio Grande watershed between Albuquerque and San Acacia consists of a strip of land bounded by mountains on the east and west. The climate is generally arid or semiarid. Figure 1 shows the study area and the watershed upstream of San Acacia. The following characteristics apply to the study reach:

- The Rio Grande is laden with sediment contributed by the Rio Puerco and the Rio Salado. These tributaries are intermittent and have some of the highest sediment concentrations in the world. No other large tributaries contribute within the study area.

- Present water management in the Middle Rio Grande Valley includes flood risk and sediment management dams and reservoirs, irrigation storage reservoirs, levees, channel maintenance, irrigation diversions, drainage systems, and runoff conveyance systems.

- The Low Flow Conveyance Channel (LFCC) was constructed by the U.S. Bureau of Reclamation (Reclamation) west of the river to efficiently convey up to 2,000 cubic feet per second (cfs) of Rio Grande water from the San Acacia Diversion Dam downstream to Elephant Butte Reservoir. Reclamation does not currently use the LFCC for that purpose, and the LFCC presently conveys only groundwater and local drainage. When Reclamation constructed the LFCC, a spoil-bank levee between the river and the LFCC was constructed using the excavated material.

- The Rio Grande floodway includes the river and the floodplain to the east of the spoil-bank levee. The spoil-bank levee limits meandering to the areas east of the levee and controls the degradation and aggradation processes. The floodway has aggraded because of the sediment that has accumulated in the avulsing system so that the floodway is elevated as much as 15 feet above the historic floodplain.

Figure 1. Study Area.

2 PREVIOUS HYDROLOGY, HYDRAULIC, AND SEDIMENT ANALYSES

The Flood Control Act of 1948 authorized construction of the Rio Grande Floodway, which extended for approximately 213 miles from Velarde, New Mexico, to Elephant Butte Reservoir. The San Acacia to Bosque del Apache Unit Project was part of this comprehensive flood risk management plan. To address the San Acacia to Bosque del Apache Unit, the Corps designed a project, the Authorized Project, to reduce the risk of flooding along the Rio Grande from a 0.5%-chance flood event. The Authorized Project consisted of a levee extending from the San Acacia Diversion Dam to Elephant Butte Reservoir, a distance of approximately 58 miles. The Corps designed the levee using the freeboard concept to account for hydrologic, hydraulic, economic, and geotechnical uncertainties. The levee would replace the spoil-bank levee that exists between the LFCC and the Rio Grande floodway. The Middle Rio Grande Conservancy District would be the project sponsor. However, because funds for construction of levees for the San Acacia to Bosque del Apache Unit were not appropriated, this section of levee was never constructed.

In 1988, the Corps issued a Decision Document that reaffirmed the original Authorized Project. In 1994, new issues and information emerged, and the Corps temporarily halted the study. These issues and information include:

- A levee design criteria to address long duration flows has been adopted by the Corps since 1993. Any proposed plan would have to incorporate design features to prevent seepage through the levee or its foundation due to prolonged flow against the riverward toe..

- Identification within the study area of three threatened or endangered species: the Rio Grande silvery minnow, the Southwestern Willow Flycatcher, and the Pecos Sunflower.

- Elimination of the Tiffany Junction-to-Elephant Butte Reservoir reach of the project based on Rio Grande inundation of the lower 12 miles of levee during several wet years and high water levels in Elephant Butte Reservoir, reducing the project reach length to 43 miles.

- Realignment of the LFCC at two locations and shortening of the length of levee at the downstream end.

- The availability of a longer period of hydrologic records to permit improved and updated hydrologic analysis.

- A new data set for the Reclamation Aggradation/Degradation lines permitted further assessment of long-term sedimentation trends within the study area.

Accordingly, the Draft *Rio Grande Floodway, San Acacia to Bosque del Apache Unit, Socorro, NM, Flood Damage Reduction Project, Limited Reevaluation Report* (LRR) was recommended and initiated to determine the feasibility and implementation of an alternative plan that would address the new information. During the course of the LRR, Reclamation initiated a study to address the feasibility of abandoning the LFCC. In 1999, the Corps recommended postponing the completion of the LRR until a Reclamation decision was made. In 2002, the Corps received a

letter from Reclamation indicating their continued operation of the LFCC as a passive drain to intercept and convey groundwater and irrigation return flows downstream to Elephant Butte Reservoir, and the Corps reinitiated the LRR in 2003. The current GRR incorporates the new and improved hydrologic and hydraulic analytical techniques. The GRR describes the existing and future without-project and future with-project conditions in the study area and explains the array of alternative plans considered for modification of the Authorized Project.

The Corps previously performed hydrologic and hydraulic analyses for the study area, and the sedimentation issues have been analyzed. Recent Corps reports include:

- The initial hydrologic analysis was presented in the report *Rio Grande Basin, New Mexico, Rio Puerco and Rio Salado Watersheds, Design Memorandum No. 1, Hydrology* (DM No. 1), issued by the Corps in 1979.

- The hydraulic analysis supporting the recommendation for an earthen levee extending 58 miles along the west bank of the Rio Grande from the San Acacia Diversion Dam to the downstream end of the LFCC at the headwaters of Elephant Butte Reservoir appears in the report *Rio Grande Floodway, San Acacia to Bosque del Apache Unit, NM, General Design Memorandum* (GDM No. 1), issued in 1990, and the report *Rio Grande Floodway, San Acacia to Bosque del Apache Unit, NM, Feature Design Memorandum No. 2,* issued in 1991.

- A detailed sediment study concluded by Simons, Li, and Associates, Inc., in 1981 is described in GDM No. 1.

3 SUMMARY OF HYDROLOGIC ANALYSIS

Details of the most recent hydrologic analysis are included in the Attachment to Appendix F-2, *Rio Grande Floodway: San Acacia to Bosque del Apache Unit, Socorro, NM, Flood Damage Reduction Project, Hydrologic Analysis (Hydrologic Analysis),* completed by the Corps and dated December 2004. Pertinent information and methodology from the Attachment are summarized in the following sections.

3.1 HYDROLOGIC CHARACTERISTICS

Flood flows in the Middle Rio Grande are of two general types. One type commonly occurs from April through June as a result of snowmelt, which may be augmented by general precipitation. Spring flows are characterized by gradually rising hydrographs, moderate discharge rates, and large runoff volumes. Upstream flow regulation on the Rio Grande substantially limits the potential for spring flooding through the study area. The other type of flow is summer monsoonal flash floods that normally occur from May through October. Summer monsoonal flows are characterized by sharp, high peak flows that recede quickly and generally have smaller runoff volumes than the snowmelt flows. However, the majority of the floods that produce the greatest damage within the study area have been caused by summer storms and subsequent floods contributed by the Rio Puerco and the Rio Salado tributaries.

For the hydrologic analysis, the Corps divided the area into four watersheds including (1) the Rio Puerco tributary; (2) the Rio Salado tributary; (3) the regulated Albuquerque drainage area, which

includes contribution from Cochiti Dam and Lake, Jemez Canyon Reservoir, Galisteo Dam, and Abiquiu Reservoir and their watersheds; and (4) the unregulated Rio Grande watershed downstream of Albuquerque. Runoff events from snowmelt that produce peaks at San Acacia originate in the regulated portion of the watershed and generally represent steady flows released from the dams. The maximum reservoir release, because of gate constraints at the dams, is 10,000 cfs. The Corps assumed that flood flows of 10,000 cfs or less measured at San Acacia originate from snowmelt event dam releases. These releases occur over an extended period of time, and attenuation throughout the study reach was assumed to be minimal for these high-volume, lesser-peak events.

For flood events at San Acacia of magnitude greater than 10,000 cfs, flooding is caused by rainfall events that originate in the unregulated watershed downstream of Albuquerque and from the Rio Puerco and the Rio Salado. General storms, which cover a large areal extent compared to localized thunderstorms, rarely occur in the San Acacia watershed, but could produce very high flow events. If a general storm were to occur, flooding from all of the major watersheds could coincidently contribute to the flow hydrograph at San Acacia. The volume of the resulting flood hydrograph would be much greater than a hydrograph generated by a single localized event. Therefore, the Corps adopted the conservative approach and assumed that this generalized flooding will occur with very high flows. This assumption is supported by accounts of floods of record in the study area that resulted from general storms in 1895, 1929, 1936, 1941, 1955, 1967, and 1972. The 1979 Design Memorandum No. 1 describes these events.

3.2 FLOOD FREQUENCY AT SAN ACACIA

To determine flood frequency flows at the upstream end of the study area, the Corps developed a discharge frequency relationship for the Rio Grande at San Acacia. The U.S. Geological Survey (USGS) has operated the stream gage, *Rio Grande Floodway at San Acacia*, Station 08354900, during most of the period from 1936 to present. In 1965, the USGS stopped publishing instantaneous annual peak flows but continued to provide mean daily stream flow data. The Corps obtained the peak flow record from the USGS web site. The annual instantaneous peak flow record was revised to fill data gaps, and additional peak data were acquired from other sources including the USGS and the Corps Reservoir Control Branch. The flow data include flow peaks occurring prior to 1975, when Cochiti Dam and Lake began the regulation of Rio Grande flows. The Corps computed an adjusted record of peak flows so that peaks represent regulated conditions resulting from the construction of the upstream reservoirs. The Corps used the adjusted record of annual maximum instantaneous peaks as the basis for the discharge frequency analysis.

The Corps evaluated the affect of the major unregulated tributaries, the Rio Puerco and Rio Salado, on the frequency analysis at San Acacia. The Corps estimated secondary peaks from these tributaries by routing recorded flows from the tributaries and combining them with coincident recorded flows on the Rio Grande. The Corps developed flood hydrographs required for the routings for the Rio Grande at San Acacia based on peak and volume frequency relationships. The Corps used the USGS stream gages *Rio Puerco near Bernardo* (Station 08353000) and *Rio Salado near San Acacia* (Station 0835400) to estimate mean daily flows to develop the hydrograph volumes, and instantaneous peak data were used with the mean daily flows to estimate the shape of the hydrographs. The Corps used FLO-2D, a two-dimensional unsteady flow model, to route and combine hydrographs. More information about FLO-2D and

the routing process can be found in the attachment to this appendix, *Hydrologic Analysis*. When secondary peaks from the unregulated tributaries were of greater magnitude than the adjusted peaks from the regulated area, the secondary peaks were used in the frequency analysis.

The Corps attempted to use the Flood Frequency Analysis (FFA) program, developed by the Corps Hydrologic Engineering Center, to perform the flood frequency analyses in accordance with Bulletin 17B, *Guidelines for Determining Flood Flow Frequency*. However, the principles applied by Bulletin #17B require homogenous data. Because the peak flows at San Acacia represent both snowmelt and rain flood data and flow from both regulated and unregulated areas from the Rio Grande, the Rio Puerco and Rio Salado, the Corps computed a graphical frequency relationship instead of using the FFA program. The graphical frequency curve incorporates the following assumptions:

- The analysis revised the instantaneous peak flow record to represent present conditions
- The analysis included a single historic peak, the 1929 estimated flood peak
- The analysis used median plotting positions

Figure 2 displays the graphical frequency curve, and Table 1 summarizes the results of the frequency analysis at San Acacia.

3.3 FLOOD FREQUENCY DOWNSTREAM OF SAN ACACIA

Throughout the project area, the Rio Puerco, the Rio Salado, and the Rio Grande upstream of San Acacia provide the only significant sources of flood flows. Because these flows enter the study reach upstream of San Acacia, the Corps routed the computed flood hydrographs from the upstream reach to estimate flood frequencies at locations within the study area from San Acacia downstream to San Marcial. The Corps used FLO-2D for routing and estimating floods at the downstream locations. Hydrologic routing models represent existing without- and with-project conditions (without and with the proposed levees).

Routing of the flood hydrographs, both with and without the proposed levee, shows a significant attenuation in the study reach. The high amount of attenuation is largely due to the relatively low volume of the rainfall flood peak flows. In some cases, the routed frequency rainfall flood flows are of lesser magnitude than the corresponding frequency snowmelt floods because the snowmelt events experience no significant attenuation. For these situations, the snowmelt event was used as the flood flow at the selected location.

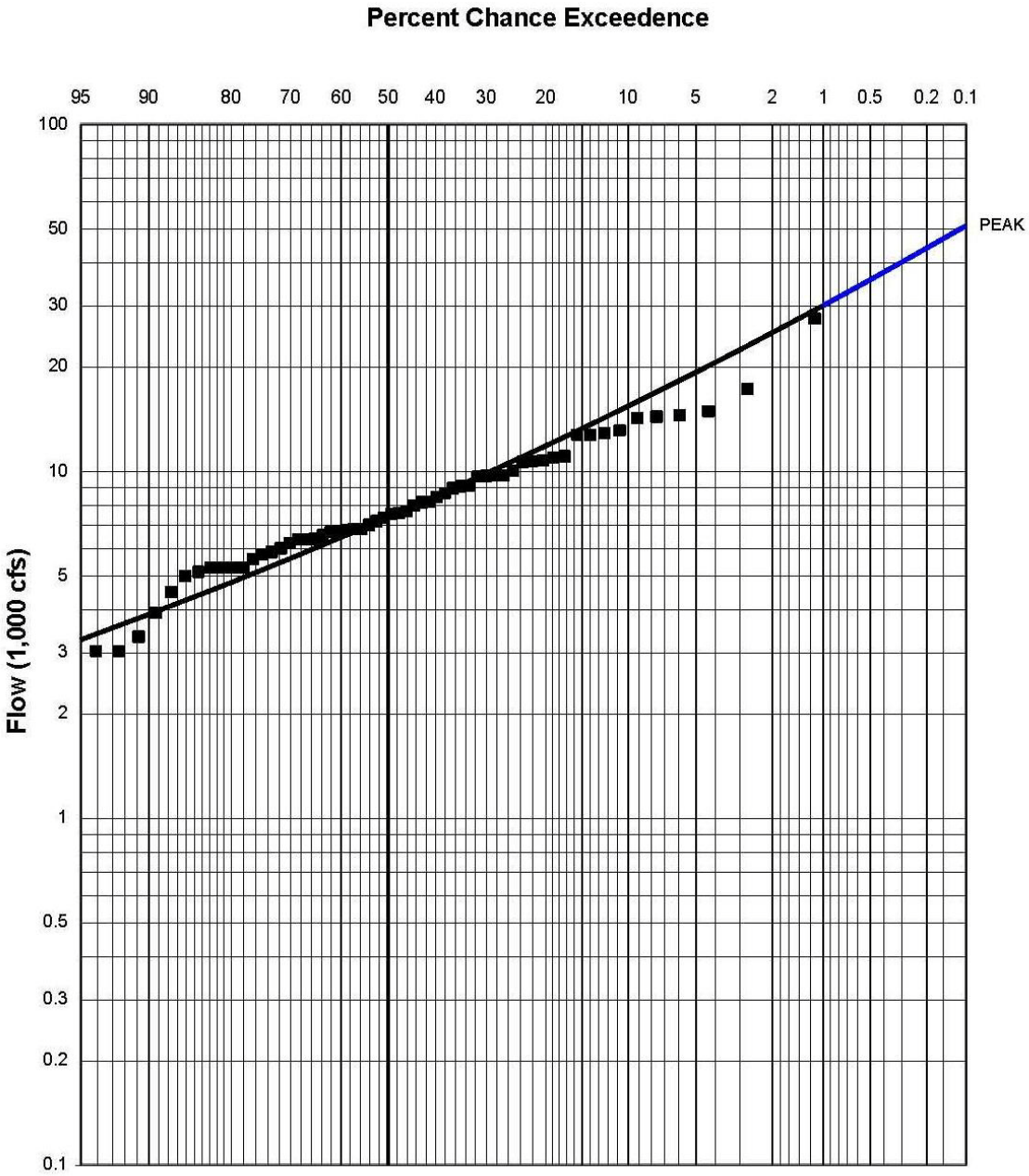
Attenuation is also related to flow in the floodplain and overbanks in both the without- and with-project conditions, and significant storage in the overbank area can greatly reduce the flood peak. Although the overbank area is reduced in the with-project condition, in some places the proposed levee is offset 500 feet or more from the river and offers considerable storage area. The without-project flood routing is the extreme case. It reflects the assumption that the spoil-bank levees fail completely. Floodwaters flow from the perched floodway onto the historic floodplain, which is approximately 10 to 15 feet lower than the floodway. The floodplain ranges up to three miles in width in the lower reach of the study area. More than 25,000 acres of floodplain are inundated in the 0.1% exceedance probability without-project flood event. Because the channel is perched, the flow that leaves the channel in the without-project condition does not directly return to the

channel. A significant volume of floodwaters remains in the floodplain and is lost to the river system. The without-project flood wave attenuation is greatly increased because of these losses.

Table 2 shows the without-project routed Rio Grande flood peaks at selected locations between San Acacia and San Marcial; Table 3 displays the with-project routed peak flows at the same locations between San Acacia and San Marcial.

Table 1. Flood Flow Frequency at San Acacia

Return Period Flood Event	Percent Chance Exceedance	Flow in CFS
500 Year	0.2	43500
200 Year	0.5	35300
100 Year	1.0	29900
50 Year	2.0	25000
20 Year	5.0	19200
10 Year	10.0	15400
5 Year	20.0	11800
2 Year	50.0	7380
1.25 Year	80.0	4770
1.11 Year	90.0	3860
1.05 Year	95.0	3260
1.01 Year	99.0	2420



NOTES:

1. USGS Sta No. 08354900
2. Median plotting positions
3. Drainage area 26,770 sq. mi.
4. Years of record: 62 years of peaks flows

San Acacia to Bosque del Apache Unit, Socorro NM
Rio Grande

PEAK FLOW FREQUENCY CURVE
RIO GRANDE AT SAN ACACIA

WATER YEARS 1936 - 2002

U.S ARMY CORPS OF ENGINEERS
ALBUQUERQUE DISTRICT

Figure 2. Peak Flow Frequency Curve for the Rio Grande at San Acacia

Table 2. Without-Project (No Levee) Routed Peak Flows on the Rio Grande between San Acacia and San Marcial

Reclamation Range Lines	Landmarks	0.5%-Chance Peak Flow (cfs)	1.0%-Chance Peak Flow (cfs)	10.0%-Chance Peak Flow (cfs)	50.0%-Chance Peak Flow (cfs)
SA 1206 - SA 1234	From the San Acacia Diversion Dam downstream	35300	29900	15400	7380
SA 1235 - SO 1308		33710	28760	14635	7380
SO 1309 - SO 1327	Upstream of the Escondida Bridge to the N. Socorro Div. Channel	25725	20905	11910	7380
SO 1328 - SO 1389	Socorro	23485	18880	10575	7380
SO 1390 – SO 1429		21360	17100	10000	7380
SO 1430 – SO 1474		20715	16575	10000	7380
SO 1475 – SO 1510	Hwy. 380 Bridge to the north boundary of the Bosque del Apache	18605	14930	10000	7380
SO 1511 – SO 1568	Bosque del Apache	18025	14605	10000	7380
SO 1569 – SO 1649	Bosque del Apache	12670	10415	10000	7380
SO 1650 – SO 1669	Bosque del Apache	11990	10000	10000	7380
SO 1670 to SO 1709	From Tiffany Junction downstream to below San Marcial Railroad Bridge	11185	10000	10000	7380

Table 3. With-Project (With Levee) Routed Peak Flows on the Rio Grande between San Acacia and San Marcial

Reclamation Range Lines	Landmarks	0.5%-Chance Peak Flow (CFS)	1.0%-Chance Peak Flow (CFS)	10.0%-Chance Peak Flow (CFS)	50%-Chance Peak Flow (CFS)
SA 1206 – SA 1234	From the San Acacia Diversion Dam downstream	35300	29900	15400	7380
SA 1235 – SO 1308		34050	28670	14635	7380
SO 1309 – SO 1327	Upstream of the Escondida Bridge to the North Socorro Diversion Channel	27000	21650	11980	7380
SO 1328 – SO 1389	Socorro	26170	20440	11110	7380
SO 1390 – SO 1429		25280	19895	10000	7380
SO 1430 – SO 1474		24390	19350	10000	7380
SO 1475 – SO 1510	Hwy. 380 Bridge to the north boundary of the Bosque del Apache	22150	17655	10000	7380
SO 1511 – SO 1568	Bosque del Apache	21590	17310	10000	7380
SO 1569 – SO 1649	Bosque del Apache	21030	16960	10000	7380
SO 1650 – SO 1669	Bosque del Apache	20475	16615	10000	7380
SO 1670 – SO 1709	From Tiffany Junction downstream to below San Marcial Railroad Bridge	18565	14890	10000	7380

4 HYDRAULIC ANALYSIS

4.1 OVERVIEW OF HYDRAULIC ANALYSIS

The hydraulic analysis, used in conjunction with the sediment analysis, contributes to the evaluation of the potential for flooding and the proposed actions to alleviate high-water conditions. Specific applications for the hydraulic analysis in the project area include:

- Generation of with- and without-project floodplains
- Contribution to the economic analysis
- Contribution to risk assessment used in the determination of damage-frequency relationships and design parameters such as levee heights
- Evaluation of impacts and performance of the proposed Tiffany Basin sediment management feature
- Evaluation of impacts and performance of the proposed replacement of the San Marcial Railroad Bridge
- Evaluation of environmental impacts of other proposed project alternative features
- Evaluation of potential induced damages of proposed project alternative features

The Corps used the following two numeric models, each with advantages for particular applications, for the hydraulic analysis:

- HEC-RAS, the River Analysis System, is software provided by the Corps' Hydrologic Engineering Center. HEC-RAS is widely used for one-dimensional hydraulic modeling. The Corps used HEC-RAS primarily to establish water-surface profiles for the alternatives evaluated and to determine parameters for alternative feature design.

- FLO-2D is an unsteady two-dimensional hydraulic model. The Corps used FLO-2D for hydrologic routing, for with- and without-project floodplain determination, and to supplement the discharge-stage rating curves for economic evaluation. FLO-2D routes one or more hydrographs in a time series simulation using a two-dimensional geometry. The floodplain is represented by a numbered grid, and each grid element has associated with it a physical location, elevation, and roughness (Manning's *n*) coefficient. For this project, the model uses 500-foot-square grids. Smaller topographic features such as roadway embankments were field verified and manually added to the FLO-2D grid. The channel is located within the grid, and the channel hydraulics are calculated using a cross section in each grid that has a channel element. One of the salient features of FLO-2D is that it conserves volume. More information about FLO-2D can be found in the Attachment, *Hydrologic Analysis*, found at the end of this appendix.

The advantage of HEC-RAS is its ability to compute water surface elevations. The water surface elevations predicted by HEC-RAS and FLO-2D did not always correlate, due in large part to differing algorithmic and reporting approaches as well as to data sources and assumptions. For the majority of the project design, the Corps used HEC-RAS because of its well-established acceptance, as well as its appropriateness to the confined floodway of the with-project condition.

The two-dimensional FLO-2D model offers a superior tool to evaluate flood location and extent than would be possible with a one-dimensional hydraulic model. Because the Rio Grande

floodway is elevated above the floodplain by as much as 10 to 15 feet in the study area, the without-project flow is divided between the floodway and the floodplain. One of the benefits of the FLO-2D model is the ability to evaluate floodplain flow versus floodway flow throughout the study reach. FLO-2D provides a means to estimate the flow that leaves the floodway and is lost from the river.

In collaboration with Federal and state agencies, the Corps originally developed a FLO-2D model for the Upper Rio Grande Water Operations Project (URGWOP) to evaluate water operations in the upper Rio Grande. The URGWOP model is documented in the report titled *Development of the Middle Rio Grande FLO-2D Flood Routing Model Cochiti Dam to Elephant Butte Reservoir*, prepared by TetraTech, Inc., in 2002. The Corps used the URGWOP FLO-2D model as the basis for the San Acacia to San Marcial FLO-2D model. The San Acacia to San Marcial study requires models representing both without-project and with-project conditions. The with-project FLO-2D model for the San Acacia to San Marcial reach is very similar to the URGWOP FLO-2D model. The URGWOP FLO-2D model represents existing conditions and uses the assumption that the spoil-bank levee is a viable levee. The Corps made two significant revisions to adapt the URGWOP FLO-2D model for use as the without-project San Acacia to San Marcial model. First, the Corps removed the spoil-bank levees to reflect the assumption that the spoil-bank levees will fail when in contact with floodwaters. Second, because the extent of the URGWOP model grid was not adequate for the without-project conditions, the Corps extended the grid to the west to encompass the historic floodplain.

The Corps evaluated both existing- and future-conditions models for the without-project hydraulic analysis and present- and future-conditions models for the with-project hydraulic analysis. The present-conditions with-project model represents existing conditions but with the proposed levee in place. The future-conditions models represent the channel and floodplain 50 years into the future. The lower portion of the watershed, in particular, is expected to experience significant changes based on the sedimentation patterns of the past. Development of future-conditions models is addressed in Section 5, *Sedimentation Analysis.*

The Corps selected reaches for the hydraulic analysis of the Rio Grande between San Acacia and San Marcial in terms of reach similarity based on the following key hydraulic parameters:

- Maximum channel velocity
- Maximum flow depth in the channel and expanded floodplain
- Maximum discharge in the channel
- Slope

The FLO-2D routing for a steady 10,000 cfs flow was the basis for evaluating velocity, flow depth, and maximum discharge. Table 4 shows the performance locations that were used and the reference range lines and grid cells associated with each location.

Table 4. Reaches for FLO-2D Hydraulic Analysis San Acacia to Bosque del Apache

Performance Location	Description	Reference Range Lines			Reference Grid Cells	
		U/S	D/S	Typical	U/S	D/S
1	U/S of San Acacia Div. Dam	CO 1174	SA 1210	RP 1190	23372	23797
2	D/S of San Acacia Div. Dam	SA 1210	SA 1232	SA 1218	23797	24195
3		SA 1232	SA 1259	SA 1256	24195	24447
4		SA 1259	SO 1298	SA 1268	24447	24800
5		SO 1298	SO 1304	SO 1299	24800	24851
6	Escondida Bridge	SO 1304	SO 1324	SO 1320	24851	25013
7	Socorro North Div. Channel	SO 1324	SO 1337	SO 1327	25013	25072
8		SO 1337	SO 1340	SO 1339	25072	25091
9		SO 1340	SO 1349	SO 1346	25091	25159
10	Socorro area	SO 1349	SO 1368	SO 1360	25159	25249
11		SO 1368	SO 1400	SO 1394	25249	25405
12		SO 1400	SO 1409	SO 1401	25405	25478
13		SO 1409	SO 1419	SO 1414	25478	25543
14		SO 1419	SO 1472	SO 1450	25543	25936
15	Hwy. 380 Bridge	SO 1472	SO 1484	SO1482.6	25936	26039
16		SO 1484	SO 1498	SO 1491	26039	26162
17	BDANWR	SO 1498	SO 1531	SO 1517.2	26162	26477
18	BDANWR	SO 1531	SO 1595	SO 1550	26477	26929
19	BDANWR D/S of RM 78	SO 1595	SO 1616	SO 1603.7	26929	27086
20	BDANWR South Boundary	SO 1616	SO 1652	SO 1641	27086	27704
21		SO 1652	SO 1682	SO 1662	27704	28414
22	San Marcial Railroad Bridge	SO 1682	EB 14	SO 1701.3	28414	28433

4.2 WITHOUT-PROJECT HYDRAULIC ANALYSIS

4.2.1 WITHOUT-PROJECT HYDRAULIC MODELS

The Corps used FLO-2D to model the flooding locations and extents for the without-project analysis, whereas HEC-RAS was implemented to model bridges and in-stream structures in the without-project analysis. FLO-2D does not directly model structures as does HEC-RAS; FLO-2D uses rating tables to describe the structures. The Corps used the HEC-RAS results to construct rating tables to be used in the FLO-2D model. As explained in Section 4.1, *Overview of Hydraulic Analysis*, the Corps modified an existing FLO-2D model to meet the needs of this project.

4.2.2 DATA USED FOR WITHOUT-PROJECT HYDRAULIC MODELS

Geographic data are represented in the FLO-2D model in two ways. The floodplain is characterized using a grid, which covers the entire floodplain. The size of the grid is 500 feet square. Like HEC-RAS, FLO-2D represents the channel using cross-sections. The vertical datum used for the FLO-2D model is North American Vertical Datum of 1988 (NAVD 1988), and the horizontal datum is New Mexico State Plane Central North American Datum of 1983 (NAD 1983). The mapping data that were used to generate the original URGWOP FLO-2D grid

in the study area were derived from several sources. The without-project floodplain to the west of the levee in the study area was extended and added to the model using the best available elevation data. The best available data proved to be the USGS 10-meter Digital Elevation Model data.

The FLO-2D model has a channel cross section every 500 to 800 feet. The channel cross sections were surveyed between 1997 and 2004 at intervals of approximately 2,000 feet. Intervening cross sections were interpolated. In the FLO-2D model, the Manning's *n* value and infiltration parameters in the floodplains were estimated based on field observations and land-use identification. Aerial photography was used to identify land use. Floodplain features such as major berms, including roadway and railroad embankments, were entered in the without-project FLO-2D model. Culverts located in the field were added to the model to account for the movement of flows between areas that would otherwise trap floodwaters.

4.2.3 MODEL ASSUMPTIONS

The Corps used the following assumptions to develop the without-project hydraulic models for the study reaches:

- The present non-engineered spoil-banks will fail to confine flood flows to the perched floodway, and were removed from the model
- Infiltration losses are included (FLO-2D)
- Evaporation losses are not included

4.3 WITH-PROJECT HYDRAULIC ANALYSIS

4.3.1 WITH-PROJECT HYDRAULIC MODELS

The Corps used HEC-RAS to produce water-surface profile calculations and, subsequently, to support levee-height selection. The Corps used the FLO-2D model to determine the areal extent of flooding to plot floodplains for the with-project conditions.

4.3.2 DATA USED AND/OR MODIFIED FOR WITH-PROJECT HYDRAULIC MODELS

Reclamation obtains cross section (range-line) surveys approximately every 10 years within the floodway in the study area for the purpose of evaluating aggradation and degradation of sediment in the Rio Grande channel and floodway. Reclamation cross sections are separated by approximately 500 feet and are referenced to the NAVD 1988. Reclamation uses aerial photography to obtain these data; therefore, the under-water bathymetry is not captured. The Corps used the photogrammetrically surveyed 2002 Reclamation cross-sectional data for the with-project HEC-RAS model, supplemented with additional field-collected and photogrammetrically-obtained topographic information.

FLO-2D elevation data exist both in extended floodplains outside the floodway and also in detailed surveyed channel sections, and the FLO-2D data were used where Reclamation range-line data were not complete. The Corps measured the dimensions of bridges within the study

reach, and the San Marcial Railroad Bridge was modeled based on the then-current level of design.

4.3.3 HEC-RAS MODELING

The HEC-RAS models represent terrain as a series of cross sections in the river corridor perpendicular to the assumed flow direction. The HEC-RAS model used Reclamation's 2002 channel cross sections located approximately every 500 feet. Intervening cross sections were interpolated. Manning's *n* values were estimated based on field observations and on land-use identification. The Corps used aerial photography to identify land-use conditions.

The under-water channel prism was calculated based on an assumed trapezoidal shape. The Corps used the flow conditions at the time of photography and relevant Manning's *n* values to calculate a flow area. The portion of the channel underwater at the time of the aerial survey was subsequently edited to represent this flow area.

All significant bridges and structures within the study reach were modeled. These included the San Acacia Diversion Dam at the upstream end of the project, Escondida Bridge near Socorro, Highway 380 Bridge, and the Burlington Northern Santa Fe (BNSF) Railroad Bridge at San Marcial.

4.3.4 FLO-2D MODELING

The FLO-2D model determined the aerial extent of flooding to plot floodplains for the with-project conditions. Additionally, the FLO-2D model supplemented the discharge-stage rating curves for economic evaluation. The Corps did not use the FLO-2D model for design of levee heights or other structures.

4.3.5 MODEL ASSUMPTIONS

The Corps used the following assumptions to develop the with-project hydraulic models:

- Linearly-varied peak discharge between hydrologic flow nodes
- Future sediment deposition distributed uniformly across cross-sections

For the with-project conditions, the Corps determined that interior drainage does not pose flooding problems behind the leveed areas of the study reach. Also, relatively few damageable properties exist within the floodway that would be impacted by an increase in stage due to the constructed levee.

4.3.6 DOWNSTREAM EFFECTS

The San Marcial (BNSF) Railroad Bridge is located at the downstream end of the San Acacia to San Marcial study reach. The Corps analyzed the bridge to determine the probability of flooding at the bridge under existing conditions and the probability of flooding after construction of the proposed levee project, to evaluate potential 5th Amendment *takings*.

BNSF provided the Corps with three conditions for which flood water at the San Marcial Railroad Bridge would cause (1) closure and service interruption, (2) damage to the bridge, and (3) bridge destruction. The BNSF defined the three conditions and their associated water surface elevations as follows:

- Closure Elevation: Elevation at the bottom chord, or low steel, of the bridge. When the water surface reaches this elevation, the bridge would hypothetically be closed to traffic.

- Damage Elevation: Elevation at which structural damage to the bridge was estimated to begin occurring. This elevation is achieved when the water surface reaches one foot above the low chord of the bridge.

- Destruction Elevation: Elevation at which the bridge was estimated to be destroyed. This occurs when the water surface reaches one foot above the bridge deck, or "top of rail".

To determine the probability of the water surface reaching these damaging elevations for the without- and with-project conditions, the Corps created a HEC-RAS model of the existing San Marcial Railroad Bridge. The Corps used the HEC-RAS model to develop a rating curve to determine the water surface elevation at the bridge for various flows. The bridge is difficult to model for several reasons, including the orientation of the bridge, the channel-elevation variation at the bridge, and the absence of actual high flows within recent history to use for calibration purposes. The Corps created separate geometry files within the HEC-RAS model to characterize the range of possible conditions at the bridge. The various geometry files consider pressure flow, scour under the bridge, and weir flow over the bridge and embankment. The results from these models were combined to represent the expected water surface elevations associated with a large range of flows and the different conditions. The stage-discharge rating curve incorporating the results of the expected conditions is presented in Figure 3. Figure 3 also displays the three water surface elevations that the BNSF predicts would cause closure, damage, and destruction to the San Marcial Railroad Bridge. Figure 3 shows that the water surface elevation will reach the low chord, or closure elevation, of the bridge during a flow of approximately 2,500 cfs. The water surface will reach the damaging elevation during a flow of approximately 4,600 cfs. The water surface will reach the bridge destruction elevation during a flow of approximately 19,000 cfs.

The Corps routed the 0.50%-, 0.10%-, 1.0%-, and 0.5%-chance mean flood flows through the study area and to the San Marcial Railroad Bridge for both the without-project and with-project conditions. Tables 9 and 10 of the Attachment, *Hydrologic Analysis*, present the flows associated with these frequencies. The Corps plotted the flows and their associated probabilities on log-Pearson type III probability paper and correlated the probabilities with the stages attained by the discharge frequency flows to determine the probability of the frequency flows affecting the San Marcial Railroad Bridge under the three damaging conditions for the without-project and with-project conditions.

Table 5 shows the annual probability of the flows damaging the San Marcial Railroad Bridge under the three events for the existing and future without-project models and the present and future with-project models. No difference exists in the annual probability of a closure event or damage event occurring with or without the project. The annual probability of a destruction event occurring increases from 0.002 to 0.005 with the project levees in place. For future conditions,

the San Marcial Railroad Bridge flow conveyance capacity is expected to be virtually eliminated by sediment deposition. If the historic rate of aggradation in this reach continues, the Rio Grande channel invert elevation would reach the elevation of the low chord of the bridge in approximately 20 years. Thus, the annual probabilities of reaching any of the three analysis conditions approach unity by year 50, with or without the project.

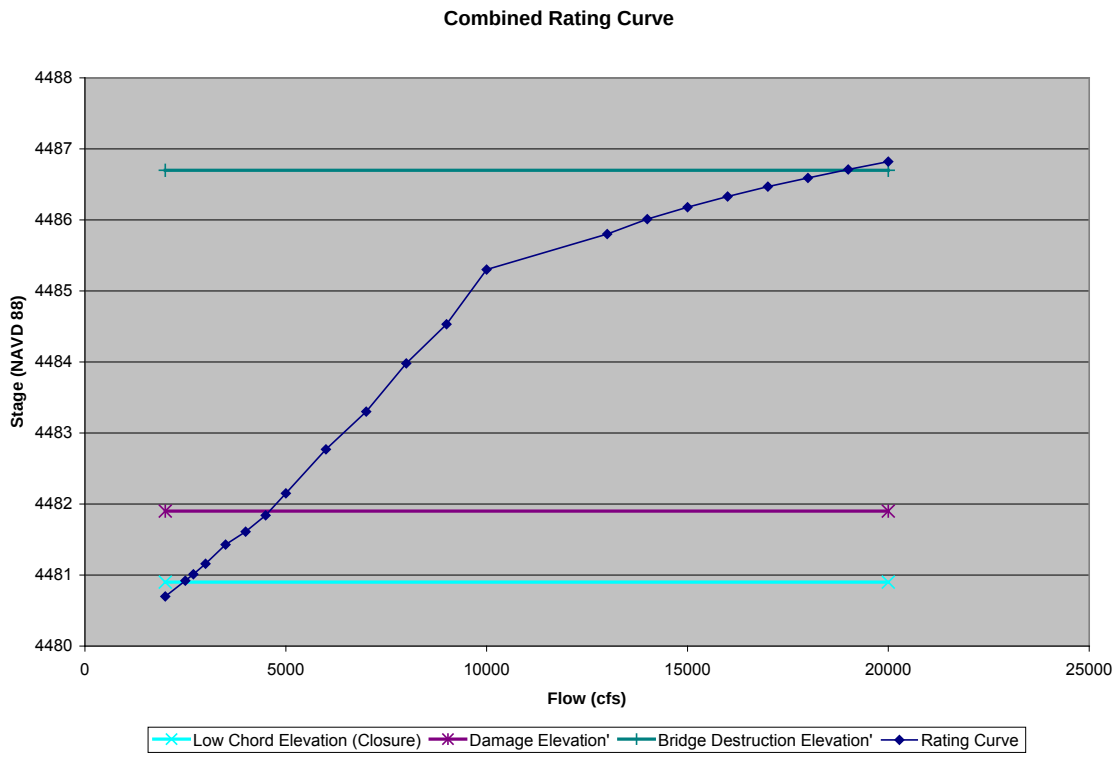


Figure 3. Combined Rating Curve

Table 5. Annual Probability that Flood Event Affects San Marcial Railroad Bridge

ANNUAL PROBABILITY THAT FLOOD EVENT AFFECTS BRIDGE				
	Without Project Year 1	*Without Project* Year 50	*With Levee Project* Year 1	*With Levee Project* Year 50
Closure Event (low chord)	>0.5	0.99	>0.5	0.99
Damage Event (low chord + 1')	>0.5	0.99	>0.5	0.99
Destruction Event (top of rail + 1')	<0.002	0.99	0.005	0.99

4.4 ALTERNATIVE PLANS AND DESIGN FEATURES

The Corps formulated and evaluated a range of alternative plans to address flood risk management in the Rio Grande. In addition, the Corps evaluated design features that would meet objectives other than flood risk management, and these features are grouped into two distinct categories: the acquisition and rehabilitation of 2,053 acres within the Tiffany Basin and the replacement of the railroad bridge at San Marcial.

4.4.1 SAN MARCIAL RAILROAD BRIDGE EVALUATION

The existing San Marcial Railroad Bridge, originally constructed in 1929, is a significant restriction to passing flood flows through the study area. The restriction limits the capacity of the channel to pass flood flow downstream and augments the deposition of sediment and aggradation of the river channel and floodplain. A potential interruption to railroad traffic over the bridge would occur if the bridge were to fail. Sedimentation impacts in the immediate vicinity of the existing San Marcial Railroad Bridge have been significant, and increasing as time goes on in terms of conveyance capacity and maintenance. The Corps examined the sedimentation impacts under the assumption that the sediment would continue to deposit and that the floodway would continue to aggrade at historic rates. For conditions 50 years into the future, the Corps assumed that the BNSF will replace the bridge at some point during the intervening years.

The Corps analyzed the San Marcial Railroad Bridge feature to determine the probability of flooding the bridge under without- and with-project conditions to address the possible replacement of the bridge. The Corps used HEC-RAS to model the bridge alternatives, and the Corps analyzed the alternatives to determine the required span and elevation of the bridge to pass flows and the hydraulic variables for scour and sediment transport calculations. The model predicted the effect the bridge would have on upstream water surface elevations.

Bridge alternatives consider a variation in the number of bridge spans. Based on structural design recommendations, the Corps assumed an 88-foot maximum clear span between bridge piers. The minimum number of spans considered was three with a total bridge span of 270 feet. The Corps also considered five, seven, and nine bridge spans with total spans of 450 feet, 630 feet, and 810 feet, respectively. The Corps made comparisons between the alternatives for the present-conditions sedimentation. HEC-RAS modeling showed little difference in the backwater effects among alternatives except for the three-span bridge, which, when considering the 1.0%-chance flood discharge, increased the water surface elevation upstream of the bridge approximately two to three feet above the water surface elevation produced by the other alternatives. The Corps performed a sediment analysis for the different span alternatives, and the analysis is discussed in detail in Section 5.4, *Bridge Replacement Alternative Capacity Evaluation*. As a result of this analysis, the Corps selected the seven-span bridge alternative.

The Corps determined the bridge height using the 1.0% exceedance probability discharge after 50 years of predicted sediment aggradation. The Corps set the low chord of the bridge one foot above the water surface elevation, based on design guidance received from the BNSF. The design height of the relocated bridge would be approximately 10 feet higher than the existing bridge relative to the channel invert elevation.

4.4.2 TIFFANY BASIN SEDIMENT MANAGEMENT FEATURE EVALUATION

The Corps considered the Tiffany Basin sediment management feature to control sediment aggradation within the Rio Grande. Tiffany Basin exists on the west side of the river channel, near the Tiffany Junction railroad siding and immediately upstream of the San Marcial Railroad Bridge. The basin is bounded on all sides by either spoil-bank levees or railroad embankment and is generally isolated from sediment-laden river flows. The existing spoil-bank levee splits at the upstream end of Tiffany Basin, and the west spoil-bank levee combines with the railroad embankment to separate the basin from the LFCC west of the basin. The existing east spoil-bank levee, on the east and south sides of the basin, separates the basin from the Rio Grande floodway. The absence of frequent deposition has left this basin at a significantly lower elevation as compared to the adjacent river floodway. The Tiffany Basin sediment management feature would allow controlled routing of a portion of the sediment-laden river through the basin, and would serve to decrease the sediment deposition in the project reach of the Rio Grande immediately upstream of the basin, as well as downstream and within Elephant Butte Reservoir.

The Tiffany Basin and downstream project area received a considerable amount of scrutiny primarily because of concerns that uncontrolled flows entering the lower-elevation areas beyond the existing spoil bank levees in this vicinity had the potential to initiate a significant headcut. Development of a deep cut in this area would subsequently put the foundation of the new engineered levee at risk. The most economical means of mitigating this as a risk to the upstream engineered levee, or to what level, was not clear early on. Options available include (a) construct a hardened grade control across the floodway at the upstream end of Tiffany Basin, (b) add toe protection in the form of riprap to the engineered levee a short distance upstream of the basin, (c) add height and/or functional integrity to the inner spoil-bank levee, or (d) accept the finite risk that a short portion of the downstream end could require repair or replacement during the project life. From among the options evaluated, armoring of a length of the downstream engineered levee toe appears most cost effective and was selected.

4.4.3 ARRAY OF ALTERNATIVE PLANS

The Corps assembled an array of alternatives, mixing various proposed features at the downstream end of the proposed levee project, for evaluation to determine the various benefits and opportunities associated with the features. The Corps evaluated hydrodynamic performance of the majority of these alternatives, including the “No Action Alternative” for completeness and to serve as a baseline for comparison. (Some additional alternatives were subsequently added to the array, but did not require hydraulic evaluation due to their similarity to other alternatives already considered.) The following narrative describes the alternatives evaluated, describes the methodology and assumptions used to evaluate their performance, and summarizes the major differences between the alternatives from a hydrologic and hydraulic perspective. Table 6 lists the significant features of the alternatives, and Figures 4.1, 4.2, and 4.3 display the alternatives. Because the proposed levee reconstruction feature upstream of Tiffany Basin is common to all alternatives that include the engineered levee, Figures 4.1, 4.2, and 4.3 show only the proposed features within the Tiffany Basin area where the variation occurs.

- No Action Alternative: This alternative illustrates the expected performance of the lower reach of the project with the existing east spoil-bank levee separating the river floodway from the lower-elevation Tiffany Basin and with the existing BNSF railroad bridge in

place. The No Action Alternative is synonymous with the without-project condition, and the Corps evaluated the alternative to represent the conditions currently present without the engineered levee upstream of Tiffany Junction. Without the engineered levee in place, the evaluation hydrographs for the higher magnitude rainfall storms (0.05 through 0.002 exceedance probability) display a more pronounced attenuation of their peaks when compared to the condition with the engineered levee in place. The more frequent events (0.50 and 0.10 exceedance probability) represent long-duration spring snowmelt floods and do not experience a significant difference in attenuation between the without- and with-levee conditions.

- Alternative A: This alternative includes a 43-mile engineered levee extending from the San Acacia Diversion Dam downstream to Tiffany Junction, which is located north of the basin. The new levee embankment material would be obtained by reconstructing the existing spoil-bank levee located between the floodway and the LFCC. Alternative A is otherwise similar to the No Action Alternative, which includes the existing railroad bridge and the existing east spoil-bank levee between Tiffany Basin and the floodway. With this alternative, attenuation is reduced for the rainfall storms when the flows are contained by the proposed upstream engineered levee.

- Alternative B: Alternative B is similar to Alternative A and includes the upstream 43-mile engineered levee and the existing railroad bridge, but adds the Tiffany Basin sediment management feature. With this alternative, attenuation is reduced for the rainfall storms when the flows are contained by the proposed upstream engineered levee.

- Alternative C: Alternative C is similar to Alternative A and includes the upstream 43-mile engineered levee and the existing east spoil-bank levee between Tiffany Basin and the floodway, but with the addition of the San Marcial Railroad Bridge feature to remove the existing San Marcial Railroad Bridge and construct a new railroad bridge in a more efficient location. With this alternative, attenuation is reduced for the rainfall storms when the flows are contained by the proposed upstream engineered levee.

- Alternative D: Alternative D is similar to Alternative A and includes the upstream 43-mile engineered levee from San Acacia Diversion Dam to Tiffany Junction, but with the addition of the Tiffany Basin sediment management feature and the San Marcial Railroad Bridge replacement feature.

- Alternative E: This alternative is similar to the No Action Alternative, with no upstream engineered levee and with the existing east spoil-bank levee between Tiffany Basin and the floodway, but with the addition of the San Marcial Railroad Bridge replacement feature.

- Alternative F: Alternative F is similar to Alternative E, with no upstream engineered levee, but with the new San Marcial Railroad Bridge and the Tiffany Basin sediment management features.

- Alternative G: Alternative G includes an upstream engineered 43-mile levee, but extends the engineered levee downstream along the west side of Tiffany Basin to the new bridge location. The levee extension serves to protect the railroad tracks from sedimentation and

flooding that originates in the Tiffany Basin. The alternative includes the new San Marcial Railroad Bridge and the Tiffany Basin sediment management features.

- Alternative H: Alternative H is similar to Alternative G, with the upstream engineered levee and the Tiffany Basin sediment management feature. However, Alternative H does not include the San Marcial Railroad Bridge replacement feature, and the engineered levee is extended downstream along the west side of Tiffany Basin to the existing railroad bridge.

- Alternative I: Alternative I includes the extension of the upstream engineered levee downstream to the new railroad bridge along the west side of Tiffany Basin similar to Alternative G; however, Alternative I does not include the Tiffany Basin sediment management feature. Therefore, Alternative I features the east spoil-bank levee between Tiffany Basin and the floodway.

- Alternative J: This alternative is similar to Alternative I, with the upstream engineered levee extending downstream to the new San Marcial Railroad Bridge feature; however, the levee is extended along the existing east spoil-bank levee alignment between Tiffany Basin and the floodway. Alternative J does not include the Tiffany Basin sediment management feature.

- Alternative K: This alternative is similar to Alternative J, extending the engineered levee along the east spoil-bank levee between Tiffany Basin and the floodway, but the levee extends downstream to the existing railroad bridge. Alternative K does not include the Tiffany Basin sediment management feature or the San Marcial Railroad Bridge replacement feature.

Table 6. Significant Features of the Alternatives

Alternative	Includes Engineered Levee down to Tiffany Junction	Includes Extended Engineered Levee to Bridge along West Alignment	Includes Extended Engineered Levee to Bridge along East Alignment	Includes Tiffany Basin Sediment Management Feature	Includes New San Marcial Railroad Bridge Feature
No Action	No	No	No	No	No
A	Yes	No	No	No	No
B	Yes	No	No	Yes	No
C	Yes	No	No	No	Yes
D	Yes	No	No	Yes	Yes
E	No	No	No	No	Yes
F	No	No	No	Yes	Yes
G	Yes	Yes	No	Yes	Yes
H	Yes	Yes	No	Yes	No
I	Yes	Yes	No	No	Yes
J	Yes	No	Yes	No	Yes
K	Yes	No	Yes	No	No

Figure 4.1. Alternatives A, B, C, and D

Figure 4.2. Alternatives E, F, G, and H

Figure 4.3. Alternatives I, J, and K

4.4.3.1 Evaluation Methodology

The Corps evaluated the significant performance differences between the alternatives by evaluating the assortment of existing and potential feature combinations in the Tiffany Basin area because the proposed levee reconstruction feature upstream of this areas was the same for all of the alternative plans that included the engineered levee.

During the 2005 spring runoff, Reclamation devoted considerable effort in the field to prevent the collapse and subsequent overtopping of the east spoil-bank levee. Significant seepage through the material and sloughing on the land-side occurred during the event. Reclamation's effort and the relatively short duration of the event averted failure; however, the measure of performance can not depend on flood fighting. For without-project conditions, and for damage assessment in the areas adjacent to the existing spoil-bank levees but downstream of the proposed levee alternatives, the Corps assumed that the spoil-bank levees would fail. However, the spoil-bank levees would remain in place for some period of time before failure and result in an increased stage in the upstream levee cross section. For the with-project conditions, spoil-bank levees downstream of the proposed levee alternatives were modeled and assumed not to fail when determining stage information within the upstream reach.

4.4.3.2 Inflow hydrographs

The Corps routed the appropriate 0.05-through-0.002-probability with-project and without-project hydrographs to determine water-surface profiles for levee design in the reach from the San Acacia Diversion Dam downstream to Tiffany Junction for the alternative evaluations based on whether or not the alternative included the upstream engineered levee. The proposed engineered levee has a significant impact on the hydrologic routing and subsequent attenuation of larger floods originating upstream of the study area. This impact was quantified in the hydrologic analysis and is illustrated in Tables 2 and 3 in Section 3.2, *Flood Frequency at San Acacia*.

The routing differences are most pronounced for the high-peak, low-volume hydrographs associated with the monsoonal rainfall events contributed by the Rio Puerco and Rio Salado upstream of San Acacia. Conversely, the high-volume and extended-duration snowmelt floods do not experience significant attenuation. Therefore, the 0.50- and 0.10-chance inflow hydrographs generated by snowmelt are the same for the without-project and with-project conditions evaluated in the array of alternatives. Despite the lack of difference in these hydrographs associated with the upstream levee condition, their high volumes serve to illustrate the performance differences between the various alternatives. The inflow hydrograph boundary conditions used for the array of alternatives are consistent with the hydrologic analysis.

4.4.3.3 Modeling parameters

Because the various components of the alternatives were all located at the downstream end of the project, the evaluation described in this section was focused on the areas above and below the railroad bridge and the Tiffany basin area and floodway upstream. A significant effort went into simulating the potential breaching of the existing spoil-bank levee on the east side of Tiffany Basin (between Tiffany Basin and the floodway) for many of the alternatives, in order to illustrate the potential temporal influence the Tiffany Basin storage volume could exhibit on the flood volumes, between the various alternatives. Also of concern was the potential for flows to overtop

the railroad embankment that runs along the west side of Tiffany basin at an elevation of 4485 feet (NGVD).

The Corps calculated hydraulic conditions for a "unit" (one-foot width) overflow, assumed to behave as broad-crested-weir flow, of a typical prism of the existing spoil-bank levee for various overflow depths. The resulting hydraulic variables were applied, using a sediment transport relationship based on a Yang transport function, to calculate transport rates and associated times required to mobilize the volumes of one-foot vertical increments of the assumed typical spoil-bank prism. The Corps used a table of averages from the distribution of the results of these various iterations to approximate the time required to erode one-foot-deep segments from the top of the spoil-bank levee, to evaluate the breaching process from a surface water hydraulics perspective, and track the duration of overtopping and flow into the basin at two locations within the Tiffany east levee. Testing of the initial and incremental width variables' influence on breach propagation was undertaken and, based largely on professional judgment, an initial breach width of 100 feet was adopted at initiation of breaching, with an increase in width of 10 feet for each additional hour of flow through the breach. [Note that this is a departure from the *study reach* hydraulic modeling described in other areas of this Appendix, where spoil banks were assumed to fail and were not defined as confining features within the FLO-2D or HEC-RAS models for without-project conditions.] The approach employed for the alternative array evaluation has some limitations in that the approach does not account for geotechnical failures of the spoil-bank levee prior to overtopping, especially those associated with the seepage and saturation that would be expected under spring runoff conditions. Nevertheless, it was employed to help illustrate a range of differing temporal behaviors among the array of alternatives that is intended to be representative of the hydrodynamic behaviors.

4.4.3.4 Results

This section summarizes the significant performance characteristics and contrasts them with the alternatives. The No Action Alternative exhibits a variety of unfavorable conditions for the snowmelt events. At the 50%-chance exceedance probability and with the existing constrictive railroad bridge, the river stages remain just below the point of overtopping the east spoil-bank levee, and breaching does not occur. Similar to the experience during the spring of 2005 at this location, the event caused considerable activity, but a breach into Tiffany Basin did not occur. At the higher discharge 10.0%-chance exceedance probability, breaching in the two modeled potential locations does occur and reaches a point sufficient to divert all of the river flow into the Tiffany Basin. The basin fills to the point of overtopping the railroad tracks adjacent to the basin. For the lower-volume rainfall events, breaching does not occur until the 0.5%-chance flood. The volume of this event that flows into Tiffany Basin is sufficient to spill over the adjacent railroad tracks. The 0.2%-chance event yields similar results, but more quickly and with higher magnitude.

Alternative A behaves the same as the No Action Alternative for the 50.0%- and 10.0%-chance events and with the same results. The rainfall events experience less attenuation due to the upstream engineered levee, and breaching of the east spoil bank occurs at a lesser frequency, the 2.0%-chance event, in addition to the 1.0%-, 0.5%-, and 0.2%-chance simulations. The associated impacts of the east spoil bank breaching are similar to those for the No Action Alternative, with Tiffany Basin filling and spilling over the adjacent railroad tracks.

Alternative E exhibits behavior similar to the No Action Alternative, except that the changes in impacts from the new railroad bridge are suggested. For this alternative, the model indicates sufficient reduction in the river stage to preclude breaching of the inner spoil-bank levee for the 10.0%-chance event, but with the flow scarcely at 0.2 feet below the threshold spoil-bank levee crest. This small increment of safety is well within the error range of uncertainties, and the result should not be viewed in an absolute sense. The spoil-bank levee would probably not survive a mean water surface elevation within 0.2 feet of the crest for this duration, even if the other aspects of the determination were certain. Rather, the simulation results illustrate that replacement of the existing railroad bridge has positive water-surface-profile impacts within this area of concern. Because this alternative does not include the upstream engineered levee, prevention of breaching until the 0.2%-chance rainfall event further illustrates the difference that the new railroad bridge can play in the alternative array.

Similarly, Alternative C can minimally pass the 10%-chance event without breaching the inner (*i.e.*, east) spoil-bank levee, again reflecting the change in the water-surface profile associated with the new railroad bridge at critical locations along the inner spoil-bank. The higher-peaked rainfall inflow hydrographs, however, result in a spoil bank breach starting with the 1.0%-chance event, although this results in only partial diversion of river flows into Tiffany Basin. The basin does not fill to the point of overtopping the adjacent railroad tracks until the 0.5%-chance event, as it does for the 0.2%-chance event; however, the overtopping occurs more quickly.

Alternative I performs similarly to Alternative C; however, breaching of the inner spoil-bank levee does not result in overtopping of the railroad tracks adjacent to the basin because the extended engineered levee exists in this reach, protecting the track section. Again, the 1.0%-chance-event spoil bank breach does not fully develop, resulting in only partial filling of the basin. The 0.5%- and 0.2%-chance events fill the basin; however, escaping flows return to the floodway.

Alternatives J and K restrict flows to the floodway with an engineered inner levee and preclude breaching or filling of the basin for the events considered. These two alternatives are essentially the same in terms of basin and adjacent railroad impacts. The differences between the two are limited to the changes in river stage associated with the bridge configuration (existing bridge versus new bridge) as they translate upstream for a limited distance.

Alternatives B, D, F, G, and H include the Tiffany Basin sediment management feature. These alternatives easily handle the 5.0%-chance event hydrograph, diverting enough flow into the basin to keep river stages along the inner spoil-bank levee at a level lower than the simulations without the Tiffany Basin sediment management feature. In addition, the alternatives handle the 10.0%-chance event without attaining spoil bank breach elevation thresholds; however, the margin is considerably less because the 10.0%-chance conditions control the configuration of this feature to function as planned due to the extended duration of the hydrograph. The primary differences for the alternatives at the 10.0%-chance level is in the volume diverted to Tiffany Basin (and corresponding peak stage within the basin) as a result of the differences in inflow hydrographs (with or without the upstream engineered levee) and the different river stage-discharge relationships associated with the bridge condition (existing bridge versus new bridge). For all of the rainfall events simulated up through the 0.2%-chance event, the stage elevations within the basin never exceed 4483 feet because of the smaller volumes of the rainfall hydrographs. For all of the rainfall events simulated up through the 0.2%-chance event, the stage elevations within the basin never exceed 4483 feet, 2 feet below the threshold railroad

embankment elevation noted above. Some of these rainfall events do exhibit sufficient river stages, over shorter periods, to initiate overtopping and breaching of the inner spoil-bank levee.

This risk to the inner spoil-bank levee is minimal (0.2%-chance exceedance probability) for Alternative F, which incorporates the new railroad bridge and experiences the lower-magnitude peaks associated with no engineered levee upstream. Alternatives D and G exhibit an increased risk, with potential for overtopping for the 1.0%-chance event through 0.2%-chance event simulations. Alternatives B and H, which do not include the new railroad bridge, exhibit the highest risk to the spoil bank, starting at the 2.0%-chance event.

4.4.4 DOWNSTREAM LEVEE TIE-BACK ANALYSIS

The LFCC constituted a major factor in the choice of a tie-back alternative. The LFCC will be protected by the proposed levee because the proposed levee is located between the LFCC and the floodway. In order to connect the levee to high ground, the levee would be required to cross the LFCC at the downstream end. A LFCC crossing would include a gated closure of some type. The LFCC is constantly recharged from groundwater and maintains a relatively-constant flow, and any closure of the LFCC would cause water to back up behind the closure. Therefore, the alternatives analyzed must consider flooding induced by closure of the LFCC. The Corps considered ending the levee without a tieback to high ground; however, this could conceivably produce a backwater effect from a flood event traveling down the Rio Grande. The Corps considered the following three closure alternatives for the downstream end of the levee for each of the alternative levee alignments:

- Closure Alternative 1: Connect the levee to high ground at the upper end of Tiffany Basin. This would require crossing the LFCC immediately south of the existing railroad bridge crossing of the LFCC. The closure structure would include three eight-foot-diameter gated culverts that would remain open except during high flow events on the Rio Grande. Closure of the gates during a high flow event would cause water flowing down the LFCC to back up behind the closure structure.

- Closure Alternative 1a: Same as Alternative 1, but the alternative includes a pump at the closure structure in the LFCC. The pump would be used during high flow events on the Rio Grande when the gates are closed. The pump would pump water flowing in the LFCC through the closure structure to prevent water backing up behind the closure structure.

- Closure Alternative 2: Continue the levee to the existing railroad alignment at the north end of Tiffany Basin at a location where the railroad embankment is elevated above the selected frequency water surface elevation. The levee would tie to the railroad embankment at that location and would not connect to high ground to the west. Because the LFCC is located to the west of the railroad alignment, the levee would not cross the LFCC.

4.4.4.1 Tie-back Alternative Selection

The Corps used the two-dimensional FLO-2D model to evaluate the extent of backwater flooding for the closure alternatives. The Corps selected Closure Alternative 2 because modeling shows it

to have minimal backwater flooding upstream of the connection to high ground, and Alternative 2 is in all probability the least costly alternative. Figure 5 displays the floodplain maximum flow depths associated with Closure Alternative 2.

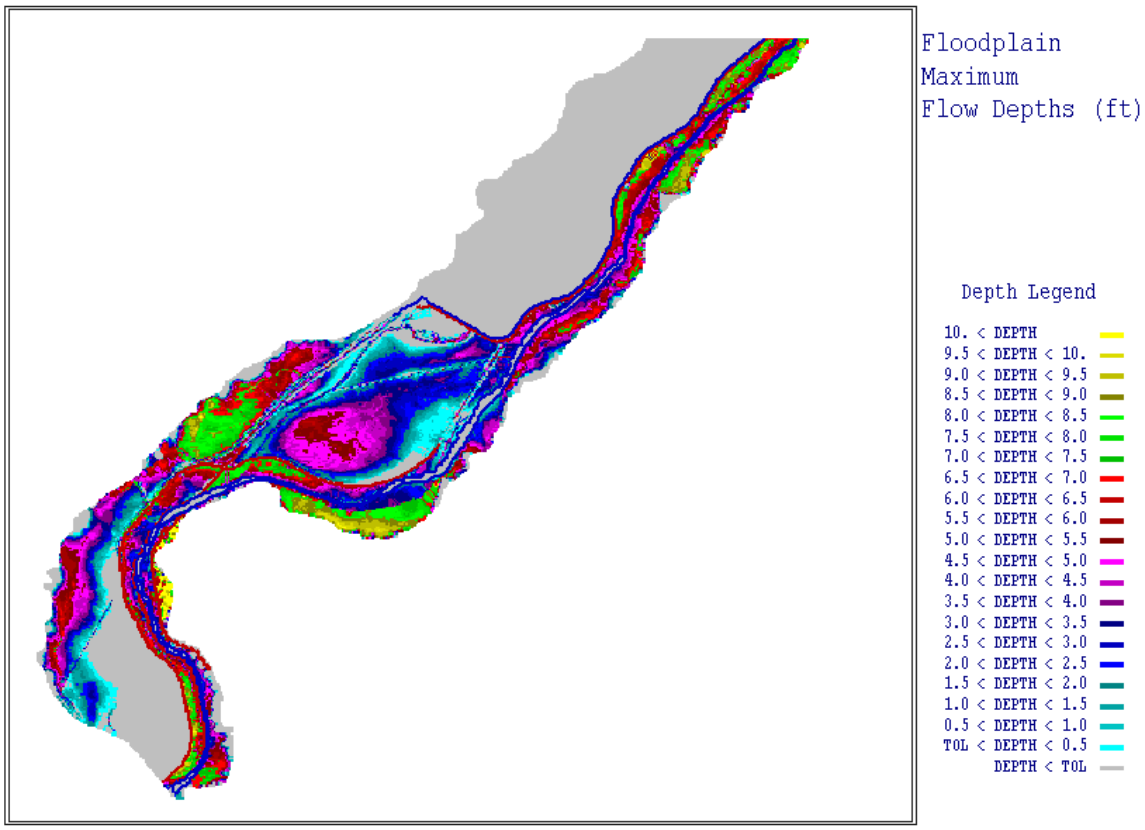


Figure 5. Floodplain Maximum Flow Depths for Closure Alternative 2Showing No Backwater Effect Upstream of Tiffany Basin

5 SEDIMENTATION ANALYSIS

Sedimentation within the study area has exhibited a significant influence on historical channel profiles and river stages, and is well-documented, particularly within the lower reach, by Leopold *et al* (1990), Vanoni (1977), and many others. From a flood risk management perspective, the primary influence is clearly the reduction in slope and floodway capacity, and coincident increase in stage, progressing in the downstream direction, associated with the long-term aggradational regime. The Corps analyzed existing sedimentation trends to predict future sedimentation trends for the without- and with-project conditions. General Design Memorandum No. 1 describes a detailed sediment study conducted by Simons, Li, and Associates, Inc. (SLA, 1981). However, as presented in the 1999 draft LRR, analysis of the Reclamation range-line surveys of 1972 and 1992 show that aggradation during this 20-year period exceeded the predicted SLA aggradation rates. A subsequent analysis conducted for the current study of the 1972 and 2002 Reclamation range-line surveys confirms that long-term aggradation is the factor with the highest potential to affect water-surface elevations and, consequently, levee performance over the life of the project.

5.1 OVERVIEW OF SEDIMENTATION ANALYSIS

For the 1999 draft LRR, the Corps performed an analysis of the cross-sectional areal and volumetric changes for the Middle Rio Grande using the 1972 and 1992 Reclamation range-line surveys within the San Acacia study reach. The Corps updated the analysis for the current study using the newly available 2002 Reclamation range-line surveys. Areal changes between the 1972 and 2002 range lines were computed and combined with the reach lengths between adjacent range lines to arrive at volumetric changes for the period. The Corps divided the volumetric changes by the product of their respective lengths and average top widths to arrive at an average deposition depth. Dividing the average deposition depth by the 40-year period between range-line surveys produced an average annual deposition depth. The Corps divided the information into representative subreaches and computed average values. The average values were multiplied by an assumed 50-year project life for the proposed levee. The Corps applied the calculated depositional values to edit the associated geometry files in the hydrologic routing (FLO-2D) and hydraulic water surface profile (HEC-RAS) numeric models to raise the elevation of the entire floodway for the future conditions scenarios, in order to assess the impacts associated with the primary long-term sedimentation trend.

5.2 WITHOUT-PROJECT SEDIMENTATION ANALYSIS

5.2.1 WITHOUT-PROJECT SEDIMENTATION DATA

The Corps used surveyed range lines provided by Reclamation from 1972, 1992, and 2002 to analyze the long-term aggradational and degradational trends for the study reach to determine without-project sediment trends. The Corps calculated the area between a bounding elevation (5,500 feet) and the cross-section elevations for each range line, for each survey year. The Corps used the year-to-year differences between these cross-sectional areas as the basis to analyze the trends.

5.2.2 WITHOUT-PROJECT SEDIMENT ANALYSIS METHODOLOGY

The Corps compared the cross-sectional areas for each year for the periods 1972 to 1992, 1972 to 2002, and 1992 to 2002. In each case, the area of the later year was subtracted from the area of the earlier year. A positive value indicated an aggradational trend for that range line, and a negative value indicated a degradational trend. The Corps plotted these values against the range line numbers to determine where the reach had a general aggradational or degradational trend. Analysis showed that the reach had a general degradational trend upstream of range line 1412 and an aggradational trend downstream of range line 1412. Range line 1412 is located approximately 10 miles south of the Escondida Bridge.

The Corps analyzed the reach downstream of range line 1412 to range line 1781, approximately seven miles south of the San Marcial Railroad Bridge, to quantify the aggradational trend. The Corps performed a regression analysis on each data set (1972 to 1992, 1992 to 2002, and 1972 to 2002). The 1972 to 2002 data set was ultimately used because the 1992 data set apparently contains flaws. In addition, the 1972 to 2002 data set provides the longest period of record.

The Corps developed a relationship between the rate of aggradation to the position in the reach. Figure 6 shows the predicted 50-year aggradation at range lines along the aggradational reach. The Corps applied the predicted 50-year aggradation to the future-conditions models. In both the HEC-RAS and the FLO-2D future-conditions models, the Corps raised the entire floodway by an amount corresponding to its position in the aggradational reach. The future-conditions HEC-RAS model ignored degradation to apply the conservative approach for design. For floodplain calculation and economic analysis, the Corps used the future-conditions FLO-2D model and applied degradation to the channel only in the degradational reach.

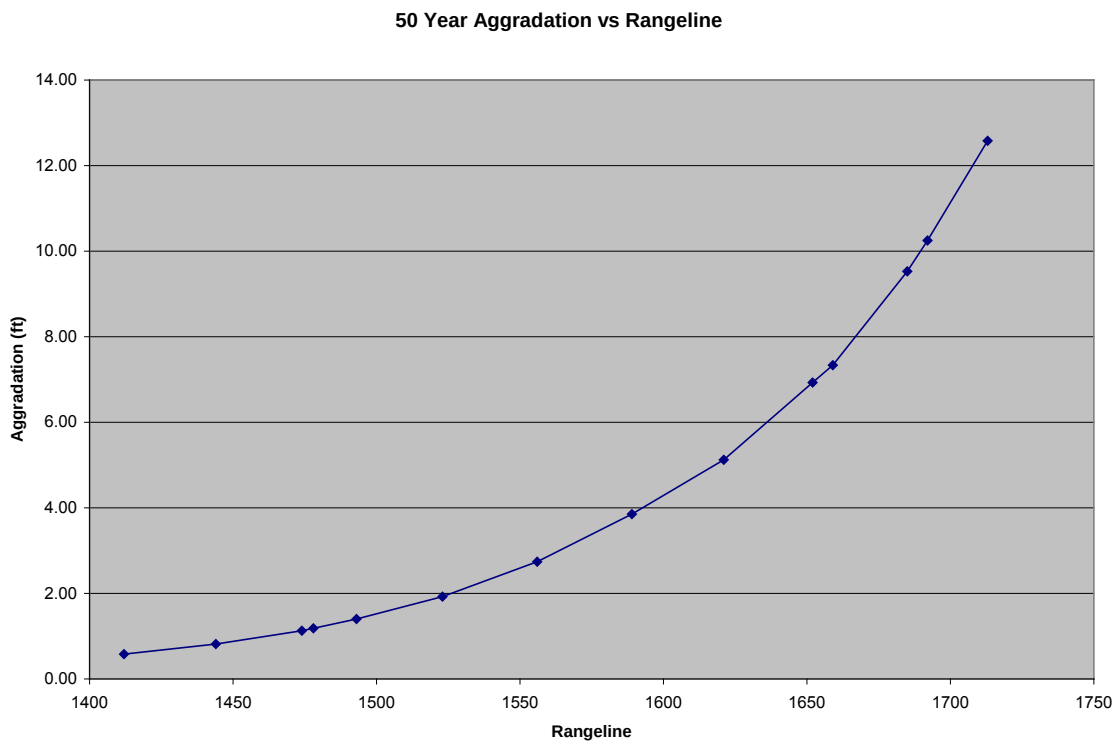


Figure 6. Predicted 50-Year Aggradation for Selected Range Lines Along the Project Reach

5.2.3 WITHOUT-PROJECT SEDIMENT ANALYSIS ASSUMPTIONS

The Corps assumed that the rate of aggradation observed from analysis of the relatively short 1972-through-2002 data set would continue in the future. The Corps compared the calculated rate of aggradation with historic long-term rates observed by Leopold (Leopold *et al.*, 1992) in the San Marcial vicinity, and the rates proved consistent. In addition, agreement exists between the calculated rate of aggradation and circumstantial evidence, including measured floodplain elevations within and outside of the existing spoil-bank levees and historic documentation of bridge elevation changes.

The Corps assumed that long-term aggradation occurs evenly across the entire floodway, including the overbank areas. The assumption could cause the model to under predict the aggradation of the channel in the short term because the majority of sediment deposition occurs

within the channel and on the overbank areas immediately adjacent to the channel. Channel deposition can raise the channel to an elevation greater than the floodplain elevation and create the perched channel, such as the one that exists in much of the project area. However, in time, the channel will avulse to the lower overbank areas and deposit material there as it has in the past. Thus, the decision was made to distribute the aggradation evenly across the cross section within the floodway.

5.3 WITH-PROJECT SEDIMENTATION ANALYSIS

5.3.1 WITH-PROJECT SEDIMENT ANALYSIS DATA AND METHODOLOGY

The Corps completed the with-project analysis employing the same data and methodology used for the without-project analysis. The Corps assumed the same aggradational and degradational rates for the without- and with-project conditions with the exception of the with-project alternatives that include the Tiffany Basin sediment management feature.

5.3.2 TIFFANY BASIN SEDIMENT MANAGEMENT FEATURE ASSUMPTIONS

The Corps calculated transport rates from various sources, primarily from Reclamation functions derived from measured data. For the purposes of plan formulation, two assumptions controlled the design of the Tiffany Basin sediment management feature. The first assumption is that the Tiffany Basin would fill with sediment to an elevation equal to the predicted future-conditions floodplain elevation within the existing floodway during the 50-year evaluation period of the project. This assumption is based on the predicted diversion concentrations, ponded conditions, and near 100% trap efficiency that would be expected for the feature. The second assumption is that the proposed Tiffany Basin sediment management feature is expected to alleviate some of the aggradation of the Rio Grande channel and floodway within the 50-year life of the project, based on the volume associated with the first assumption. For the purpose of plan formulation and levee design heights, the Corps subtracted 50% of the volume of sediment expected to be trapped in Tiffany Basin from the volume of the Rio Grande floodway in the aggradational reach from the San Marcial Railroad Bridge (range line 1706.6) upstream to approximately range line 1412. The Corps used only 50% of the predicted volume to account for uncertainties associated with the proposed project feature's performance as it relates to levee height impacts. Figure 7 displays the range lines 50-year expected aggradation considering the conditions; without Tiffany Basin, with Tiffany Basin, and with Tiffany Basin at 50% trap efficiency.

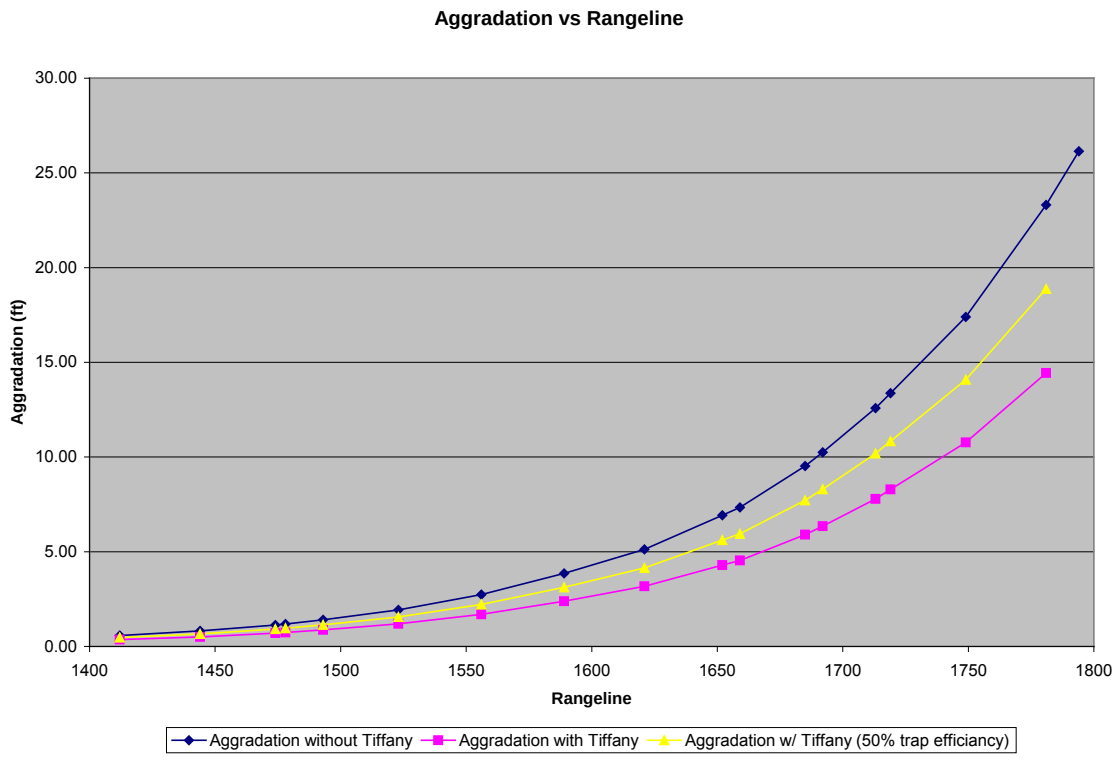


Figure 7. Aggradation versus Range line

5.4 BRIDGE REPLACEMENT ALTERNATIVE CAPACITY EVALUATION

Sedimentation impacts in the immediate vicinity of the existing San Marcial Railroad Bridge have been significant, and increasing as time goes on, in terms of conveyance capacity and maintenance. The Corps examined the sedimentation impacts of the various proposed BNSF San Marcial Railroad Bridge replacement alternatives. Four alternatives, each with 88-foot bays, were examined: (1) a three-bay bridge, (2) a five-bay bridge, (3) a seven-bay bridge, and (4) a nine-bay bridge. The examination consisted of a basic sediment continuity analysis using hydraulic parameters from the present-conditions with-project HEC-RAS model at four representative cross sections approaching and within the bridge crossing. The Corps developed sediment transport rating curves using the software program SAM, *Hydraulic Design Package for Channels*, created by the Corps Coastal and Hydraulics Laboratory, Engineer Research and Development Center (CHL-ERDC, 2002) and spreadsheets for the four cross sections using Yang's (d50) and Brownlie's transport functions. Annual yield rates, calculated in tons per year, were determined for the four cross sections and compared successively by subtracting the current cross section supply rate from the next upstream cross section supply rate to determine scour and deposition rates for each of the bridge-span alternatives. The transport calculations were not calibrated to measured data, and the magnitudes are not exact; however, the relative trends are useful in discerning between the bridge-span alternatives.

Tables 7 and 8 show the results of the calculations for the Brownlie transport function. The Yang calculations produced comparable ordinal results. Table 7 illustrates the potential for influencing

the transport approaching and through the bridge by varying the number of bays. For example, at cross section 1706.65, the contraction, and consequent acceleration, of flow for the three-bay alternative yields a dramatically higher transport rate through the bridge than the wide nine-bay alternative by an order of magnitude. Table 8 shows that the relative scour and deposition differences between cross sections are also affected by the bridge alternatives. The three-bay alternative indicates a scour condition, of relatively high magnitude, at the bridge cross section 1706.65 that could present additional risk to the bridge piers. The five-bay configuration also yields a scour situation at the bridge. Based on these results, the seven-bay alternative appears to perform best in terms of overall sediment transport balance. The least magnitude absolute value of the summation indicates the seven-bay configuration would have the least scour or deposition and be the lowest maintenance alternative. An expectation for some deposition exists at the bridge given that the value is positive; however, this reach is depositional and has been so historically, and the depositional rate for the bridge section is the lowest magnitude of the alternatives. The Corps recommends the seven-bay bridge alternative because the alternative appears to provide the advantages of reduced maintenance and low potential for increased impacts to the structural integrity of the bridge.

Table 7. Annual Transport Yields by Cross-section

Cross Section	3-Bay (Ton/year)	5-Bay (Ton/year)	7-Bay (Ton/Year)	9-Bay (Ton/Year)	Comment
1618	552,283	552,283	552,283	552,283	Upstream Tiffany
1650	524,826	524,826	524,826	524,826	Mid Tiffany
1698	457,002	457,002	457,002	457,002	Lower Tiffany
1706	403,014	393,365	380,588	374,119	Approach
1706.65	2,084,608	816,336	371,842	235,739	Bridge

Table 8. Annual Scour (-) / Deposition (+) Rates

Cross Section	3-Bay (Ton/Year)	5-Bay (Ton/Year)	7-Bay (Ton/Year)	9-Bay (Ton/Year)	Comment
1650	27,457	27,457	27,457	27,457	Mid Tiffany
1698	67,824	67,824	67,824	67,824	Lower Tiffany
1706	53,988	63,637	76,414	82,883	Approach
1706.65	-1,681,595	-422,971	8,746	138,380	Bridge
Summation	-1,532,326	-264,053	180,441	316,543	

6 FLOODPLAINS

The Corps used the FLO-2D model to generate floodplains. For the 10.0%-chance event, the flood hydrograph from rainfall events attenuates below 10,000 cfs within the project area. Downstream of the location where this occurs, the 10.0%-chance snowmelt hydrograph measuring a constant 10,000 cfs dominates. Therefore, floodplains are mapped for rainfall events upstream and snowmelt events downstream of this location.

For the without-project condition, the Corps assumed that the existing spoil-bank levees would not contain flood flows, and the spoil-bank levees were completely removed from the without-project model. For the with-project conditions, the Corps assumed that the existing spoil-bank levees beyond the downstream end of the project would not contain flood flows. Because this would potentially create a backwater effect beyond the downstream end of the constructed levee, the Corps created a separate FLO-2D model with a 100-foot grid to model the backwater effect of the spoil-bank levee failure beyond the downstream end of the project and to plot the floodplain in this area.

The active floodway is expected to change geomorphically in the future, and the Corps created a future-conditions model in which individual cross section were uniformly raised or lowered to account for predicted aggradation and degradation 50 years into the future. The channel is expected to degrade in the upper reach immediately downstream of the San Acacia Diversion Dam. The channel becomes fairly stable for the remaining upper third of the project area. Downstream from approximately the Socorro area, the channel and floodplain within the floodway become aggradational.

Floodplains for the 0.2%-chance event for the without-project condition and the with-project condition, representative of Alternative A, are presented in Figures 8.1 through 8.7. Alternative A includes the 43-mile engineered levee extending from the San Acacia Diversion Dam to Tiffany Junction. The floodplains are computer generated using flood elevations in the 500-foot computational grid and the best available mapping data. The floodplains do not comply with FEMA standards.

7 RISK AND UNCERTAINTY

The Corps acknowledges risk and uncertainty in the prediction of floods and their impacts. Historically, the Corps relied on the application of safety factors and freeboard, designing for worst-case conditions and other indirect solutions to compensate for uncertainty. These indirect approaches were necessary because of the lack of technical knowledge of the complex interaction of uncertainties. However, with advances in statistical hydrology and the availability of analysis tools, it is now possible to describe the uncertainty in the choice of hydrologic and hydraulic functions. The policies, methods, and procedures for the risk-based analysis are detailed in Engineering Regulation (ER) 1105-2-101, *Risk Analysis for Flood Damage Reduction Studies*, and in Engineering Manual (EM) 1110-2-1619, *Risk-Based Analysis for Flood Damage Reduction Studies*. The risk analysis considers present and future conditions for both without-project and with-project models.

Hydrologic risk analysis estimates the variability in the predicted peak discharges and volumes of the flood hydrographs generated by the watershed. The primary source of hydrologic uncertainty in the analysis is the length of the stream gage record used to compute a discharge-frequency relationship. The Corps computed the hydrologic uncertainty for the study area using an equivalent record length of 61 years based on stream gage and historical information. The Corps does not anticipate a significant increase in development within the watershed, and peak discharges are not expected to increase. Therefore, the Corps used the same discharges for the existing- and future-conditions models. Although some of the decisions made in the hydrologic analysis predate the adoption of risk analysis, the assumptions incorporated in the analysis, including reservoir releases and rates of hydrograph attenuation and evaporation and infiltration losses, represent expected performance and lie within appropriate limits of confidence.

A primary purpose of the hydraulic risk analysis is to estimate the variability of the water surface to complete the stage-discharge relationship. The parameter used to define the uncertainty of the stage-discharge relationship is standard deviation. Hydraulic uncertainties that affect the water surface elevations include channel and overbank Manning's *n* values, modeling geometry sources (*e.g.*, mapping), debris, and sedimentation. The Corps developed stage standard deviation estimates for both present and future conditions. Because watershed development is not anticipated, the Corps does not expect the hydrologic parameters to change in the future conditions model. However, aggradational and degradational changes within the floodway are expected in the future, and the future-conditions model includes estimated future sedimentation. The performance locations described in Section 4, *Hydraulic Analysis*, were used as locations to develop the standard deviations of the water surface elevations. These standard deviations can then be used in the evaluation of project performance and economic risk.

7.1 WITHOUT-PROJECT HYDRAULIC RISK

Without-project risk was considered from a number of perspectives following Corps guidance. The Corps investigated several relationships used to compute the standard deviation for the uncertainties and compared the results to adopt the most reasonable standard deviations to use in the risk analysis. To account for variabilities expected over time, two "snapshots" were characterized at each end of an assumed linearly varied project evaluation period. The snapshots are labeled as *present* and *future* and depict the beginning and end, respectively, of a 50-year evaluation period. EM 1110-2-1619, *Engineering and Design - Risk-Based Analysis for Flood Damage Reduction Studies* (USACE 1996), provides numerous relationships that can be used for quantifying stage uncertainty in terms of hydraulic variables.

As presented in EM 1110-2-1619, Freeman *et al.* (1996) categorized uncertainty into three classes denoted as "natural", "measurement", and "modeling". Using data from 116 river gage records along with HEC-2 model runs, Freeman derived a relationship based on the derived maximum stage range, the basin area, and the 1.0%-chance flood discharge to account for these three uncertainty sources and compute the standard deviation (U_S). Freeman presented the relationship in equation form:

$$U_s = \left[0.07208 - 2.2626x10^{-7}\, A_{Basin} + 0.0216 H_{Range} + 1.419x10^{-5} Q_{100} + 0.04936 I_{Bed}\right]^2$$

$$U_S = Standard\ Deviation\ of\ Stage - Discharge\ Uncertainty$$
$$H_{Range} = Maximum\ Stage\ Range\ (m)$$

$$A_{Basin} = Basin\ Area\ Above\ Gage\ (km^2)$$
$$Q_{Max} = 100\ Year\ Flood\ Flow\ \left(\frac{m^3}{s}\right)$$
$$I_{Bed} = Bed\ Identifier$$

Based on this relationship, and the fact that the 1.0%-chance flood discharge remains the same for present and future conditions, the Corps calculated a standard deviation (U_S) of approximately 0.38 feet using the study area variables for both present and future conditions.

EM 1110-2-1619 also provides Equation 5-6 which illustrates a method for combining various sources, or categories, of uncertainty to arrive at a composite estimate of standard deviation (S_{total}) in stage:

$$S_t = \sqrt{S_{natural}^2 + S_{model}^2 +}$$

S_t is standard deviation of the total uncertainty (S_{total})
$S_{natural}$ is natural uncertainty
S_{model} is modeling uncertainty

Table 5-2 of EM 1110-2-1619 provides *minimum* values of standard deviation (S_{min}) based on parameters largely associated with mapping and modeling uncertainty. For this study, the without-project FLO-2D models incorporated cross-sectional geometry based on topographic mapping consistent with the accuracy of a topographic map with 2-5 foot contours. Table 5-2 assigns a minimum standard deviation range between 0.6 and 1.5 for this condition. The standard deviation is further dependant on Manning's n-value coefficient reliability. Available prototype stage information, within the project effective range, is essentially non-existent, resulting in a Manning's n-value rating of "Poor" (Table 5-2). The "Poor" Manning's n-value reliability limits the *minimum* standard deviation to the threshold value of 1.5 feet.

The sensitivity of the computed water-surface elevations to modeling uncertainties was determined by modeling "high" and "low" conditions. As previously described, the FLO-2D model is capable of addressing the perched channel and split flows that exist in the without-project condition. The Corps modified the hydraulic parameters in the 1.0%-chance existing-condition FLO-2D model to estimate the variability of water-surface elevations for the without-project condition to estimate the "reasonable bounds" that would be expected to capture the majority of variability in computed stages associated with modeling uncertainty. The modified modeling parameters include the channel Manning's *n* value, the overbank Manning's *n* value, the hydraulic conductivity in the channel, and the sediment. Table 9 shows the changes that were made to the model to develop high-water and low-water conditions. The expected column is the without-project model. These "reasonable bounds" were assumed to capture approximately 95%, or approximately two standard deviations, in water surface elevation variability for the without-project present condition. Using this range of "reasonable bounds" to represent the 95% confidence interval (in addition to other simplifying assumptions) allows estimation of modeling standard deviations (S_{model}) using Equation 5-7 from EM 1110-2-1619:

$$S = \frac{E_{mean}}{4}$$

S is the standard deviation of modeling uncertainty (S_{model})
E_{mean} is the mean stage difference between the "high" and "low" modeling conditions

In his presentation, *Uncertainty in Stage-Discharge Relationships*, Brunner (HEC undated) also reported a relationship developed to account for uncertainty associated with the terrain standard deviation (S_{ter}) related to photogrammetry in the form:

$$SD = 0.0657 \; x \; S_0^{0.592} \; x \; S_n^{0.738}$$

SD is the standard deviation of terrain uncertainty (S_{ter})
S_0 is stream slope (feet/mile)
S_n is the underlying mapping contour interval (feet) divided by 10
(Within the study area, the values of S_0 and S_n are 4 and 0.2, respectively)

With these two sources of uncertainty (*i.e.*, modeling and terrain) determined, attention turned to a third uncertainty that would be associated with the "natural" category described previously. An important area of "natural" uncertainty in the study area is sedimentation. Sedimentation, in particular aggradation, has the potential to significantly affect water surface elevations over the life of the proposed project and is an important source of uncertainty. The Rio Grande within the study reach has a long history of pronounced aggradation, as documented by Leopold *et al.* (1992) as far back as the late 1890s. And while anthropogenic effects have added more and more complexity to this behavior, the overall trend has remained aggradational over long-term periods. Projection of future sedimentation for this study relied on historical cross-sectional measurements throughout the study area to develop a mathematical relationship using a logarithmic transformation.

The Corps computed a standard deviation ($S_{ag/deg}$) to account for the aggradation uncertainty by statistical analysis of the residuals of the log-transform function developed. The standard deviation value computed for this function was 0.045 feet/year. For the present condition with-project, a zero value was used for $S_{ag/deg}$ as there was no cross sectional adjustment for aggradation.

The Corps combined the three uncertainty source standard deviations, using Equation 5-6, to arrive at a total standard deviation (S_{total}) to account for the hydraulic uncertainties. The three uncertainty sources include the terrain standard deviation from Brunner's equation (S_{ter}), the "reasonable bounds" modeling standard deviation (S_{model}) estimate, and the sedimentation standard deviation ($S_{ag/deg}$) values. The resulting composite hydraulic standard deviation values computed for each Performance Location were compared (along with the combined values computed using the Freeman equation) to the minimum standard deviation threshold presented in Table 5-2 of EM 1110-2-1619. Because the computed standard deviations fall below the minimum standard deviation threshold, the Corps adopted the minimum standard deviation of 1.5

feet. Tables 10 and 11 show the various computed standard deviations using the methods described above, and the adopted standard deviation values used to characterize the hydraulic uncertainty for the present condition of the without-project period. Standard deviations expected for the water level in the channel/floodway are shown in Table 10. Standard deviations expected for the water level in the floodplain are shown in Table 11.

For the future condition, the FLO-2D model geometry was first adjusted to simulate long-term aggradation. Long-term aggradational trends, derived from measured data as described in Section 5, *Sediment Analysis*, were developed and used to estimate future conditions. The same hydraulic modeling parameters, described above and shown in Table 9, were then modified to again estimate high- and low-stage ranges.

Because the log-transform aggradation function was derived to estimate an average *annual* cross-sectional elevation change throughout the study reach, the resulting standard deviation ($S_{ag/deg}$) value of 0.045 feet/year was multiplied by 50 to arrive at a standard deviation value of 2.24 feet for the aggradation projection uncertainty. In addition, while there is a clear positive correlation between changes in the hydraulic model geometry elevations and changes in computed water surface elevations, there is also some uncertainty associated with this water surface response as it relates to geometry elevation changes. To account for the uncertainty associated with cross-sectional elevation change and associated water surface elevation change, another statistical analysis was performed on the differences between present and future modeled water surface elevations minus the present and future minimum channel elevations (*i.e.,* the differences between the present and future computed maximum channel flow depths). As described under sections 5.1 through 5.3, the model geometries were adjusted for the future conditions to account for expected depositional changes to the floodway, and the consequent changes is floodway water surface profiles. Evaluation of these results for the 1.0% exceedance event yielded a deviation value of 0.28 feet. The 0.28 feet value for elevation-water surface deviation was combined with the 2.24 feet value above, by way of the square-root-of-the-sum-of-squares form shown in Equation 5-6. The adopted standard deviation values of 2.25 to 2.26 feet reflect the total standard deviation computed using Equation 5.6 that combines the three uncertainty source standard deviations, and represents the widest range of deviation expected in the floodway (*i.e.,* channel) based on the uncertainties. Table 12 shows the resulting computed standard deviations and the adopted standard deviation values computed for each Performance Location and used to characterize the hydraulic uncertainty in the floodway for the future condition of the with-project period. Sedimentation is not anticipated to significantly influence the expected water surface within the floodplain, and the standard deviations computations and adopted values (Table 13) more closely follow the present-condition characterization, described above, with the minimum threshold values from *EM 1110-2-1619* Table 5-2 values receiving priority.

7.2 WITH-PROJECT HYDRAULIC RISK

Paralleling the without-project risk characterization, the with-project hydraulic uncertainties were also considered from a number of perspectives following Corps guidance. The Corps investigated several relationships used to compute the standard deviation and compared the results to adopt the most reasonable standard deviations to use in the risk analysis for the with-project condition. To account for variabilities expected over time, two “snapshots” were again characterized at each end of an assumed linearly varied project evaluation period. The snapshots are labeled as *present*

and *future*, as in the without-project description, above, and depict the beginning and end, respectively, of a 50-year evaluation period.

For this study, the with-project HEC-RAS models incorporated cross-sectional geometry based on aerial topographic surveys. Table 5-2 assigns a *minimum* standard deviation range between 0.3 and 1.3 for this condition. The standard deviation is further dependant on Manning's n-value coefficient reliability. Available prototype stage information, within the project effective range, is essentially non-existent, resulting in a Manning's n-value rating of "Poor" (Table 5-2). The "Poor" Manning's n-value reliability limits the minimum standard deviation to the threshold value of 1.3 feet.

The Corps modified the hydraulic parameters in the 1.0%-chance present-condition HEC-RAS model, based largely on professional judgment, condition to estimate the "reasonable bounds" that would be expected to capture the majority of variability in computed stages associated with modeling uncertainty. Table 12 shows the changes that were made to the model to develop high-stage and low-stage conditions for the present-condition with-project models.

For the future condition, the FLO-2D model geometry was first adjusted to simulate long-term aggradation. Long-term aggradational trends, derived from measured data as described in Section 5, *Sediment Analysis*, were developed and used to estimate future conditions. The same hydraulic modeling parameters, described above and shown in Table 9, were then modified to again estimate high- and low-stage ranges.
The adopted standard deviation values of 2.25 to 2.30 feet reflect the total standard deviation computed using Equation 5.6 that combines the three uncertainty source standard deviations, and represents the widest range of deviation expected based on the uncertainties. Table 14 shows the resulting computed standard deviations and the adopted standard deviation values computed for each Performance Location and used to characterize the hydraulic uncertainty for the future condition of the with-project period.

Table 9. Hydraulic Parameters Varied for the Risk Analysis Hydraulic Models for the Without-Project Condition

Risk Parameter	Risk Scenario		
	Low	Expected	High
Channel n-value	-0.005 (n>0.015)	0.016-0.038	+0.005
Overbank n-value	-0.02	0.065/0.1	+0.02
Infiltration - Hydraulic Conductivity in Channel	0.11	0.1	0.09
Sediment	N/A	N/A	Simulated sediment plug in the Tiffany reach

Table 10. Variation in Water Surface Elevations and Standard Deviations Expected for the Water Surface in the Channel for the Present Without-Project Condition

Channel Hydraulic Uncertainty Present Conditions Without Project								
a	b	c	d	e	f	g	h	i
Performance Location ID	E_{mean} (Feet)	U_s (Feet)	SD1 S_{model} (Feet)	SD2 $S_{ag/deg}$ (Feet)	SD3 S_{ter} (Feet)	SD S_{total} (Feet)	SD S_{min} (Feet)	Adopted Standard Deviation (Feet)
2	0.82	0.38	0.21	0.00	0.05	0.21	1.50	1.50
3	0.53	0.38	0.13	0.00	0.05	0.15	1.50	1.50
4	0.69	0.38	0.17	0.00	0.05	0.18	1.50	1.50
5	0.74	0.38	0.19	0.00	0.05	0.20	1.50	1.50
6	0.14	0.38	0.03	0.00	0.05	0.07	1.50	1.50
7	0.01	0.38	0.00	0.00	0.05	0.06	1.50	1.50
8	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
9	0.17	0.38	0.04	0.00	0.05	0.08	1.50	1.50
10	0.30	0.38	0.08	0.00	0.05	0.10	1.50	1.50
11,12	0.41	0.38	0.10	0.00	0.05	0.12	1.50	1.50
13	0.18	0.38	0.05	0.00	0.05	0.08	1.50	1.50
14	0.15	0.38	0.04	0.00	0.05	0.07	1.50	1.50
15	0.18	0.38	0.05	0.00	0.05	0.08	1.50	1.50
16	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
17	0.01	0.38	0.00	0.00	0.05	0.06	1.50	1.50
18	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
19	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
20	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
21	0.16	0.38	0.04	0.00	0.05	0.08	1.50	1.50
22	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50

Notes (Channel Present Without-Project Condition):

b Difference between high- and low-risk conditions using present-condition FLO-2D model (Table 9)
c Standard deviation of stage-discharge uncertainty (Freeman et. al.)
d Standard deviation for hydraulic model uncertainty ($E_{mean}/4$) (EM 1110-2-1619, Equation 5-7)
e Standard deviation for aggradation/degradation uncertainty (EM 1110-2-1619, Equation 5-6)
f Standard deviation for terrain uncertainty (Brunner, undated)
g Square root of sum of squares of columns d, e, and f (EM 1110-2-1619, Equation 5-6)
h Minimum Standard deviation for Poor n Reliability, 2-5' Contour Accuracy (EM 1110-2-1619, Table 5-2)

Table 11. Variation in Water Surface Elevations and Standard Deviations Expected for the Water Surface in the Floodplain for the Present Without-Project Condition

Floodplain Hydraulic Uncertainty Present Conditions Without Project								
a	b	c	d	e	f	g	h	i
Performance Location ID	E_{mean} (Feet)	U_s (Feet)	SD1 S_{model} (Feet)	SD2 $S_{ag/deg}$ (Feet)	SD3 S_{ter} (Feet)	SD S_{total} (Feet)	SD S_{min} (Feet)	Adopted Standard Deviation (Feet)
2	1.26	0.38	0.32	0.00	0.05	0.32	1.50	1.50
3	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
4	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
5	0.88	0.38	0.22	0.00	0.05	0.23	1.50	1.50
6	0.80	0.38	0.20	0.00	0.05	0.21	1.50	1.50
7	1.20	0.38	0.30	0.00	0.05	0.31	1.50	1.50
8	1.18	0.38	0.30	0.00	0.05	0.30	1.50	1.50
9	1.18	0.38	0.30	0.00	0.05	0.30	1.50	1.50
10	1.01	0.38	0.25	0.00	0.05	0.26	1.50	1.50
11,12	3.06	0.38	0.76	0.00	0.05	0.77	1.50	1.50
13	0.77	0.38	0.19	0.00	0.05	0.20	1.50	1.50
14	0.43	0.38	0.11	0.00	0.05	0.13	1.50	1.50
15	0.26	0.38	0.07	0.00	0.05	0.09	1.50	1.50
16	0.31	0.38	0.08	0.00	0.05	0.10	1.50	1.50
17	0.35	0.38	0.09	0.00	0.05	0.11	1.50	1.50
18	0.10	0.38	0.03	0.00	0.05	0.07	1.50	1.50
19	0.14	0.38	0.03	0.00	0.05	0.07	1.50	1.50
20	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
21	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
22	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50

Notes (Floodplain Present Without-Project Condition):

b Difference between high- and low-risk conditions using present-condition FLO-2D model (Table 9)
c Standard deviation of stage-discharge uncertainty (Freeman et. al.)
d Standard deviation for hydraulic model uncertainty ($E_{mean}/4$) (EM 1110-2-1619, Equation 5-7)
e Standard deviation for aggradation/degradation uncertainty (EM 1110-2-1619, Equation 5-6)
f Standard deviation for terrain uncertainty (Brunner, undated)
g Square root of sum of squares of columns d, e, and f (EM 1110-2-1619, Equation 5-6)
h Minimum Standard deviation for Poor n Reliability, 2-5' Contour Accuracy (EM 1110-2-1619, Table 5-2)

Table 12. Variation in Water Surface Elevations and Standard Deviations Expected for the Water Surface in the Channel for the Future Without-Project Condition

Channel Hydraulic Uncertainty Future Conditions Without Project								
a	b	c	d	e	f	g	h	i
Performance Location ID	E_{mean} (Feet)	U_s (Feet)	SD1 S_{model} (Feet)	SD2 $S_{ag/deg}$ (Feet)	SD3 S_{ter} (Feet)	SD S_{total} (Feet)	SD S_{min} (Feet)	Adopted Standard Deviation (Feet)
2	0.82	0.38	0.21	2.25	0.05	2.26	1.50	2.26
3	0.53	0.38	0.13	2.25	0.05	2.26	1.50	2.26
4	0.69	0.38	0.17	2.25	0.05	2.26	1.50	2.26
5	0.74	0.38	0.19	2.25	0.05	2.26	1.50	2.26
6	0.14	0.38	0.03	2.25	0.05	2.25	1.50	2.25
7	0.01	0.38	0.00	2.25	0.05	2.25	1.50	2.25
8	0.00	0.38	0.00	2.25	0.05	2.25	1.50	2.25
9	0.17	0.38	0.04	2.25	0.05	2.25	1.50	2.25
10	0.30	0.38	0.08	2.25	0.05	2.25	1.50	2.25
11,12	0.41	0.38	0.10	2.25	0.05	2.26	1.50	2.26
13	0.18	0.38	0.05	2.25	0.05	2.25	1.50	2.25
14	0.15	0.38	0.04	2.25	0.05	2.25	1.50	2.25
15	0.18	0.38	0.05	2.25	0.05	2.25	1.50	2.25
16	0.00	0.38	0.00	2.25	0.05	2.25	1.50	2.25
17	0.01	0.38	0.00	2.25	0.05	2.25	1.50	2.25
18	0.00	0.38	0.00	2.25	0.05	2.25	1.50	2.25
19	0.00	0.38	0.00	2.25	0.05	2.25	1.50	2.25
20	0.00	0.38	0.00	2.25	0.05	2.25	1.50	2.25
21	0.16	0.38	0.04	2.25	0.05	2.25	1.50	2.25
22	0.00	0.38	0.00	2.25	0.05	2.25	1.50	2.25

Notes (Channel Future Without-Project Condition):

b Difference between high- and low-risk conditions using present-condition FLO-2D model (Table 9)
c Standard deviation of stage-discharge uncertainty (Freeman et. al.)
d Standard deviation for hydraulic model uncertainty ($E_{mean}/4$) (EM 1110-2-1619, Equation 5-7)
e Standard deviation for aggradation/degradation uncertainty (EM 1110-2-1619, Equation 5-6)
f Standard deviation for terrain uncertainty (Brunner, undated)
g Square root of sum of squares of columns d, e, and f (EM 1110-2-1619, Equation 5-6)
h Minimum Standard deviation for Poor n Reliability, 2-5' Contour Accuracy (EM 1110-2-1619, Table 5-2)

Table 13. Variation in Water Surface Elevations and Standard Deviations Expected for the Water Surface in the Floodplain for the Future Without-Project Condition

Floodplain Hydraulic Uncertainty Future Conditions Without Project								
a	b	c	d	e	f	g	h	i
Performance Location ID	E_{mean} (Feet)	U_s (Feet)	SD1 S_{model} (Feet)	SD2 $S_{ag/deg}$ (Feet)	SD3 S_{ter} (Feet)	SD S_{total} (Feet)	SD S_{min} (Feet)	Adopted Standard Deviation (Feet)
2	1.26	0.38	0.32	0.00	0.05	0.32	1.50	1.50
3	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
4	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
5	0.88	0.38	0.22	0.00	0.05	0.23	1.50	1.50
6	0.80	0.38	0.20	0.00	0.05	0.21	1.50	1.50
7	1.20	0.38	0.30	0.00	0.05	0.31	1.50	1.50
8	1.18	0.38	0.30	0.00	0.05	0.30	1.50	1.50
9	1.18	0.38	0.30	0.00	0.05	0.30	1.50	1.50
10	1.01	0.38	0.25	0.00	0.05	0.26	1.50	1.50
11,12	3.06	0.38	0.76	0.00	0.05	0.77	1.50	1.50
13	0.77	0.38	0.19	0.00	0.05	0.20	1.50	1.50
14	0.43	0.38	0.11	0.00	0.05	0.13	1.50	1.50
15	0.26	0.38	0.07	0.00	0.05	0.09	1.50	1.50
16	0.31	0.38	0.08	0.00	0.05	0.10	1.50	1.50
17	0.35	0.38	0.09	0.00	0.05	0.11	1.50	1.50
18	0.10	0.38	0.03	0.00	0.05	0.07	1.50	1.50
19	0.14	0.38	0.03	0.00	0.05	0.07	1.50	1.50
20	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
21	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
22	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50

Notes (Floodplain Future Without-Project Condition):

b Difference between high- and low-risk conditions using present-condition FLO-2D model (Table 9)
c Standard deviation of stage-discharge uncertainty (Freeman et. al.)
d Standard deviation for hydraulic model uncertainty ($E_{mean}/4$) (EM 1110-2-1619, Equation 5-7)
e Standard deviation for aggradation/degradation uncertainty (EM 1110-2-1619, Equation 5-6)
f Standard deviation for terrain uncertainty (Brunner, undated)
g Square root of sum of squares of columns d, e, and f (EM 1110-2-1619, Equation 5-6)
h Minimum Standard deviation for Poor n Reliability, 2-5' Contour Accuracy (EM 1110-2-1619, Table 5-2)

Table 14. Hydraulic Parameters Varied for the Risk Analysis Hydraulic Models for the With-Project Condition

Risk Parameter	Risk Scenario		
	Low	Expected	High
Channel n-value	0.012 – 0.030	0.013 – 0.033	0.014 – 0.036
Overbank n-value	0.045 – 0.09	0.05 – 0.10	0.055 – 0.11
Infiltration - Hydraulic Conductivity in Channel	N/A	N/A	N/A
Sediment	N/A	N/A	Simulated Sediment Plug in the Tiffany Reach

Table 15. Variation in Water Surface Elevations and Standard Deviations Expected for the Water Surface in the Present With-Project Condition

Hydraulic Uncertainty Present Conditions With Project								
a	b	c	d	e	f	g	h	i
Performance Location ID	E_{mean} (Feet)	U_s (Feet)	SD1 S_{model} (Feet)	SD2 $S_{ag/deg}$ (Feet)	SD3 S_{ter} (Feet)	SD S_{total} (Feet)	SD S_{min} (Feet)	Adopted Standard Deviation (Feet)
2	0.65	0.38	0.16	0.00	0.05	0.17	1.30	1.30
3	0.37	0.38	0.09	0.00	0.05	0.10	1.30	1.30
4	0.66	0.38	0.17	0.00	0.05	0.17	1.30	1.30
5	0.75	0.38	0.19	0.00	0.05	0.19	1.30	1.30
6	1.01	0.38	0.25	0.00	0.05	0.26	1.30	1.30
7	0.81	0.38	0.20	0.00	0.05	0.21	1.30	1.30
8	0.45	0.38	0.11	0.00	0.05	0.12	1.30	1.30
9	0.43	0.38	0.11	0.00	0.05	0.12	1.30	1.30
10	0.00	0.38	0.00	0.00	0.05	0.05	1.30	1.30
11,12	0.36	0.38	0.09	0.00	0.05	0.10	1.30	1.30
13	0.45	0.38	0.11	0.00	0.05	0.12	1.30	1.30
14	0.40	0.38	0.10	0.00	0.05	0.11	1.30	1.30
15	0.68	0.38	0.17	0.00	0.05	0.18	1.30	1.30
16	0.53	0.38	0.13	0.00	0.05	0.14	1.30	1.30
17	0.51	0.38	0.13	0.00	0.05	0.14	1.30	1.30
18	0.50	0.38	0.13	0.00	0.05	0.13	1.30	1.30
19	0.74	0.38	0.18	0.00	0.05	0.19	1.30	1.30
20	0.69	0.38	0.17	0.00	0.05	0.18	1.30	1.30
21	0.64	0.38	0.16	0.00	0.05	0.17	1.30	1.30
22	2.24	0.38	0.56	0.00	0.05	0.56	1.30	1.30

Notes (Present With-Project Conditions):

b Difference between high- and low-risk conditions using present-condition HEC-RAS model (Table 14)
c Standard deviation of stage-discharge uncertainty (Freeman et. al.)
d Standard deviation for hydraulic model uncertainty ($E_{mean}/4$) (EM 1110-2-1619, Equation 5-7)
e Standard deviation for aggradation/degradation uncertainty (EM 1110-2-1619, Equation 5-6)
f Standard deviation for terrain uncertainty (Brunner, undated)
g Square root of sum of squares of columns d, e, and f (EM 1110-2-1619, Equation 5-6)
h Minimum Standard deviation for Poor n Reliability, Aerial Spot Elevation conditions (EM 1110-2-1619, Table 5-2)

Table 16. Variation in Water Surface Elevations and Standard Deviations Expected for the Water Surface in the Future- With-Project Condition

Hydraulic Uncertainty Future Conditions With Project								
a	b	c	d	e	f	g	h	i
Performance Location ID	E_{mean} (Feet)	U_s (Feet)	SD1 S_{model} (Feet)	SD2 $S_{ag/deg}$ (Feet)	SD3 S_{ter} (Feet)	SD S_{total} (Feet)	SD S_{min} (Feet)	Adopted Standard Deviation (Feet)
2	0.64	0.38	0.16	2.25	0.05	2.26	1.30	2.26
3	0.37	0.38	0.09	2.25	0.05	2.26	1.30	2.26
4	0.66	0.38	0.16	2.25	0.05	2.26	1.30	2.26
5	0.73	0.38	0.18	2.25	0.05	2.26	1.30	2.26
6	0.87	0.38	0.22	2.25	0.05	2.26	1.30	2.26
7	0.69	0.38	0.17	2.25	0.05	2.26	1.30	2.26
8	0.45	0.38	0.11	2.25	0.05	2.26	1.30	2.26
9	0.43	0.38	0.11	2.25	0.05	2.26	1.30	2.26
10	0.00	0.38	0.00	2.25	0.05	2.25	1.30	2.25
11,12	0.36	0.38	0.09	2.25	0.05	2.26	1.30	2.26
13	0.44	0.38	0.11	2.25	0.05	2.26	1.30	2.26
14	0.41	0.38	0.10	2.25	0.05	2.26	1.30	2.26
15	0.69	0.38	0.17	2.25	0.05	2.26	1.30	2.26
16	0.53	0.38	0.13	2.25	0.05	2.26	1.30	2.26
17	0.52	0.38	0.13	2.25	0.05	2.26	1.30	2.26
18	0.51	0.38	0.13	2.25	0.05	2.26	1.30	2.26
19	0.77	0.38	0.19	2.25	0.05	2.26	1.30	2.26
20	0.63	0.38	0.16	2.25	0.05	2.26	1.30	2.26
21	0.35	0.38	0.09	2.25	0.05	2.26	1.30	2.26
22	1.76	0.38	0.44	2.25	0.05	2.30	1.30	2.30

Notes (Future With-Project Condition):

b Difference between high- and low-risk conditions using future-condition HEC-RAS model (Table 14)
c Standard deviation of stage-discharge uncertainty (Freeman et. al.)
d Standard deviation for hydraulic model uncertainty ($E_{mean}/4$) (EM 1110-2-1619, Equation 5-7)
e Standard deviation for aggradation/degradation uncertainty (EM 1110-2-1619, Equation 5-6)
f Standard deviation for terrain uncertainty (Brunner, undated)
g Square root of sum of squares of columns d, e, and f (EM 1110-2-1619, Equation 5-6)
h Minimum Standard deviation for Poor n Reliability, Aerial Spot Elevation conditions (EM 1110-2-1619, Table 5-2)

Figure 8.1. Without-Project Floodplain and With-Project Floodplain index

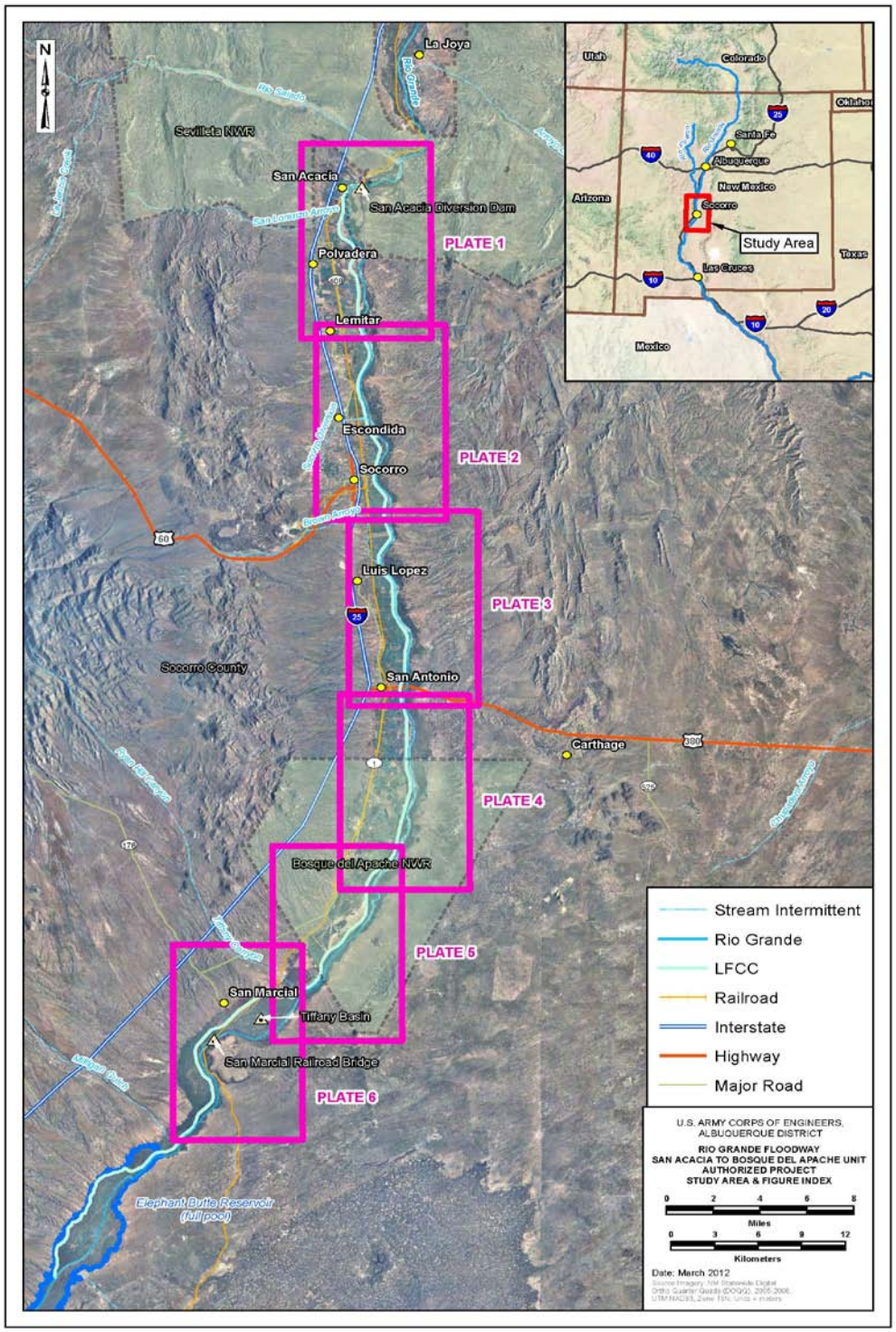


Figure 8.2. Without-Project Floodplains and With-Project Floodplains (Alternative A)

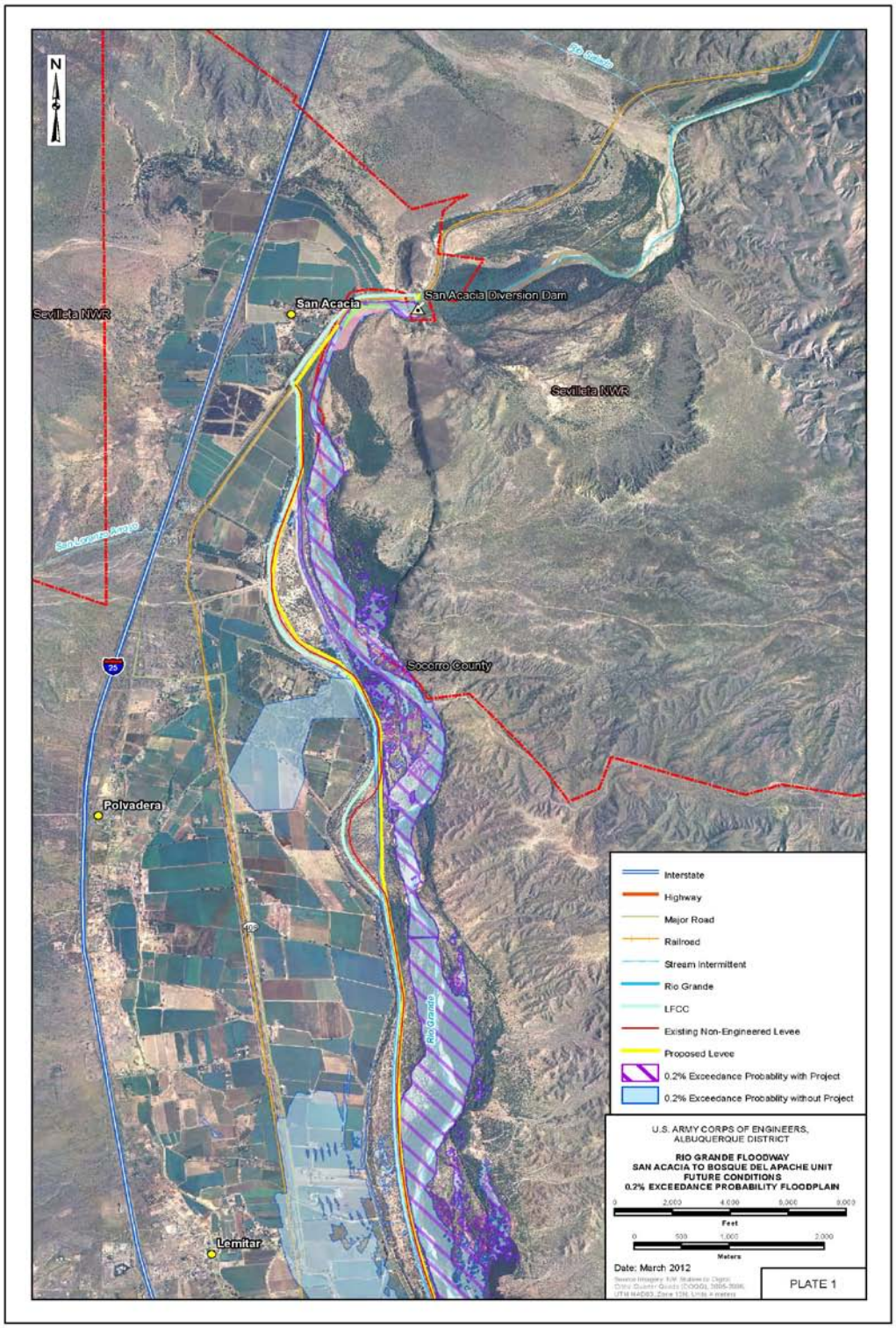


Figure 8.3. Without-Project Floodplains and With-Project Floodplains (Alternative A)

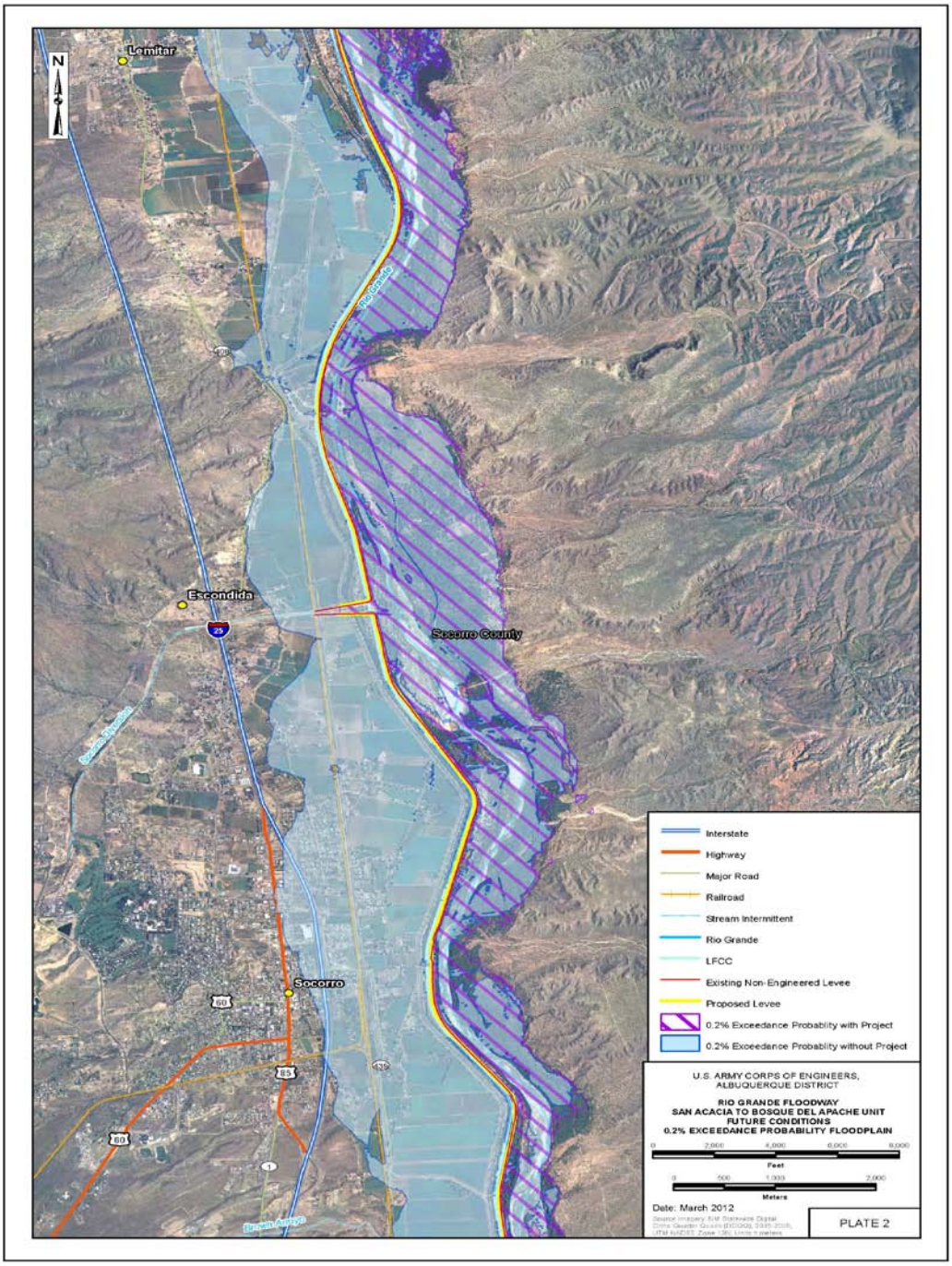


Figure 8.4. Without-Project Floodplains and With-Project Floodplains (Alternative A)

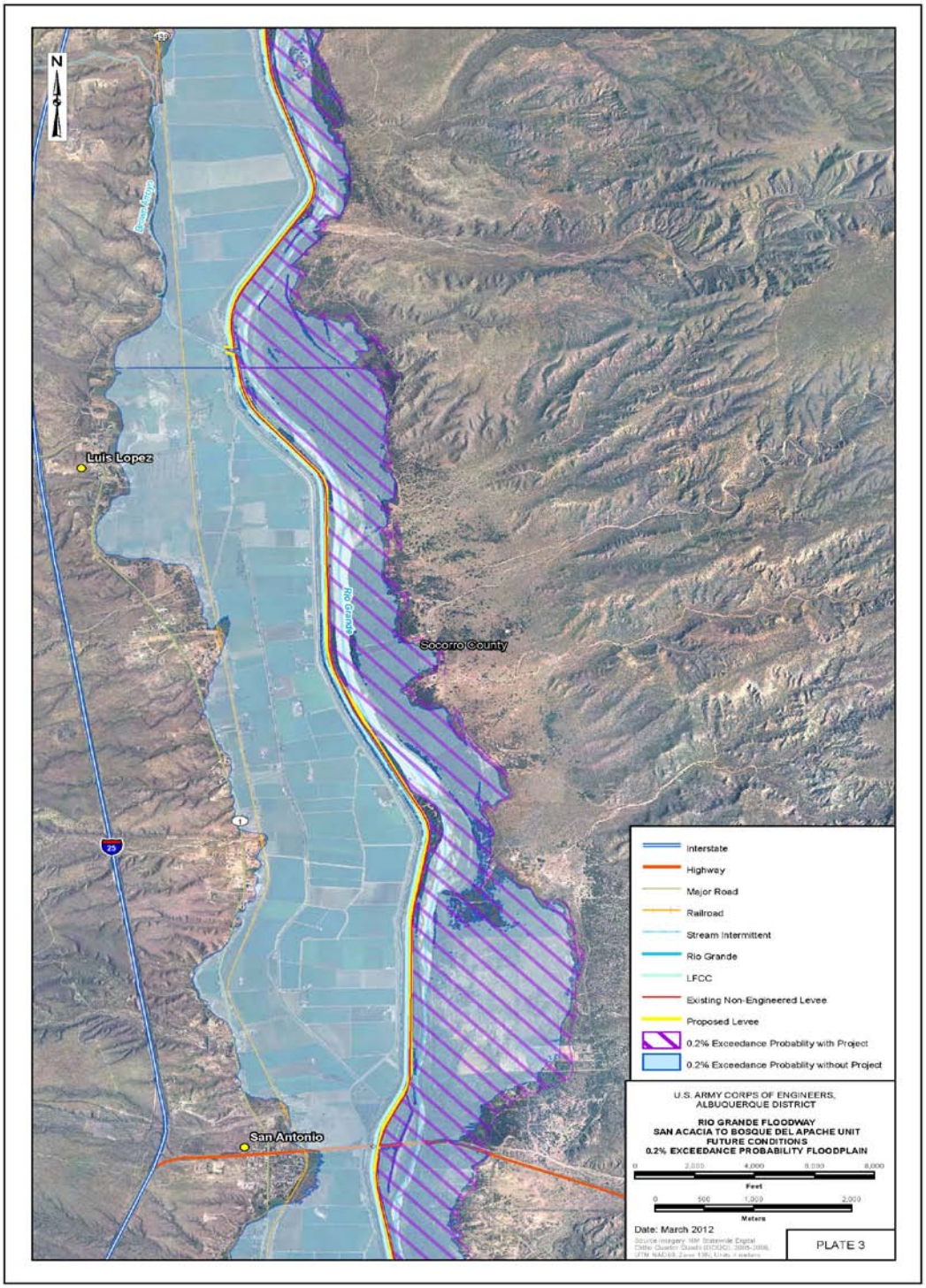


Figure 8.5. Without-Project Floodplains and With-Project Floodplains (Alternative A)

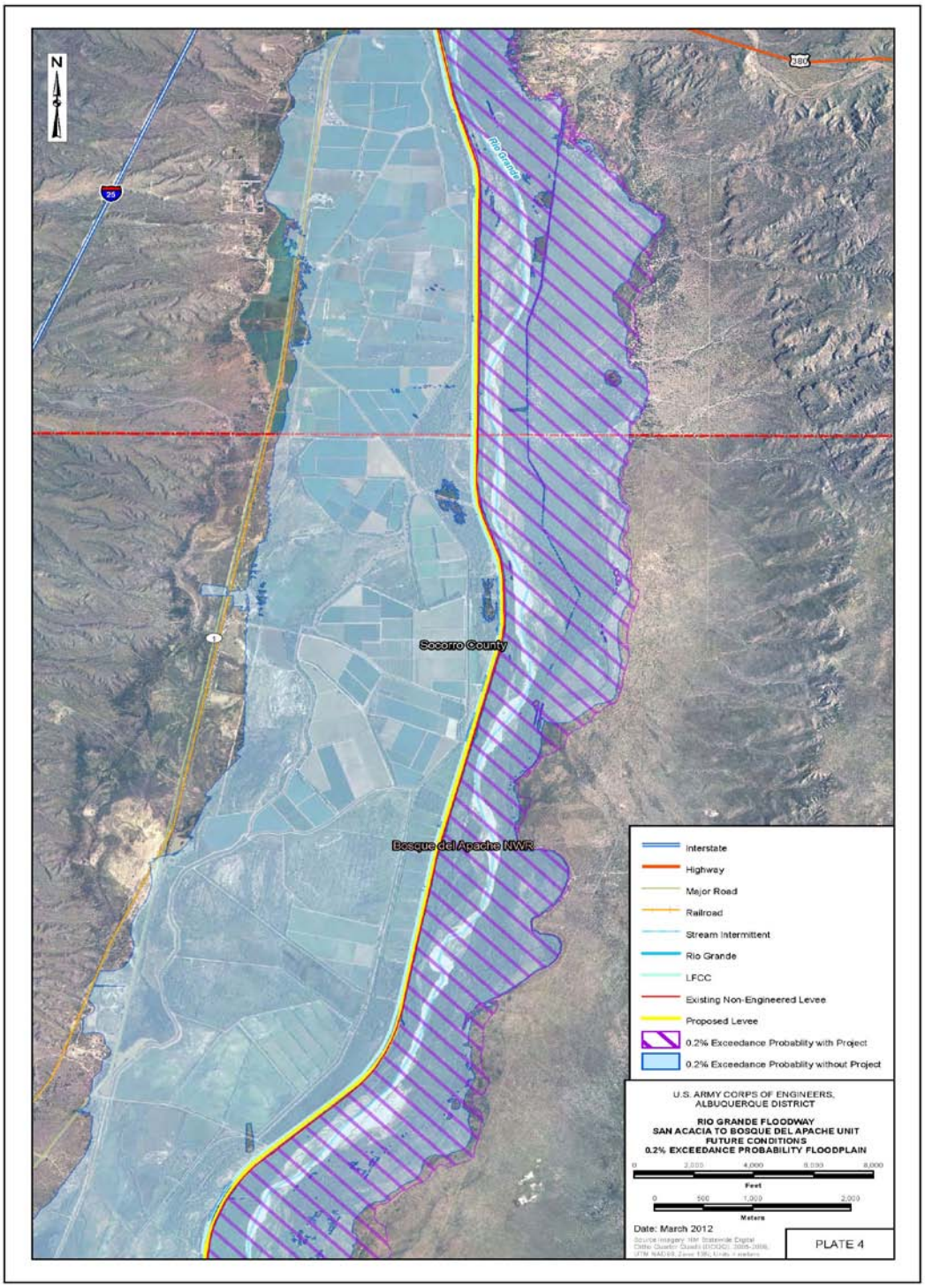


Figure 8.6. Without-Project Floodplains and With-Project Floodplains (Alternative A)

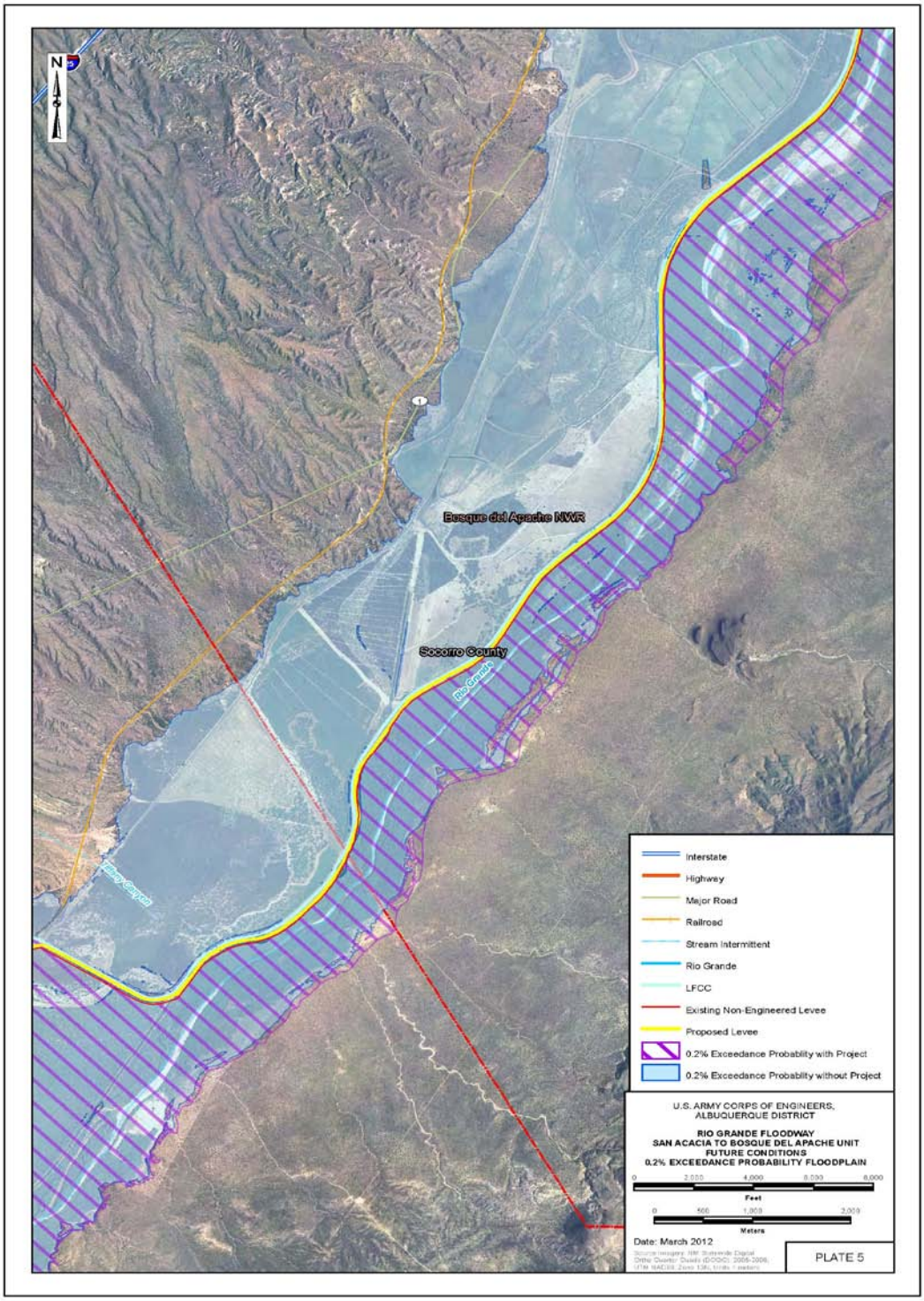
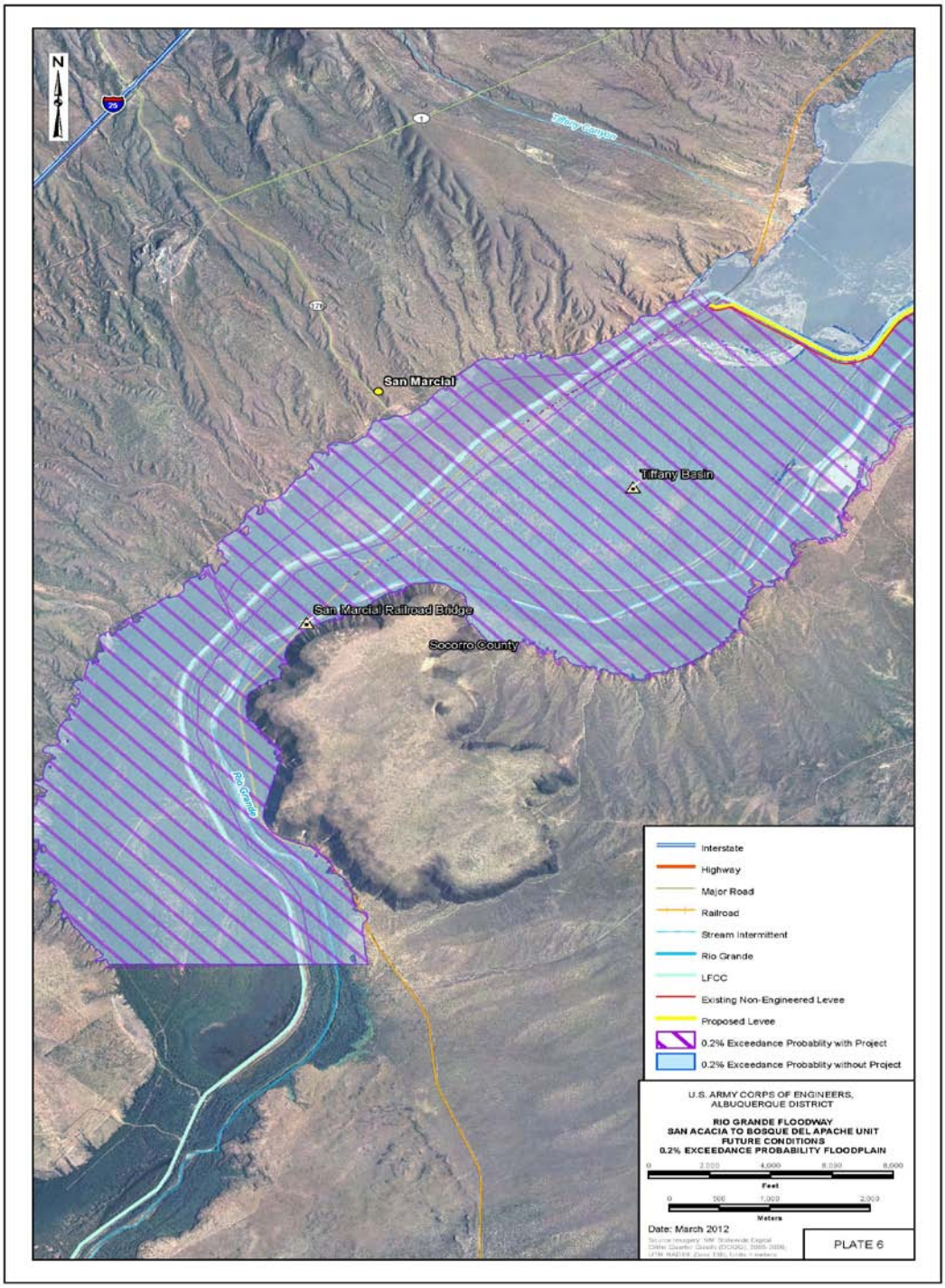


Figure 8.7. Without-Project Floodplains and With-Project Floodplains (Alternative A)



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Appendix F-2, Hydrology, Hydraulics, and Sedimentation

ATTACHMENT

Rio Grande Floodway
San Acacia to Bosque del Apache Unit, Socorro, NM
Flood Damage Reduction Project

HYDROLOGIC ANALYSIS

December 2004

Feasibility Report

Limited Reevaluation Report

Supplemental Environmental Impact Statement
for the Authorized
Rio Grande Floodway: San Acacia to Bosque del Apache Unit, Socorro NM,
Flood Damage Reduction Project

Hydrologic Analysis

Hydrology
Rio Grande Floodway: San Acacia to San Marcial, Socorro County, N.M

Feasibility Report

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1.0 Purpose and Scope of Report. The scope of this report is to present a hydrologic analysis for the Rio Grande floodway between San Acacia and San Marcial.

1.1. Summary of Hydrologic Analysis

In order to estimate the hydrology for the project area, the following tasks were accomplished:

- Discharge frequency relationships were developed for the Rio Grande at San Acacia. An adjusted record of annual maximum instantaneous peaks was developed and used as the basis of the discharge frequency analysis. The adjustments to peak flows were made so that peaks represent regulated conditions. Whenever secondary peaks from unregulated areas were of greater magnitude than the adjusted peaks, the secondary peaks were used.
- Secondary peaks were estimated by routing recorded flows from major unregulated tributaries and combining them with coincident recorded flows on the mainstem Rio Grande. FLO-2D, a 2-dimensional unsteady flow model, was used to route and combine hydrographs representing the relevant gage data.
- Design hydrographs were developed for the Rio Grande at San Acacia based on peak and volume frequency relationships.
- Flood frequencies for the project area from San Acacia to San Marcial were determined by routing the design hydrographs downstream using FLO-2D.

The results of the frequency analysis at San Acacia are summarized in Table 1. A complete discussion of the analytic methods and the rationale for using these methods is presented in following sections of this report.

1.2. Primary Purpose of Hydrology: Feasibility Evaluation of Proposed Corps of Engineers Flood Damage Reduction Project

The *Rio Grande Floodway: San Acacia to Bosque del Apache Unit, Socorro NM, Flood Damage Reduction Project*, is a reevaluation of a Corps of Engineers flood protection project that was last proposed in 1999. There are several previous project reports.

- In 1999 a Limited Reevaluation Report and Supplemental Environmental Impact Statement (LRR/SEIS) was issued, with a recommendation for an earthen levee extending 43.5 miles along the west bank of the Rio Grande from the San Acacia Diversion Dam to approximately 3 miles north of the San Marcial railroad bridge. The Tiffany sediment control area was also recommended in this report.
- In 1992 a SEIS was issued.
- In 1991 a General Design Memorandum (GDM #2) was issued, with a recommendation for an earthen levee extending 54.3 miles along the west bank of the Rio Grande from the San Acacia Diversion dam to the end of the Low Flow Conveyance Channel at the headwaters of Elephant Butte Lake. In 1992 the corresponding SEIS was issued.

The project area is the Rio Grande and its associated floodplain beginning at the diversion dam at San Acacia and extending to San Marcial, in the headwaters of Elephant Butte Lake, Socorro County, NM. The length of the project area is approximately 48 river miles. Project features that will be evaluated include:

1) Engineered levees on the west side of the Rio Grande floodway. The floodway is bounded to the east by high ground.
2) A sediment control area at Tiffany, immediately upstream of San Marcial.
3) Relocation of a railroad bridge at San Marcial. The San Marcial railroad bridge is virtually parallel to the Rio Grande, intersecting the river at an angle of 70 degrees to the perpendicular. In the past 100 years, approximately 24 feet of sediment have accumulated at the location of the railroad bridge, and it has been raised twice to accommodate the aggrading riverbed. There is a proposal to move the bridge to a location where it will be approximately perpendicular to the flow.

Table 1. Flood Flow Frequency at San Acacia

Return Period Flood Event	Percent Chance Exceedance	Flow in CFS
500 yr	.2	43500
200 yr	.5	35300
100 yr	1.0	29900
50 yr	2.0	25000
20 yr	5.0	19200
10 yr	10.0	15400
5 yr	20.0	11800
2 yr	50.0	7380
1.25 yr	80.0	4770
1.11 yr	90.0	3860
1.05 yr	95.0	3260
1.01 yr	99.0	2420

1.3. Secondary Purpose of Hydrology: Compare This Analysis to Other Federal Hydrologic Studies that Pertain to the Project Area and Provide Perspective on the Differences

The hydrology of the Rio Grande in the project area has been studied for many years by various Federal, State and local government agencies, including the Corps of Engineers. Some of the Federal agencies that have responsibilities for river information and management in the Rio Grande watershed are:

- Bureau of Reclamation (BOR)
- U.S. Fish and Wildlife Service (USFWS)
- U.S. Geological Survey (USGS)
- U.S. Army Corps of Engineers (COE)

Each of these entities has performed independent hydrologic analyses. For this reason there are several different versions of flood hydrology for the project area. In each case, these analyses meet the agency needs, but there is not much consistency in approach or in results between the various versions.

One of the most important developments in recent years is a growing public interest in the water resources of the Rio Grande river basin, as part of an increased emphasis on protecting the environment. The past few years have been relatively dry ones. There has been a significant amount of public attention focused on the implications for the environment, for endangered species, for preservation of native plants and wildlife, for meeting New Mexico's commitment to deliver river water in accordance with the Rio Grande Compact for commercial and residential water use, for recreation, and for support of traditional lifestyles such as farming and ranching.

Flood hydrology in the Rio Grande watershed has, over time, been complicated by a number of factors, such as the construction of dams that regulate flows and movement of sediment. Different ways of addressing these factors have contributed to the differences in the hydrologic analyses. However, given the level of public attention to river resource management, hydrologists and engineers at some of the Federal agencies have agreed that it will be useful to explore whether newly available analytic tools can be used to provide insight into apparent inconsistencies. Perhaps some of the differences in the analyses can be more easily understood and the applicability of these analyses can be clarified.

This subject is discussed further in Section 6 below, together with a discussion of results of this analysis. Table 9 in Section 6 provides a summary of hydrologic estimates for San Acacia peak flows from Federal agencies, including the results of this study.

2.0. Watershed Characteristics

2.1. Basin characteristics

The size of the watershed at San Acacia is 26,770 square miles, including 2,940 square miles in a closed basin in San Luis Valley, CO. A watershed map is provided in Figure 1.

The climate is generally arid or semiarid. Elevations range from over 14,000 feet in the Colorado mountains to 4,660 feet at San Acacia. Vegetation is sparse in much of the watershed, other than at high elevations. Shrubs and grasses dominate the lower elevations. Junipers and pinions are common at intermediate elevations, while pine and fir forests are found at high elevations.

The Rio Grande rift is a geologic feature that separates the Great Plains from the Colorado Plateau and defines the location of the river. The Rio Grande valley in New Mexico flows in the rift through a system of linked basins flanked by uplifts. Over time, the Rio Grande rift has filled with several thousand feet of sediments. Near Albuquerque, the depth of alluvium is more than 5,000 feet.

A system of drains and spoil bank levees was completed in 1936 in much of the Rio Grande floodplain, confining much of the floodway. Since the levees were constructed, the sediment moving through the river has deposited within the levees and created a floodway that is higher than the floodplain outside the levees in many places. Another effect of the levee system has been to disconnect the river from smaller tributaries that had been a source of inflow and sediment.

It is important to note that one of the authorized purposes of Cochiti, Jemez and Galisteo dams is to regulate sediment. An estimated 1000 acre-feet of sediment reaches Cochiti Dam each year. The dams control approximately 80% of the sediment inflow above Albuquerque. At the time that the dams were constructed, the floodway was aggrading to the extent that it had become perched in most locations between Cochiti and the project area. Where there were engineered levees, there was concern that the increasing sediment in the floodway would prevent the levees from containing high flow events. Examples of the impacts of reduced sediment include channelization of the river and decreased connection between the river and its floodplain. The effect of the sediment reduction arguably extends south beyond Albuquerque.

In order to address the hydrology, the area was divided into four subwatersheds. They include the watersheds of two major tributaries, the Rio Puerco and the Rio Salado; the Albuquerque drainage area, including the Cochiti, Jemez and Galisteo watersheds; and the mainstem Rio Grande downstream of Albuquerque. Table 2 provides some characteristics of the subwatersheds.

2.1.1. Rio Puerco and Rio Salado Subwatersheds

The Rio Puerco and the Rio Salado watersheds are drainage areas of two major tributaries to the Rio Grande that have their confluences immediately upstream of the project area, both within 12 river miles. They are unregulated and are significant in size, 7,350 and 1,395 square miles respectively.

Table 2. Subwatershed Attributes

Subwatershed Attribute	Rio Puerco Subwatershed	Rio Salado Subwatershed	Albuquerque Subwatershed	RG Subwatrshed Albuquerque - San Acacia (w/o RP and RS subwatersheds)
Size (mi^2)	7,350	1,395	17,440	3,580
Stream Length (mi)	140	70	320	67
Ave. Slope	32 ft/mi	53 ft/mi	22.5 ft/mi	4.3 ft/mi
Record Peak Flow and Date	35,000 cfs Sept. 23, 1929	36,200 cfs July 31, 1965	25,000 cfs April 24, 1942	53,400 cfs Aug. 13, 1929

These areas are lightly populated. Commercial activities are primarily livestock and mining. The subwatersheds are contiguous and comprise much of the westernmost watershed. The lands are 20% tribal, and include reservation land belonging to the Navajo and Jicarilla Apache, and the Acoma, Isleta, Jemez, Laguna Pueblos.

The Rio Puerco subwatershed extends to the Continental Divide on the west and to the Jemez Mountains on the north. It includes 1360 square miles of non-contributing area. The Rio Puerco is an ephemeral stream with a winding and steep-walled channel. There are extensive lava flows with absorptive characteristics. Much of the flow from upstream locations greatly attenuates in this subwatershed. The soils are generally highly erosive alluvium soils and a great deal of sediment is produced by flows from the Rio Puerco.

The Rio Salado subwatershed is located to the west of San Acacia. It is bordered on the south by the Lemitar Mountains and the Gallinas Mountains, on the southwest by the Datil Mountains, on the west by the North Plains, and on the northwest by the Ladron Mountains. It is an ephemeral stream with deeply entrenched arroyos. Given the steep terrain, it is flash flood prone, with high peak flows.

2.1.2. Albuquerque Subwatershed.

Albuquerque is located on the Rio Grande, 70 river miles upstream of the project area. Flow on the Albuquerque subwatershed is directly controlled by three dams: Cochiti, Jemez Canyon, and Galisteo. The Albuquerque subwatershed comprises 65% of the San Acacia drainage area.

Cochiti Dam is the most significant of the upstream structures, located on the mainstem Rio Grande 58 miles upstream of Albuquerque. The headwaters of the Rio Grande above Cochiti Dam are in the San Juan Mountains of south-central Colorado. There are several major tributaries in the 15,900 square mile watershed above Cochiti Dam, including some that are themselves regulated.

- The Rio Chama is regulated at the El Vado Reservoir and at Abiquiu Reservoir. Heron Lake, upstream of the El Vado Reservoir, receives interbasin transfer water from the San Juan River. The Rio Chama drainage area is 3,144 square miles at Chamita, near its confluence with the Rio Grande.
- The Conejos River in Colorado is regulated by an upstream dam, Platoro Dam.
- Other upstream reservoirs include Wagon Wheel Gap Reservoir, near Creede, CO., also the Santa Maria Reservoir, Continental Reservoir and Rio Grande Reservoir.
- Major unregulated tributaries to the Rio Grande upstream of Cochiti Dam in New Mexico include the Santa Fe River, Santa Cruz River, Embudo Creek, Rio Taos, Rio Hondo, and

the Red River. In Colorado, the La Jara Creek and Alamosa Creek are major unregulated tributaries.

Two major tributaries between Cochiti Dam and Albuquerque are regulated: the Jemez River and Galisteo Creek. Reservoir discharges from the 3 dams, including Cochiti, are coordinated to limit the flow at Albuquerque to 7000 cfs. Other major tributaries to the Rio Grande in Albuquerque are the Tonque Arroyo, North and South Diversion Channels in Albuquerque. These disconnected arroyos can contribute locally high flows on the Rio Grande, but the flood hydrographs attenuate rapidly once they reach the Rio Grande river channel.

2.1.3. Rio Grande Subwatershed from Albuquerque to San Acacia (without the Rio Puerco and Rio Salado subwatersheds)

The remainder of the Rio Grande watershed between Albuquerque and San Acacia, not including the Rio Puerco and the Rio Salado subwatersheds, consists of a strip of land approximately 70 miles long that includes the Rio Grande valley and is bounded by mountains on the east and west. Its total area is 3,580 square miles, 12% of the San Acacia watershed. The drainage is characterized by relatively short, steep arroyos that have high peak flows and low volume. The largest of these is Abo Arroyo, located about 9 miles upstream of Bernardo to the east, with a drainage area of 290 square miles. Most of the tributaries are not directly connected to the river. Instead they disgorge onto the valley floor, which is lower than the Rio Grande floodway and separated from it by spoil bank levees.

2.2. **Precipitation**.

Average annual rainfall in the watershed varies from over 40 inches near the Continental Divide in Colorado to less than 8 inches in some of the valleys.

Winter is the driest season. Winter storms typically come from the Pacific Ocean, moving from west to east. Winter precipitation is mostly in the form of snow, and quantity varies dramatically over the watershed. Average annual snowfall in Cuba, NM, is 40 inches, 30 inches at Bandelier National Monument, NM, and in Magdalena, NM, it is 18 inches. At Red River, NM, the average annual snowfall is 136 inches, and at Cumbres, CO, the average annual snowfall is 289 inches.

Approximately half the total annual precipitation occurs during July through October, when inflows of moist air from the Gulf of Mexico or the Gulf of California may take place. The resulting convective thunderstorm activity can produce intense but short-lived rainfall events. In some cases, air masses associated with hurricanes in the Gulf of Mexico have produced general storms over much of the watershed. Historic high magnitude flood events have occurred during these months.

Figure 2 shows the 100-year 24-hour isopluvials in New Mexico.

2.3. Runoff

Historically, two types of runoff events have occurred in the project area.

Snowmelt events of significance originate in the Albuquerque subwatershed, and are thus presently regulated. Regulated peak flows have been held to 7000 cfs at the Albuquerque gage. However, the Albuquerque District has a stated goal of releasing 10000 cfs, and that would allow the reservoirs to draw down faster. A second advantage to a higher reservoir release is that the flow could better resemble the natural hydrograph, which would provide environmental benefits.

The Rio Grande watershed can produce a large volume of snowmelt. Attachment 3 shows historic Cochiti releases. There are several years when the duration of the snowmelt release was longer than a month. These data demonstrate that when high flows occur over an extended period, there are virtually no losses between Cochiti Dam to San Marcial, at the lower end of the project area.

Rainfall runoff events occur primarily in the July to October timeframe. Rainfall runoff of magnitude has come from both the Rio Puerco and the Rio Salado subwatersheds. These subwatersheds are unregulated and they enter the mainstem Rio Grande in close proximity to the project area. The Rio Puerco and Rio Salado subwatersheds are therefore expected to be the source for high flow events in the Rio Grande at San Acacia.

There are historic accounts of general storms in the Rio Grande watershed that led to great damages in the project area. One of these occurred in 1904, and two occurred in 1929. Because of the time that has elapsed since these events, reliable rainfall and river flows generally cannot be obtained. The Albuquerque subwatershed was not regulated at that time.

Rain on snow events have not had impact on the project area in the past, mostly because of the watershed characteristics and the typical spring weather patterns.

2.4. Features of the Project Area

The project area is the Rio Grande floodway extending from the diversion dam at San Acacia to San Marcial, Socorro County, N.M. The length of the project area is approximately 49 river miles. The elevation at the upper end of the project area is 4,660 ft. (NGVD 1929 datum), and at San Marcial the elevation is 4,460 ft. The area is lightly populated and primarily agricultural. Located at the lower end of the project area is the Bosque del Apache National Wildlife Refuge. At the most downstream end of the project area, at San Marcial, there is a railroad bridge that crosses the river at an angle that is 70 degrees from the perpendicular.

Throughout the project area, the river is presently bounded on the west by a spoil bank levee. On the east side of the floodway, the floodplain is generally narrow with little development.

To the east, a series of arroyos drain relatively small watersheds. When a storm occurs in these areas, the inflow of sediment can result in local high water at the confluence of the arroyo with the Rio Grande. The larger of the arroyos draining into the project area are located on the west side. Only 2 of these, Nogal Arroyo and Socorro Canyon, are greater than 100 square miles in size.

To the west side of the levee, the floodplain is as much as 10 to 15 feet lower in elevation than the river bed, due to sediment deposition in the Rio Grande floodway. A riverside drain is located on the west side of the levee.

The Low Flow Conveyence Channel (LFCC) is also located on the west side of the levee. The San Acacia Diversion Dam is the upstream end of the LFCC. It was designed for efficient conveyence of 2000 cfs of river water downstream to Elephant Butte Lake in order to meet New Mexico's obligations for water delivery downstream. The LFCC was constructed in 1958 and operated to convey 2000 cfs until 1979. Since 1985 the LFCC has not been operated to convey Rio Grande water.

The San Acacia Diversion Dam, located at the upstream end of the project area, is operated by the Middle Rio Grande Conservancy District (MRGCD). It impounds a small volume of water and sediment. River water is diverted to the Socorro Main Canal North at this location. The diversion to the LFCC is also located at this facility.

"With project" and "without project" conditions are Corps of Engineers scenarios used for project evaluation. Because the present spoil bank levee will not reliably contain flood waters, "without project" conditions represent the assumption that there is no levee on the west side of the Rio Grande. "With project" implies that a new levee has been constructed to the west of the river, and it will be similar in location to the present spoil bank levee.

3.0. Methods of Hydrologic Analysis

There are several methods for estimating peak flows that are widely used, and all have applicability, depending on the watershed characteristics, including the size of the watershed, whether the watershed is gaged, and the purpose of the hydrologic analysis. The frequently used methods include:

- Flood frequency analysis. Wherever there is adequate river gage data, this statistical method of analysis is considered the most accurate. Because the underlying assumption is that present and future flood flows can be estimated based on past flow peaks, the watershed should be stable in terms of hydrologic parameters, such as land use. It is also important that a long enough stream gage record is available to statistically represent typical flows. Low frequency flood events are often not estimated well using this method. However, the range of events that result in high flows is best captured in this method of analysis.
- Estimation of storm runoff, including rainfall runoff models. Some of the commonly used rainfall runoff computer models are HEC-1 and HMS, and TR-20. These models estimate watershed runoff from subwatersheds, then mathematically store, combine and route the flows to mimic physical processes. The estimated rainfall may be live rainfall data, historic storm data, or a synthetic storm. Adjustments can be made to account for anticipated land use changes. However, in watersheds where snowmelt is a factor, synthetic storms may give only partial information. Also, if there are not adequate rain gage data and high water marks to use for calibration, this method is only as good as the assumed model parameters.
- Regional flood-frequency equations using generalized least-squares regression are frequently used for smaller ungaged watersheds. These equations are generally not used for large and nonhomogeneous watershed like the Rio Grande above San Acacia.
- Flows are sometimes estimated using known flow frequencies at upstream or downstream locations. A multiplier can be derived to apply to peak flows to translate them to a location upstream or downstream. The multiplier is characteristically based on the ratio of the drainage areas, and a regional exponent is applied. It is implied that the hydrologic and meteorological characteristics of both the upstream and downstream areas are similar. The ratio of the upstream and downstream drainage areas should be between 0.5 and 1.5.

4.0. Issues Relating to Application of Analytic Methods in the Project Area

Flood flow frequency analysis was selected as the method for hydrologic analysis at the most upstream location in the study area, San Acacia. Hypothetical flood flow hydrographs were generated at San Acacia and routed downstream to estimate flood flow frequencies at other locations within the project area.

In order to verify that flood frequency analysis is applicable, "Guidelines for Determining Flood Flow Frequency", Bulletin 17-B of the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data was referenced. Bulletin 17B provides a consistent approach to applying flood flow frequency analysis for Federal agencies. Its purpose is to present currently accepted methods for analyzing peak flow frequency data in order to promote uniformity of application within Federal agencies.

Another reference that was used to verify applicability of flood frequency analysis was Corps of Engineers Regulation No. 1110-2-1450, "Engineering and Design Hydrologic Frequency Estimates".

4.1. Watershed Regulation and Flood Flow Frequency Analysis

Of the subwatersheds to the Rio Grande watershed at San Acacia, the area upstream of Albuquerque is the only portion that is regulated by reservoirs. The other major subwatersheds, the Rio Puerco and the Rio Salado, are unregulated.

The three reservoirs that directly control flow at Albuquerque are: Cochiti, Jemez Canyon and Galisteo. Of these, Cochiti regulates 85% of the watershed area and is the most significant in size. The reservoirs have been operated for flood control to achieve a maximum flow of 7,000 cfs at Albuquerque.

Bulletin 17B provides the following guidance:

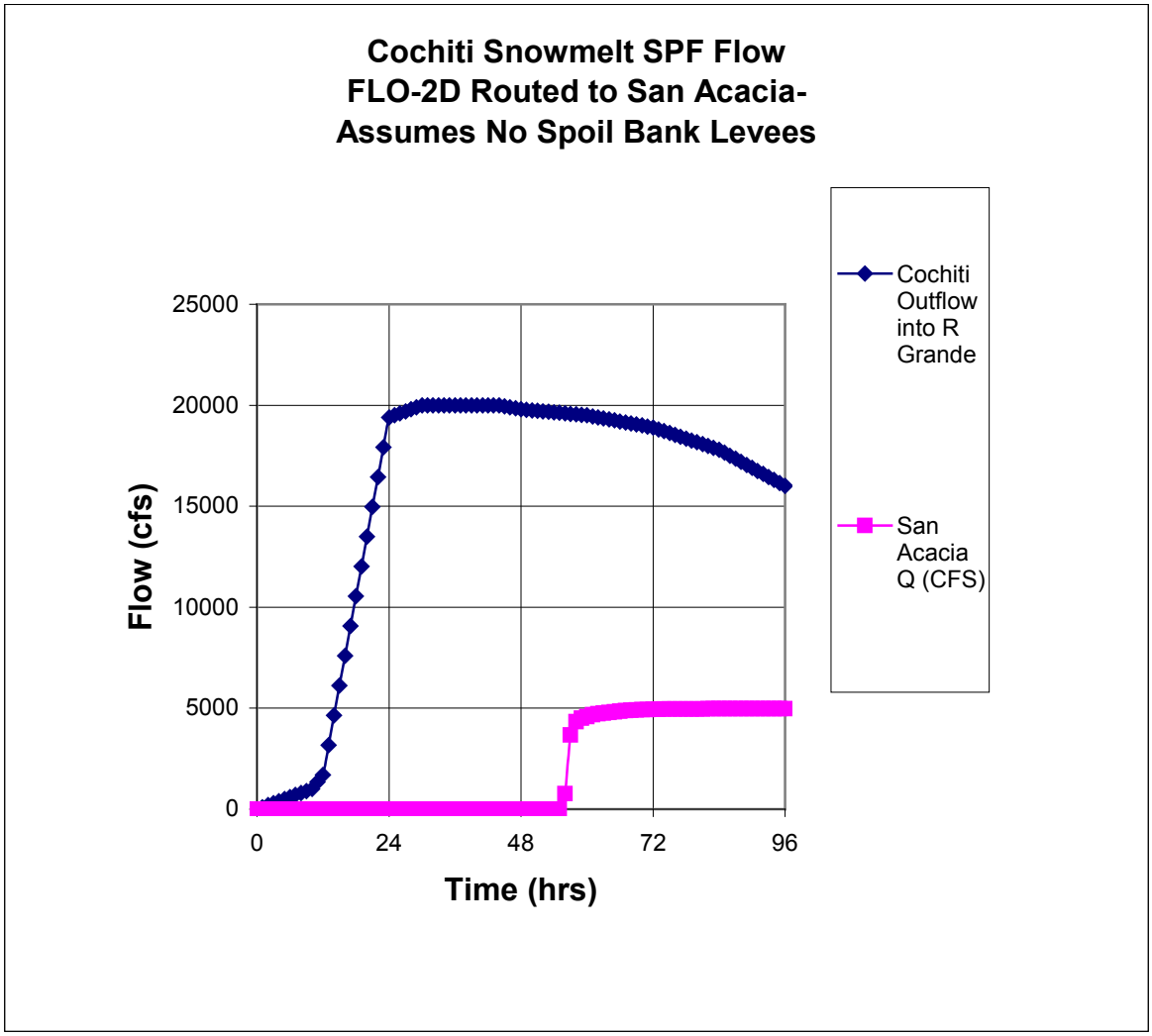
> "It is becoming increasingly difficult to find watersheds in which the flow regime has not been altered by man's activity…. Special effort should be made to identify those records which are not homogeneous. Only records which represent relatively constant watershed conditions should be used for frequency analysis."

The records that are used for flood flow frequency analysis are instantaneous peak flows. In order to use records that represent constant watershed conditions, the instantaneous peak flow record was adjusted to represent current regulated flow conditions. Peaks that occurred prior to operation of Cochiti were reviewed. Peak flows that originated upstream of Albuquerque were adjusted to reflect the maximum flow of 7,000 cfs at Albuquerque. The Cochiti Water Control Manual states that all previous high flow events would have been completely controlled by Cochiti Dam, and so it was assumed that 7,000 cfs at Albuquerque would have been achieved for these runoff events. In some cases, secondary high flows originating in the Rio Puerco or the Rio Salado would have become the peak flow at San Acacia. These secondary San Acacia peaks were estimated as described below in Section 4.5 and used to revise the record to reflect present flow conditions. The adjustments that were made to the annual peak flow record are provided in Section 5.1.

In order to evaluate the effect of Cochiti Dam on large flood flows at San Acacia, 115 river miles downstream, a FLO-2D model was used to route standard project flood (SPF) hydrographs originating at Cochiti Dam downstream to San Acacia. The SPF flood hydrographs that were modeled were those presented in the Cochiti Water Control Manual, both for the snowmelt SPF flood and for the summer rainfall runoff SPF flood. The hydrographs include the peak flows and are lengthy enough to route the peaks to San Acacia. Figures 3 and 4 show the Cochiti SPF hydrographs and routed hydrographs at San Acacia. Both for snowmelt and summer floods, the peak flows that result from the SPF floods at Cochiti attenuate to approximately 5,000 cfs at San Acacia. This flow is less than the 2-year flood event at San Acacia. (Note: An assumption made for routing the flows is that the spoil bank levees do not remain viable during a high water event.)

It is significant that high flow events originating in the controlled portion of the watershed attenuate to such a degree by the time they reach San Acacia. It can be concluded that large flood flow events at San Acacia and downstream, under present regulated conditions, originate in the uncontrolled areas.

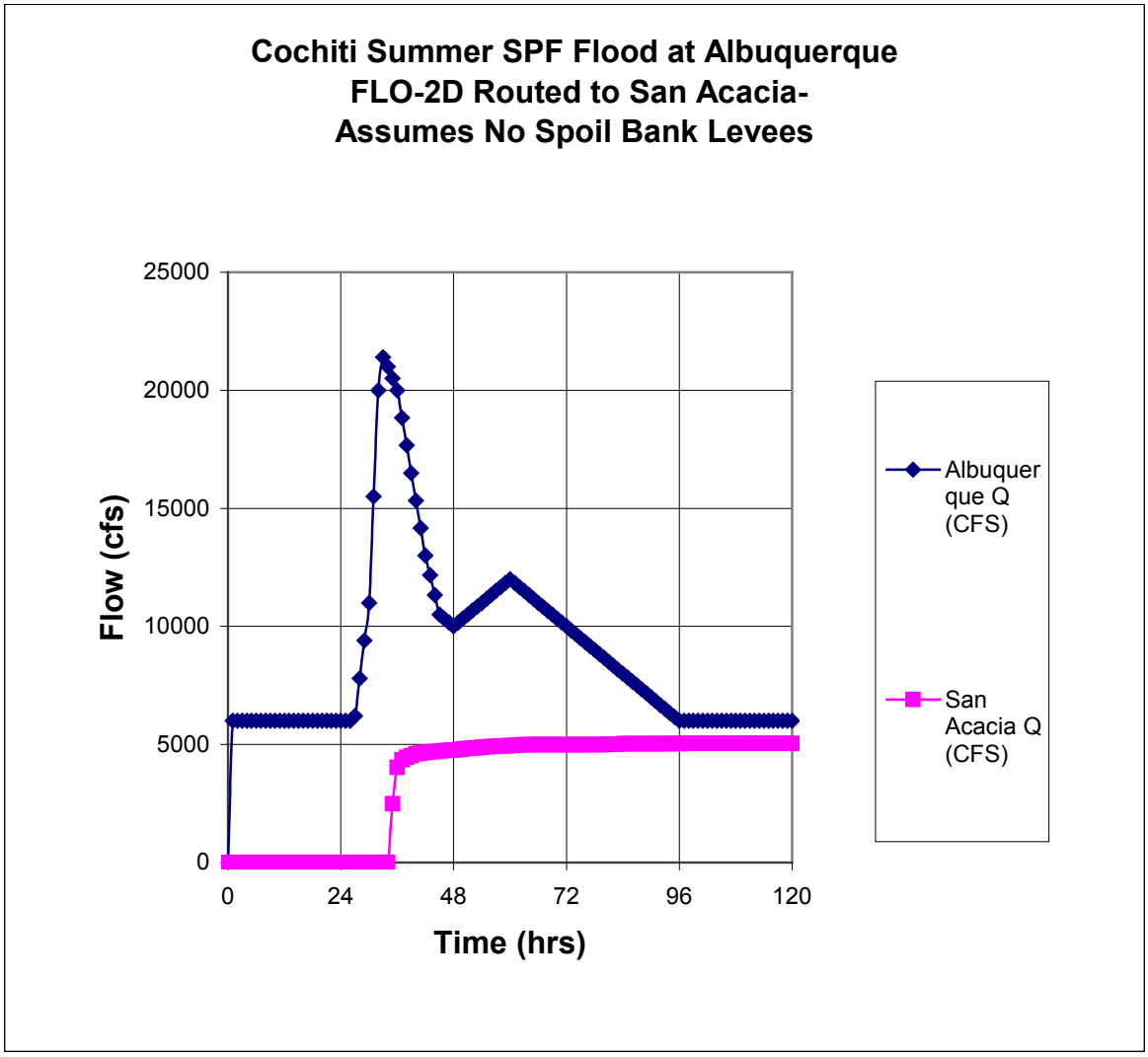
Figure 3. Cochiti Snowmelt SPF Flow Routed to Downstream Locations



4.2. Length of Record and Quality of Peak Flow Data at San Acacia

The USGS river gage at San Acacia has been in operation during most of the period from 1936 to present. Beginning in 1965, the USGS stopped publishing instantaneous annual peak flows but continued to provide mean daily stream flow. Instantaneous peaks should be used for a peak flood flow frequency analysis. The instantaneous peaks that were used for the flood flow frequency analysis were adjusted to reflect present regulated flow conditions. A detailed explanation of the adjustment process is presented in Section 5.1.

Figure 4. Cochiti Summer SPF Flow Routed to Downstream Locations



The San Acacia Diversion Dam, located 0.2 miles upstream from the gage, is operated by the Middle Rio Grande Conservancy District (MRGCD). It impounds a small volume of water and sediment. Periodically, the MRGCD releases a surge of water and sediment. The USGS adjusts the data to account for the instantaneous peaks that are caused by the MRGCD releases. Because the volume of water and sediment that is contained behind this dam is relatively small, it was assumed not to be significant for the purposes of this analysis.

Two diversions exist at the San Acacia Diversion Dam: the Low Flow Conveyance Channel, and the Socorro Main Canal North. These diversions do not affect gage data, since the diversions will typically be closed during high water events to prevent large amounts of sediment from entering the channels.

It should be noted that estimates of flow at stream gages are made on the basis of stage data. However, because of the volume of sediment that moves through the Rio Grande system, the

easily erodable streambanks, and the variable channel scour, the correlation between stage and flow in the Rio Grande is not as well established as in other environments.

A stream gage is also located at San Marcial, immediately downstream of the railroad bridge. The floodway has aggraded at San Marcial, and the riverbed rose approximately 24 feet between 1895 and 1989. The gage data at San Marcial do not correlate well with other gage data in the watershed and so these data were not considered in this study.

4.3. Statistical Independence of Subwatersheds

The result of regulation for the Albuquerque subwatershed is that the portion of high flow events coming from upstream of Albuquerque is no longer a significant factor at San Acacia. Section 4.1 above provides an explanation of the reduced contribution of the Albuquerque subwatershed to high flows at San Acacia. The remaining contributing areas for high flows at San Acacia are: the Rio Puerco and Rio Salado subwatersheds and the remaining Rio Grande subwatershed below Albuquerque.

It can be assumed that coincidence of high flows from these 3 contributing areas is embedded in the peak flow data at San Acacia, and does not therefore affect the frequency analysis. However, the shape and volume of the hydrographs that are used to estimate high flow flows downstream of San Acacia are impacted by coincidence of flows from these areas. Flood routing hydrographs are discussed further in Section 4.5 below.

Table 3 below summarizes the data available for high flow events from the Rio Puerco and the Rio Salado relating to coincidence of flows from other areas. Bernardo data prior to reservoir regulation was not included, and so these high flow data represent current regulated conditions. These data support the assumption that the contributing areas are statistically independent. No high flow event greater than the 5-year event from any contributing area corresponds to a similarly high flow event from one of the other contributing areas.

4.4. Use of FLO-2D for Flood Flow Routing

4.4.1. The FLO-2D Model

FLO-2D is a two-dimensional hydraulic model that estimates routing of one or more inflows over a grid system representing the floodplain. It includes a one-dimensional hydraulic model for channels. FLO-2D uses volume conservation and the momentum equation as the basis for a time sequence simulation model of unconfined flows. Channel and floodplain flows are calculated using standard hydraulic parameters. FLO-2D can be applied to analyze split channel flows, sediment movement, mud and debris flows, and flows over alluvial fans. A detailed FLO-2D model could simulate rainfall and infiltration, and flows with respect to levees, hydraulic structures, streets, buildings and flow obstructions.

FLO-2D numerically routes one or more hydrographs that can be introduced to the channel or floodplain at any location and at any time in the simulation. It accounts for tributary flow and interaction of high flows with the other flows in the system. FLO-2D provides an estimate for hydraulic parameters such as flow depth, velocity and area of inundation. The model is an effective tool for predicting channel and overbank flow.

The FLO-2D model of the channel-floodplain interface provides for flow exchange in both directions based on the difference in water surface elevations. The diffusive wave equation and the floodplain roughness are the basis of the computation. The elevation of the channel bank is found in the channel cross-section data.

Table 3. Instantaneous Peak Flows Greater Than 5-Year Event from Major Tributaries with Coincident Mean Daily Peaks from Other Contributing Areas

Rio Puerco Flow (cfs)	Date	Frequency of Rio Puerco Flow Event	Coincident Mean Daily Flow at Bernardo (cfs)	Frequency of Bernardo Flow Event	Coincident Mean Daily Flow on Rio Salado (cfs)	Frequency of Rio Salado Flow Event
18800	9/23/1941	1.5%	No Data	N/A	No Data	N/A
12900	10/25/1941	3.6%	3960	57%	No Data	N/A
11100	6/30/1943	5.3%	No Data	N/A	No Data	N/A
9220	9/14/1972	7.9%	0	~100%	1330	28%
9020	8/23/1947	8.3%	1450	93%	No Data	N/A
8000	8/12/1955	10.6%	1120	96%	570	60%
7920	9/27/1954	11%	No Data	N/A	480	66%
7860	8/13/1967	11.2%	1750	90%	314	79%
7200	8/27/1940	14.2%	No Data	N/A	No Data	N/A
6940	10/24/1969	14.5%	1170	96%	3	~100%
6260	10/19/1944	17%	1830	88%	No Data	N/A
5800	8/11/1946	19.6%	23	~100%	No Data	N/A
5680	8/18/1957	20.1%	2750	76%	610	58%
Rio Salado Flow (cfs)	Date	Frequency of Rio Salado Flow Event	Coincident Mean Daily Flow at Bernardo (cfs)	Frequency of Bernardo Flow Event	Coincident Mean Daily Flow on Rio Puerco (cfs)	Frequency of Rio Puerco Flow Event
36200	7/31/1965	1.8%	9	~100%	140	~100%
27400	8/12/1929	5.5%	No Data	N/A	No Data	N/A
22000	10/13/1972	9.9%	0	~100%	305	~100%
18500	9/11/1972	14.5%	0	~100%	2080	30%
17400	8/10/1967	16.2%	2190	85%	775	76%
16600	6/25/1954	18%	No Data	N/A	0	~100%
15400	8/21/1975	20.8%	214	~100%	1.2	~100%

In order to prevent numeric surging, FLO-2D balances the relationship between slope, flow area and roughness throughout the simulation. Internal to the calculation, Mannings n is adjusted accordingly. These adjustments are explained in the “FLO-2D User’s Manual”.

The Grid Developer System (GDS) is a FLO-2D preprocessor that generates the FLO-2D grid. It uses a set of digital terrain model (DTM) points, overlays the grid onto the DTM, interpolates and assigns elevations to each grid element. A statistical distribution of random elevation points is generated for each grid elements. A data filter can be used to eliminate points that would distort the average elevation, such as elevations of treetops and rooftops. The elevation is then calculated using inverse weighted distance averaging.

The most recent version of the “FLO-2D User’s Manual” was released in 2003. It provides an explanation of the governing equations, model logic, limits and assumptions, as well as application of specific model components.

4.4.2. The Middle Rio Grande FLO-2D Flood Routing Model

A FLO-2D model of the Rio Grande was developed and calibrated as part of an interagency project, the Upper Rio Grande Watershed Operations Review (URGWOPs). The Corps of

Engineers is one of the participating Federal agencies in the URGWOPs project. The URGWOPs FLO-2D model extends from Cochiti Dam downstream through the project area.

The URGWOPs model was ideal as the basis for a flood flow routing model for the study area. It uses the following base data:

- A 500-ft grid system with elevations from various sources. In the project area the majority of the elevations were developed using a 1991 BOR DTM. The vertical datum was converted from NGVD 29 to NAVD 88.
- Parameters related to the grid and channel system that were initially estimated based on engineering judgment. Channel roughness and infiltration have since been calibrated.
- Channel sections that have been surveyed over the past 5 years. Intermediate sections are interpolated from the surveyed sections.
- Levee elevation data obtained from surveys and DTMs.

Survey data and mapping that was used to develop the URGWOPs model channel and grid can be obtained from the BOR in Albuquerque or from Tetra Tech, Inc., in Albuquerque, NM. The FLO-2D grid that was used can be obtained from the Albuquerque District Corps of Engineers or from Tetra Tech, Inc., in Albuquerque, NM.

“Development of the Middle Rio Grande FLO-2D Flood Routing Model Cochiti Dam to Elephant Butte Reservoir” is a 2004 report by Tetra Tech, Inc., that documents the URGWOPs model. It provides a description of the data used to develop the model, its components, and some of its applications.

The model was calibrated using 1997, 1998 and 2001 gage data and aerial photographs. Parameters that were adjusted include channel roughness and channel infiltration, in order to improve hydrograph timing, shape and volume. The calibration data did not represent a large flood event, since no high flows of significance have occurred in the past 30 years. The data that were used for calibration were gage data, since no high water marks were available. When more flood data become available, additional calibration will be done. Information about the model calibration is provided in a 2002 report titled “Development and Calibration of the Middle Rio Grande FLO-2D Flood Routing Model”, by TetraTech, Inc.

A new version of the FLO-2D model was released in 2003, after the model calibrations described above were performed. It is the 2003 version of FLO-2D that was used for the hydrologic routing described in this report. Tetratech has stated that none of the changes to the model made in 2003 would affect the results of the Middle Rio Grande FLO-2D calibration that was done previously.

4.4.3. FLO-2D Flood Routing Model for the Project Area

The URGWOPs FLO-2D model was modified to meet project needs, then the resulting FLO-2D models were used to route flood flow hydrographs.

The “With-Project” FLO-2D Model. The URGWOPs FLO-2D model is based on the assumption that the existing levees are viable, and so existing spoil bank levees are represented as the levee system. Because the proposed “with-project” levee will be constructed on approximately the same alignment as the existing spoil bank levee, the URGWOPs model provides a good representation of “with-project” conditions.

- The levee data in this “with-project” model was modified by increasing levee height in some locations so that overtopping would not result from the design flows. The “with-project” levee height has yet to be determined, and so this change was consistent with the purpose of the flood routing model.
- The URGWOPs model infiltration parameters, like the values for Manning’s n, have been calibrated. When applied, they show significant losses during high flow events due to

infiltration. The more conservative assumption is that the floodplain is saturated and that infiltration losses are not a factor. Because the purpose of this project is design, the more conservative modeling approach was used and infiltration was assumed not to be a factor.

The "Without-Project" FLO-2D Model. Removal of the levee data from the URGWOPs model in the project area results in a model that, for the most part, represents the project area without a levee. However, there are sections of the URGWOPs grid that were based on BOR elevation data, collected only within the floodway. For that part of the project area, there is no floodplain represented outside the levee in the URGWOPs model.

- In order to have a FLO-2D model represent "without-project conditions", the grid system for the URGWOPs model was extended to include the remaining floodplain. Elevation data for the extended grid were derived from the USGS Digital Elevation Models (DEMs).
- With the spoil bank levee removed, as much as ¾ of the flow is relocated from the floodway to the floodplain. The floodplain is as much as 10 to 15 feet lower in elevation than the floodway. It was assumed that infiltration would not be a factor because the floodplain would become saturated in a high water event.

The URGWOPs FLO-2D model was also modified to route flood flows to San Acacia from upstream locations, such as Cochiti Dam and the confluence of the Rio Grande and the Rio Puerco. The spoil bank levees in the Rio Grande floodway upstream of the project area were removed from the FLO-2D model except for the reaches that have engineered levees. This was done to represent the assumption that non-engineered levees will fail during flood events.

4.5. Hydrographs Used for FLO-2D Routing and Volume Frequency

FLO-2D routing was used for 2 different purposes in this analysis:

- Estimation of secondary peak flows at San Acacia based on recorded upstream flows from the contributing areas. These secondary peaks were used as part of the San Acacia instantaneous peak record, for flood frequency analysis.
- Estimation of peak flows downstream of San Acacia during hypothetical flood events.

4.5.1. Estimation of Secondary Peak Flows at San Acacia

In order to evaluate San Acacia flows during high flow events from the Rio Salado and the Rio Puerco, a hydrograph from each of the contributing areas was estimated. USGS gage-based data records from the three contributing areas, Rio Salado, the Rio Puerco, and the Rio Grande at Bernardo, were the basis of the estimated hydrographs. The estimated hydrographs were routed by the FLO-2D model over a simulated period of 96 hours.

Mean daily flow records provided a basis for estimating flow volume for each of the 3 contributing areas. Instantaneous peak data, wherever available, were used along with the mean daily flows to estimate a hydrograph from each contributing area such that the peak and mean flows corresponded with the recorded peak and mean flows.

The estimated hydrographs were routed downstream to San Acacia using FLO-2D in order to estimate a peak at San Acacia that corresponded to the recorded flows upstream. Secondary peaks that would have been the peak flow under present regulated flow conditions were used to adjust the San Acacia peak flow record to reflect regulated conditions. The adjusted peaks are provided in Section 5.1.

An example of routing to estimate a secondary peak using USGS recorded data is shown in Attachment 4.

4.5.2. Estimation of Hypothetical Peak Flood Events at San Acacia

Throughout the project area, the Rio Grande upstream of Bernardo, the Rio Puerco and the Rio Salado are the only significant sources of flood flows. For this reason, it was valid to estimate flow frequencies at locations downstream from San Acacia by routing flood hydrographs downstream through the project area. FLO-2D was used to route flood flows. FLO-2D routings were performed for frequency flood events at San Acacia, using both a with-project (with levee) model and a without-project (no levee) model.

The hydrograph volume has a great impact on the amount of attenuation that takes place as the flood wave moves downstream. Volumes for the 1-day, 2-day and 3-day flood events were evaluated for the Rio Grande at San Acacia rainfall-runoff events, and for the Rio Puerco and the Rio Salado at their confluences with the Rio Grande. These volumes were then used in developing routing hydrographs. In analyzing flood volumes, only rainfall-runoff events were considered at San Acacia, because the Rio Puerco and Rio Salado high flows are comprised exclusively of rainfall runoff. The 1-day, 2-day and 3-day flood volume frequency analysis is provided in more detail in Section 5.2.

Runoff events from snowmelt that produce peaks at San Acacia originate in the regulated portion of the watershed, and are steady releases from the dams. The maximum snowmelt flood, because of gate constraints at the dams, is 10,000 cfs. It was assumed that flood flows of 10,000 cfs or less originate from snowmelt event dam releases. These releases occur over an extended period and do not attenuate.

For flood events of magnitude greater than 10000 cfs, flooding is caused by rainfall events that originate in the unregulated areas, the Rio Puerco and the Rio Salado. In order to estimate the effect of these rainfall events downstream of San Acacia, hypothetical flood hydrographs were developed to use for FLO-2D routing.

General storms occur rarely in the San Acacia watershed, but are a possible scenario leading to very high flow events. If a general storm were to occur, flooding from all of the major subwatersheds could contribute to the flow hydrograph at San Acacia at the same time. The volume of the resulting flood hydrograph would be much greater than it would if it resulted from a single localized event. The conservative approach is therefore to assume that this generalized flooding will occur with very high flows. This assumption is supported by accounts of floods of record described in the 1979 Albuquerque District report , “Rio Grande Basin, New Mexico, Rio Puerco and Rio Salado Watersheds Design Memorandum No. 1.” Flood events in the project area resulted from general storms in 1895, 1929, 1936, 1941, 1955, 1967, and 1972.

Table 4 shows a tabulation of the flow coincidence that was assumed for development of flood hydrographs at San Acacia, together with associated flood volumes. These volumes in turn were used to adjust the frequency hydrographs. Adjusted frequency hydrographs used for routing flood flows downstream from San Acacia through the project area are shown in Figure 5.

The steps that were taken to develop the 96-hour high flow flood hydrographs are:

- Peak flows for various return periods were selected from the San Acacia flood flow frequency analysis provided in Table 1.
- For the 100-year event, a hypothetical flood hydrograph was produced that attained the 100-year peak. It was adjusted to have the same volumes as the 1-day, 2-day and 3-day estimated flood volumes given in Table 4.
- The resulting 100-year hydrograph was scaled to peak flows for other frequency events. If needed these hydrographs were adjusted to attain the flood volumes shown in Table 4.

Figure 5. Hydrographs Used for Routing Flood Flows from San Acacia Downstream

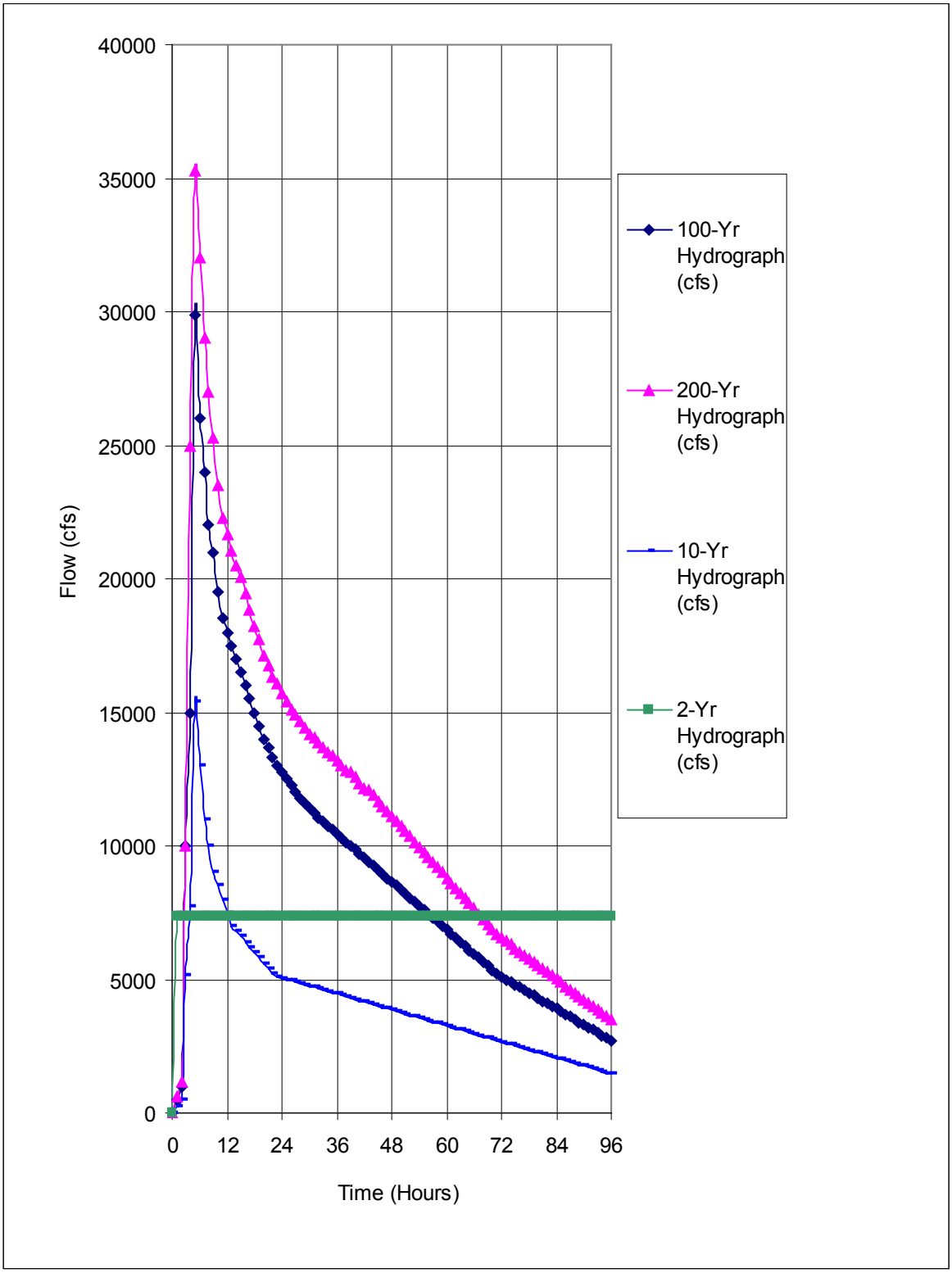


Table 4. Tabulation of Assumed Flood Flow Coincidence of Tributaries with Corresponding Daily Flows and Flood Volumes Used for Development of Flood Routing Hydrographs

ASSUMED COINCIDENCE OF FLOODING FROM CONTRIBUTING WATERSHEDS									
Contributing Watersheds	200-Yr Flood Event			100-Yr Flood Event			10-Yr Flood Event		
	Return Pd.	Average Daily Flow in cfs		Return Pd.	Average Daily Flow in cfs		Return Pd.	Average Daily Flow in cfs	
Rio Puerco (Greatest Volume Flooding)	200	1-Day	10900	100	1-Day	8810	10	1-Day	3700
		2-Day	8730		2-Day	7070		2-Day	2990
		3-Day	6520		3-Day	5380		3-Day	2400
Rio Salado (Coincident Volume Flood)	20	1-Day	2900	10	1-Day	2270	2	1-Day	752
		2-Day	2240		2-Day	1730		2-Day	543
		3-Day	1810		3-Day	1380		3-Day	414
Rio Grande (Coincident Volume Flood- no R Puerco/ R Salado Component)	20	1-Day	5790	10	1-Day	4870	2	1-Day	2510
		2-Day	5340		2-Day	4450		2-Day	2210
		3-Day	5220		3-Day	4300		3-Day	2040
TOTAL HYDROGRAPH VOLUME	Return Pd.	Ave. Daily Volume in cfs-day		Return Pd.	Ave. Daily Volume in cfs-day		Return Pd.	Ave. Daily Volume in cfs-day	
	200	1-Day	19590	100	1-Day	18220	10	1-Day	6950
		2-Day	16965		2-Day	13250		2-Day	5735
		3-Day	13550		3-Day	11060		3-Day	4855

5.0. Analysis

Peak flood flow frequency analyses are presented below for the Rio Grande at San Acacia, and for the Rio Puerco and the Rio Salado at their confluences with the Rio Grande. Frequency analyses were performed to obtain volume frequencies for one-day, two-day and three-day rainfall events at the same locations as the peak flows. For high flow floods, frequency flood hydrographs representing rainfall events at San Acacia were estimated using the peak flow frequencies together with volume frequencies. These hydrographs were routed using FLO-2D to estimate flood frequencies at locations in the project area downstream of San Acacia.

Flooding from snowmelt originates in the regulated watershed upstream of Albuquerque and produces flood peaks of 10,000 cfs or less. To be conservative, floods of 10,000 cfs or less at San Acacia were treated in this hydrologic analysis as snowmelt floods. These are steady flows that can last for many weeks and do not attenuate significantly.

The HEC FFA program, provided by the Corps of Engineers Hydrologic Engineering Center, was used to perform frequency analyses in accordance with Bulletin 17B. Attachment 2 provides more information about FFA.

5.1. Peak Flow Frequency Analysis

5.1.1. Peak Flow Frequency Analysis at San Acacia

The peak flow record, used as a basis of the frequency analysis, was obtained from the USGS web site. Before applying FFA, the following steps were taken:

- Data were adjusted to account for watershed regulation, as explained below in Section 5.1.1.1. These data were flow peaks prior to 1975, when regulation of Rio Grande flows began at Cochiti Dam.
- The annual instantaneous peak flow record was revised to fill in data gaps. Additional peak data were acquired from other sources.

Table 5 summarizes the data revisions.

The peak flows at San Acacia are mixed in that they represent both snowmelt and rainflood data, and in that they represent flooding from regulated and unregulated areas. A graphical frequency curve was therefore drawn instead of using the FFA program to apply principles from Bulletin 17B that relate to homogenous data. Assumptions are:

- The instantaneous peak flow record was revised to represent present conditions.
- A single historic peak, the 1929 estimated flood peak, was included.
- Median plotting positions were used.

The data and analytic results are summarized in Table 6. The peak flow frequency curve at San Acacia is shown in Figure 6.

5.1.1.1. Adjustment of Annual Peaks to Estimate Effect of Watershed Regulation

For years when there were high flows that originated upstream of Albuquerque and there were no significant high flows from the Rio Puerco or the Rio Salado, the assumption was made that the flow peak would have been reduced in accordance with the Cochiti Dam operations policies. Under normal conditions, the Cochiti release is made to keep flows at Albuquerque at 7000 cfs or less. A FLO-2D model was used to route a flow of 7000 cfs from Albuquerque, in order to estimate the flow that would result at San Acacia. The routed hydrograph produced a flow of 5250 cfs at San Acacia. Therefore, for years when the annual flood peak would have been regulated by Cochiti Dam, the flow at San Acacia was estimated to be 5250 cfs.

For some of the record, after peak flows were adjusted downward as described above, there were secondary peaks that replaced the recorded annual instantaneous peaks. The secondary peaks were not available from the gage records. Instead, secondary peaks were estimated by routing recorded peak flows from the Rio Puerco and the Rio Salado. FLO-2D was used to route hydrographs that represented peak flows from the contributing areas in order to estimate the flow at San Acacia. Section 4.5 provides an explanation of the development of these hydrographs.

5.1.1.2. Adjustment of Annual Peaks due to Data Gaps

In 1965, the USGS stopped publishing annual instantaneous peak flow data at San Acacia. For some post-1965 years, instantaneous peak flows have been obtained from a variety of other reliable sources. The USGS has provided some instantaneous flow peaks, both in email and telephone communications. The COE Reservoir Control Section maintains a database of gage data from key locations that updates on a regular basis using satellite transmissions. For the most recent years, instantaneous peak flows could be obtained from that database. For the years 1981 and 1986 through 1989, no instantaneous peak flows were available, and so those years were omitted from the record.

Previous COE frequency analyses included two historic peaks. The first of these was a 1904 peak flow of 60,000 cfs at San Acacia, and the USGS was not able to verify this peak. The 1904 historic peak was therefore not included with the FFA data. The second historic peak occurred in 1929. The USGS verified the 1929 peak, and it was included in this analysis.

Table 5. Adjusted Annual Peak Flows Used for Peak Flood Frequency Analysis at San Acacia

Water Year	Date	Annual Instantaneous Peak Q from USGS Gage Data (cfs)	Estimated Annual Peak Flow (cfs) Used for FFA	Notes
1929	8/13/1929	N/A	53400	Historic event verified by USGS
1936	8/5/1936	27400	27400	Gage Data Unchanged
1937	5/28/1937	18600	5250	Re-estimated for max Albuquerque flow of 7000 cfs
1938	5/22/1938	10500	10000	Re-estimated for max Albuquerque flow of 7000 cfs
1939	8/4/1939	12700	12700	Gage Data Unchanged
1940	8/24/1940	10600	10600	Gage Data Unchanged
1941	9/24/1941	25400 on 5/18/41	9610	Basis: FLO-2D estimated flows
1942	10/26/1941	22000 on 4/25/42	9710	Basis: FLO-2D estimated flows
1943	6/29/1943	9660	9660	Gage Data Unchanged
1944	7/22/1944	10300 on 5/28/44	8400	Basis: FLO-2D estimated flows
1945	5/14/1945	11000	5250	Re-estimated for max Albuquerque flow of 7000 cfs
1946	8/11/1946	3900	3900	Gage Data Unchanged
1947	8/18/1947	6170	6170	Gage Data Unchanged
1948	5/28/1948	11000	5250	Re-estimated for max Albuquerque flow of 7000 cfs
1949	6/24/1949	10300	6330	Adjusted for Upstream Control
1950	8/3/1950	5110	5110	Gage Data Unchanged
1951	8/24/1951	5550	5550	Gage Data Unchanged
1952	6/3/1952	8210	6650	Adjusted for Upstream Control
1953	7/19/1953	7150	7150	Gage Data Unchanged
1954	9/26/1954	10700	10700	Gage Data Unchanged
1955	8/12/1955	12800	12800	Gage Data Unchanged
1956	8/18/1956	4960	4960	Gage Data Unchanged
1957	8/31/1957	12700	12700	Gage Data Unchanged
1958	6/1/1958	11200	5250	Re-estimated for max Albuquerque flow of 7000 cfs
1959	5/24/1959	6050	6680	Adjusted for Upstream Control
1960	6/11/1960	8900	8900	Gage Data Unchanged
1961	9/11/1961	8620	8620	Gage Data Unchanged
1962	4/24/1962	7920	7920	Gage Data Unchanged
1963	8/29/1963	11000	11000	Gage Data Unchanged
1964	7/13/1964	3020	3020	Gage Data Unchanged
1965	8/1/1965	Not Available	17200	Adjusted for Upstream Control
1966	9/19/1966	Not Available	7550	Adjusted for Upstream Control
1967	8/14/1967	Not Available	13050	Basis: FLO-2D estimated flows

Table 5, Continued. Adjusted Annual Peak Flows Used for Peak Flood Frequency Analysis at San Acacia

Water Year	Date	Annual Instantaneous Peak Flow from Gage Data (cfs)	Estimated Annual Peak Flow (cfs) Used for FFA	Notes
1968	8/14/1968	Not Available	8140	Adjusted for Upstream Control
1969	7/31/1969	Not Available	8100	Adjusted for Upstream Control
1970	10/24/1969	Not Available	10640	Adjusted for Upstream Control
1971	8/29/1971	Not Available	2530	Adjusted for Upstream Control
1972	9/11/1972	Not Available	14810	Basis: FLO-2D estimated flows
1973	10/13/1972	Not Available	14430	Basis: FLO-2D estimated flows
1974	8/3/1974	Not Available	3020	Adjusted for Upstream Control
1975	9/11/1975	Not Available	14200	Adjusted for Upstream Control
1976	7/24/1976	Not Available	6980	Adjusted for Upstream Control
1977		Not Available	9030	Adjusted for Upstream Control
1978	5/21/1978	Not Available	2750	Adjusted for Upstream Control
1979	June/1979	Not Available	6780	Adjusted for Upstream Control
1980	6/9/1980	Not Available	14300	Adjusted for Upstream Control
1982	10/11/1981	Not Available	9690	Adjusted for Upstream Control
1983	8/3/1983	Not Available	6750	Adjusted for Upstream Control
1984	8/6/1984	Not Available	10910	Basis: FLO-2D estimated flows
1985		Not Available	7500	Basis: “Historic Cochiti Releases”
1990	7/16/1990	Not Available	3320	Basis: Direct Contact with USGS
1991	6/15/1991	Not Available	5970	Basis: Direct Contact with USGS
1992	5/12/1992	Not Available	6320	Basis: Direct Contact with USGS
1993	6/7/1993	Not Available	6510	Basis: Direct Contact with USGS
1994	5/12/1994	Not Available	7650	Basis: Direct Contact with USGS
1995	5/26/1995	Not Available	6350	Basis: Direct Contact with USGS
1996	6/28/1996	Not Available	7325	Basis: COE Reservoir Control Data
1997	7/30/1997	Not Available	5720	Basis: Direct Contact with USGS
1998	7/28/1998	Not Available	5831	Basis: COE Reservoir Control Data
1999	8/11/1999	Not Available	9020	Basis: Direct Contact with USGS
2000	5/25/2000	Not Available	1830	Basis: Direct Contact with USGS
2001	5/24/2001	Not Available	4460	Basis: COE Reservoir Control Data
2002	9/11/2002	Not Available	6790	Basis: COE Reservoir Control Data

5.1.2. Rio Puerco and Rio Salado Peak Flow Frequency Analysis

The FFA program was applied to evaluate peak flow frequencies for the Rio Puerco and the Rio Salado at their confluences with the Rio Grande, Bernardo and San Acacia, respectively. Instantaneous peak data from the USGS web site were used for the analysis. The skews that were calculated within the FFA program were applied to the frequency curves.

The instantaneous peak data and analytic results are summarized in Tables 7 and 8. Peak flow frequency curves for the Rio Puerco and the Rio Salado at their confluences with the Rio Grande are shown in Figures 7 and 8, together with 1-day, 2-day and 3-day flow frequency curves.

5.2. 1-Day, 2-Day and 3-Day Volume Frequency Analysis

The purpose of the multiple-day frequencies is to estimate probable peak flood volumes. Peak flood volumes are of importance because they have a significant impact on the amount of attenuation that can be expected as the flood wave moves downstream.

1-day, 2-day and 3-day peak flows were computed using spreadsheets to calculate multiple-day volumes and annual peaks. FFA software was used to perform the frequency analyses. Peak flow data are provided in Tables 6 through 8. The source data were USGS mean daily peaks that were obtained from the USGS web site. The gages that were used were the Rio Grande at San Acacia, the Rio Puerco at Bernardo (confluence with the Rio Grande), and the Rio Salado at San Acacia (confluence with the Rio Grande). Peak floods at San Acacia, for large events, originate in the Rio Puerco and the Rio Salado watersheds. Large floods are therefore all rainfall runoff events, not snowmelt events.

In order to be consistent, snowmelt peaks for the Rio Grande at San Acacia were eliminated from the data set. Peaks that occurred before 1975 on the Rio Grande were removed from the record, in order that the Rio Grande flow data would reflect only regulated rainfall events. However, it should be noted that flows that occurred at San Acacia since 1975 are not representative of the complete period of record. Since 1975, no flows from any of the contributing watersheds have exceeded the 10-year event. This phenomenon is thought to be related to the hydrologic cycle. Land use changes are not well documented, but could also be a contributing factor. The 1-day, 2-day and 3-day volume frequencies based on flow data since 1975 are therefore expected to be appreciably lower than those that would have been attained from a longer period of record, had the data been available.

The analytic results are summarized in Tables 6 through 8. Rio Puerco and Rio Salado volume frequency curves are plotted together with peak flood frequency curves in Figures 7 and 8. The Rio Grande volume frequency curves were not plotted.

5.3. Flood Flow Frequency in the Project Area Downstream of San Acacia

There are no significant sources of inflow to the Rio Grande within the project area, and so the only source of major flood flows is the watershed upstream of San Acacia. Flow frequencies downstream from San Acacia were estimated using the following procedure:

- Hydrographs representing frequency event flood flows at San Acacia from rainfall floods were developed to be consistent with peak frequencies, as described in Section 4.5.
- The hydrographs were routed using the FLO-2D model from San Acacia downstream through the project area to estimate the response of the channel and overbanks during the corresponding storm event.

Table 6. Peak Flow Data and Flood Frequency Statistics for the Rio Grande at San Acacia

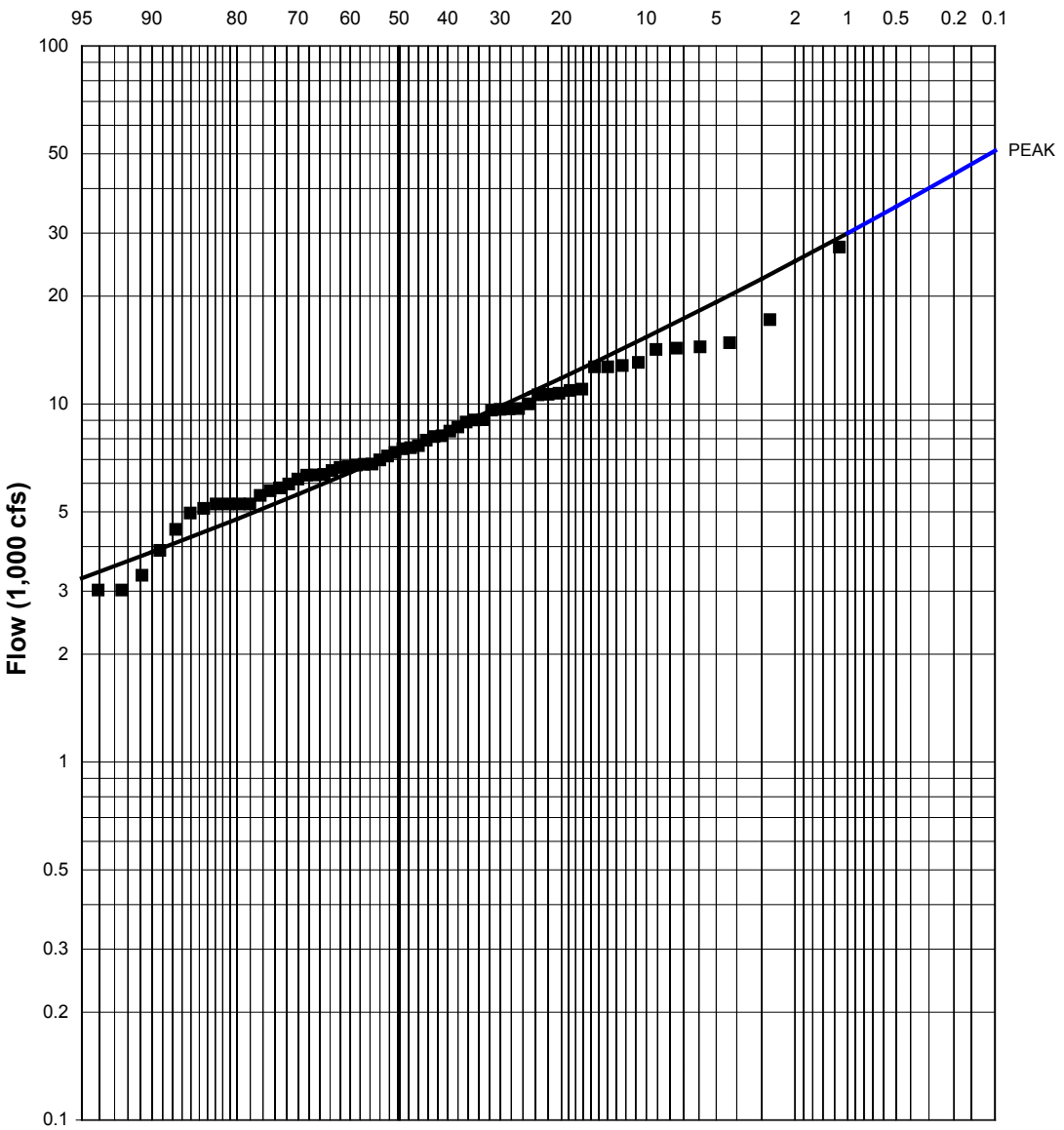
Annual Peak Flows at San Acacia Used as Basis for Flood Frequency Analyses							
Instantaneous Peak Flow		Peak 1-Day Mean Daily Flow		Peak 2-Day Mean Daily Flow		Peak 3-Day Mean Daily Flow	
Date	Peak Q (cfs)	Date	1-Day Q (cfs)	Date (1st Day of Event)	2-Day Q (cfs)	Date (1st Day of Event)	3-Day Q (cfs)
8/5/1936	27400	NOTE: Water Years 1936 – 1974 were omitted from the volume frequency analysis because the volumes from these years are not consistent with volumes from later years. Data from water years prior to 1975 represent unregulated flow conditions. Current regulated flow conditions are represented by water years beginning in 1975, as are other flood data in this analysis.					
5/28/1937	5250						
5/22/1938	10000						
8/4/1939	12700						
8/24/1940	10600						
9/24/1941	9610						
10/26/1941	9710						
6/29/1943	9660						
7/22/1944	8400						
5/14/1945	5250						
8/11/1946	3900						
8/18/1947	6170						
5/28/1948	5250						
6/24/1949	6330						
8/3/1950	5110						
8/24/1951	5550						
6/3/1952	6650						
7/19/1953	7150						
9/26/1954	10700						
8/12/1955	12800						
8/18/1956	4960						
8/31/1957	12700						
6/1/1958	5250						
5/24/1959	6680						
6/11/1960	8900						
9/11/1961	8620						
4/24/1962	7920						
8/29/1963	11000						
7/13/1964	3020						
8/1/1965	17200						
9/19/1966	7550						
8/14/1967	13050						
8/14/1968	8140						
7/31/1969	8100						
10/24/1969	10640						
7/31/1971	2530						
9/11/1972	14810						
10/13/1972	14430						
8/4/1974	3020						
9/11/1975	14200	9/12/1975	5080	9/12/1975	4100	9/11/1975	3703
7/24/1976	6980	11/3/1975	895	11/2/1975	789	11/2/1975	691
8/12/1977	9030	8/14/1977	3460	8/14/1977	2450	8/13/1977	1818

Table 6, Cont. Peak Flow Data and Flood Frequency Statistics for the Rio Grande at San Acacia

Instantaneous Peak Flow		Peak 1-Day Mean Daily Flow		Peak 2-Day Mean Daily Flow		Peak 3-Day Mean Daily Flow	
Date	Peak Q (cfs)	Date	1-Day Q (cfs)	Date (1st Day of Event)	2-Day Q (cfs)	Date (1st Day of Event)	3-Day Q (cfs)
5/21/1978	2750	7/25/1978	335	7/24/1978	312	7/24/1978	292
6/1/1979	6780	8/17/1979	1040	8/17/1979	747	8/17/1979	598
6/9/1980	14300	9/9/1980	1990	9/9/1980	1750	9/9/1980	1590
10/11/1981	9690	7/12/1981	1840	7/12/1981	1028	7/12/1981	811
6/11/1983	6750	9/21/1982	5040	9/21/1982	4270	9/21/1982	3907
8/6/1984	10910	11/13/1982	1850	11/13/1982	1785	11/12/1982	1727
6/11/1985	7500	11/18/1983	1060	11/17/1983	1030	11/16/1983	952
7/16/1990	3320	9/22/1985	3020	9/22/1985	2975	9/22/1985	2870
6/15/1991	5970	7/2/1986	5250	7/5/1986	5180	7/6/1986	5137
5/12/1992	6320	7/20/1987	5240	7/23/1987	5120	7/22/1987	5117
6/7/1993	6510	9/15/1988	4160	9/14/1988	4080	9/13/1988	3880
5/12/1994	7650	11/16/1988	2190	11/16/1988	2040	11/16/1988	1890
5/26/1995	6350	7/16/1990	2490	7/15/1990	2175	7/14/1990	1920
6/28/1996	7325	8/8/1991	4080	7/26/1991	3935	7/26/1991	3807
7/30/1997	5720	11/17/1991	2670	11/13/1991	2480	11/13/1991	2467
7/28/1998	5831	8/27/1993	3700	8/28/1993	3300	8/28/1993	2903
8/11/1999	9020	8/18/1994	3100	8/17/1994	2650	8/16/1994	2467
5/25/2000	1830	11/20/1994	2220	11/19/1994	2160	11/19/1994	2053
5/24/2001	4460	11/3/1995	1300	11/2/1995	1285	11/2/1995	1223
9/11/2002	6790	9/21/1997	3890	9/21/1997	3075	9/21/1997	2717

Flood Frequency Statistics at San Acacia				
	Instantaneous Peak	1-Day Peak	2-Day Peak	3-Day Peak
Pct. Chance Exceedence	Frequency Curve	Frequency Curve Computed Q	Frequency Curve Computed Q	Frequency Curve
0.2	43500	9880	9400	9400
0.5	35300	8730	8240	8240
1	29900	7850	7370	7340
2	25000	6970	6500	6420
5	19200	5790	5340	5220
10	15400	4870	4450	4300
20	11800	3920	3540	3370
50	7380	2510	2210	2040
80	4770	1540	1320	1190
90	3860	1180	993	877
95	3260	934	778	677
99	2420	592	481	406
Systematic Events	62	28	28	28
Mean	3.8791	3.3869	3.3309	3.2968
Std. Deviation	0.235	0.2415	0.255	0.2704
Computed Skew	0.2899	-0.2946	-0.2527	-0.27
Adopted Skew	0.3	-0.3	-0.3	-0.3

Figure 6. Peak Flow Frequency Curve for the Rio Grande at San Acacia



NOTES:

1. USGS Sta No. 08354900
2. Median plotting positions
3. Drainage area 26,770 sq. mi.
4. Years of record: 62 years of peaks flows

San Acacia to Bosque del Apache Unit, Socorro NM
Rio Grande

PEAK FLOW FREQUENCY CURVE
RIO GRANDE AT SAN ACACIA

WATER YEARS 1948-1984

U.S ARMY CORPS OF ENGINEERS
ALBUQUERQUE DISTRICT

Table 7. Peak Flow Data and Flood Frequency Statistics for the Rio Puerco at Bernardo (Confluence with the Rio Grande)

Annual Peak Flows for the Rio Puerco at Bernardo- Used as Basis for Flood Frequency Analyses							
Instantaneous Peak Flow		Peak 1-Day Mean Daily Flow		Peak 2-Day Mean Daily Flow		Peak 3-Day Mean Daily Flow	
Date	Peak Q (cfs)	Date	1-Day Q (cfs)	Date (1st Day of Event)	2-Day Q (cfs)	Date (1st Day of Event)	3-Day Q (cfs)
8/27/1940	7200						
9/23/1941	18800	5/5/1941	5980	5/5/1941	3655	5/3/1941	2873
10/25/1941	12900	10/25/1941	3850	10/4/1941	3285	10/4/1941	2314
6/30/1943	11100	6/29/1943	2510	6/29/1943	2440	6/29/1943	1752
7/22/1944	11000	7/22/1944	4300	7/21/1944	3340	7/21/1944	2357
10/19/1944	6260	8/13/1945	1320	8/14/1945	1047	10/17/1944	861
8/11/1946	5800	8/11/1946	2820	8/10/1946	1750	8/10/1946	1304
8/23/1947	9020	8/17/1947	4630	8/17/1947	3620	8/17/1947	3337
9/26/1948	1570	9/27/1948	503	9/26/1948	385	9/26/1948	298
7/24/1949	3220	7/24/1949	1540	7/24/1949	941	7/24/1949	759
9/21/1950	4140	9/20/1950	1560	9/20/1950	1455	9/20/1950	1018
8/2/1951	4450	8/2/1951	1830	8/24/1951	1144	8/23/1951	1186
9/23/1952	1820	7/9/1952	557	7/8/1952	525	7/7/1952	496
7/19/1953	5490	7/19/1953	3380	7/18/1953	2515	7/18/1953	1900
9/27/1954	7920	9/27/1954	4400	9/26/1954	3885	9/26/1954	2778
8/12/1955	8000	8/12/1955	4100	8/11/1955	3485	7/27/1955	2550
8/18/1956	5200	8/18/1956	1830	8/18/1956	1033	8/1/1956	911
8/7/1957	5680	8/7/1957	5010	8/7/1957	4070	8/6/1957	3230
10/21/1957	5340	10/21/1957	3600	10/21/1957	2910	10/20/1957	2543
5/24/1959	4020	8/26/1959	1380	8/8/1959	1053	8/8/1959	990
3/10/1960	3880	3/10/1960	1480	3/9/1960	1455	3/9/1960	1367
8/19/1961	2470	10/19/1960	1200	8/19/1961	1175	8/19/1961	882
9/29/1962	900	9/28/1962	430	9/28/1962	428	9/28/1962	380
8/5/1963	1210	8/5/1963	900	8/31/1963	779	8/31/1963	682
7/13/1964	2640	8/14/1964	1660	8/14/1964	1232	8/13/1964	999
8/3/1965	3210	8/3/1965	2850	8/2/1965	2570	8/2/1965	2113
8/31/1966	1800	8/3/1966	1060	8/2/1966	649	8/2/1966	490
8/13/1967	7860	8/13/1967	4770	8/13/1967	3585	8/13/1967	3223
8/8/1968	3420	8/13/1968	1760	8/12/1968	1500	8/13/1968	1145
9/21/1969	3580	8/2/1969	1720	8/31/1969	1180	8/31/1969	829
10/24/1969	6940	10/24/1969	4600	10/23/1969	3860	10/22/1969	2900
8/24/1971	1300	8/24/1971	496	8/24/1971	368	8/23/1971	323
9/14/1972	9220	9/14/1972	4930	9/13/1972	4315	9/12/1972	3620
7/16/1973	3920	10/20/1972	1620	10/20/1972	1615	10/20/1972	1366
8/4/1974	2980	8/4/1974	1140	8/4/1974	779	8/4/1974	546
9/12/1975	3520	9/13/1975	1560	9/12/1975	1545	9/11/1975	1507
8/20/1976	2280	8/21/1976	896	8/20/1976	784	8/20/1976	606
8/13/1977	3010	8/13/1977	1290	8/13/1977	1235	8/13/1977	1046
10/6/1977	1330	7/23/1978	321	7/23/1978	212	7/23/1978	145
2/17/1979	1960	2/17/1979	1130	2/16/1979	1033	2/16/1979	845
9/11/1980	2450	9/11/1980	950	9/10/1980	911	9/9/1980	708
9/7/1981	1620	9/7/1981	1060	9/7/1981	822	9/7/1981	728

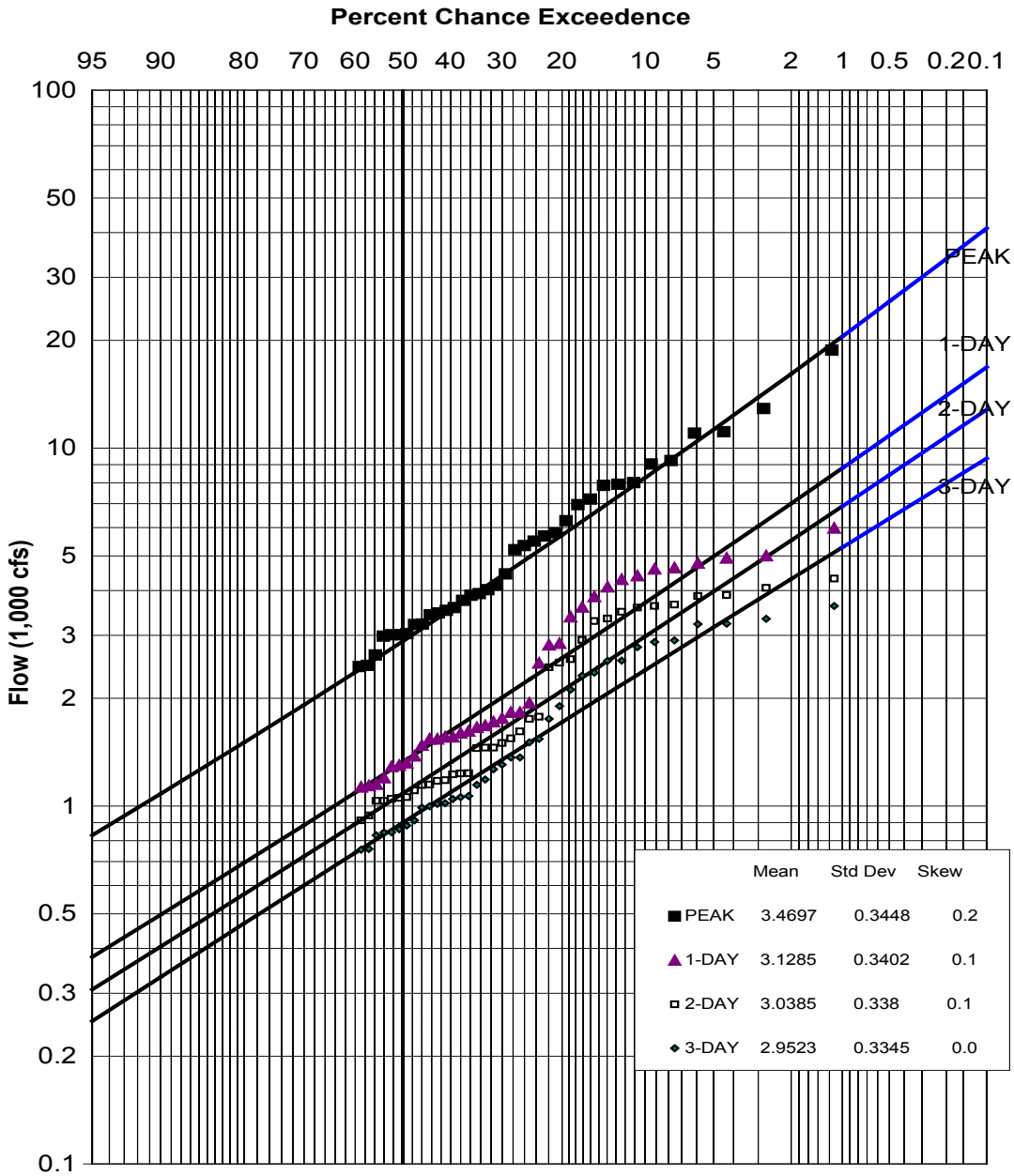
Table 7, Continued. Peak Flow Data and Flood Frequency Statistics for the Rio Puerco at Bernardo (Confluence with the Rio Grande)

Instantaneous Peak Flow		Peak 1-Day Mean Daily Flow		Peak 2-Day Mean Daily Flow		Peak 3-Day Mean Daily Flow	
Date	Peak Q (cfs)	Date	1-Day Q (cfs)	Date	Peak Q (cfs)	Date	1-Day Q (cfs)
9/19/1982	3460	9/19/1982	1540	8/27/1982	1148	9/19/1982	1013
6/26/1983	1580	8/4/1983	458	8/4/1983	329	8/3/1983	249
8/24/1984	1690	10/3/1983	882	10/2/1983	677	10/2/1983	485
3/14/1985	1400	3/14/1985	947	3/14/1985	674	4/30/1985	576
7/6/1986	1170	7/6/1986	1060	7/6/1986	620	7/5/1986	452
11/5/1986	2260	10/14/1986	988	10/14/1986	888	10/13/1986	755
8/8/1988	3750	9/15/1988	1940	9/14/1988	1775	8/27/1988	1540
8/2/1989	912	8/2/1989	623	8/2/1989	614	8/2/1989	472
7/15/1990	1100	9/23/1990	670	9/23/1990	605	9/22/1990	570
7/26/1991	3030	7/26/1991	1600	7/26/1991	1450	7/25/1991	1267
8/27/1992	997	8/27/1992	743	8/26/1992	690	8/26/1992	505
6/20/1993	1400	8/31/1993	771	8/30/1993	721	8/30/1993	661
8/18/1994	3010	8/18/1994	1680	8/17/1994	1059	8/16/1994	844
8/29/1995	662	8/29/1995	325	8/28/1995	288	8/27/1995	237
6/28/1996	1330	6/29/1996	1300	6/28/1996	1225	8/24/1996	1067
9/25/1997	1280	9/24/1997	912	9/23/1997	760	9/22/1997	658
7/29/1998	640	7/28/1998	433	7/28/1998	331	7/28/1998	311
8/6/1999	1330	8/5/1999	1150	8/5/1999	1105	8/5/1999	1058
		4/2/2000	391	4/2/2000	360	4/2/2000	289
		8/16/2001	381	8/15/2001	280	8/14/2001	260
		9/14/2002	424	9/13/2002	408	9/12/2002	362

Flood Frequency Statistics for the Rio Puerco at Bernardo

	Instantaneous Peak	1-Day Peak	2-Day Peak	3-Day Peak
Pct. Chance Exceedence	Frequency Curve Computed Q	Frequency Curve Computed Q	Frequency Curve Computed Q	Frequency Curve Computed Q
0.2	33800	14100	11300	8230
0.5	25700	10900	8730	6520
1	20500	8810	7070	5380
2	16100	7000	5630	4360
5	11300	4980	4020	3180
10	8260	3700	2990	2400
20	5710	2590	2100	1710
50	2890	1330	1080	896
80	1500	693	566	469
90	1080	497	407	334
95	829	379	311	252
99	510	230	189	149
Systematic Events	60	62	62	62
Mean	3.4697	3.1285	3.0385	2.9523
Std. Deviation	0.3448	0.3402	0.338	0.3345
Computed Skew	0.1586	0.0961	0.0512	-0.0315
Adopted Skew	0.1586	0.1	0.1	0

Figure 7. Peak and Duration Flow Frequency Curves for the Rio Puerco at Bernardo



NOTES:

1. USGS Station 08353000
2. Median plotting positions
3. Drainage area 7350 sq. mi.
4. Years of Record- 60 Inst. Pks
5. Years of Record- 62 Mean Daily Pks

San Acacia to Bosque del Apache Unit, Socorro NM
Rio Grande

RIO PUERCO NR BERNARDO, NM
RIO GRANDE UNIT

WATER YEARS 1941 - 2002

U.S ARMY CORPS OF ENGINEERS
ALBUQUERQUE DISTRICT

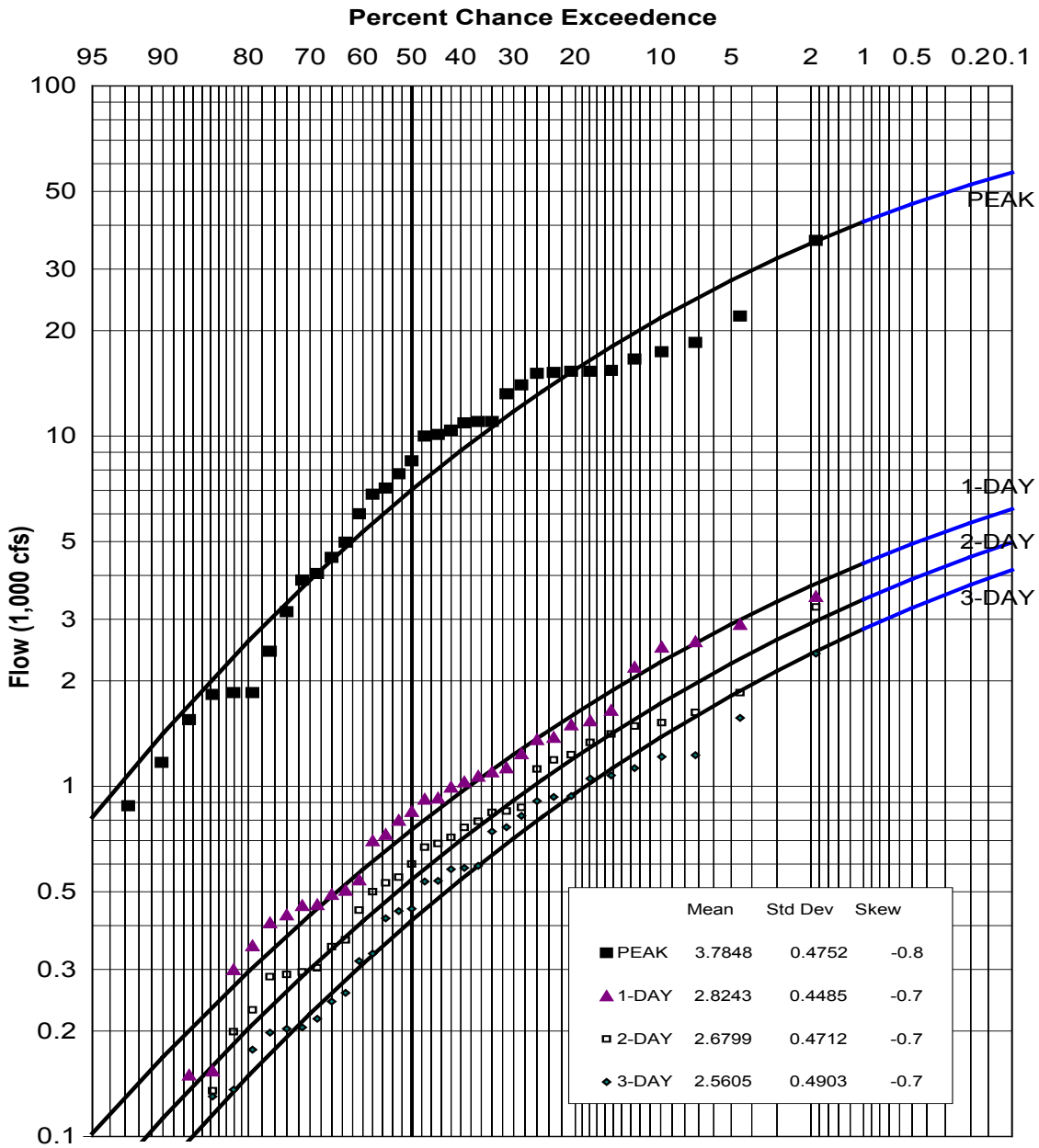
Table 8. Peak Flow Data and Flood Frequency Statistics for the Rio Salado at San Acacia (Confluence with the Rio Grande)

Annual Peak Flows for Rio Salado at San Acacia- Used as Basis for Flood Frequency Analyses							
Instantaneous Peak Flow		Peak 1-Day Mean Daily Flow		Peak 2-Day Mean Daily Flow		Peak 3-Day Mean Daily Flow	
Date	Peak Q (cfs)	Date	1-Day Q (cfs)	Date (1st Day of Event)	2-Day Q (cfs)	Date (1st Day of Event)	3-Day Q (cfs)
9/26/1948	1830	9/26/1948	351	9/26/1948	199	9/26/1948	136
7/13/1949	4050	7/23/1949	492	7/22/1949	348	7/21/1949	243
9/24/1950	3150	9/24/1950	408	9/24/1950	286	9/23/1950	198
8/24/1951	8500	8/2/1951	848	8/23/1951	842	8/22/1951	823
7/14/1952	13200	7/14/1952	430	7/14/1952	295	7/14/1952	217
8/13/1953	7800	8/13/1953	1070	8/13/1953	763	8/12/1953	535
9/25/1954	16600	9/25/1954	1500	9/25/1954	1485	9/24/1954	1227
8/20/1955	11000	8/20/1955	1650	8/20/1955	1625	8/19/1955	1127
7/30/1956	4500	8/2/1956	505	8/1/1956	364	7/3/1956	257
8/24/1957	7100	7/26/1957	1100	7/26/1957	600	7/24/1957	585
10/13/1957	636	10/13/1957	90	10/12/1957	83	10/11/1957	55
8/6/1959	15200	8/7/1959	700	8/6/1959	550	8/6/1959	440
9/10/1960	6000	9/10/1960	995	9/10/1960	500	9/9/1960	333
9/11/1961	10900	8/23/1961	1240	10/17/1960	715	10/17/1960	537
8/21/1962	6820	9/25/1962	920	9/24/1962	870	9/24/1962	593
8/29/1963	15300	9/22/1963	1130	8/30/1963	795	8/29/1963	743
9/12/1964	10000	9/12/1964	800	7/12/1964	530	7/11/1964	420
7/31/1965	36200	8/1/1965	2500	7/31/1965	1850	7/31/1965	1567
8/10/1966	3880	8/10/1966	730	8/9/1966	670	8/8/1966	447
8/10/1967	17400	8/10/1967	926	8/10/1967	686	8/10/1967	764
8/2/1968	10400	8/2/1968	541	8/1/1968	443	8/1/1968	317
7/31/1969	10100	9/12/1969	460	9/11/1969	230	9/12/1969	177
8/16/1970	4980	8/16/1970	1030	8/16/1970	850	8/16/1970	580
8/29/1971	1850	10/4/1970	300	10/4/1970	290	10/3/1970	205
9/11/1972	18500	8/26/1972	3490	8/26/1972	3250	8/26/1972	2393
10/13/1972	22000	10/13/1972	2590	10/13/1972	1335	10/13/1972	908
8/3/1974	1850	8/3/1974	457	8/2/1974	303	8/2/1974	203
8/21/1975	15400	9/12/1975	2190	9/11/1975	1231	9/10/1975	1075
6/8/1976	2430	6/8/1976	70	6/8/1976	40	9/22/1976	30
8/14/1977	11000	8/14/1977	1380	8/14/1977	1190	8/14/1977	938
10/6/1977	368	10/6/1977	82	10/5/1977	52	10/5/1977	35
9/14/1979	880	6/8/1979	99	6/8/1979	52	6/8/1979	35
6/10/1980	15300	9/9/1980	1360	9/9/1980	1120	9/9/1980	932
7/12/1981	1170	7/12/1981	154	7/12/1981	135	7/12/1981	130
8/26/1982	15100	9/21/1982	2900	8/25/1982	1520	8/24/1982	1215
8/3/1983	1550	9/9/1983	150	9/9/1983	85	9/9/1983	58
8/5/1984	14000	8/5/1984	1540	8/5/1984	1410	8/4/1984	1052

Table 8, Continued. Peak Flow Data and Flood Frequency Statistics for the Rio Salado at San Acacia (Confluence with the Rio Grande)

Flood Frequency Statistics for the Rio Salado at San Acacia				
	Instantaneous Peak	1-Day Peak	2-Day Peak	3-Day Peak
Pct. Chance Exceedence	Frequency Curve Computed Q	Frequency Curve Computed Q	Frequency Curve Computed Q	Frequency Curve Computed Q
0.2	49500	5580	4460	3710
0.5	44100	4880	3870	3200
1	39600	4310	3400	2790
2	34600	3720	2910	2380
5	27500	2900	2240	1810
10	21700	2270	1730	1380
20	15500	1620	1210	957
50	7080	752	543	414
80	2610	295	203	149
90	1410	168	113	81
95	809	102	67	47
99	252	36	22	15
Systematic Events	37	37	37	37
Mean	3.7848	2.8243	2.6799	2.5605
Standard Deviation	0.4752	0.4485	0.4712	0.4903
Computed Skew	-0.831	-0.6843	-0.7245	-0.7299
Adopted Skew	-0.831	-0.7	-0.7	-0.7

Figure 8. Peak and Duration Flow Frequency Curves for the Rio Salado at San Acacia



NOTES:

1. USGS Sta No. 08354000
2. Median plotting positions
3. Drainage area 1395 sq. mi.
4. Years of Record 38

Socorro NM
Rio Grande

RIO SALADO NEAR SAN ACACIA, NM
RIO GRANDE UNIT

WATER YEARS 1948-1984

U.S ARMY CORPS OF ENGINEERS
ALBUQUERQUE DISTRICT

Table 9. Without-Project (No Levee) Routed Peak Flows on the Rio Grande between San Acacia and San Marcial

BOR Range Lines	Landmarks	200-Year Peak Flow (CFS)	100-Year Peak Flow (CFS)	10-Year Peak Flow (CFS)	2-Year Peak Flow (CFS)
SA 1206 - SA 1234	From the San Acacia Diversion Dam downstream	35300	29900	15400	7380
SA 1235 - SO 1308		33710	28760	14635	7380
SO 1309 - SO 1327	Upstream of the Escondida Bridge to the N. Socorro Div. Channel	25725	20905	11910	7380
SO 1328 - SO 1389	Socorro	23485	18880	10575	7380
SO 1390 – SO 1429		21360	17100	10000	7380
SO 1430 – SO 1474		20715	16575	10000	7380
SO 1475 – SO 1510	Hwy. 380 Bridge to the north boundary of the Bosque del Apache	18605	14930	10000	7380
SO 1511 – SO 1568	Bosque del Apache	18025	14605	10000	7380
SO 1569 – SO 1649	Bosque del Apache	12670	10415	10000	7380
SO 1650 – SO 1669	Bosque del Apache	11990	10000	10000	7380
SO 1670 to SO 1709	From Tiffany Junction downstream to below San Marcial RR Bridge	11185	10000	10000	7380

- Routed flood flows provide an estimate of corresponding flood flows at downstream locations for various frequencies. In some cases the routed flood flows are of lesser magnitude than the corresponding frequency snowmelt event, since the snowmelt events have no significant attenuation. The snowmelt event was then used as the flood flow.

“Without-project” (no levee) and “with-project” (with levee) flows were estimated separately for purposes of the Corps of Engineers feasibility economic evaluation. The separate FLO-2D models representing these scenarios, without and with the proposed levee, are described in Section 4.4. The FLO-2D model routing results are shown in Tables 9 and 10 for “without-project” and “with-project” conditions, respectively.

Routing results, both with and without the proposed levee, show that there is significant attenuation in the 48-mile project reach. The high amount of attenuation is primarily due to the relatively low volume of the peak flows. It is also related to flow in the floodplain and overbanks. There is significant storage in the overbanks, even for the “with-project” model.

The without-project flood routing is the extreme case. It reflects the assumption that the spoil bank levees fail completely. Floodwaters would flow from the perched floodway to the historic floodplain, which is approximately 10 to 15 feet lower than the floodway. The floodplain ranges

Table 10. With-Project (With Levee) Routed Peak Flows on the Rio Grande between San Acacia and San Marcial

BOR Range Lines	Landmarks	200-Year Peak Flow (CFS)	100-Year Peak Flow (CFS)	10-Year Peak Flow (CFS)	2-Year Peak Flow (CFS)
SA 1206 - SA 1234	From the San Acacia Diversion Dam downstream	35300	29900	15400	7380
SA 1235 - SO 1308		34050	28670	14635	7380
SO 1309 - SO 1327	Upstream of the Escondida Bridge to the North Socorro Diversion Channel	27000	21650	11980	7380
SO 1328 - SO 1389	Socorro	26170	20440	11110	7380
SO 1390 – SO 1429		25280	19895	10000	7380
SO 1430 – SO 1474		24390	19350	10000	7380
SO 1475 – SO 1510	Hwy. 380 Bridge to the north boundary of the Bosque del Apache	22150	17655	10000	7380
SO 1511 – SO 1568	Bosque del Apache	21590	17310	10000	7380
SO 1569 – SO 1649	Bosque del Apache	21030	16960	10000	7380
SO 1650 – SO 1669	Bosque del Apache	20475	16615	10000	7380
SO 1670 to SO 1709	From Tiffany Junction downstream to below San Marcial RR Bridge	18565	14890	10000	7380

to 3 miles in width in the lower end of the watershed, and more than 25,000 acres of floodplain are inundated in the 100-year without-project flood event. Because the channel is perched, the flow that leaves the channel in the without-project scenario does not directly return to the channel. A significant volume of floodwaters remains in the floodplain and is lost to the river system. As an example, the model results show that more than 40% of the 100-year flood volume remains in the floodplain at the end of the 108-hour 100-year flood simulation. The without-project flood wave attenuation greatly increases as floodwaters are lost from the floodway.

The with-project FLO-2D routing scenario is very similar to the URGWOPs scenario, which represents existing conditions and assumes that the spoil bank levee remains viable. The assumption that infiltration will not be a factor in flood routing is the most significant difference between the FLO-2D routing model and the URGWOPs FLO-2D model. Even with levees in place, in many locations the river is 500 feet or more away from the levees. This leads to overbank flow that greatly reduces the flood peak. As an example, the model results show that more than 10,000 acres of floodplain are inundated during the 108-hour 100-year flood simulation

5.4. Verification of Analytic Results: Comparison of 100-Year Flood Events and Flood Routings from the Rio Puerco, the Rio Salado and the Rio Grande at San Acacia

One unexpected result of the frequency analyses described above was that the Rio Salado 100-year peak of 39,600 cfs is greater than the downstream 100-year peak of 29,900 cfs at San Acacia. Even though the Rio Salado peaks are low in volume, the confluence of the Rio Salado with the Rio Grande is approximately 2 miles upstream of the gage at San Acacia. The attenuation that would occur in the Rio Grande between the two locations is limited by distance.

In order to check that the results of the frequency analyses at the Rio Salado and at San Acacia are consistent with one another, hydrographs representing 100-year flood events from the Rio Puerco and the Rio Salado were constructed and routed downstream to San Acacia. FLO-2D was used for routing. The routing results from the tributary peaks were compared with the expected 100-year peak at San Acacia. In both cases the result of the flood flow routing is consistent with the hydrologic analyses presented above for the Rio Grande at San Acacia.

The flood hydrographs were formulated to be consistent with instantaneous peaks and 1-day, 2-day and 3-day floods, shown in Tables 7 and 8. It was assumed that a moderate baseflow in the Rio Grande floodway (500 cfs) was coincident with the San Acacia flood events.

The 100-year flood originating in the Rio Salado, in order to attain the instantaneous peak of 39,600 cfs and mean daily one-day peak of 4310 cfs, is a fairly low volume hydrograph with a very short duration peak flow. That is consistent with the topography of the Rio Salado watershed, which is flash-flood prone, extremely steep and having roughly equal major flow paths. Figure 9 shows the 100-year flood hydrograph originating in the Rio Salado watershed together with the routed Rio Salado 100-year flood hydrograph routed to San Acacia and the 100-year San Acacia flood hydrograph, for comparison. The FLO-2D model provides an estimate of the 39,600 cfs flood flow from the Rio Salado attenuating to 12,140 cfs at San Acacia. The confluence of the Rio Salado is approximately 2 miles upstream of San Acacia. Even so, there is extreme attenuation. This is due to the low volume of the flood peak along with two other factors. One, the Rio Grande channel is wider then the Rio Salado channel and thus accommodates more flow. More importantly, the flood flow coming from the Rio Salado would not enter the Rio Grande and flow directly downstream. Instead it would flow both upstream and downstream, and would cause backwater effects approximately 5 miles upstream of the confluence of the Rio Salado with the Rio Grande. The FLO-2D model is able to capture this phenomenon.

Figure 10 shows the 100-year flood hydrograph originating in the Rio Puerco watershed together with the routed Rio Puerco 100-year flood hydrograph routed to San Acacia and the 100-year San Acacia flood hydrograph. The Rio Puerco watershed is very large (7350 square miles), with many losses and a complicated flow network. Flood flows from the Rio Puerco do not peak as sharply as those from the Rio Salado, and Rio Puerco flood flows have greater flood volumes than do those from the Rio Salado watershed. The confluence of the Rio Puerco is approximately 11 miles upstream of San Acacia. Again, the attenuation is extreme. In routing the Rio Puerco flood flow entering the Rio Grande, the assumption was again made that flow in the Rio Grande would be 500 cfs at Bernardo. The FLO-2D flood flow routing showed that the flood wave would move upstream approximately 4 miles, in addition to flowing in the downstream direction, contributing to the attenuation of the flood peak.

Figure 9. Graphical Comparison: Routed 100-Yr Flow from the Rio Salado to San Acacia Compared with 100-Yr San Acacia Flow

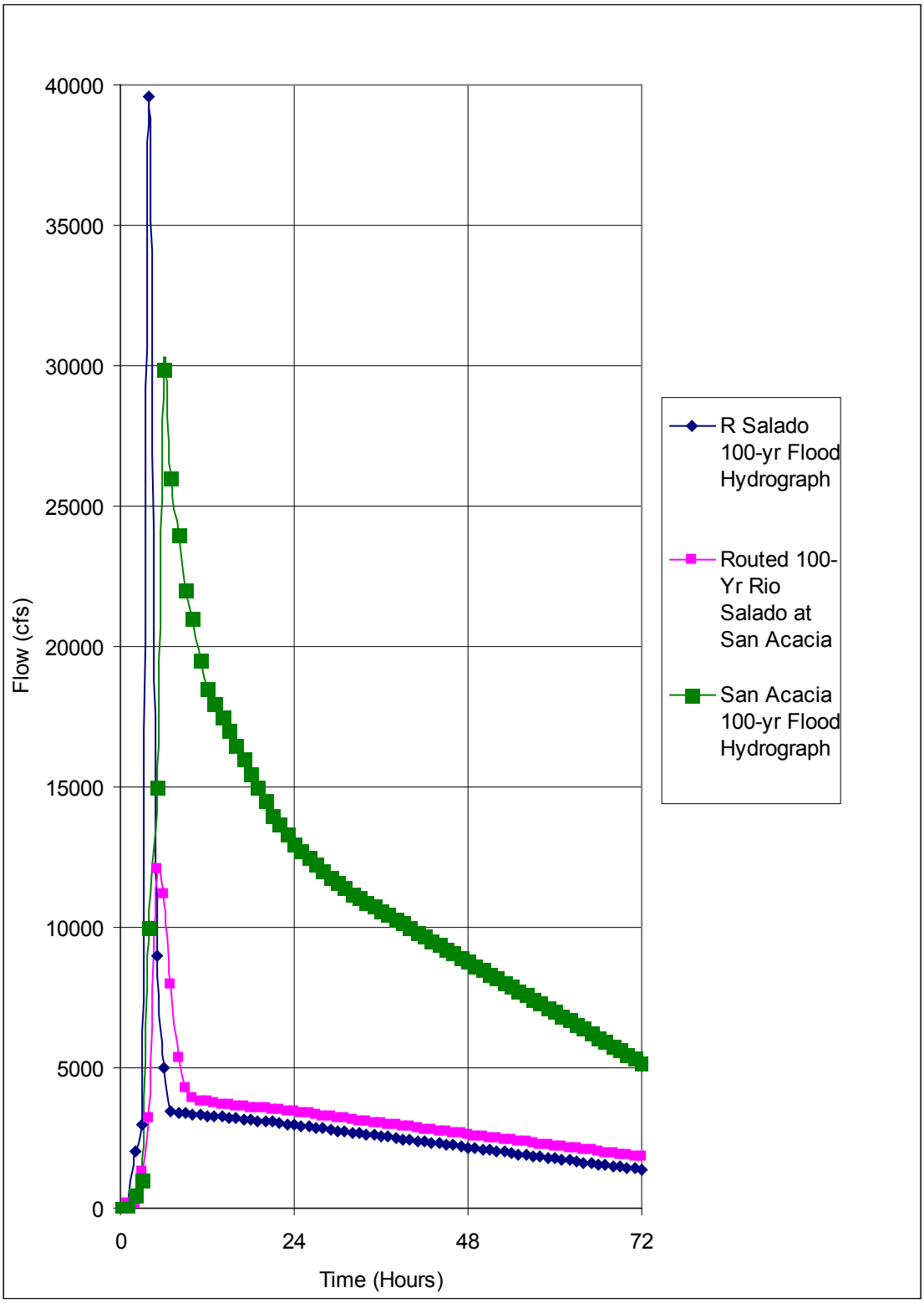
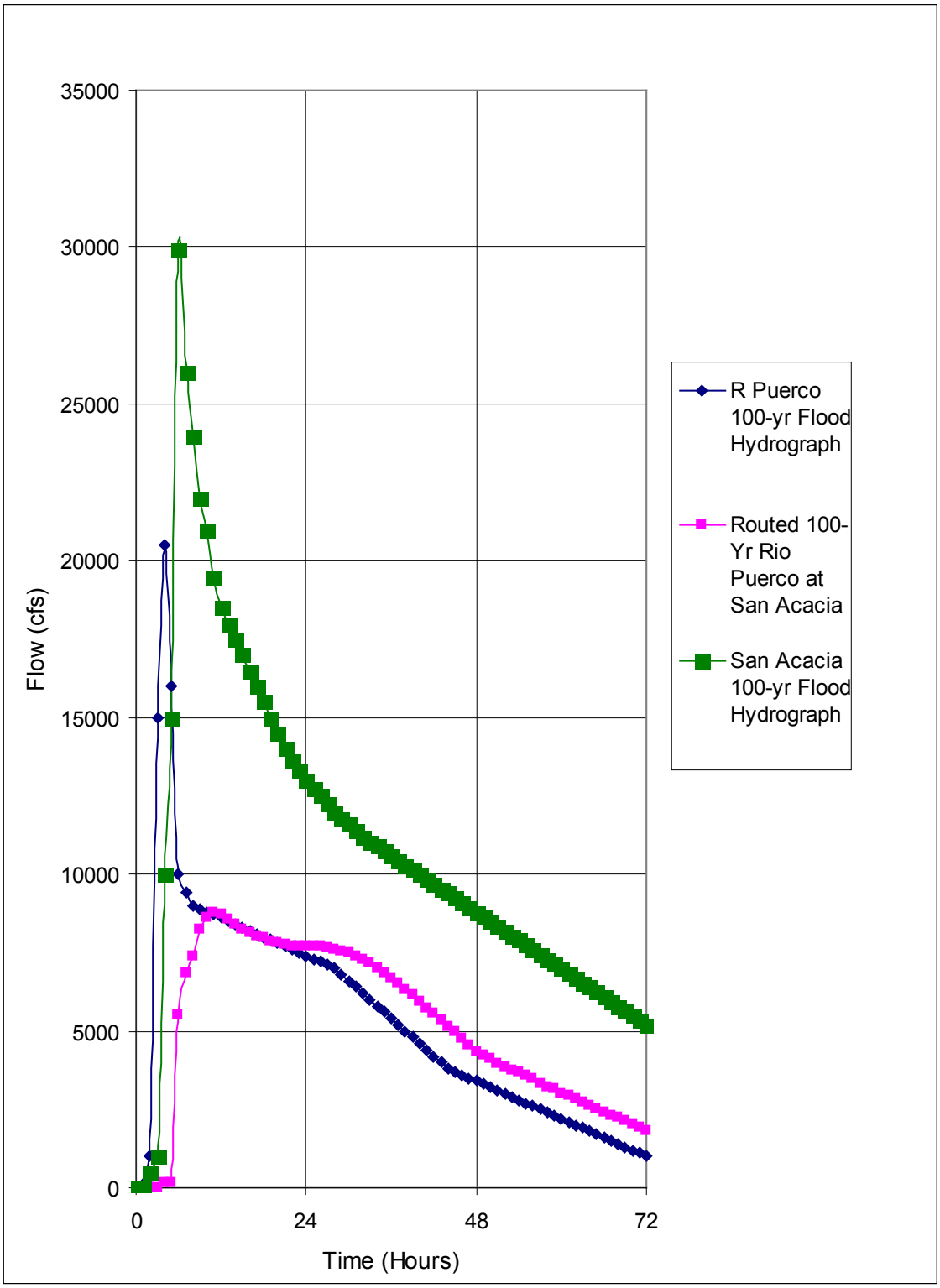


Figure 10. Graphical Comparison: Routed 100-Yr Flow from the Rio Puerco to San Acacia Compared with 100-Yr San Acacia Flow



6.0 Conclusions

6.1. Effect of Assumptions on Analytic Results

In applying flood frequency analysis at San Acacia, several assumptions were made that affect results of the frequency analysis and its applicability. Major assumptions are:

- Peak flow data were adjusted to represent regulated flow conditions. Therefore, the flow frequency applies to present conditions only.
- Spoil bank levees, common throughout the watershed, fail when floodwaters reach them. This assumption has an effect on routing of flows, particularly since the floodway is perched above the floodplain in many areas. It leads to significantly more attenuation than would be the case if it were assumed that the spoil bank levees remain viable.
- Flow diversions are not in use within the project area. It was assumed that during high flow events all diversions are closed, and that flow diversions are therefore not a complicating factor in the analysis. Annual peaks for frequently occurring events may be misrepresented by not including diversion data.

6.2 Comparison of Analysis with Other Federal Agency Hydrologic Analyses

As was noted above, some Federal agencies that are engaged in river information and management for the Rio Grande are:

- Bureau of Reclamation
- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- U.S. Army Corps of Engineers

Each of these agencies has its own focus and set of responsibilities, and to some extent these mesh. In order to meet their own responsibilities, the Federal agencies have performed independent hydrologic analyses. As a result, there are several different versions of hydrology for the project area. Table 11 provides estimates of flow frequency at San Acacia from some of the agencies. In each case, the analyses meet the agency needs, but they are not consistent with one another in approach or in results.

The USGS has performed flood flow frequency analyses for the Rio Grande at San Acacia using the instantaneous peak flow gage data that is available. These gage data were collected prior to Cochiti Dam being built, and results are thus applicable to pre-regulation hydrology.

The US Fish and Wildlife Service and the Bureau of Reclamation have focused on the most frequently occurring high flows, such as the bankfull discharge. The bankfull discharge is approximately the same as the mean annual flood, with a recurrence interval from 1.5 to 2.33 years. Peak flows in the range of the bankfull discharge are of great importance to the native vegetation, fish and wildlife.

Several hydrologic analyses are in use by the Bureau of Reclamation, the most prominent of which was written by Bullard and Lane in 1992. This hydrology is widely applied in sedimentation studies and low flow analyses.

Another BOR hydrologic analysis was completed in 2000. It is titled “Middle Rio Grande Low Range Peak Flow Frequency Study Estimating Peak Flows in the Range 1.1 – 5.0 Years Return Periods for Regulated Conditions and with Wet and Dry Cycles”. It is a peak flow frequency analysis, but with separate partial duration series for wet and dry hydrologic cycles. Partial duration frequency analyses are especially applicable to low flow conditions. This report refines the estimates for low flow years provided in the 1992 Bullard and Lane report.

Table 11. San Acacia Peak Flows from Federal Agencies

Return Period Flood Event	Percent Chance Exceednce	Current Study-Corps of Engineers Flow (CFS)	BOR 1992 Bullard and Lane Report-Regulated Flow (CFS)	BOR 1992 Bullard and Lane Report-Unregulatd Flow (CFS)	BOR 2000 Partial Series Wet Cycle Peak Flows-Regulated (CFS)	USGS 2003 Flood Frequency Analysis-Unregulatd Flow (CFS)
500 yr	.2	43500				41,770
200 yr	.5	35300				35,750
100 yr	1.0	29900	20,790	30,833		31,450
50 yr	2.0	25000	19,820	28,057		27,330
20 yr	5.0	19200				
10 yr	10.0	15400	16,450	21,061		18,380
5 yr	20.0	11800	13,620	17,649	6759	14,660
2 yr	50.0	7380	9,100	12,239	3836	9,513
1.25 yr	80.0	4770				6,175
1.11 yr	90.0	3860			391	4,927
1.05 yr	95.0	3260				4,089
1.01 yr	99.0	2420				2,883

There is some consistency in results among the agencies. For the 50-year flood and greater flood events at San Acacia, the USGS flood frequencies and COE flood frequencies are within 10% of one another. Additionally, the Bullard and Lane unregulated flood frequencies are within 5% of the USGS flood frequencies for the 50-year and greater flood events at San Acacia.

6.3. Applicability of Different Frequency Analyses

The mission of the agencies provides the basis for the assumptions found in the hydrologic studies, and may best explain the differences in the results.

The purpose of this Corps of Engineers analysis is the design of structures that will provide flood damage reduction. The focus is prevention of damages from flood events that will occur only rarely. The Corps of Engineers will turn over maintenance responsibilities to a local government agency. A goal for the COE is to construct facilities that will function for 50 years into the future. Flow estimates focus on rare flood events and are meant to be conservative, but not so much as to add unnecessary costs to proposed construction. All the assumptions that are summarized in Section 6.1 pertain to design of effective flood control structures.

It follows that the frequency estimates provided by the Corps of Engineers are likely most applicable to significant flood conditions. The COE frequency estimates should be considered conservative at San Acacia and applicable to present watershed conditions. “Without-project” conditions leading to routed flow frequencies at downstream locations provides too much attenuation to be meaningful for wide application, although this scenario is needed for the COE analysis. “With-project” conditions for routed flow within the project area may provide reasonable expected frequency estimates for present perched-floodway conditions if the spoil bank levees remain intact.

One purpose for the Bureau of Reclamation activities in the mainstem Rio Grande is to maintain the channel and floodway. Low flows occur the majority of the time, and pertain to the activities of the BOR from year to year. Therefore the BOR estimates, particularly those derived from partial duration series, are very applicable for frequent flood events.

Attachment 1

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Attachment 2

Model Overview: HEC-FFA

HEC-FFA, the Flood Frequency Analysis computer program developed at the Corps of Engineers Hydrologic Engineering Center, was used for this frequency analysis.

The FFA analytic method is in accordance with the methodology presented in Bulletin 17B, "Guidelines for Determining Flood Flow Frequency Analysis," by the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data. Bulletin 17B provides a standard technique for determining flood flow frequency to be used in all Federal planning involving water and related land resources, and is widely used outside the Federal government as well. In accordance with these guidelines, the log-Pearson Type III distribution is used to compute the frequency curve.

FFA is applicable to gage data where there is an adequate period of record for a gage. The FFA program is meant for use with instantaneous annual peak flows to compute flood flow frequency curves. The skew coefficient can be input as part of the data, and the program weights it with the calculated skew coefficient.

A broken record is analyzed as a continuous record. Historic events are included in the analysis. The .05 and .95 confidence limit curves are computed and plotted along with the frequency curve.

The data may be arrayed and plotted using the Weibull, median or Hazen formulae. In this case the Weibull method was selected.

Attachment 3

Historic Cochiti Releases

Year	Maximum Discharge at Cochiti	Average Discharge at Cochiti	Duration in Days	Maximum Discharge at San Marcial
1973	8,100 cfs	7,660 cfs	5	7,660 cfs
1979	6,280 cfs	5,850 cfs	100	6,260 cfs
1980	6,840 cfs	6,250 cfs	51	6,040 cfs
1983	6,670 cfs	6,060 cfs	38	4,990 cfs
1984	8,000 cfs	7,580 cfs	23	7,580 cfs
1985	8,290 cfs	7,440 cfs	30	7,440 cfs
1992	5,580 cfs	5,210 cfs	19	5,150 cfs
1993	7,230 cfs	7,140 cfs	7	7,140 cfs
1994	6.230 cfs	5,200 cfs	49	5,440 cfs
1995	6,410 cfs	5,520 cfs	59	4,880 cfs
1997	6,610 cfs	5,850 cfs	29	4,320 cfs

Attachment 4

Example of Routing to Estimate a Secondary Peak Using Recorded Flows

The following is an example to demonstrate the methodology for determining FLO-2D inflow hydrographs that were used to estimate secondary peaks.

The high flow event was August 10 – 14, 1967.

The river gages and associated data are shown in Table 4-1.

Table 4-1. River Gage Data, August 10 – 14, 1967

River Gage	Date	Mean Daily Peak Flow (cfs)	Instantaneous Peak Flow (cfs)
Rio Grande at Bernardo	8/10/1967	2190	
	8/11/1967	4670	
	8/12/1967	2320	
	8/13/1967	1750	
	8/14/1967	2640	
Rio Puerco at Bernardo	8/10/1967	775	
	8/11/1967	931	
	8/12/1967	1700	
	8/13/1967	4770	7860
	8/14/1967	2400	
Rio Salado at San Acacia	8/10/1967	926	17400
	8/11/1967	446	
	8/12/1967	919	
	8/13/1967	314	
	8/14/1967	3.9	

The inflow data file is given in Table 4-2, with explanatory comments in italics.

Table 4-2. FLO-2D Inflow Data File

Data Records			Explanatory Comment
3	0	0	3 Inflow Hydrographs in File
C	0	21129	Inflow 1- Bernardo
H	0	0	1st hydrograph record is time=0 and q=0
H	1	2190	2nd hydrograph record is time=1 and q=2190
H	12	2190	
H	36	4670	
H	60	2320	
H	84	1750	
H	108	2640	
H	120	2640	Last hydrograph record is time=120 and q=2640
C	0	22198	Inflow 2- Rio Puerco at the Rio Grande
H	0	0	1st hydrograph record is time=0 and q=0
H	1	775	
H	12	775	

Table 4-2, continued. FLO-2D Inflow Data File			
Data Records			Explanatory Comment
H	36	931	
H	60	1700	
H	71	1700	
H	72	3000	
H	73	3500	
H	74	3600	
H	79	3600	
H	80	3700	
H	81	4500	
H	82	6000	
H	83	7400	Hour 83- Instantaneous Peak
H	84	7860	
H	85	7800	
H	86	7400	
H	87	6500	
H	88	5500	
H	89	4500	
H	90	3720	
H	91	3600	
H	95	3600	
H	96	3500	
H	97	2400	
H	120	2400	Last hydrograph record is time=120 and q=2400
C	0	23428	Inflow 3- Rio Salado at the Rio Grande
H	0	0	1st hydrograph record is time=0 and q=0
H	20	0	
H	21	100	
H	22	3000	
H	23	17400	Hour 23- Instantaneous Peak
H	24	3500	
H	25	1500	
H	26	700	
H	27	400	
H	28	325	
H	29	300	
H	48	300	
H	49	919	
H	72	919	
H	73	314	
H	96	314	
H	97	3.9	
H	120	3.9	Last hydrograph record is time=120 and q=3.9

Figures 4-1 through 4-3 provide hydrographs showing these data.

Figure 4-1. High Flow Event of August 1967- Bernardo Inflow to FLO-2D Routing

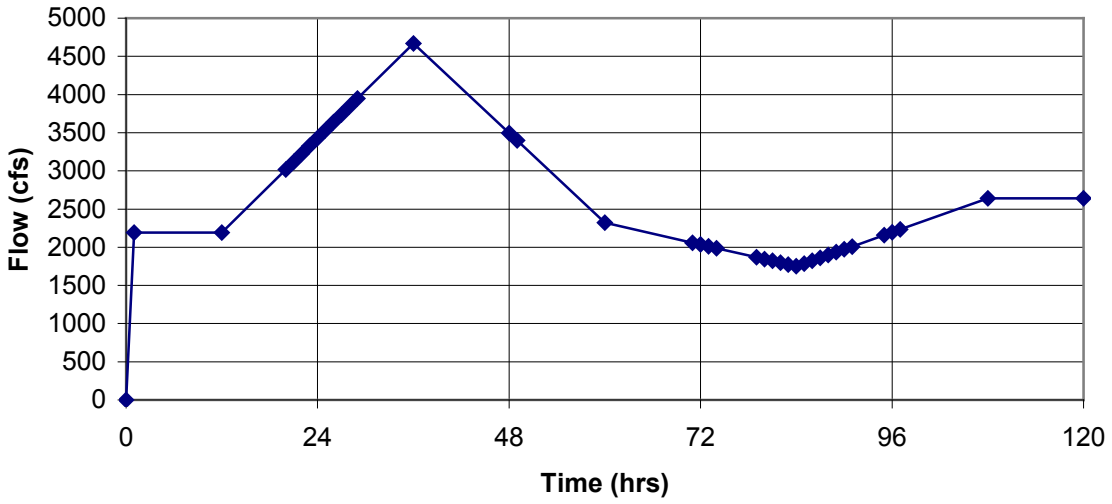


Figure 4-2. High Flow Event of August 1967- Rio Puerco Inflow to FLO-2D Routing

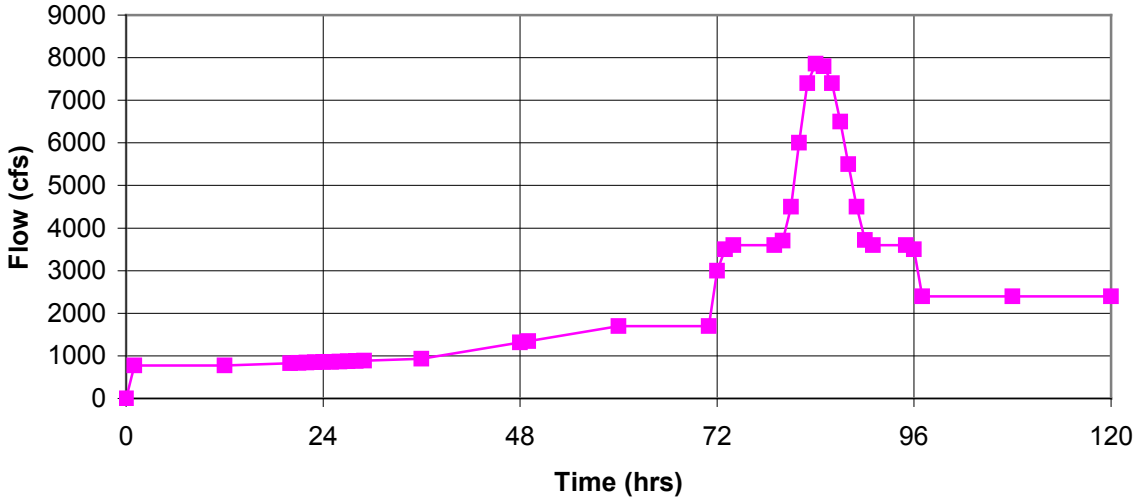
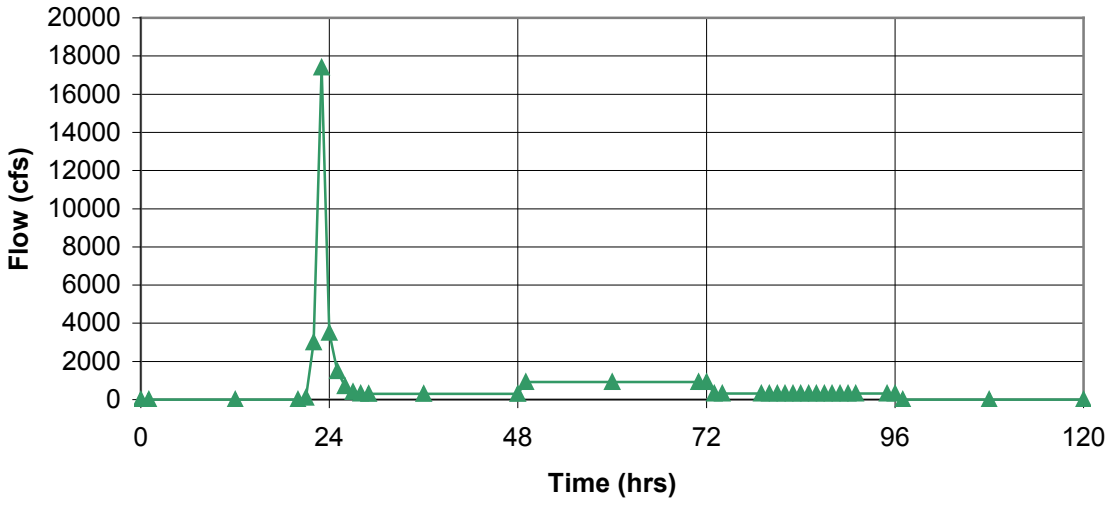


**Figure 4-3. High Flow Event of August 1967-
Rio Salado Inflow to FLO-2D Routing**



DRAFT

GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-4

Preliminary Mitigation Plan

APPENDIX F-4

PRELIMINARY MITIGATION PLAN

1. INTRODUCTION

The study area for the Rio Grande Floodway, San Acacia to Bosque del Apache Unit, Socorro County, New Mexico Project comprises a reach of the Rio Grande extending from the San Acacia Diversion Dam (SADD) south to the headwaters of Elephant Butte Reservoir. The study area is entirely contained within Socorro County, New Mexico.

The proposed plan entails the removal of approximately 43 miles of spoil bank along the west side of the Rio Grande channel and construction of an engineered levee along the spoil bank alignment. (See Section 5.1 of the *General Reevaluation Report / Supplemental Environmental Impact Statement-II* [GRR/SEIS-II] for a detailed project description.)

This appendix entails the preliminary mitigation plan for the recommended plan. The mitigation plan will be finalized after completion of Endangered Species Act consultation with the U.S. Fish and Wildlife Service (Service) and coordination with the Sevilleta and Bosque del Apache National Wildlife Refuges. The final mitigation plan will be included in the final GRR/SEIS-II.

The Endangered Species Act (ESA) requires Federal agencies to "insure that any action authorized, funded, or carried out ... is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species." A Biological Assessment for the proposed action has been completed (see Appendix C of the GRR/SEIS-II) and the Corps' consultation with the Service was initiated in December 2011.

The alignment of the proposed levee construction traverses portions of the Sevilleta and Bosque del Apache National Wildlife Refuges (NWRs), and nearly all unavoidable effects associated with the proposed action occur on lands administered by the Service. By the authority of the National Wildlife Refuge System Administration Act of 1966, the Endangered Species Act (ESA) of 1973, and Executive Orders establishing these NWRs as refuges and breeding grounds for migratory birds and other wildlife, the Refuge Managers are directed to determine the compatibility of the proposed project with refuge purposes. Service policy also requires that a proposed action on a refuge be consistent with refuge objectives. Therefore, a Determination of Compatibility and suitable mitigation measures will be included in the final GRR/SEIS-II.

The Corps' *Planning Guidance Notebook* (ER 1105-2-100) describes the process and content of mitigation plans to be included in feasibility-level reports. This mitigation plan also conforms to the requirements contained in Section 2036 of the Water Resources Development Act of 2007.

2. MITIGATION PLANNING OBJECTIVES

The *Planning Guidance Notebook* states that mitigation includes:

- Avoiding the impact altogether by not taking a certain action or part of an action;
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation;
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;
- Compensating for the impact by replacing or providing substitute resources or environments.

The Corps of Engineers Civil Works program is required to minimize and avoid damages to all significant terrestrial and aquatic ecological resources where possible, and mitigate any remaining unavoidable damages. The Corps utilizes the mitigation planning process to compensate for impacts to aquatic and terrestrial resources to ensure that the project will not have significant adverse impacts on ecological resources.

Following are project-specific mitigation planning objectives:

A. Avoid or minimize potential adverse effects to riparian. wetland, and aquatic resources in the project area by incorporating avoidance principles in the design and layout of the proposed levee.

B. Minimize the extent of disturbance of the substrate and vegetation during construction activities.

C. Avoid or minimize the potential for adverse effects to water quality during construction.

D. Avoid or minimize potential adverse effects to air quality during construction.

E. Minimize the potential for inducing or increasing the potential for the establishment of invasive species in areas disturbed during construction.

F. Avoid or minimize the potential for direct effects to listed species and designated critical habitat.

G. Mitigate, through replacement or otherwise, any unavoidable adverse impacts to vegetation and other fish and wildlife habitat resources.

H. Per planning guidance, cost effectiveness and incremental cost analysis will be used to identify least-cost mitigation plans.

3. UNCERTAINTIES

Uncertainties associated with this preliminary mitigation plan include the ongoing consultation with other Federal agencies, the preliminary nature of the levee design at this early stage of the plan, the long project construction period over which conditions on the ground may change for ecological resources, and gaps in knowledge with respect to habitat requirements for endangered species in the project area.

As stated previously, the Corps is currently consulting with the Service relative to effects the endangered Southwestern Willow Flycatcher (flycatcher) and Rio Grande silvery minnow (minnow). Similarly, the Corps is coordinating with the Sevilleta and Bosque del Apache NWRs as to the conduct of the proposed plan and suitable mitigative activities. This preliminary mitigation plan has assumed relatively standard requirements for such mitigation, and will be revised accordingly prior to submitting the final GRR-SEIS-II for approval.

The need for, and extent of, mitigative activities were based on effects determinations of the feasibility-level design of the proposed plan. The final design of project features may result in slightly different resource effects. Both the effects determinations and the mitigation needs will be revised as needed through the design process and construction.

The relatively long, 20-year construction period for the proposed project also introduces a degree of uncertainty. It is difficult at this time to accurately predict the exact condition of certain ecological resources at the time that they actually will be affected by construction activities. For instance, the location of breeding flycatchers within the southern portion of the project area varies from year-to-year based on slight changes in water regime and vegetation. The distribution of suitable riparian patches needed to maintain a viable Rio Grande flycatcher population requires additional analysis. Flycatchers along the Rio Grande have demonstrated the ability to quickly colonize areas of developing vegetation, as well as a readiness to abandon stands of over-mature vegetation. Therefore, both the project effects determinations and the mitigation plan will be revised as needed during the construction period.

The value of overbanking floods into riparian vegetation to create suitable habitat for juvenile silvery minnow recruitment needs quantification. Levee construction will have minimal effect to flooded overbank habitat area for silvery minnow recruitment. Evaluation of habitat restoration projects and water management strategies for recruitment should quantify the relationships of flow magnitude, flow duration, and inundation area to recruitment.

4. MITIGATION ACTIVITIES

4.1 Design Considerations

Variation from the alignment of the existing spoil bank was minimized to prevent significant alteration of riparian and aquatic habitats, and to minimize the amount of off-site waste spoil disposal. (This activity contributes to mitigation planning objectives A, B and F.)

4.2 Best Management Practices

Best Management Practices to avoid and minimize soil erosion and other potentially adverse effects to water quality, air quality, and other resources will be included in project specifications and the accompanying Stormwater Pollution Prevention Plan and/or Environmental Protection Plan. The following best management practices would be incorporated:

1. Silt curtains, cofferdams, dikes, straw bales and other suitable erosion control measures would be employed to prevent sediment-laden runoff or contaminants from entering the watercourse. (Contributes to mitigation planning objectives C and F.)

2. Work would be performed below the elevation of the ordinary high water mark only during low-flow periods. No erodible fill materials would be placed below the elevation of the ordinary high water mark. (Contributes to mitigation planning objectives C and F.)

3. Concrete will be poured in forms and would be contained to prevent discharge into the river. Wastewater from concrete batching, vehicle washdown, and aggregate processing would be contained, and treated or removed for off-site disposal. (Contributes to mitigation planning objectives C and F.)

4. Fuels, lubricants, hydraulic fluids and other petrochemicals would be stored outside the 1%-chance floodplain, if practical. At the least, staging and fueling areas would be located west of the LFCC and include spill prevention and containment features. (Contributes to mitigation planning objectives C and F.)

5. Construction equipment would be inspected daily to ensure that no leaks or discharges or lubricants, hydraulic fluids or fuels occur in the aquatic or riparian ecosystem. Any petroleum or chemical spills would be contained and removed, including any contaminated soil. (Contributes to mitigation planning objectives C and F.)

6. Only uncontaminated earth or crushed rock for backfills would be used. (Contributes to mitigation planning objectives C and F.)

7. Water quality would be monitored during construction to ensure compliance with state water quality standards for turbidity, pH, temperature, and dissolved solids. (Contributes to mitigation planning objectives C and F.)

8. Excavations, embankments, stockpiles, haul roads, access roads, staging areas, borrow areas, and all other work areas within or without project boundaries would be required to be maintained to prevent hazardous or nuisance airborne particulate matter. Sprinkling water or other approved temporary dust suppression methods, such as chemical treatment, light bituminous treatment, or similar methods, would be used to control dust. (Contributes to mitigation planning objective D.)

9. All areas disturbed by construction activities would be revegetated with native grasses and forbs following construction to stabilize the substrate in these disturbed areas, reduce the likelihood of invasive species establishment, and provide food and cover for wildlife species These areas include staging and access areas, the Vegetation-free Zone (the levee

itself and the 15-foot-wide strip adjacent to each toe), the eastside overbank lowering area, and the additional area within the floodway that resulted from a smaller levee footprint. Following construction, the Corp's operation and maintenance manual would require the local sponsor to maintain the Vegetation-free Zone to preclude the establishment all woody vegetation. (Contributes to mitigation planning objectives C, D, E and G.)

10. Treatments to minimize colonization by invasive plant species and noxious weeds would be included in the contract specifications. All areas disturbed during construction would be revegetated with native grasses and forbs. During the establishment of a satisfactory stand of native vegetation, colonization of invasive species within these areas would be minimized by regular mowing and, if necessary, herbicidal treatment. The operations, maintenance, repair, rehabilitation and replacement (OMRR&R) manual will require the local sponsor to continue weed-prevention treatments (primarily regular mowing and herbicidal treatment) of the Vegetation-free Zone. (Contributes to mitigation planning objectives E and G.)

11. Stream flow would be maintained at all times during construction and the streambed contoured so that fish can migrate through the project area during and after construction. (Contributes to mitigation planning objective F.)

12. Levee construction may occur throughout the calendar year; however, no construction would be performed on levee segments within 0.25 mile of occupied Southwestern Willow Flycatcher breeding territories (generally, May through August). Traffic associated with construction activities may continue along the construction alignment adjacent to occupied flycatcher breeding territories. All construction equipment and trucks would be restricted to the maintenance roads adjacent to the Low-Flow Conveyance Channel. The levee and/or spoil bank would serve as a buffer between this traffic and flycatchers within the floodway. Small vehicles (e.g., pickup trucks and SUVs) would occasionally travel along the top of the spoil bank / levee, as they do currently. (Contributes to mitigation planning objective F.)

13. Vegetation removal and clearing-and-grubbing activities would be performed between August 15 and April 15. Between April 15 and August 15, vegetation removal would only be performed if inspection by a qualified biologist determines that flycatchers (including migrant and territorial birds) are not present within 500 feet of the vegetation patch to be removed. (Contributes to mitigation planning objective F.)

4.3 Fish and Wildlife Resources

4.3.1 Vegetation planting measures

Measure A: Grass seeding along the riverside corridor of the Vegetation-free Zone

The 15-foot-wide corridor along the riverside toe of the proposed levee would be seeded with suitable riparian grass species to minimize the potential for post-construction erosion; reduce the potential for colonization by invasive weed species; and to provide vegetation usable by wildlife. Engineer Technical Letter (ETL) 1110-2-571, *Guidelines for Landscape*

Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures (USACE 2009), requires that plantings in this corridor be limited to grass species. Periodic mowing and herbicidal spot-treatment may be required to control woody and invasive herbaceous species within this corridor. These maintenance activities would be performed by the Corps in the year following seeding, and, by the project sponsor thereafter as part of the OMRR&R requirements. The area requiring such seeding along the proposed 43-mile levee entails 77.9 acres.

Measure B: Grass / shrub seeding of the Eastside Overbank Excavation area

Immediately downstream from the San Acacia Diversion Dam, approximately 9.27 acres along the east bank of the river would be excavated to form a terrace that more efficiently conveys the 10%-chance and less frequent events, and lowers velocities of the design event along the western bank in this reach. Following construction the area would be revegetated to minimize the potential for erosion; reduce the potential for colonization of invasive weed species; and to compensate for losses of wildlife habitat.

The area is currently vegetated by relict stands of salt cedar of varying densities. Channel degradation in this reach has been sufficient to remove this area from the immediate riparian zone; that is, the area is above the water surface elevation of the 20%-chance event. Even after the proposed terracing, the growing season water table would likely be sufficiently deep to prevent the establishment of native riparian vegetation. Seeding is proposed to establish upland grasses and shrubs (e.g., four-winged saltbush, with winterfat and Woods' rose) suitable to the sandy substrate.

Measure C: Willow bank stabilization

A 3.08-acre portion of the eastside terrace (vertically) below the Overbank Excavation area would also be excavated. Currently, this area is inundated by discharges larger than the 20%-chance event. The area is currently vegetated by sparse salt cedar and, at the lowest elevation, sparse coyote willow.

After excavation, approximately 2.00 acres would lie below the water surface elevation of the 50%-chance event (which also defines the Ordinary High Water Mark in this reach), and would be part of the active channel of the Rio Grande. The upper 1.08 acres of the excavated area would occupy the zone of inundation of the 20%- to 50%-chance discharges. It is recommended that willows be planted throughout the upper 1.08-acre portion of this area to help stabilize the bank in this degradational reach, and to partially replace riparian vegetation usable by fish and wildlife.

Measure D: Grass seeding in area gained from spoil bank removal

The basal width of the existing spoil bank is frequently wider than that of the proposed levee, especially in the northern (upstream) portion of the reach. A total of 85.75 acres is expected to be exposed following construction, of which approximately 50.31 acres would lie within 15 feet of the riverward levee toe and would be planted with native forbs and grasses. The remaining 35.44 acres would also require planting to minimize erosion, to minimize colonization by invasive weed species, and to provide wildlife habitat. The

majority of this area, totaling 33.86 acres, is currently vegetated by salt cedar, and the soil appears too dry to easily revegetate with native riparian shrubs. Therefore, these 33.86 acres would be seeded with appropriate grass and herbaceous species.

Measure E: Riparian shrub planting in area gained from spoil bank removal

Approximately 1.58 acres of the area gained after removal of the spoil bank (see Measure D) would be suitable to plant with willow whips and rooted stems of other riparian shrub species.

Measure F: Replacement of temporarily disturbed riparian shrubs

Along the base of the proposed soil cement embankment at the northern end of the project, approximately 1.80 acres of riparian shrubs would be removed to accommodate construction access. This area would be replanted with willow whips and rooted stems of seep-willow.

Measure G: Grass / shrub seeding at Tiffany Basin spoil deposition area

Excess soil material from the excavated spoil bank would be deposited within a 300-acre area located at Tiffany Basin. The area is currently vegetated with salt cedar of varying density, and is not inundated by flows smaller than the 10%-chance event. The fill material would be revegetated to minimize erosion, to decrease the potential for colonization by invasive weeds, and to replace shrubby wildlife habitat. Following fill deposition, the disturbed area would be seeded with a mixture of grass, herbaceous and shrub species (similar to that for Measure B).

Measure H: Riparian shrub and tree planting

Within the reach near the Bosque del Apache NWR, breeding Southwestern Willow Flycatchers currently occupy the riparian vegetation. The footprint of the proposed levee would displace approximately 8.71 acres of riparian vegetation, consisting primarily of dense shrubs. Most of the measures above would provide riparian grass habitat, but only a small amount of shrub habitat that could be utilized by breeding flycatchers and other species. This measure entails planting coyote willow and seep-willow along with cottonwood and Goodding's willow poles to provide no more than 30% tree canopy cover, in order to recreate shrub nesting habitat.

4.3.2 Cost Effectiveness / Incremental Cost Analysis.

Sufficient long-term monitoring has been conducted in habitats within the river corridor of the Middle Rio Grande valley of New Mexico that the relative value of various riparian types is well known for bird communities. Avian densities have been determined for a large variety of riparian communities based on their floristic and structural characteristics. These scaled indexes have been frequently used in cost effectiveness analyses for USACE restoration projects and mitigation plans. Table 1 summarizes avian density values over an array of habitat types found within the project area. Avian density values were used to determine the abundance of breeding-season birds within a given area of affected habitat types, as well as proposed post-construction plantings.

Table 1. Summer breeding-bird densities (birds per 100 acres) in floristic / structural vegetation types found in the project area.

Existing habitat type[a]	Equivalent type in literature	Birds per 100 ac.	Source
C / SC 1	C / SC-RO 1	265	Thompson[b]: C / SC-RO1 182 Thompson: C / SC-RO1 263 Thompson: C / RO-SC1 349
C / SC-B-SBM-NMO 1	C / NMO-__ 1	482	Thompson: C / NMO-SE1 607 Thompson: C / RO / NMO1 493 Thompson: C / RO / NMO1 346
C / SC-RO 1	C / SC-RO 1	265	Thompson: C / SC-RO1 182 Thompson: C / SC-RO1 263 Thompson: C / RO-SC1 349
C 2	C 2	500	Thompson: 614, 233; HAI[c]: 655
C / TW 2	C 2	500	Thompson: 614, 233; HAI: 655
C-TW 2	C 2	500	Thompson: 614, 233; HAI: 655
C / SC3S	C / SC 3	209	Thompson: C / SC3 209
C / SC-C 3F	C / SC 3	209	Thompson: C / SC3 209
C-SC / C-SC 3	C / SC 3	209	Thompson: C / SC3 209
RO-C / SC 3	C / SC 3	209	Thompson: C / SC3 209
SC / SC 3	C / SC 3	209	Thompson: C / SC3 209
SC / SC-CW 3	C / CW-SC 3	221	Thompson
SC-TW-C / SC-B 3	C / SC 3	209	Thompson: C / SC3 209
SC 4	SC 4	180	Thompson
SC 5	CW or TW 5	213	Thompson
CW 5	CW or TW 5	213	Thompson
SC 5	SC5	200	HAI: 207; H&O[d]: 142; Thompson: 84, 364
SC-ATX 5	SC5	200	HAI: 207; H&O: 142; Thompson: 84, 364
SC-B 5	SC5	200	HAI: 207; H&O: 142; Thompson: 84, 364
SC-RO-B 5	SC5	200	HAI: 207; H&O: 142; Thompson: 84, 364
SC 6	SC 6	120	H&O
OP	OP	222	HAI: 253; H&O: 191 DryOP
Mowed grassland *[e.g., Veg-Free-Zone]*	Mowed river edge	190	Thompson: (2 transects)
Rio Grande Channel (OW)	RV	47	H&O

[a] Habitat types follow Hink and Ohmart (1984).
[b] Thompson: Thompson *et al*. (1974): Pooled density from two consecutive years of survey.
[c] HAI: Hawks Aloft, Inc. (2010): Average of 4 to 9 consecutive years of surveys.
[d] Hink and Ohmart (1984): Pooled density from two consecutive years of survey.

IWR-Plan software was used to perform cost effectiveness and incremental cost analyses. The costs of vegetation planting measures described above were estimated from actual costs of recently Albuquerque District contracts and include a 15.8% contingency. Bird abundance was estimated based on the avian density of equivalent floristic-structural habitat types. Results are displayed in Table 2 and Figure 1.

Table 2. Results of incremental cost analysis.

Code	Measure	Cost	Bird abundance	Average cost	Incremental cost	Incremental bird abundance	Incremental cost per bird abundance unit
--	No Action Plan	$0	0	$0	$0	0	$0
A	Grass seeding along the riverside corridor of the Vegetation-free Zone	$188,084	148	$1,271	$188,084	148.0	$1,271
D	Grass seeding in area gained from spoilbank removal	$255,229	201	$1,271	$67,145	52.8	$1,272
B	Grass / shrub seeding in Eastside Overbank Excavation area	$277,611	218	$1,276	$22,382	16.7	$1,340
G	Grass / shrub seeding at Tiffany Basin spoil deposition area	$1,001,940	758	$1,323	$724,329	540.0	$1,341
C	Willow bank stabilization (Channel excavation area)	$1,006,144	760	$1,324	$4,204	2.3	$1,828
F	Replacement of temporarily disturbed riparian shrubs	$1,018,020	764	$1,333	$11,876	3.9	$3,045
E	Shrub planting in area gained from spoilbank removal	$1,071,242	780	$1,373	$53,222	16.3	$3,265
H	Riparian shrub and tree planting	$1,200,345	810	$1,482	$129,103	30.0	$4,303

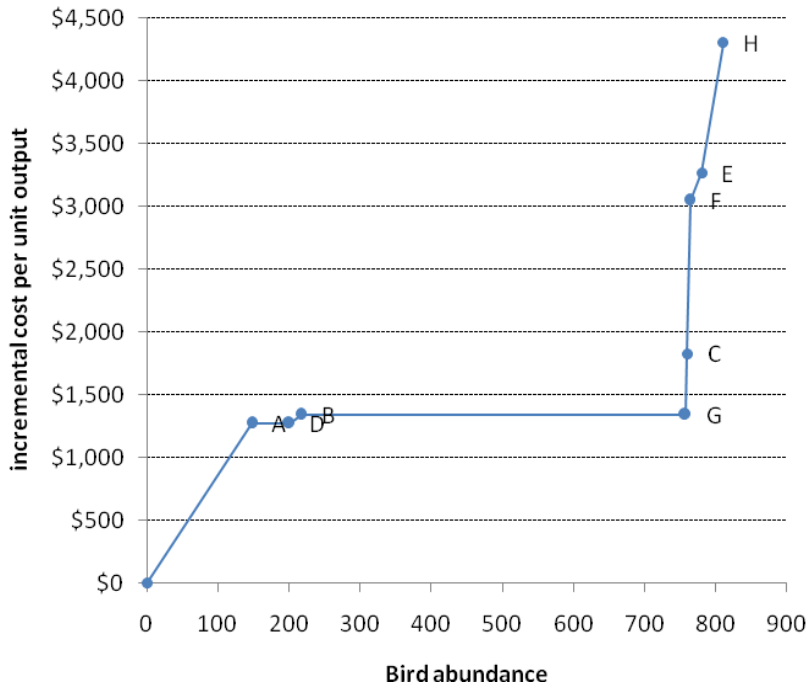


Figure 1. Incremental cost per unit of output (bird abundance).

Measures A, D, B and G entail seeding to establish vegetation and their incremental cost per unit output are similar. Measures C, F, E, and H entail the establishment of shrubs and trees, and their incremental cost per unit output increases with successively dense planting prescriptions. Although a common index of bird abundance was used to characterize the value of these habitats, it should be acknowledged that grassland and shrub habitats support a different suite of bird species, and that each type is necessary to mitigate for unavoidable effects.

All measures were determined to be cost effective, except Measure H, riparian tree and shrub plantings. Of all the revegetation measures, Measure H provides habitat most suitable for use by Southwestern Willow Flycatchers that inhabit the project area. It is anticipated that the Service will require such a compensatory measure as a reasonable and prudent alternative in the currently ongoing ESA consultation for the proposed project. Therefore, the District recommends that all proposed revegetation measures be included in the mitigation plan.

4.3.3 Compensatory value of mitigation measures

The Corps *Planning Guidance Notebook* and Section 2036 of WRDA 2007 state that losses of fish and wildlife resources will be mitigated in-kind, or include compensatory measures that provide no less than the in-kind condition, to the extent possible. In the proposed project, a relatively large area of shrub-dominated habit will be converted to grassland per the requirements of ETL 1110-2-571, and the unsuitability of some areas to support native shrub species (as opposed to exotic salt cedar). Woody riparian vegetation has been included in mitigation measures to more fully compensate for the unavoidable effects on those habitat types.

To demonstrate this, Table 3 summarizes the area and relative bird abundance of habitats affected by the proposed project and the recommended mitigation measures.

Table 3. Vegetation and channel habitat affected by the proposed project, and area revegetated (acres).

	Affected areas					Revegetated areas	
Habitat type	Temporarily disturbed vegetation (soil cement installation)	Vegetation altered in Vegetation-free Zone	East side overbank & channel excavation	Tiffany Basin spoil deposition area	Area lost due to footprint of levee, soil cement, and floodwall	Area gained by spoil bank removal & channel excavation	Other revegetated area
RIPARIAN VEGETATION:							
Native-dominated shrub/tree	0.4	2.8	0.8	--	0.9	7.7	11.6
Mixed native/exotic shrub/tree	0.5	3.7	0.0	--	0.0	0.0	0.0
Exotic-dominated shrub	1.0	19.8	0.0	--	12.1	0.0	0.0
Herbaceous / bare	0.0	1.3	0.0	--	0.0	27.8	75.9
Total Riparian Vegetation	1.8	27.6	0.8	0.0	13.0	35.5	87.5
UPLAND VEGETATION:							
Native-dominated shrub/tree	0.0	0.0	0.0	300.0	0.2	0.0	309.3
Mixed native/exotic shrub/tree	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Exotic-dominated shrub	0.0	0.9	11.6	0.0	15.2	0.0	0.0
Herbaceous / bare	0.0	1.1	0.0	0.0	1.0	0.1	1.9
Total Upland Vegetation	0.0	1.9	11.6	300.0	16.4	0.1	311.2
RIO GRANDE CHANNEL:	0.0	0.0	0.0	0.0	0.6	2.0	0.0
Total (ac.)	1.8	29.5	12.4	300.0	30.0	37.6	398.7
	373.7					436.3	
Bird abundance	3.5	65.7	20.0	600.0	22.8	199.8	593.8
	712.0					793.6	

4.4 Real Estate Considerations

The majority of the acreage proposed for vegetation plantings lies within the existing areas managed by the Bureau of Reclamation and/or the Middle Rio Grande Conservancy District (project sponsor). Revegetation areas also will be located on Federal lands managed by Sevilleta NWR and Bosque del Apache NWR. Access and conduct of the proposed project and mitigation activities will be formalized in a Determination of Compatibility with each respective NWR.

The acquisition of 300 acres for the Tiffany Basin spoil deposition site is described in detail in the Real Estate Plan for the proposed project. In addition, an estate would be obtained for an

additional two acres specifically for vegetation plantings outside of the spoil deposition area footprint.

5. MONITORING

5.1 Endangered Species

The Rio Grande silvery minnow is restricted to a variably perennial reach of the Rio Grande in New Mexico with critical habitat that overlaps the project area. Mitigation measures described above would avoid or minimize the potential for adverse effects to water quality during construction will also serve to avoid or minimize direct effects to the Rio Grande silvery minnow.

The following monitoring activity has bee specified for the silvery minnow, and has been included as a conservation measure in the Biological Assessment (USACE 2011) for the proposed project:

> Qualified fisheries biologists would evaluate measures to exclude fish from in-channel construction areas. Cofferdams and silt curtains would be deployed by Corps biologists from the shoreline into the channel to exclude fish from construction areas where possible. If appropriate, biologists would coordinate with Service personnel to seine areas prior to placement of barriers in the construction area.

The estimated labor cost for this activity is $47,000, and has been included in the estimate for the total project cost.

The Southwestern Willow Flycatcher is an obligate riparian species and nests in thickets associated with rivers, streams and wetlands with dense growth of willow, buttonbush, boxelder, Russian olive, salt cedar, or other plants. This species is known to occupy a portion of the project area. To avoid direct impacts to breeding Southwestern Willow Flycatchers, the following monitoring activities have been included as conservation measures in the Biological Assessment (USACE 2011):

> Beginning with the breeding season prior to the initiation of proposed construction, the Corps would perform or fund annual protocol surveys (5 visits per season) within the floodway from San Acacia to San Marcial. Annual surveys would continue until the completion of construction and would continue for five years following the phased construction of each levee segment.

Flycatcher surveys for each anticipated segment of construction would be conducted on the west bank of the Rio Grande on season prior to the anticipated construction. Additional segments would be added as overall construction progresses. The anticipated cost of flycatcher monitoring over 24 years following the initiation of construction is $1,414,740 (current dollars). This cost has been included in the estimate for the total project cost. Information resulting from these surveys would be used to update resource conditions, avoid direct effects from construction activities, and to revise the determination of effects of the proposed project, if needed.

5.2 Monitoring of Vegetation Plantings

5.2.1 Establishment

Construction contracts will include warranties or performance standards for the establishment of vegetation. For seeding, the requirements will specify that planted areas will exhibit vigorous growth after a one-year establishment period. Requirements typically will include stem density or percent cover measures which the Contracting Officer Representative will use to verify that the performance standards have been, or have not been, met. Any additional planting activities to meet the performance standard will be performed at the contractor's expense. The stem density or percent cover criteria included in each contract will vary depending on location-specific soil and moisture conditions, as well as the specified seed mix.

For woody plantings (trees and shrubs), the performance standard will require at least 85% survival of planted material at the end of the third growing season following planting. If survival is less than this criterion, the contractor will install additional plantings to assure at least 85% living tress or shrubs.

5.2.2 Mitigation success

The success of mitigative revegetation measures will be based on the acceptable development of vegetation and its likelihood of continued development into a mature stand. The exact criteria for success will be determined during ongoing ESA consultation with the Service and coordination with the Sevilleta and Bosque del Apache NWRs.

Avian utilization of revegetated areas will be documented through variable-distance point counts (Ralph *et al*., 1993; Martin *et al*., 1997; Bibby *et al*., 2000; Buckland *et al*., 2001), and vegetation characteristics will be measured using commensurate methods (James and Shugart, 1970; Noon, 1981; Martin *et al*., 1997). Photographs will be taken at permanently established photo points.

Monitoring will be conducted by the Corps once each year during the summer growing season for five years following planting. Monitoring requirements beyond five years (to be determined during ongoing consultation and coordination) would be conducted by the project sponsor.

An annual report on monitoring activities will be prepared. Copies of field data sheets and photographs taken will be included. Copies of the report will be furnished to the project sponsors, and pertinent Federal and local resource agencies.

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DRAFT

GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-5

Geotechnical Engineering

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

April 2012

Appendix F-5
Geotechnical Studies in Support of the Rio Grande Floodway General Re-evaluation Report

US Army Corps
of Engineers
Albuquerque District
South Pacific Division

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GEOTECHNICAL EVALUATION OF EFFECTS OF ALTERNATIVES, AND THE RECOMMENDED PLAN*

1. PHYSICAL ENVIRONMENT

1.1 GEOLOGY

Geologic conditions remain the same as presented in the approved General Design Memorandum (GDM), May 1990, and do not require further discussion in the General Reevaluation Report (GRR).

1.2 SOILS - GENERAL

The overall project consists of rehabilitating, by removing and reconstructing, 43 miles of levees along the west bank of the Rio Grande from the Middle Rio Grande Conservancy District's San Acacia Diversion Works to the northern boundary of Bosque del Apache National Wildlife Refuge, just upstream of the headwaters of Elephant Butte Lake. The recommended levees would provide the Base Levee +4 feet of protection. The levee system will provide flood protection for the U.S. Bureau of Reclamation's low flow conveyance channel, several small villages, unincorporated areas, the city of Socorro, and the U.S. Fish and Wildlife Service's Bosque del Apache National Wildlife Refuge. This GRR address conditions that have changed since the submittal of the General Design Memorandum (GDM) for this project.

1.3 SUBSURFACE INVESTIGATIONS

In 2006, 2008, 2010, additional subsurface investigations were conducted along the proposed levee alignment to indentify foundation conditions and spoil bank levee soil condition in accordance with ETL 1110-2-569 Engineering and Design: Design Guidance for Levee Underseepage.

Drilling was conducted using an 8-inch ID hollow-stem auger, sampling every 2.5 feet using a 2-inch OD by 24-inch long standard split-spoon sampler. Borings were advanced in the area of the levee alignment, to depths of 15 feet to 35 feet. Drill log data disclosed that soils would provide suitable foundation material for the proposed levee. Foundation materials may require special preparation at locations of low density foundation material. The foundation materials, generally speaking, were found to be poorly sorted sand/silty sand (SP-SM) with areas of CH, CL, CL-ML, ML, SC, SM, SP, SC-SM, SW-SM, GP, GW, and GP-GM. Relative densities, determined from correlation from Standard Penetration Tests (SPT), varied from soft/loose to hard/very dense. Generally speaking, soils were soft/loose at depths less than 50 feet with increasing relative densities with depth. Weak clay layers composed of high-plasticity clay are also present in the foundation. Exploration indicates that the layers are generally randomly located, are

relatively thin, and have sand layers above and below that allow dissipation of excess pore pressures upon construction of new levee, leading to consolidation and increased strength. Soil samples obtained during drilling were subjected to visual classification, moisture content, particle size analysis (sieve) and Atterburg limits.

1.4 EXISTING SPOIL BANK LEVEE

As described in the GDM, the existing spoil bank levee vary from approximately 3 to 18 feet in height, have a variable crest width of approximately 12 to 27 feet with side slopes of 1V:2H or flatter on both the landside and riverside. The existing spoil bank levee is not an engineered structure. The levee was constructed from spoil materials obtained originally from the construction of the riverside drain by MRGCD. The height of the levee was increased as part of the low-flow conveyance channel construction performed by the U.S. Bureau of Reclamation. No consideration was made for material selection or foundation preparation during either initial construction or the subsequent raise of the levee. Subsurface explorations disclosed that the density for the majority of materials for the existing levee is very loose to loose and were not properly compacted during construction. Also, during the investigations, large trees were found to be growing adjacent to and on the levee. Based on information obtained during these subsurface investigations, the existing levee would be removed and a new levee constructed. The PGL 26 developed as part of the 1999 LRR established the Probable Non-failure Point (PNP) and the Probable Failure Point (PFP). The locations of the points are still valid based on condition witnessed since its development. An updated H&H analysis of the PNP and PFP is included with this appendix. It was decided not to perform a geotechnical risk and uncertainty analysis on the existing levee as part of the GRR preparation because of the non-engineered nature of the levee.

1.5 NEW LEVEE EMBANKMENT SECTIONS

The area available for construction of a new levee of the proposed project is along the current alignment of the existing levee.

Because the design duration of the river flow against the levee was increased due to a balanced hydrograph, after GDM preparation. The Supplement To Report For San Acacia Levee Options For Providing Stability For Long Term Water Containment Discussion Of Finding, January 1995, it was determined that a “slurry trench” would be constructed to provide seepage control. The slurry trench would extend from two feet below the levee embankment crest to five feet into the foundation material. Foundation excavation for the slurry trench would also intercept any undesirable subsurface features prior to embankment placement. Because the proposed levee embankment would be constructed on thick deposits of pervious materials overlain with little or no impervious material, foundation seepage is a serious problem. A method of protecting the levee embankment toe from seepage and a method of intercepting shallow foundation seepage is required. Several seepage control measures were considered during design and it was determined that a network of subsurface seepage collector pipes and a landside drainage

blanket, as previously used in the Albuquerque and Corrales reaches of the flood control project, would be the best alternative. The new levees embankment would include a landside foundation drainage blanket, extending approximately 1/3 the foundation width, and a network of toe collector pipes and drains to control seepage and eliminate sloughing. Crest width, levee embankment-low flow conveyance channel clearance, embankment slopes, slurry trench and seepage control measures as discussed above are considered the minimum required to provide a stable levee structure for flood control purposes. Minor changes to the cross section may be required in future analysis.

1.6 BORROW AREAS

During the preparation of the GDM, twenty-four potential borrow areas were identified along the length of the project. These borrow areas are located in the bosque area between the previous levee alignment and the Rio Grande channel. The majority of the materials required for the construction of the levee and railroad/levee embankments was expected to be obtained from these borrow areas. However, because of environmental concerns, the borrow areas located within the bosque areas, as shown in the GDM, were eliminated as borrow sources. During FY97, eleven potential borrow areas were identified as having suitable materials for construction. These potential borrow areas were on private, Bureau of Land Management, (BLM), U.S. Fish and Wildlife Service's Bosque del Apache National Wildlife Refuge lands or lands under control of the Bureau of Reclamation (BOR). Four of these potential borrow areas were designated for use during construction; two are on BLM lands, one is at the outfall channel near the Socorro and one is the borrow area currently being used by the BOR. One additional borrow area was identified and could be used to obtain material. This borrow area is located in the middle of the U.S. Fish and Wildlife Service's Bosque del Apache National Wildlife Refuge and consists of an existing berm that the Refuge has requested be removed during construction of the new levees/railroad embankment (circa 1997). The berm was sampled and although the material in this berm is not the best for construction, an attempt could be made to use the material during construction. Specific borrow areas to be used for construction should be identified during preparation of the FDM. It is not projected that the tentatively selected plan will require any additional embankment material to construct the levee. Borrow materials will be required for slope/head cut protection and drainage/filter material. Location of a possible source of rock has been located, but further investigations are required.

1.7 ADDITIONAL SUBSURFACE EXPLORATIONS

- Additional subsurface investigations along the final alignment of the levee will be required to fulfill the requirements of EC 1110-2-6067" USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation, 9.h. Geotechnical Evaluation Guidance.

CESWA-ED-TS 23 October 1995

MEMORANDUM THRU

Chief Design Branch

Chief Planning Branch

FOR Chief Formulation Section

SUBJECT: San Acacia to Bosque del Apache, PGL-26

1. The San Acacia to Bosque del Apache project, as originally proposed, consisted of reconstructing 54.6 miles of levees. The project extended from San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir downstream of the town of Tiffany. However, the lower reach of the project has been deferred until the Bureau of Reclamation completes a three year sediment study which may result in the realignment of the lower end of the low flow conveyance channel. Currently, an existing spoil levee is present for almost the entire length of the project. Subsurface investigations were conducted for the entire length of the project. The project was originally divided into five areas for continuity but the last area is not discussed because it has been deferred as discussed above. The first area extends from San Acacia Dam, Station 14+00 to Station 73+10. This area is the very constricted area immediately downstream of San Acacia Dam and includes the dam, low flow channel and irrigation control structures and the railroad embankment and track. The second reach runs from Station 73+10 to Station 1816+50 (approximately 33 miles) and represents an area where the levee would be constructed on typical alluvial river deposits. The third reach runs from Station 1816+50 to Station 2191+00 and is an area where existing levee and borrow materials, as well as the foundations, are quite sandy. The fourth area is identified as the Tiffany Reach, Station 2191+00 to Station 2414+00. The levee alignment in this area follows an un-maintained existing levee. The last area is from Station 2414+00 to Station 2897+14.

2. Subsurface investigations of the existing levees for the GDM were conducted by Albuquerque District, U.S. Army Corps of Engineers, in 1988 and 1989. Borings were drilled at 1250 to 1500-foot spacings, using an eight-inch diameter hollow stem auger. The borings were advanced to a maximum depth of forty feet. The soils were continuously examined, classified and logged. Standard penetration tests were taken at five-foot intervals and disturbed samples obtained for mechanical analysis, Atterberg limits and moisture contents. Results of this investigation were presented in the GDM. Additional investigations were conducted in 1990 and 1991 for the F.D.M. These investigations were for the proposed Tie Back levees and the Low Flow Channel Control Structures, located at the upper and lower end of the project and for off-site borrow areas. The results of the investigations are discussed below.

3. Area Number 1 - San Acacia Dam and Vicinity. Two borings were located within this area. The borings reached refusal at depths of four and four and one half feet. Materials were silty sands and sandy clays. Visual inspection

of this area was performed to supplement the borings. The inspection, which looked at the existing low flow channel and river bank, indicates that foundations are alluvial materials, which in this area are predominantly fine silty sands and sand with traces of silts, clays and gravels. The soils are typically very loose to medium dense. Two additional borings were drilled later for the F.D.M. The borings are located at the irrigation and low flow channel control structure location (Station 32+00). The borings were drilled to a maximum depth of twenty five feet. Materials encountered are sands and silty sands of low to medium density with blow counts ranging from a low of six to twenty two.

4. Area Number 2 - Station 73+10 to Station 1816+50. This area, approximately 33 miles long, runs along the right Rio Grande riverbank. An existing spoil bank levee is present for this entire reach. One hundred and fifty-two borings were drilled for the GDM with an eight-inch auger through the existing spoil bank levee, to a maximum depth of twenty feet. Two-inch split spoon samples with standard penetration tests were taken every five feet in depth or at change of material. The subsurface explorations disclosed that the existing spoil bank levees were constructed of sands, silty sands and clayey sands. Random layers of clay were found. A review of the standard penetration test data indicate the materials range from very loose to medium (blow counts 2 to 17 per foot). The majority of the materials are very loose to loose. Foundation materials are generally sands, silty sands and sandy clays. Blow counts for the foundation materials are the same to somewhat higher than the blow counts in the spoil bank levee. Weak clay layers composed of high plasticity clay are present in the foundation. Exploration indicates that, in general, the layers are randomly located and relatively thin. The clay layers noted above could not be related to any large areal deposits. Typical river alluviums and soil deposits are quite variable and discontinuous. New exploration for the F.D.M. consisted of two holes in this reach. The first was drilled at Station 625+00 in the vicinity of the Socorro Outfall Channel and was drilled through a surface layer of sandy clay into alternating layers of silty sands and sands with blow counts from five to sixteen. The second hole was drilled at Station 1008+50 in the vicinity of the Browns Arroyo Levee tie back and was drilled through a four-foot surface layer of clay into silty and coarse sands. Blow counts varied from six to twenty three per foot. Thin clay seams were noted.

5. Area Number 3 - Station 1816+50 to Station 2191+00. This area is located within the southern half of the Bosque del Apache Refuge and continues to the start of the "Tiffany" reach. The boundaries for this area were selected because spoil levee surface materials appear to be sandier. The spoil levee materials which are obtained from excavation of the low flow channel are therefore also representative of the foundation materials. Nineteen borings were drilled within this reach. The borings were drilled to a maximum depth of forty feet below the top of the spoil bank levee. Materials ranged from loose to medium dense silty sands and sands with a few layers of sandy clay. A few thin layers of medium plasticity clay were found. The majority of the levee and foundation materials are judged to be very loose to loose based on low blow count data. Blow counts varied from a low of two to an average of eight per foot. In two borings, blow counts of twenty five were recorded in a thin layer of the foundation. Layering within the levee section is not as evident as for the previous area.

6. Area Number 4 - Station 2191+00 to Station 2414+00. This area consists of the abandoned "Tiffany" levee. Maintenance of this levee is not current and the levee has been breached near the lower limits. Ten borings to a maximum depth of twenty-four feet were drilled. Materials ranged from very loose to loose sands, silty sands and sandy clays. All materials were in relatively thin layers (less than 5 feet thick) with the exception of a sandy clay layer in one of the borings, which extended from the surface to the maximum drilled depth of fourteen feet. Blow counts varied from a low of zero to six blows per foot. Blow counts of sixteen were recorded in the foundation of one boring at a depth of twenty three feet. These borings illustrate the variability of the alluvial foundation deposits.

7. Area Number 5 - Station 2414+00 to End of Project. This area was not evaluated because the area is not included in the project as currently proposed.

8. Existing levees vary from approximately three to eighteen feet in height, have a variable crest width of twelve to twenty seven feet, with side slopes which are generally 1 vertical on 2 horizontal or flatter on the landslide and somewhat steeper on the riverside. The levees are generally overbuilt in the upper reach of the project. In place materials are sands, silty and clayey sands and sandy clays. Standard penetration tests performed during the subsurface investigations disclosed that the density of the majority of the existing levee material ranged from very loose to loose. Materials were layered, indicating that construction was perhaps phased. No identifiable zoning or seepage control measures were noted. The levees as constructed are not considered adequate to withstand water near or against the levees.

9. Discussions with Bureau of Reclamation personnel disclosed that extensive flood fighting has been required to prevent failure of the existing levees along the proposed project. Specific examples provided include two major flood fights that occurred between 1966 and 1969 in the Tiffany Junction area where large quantities of sand and rock were placed to prevent failure. The area was later lined with riprap. In 1973, water against the levee near Brown Arroyo, south of Socorro, eroded 90% of the levee between the hours of 0900 and 1430. Emergency construction was required throughout the night to save the levee. Twice between 1984 and 1989 jetty jacks and riprap had to be placed in the area between San Acacia and Polvadera to keep the saturated levee from failing. At Socorro, a training dike had to be constructed to protect the levee from flood waters. The Bureau continuously hauled granular materials between the years of 1989 and 1991 to maintain the required levee height at the lower reach of the project. During this period and in the same area, there was a levee breach and an almost complete washout of the railroad. Stabilization of the land side low flow conveyance channel, due to seepage, has been a continuing maintenance problem during flows of a frequency as low as two years. Bureau personnel indicated that these are just a few of many examples of flood fighting within the project limits required because of the poor condition of the existing spoil bank levees and without the flood fighting the levees would certainly have failed.

10. Based on subsurface exploration results, the above observations and past experience during high flows in the river, the Probable Non-failure Point (PNP) is designated as some point within the river channel. Failure could possibly occur due to foundation seepage, piping and sloughing of the land

side low flow conveyance channel, before flows break out of the river channel. The Probable Failure Point (PFP) is designated as a point at the toe of the existing levee just above the point where the water first breaks out of the river channel. As previously stated, it is strongly felt that if the levee and the low flow conveyance channel are not stabilized during possible flood fighting activities, failure will occur at some point, when the water reaches the toe of the levee.

11. If there are any questions, please contact Jimmy Medina at 766-2717.

Dwayne E. Lillard

DWAYNE E. LILLARD, P.E.
CH, GEOTECHNICAL SECTION

CESPA-PM-LH 29 June 2007

Memorandum for Record

Subject: San Acacia to Bosque del Apache LRR; PGL-26, Hydraulic Analysis of Probable Non-failure Point (PNP) and Probable Failure Point (PFP) of existing spoil bank levee

A memorandum dated 23 October 1995 discussed the geotechnical investigations of the San Acacia to Bosque del Apache project. Based on their subsurface exploration results, visual observations and experience, the following recommendations for the PNP and PFP were made:

> The PNP is designated as some point within the river channel. Failure could possibly occur due to foundation seepage, piping and sloughing of the land side low flow conveyance channel, before flows break out the (active) river channel.
>
> The PFP is designated at a point at the toe of the existing levee, just above the point where the water first breaks out of the (active) river channel.

A HEC-RAS hydraulic model using the Bureau of Reclamation's 2002 range line data was used for evaluation of the PNP and PFP. The model calculated water surfaces for cross sections along the entire reach from downstream of the San Acacia Diversion Dam to just upstream of the San Marcial Railroad Bridge. The discharge that produced a water surface that would come into contact with the existing spoil bank levee was determined for each cross section. A graph showing this discharge at each cross section (labeled by range line) is attached.

As can be seen in Figure 1, in the lower reach (from approximately range line 1500 to 1700) there are several (18) cross sections for which a discharge of 2000 cubic feet per second (cfs) would produce a water surface elevation putting water against the toe of the existing spoil bank levee. A discharge of 2000 cfs will therefore be designated as the PFP producing discharge. The probability associated with this discharge is more likely than a 50% chance-exceedance, or 2-year return frequency, based on the certified project hydrology. {It should be pointed out that a significant spring runoff in 2005 resulted in changes to the channel geometry that is not captured in the available 2002 range line geometry dataset. For example, channel incision in the lower end of the project reach in the vicinity of the Railroad Bridge (MEI, 2007), and a 'sediment plug' filled the active channel adjacent to the Tiffany basin. These changes would effect some, though not all, of the 18 cross sections described above, and were viewed as transient localized changes that were not used to represent 'typical' conditions.}

A 2000 cfs discharge could very likely be produced by a long duration snowmelt event. This would put water against the toe of the existing spoil bank levee at the PFP for an extended and constant duration, increasing the likelihood of a failure.

Another result of the long duration of a snowmelt event is the lessened attenuation of the hydrograph peak. In performing the hydrologic analysis for the LRR, long-duration, high-volume snowmelt events on the mainstem Rio Grande were considered in addition to flashy, low-volume, high-intensity summer rainfall events on the large tributaries (Rio Puerco, Rio Salado). The higher of these two types was selected for each return frequency evaluated to arrive at the representative discharge-frequency curve for the project. An assumption made for a high-volume, long-duration hygrograph was that the peak discharge would be essentially uniform as it moves down the reach, having sufficient volume to fill up the off-channel storage areas that would cause a short-duration rainfall hydrograph to attenuate significantly as it moved downstream. This is significant to note because it simplifies the analysis. For a significantly attenuated study area hydrograph (*e.g.*, a summer rainstorm event originating on a tributary), a given discharge value would have multiple exceedance probabilities depending on where within the study reach it was assessed. For a snowmelt event, a given discharge, in this case the PFP-producing discharge, has roughly the same probability of occurring throughout the project reach. Therefore, the determination of the most likely occurrence of a failure point is dependent only on the channel capacity and geometry of that location, and not on the possible attenuation resulting from the distance from the upstream end of the study reach.

A discharge of 1500 cfs will be designated as the PNP producing discharge since modeling indicated that this flow was contained in the active channel throughout the reach. It should be noted that in areas where the active river channel is directly adjacent to the existing spoil bank levee, defining the “levee toe” becomes imprecise. Thus, the potential for failure due to foundation seepage, piping and sloughing of the land side low flow conveyance channel increases even at very low flows. However, the Bureau of Reclamation monitors these areas closely, thus reducing the risk of failure.

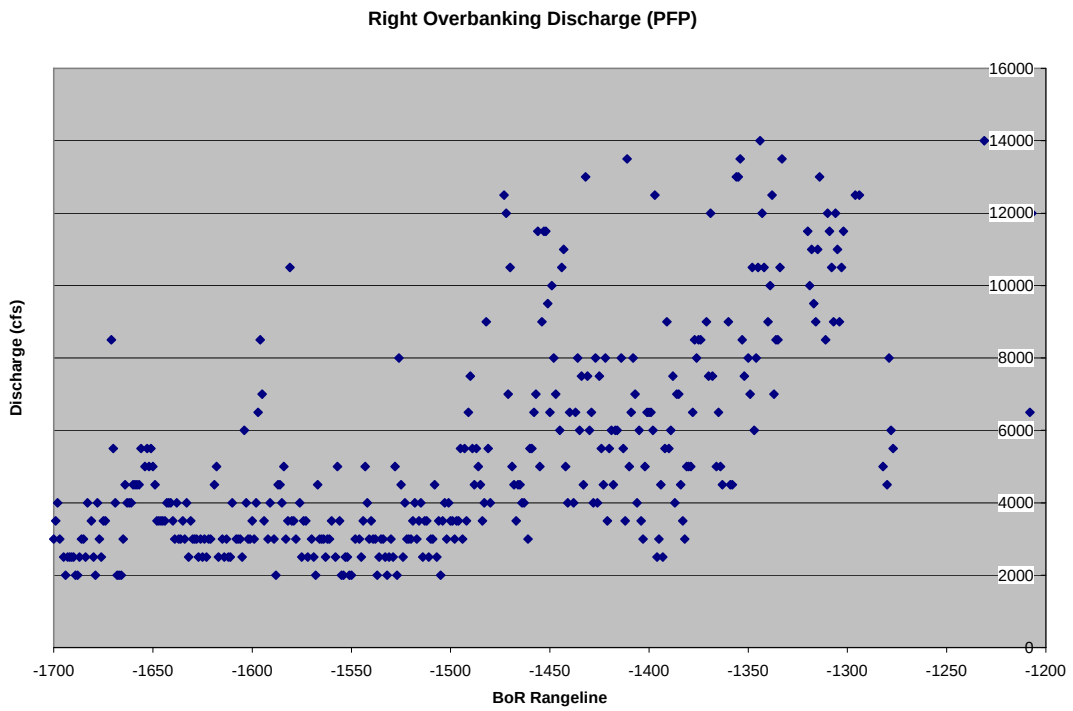

Figure 1 Discharge that would produce a water surface coming into contact with the existing spoil bank levee

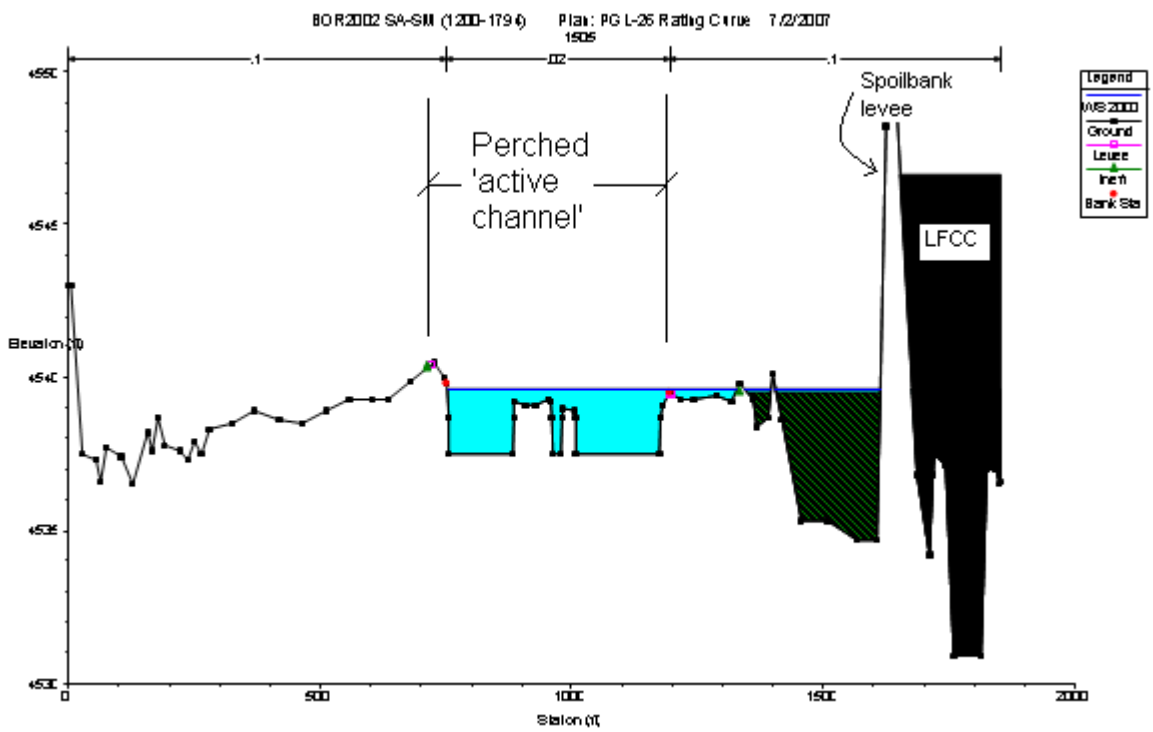

Figure 2 Typical cross section showing water against the toe of the existing spoil bank levee at a discharge of 2000 cfs.

REFERENCE

Mussetter Engineering, Inc. (MEI). *Assessment of Potential Impacts of San Acacia to Bosque del Apache Flood Damage Reduction Project on the San Marcial Railroad Bridge*, 2007.

Swell Factor	12%
Compaction Factor	25%

Alternative A 100yr +4

	BCY	CCY
Total Cut	5,233,730	
Random Fill (Levee Construction)	2,176,901	1,950,503
Spoil @ Tiffany	2,226,366	
Spoils @ R.G. Levee	656,313	
Screened Waste	174,152	
Total Cut - Random Fill, Spoils & Waste		

Alternative A 100yr

	BCY	CCY
Total Cut	5,044,508	
Random Fill (Levee Construction)	890,949	798,290
Spoil @ Tiffany	3,701,159	
Spoils @ R.G. Levee	381,124	
Screened Waste	71,277	
Total Cut - Random Fill, Spoils & Waste		

Alternative Q 100yr +4 (Alt. A w/ RM108 Alignment)

	BCY	CCY
Total Cut	5,114,648	
Random Fill (Levee Construction)	2,200,239	1,971,414
Spoil @ Tiffany	2,129,547	
Spoils @ R.G. Levee	608,842	
Screened Waste	176,020	
Total Cut - Random Fill, Spoils & Waste		

Alternative Q 100yr (Alt. A w/ RM108 Alignment)

	BCY	CCY
Total Cut	4,942,375	
Random Fill (Levee Construction)	904,523	810,453
Spoil @ Tiffany	3,605,463	
Spoils @ R.G. Levee	360,026	
Screened Waste	72,362	
Total Cut - Random Fill, Spoils & Waste		

Alternative K 100yr+4

	BCY	CCY
Total Cut	5,332,979	
Random Fill (Levee Construction)	2,333,123	2,090,478
Spoil @ Tiffany	2,162,901	
Spoils @ R.G. Levee	650,306	
Screened Waste	186,650	
Total Cut - Random Fill, Spoils & Waste		

Alternative K 100yr

	BCY	CCY
Total Cut	5,143,757	
Random Fill (Levee Construction)	916,507	821,190
Spoil @ Tiffany	3,776,023	
Spoils @ R.G. Levee	377,907	
Screened Waste	73,321	
Total Cut - Random Fill, Spoils & Waste		

Alternative K 100yr+4 w/ RM108 Alignment

	BCY	CCY
Total Cut	5,213,897	
Random Fill (Levee Construction)	2,356,461	2,111,389
Spoil @ Tiffany	2,066,083	
Spoils @ R.G. Levee	602,836	
Screened Waste	188,518	
Total Cut - Random Fill, Spoils & Waste		

Alternative K 100yr w/ RM108 Alignment

	BCY	CCY
Total Cut	5,041,622	
Random Fill (Levee Construction)	930,079	833,351
Spoil @ Tiffany	3,680,329	
Spoils @ R.G. Levee	356,809	
Screened Waste	74,405	
Total Cut - Random Fill, Spoils & Waste		

LCY

5,861,778 -

2,438,129

2,493,530

735,070

195,050

-

(1)

LCY

5,649,849

997,863

4,145,298

426,859

79,830

(1)

LCY

5,728,406

2,464,268

2,385,093

681,903

197,142

0

LCY
5,535,460
1,013,066
4,038,119
403,229
81,045
1

LCY
5,972,936
2,613,098
2,422,449
728,343
209,048
(1)

LCY
5,761,008
1,026,488
4,229,146
423,256
82,119
(1)

LCY

5,839,565

2,639,236

2,314,013

675,176

211,140

(1)

LCY

5,646,617

1,041,689

4,121,968

399,626

83,334

(0)

DRAFT

GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-6

Hazardous Toxic and Radioactive Waste

PHASE I ENVIRONMENTAL SITE ASSESSMENT

SAN ACACIA to BOSQUE DEL APACHE

FLOOD CONTROL PROJECT

NEW MEXICO

Prepared for:

United States Army Corps of Engineers
Albuquerque District
4101 Jefferson Plaza NE
Albuquerque, New Mexico

Contract No. W912PP-05-T-0043

Prepared by:

Echota Technologies Corporation
372 S. Washington Street
Maryville, Tennessee 37804

Echota Project No. 6002-02

FINAL
September 1, 2005

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ACRONYMS

ASTM	American Society for Testing & Materials
AT&SF	Atchison, Topeka & Santa Fe Railroad Co.
BNSF	Burlington Northern & Santa Fe Railroad Co.
CERCLA	Comprehensive Environmental Response, Compensation, & Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, & Liability Information System
DHHS	US Dept. of Health & Human Services
ECHOTA	Echota Technologies Corporation
EDAC	Engineering Data Analysis Center
EPA	United States Environmental Protection Agency
ERNS	Emergency Response Notification System
EDR	Environmental Data Resources, Inc.
ESA	Environmental Site Assessment
GIS	Geographical Information System
HTRW	Hazardous, Toxic, and Radioactive Waste
LUST	Leaking Underground Storage Tank
MRGCD	Middle Rio Grande Conservancy District
NFRAP	No Further Remedial Action Planned
NMED	New Mexico Environment Department
NMSEO	New Mexico State Engineer Office
NPL	National Priority List
PSTB	Petroleum Storage Tank Bureau
RCRA	Resource Conservation and Recovery Act
RCRIS	Resource Conservation and Recovery Information System
TSD	Treatment, Storage, or Disposal
UNM	University of New Mexico
US	United States
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
UST	Underground Storage Tank

EXECUTIVE SUMMARY

This report presents the results of a Phase I Environmental Site Assessment (ESA) of a tract of land located along the Rio Grande in south central New Mexico. The land is designated for improvement as part of a planned flood control project that will be managed by the United States Army Corps of Engineers (USACE), Albuquerque District. This assessment was conducted in conformance with the scope and limitations of the American Society for Testing & Materials (ASTM) Standard E 1527-00, USACE Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects, designated as ER 1165-2-132, and the US Environmental Protection Agency (EPA) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), designated as 42 USC 9601, Section 120 (h). The purpose of this Phase I ESA was to evaluate the potential for the presence of HTRW within the limits of the planned civil works project.

The land included within the project extends from the San Acacia Diversion Dam (located on the Rio Grande north of the City of Socorro, New Mexico), south to the Burlington Northern and Santa Fe Railway Co. (BNSF) bridge that crosses the Rio Grande near San Marcial, New Mexico. This 45-mile portion of the Rio Grande is located at the southern end of the Middle Rio Grande Valley in south central New Mexico. The width of the valley in the project area varies from eight to twelve miles, with the flood plain varying from one to three miles wide. A series of flood control and drainage levies are located along the west side of the river.

A site reconnaissance of the project corridor was conducted on July 20, and August 8, 2005 Land within the project boundaries is mostly rural and is not developed for industrial or commercial uses other than agricultural and low density residential. The BNSF operates a primary rail line through most of the project site. This rail line is currently used as the primary north – south line connecting El Paso, Texas and Belen, New Mexico. The railroad has been in continuous use for approximately 100 years. Currently, there are no railroad depots or maintenance facilities within the project limits; however a review of available historical information indicates that portions of the property at San Marcial were developed as a railroad maintenance shop and roundhouse in the early 1900s. These maintenance facilities were abandoned in place during a massive flood that occurred in August of 1929. These facilities have remained buried in silt and river deposits through the present. At this time, it is not known whether past land usage at the San Marcial railroad facility has environmentally impacted the site.

The U.S. Bureau of Reclamation (USBR) operates two maintenance and storage facilities on or adjacent to the project area. According to regulatory documentation, both facilities were listed as Leaking Underground Storage Tank (LUST) sites. According to records from the New Mexico Environment Department (NMED) Petroleum Storage Tank Bureau (PSTB) there is no evidence that a release of product from these facilities has impacted the environment within the project site. Additional regulatory information about these sites may be available at PSTB and at the USBR or USFWS.

1.0 INTRODUCTION

1.1 Objective

Echota Technologies, Inc. (Echota) was retained by the USACE under Contract No. W912PP-T-0043 to perform a Phase I ESA of a tract of land located in south central New Mexico. The land is designated for improvement as part of a planned flood control project that will be managed by the USACE, Albuquerque District. The purpose of this Phase I ESA was to evaluate the potential for the presence of HTRW within the limits of the planned civil works project.

In addition to the spoil levy alignment from San Acacia to San Marcial, other areas of interest included the proposed re-alignment of the conveyance channel near San Acacia; the proposed realignment of the BNSF siding and bridge; the former town site of San Marcial; and the Tiffany land acquisition area.

1.2 Scope of Work

The scope of this ESA included the following activities as specified in ASTM E 1527-00:

- An assessment of present surface and subsurface conditions from published data
- A historical review of past land use
- A site reconnaissance to observe existing conditions in the field
- A review of documents pertaining to the environmental condition of the site and site vicinity.

These activities were conducted in accordance with the following requirements:

- US EPA CERCLA Regulations designated as 42 USC 9601, Section 120 (h).
- USACE HTRW Guidance for Civil Works Projects, designated as ER 1165-2-132 (Sections 6 and 7).

1.3 Limitations

This Phase I ESA report has been prepared for the exclusive use of USACE to support planned civil works projects within the study area. This report may be used within a reasonable time following its issuance. Land use, site conditions (both off-site and on-site), or other factors may change over time; additional work may be required with the passage of time. Any other use of the report may be inappropriate.

Assessment results are based on the observations of the investigators at the time of the site visit, on reviews of publicly available information, and on information provided by persons familiar with the property. Unless contradicted by conflicting data obtained independently during the conduct of the work, all information obtained has been accepted at face value. The information obtained during interviews and from files and databases is sometimes inaccurate and/or incomplete. The information and conclusions in this report are subject to the accuracy, completeness, and availability of such data. Except as set forth in this report, Echota made no independent investigations as to the accuracy and completeness of the information derived from the listed sources.

All findings, observations, conclusions, and recommendations stated in this report are based on

the data; circumstances; applicable federal, state and local laws, rules, and regulations; and generally accepted national standards for such services in existence at the time that the report was prepared. Topics not explicitly discussed within this report should not be assumed to have been investigated or tested. This assessment does not guarantee current compliance with federal, state, or local laws, rules, or regulations.

The findings, observations, conclusions, and recommendations presented in this report, unless otherwise stated, are based solely on the information obtained and presented herein. Implementation of the recommendations contained in this report does not ensure that all environmental risks will be eliminated or that all legal obligations will be met.

This ESA did not address non-scope considerations as discussed in ASTM E 1527-00, Paragraph 12. These limitations include, but are not limited to, chemical analysis of groundwater, air or soils at the site; radiometric surveys for radon gas; asbestos/lead-based paint investigations; and evaluation of drinking water quality. This investigation was limited to non-intrusive assessments.

1.4 Limiting Conditions

Echota's on-site inspection included a walking and driving inspection of areas that were accessible, and a drive-by inspection of surrounding and adjacent properties including any properties identified in the environmental database search. No conditions that would limit Echota personnel's ability to complete the scope of work were encountered during the performance of this Phase I ESA. Due to dense forest growth and restricted access to private property in the Tiffany area and San Marcial town site, aerial photographs, review of topographic map changes, and interviews of local personnel were used to conduct portions of the investigation.

1.5 Definitions

Our investigation consisted of an integration of data from four areas of influence, as defined below:

- "site" "property" and "subject property" refers to land within the specified boundaries of the properties described in Section 2.0 of this report.
- "adjacent sites" refers to properties immediately bordering the site
- "site area" refers to properties within a one-quarter mile radius of the site.
- "site vicinity" indicates properties within a two-mile radius of the site.

The term "recognized environmental conditions" is defined by ASTM Standard E 1527-00 to mean the presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater, or surface water of the property. The term includes hazardous substances or petroleum products even under conditions in compliance with the law. The term is not intended to include de minimis conditions that generally do not present a material risk of harm to public health or the environment and that generally would not be the subject of an enforcement action if brought to the attention of appropriate governmental agencies. Conditions determined to be de minimis are not recognized environmental conditions. (ASTM, 2000).

2.0 SITE LOCATION AND DESCRIPTION

2.1 Location and Description

The project site extends from the San Acacia Diversion Dam (located on the Rio Grande north of the City of Socorro, New Mexico) south to the BNSF Bridge No. 1006A, near San Marcial, New Mexico. This 45-mile portion of the Rio Grande is located at the southern end of the Middle Rio Grande Valley in south central New Mexico. The width of the valley in the project area varies from eight to twelve miles, with the flood plain varying from one to three miles wide. In addition, an approximate 2,000- acre tract of land designated as the Tiffany Area is located at the southern end of the project site.

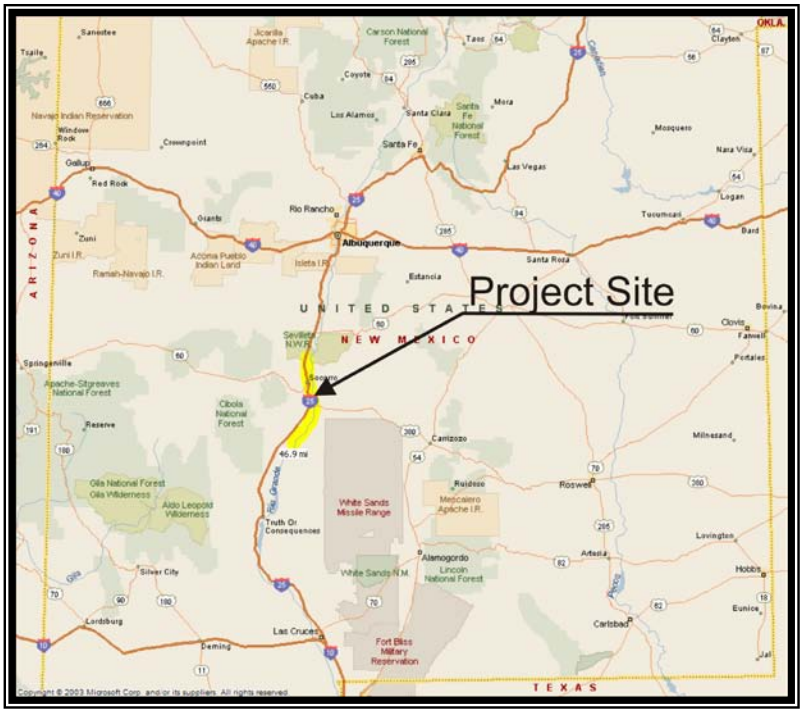

Figure 1 – Project Site Map

2.2 Vicinity and Site Characteristics

The project site includes the Rio Grande valley and its flood plain. The floodplain and bordering terraces are mostly rural and used for irrigated farmland, livestock grazing and wildlife conservation and enhancement. The project area lies within Socorro County, New Mexico with a 2000 census population of 18,078. The county seat and major population center is the city of Socorro with a 2000 census population of 8,877. Smaller communities in the area include San Acacia, Polvadera, San Luis, Lemitar, Escondida, San Pedro and San Antonio.

2.3 Current Use of the Property

Land within the project corridor is mostly rural and is not developed for industrial or commercial uses other than agricultural and low-density residential use. The BNSF operates a primary rail line through most of the project site. This rail line is currently used as the primary north – south line connecting El Paso Texas and Belen New Mexico. Railroad use has been continuous for approximately 100 years. Currently, there are no railroad depots or maintenance facilities within the project limits. Additionally, a series of flood control and drainage levees are located along the west side of the river. The levees were constructed by the USBR and the USACE in the late 1930s and early 1940s. Currently, the levees are under the jurisdiction of the Middle Rio Grande Conservancy District (MRGCD), the USBR and the USACE.

The USBR owns and operates two small maintenance facilities within the project area. These facilities are used to store equipment and vehicles used for construction and maintenance activities for the river levees. Other property uses include agriculture, residential and wildlife preserves.

2.4 Descriptions of Structures, Roads, Other Improvements on the Site

Figure 2 - San Acacia Diversion Works

There are two major structures located within the project site. The levee system extends from near San Acacia at the northern end of the project through San Marcial at the southern end. The levee system consists of a linear earthen bank approximately 15 feet in height and approximately 40 feet wide at the toe. This "spoil bank" levee is continuous along the west side of the river from San Acacia to the Nogal Arroyo just north of Socorro. The levee continues from the Nogal Arroyo outlet through the Bosque Del Apache National Wildlife refuge to the proposed new BNSF Railroad bridge site. This levee system includes a low flow conveyance channel, various interior drain channels and diversion structures. The largest structure associated with the levee system is the San Acacia diversion dam located at the northern end of the project. Smaller diversion structures used for irrigation and flood control along the flood plain are located throughout the project area.

The BNSF Railroad main line is located on the west side of the Rio Grande and extends along the west toe of the levee. Portions of the rail line are located outside of the project limits south of San Acacia and north of Socorro. The portion of the rail line located within the project limits includes an elevated rail bed with one pair of tracks and a double pair of tracks or sidings located at approximate 10-mile intervals. The only structures associated with the railroad (within the project limits) are small utility buildings or sheds located at each siding.

Other developments within the project area include widely spaced single-family homes, secondary roadways and irrigation systems. No evidence of mining, mineral exploration, or other large-scale development was observed.

2.5 Current Uses of the Adjoining Properties

The area to the west of the project limits consists of low hills and arid terraces. Most of the developed land adjacent to the project site (including Socorro, San Antonio and smaller communities) is located on or west of the terraces. There is virtually no development of properties along the east side of the project corridor. This area consists mostly of arid hills and playas. Adjoining properties located within the river valley are densely vegetated with trees, shrubs and grasses. Large wetland areas are also located along the valley, particularly in the Bosque Del Apache Wildlife Refuge.

3.0 RECORDS REVIEW

Various databases were reviewed to obtain information on the physical setting, past land ownership, and environmental conditions within the project site and vicinity. The following information was reviewed:

- A series of aerial photographs from the years 1935, 1953, 1972, 1973, and 1996
- Sanborn Fire Insurance maps
- USGS 7.5' topographic maps for the project area
- City directories (none were available for the project site)
- Published geologic/hydrologic reports
- An Environmental Data Resources, Inc (EDR) Site Assessment Report for the location
- MRGCD land ownership maps
- Various references providing information on the history of San Marcial.

3.1 Physical Setting

Topography, drainage patterns, soil types, depth to groundwater, groundwater flow direction and gradient, and other factors can affect the transport of HTRW on and beneath the ground surface. An understanding of the geologic, surface water and hydrogeologic settings can help in evaluating the susceptibility of the property to contamination. Typically, contaminants migrate vertically through porous soils to the water table (unconfined aquifer conditions), and then travel with the flow of groundwater. Locally, man-made conduits such as sewers, water lines, or wells can divert subsurface transport. Poorly constructed groundwater wells can serve as conduits for vertical transport of contaminants. Available data pertaining to the geologic and hydrogeologic setting of the property are provided in the following sections.

3.1.1 Geologic Setting

The project corridor is situated in the lower middle section of the Rio Grande Valley. The Socorro Mountains are the source of alluvial deposits that underlie the higher elevations of the river valley. The Socorro Mountains are a remnant of the northeast edge of the 25-mile long Socorro Cauldron and associated volcanic field consisting of rhyolitic ignimbrite (tuffs), trachyte and andesite. This portion of the Rio Grande Valley is one of the most seismically active areas in New Mexico. (New Mexico Bureau of Mines & Mineral Resources, 1977). The master fault of the Rio Grande rift underlies the axis of the river valley and is interconnected with extensional fault systems, which have extended to the east and west of the rift.

Surface deposits include alluvial fan and eolian deposits that are locally composed of interbedded silty to clayey sands with some gravel and occasional layers of sandy silts or clays. Beneath the alluvial fan deposits are older Santa Fe Group deposits. (Lindsey, 1999)

3.1.2 Surface Water, Topography, and Drainage

Topography within the site vicinity consists of a floodplain that slopes to the west. Surface run-off along the west side of the Rio Grande is directed to numerous small arroyos and drainage ditches. All of the runoff is channeled into the Rio Grande or the low flow conveyance channel. Elevation within the project area

Figure 3 –Section of Low Flow Conveyance Channel

ranges from 4,676 feet above mean sea level at the northern end of the project area to 4,450 feet near San Marcial at the southern end. (Lindsey, 1999)

3.1.3 Groundwater

The Socorro graben basin contains the aquifer that underlies the project site. The Socorro Basin is divided into several smaller basins including the Jornado del Muerto Basin and the San Marcial Basin. According to information provided by the New Mexico State Engineer Office (NMSEO), and EDR, the depth to groundwater within the project site ranges from 5 to 30 feet below the surface. Groundwater data from Lindsey (1999) indicates a general groundwater flow direction of west-southwest. The alluvial groundwater is generally of a chemical quality suitable for domestic and industrial use.

3.2 Historical Use Information

The original town of San Marcial had its beginning in the early 1850s on the east bank of the Rio Grande a few miles south of what was then Fort Conrad. In 1866, the town was wiped away by a flood. Fort Conrad had been relocated to the west bank of the Rio Grande a few years before the flood. This provided reason to rebuild San Marcial on the west bank and the people lost no time in re-establishing their community. No sooner had the new town began to grow than, in July of 1881, it was nearly totally destroyed by fire. Once again, the town was rebuilt and grew to a community of a thousand residents and became the center for agricultural and irrigation projects. By 1929 the population peaked at fourteen hundred. Then on the night of August 13, the waters of the mighty Rio Grande began to rise and soon reached flood stage. By the next morning the town was submerged up to the second floor of the buildings. Most of the residents, seeing their homes a total loss, left. The only visual evidence remaining today is a lonely cemetery hidden in the mesquite. (Chenoweth, 2005).

This study evaluated the history of the site utilizing aerial photographs, topographic maps, fire insurance rate maps, and city directories. Additional information related to historical use of the property is provided in the Interviews Section of this report (Section 4.0).

3.2.1 Topographic Map Review

U.S. Geological Survey (USGS) 7.5-minute topographical quadrangle maps reviewed for this assessment include the following:

- San Acacia, NM, published in 1952 and photo revised in 1971
- Lemitar, NM, published in 1959 and photo revised in 1971
- Socorro, NM, published in 1959 and photo revised in 1979
- San Antonio, NM, published in 1981
- San Antonio SE, NM, published in 1982
- San Marcial, NM, published in 1948 and photo revised in 1982

A review of historic and current USGS maps show the project site has remained relatively unchanged from the earliest available edition of these maps through the current editions. When comparing the earliest editions of the maps to the most current edition, the following data points become clear:

- The Village of San Acacia appears to have decreased in population as indicated by fewer structures or homes shown on the latest San Acacia map. All of the structures depicted within the project site on the San Acacia map appear to be single-family homes.
- The Lemitar area shows very limited growth and consists primarily of ranches and ranch homes with no indication of retail or industrial facilities within the project site.
- The Socorro map shows scattered ranch homes and single-family homes located within one mile of the Rio Grande. The area shows significant growth that is contained primarily along the I-25 corridor and outside the project site.
- The San Antonio and San Antonio SE maps show the village of San Antonio located approximately one half mile to the west of the Rio Grande with no residential or commercial development within the project site.
- The 1948 edition of the San Marcial USGS map shows that numerous structures indicated as “ruins” were located within the project limits. The ruins are depicted near the villages of Valverde, Tiffany, and San Marcial.

All of the topographic maps reviewed for this project show that drainage canals and flood control structures were constructed prior to the earliest available edition (1948) of these maps. The BNSF Railroad, formerly Atchison, Topeka & Santa Fe Railroad (AT&SF), is depicted in the earliest edition of maps as well. The maps do not indicate the presence of any bulk oil storage, manufacturing, or mining activities. Current topographic maps are included in Appendix A. (USGS, various years)

3.2.2 Fire Insurance Rate Maps

Sanborn Fire Insurance maps were compiled from the late 1800s to the early 1970s for medium and large sized cities across the United States. These maps provide baseline information on construction materials used in developed areas within city limits. Sanborn maps can provide information about historic land use and possible environmental concerns.

An inquiry with EDR Sanborn, Inc., as to the availability of Sanborn maps for the area revealed that historic Sanborn maps were produced for the town of San Marcial for the years 1893, 1898, 1902 and 1908 as shown in Figure 28 in Appendix F. A review of these maps shows that San Marcial was a relatively large town with an 1898 population of 896. These maps depict a relatively large “new town” in addition to an old town located northeast of the railroad depot. Several two and three story commercial structures are located along Main Street in addition to numerous smaller commercial and residential structures. These historic maps are available from the Map and Geographic Information Library at the University of New Mexico (UNM). Photos of all referenced maps are included on the attached DVD-ROM. (EDR Sanborn, 1893, 1898, 1902, and 1908)

3.2.3 MRGCD Maps

The MRGCD maintains a set of maps for the portion of the Rio Grande Valley under jurisdiction of the conservancy district. The first set of MRGCD maps were published in 1926 and 1927. The maps of the project area were updated in the mid-1930’s as plans for the San Marcial Channel were being developed. No specific date was available for the update, but Mr. Doug Strech (2005), the Geographical Information Systems (GIS) Coordinator for MRGCD estimated that the update was performed in 1932, based on known dates for the planning stages. These maps were not updated again due to a shift of jurisdiction upon the establishment of the Bosque del

Apache National Wildlife Refuge in 1939.

A review of these historic maps for the project site show the town of Marcial located along the west side of the Rio Grande and approximately one mile north of the railroad bridge (Bridge No. 1006A). A review of the 1926 map shows that a large AT&SF Railroad maintenance facility was located in San Marcial. The facility included maintenance shops, a round house, offices and living quarters. The maintenance facility appears to be located adjacent to the west side of the Rio Grande, approximately one mile north of Bridge No. 1006A.

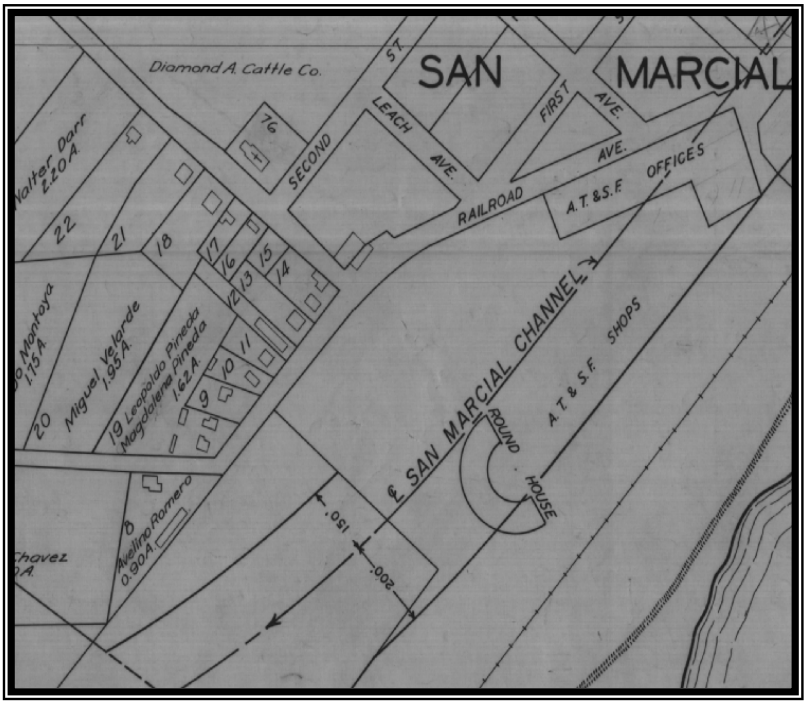

Figure 4 - 1926 MRGCD Map No. 187 (Revised mid-1930's)

When this map was revised in the mid-1930s during the planning stages of the San Marcial channel and the low flow conveyance channel. It indicates the centerline of the San Marcial channel to be immediately north of the roundhouse and maintenance shop facilities. The exact location of the AT&SF Railroad maintenance facility could not be determined using this map alone. Figure 16 in Appendix A shows the Figure 4 superimposed on a 1982 USGS 7.5 min topographic map of San Marcial, NM, providing an estimated location of the facilities. The MRGCD maps also show extensive development of properties along the west side of the Rio Grande extending into the planned Tiffany land acquisition area. Additional property development includes single-family homes, commercial/retail buildings and hotels.

Historic MRGCD maps showing the Rio Grande Valley north of San Marcial do not indicate significant change in land use from 1926 through the present. With the exception of the San Marcial area, properties along the Rio Grande appear to have remained undeveloped or used for agricultural purposes. The maps used to make these determinations are included in Appendix A and on the attached DVD-ROM.

3.2.4 Aerial Photographs

Aerial photographs were examined to assist in determining past and current uses of the property. The effectiveness of this technique depends on the scale and quality of the photographs and the available coverage. Readily available aerial photographs for this site were obtained from the Earth Data Analysis Center (EDAC) at UNM. The photographs reviewed were generally clear and of fair-to-good quality. Three sets of historical aerial photographs from 1935 (the earliest readily available) to 2004 (the latest available photograph) were reviewed to evaluate past land use at the site and in the surrounding area. The photos reviewed are summarized in the following paragraphs and selected aerial photographs are provided in Appendix B.

1935 Available 1935 photographs do not provide coverage of the entire project site. The portions of the site that were not available include an approximate six-mile area north of the San Antonio Bridge. A review of this series of photographs shows most of the property within the Rio Grande flood plain as undeveloped. Exceptions include isolated agricultural areas near Socorro, San Antonio and San Marcial. The adjacent photograph shows the remains of the San Marcial town site including the post-flood ruins of the AT&SF round house.

Figure 5 - 1935 Aerial Photo of San Marcial, NM

Figure 6 - 1953 Aerial Photo of Socorro area

1953 The 1953 photographic series shows low-density development of properties along the Rio Grande in the vicinity of San Acacia, Socorro and San Antonio. This development is mostly agricultural with associated access roads and widely spaced single-family homes. This series of photographs also shows that extensive flood control measures were in place along the river from San Acacia to San Marcial. Small diversion dams, levees and drainage channels were constructed prior to the date of these photographs.

1972 - 1973 Photographs taken in 1972 and 1973 show little change along the Rio Grande valley compared to the 1953 series of photographs. There is no evidence of extensive property development adjacent to the Rio Grande. The Nogal Arroyo outlet levees near Socorro appear to have been expanded with the construction of Interstate Highway 25 west of the property. The 1973 photographs show additional development of properties near the town of Socorro. This new development is confined to the Interstate 25 corridor and does not appear to have included property within the project limits.

1996 The 1996 series of photographs show the Rio Grande Valley as it currently exists. No additional development along the Rio Grande was noted in these photographs. Most of the modern development appears to be taking place along the Interstate 25 corridor and not in the river valley.

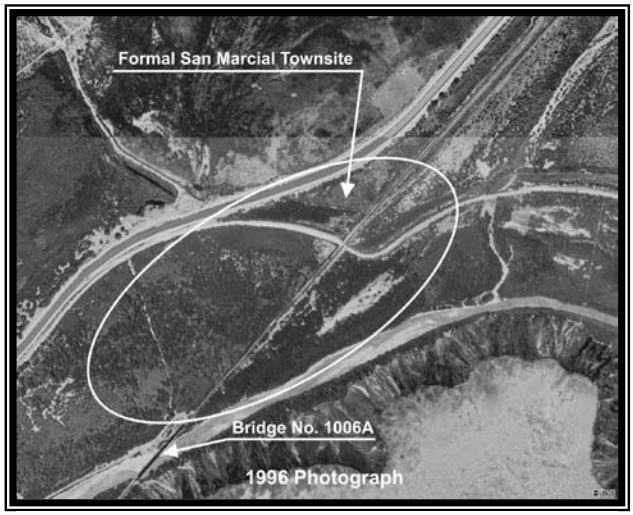

Figure 7 - 1996 Aerial Photo of San Marcial

The 1996 photograph of the San Marcial town site shows no remains or ruins of the former town. The town site appears to have been covered with silt and vegetation prior to the date of this photograph. Bridge No. 1006A and the rail siding, however, are visible in this photograph.

None of the photographs indicate any evidence of landfills, impoundments, pits, or quarries. Additional aerial photographs used to make this determination are included in Appendix D and on the attached DVD-ROM.

3.2.5 City Directories

A review of city directories for the project site revealed no listings for the property. These directories are available in the Special Collections Branch of the Albuquerque Public Library, and in Zimmerman Library, Southwest Collections at UNM.

3.3 Environmental Database Review

Regulatory databases were reviewed as part of this assessment. An EDR Site Assessment Report was obtained on August 4, 2005. This report, presented in Appendix C, contains the following information sources:

- CERCLIS - Comprehensive Environmental Response, Compensation, and Liability Information System
- CERCLIS NFRAP – Comprehensive Environmental Response, Compensation, and Liability Information System No Further Action Planned
- CONSENT - Superfund (CERCLA) Consent Decrees
- CORRACTS - Corrective Action Report
- ERNS - Emergency Response Notification System
- FINDS - Facility Index System
- HMIRS - Hazardous Materials Information Reporting System
- MLTS - Material Licensing Tracking System
- NPL - National Priority List
- Delisted NPL - NPL Deletions
- NPL Lien - Federal Superfund Liens
- PADS - PCB Activity Database System
- RAATS - RCRA Administrative Action Tracking System
- RCRIS SQG - Resource Conservation and Recovery Information System Small Quantity Generator
- RCRIS LQG - Resource Conservation and Recovery Information System Large Quantity Generator
- RCRIS-TSD - Resource Conservation and Recovery Information System Transportation, Storage, Disposal Facility
- ROD - Records of Decision
- SHWS - State Hazardous Waste Sites
- SWF/LF - Solid Waste Facilities / Landfills
- TRIS - Toxic Chemical Release Inventory System
- TSCA - Toxic Substances Control Act

Minimum database search distances utilized for this ESA meet or exceed the standards outlined in ASTM E 1527-00 as summarized in Table 1.

TABLE 1: Records Search Distances

RECORD	ASTM MINIMUM SEARCH DISTANCE (miles)	ECHOTA SEARCH DISTANCE (miles)
Federal NPL Site List	1.0	1.00
Federal CERCLIS List	0.5	0.50
Federal RCRA Corrective Action List	1.0	1.00
Federal RCRA TSD Facilities List	0.5	0.50
Federal RCRA Generators List	Property/adjoining property.	0.25
Federal ERNS List	Property only	0.50
State Leaking UST List	0.5	0.50
State Registered UST List	Property/adjoining property.	0.25
State Hazardous Waste Investigation and/or Remediation	1.0	1.00
State Solid Waste Disposal Site List	0.5	0.50

Pertinent information included in the EDR report is summarized in the following sections.

3.3.1 CERCLIS/NPL

The US EPA maintains the CERCLIS/NPL compilation of sites that (1) meet or exceed a predetermined hazard ranking system score, (2) are chosen as top priority sites by the state, or (3) meet specific criteria established by the U.S. Department of Health and Human Services (DHHS) jointly with the US EPA. These sites are identified for priority remedial action under the Federal Superfund program.

The project site was not on this list and there are no NPL sites listed within one mile of the site.

3.3.2 RCRA CORRACTS Facilities

The RCRA CORRACTS Facilities are facilities that treat, store, and dispose of hazardous waste, and that have been subject to a corrective action by the US EPA in the past.

The site was not listed in the EDR report as a RCRA CORRACTS site.

3.3.3 RCRA Treatment, Storage, and Disposal Facilities

The EPA maintains a database of all RCRA-regulated TSD facilities in the United States. RCRA-regulated facilities are those that treat, store, dispose of, or transport hazardous wastes.

The site was not listed in the EDR report as a RCRA TSD site and no RCRA TSD sites are listed within the search distance.

3.3.4 Emergency Response Notification System /RCRA Generators

The ERNS database contains information from spill reports made to the EPA, the U.S. Coast Guard, the National Response Center, and the U.S. Department of Transportation.

The site was not listed in the EDR report as an ERNS site and the site was not listed in the EDR report as a RCRA generator.

3.3.5 Underground Storage Tanks/Leaking Underground Storage Tanks

NMED PSTB maintains a list of sites where releases of petroleum products have occurred from USTs. The property is not listed as a current UST facility.

Although no UST facilities or LUST facilities were identified in the EDR Report, two LUST facilities were identified on the NMED PSTB historic list included in Appendix E. Both facilities were owned and operated by the USBR and are described below:

- San Acacia Bureau of Reclamation Yard - Located 0.15-mile west of San Acacia Diversion dam near the west perimeter of the project limits, this facility was removed in 1991 and a release was reported at the time of removal. According to information contained in the NMED PSTB list of former LUST sites (NMED PSTB, 2005 [2 references]), there is no evidence that a release of product from these facilities has impacted the environment within the project site.

- San Marcial Bureau of Reclamation Yard - Located 0.49-mile north/northwest of the low flow conveyance channel near the Tiffany area, this facility was removed in 1991 and a release was reported at the time of removal. According to information contained in the NMED PSTB list of former LUST sites (NMED PSTB, 2005 [2 references]), there is no evidence that a release of product from these facilities has impacted the environment within the project site.

If additional regulatory information is desired for these sites, a lead-time of approximately ninety days is required for State personnel at the PSTB to extract it from archived records.

3.3.6 Landfills/Solid Waste Disposal Facilities

According to the EDR report, there are no permitted or listed landfills or specified solid waste disposal facilities within the 0.5-mile search distance from the site.

3.3.7 Other Facilities

3.3.7.1 Formerly Used Defense Sites (FUDS)

According to the EDR database, there is one FUDS, EPA ID No. 1007212188, identified as “Kirtland AFB PBR 19 TRGT S-6” located near the project site. Information provided by EDR indicates that this site is located in San Acacia and is currently being investigated by the USACE-Albuquerque District. Additional information supplied by the Albuquerque District indicates that the site was a former bombing target for the former Kirtland Army Airfield, identified as “S6-PBR-19”. This site is located 10.8 miles northwest of San Acacia, with the closest point at 7.8 miles from the site vicinity.

3.3.7.2 Orphan Sites

The EDR Database Report listed 10 orphan sites, of which two are also referred to as LUST sites and are addressed previously in Section 3.3.5 of this report. The remaining eight orphan sites are located outside of the project site.

3.4 Prior Assessment Reports

No prior ESA reports were identified during this study.

An archeological report prepared by Ms. Karen Van Citters with Van Citters Historic Preservation LLC., was made available from the University Of New Mexico Office Of Contract Archeology. According to this report, San Marcial was founded in 1854 and experienced extensive growth in the 1880s with the establishment of a major railroad facility. AT&SF Railroad constructed and operated a repair shop and roundhouse in San Marcial from about 1880 to 1929 when the site was abandon. Successive floods from 1929 through the 1950s have covered most of the former town site, including the railroad facilities, with approximately 30 feet of sediment. Presently, there are no indications of former structures on the surface in the vicinity of Bridge 1006A. Aerial photographs in Appendix B and Figure 16 provide the best location information currently available.

Fig. 8-1929 Photo of Round House at San Marcial

Figure 9 - 1929 Photo of San Marcial Main Street

4.0 INTERVIEWS

Interviews were conducted, as appropriate, with local residents, property owners, workers, and public agencies. The intent of interviews was to gain information regarding current and past land use, potential contamination, and any history of HTRW use or releases. Results of these interviews are presented below.

Mr. Bob Miller, NMED PSTB, Phone: (505) 462-3597, was interviewed by telephone concerning the USBR sites on or near the project site. According to Mr. Miller, the PSTB no longer has records of the removal of the USTs on the Bureau of Reclamation sites. Mr. Miller further stated that he was not aware of any LUST sites located on or near the project site.

Mr. Chris Gorbach, USBR, Phone: (505) 462-3553, was interviewed by telephone concerning the underground fuel tanks formerly located at the San Acacia and San Marcial sites. According to Mr. Gorbach, USTs were removed from both locations in about 1991. However, Mr. Gorbach stated that at this time, there are no records on file that would indicate the condition of the removed tanks or if there was any indication of a release at either site.

Mr. Doug Strech, MRGCD GIS Coordinator Phone: (505) 565-8453, was interviewed in person concerning historic land use on the project site. According to Mr. Strech, there has been no development of properties along the Rio Grande Valley in the vicinity of the project site that would be classified as industrial or large-scale commercial projects. Mr. Strech stated that the only portion of the property that was developed for industrial/commercial uses was the former town of San Marcial. Mr. Strech provided historic MRGCD land use maps for the entire project site including the San Marcial and Tiffany areas.

Mr. Rob Larner, BNSF Railroad, Phone: (505) , was interviewed by telephone concerning possible environmental issues associated with current and past operations of the BNSF Railroad. According to Mr. Larner, there are no records of reportable spills or releases associated with either the BNSF or AT&SF Railroads. Mr. Larner also stated that the BNSF Railroad does not currently operate UST facilities within the project limits. In addition, Mr. Larner stated that he was not aware of any HTRW in the vicinity of the project site.

Mr. John Schelberg, USACE Albuquerque District, Archeologist, Phone: (505) 342-3359, was interviewed by telephone concerning possible environmental issues within the project limits. According to Mr. Schelberg no HTRW were encountered during the recently complete archeological survey of the project site.

Ms. Karen Van Citters, CSI, CDT, Van Citters Historic Preservation, LLC, Phone: (505) 268-1324, was interviewed by telephone concerning historic land use on the project site. According to Ms. Van Citters, operations at the former railroad maintenance facility likely included the use of petroleum products and lubricants. Ms. Van Citters further stated that, historically, if a roundhouse was included with railroad maintenance facilities, usually extensive overhauling and rebuilding operations were conducted at the facility. Ms. Van Citters also provided several circa 1920 photographs of the railroad facility.

Figure 10 - 1929 Photo of Round House

Mr. Tony Hernandez, BNSF line maintenance, Phone: (505) 864-5114, was interviewed in person at the time of our site reconnaissance. Mr. Hernandez stated that he has been in charge of the Bridge No. 1006A and San Marcial section of trestle for approximately 20 years. According to Mr. Hernandez, portions of the former roundhouse were visible on the surface until about 1990. After 1990 the vicinity was overgrown with Russian Olive and Salt Cedar trees and was no longer visible. Mr. Hernandez identified the location of the roundhouse during our site visit.

Figure 11 – Location identified as Roundhouse

5.0 SITE RECONNAISSANCE

A site reconnaissance of the project corridor was completed on July 20, and August 8, 2005. Personnel included Mr. Tony Apodaca with the USACE, Mr. Darrell Nicholas with Echota and Mr. James Criss with AMEC, subcontracted to Echota. The site visit consisted of traverses along the perimeter and interior portions of the project site in addition to a visual survey of adjacent sites and properties in the site vicinity. The intent of the site reconnaissance was to visually observe any indication of the potential presence of HTRW. The reconnaissance was non-intrusive. Results are discussed in the following paragraphs.

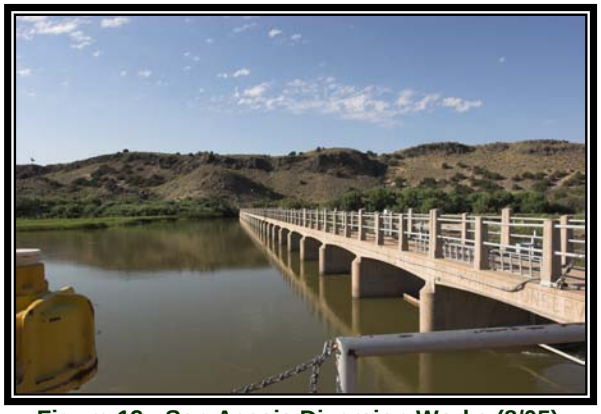

Figure 12 - San Acacia Diversion Works (8/05)

At the time of our site reconnaissance the property was mostly undeveloped with isolated areas of irrigated farmland. The undeveloped area consists of riparian woodlands and isolated wetlands. Developed sections of the property consist of flood control structures including the San Acacia Diversion, numerous levees, and drainage canals. Other developed areas include widely scattered single-family homes associated with farms or ranches usually located on or near the terraces. The USBR is currently improving the low flow conveyance channel in a section between Socorro and San Acacia. Improvements include construction of a new channel in sections adjacent to the existing channel and replacing tracts of Salt Cedar with native trees and shrubs. The construction yards associated with this project appear to be organized and well maintained with no evidence of improper environmental practices.

Figure 13 - Typical Railroad Trestle Location (8/05)

A visual survey of the BNSF Railroad trestle located along most of the project area did not indicate the improper use of HTRW associated with present day rail traffic. There was no evidence of USTs, dumpsites or spills along the railroad.

A visual survey of the Tiffany Land Acquisition area and the proposed new railroad alignment did not indicate the improper use of HTRW or the existence of dumpsites in this section of the project area. Dense Salt Cedar and Cottonwood trees cover most of the Tiffany area. A complete visual survey of the Tiffany Area was impractical at this time due to dense vegetation.

Figure 14 - Tiffany land Acquisition Area (8/05)

Adjacent properties along the east side of the

Rio Grande are not developed and there is no indication of historical development of these properties. Adjacent property to the west is developed near the Interstate 25 corridor and near towns and villages such as Socorro and San Antonio. There was no evidence of HTRW in this portion of the project site.

The following general observations were noted during the site reconnaissance:

- There was no observed HTRW on the site
- There was no observed underground or aboveground storage tanks
- There was no observed large capacity containers or drums on the site
- There was no observed evidence of improper waste disposal practices
- There was no observed evidence of solid waste disposal on the property
- There was no observed evidence of pits, ponds, lagoons, or effluent disposal systems
- There was no observed evidence of chemical spills
- There was no observed evidence of discolored or stained soils
- There was no observed evidence of dry wells on the site

Additional photographs taken during the site reconnaissance are provided in Figure 27, Appendix D. Additional photographs not included in the report are provided on the enclosed DVD-ROM.

6.0 FINDINGS AND CONCLUSIONS

We have performed a Phase I Environmental Site Assessment in conformance with the scope and limitations of ASTM Standard E 1527-2000 of the project site. Any exceptions to, or deletions from, this practice are described in Section 1.3 of this report. This assessment has revealed no evidence of recognized environmental conditions in connections with the property except for the following:

1. No evidence of HTRW or other recognized environmental conditions or CERCLA 120(h) concerns were identified on this property.

2. A review of historical information indicates that the town site of San Marcial was formerly developed with industrial facilities associated with the railroad. Although physical evidence of the facilities is not available, historical records suggest that the roundhouse and maintenance shops were abandoned in place in 1929 and have since been covered by approximately 30 feet of silt and mud. It is possible that historic use of this site has environmentally impacted the property in the past. However, the proximity of the river and San Marcial channel combined with a shallow water table would result in flushing and biodegradation of most HTRW that was likely to have been present. At this time there is no evidence that indicates these facilities have adversely impacted the project site.

3. According to information provided by the NMED PSTB, two LUST facilities were removed from USBR properties on or adjacent to the project area. According to available records from there is no evidence that a release of product from these facilities has impacted the environment within the project site. However, the magnitude of a past release or impact to the soil and groundwater beneath these sites is not specified. The report in Appendix E gives some indication that both facilities were investigated in 1991 when the UST facilities were decommissioned. The findings of this report indicate that as of 1993, “no further action [is] required”. Additional regulatory information about these

sites can be obtained through the PSTB and possibly the USBR.

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8.0 QUALIFICATIONS OF REPORT PREPARER

Mr. James E. Criss prepared this report. His qualifications include the following:

- Bachelor of Science in Environmental Studies from the University of New Mexico 1984.
- Certificate in Hazardous Materials Management from BLM National Training Center Environmental Site Assessment Training from Government Institutes.
- Completion of over 300 Phase I and II Site Investigations and Phase III Remedial Actions.

9.0 APPROVALS

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APPENDIX A

Site Maps

APPENDIX B

Aerial Photographs

APPENDIX C

Environmental Data Resources Data Base Review Report

APPENDIX D

Site Photographs

APPENDIX E

NMED PSTB LUST Reports

APPENDIX F

Sanborn Fire Insurance Maps

DRAFT

GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-7

Cost Estimates

COST ESTIMATE

1. ACCOUNT NARRATIVES

1.1 GENERAL PROJECT

This project consists of constructing approximately 41.7 miles of engineered levee along the Rio Grande in central New Mexico. The project will extend on the west bank of the Rio Grande from the upper end of the U.S. Bureau of Reclamation's low-flow conveyance channel at the San Acacia Diversion Dam to the Tiffany Basin which is roughly 28 miles from the end of the conveyance channel at Elephant Butte Reservoir. The estimate represents the cost to construct Alternative A which is the Tentatively Selected Plan.

The assumed cost sharing with the project sponsor is 85.74 percent federal dollars to 14.26 percent non-federal dollars. At this point in the design process there is no specified contracting mechanism, but the acquisition assumption for the estimate is this will be a small business competitive IFB (lowest price).

The project is first broken into segments with varying lengths chosen for their natural end points. Each segment can function, when finished, independent of other segments. Each segment is then broken into smaller phases. It is anticipated that this project will be constructed in no less than 20 phases with an approximate duration of 1 year for each phase. Project phase size is controlled by anticipated annual funding amount throughout the project with the final phase in each segment picking up any additional construction needed to complete the segment. Table 2 shows each of the construction phases and segments and the major features of construction contained within each phase.

The prime contractor for every phase of the project is estimated as a heavy civil oriented contractor who will subcontract some portions of the work. Subcontracted work will include all concrete work, rock blasting and processing and trucking. This size of contractor is the basis for estimate crew numbers, sizes and production rates and this contractor is reasonably estimated to be capable of performing more than the annual funding amount of work per year. Refer to "Schedule For Design And Construction" for activity durations based on production rates used to build the estimate. Items such as overtime or shift work are not included in the estimate as they are not required to complete the work in the assumed 1 year allotted time per phase.

Contractor field office overhead, job office overhead and profit are applied in the estimate as running percentages of the costs. As the design is finalized prior to construction the job office overhead will be detailed for each specific phase. The contractor is also assumed to be a predominately local contractor or predominately staffed with local personnel at rates consistent with local wage determinations for the area. The estimate does not directly account for additional costs associated with providing subsistence for non-local workers. This is accounted

for in the risk analysis and resulting contingencies used for the estimate to reflect the possibility that some subsistence may ultimately be necessary.

1.2 ACCOUNT 01- LANDS AND DAMAGES

The majority of the real estate required for the levee footprint, temporary construction easement, and staging areas has already been secured by the MRGCD on behalf of Reclamation as part of previous federally funded projects. The local sponsors will only credit land cost required for the construction of the project for parcels of land that they do not own. The estimate for realty costs was provided by the local district Realty Specialist and is the basis for realty costs in the project estimate.

- It is estimated that approximately 300 additional acres of land are needed for staging and waste areas required for the construction of the project. Most of the land is located within the Tiffany Basin. This land will be procured for the start of Phase 1 as waste will be generated shortly after levee construction starts.
- Other realty costs not specifically attributable to a phase are distributed among all phases weighted by the physical length of the phase.
- Contingency for this item is applied by the Realty Specialist at 30% and is intended to cover uncertainty in land values and unknown resolution of land ownership and is included in the cost value. Additional contingency is not provided in the estimate upper levels.

1.2 ACCOUNT 02 - RELOCATIONS

Approximately 16 miles of an existing fiber optic line are required to be relocated to allow construction of the southern end of the levee. The line is operated by a local utility owner in the existing easement.

- The estimate assumes the size of the fiber optic cable is 144 fibers. The line is pulled in 1000 LF lengths in a 4" conduit that is direct buried. The trench required for the installation of the line is assumed to be 2' X 2'. A 4' x 4' x 2' precast hand hole is placed every 1000 feet to allow for proper installation.
- The relocation of the fiber optic line is broken down into five separate tasks in the estimate; excavation, conduit placement, hand hole placement, cable installation (including splicing) and backfilling & compaction.
- Contingency for relocations is based on a lack of detail for the existing utility. Because this utility is located at the end of the project physically and schedule wise there is ample opportunity to resolve conflicts and a schedule impact is very unlikely.

1.3 ACCOUNT 09 - CHANNELS AND CANALS

Overbank excavation and channel widening are required at the northern end of the project site in the area of the San Acacia Diversion Dam. It is projected that excavation of the east bank of river terrace will effectively alleviate erosive velocities that threaten the integrity of the new proposed levee. Channel widening will increase the cross sectional flow area and subsequently decrease the velocity.

- 10 acres of clearing and grubbing is required. It is assumed that the clearing consists of small trees and brush. All of the debris is disposed at a local landfill assumed to be within a 30 mile radius of the project site. The clearing crew consists of a dozer, equipment operator, and laborers. The productivity rate is assumed to be approximately 0.33 acres per hour.
- Quantities for the amount of material to be excavated were provided by the local District General Engineering Section. It is estimated that approximately 152,650 cubic yards of material will be excavated. The excavated material is hauled and dumped at a waste area located within a 46 mile distance from the work area. The excavation crew consists of a hydraulic excavator with an equipment operator. The productivity rate is assumed to be 80 cubic yards be hour. A portable cofferdam system is assumed for protection from water flow during earthmoving operations.
- A temporary 0.5 mile haul road is required to access the overbank excavation/ channel widening site. The temporary crossing consists of an earthen ramp with a 15 foot top width and 2.5 to 1 foot side slopes. Six 60-inch corrugated metal pipes are used to allow low flows to pass through the crossing to maintain a wet river channel during construction. The earthen material for the haul road comes from a borrow area, and the pipe comes from an area vendor and is delivered to the job site. The haul road is constructed using a crew consisting of a hydraulic excavator, front end loader, roller, water truck, and laborers. It is assumed that the temporary haul road is built in 48 hours and demolished in 40 hours.
- Contingency for this account is based on the limited amount of design available at this stage. It is expected that quantities will vary somewhat as the design progresses, but current estimated quantities are reasonable.

1.4 ACCOUNT 11- LEVEES AND FLOODWALLS

This account encompasses the majority of the work for this project. The new levee which will replace the existing spoil bank will have a trapezoidal cross-section with a 15-foot-wide crest.

Side slopes would vary between 1 vertical to 2.5 horizontal and 1 vertical to 3 horizontal, depending on the height of the levee. The levee height ranges from 1 foot at the northern end to 14 feet at the southern end and per data supplied by the local District General Engineering Section will require approximately 4,600,000 cubic yards of random fill for construction. For levee heights greater than 5 feet, perforated pipe toe drains, discharge pipes into the Low Flow Conveyance Channel, and risers as well as an 8-foot-wide by 4-foot-high inspection trench with 1V:1H side slopes are required. In addition, a 2-foot-wide bentonite slurry trench will extend from 2 feet below the levee embankment crest to 5 feet into the foundation material for levee heights over 5 feet. Material making up the existing spoil bank is used to construct the new levee except for select material such as bentonite clay and rock rip rap. Additional material is spoiled on the landside of the levee where easements permit (typically along the upper reach of the levee) to avoid long distance hauling of waste. Despite the disposal of spoil material along the upper reach of the levee, approximately 2,900,000 loose cubic yards of excess material will be spoiled at an approved location outside the levee footprint. For the estimate this is assumed to be the Tiffany Basin waste area.

Some segments of the new levee require toe scour protection. The protected segments range from 500 to 5,000 feet in length, and the total length of erosion protection is approximately 35,500 linear feet (6.7 miles). Rip rap protection will blanket the riverward slope of the levee from crest to toe, and is buried to a depth of 6.5 to 12 feet beneath the levee toe. “Launchable” rip rap is buried below the ground surface at the toe of the levee for potential scour depths greater than 12 feet but not exceeding 17 feet. Rock sizes used for rip rap vary from 0.75 to 3.5 feet depending on the velocities at the potential scour location. The estimate is based on rock quantities and sizes provided by the local District General Engineering Section.

Levee Earthwork

- Due to flood risks no more than 1 mile of levee will be allowed to be open at any given time. A system will be developed so that the construction activities including excavation, hauling, processing, and construction of the new levee are cycled in order to satisfy the condition of only having 1 mile of levee open at any given time. For the estimate it is assumed this protection is provided by a portable cofferdam system which is quickly and easily relocated as construction progresses.
- It is assumed the entire required fill for the new levee is obtained from the existing spoil levee. The material is excavated and then hauled to a material processing area within an average 0.75 mile radius of the job site. The excavation crew consists of a hydraulic excavator and equipment operator. The productivity rate is assumed to be 200 cubic yards per hour.
- The processed material will be stockpiled at the screening area until it is hauled off to the area where it will be utilized. A 25 percent shrink factor and a 10 percent non usable

material factor are assumed for the screening operation required for the spoil material processing.

- The material required for the construction of the new levee is hauled from a stockpile area within an average 0.25 mile radius of the job site. It is estimated that the loading and hauling from the stockpile is accomplished by a crew consisting of a loader, dump trucks, and laborers. The productivity is assumed to be 165 cubic yards per hour.
- It is estimated that the new levee is constructed in six inch lifts to reach required compaction. A crew consisting of a hydraulic excavator, compaction roller and water truck with required operators can accomplish the placement and compaction of the fill material at the rate of 165 cubic yards per hour.
- Unused material not needed for the construction of the new levee will be deposited in either the land side of the new levee or the Tiffany Basin.
- For material deposited on the land side of the new levee the quantities were generated by analyzing levee heights throughout the alignment and providing average cross sections of waste material that the given height could allow. It is assumed that the material will be hauled within an average 1 mile radius of the job site to the area where it will be deposited.
- It is estimated that the material to be spoiled on the land side of the new levee will be placed by dumping the material onto the sloped side of the engineered levee with rear dump body dump trucks. The productivity rate for depositing material is assumed to be 200 cubic yards per hour.
- The remaining spoil levee material not be for the construction of the new levee is hauled to the assumed dump site (Tiffany Basin). It was estimated that several trucking subcontractors will be required to support this operation.
- To develop approximate hauling distances to the waste area the entire levee alignment is broken up into 9 sections and the midpoint of each segment is used to compute the haul distance to the waste area (Tiffany Basin). The use of only Tiffany Basin for waste material disposal is the basis for the estimate as it is a known workable plan. It is possible that throughout the course of the long term project other closer areas may be identified by the designers or contractors. This possibility is investigated in the project risk analysis and could provide potential savings.
- The area to be covered by the spoils within Tiffany basin is calculated to be approximately 300 acres with at a depth of 6.5 feet for the selected plan. Screened oversized waste (large rocks) not appropriate for random fill, are separately stockpiled for use as rip rap thus reducing the required rip rap quantity.
- Levee tie backs are required at San Lorenzo Arroyo and Socorro Arroyo. It is assumed that the levee tie backs follow the same construction methodology as the engineered levee and include the same requirements with the exception of a slurry trench and toe drain system.

- Contingency for the levee earthwork are based on the current level of design and potential differences between assumed and actual production rates. It is expected that future levee design refinements will change overall quantities, and risk analysis investigates the effects of quantity and production rate differences from the estimate assumptions.

Levee Drainage System

- The toe drain system required for seepage control consists of a perforated main line with risers and clean-outs every 300 feet and outlets every 900 feet throughout the entire alignment. It is estimated that six inch diameter plastic pipe are utilized in the system. The pipe material is purchased from an area supplier and is delivered to the job site. A crew consisting of a pipe layer and laborers places the pipe. The productivity rate is assumed to be 40 linear feet per hour.
- The placement of the toe drain system requires the excavation and backfilling of soil material and installation of rock filter material, a product of the riprap excavation and processing operation. It is estimated that a portion of the excavated soil material is stockpiled for reuse in the backfill operation with the remainder being spread along the access road. It is estimated that a crew consisting of a loader/backhoe and laborer is utilized for the excavation operation. The assumed productivity rate is 18 cubic yards per hour .

Slurry Trench

- A 2 foot wide slurry trench with a depth that is dependent on the levee height is the current slurry trench design. It is estimated that bentonite will be added to the levee soil at a proportion of five percent by weight, (2.85 lbs/cf) to create the impervious backfill. Additionally, a slurry mix will contain 22.5 pounds of bentonite per 42 gallons of water and will fill the excavated trench prior to backfilling with the core material. The bentonite will be purchased from an offsite source and will be delivered to the job site for mixing in each operation.
- The trench excavation will be accomplished by a hydraulic excavator and the assumed productivity rate is 55 cubic yards per hour. The removed material is assumed to be trucked to a plant for mixing with bentonite and then trucked back to the wall backfilling operation. The average haul distance will be 5 miles. Backfilling is accomplished by bulldozer. During trench excavation and before backfilling the trench will be filled with a bentonite slurry. This slurry will be created in a mobile or skid mounted venturi type mixer and pumped into the trench to seal the trench walls.

Riprap

- Based on neat line in-place quantities provided by the local District General Engineering Section, it is estimated that a total of 525,000 cubic yards of in situ material needs to be excavated for the current riprap design. It is assumed that the rip rap material comes from an unknown borrow source at the northern end of the project. A swell factor of 55% is assumed from in-place to blasted state. The rock excavation is accomplished utilizing a 6" diameter hole, 18x12 blast hole pattern, 30 linear foot hole depth, 4 feet of sub drilling, and a 1.0 lb/cy powder factor. It is assumed that the blasting agent is ANFO. A crew consisting of three air trac drills, blaster, and two helpers is utilized for the excavation operation. The assumed productivity rate for drilling is 115 linear feet per hour and the productivity rate for blasting is 895 pounds per hour. It is assumed that the worked performed for the blasting is accomplished by a subcontractor.
- The riprap design calls for a wide range of riprap sizes which need to be screened and processed. For rip rap screening and processing a non usable factor of 30% is assumed. It is also assumed that the screening/ processing area is within two thirds of a mile from the excavation area. It is estimated that the processing of the riprap is accomplished by a crew consisting of front end loaders, screening plant, and grizzlies. The productivity rate is assumed to be 110 cubic yards per hour. After the material is processed it is hauled to the project site which is at an approximate distance of 25 miles.
- Contingency for this item is based primarily on the unknown location for the quarry site. The risk analysis considers the possibility that the actual quarry will be located farther or closer to the project than the assumed distance of 25 miles.

Clearing and Grubbing

- Clearing and grubbing is required throughout the entire levee alignment. It is assumed that trees and small brush are removed. Trees are chipped on site and disposed of at a local landfill located within a thirty mile radius of the job site. The clearing and grubbing is accomplished using a crew consisting of hydraulic excavator, bulldozer, front end loader, chipper, dump trucks, and laborers.

Care and Diversion of Water

- The project requirements state that there cannot be a break in the levee; therefore a temporary dike system will be required. It is assumed that the temporary dike systems is constructed in two sections that have a maximum length of 1/2 mile. Breaking the temporary dike system into two sections allows for a more efficient construction for the new levee and mitigates the interruptions that are caused by the requirement for a temporary dike system. Costs for a *Portadam* type of cofferdam are used in the estimate. Once the first section of the dike is complete the new levee construction can began while the second section of the temporary dike system is constructed. When the new levee

correlated with the first dike section is complete the first section of the dike system will be relocated behind the second section. This leap frog process will continue until the completion of the new levee and will allows the linear construction of the levee to continue without having a breach in the protection.

- It is estimated that construction of the deep toe portions of the riprap protection require dewatering for placement. The toe key for the riprap slope protection will have a minimum depth of 5 feet and a maximum depth of 17 feet. For the estimate the water table in the excavation exists 8’ below the levee toe. The dewatering is accomplished using a deep well type system consisting of wells placed at 50' on center.
- The depth of the wells is varied based on the depth of the construction excavation. Each well will have an electric submersible pump and discharge piping. Power is estimated to be supplied by a skid mounted generator which can power a line of pumps up to 500 ft long. It is estimated that the pumps are operated continuously for the duration of the toe riprap placement. The crew consists of a truck mounted well drilling rig, loader/backhoe and pipe layers for the drilling and installation of the wells and construction of the discharge piping system. The electrical system for powering the pumps is constructed by a crew of electricians. A crew of a skilled laborer is used part time to maintain the system while operating.

Brown Arroyo Structure

- A major gated reinforced concrete structure is required at the confluences of the Brown Arroyo and the Rio Grande. Quantities for the estimate originate from take offs performed by the Cost Engineering Section on the current drawings for the structure.
- It is assumed that care and diversion of water is not necessary to minimize effects from flows. It is also assumed based on the location of the structure and the relatively shallow depth of the excavation required for the foundation construction that dewatering is not necessary to construct the turndowns.
- The foundation for the structure consists of a concrete slab with turndowns, the low flow section and the stem for the wall to finish grade. The wall section consists of the concrete from finish grade to top of structure.
- The structure is cast in place and requires wooden formwork. A factor of 12 percent is included to account for waste and braces. It is estimated that the structure requires 100 pounds of steel reinforcement per cubic yard concrete as detailed reinforcing drawings are not available at this design stage. A 12 percent factor is also included to account for high chairs, tie wire, and laps. Concrete includes a factor of 8 percent to account for losses and waste. It is assumed that all of the materials and supplies are purchased from an area and delivered to the job site.
- The Brown Arroyo Structure also requires the placement of 8 - 7' x 10' and 2 - 10' x 10' slide gates. It is estimated that the gates are purchased from an area supplier and are

delivered to the job site. The gates are placed by a crew consisting of a crane at half time, operator, steel workers, and a laborer.

- The structure requires the placement of 500 linear feet of pedestrian railing along the walkway for fall protection. It is assumed that the railing is fabricated by an offsite source and is delivered to the job site. It is estimated that the railing is placed by a crew consisting of a crane, man lift, steel workers, and laborers.
- Upstream and downstream adjacent to the structure riprap is required for scour protection. The area south of the structure is filled and graded, but not protected with rock as is the cast for the upstream area beyond the structure apron. The riprap is assumed to be 21" dumped rock for all areas and is obtained from the rip rap operations associated with the main levee construction.

Upstream Construction / San Acacia Diversion Dam Improvements

Soil Cement Armoring

- Quantities and area to be armored were provided by the local District General Engineering Section. It is assumed that approximately 1500' of the area to be soil cement protected requires the diversion of the river in the area. It is assumed that the diversion will be accomplished using a portable dam system in conjunction with a well dewatering operation. It is also assumed that the channel widening will be done before this diversion takes place to provide a larger area for the diverted water to flow in. It is estimated that the diversion will be in place for approximately 3 months to include time for setup / teardown and completion of the armoring work.
- It is estimated that the construction of the soil cement armoring requires the clearing and grubbing trees and small brush. Trees are chipped and disposed of at a local landfill, within a thirty mile radius of the job site. Clearing and grubbing activities are accomplished using a crew consisting of hydraulic excavator, bulldozer, front end loader, chipper, dump trucks, and laborers.
- It is assumed that 314,247 cubic yards of excavation is required in order to place the soil cement at the required scour depth. The material is removed using a bulldozer and temporarily stockpiled adjacent to the work area. The crew consists of a tracked bulldozer with operator. The crew operates at an assumed productivity rate of 70 cubic yards per hour.
- A total of 95,079 cubic yards of soil cement mixture is required to be placed and compacted to construct the armoring in the vicinity of the San Acacia Diversion Dam. The soil cement is batched at an on-site batch plant with local soil and imported cement and trucked to the placement location. It is assumed that the soil cement is placed utilizing an excavator taking material from a bedding box loaded by a loader. The material will be compacted on the slope using a smooth drum roller and a deadman and

winch system. It is estimated that material can be placed at a rate of 80 cubic yards per hour.

Roller Compacted Concrete Armoring

- Roller Compacted Concrete armoring is required in the vicinity of the San Acacia diversion outlet to the irrigation system. Approximately 5,764 cubic yards of material is excavated by bulldozer from the area requiring RCC armoring. The bulk of the material is hauled off by the main levee construction operation.
- Detailed design is not available at this design stage so the estimate assumes that the roller compacted concrete cap is constructed in 1' lifts at a width possible to lay down with a paving machine. Compaction of the material is done by a double drum roller after placement.
- The concrete required for the RCC is provided by an on-site batch plant located in the vicinity of the worksite and material is trucked from the batch plant to the laydown machine. The placement of the RCC is done at an assumed productivity rate of 100 cubic yards per hour.

Concrete Floodwall

- The upstream construction features also include the construction of a concrete floodwall. Current drawings depict the general layout of the wall and quantities were derived from this and a draft cross-section of the wall by the Cost Engineering Section. Detailed reinforcement drawings are not available so the estimate assumes a reinforcement density.
- The concrete floodwall is assumed to have a cross sectional area of 109 square feet. The footing of the structure is cast first followed the by the wall. A waterstop is assumed to be required to be installed in the construction joint between the wall foundation and the wall. The floodwall also includes a 2 ft x 2 ft toe drain.
- It is assumed that 100 pounds of steel reinforcing will be required per cubic yard of concrete. A factor of 12 percent will be included to account for high chairs, tie wire, laps, and waste. The material required for the reinforcing is purchased from an area supplier and delivered to the job site.
- Wooden forms are used for forming the structure. A 12 percent factor is allowed for waste, braces, etc. All of the material required for the formwork is purchased from an area supplier. It is estimated that a crew consisting of 3 carpenters and a laborer is used for the formwork operation.
- Concrete is be produced at the batch plant on site. A factor of 8 percent is included to account for losses and waste. It is estimated that a crew consisting of masons and laborers will be utilized for the placing of the concrete along with a pump and operator.

Culvert Extensions

- The design calls for 5 existing 7’ x 7’ concrete box culverts to be extended approximately 380 feet to allow the construction of the proposed floodwall. The culverts are assumed to be cast in place and require steel reinforcing. This portion of the work also includes the extension of approximately 65 feet of an existing 5 feet (diameter) corrugated metal pipe. It is assumed that all supplies and material are purchased from an area supplier and are delivered to the job site.

2. COST ESTIMATE

2.1 MCACES COST ESTIMATE

The general intent in the preparation of the project baseline cost estimate was to create an independent, detailed estimate reflective of the level of design available at the time of preparation. The estimate is ordered at the upper level into the planned phases for construction. Below the phase level the estimate is organized into the Civil Works Breakdown Structure in accordance with ETL 1110-2-573. The estimate was prepared using the current MCACES Unit Price Book, the current MII Equipment Region 6 database (2009) and current Davis-Bacon Wage Rates for Heavy Construction in Socorro County (06 Jan 2012). All costs are current as of the estimate preparation date (Feb 2012).

Total Project Cost for Alternative A Base + 4 feet is estimated to be $290,237,000 with contingency and escalation included. A summary of the estimate breakdown per cost account is included as Table 2. The Total Project Cost Summary sheet is included showing the total project cost with contingency escalated through planned project completion as Table 3.

3. RISK ANALYSIS

3.1 COST AND SCHEDULE RISK ANALYSIS

A formal risk analysis was performed on the selected plan and the results of the analysis are included in this appendix as a separate attachment. The analysis was started by gathering a team consisting of PDT members and Cost Engineering personnel. The team identified various project elements where uncertainties exist which could impact the estimated total project schedule and/or cost.

These items were assembled into a risk register and each item was assigned a value for the likeliness of occurrence and the amount of possible impact the item could have on the project cost and project schedule relative to the current cost estimate assumptions. Items deemed by the

team to rate a “moderate” or higher risk were then further analyzed by producing anticipated best case, worse case and most likely values.

This data was then processed using Crystal Ball software by the Cost Engineering DX to produce the final risk analysis reports. Contingency is applied at 15.8% to the estimate representing the value with an 80% confidence of successful execution and completion. The complete Cost and Schedule Risk Analysis is included as a separate report to this appendix.

SCHEDULE FOR DESIGN AND CONSTRUCTION

1. PROJECT SCHEDULE

1.1 GENERAL

The San Acacia Levee Improvements is projected to have an overall project duration of 20 years. Microsoft Project 2007 critical path method design and construction schedules are included in the appendix as Fig 1 for design details and Fig 2 for construction details. The duration of the project is dictated by the anticipated amount of annual funding received each year. Design for each phase is assumed to take place the fiscal quarters before the construction of each phase. Design of Phase 1 of the project is planned for the 3rd and 4th quarters of fiscal year 2012 with a Phase 1 contract award and Notice to Proceed in the first quarter of fiscal year 2013. Each phase is assumed to follow in sequential order each following year until all phases are complete.

Due to funding controlling the amount of work completed each phase, the overall project schedule is relatively immune to delays and typical schedule risks. It is anticipated that a medium sized contractor will have ample time each phase to complete the required work. Schedule delays within the phase are unlikely to delay work past the scheduled end of the phase. If such a delay was to occur, the delayed work would not affect work on the subsequent phase because of the large distances between work areas and a subsequent phase's work not being dependent on the previous phase being complete. This same reasoning makes it possible to not receive funding during a year and make it up in following years by awarding multiple phases in a single year.

These scenarios are taken into account in the risk analysis for the cost and schedule and the result is a schedule that is at low risk of being delayed overall. This in turn results in low risk to the cost increasing because of schedule delays due to the many opportunities available to complete work without affecting the final completion date.

1.2 DESIGN SCHEDULE

The design schedule is phased to follow the overall project phasing with each construction phase being designed in the period before award. Phase design is expected to be repetitive in nature and will generally involve taking each 35% design through to completion without major revisions. It is anticipated that each design will require approximately 140 working days to complete and is assumed to be designed and advertised by local District personnel. The schedule as depicted is also based on a normal 40 hour 5 day workweek inclusive of normal holidays.

For similar reasons as stated in 1.1 General the overall design schedule is also flexible and not easily delayed. There are multiple opportunities to design phases throughout the project and the designs are relatively independent from one another. The risk analysis shows that design delays have little chance of creating a delay to the total project completion. A printout of the detailed

design schedule is included as Fig 1. In this figure the construction activities are reduced to a summary bar to aid readability.

1.3 CONSTRUCTION SCHEDULE

The construction schedule is broken into 20 phases with each phase controlled by the amount of anticipated funding for each year. The phase 1 construction is planned for an early fiscal year 2013 first quarter notice to proceed with each phase following in turn each fiscal year through to project completion. This results in a final project completion in June 2032. A printout of the estimated construction schedule detail is included as Fig 2. In this figure the design activities are reduced to a summary bar in each phase to aid readability.

Construction activities for the schedule mirror the construction activities from the cost estimate. The durations for each of the activities are also derived from the production rates and quantities used in the cost estimate. A spreadsheet was used to take the production rate and quantity for each activity and calculate a workday duration for the activity. This value is then used in the schedule.

Logic was created in the schedule to reflect the anticipated construction pattern in each phase. Activities are expected to flow from initial clearing to existing levee excavation, material processing and then new levee fill construction. During the fill construction the levee slurry trench and drainage features will be installed. Riprap installation is the last item to be installed when completing a portion of levee. This order of activities is expected to be followed as each levee piece is constructed within a phase. The phase fully completes when the entire levee is constructed and the area is stabilized by seeding. The schedule logic contains many start to start and finish to finish relationships with appropriate lag as the majority of items will start shortly after the preceding operation is far enough ahead. In the same vein the majority of activities cannot complete without the preceding activity having been completed a few days ahead. The activity that tends to drive this logic is the fill construction of the new levee. Only a couple of phases have construction that is independent of the main levee construction. This dependence of activities on the main levee fill construction means that the prime contractor will be controlling the overall pace of the work and the time that subcontractors will be on site. Opportunities for subcontractors to finish work at a separate pace generally do not exist.

When the estimate production rates are input into the schedule it is apparent that ample time is available for each phase to be completed. This is without making assumptions that multiple crews are performing the same activity in different locations at the same time. The schedule as depicted is also based on a normal 40 hour 5 day workweek inclusive of normal holidays. The time available creates a low risk that production or other schedule delays can adversely affect the overall project schedule as the contractor has opportunity to work multiple levee pieces at the same time as well as shift work or overtime to make up for delays.

Outside influences are also considered in the schedule. The project is located in an area where warm year round temperatures allow all year construction so winter shutdowns are very unlikely. Endangered species are a factor, but if they are present are felt to likely only affect a small portion of a phase temporarily (during a nesting season). The phase construction will be able to continue around the area. There is potential for construction to be delayed by rainfall events, but outside of a catastrophic flood event delays should be limited to a few days which can easily be made up given the time available in the schedule. These items are addressed in the risk register and are inputs to the full Cost and Schedule Risk Analysis which is provided as a separate attachment to this appendix.

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: San Acacia Levee Improvements
LOCATION: Socorro County, New Mexico

DISTRICT: SPA Albuquerque, NM PREPARED: 3/16/2012
POC: CHIEF, COST ENGINEERING, Michael Prudhomme

This Estimate reflects the scope and schedule in report; San Acacia Levee Improvements - GRR - 2012

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	BASE COST TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	FIRST COST TOTAL ($K)	FULLY FUNDED PROJECT ESTIMATE Spent Thru: 1-Jan-12 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
02	RELOCATIONS	$2,437	$385	15.8%	$2,822	1.2%	$2,467	$390	**$2,856**			$3,004	$475	$3,478
09	CHANNELS & CANALS	$4,111	$650	15.8%	$4,761	1.2%	$4,161	$657	**$4,818**			$4,739	$749	$5,488
11	LEVEES & FLOODWALLS	$163,264	$25,796	15.8%	$189,060	1.2%	$165,241	$26,108	**$191,349**	$ 12,511		$194,954	$30,803	$238,268
			-			-								
			-			-								
	CONSTRUCTION ESTIMATE TOTALS:	$169,812	$26,830		**$196,642**	1.2%	$171,868	$27,155	**$199,023**	12,511		$202,697	$32,026	$247,234
01	LANDS AND DAMAGES*	$1,017	$305	30.0%	$1,322	1.2%	$1,029	$309	**$1,338**			$1,158	$348	$1,506
30	PLANNING, ENGINEERING & DESIGN	$9,022	$1,425	15.8%	$10,447	2.2%	$9,220	$1,457	**$10,677**			$12,930	$2,043	$14,973
31	CONSTRUCTION MANAGEMENT	$15,600	$2,465	15.8%	$18,065	2.2%	$15,942	$2,519	**$18,461**			$22,905	$3,619	$26,524
	PROJECT COST TOTALS:	$195,451	$31,026	15.9%	**$226,477**	1.3%	$198,059	$31,440	**$229,499**	12,511		$239,690	$38,036	$290,237

* Lands and Damages Cost contingency applied by Real Estate

ESTIMATED FEDERAL COST:	85.74%	**$238,122**
ESTIMATED NON-FEDERAL COST:	14.26%	**$52,115**
ESTIMATED TOTAL PROJECT COST:		**$290,237**

_____ CHIEF, COST ENGINEERING, Michael Prudhomme

_____ PROJECT MANAGER, Jerry Nieto

_____ CHIEF, REAL ESTATE, Karen Kennedy

_____ CHIEF, PLANNING, Kristopher Schafer

_____ CHIEF, ENGINEERING, Ben Alanis

_____ CHIEF, CONSTRUCTION, Carlos Salazar

O&M OUTSIDE OF TOTAL PROJECT COST: $0

**** CONTRACT COST SUMMARY ****

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: San Acacia Levee Improvements
LOCATION: Socorro County, New Mexico
This Estimate reflects the scope and schedule in report; San Acacia Levee Improvements - GRR - 2012

DISTRICT: SPA Albuquerque, NM PREPARED: 3/16/2012
POC: CHIEF, COST ENGINEERING, Michael Prudhomme

Estimate Prepared: 9-Mar-12
Effective Price Level: 1 OCT 12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

WBS NUMBER	Civil Works Feature & Sub-Feature Description	RISK BASED COST ($K)	RISK BASED CNTG ($K)	RISK BASED CNTG (%)	RISK BASED TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FULLY FUNDED PROJECT ESTIMATE Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$9,546	$1,508	15.8%	$11,054	1.21%	$9,662	$1,527	$11,188	2013Q2	0.4%	$9,700	$1,533	$11,233
	CONSTRUCTION ESTIMATE TOTALS:	$9,546	$1,508	15.8%	**$11,054**		$9,662	$1,527	$11,188			$9,700	$1,533	$11,233
01	LANDS AND DAMAGES	$362	$109	30.0%	$471	1.21%	$367	$110	$477	2013Q2	0.4%	$368	$110	$479
30	PLANNING, ENGINEERING & DESIGN	$453	$72	15.8%	$525	2.19%	$463	$73	$536	2013Q1		$463	$73	$536
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.19%	$797	$126	$923	2013Q2	0.7%	$803	$127	$930
	CONTRACT COST TOTALS:	$11,141	$1,812		**$12,953**		$11,288	$1,836	$13,124			$11,334	$1,843	**$13,177**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: San Acacia Levee Improvements
LOCATION: Socorro County, New Mexico
This Estimate reflects the scope and schedule in report; San Acacia Levee Improvements - GRR - 2012

DISTRICT: SPA Albuquerque, NM PREPARED: 3/16/2012
POC: CHIEF, COST ENGINEERING, Michael Prudhomme

Estimate Prepared: 9-Mar-12
Effective Price Level: 1 OCT 12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 2													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$8,715	$1,377	15.8%	$10,092	1.2%	$8,821	$1,394	$10,214	2014Q2	2.1%	$9,005	$1,423	$10,428
	CONSTRUCTION ESTIMATE TOTALS:	$8,715	$1,377	15.8%	**$10,092**		$8,821	$1,394	$10,214			$9,005	$1,423	$10,428
01	LANDS AND DAMAGES	$47	$14	30.0%	$61	1.2%	$47	$14	$62	2014Q2	2.1%	$48	$15	$63
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2013Q3	1.8%	$469	$74	$543
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2014Q2	5.1%	$838	$132	$970
	CONTRACT COST TOTALS:	$9,993	$1,586		**$11,578**		$10,126	$1,607	$11,733			$10,361	$1,644	**$12,005**

**** TOTAL PROJECT COST SUMMARY ****

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DISTRICT: SPA Albuquerque, NM PREPARED: 3/16/2012
POC: CHIEF, COST ENGINEERING, Michael Prudhomme

Estimate Prepared: 9-Mar-12
Effective Price Level: 1 OCT 12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 3													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$11,111	$1,756	15.8%	$12,867	1.2%	$11,246	$1,777	$13,022	2015Q2	3.8%	$11,676	$1,845	$13,521
	CONSTRUCTION ESTIMATE TOTALS:	$11,111	$1,756	15.8%	**$12,867**		$11,246	$1,777	$13,022			$11,676	$1,845	$13,521
01	LANDS AND DAMAGES	$25	$8	30.0%	$33	1.2%	$26	$8	$33	2015Q2	3.8%	$27	$8	$35
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2014Q3	6.2%	$489	$77	$567
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2015Q2	9.4%	$872	$138	$1,010
	CONTRACT COST TOTALS:	$12,367	$1,958		**$14,325**		$12,529	$1,983	$14,512			$13,064	$2,068	**$15,132**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: San Acacia Levee Improvements
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This Estimate reflects the scope and schedule in report; San Acacia Levee Improvements - GRR - 2012

DISTRICT: SPA Albuquerque, NM PREPARED: 3/16/2012
POC: CHIEF, COST ENGINEERING, Michael Prudhomme

Estimate Prepared: 9-Mar-12
Effective Price Level: 1 OCT 12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 4													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$8,249	$1,303	15.8%	$9,552	1.2%	$8,349	$1,319	$9,668	2016Q2	5.6%	$8,816	$1,393	$10,209
	CONSTRUCTION ESTIMATE TOTALS:	$8,249	$1,303	15.8%	**$9,552**		$8,349	$1,319	$9,668			$8,816	$1,393	$10,209
01	LANDS AND DAMAGES	$42	$13	30.0%	$55	1.2%	$43	$13	$56	2016Q2	5.6%	$45	$14	$59
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2015Q3	10.5%	$509	$80	$590
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2016Q2	13.8%	$907	$143	$1,050
	CONTRACT COST TOTALS:	$9,522	$1,511		**$11,033**		$9,650	$1,531	$11,180			$10,278	$1,630	**$11,908**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

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This Estimate reflects the scope and schedule in report; San Acacia Levee Improvements - GRR - 2012

DISTRICT: SPA Albuquerque, NM PREPARED: 3/16/2012
POC: CHIEF, COST ENGINEERING, Michael Prudhomme

Estimate Prepared: 9-Mar-12
Effective Price Level: 1 OCT 12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 5													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$7,996	$1,263	15.8%	$9,259	1.2%	$8,093	$1,279	$9,371	2017Q2	7.5%	$8,698	$1,374	$10,073
	CONSTRUCTION ESTIMATE TOTALS:	$7,996	$1,263	15.8%	**$9,259**		$8,093	$1,279	$9,371			$8,698	$1,374	$10,073
01	LANDS AND DAMAGES	$18	$5	30.0%	$23	1.2%	$18	$5	$23	2017Q2	7.5%	$19	$6	$25
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2016Q3	14.9%	$529	$84	$613
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2017Q2	18.2%	$942	$149	$1,091
	CONTRACT COST TOTALS:	$9,245	$1,463		**$10,708**		$9,369	$1,483	$10,852			$10,189	$1,613	**$11,802**

**** TOTAL PROJECT COST SUMMARY ****

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Estimate Prepared: 9-Mar-12
Effective Price Level: 1 OCT 12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 6													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$7,935	$1,254	15.8%	$9,189	1.2%	$8,031	$1,269	$9,300	2018Q2	9.4%	$8,788	$1,388	$10,176
	CONSTRUCTION ESTIMATE TOTALS:	$7,935	$1,254	15.8%	**$9,189**		$8,031	$1,269	$9,300			$8,788	$1,388	$10,176
01	LANDS AND DAMAGES	$50	$15	30.0%	$65	1.2%	$51	$15	$66	2018Q2	9.4%	$55	$17	$72
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2017Q3	19.3%	$550	$87	$637
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2018Q2	22.6%	$977	$154	$1,131
	CONTRACT COST TOTALS:	$9,216	$1,463		**$10,679**		$9,340	$1,483	$10,823			$10,369	$1,646	**$12,016**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: San Acacia Levee Improvements
LOCATION: Socorro County, New Mexico
This Estimate reflects the scope and schedule in report; San Acacia Levee Improvements - GRR - 2012

DISTRICT: SPA Albuquerque, NM PREPARED: 3/16/2012
POC: CHIEF, COST ENGINEERING, Michael Prudhomme

Estimate Prepared: 9-Mar-12
Effective Price Level: 1 OCT 12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 7													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$7,721	$1,220	15.8%	$8,941	1.2%	$7,814	$1,235	$9,049	2019Q2	11.4%	$8,704	$1,375	$10,080
	CONSTRUCTION ESTIMATE TOTALS:	$7,721	$1,220	15.8%	**$8,941**		$7,814	$1,235	$9,049			$8,704	$1,375	$10,080
01	LANDS AND DAMAGES	$51	$15	30.0%	$66	1.2%	$51	$15	$67	2019Q2	11.4%	$57	$17	$74
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2018Q3	23.7%	$570	$90	$660
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2019Q2	26.9%	$1,012	$160	$1,172
	CONTRACT COST TOTALS:	$9,003	$1,430		**$10,432**		$9,124	$1,449	$10,573			$10,343	$1,642	**$11,986**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: San Acacia Levee Improvements
LOCATION: Socorro County, New Mexico
This Estimate reflects the scope and schedule in report; San Acacia Levee Improvements - GRR - 2012

DISTRICT: SPA Albuquerque, NM PREPARED: 3/16/2012
POC: CHIEF, COST ENGINEERING, Michael Prudhomme

Estimate Prepared: 9-Mar-12
Effective Price Level: 1 OCT 12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 8													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS	$4,111	$650	15.8%	$4,761	1.2%	$4,161	$657	$4,818	2020Q3	13.9%	$4,739	$749	$5,488
11	LEVEES & FLOODWALLS	$17,908	$2,829	15.8%	$20,737	1.2%	$18,125	$2,864	$20,989	2020Q3	13.9%	$20,645	$3,262	$23,907
	CONSTRUCTION ESTIMATE TOTALS:	$22,019	$3,479	15.8%	**$25,498**		$22,286	$3,521	$25,807			$25,385	$4,011	$29,395
01	LANDS AND DAMAGES	$32	$9	30.0%	$41	1.2%	$32	$10	$41	2020Q2	13.4%	$36	$11	$47
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2019Q3	28.1%	$590	$93	$683
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2020Q3	32.5%	$1,057	$167	$1,223
	CONTRACT COST TOTALS:	$23,282	$3,683		**$26,965**		$23,576	$3,729	$27,305			$27,067	$4,282	**$31,349**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

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DISTRICT: SPA Albuquerque, NM PREPARED: 3/16/2012
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FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 9													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$7,385	$1,167	15.8%	$8,552	1.2%	$7,474	$1,181	$8,655	2021Q2	15.4%	$8,628	$1,363	$9,991
	CONSTRUCTION ESTIMATE TOTALS:	$7,385	$1,167	15.8%	**$8,552**		$7,474	$1,181	$8,655			$8,628	$1,363	$9,991
01	LANDS AND DAMAGES	$32	$10	30.0%	$42	1.2%	$33	$10	$43	2021Q2	15.4%	$38	$11	$49
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2020Q3	32.5%	$611	$97	$707
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2021Q2	35.9%	$1,083	$171	$1,255
	CONTRACT COST TOTALS:	$8,648	$1,371		**$10,019**		$8,765	$1,390	$10,155			$10,360	$1,642	**$12,002**

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Program Year (Budget EC): 2013
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FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 10													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$6,955	$1,099	15.8%	$8,054	1.2%	$7,039	$1,112	$8,151	2022Q2	17.5%	$8,272	$1,307	$9,579
	CONSTRUCTION ESTIMATE TOTALS:	$6,955	$1,099	15.8%	**$8,054**		$7,039	$1,112	$8,151			$8,272	$1,307	$9,579
01	LANDS AND DAMAGES	$33	$10	30.0%	$43	1.2%	$33	$10	$44	2022Q2	17.5%	$39	$12	$51
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2021Q3	37.0%	$632	$100	$731
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2022Q2	40.4%	$1,119	$177	$1,296
	CONTRACT COST TOTALS:	$8,219	$1,303		**$9,522**		$8,331	$1,321	$9,652			$10,062	$1,595	**$11,657**

**** TOTAL PROJECT COST SUMMARY ****

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Program Year (Budget EC): 2013
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FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 11													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$6,867	$1,085	15.8%	$7,952	1.2%	$6,950	$1,098	$8,048	2023Q2	19.6%	$8,314	$1,314	$9,628
	CONSTRUCTION ESTIMATE TOTALS:	$6,867	$1,085	15.8%	**$7,952**		$6,950	$1,098	$8,048			$8,314	$1,314	$9,628
01	LANDS AND DAMAGES	$38	$11	30.0%	$49	1.2%	$38	$11	$50	2023Q2	19.6%	$46	$14	$59
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2022Q3	41.5%	$652	$103	$755
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2023Q2	45.0%	$1,156	$183	$1,338
	CONTRACT COST TOTALS:	$8,136	$1,291		**$9,426**		$8,246	$1,308	$9,555			$10,168	$1,613	**$11,781**

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Program Year (Budget EC): 2013
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FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 12													
02	RELOCATIONS	$2,437	$385	15.8%	$2,822	1.2%	$2,467	$390	$2,856	2024Q2	21.8%	$3,004	$475	$3,478
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$4,335	$685	15.8%	$5,020	1.2%	$4,387	$693	$5,081	2024Q2	21.8%	$5,343	$844	$6,187
	CONSTRUCTION ESTIMATE TOTALS:	$6,772	$1,070	15.8%	**$7,842**		$6,854	$1,083	$7,937			$8,347	$1,319	$9,666
01	LANDS AND DAMAGES	$24	$7	30.0%	$31	1.2%	$24	$7	$31	2024Q2	21.8%	$29	$9	$38
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2023Q3	46.1%	$674	$106	$780
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2024Q2	49.6%	$1,193	$188	$1,381
	CONTRACT COST TOTALS:	$8,027	$1,272		**$9,298**		$8,136	$1,289	$9,425			$10,243	$1,623	**$11,865**

****** TOTAL PROJECT COST SUMMARY ******

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Program Year (Budget EC): 2013
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FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 13													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$6,808	$1,076	15.8%	$7,884	1.2%	$6,890	$1,089	$7,979	2025Q2	24.0%	$8,542	$1,350	$9,892
	CONSTRUCTION ESTIMATE TOTALS:	$6,808	$1,076	15.8%	**$7,884**		$6,890	$1,089	$7,979			$8,542	$1,350	$9,892
01	LANDS AND DAMAGES	$34	$10	30.0%	$44	1.2%	$34	$10	$45	2025Q2	24.0%	$42	$13	$55
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2024Q3	50.8%	$695	$110	$805
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2025Q2	54.3%	$1,230	$194	$1,424
	CONTRACT COST TOTALS:	$8,073	$1,280		**$9,353**		$8,183	$1,298	$9,480			$10,510	$1,667	**$12,176**

****** TOTAL PROJECT COST SUMMARY ******

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FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 14													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$6,571	$1,038	15.8%	$7,609	1.2%	$6,651	$1,051	$7,701	2026Q2	26.2%	$8,393	$1,326	$9,719
	CONSTRUCTION ESTIMATE TOTALS:	$6,571	$1,038	15.8%	**$7,609**		$6,651	$1,051	$7,701			$8,393	$1,326	$9,719
01	LANDS AND DAMAGES	$32	$10	30.0%	$42	1.2%	$33	$10	$43	2026Q2	26.2%	$41	$12	$54
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2025Q3	55.5%	$717	$113	$830
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2026Q2	59.1%	$1,268	$200	$1,468
	CONTRACT COST TOTALS:	$7,834	$1,242		**$9,077**		$7,941	$1,259	$9,201			$10,419	$1,652	**$12,072**

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FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 15													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$6,549	$1,035	15.8%	$7,584	1.2%	$6,628	$1,047	$7,676	2027Q2	28.5%	$8,516	$1,345	$9,861
	CONSTRUCTION ESTIMATE TOTALS:	$6,549	$1,035	15.8%	**$7,584**		$6,628	$1,047	$7,676			$8,516	$1,345	$9,861
01	LANDS AND DAMAGES	$34	$10	30.0%	$44	1.2%	$34	$10	$45	2027Q2	28.5%	$44	$13	$57
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2026Q3	60.3%	$739	$117	$856
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2027Q2	63.9%	$1,307	$206	$1,513
	CONTRACT COST TOTALS:	$7,814	$1,239		**$9,053**		$7,921	$1,256	$9,177			$10,605	$1,682	**$12,287**

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FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 16													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$11,041	$1,744	15.8%	$12,785	1.2%	$11,175	$1,766	$12,940	2028Q2	30.8%	$14,615	$2,309	$16,924
	CONSTRUCTION ESTIMATE TOTALS:	$11,041	$1,744	15.8%	**$12,785**		$11,175	$1,766	$12,940			$14,615	$2,309	$16,924
01	LANDS AND DAMAGES	$50	$15	30.0%	$65	1.2%	$51	$15	$66	2028Q2	30.8%	$66	$20	$86
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2027Q3	65.2%	$761	$120	$882
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2028Q2	68.9%	$1,346	$213	$1,559
	CONTRACT COST TOTALS:	$12,322	$1,954		**$14,276**		$12,483	$1,980	$14,463			$16,789	$2,662	**$19,451**

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WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 17													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$6,153	$972	15.8%	$7,125	1.2%	$6,228	$984	$7,211	2029Q2	33.1%	$8,291	$1,310	$9,601
	CONSTRUCTION ESTIMATE TOTALS:	$6,153	$972	15.8%	**$7,125**		$6,228	$984	$7,211			$8,291	$1,310	$9,601
01	LANDS AND DAMAGES	$38	$11	30.0%	$49	1.2%	$38	$11	$50	2029Q2	33.1%	$51	$15	$66
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2028Q3	70.2%	$784	$124	$908
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2029Q2	74.0%	$1,387	$219	$1,606
	CONTRACT COST TOTALS:	$7,422	$1,178		**$8,600**		$7,524	$1,194	$8,718			$10,513	$1,668	**$12,182**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

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WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 18													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$5,967	$943	15.8%	$6,910	1.2%	$6,039	$954	$6,993	2030Q2	35.5%	$8,186	$1,293	$9,479
	CONSTRUCTION ESTIMATE TOTALS:	$5,967	$943	15.8%	**$6,910**		$6,039	$954	$6,993			$8,186	$1,293	$9,479
01	LANDS AND DAMAGES	$28	$9	30.0%	$37	1.2%	$29	$9	$37	2030Q2	35.5%	$39	$12	$51
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2029Q3	75.3%	$808	$128	$935
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2030Q2	79.1%	$1,428	$226	$1,653
	CONTRACT COST TOTALS:	$7,226	$1,146		**$8,372**		$7,326	$1,162	$8,488			$10,460	$1,658	**$12,118**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: San Acacia Levee Improvements
LOCATION: Socorro County, New Mexico
This Estimate reflects the scope and schedule in report; San Acacia Levee Improvements - GRR - 2012

DISTRICT: SPA Albuquerque, NM PREPARED: 3/16/2012
POC: CHIEF, COST ENGINEERING, Michael Prudhomme

Estimate Prepared: 9-Mar-12
Effective Price Level: 1 OCT 12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 19													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$5,886	$930	15.8%	$6,816	1.2%	$5,957	$941	$6,899	2031Q2	38.0%	$8,220	$1,299	$9,518
	CONSTRUCTION ESTIMATE TOTALS:	$5,886	$930	15.8%	**$6,816**		$5,957	$941	$6,899			$8,220	$1,299	$9,518
01	LANDS AND DAMAGES	$28	$8	30.0%	$36	1.2%	$28	$8	$36	2031Q2	38.0%	$39	$12	$50
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2030Q3	80.4%	$832	$131	$963
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2031Q2	84.4%	$1,470	$232	$1,702
	CONTRACT COST TOTALS:	$7,145	$1,133		**$8,277**		$7,243	$1,148	$8,392			$10,560	$1,674	**$12,233**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: San Acacia Levee Improvements
LOCATION: Socorro County, New Mexico
This Estimate reflects the scope and schedule in report; San Acacia Levee Improvements - GRR - 2012

DISTRICT: SPA Albuquerque, NM PREPARED: 3/16/2012
POC: CHIEF, COST ENGINEERING, Michael Prudhomme

Estimate Prepared: 9-Mar-12
Effective Price Level: 1 OCT 12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 20													
02	RELOCATIONS			15.8%										
09	CHANNELS & CANALS			15.8%										
11	LEVEES & FLOODWALLS	$9,566	$1,511	15.8%	$11,077	1.2%	$9,682	$1,530	$11,212	2032Q2	40.5%	$13,599	$2,149	$15,748
	CONSTRUCTION ESTIMATE TOTALS:	$9,566	$1,511	15.8%	**$11,077**		$9,682	$1,530	$11,212			$13,599	$2,149	$15,748
01	LANDS AND DAMAGES	$19	$6	30.0%	$25	1.2%	$19	$6	$25	2032Q2	40.5%	$27	$8	$36
30	PLANNING, ENGINEERING & DESIGN	$451	$71	15.8%	$522	2.2%	$461	$73	$534	2031Q3	85.7%	$856	$135	$991
31	CONSTRUCTION MANAGEMENT	$780	$123	15.8%	$903	2.2%	$797	$126	$923	2032Q2	89.7%	$1,512	$239	$1,751
	CONTRACT COST TOTALS:	$10,816	$1,712		**$12,528**		$10,959	$1,734	$12,694			$15,995	$2,531	**$18,526**

San Acacia Alt A Base +4
Rio Grande Floodway
San Acacia Levee Improvements Alternative A Base +4
Socorro County, New Mexico

This project consists of constructing approximately 41.7 miles of engineered levee along the Rio Grande in central New Mexico. The project will extend on the west bank of the Rio Grande from the upper end of the U.S. Bureau of Reclamation's low-flow conveyance channel at the San Acacia Diversion Dam to the Tiffany Basin which is roughly 28 miles from the end of the conveyance channel at Elephant Butte Reservoir. The estimate represents the cost to construct Alternative A Base +4 which is the Tentatively Selected Plan.

Estimated by	P. Gonzalez, B. Davis, J. Crooker-Flint
Designed by	USACE Albuquerque District
Prepared by	P. Gonzalez, B. Davis, J. Crooker-Flint
Preparation Date	3/14/2012
Effective Date of Pricing	1/13/2012
Estimated Construction Time	7,300 Days

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Description	UOM	Quantity	CostToPrime	PrimeCMU	ContractCost	Contingency	Escalation	ProjectCost
SUMMARY			**135,083,191.47**	**59,335,358.76**	**195,741,454.51**	**30,718,130.94**	**51,294,689.09**	**277,754,274.54**
Alternative A	**EA**	**1.0000**	**135,083,191.47**	**59,335,358.76**	**195,741,454.51**	**30,718,130.94**	**51,294,689.09**	**277,754,274.54**
Base Levee +4	**EA**	**1.0000**	**135,083,191.47**	**59,335,358.76**	**195,741,454.51**	**30,718,130.94**	**51,294,689.09**	**277,754,274.54**
Phase 1 - Sta 645+00 to 800+00	**LS**	**1.0000**	**7,530,624.86**	**3,247,393.00**	**11,249,281.67**	**1,702,926.82**	**223,309.24**	**13,175,517.74**
Lands and Damages	**LS**	**1.0000**	**0.00**	**0.00**	**471,263.81**	**0.00**	**7,587.35**	**478,851.16**
Levees and Floodwalls	**LS**	**1.0000**	**7,017,130.40**	**2,528,500.77**	**9,545,631.17**	**1,508,209.73**	**177,966.84**	**11,231,807.73**
Planning Engineering and Design	**LS**	**1.0000**	**188,586.55**	**264,021.18**	**452,607.73**	**71,512.02**	**11,478.22**	**535,597.97**
Construction Management	**LS**	**1.0000**	**324,907.90**	**454,871.06**	**779,778.96**	**123,205.08**	**26,276.84**	**929,260.87**
Phase 2 - Sta 800+00 to 950+00	**LS**	**1.0000**	**6,918,863.51**	**3,026,071.96**	**10,006,068.27**	**1,571,299.80**	**425,057.32**	**12,002,425.40**
Lands and Damages	**LS**	**1.0000**	**0.00**	**0.00**	**61,132.80**	**0.00**	**2,029.61**	**63,162.41**
Levees and Floodwalls	**LS**	**1.0000**	**6,406,218.84**	**2,308,369.42**	**8,714,588.27**	**1,376,904.95**	**335,037.57**	**10,426,530.79**
Planning Engineering and Design	**LS**	**1.0000**	**187,736.77**	**262,831.47**	**450,568.24**	**71,189.78**	**21,079.02**	**542,837.05**
Construction Management	**LS**	**1.0000**	**324,907.90**	**454,871.06**	**779,778.96**	**123,205.08**	**66,911.12**	**969,895.15**
Phase 3 - Sta 950+00 to 1030+00	**LS**	**1.0000**	**8,680,207.10**	**3,660,741.46**	**12,373,552.72**	**1,949,869.87**	**802,493.62**	**15,125,916.21**
Lands and Damages	**LS**	**1.0000**	**0.00**	**0.00**	**32,604.16**	**0.00**	**1,646.51**	**34,250.67**
Levees and Floodwalls	**LS**	**1.0000**	**8,167,562.43**	**2,943,038.92**	**11,110,601.35**	**1,755,475.01**	**649,736.86**	**13,515,813.22**
Planning Engineering and Design	**LS**	**1.0000**	**187,736.77**	**262,831.47**	**450,568.24**	**71,189.78**	**44,558.14**	**566,316.16**
Construction Management	**LS**	**1.0000**	**324,907.90**	**454,871.06**	**779,778.96**	**123,205.08**	**106,552.12**	**1,009,536.15**
Phase 4 - Sta 145+00 to 262+00	**LS**	**1.0000**	**6,576,306.23**	**2,902,637.41**	**9,534,061.46**	**1,497,673.09**	**873,689.40**	**11,905,423.95**
Lands and Damages	**LS**	**1.0000**	**0.00**	**0.00**	**55,117.82**	**0.00**	**3,781.08**	**58,898.90**
Levees and Floodwalls	**LS**	**1.0000**	**6,063,661.56**	**2,184,934.87**	**8,248,596.44**	**1,303,278.24**	**655,258.60**	**10,207,133.28**
Planning Engineering and Design	**LS**	**1.0000**	**187,736.77**	**262,831.47**	**450,568.24**	**71,189.78**	**67,463.31**	**589,221.34**
Construction Management	**LS**	**1.0000**	**324,907.90**	**454,871.06**	**779,778.96**	**123,205.08**	**147,186.40**	**1,050,170.43**
Phase 5 - Sta 262+00 to 319+00	**LS**	**1.0000**	**6,390,481.74**	**2,835,678.79**	**9,249,390.99**	**1,457,733.36**	**1,094,684.51**	**11,801,808.86**
Lands and Damages	**LS**	**1.0000**	**0.00**	**0.00**	**23,230.46**	**0.00**	**2,041.96**	**25,272.42**
Levees and Floodwalls	**LS**	**1.0000**	**5,877,837.08**	**2,117,976.25**	**7,995,813.33**	**1,263,338.51**	**813,879.45**	**10,073,031.28**
Planning Engineering and Design	**LS**	**1.0000**	**187,736.77**	**262,831.47**	**450,568.24**	**71,189.78**	**90,942.42**	**612,700.45**
Construction Management	**LS**	**1.0000**	**324,907.90**	**454,871.06**	**779,778.96**	**123,205.08**	**187,820.68**	**1,090,804.71**
Phase 6 - Sta 319+00 to 479+00	**LS**	**1.0000**	**6,345,916.10**	**2,819,620.34**	**9,230,744.76**	**1,448,154.76**	**1,333,944.58**	**12,012,844.10**
Lands and Damages	**LS**	**1.0000**	**0.00**	**0.00**	**65,208.32**	**0.00**	**6,983.81**	**72,192.13**

Description	UOM	Quantity	CostToPrime	PrimeCMU	ContractCost	Contingency	Escalation	ProjectCost
Levees and Floodwalls	LS	1.0000	5,833,271.44	2,101,917.80	7,935,189.24	1,253,759.90	984,136.45	10,173,085.59
Planning Engineering and Design	LS	1.0000	187,736.77	262,831.47	450,568.24	71,189.78	114,369.36	636,127.38
Construction Management	LS	1.0000	324,907.90	454,871.06	779,778.96	123,205.08	228,454.96	1,131,439.00
Phase 7 - Sta 479+00 to 640+00	LS	1.0000	6,188,155.45	2,762,774.03	9,016,545.35	1,414,246.86	1,553,315.22	11,984,107.43
Lands and Damages	LS	1.0000	0.00	0.00	65,615.87	0.00	8,359.46	73,975.33
Levees and Floodwalls	LS	1.0000	5,675,510.78	2,045,071.50	7,720,582.28	1,219,852.00	1,139,011.33	10,079,445.61
Planning Engineering and Design	LS	1.0000	187,736.77	262,831.47	450,568.24	71,189.78	137,848.47	659,606.49
Construction Management	LS	1.0000	324,907.90	454,871.06	779,778.96	123,205.08	268,095.96	1,171,080.00
Phase 8 - Sta 68+00 to 145+00 and Upstream Improvements	LS	1.0000	16,699,193.73	6,550,243.67	23,290,358.67	3,673,411.11	4,380,765.36	31,344,535.14
Lands and Damages	LS	1.0000	0.00	0.00	40,921.26	0.00	6,039.98	46,961.24
Channels and Canals	LS	1.0000	3,021,795.71	1,088,851.47	4,110,647.19	649,482.26	726,871.77	5,487,001.21
Levees and Floodwalls	LS	1.0000	13,164,753.35	4,743,689.67	17,908,443.02	2,829,534.00	3,166,689.09	23,904,666.11
Planning Engineering and Design	LS	1.0000	187,736.77	262,831.47	450,568.24	71,189.78	161,327.58	683,085.61
Construction Management	LS	1.0000	324,907.90	454,871.06	779,778.96	123,205.08	319,836.95	1,222,820.98
Phase 9 - Sta 1030+00 to 1134+00	LS	1.0000	5,941,429.33	2,673,870.57	8,657,685.31	1,361,217.38	1,978,025.16	11,996,927.86
Lands and Damages	LS	1.0000	0.00	0.00	42,385.41	0.00	7,112.27	49,497.68
Levees and Floodwalls	LS	1.0000	5,428,784.67	1,956,168.04	7,384,952.70	1,166,822.53	1,434,987.88	9,986,763.11
Planning Engineering and Design	LS	1.0000	187,736.77	262,831.47	450,568.24	71,189.78	184,754.52	706,512.54
Construction Management	LS	1.0000	324,907.90	454,871.06	779,778.96	123,205.08	351,170.49	1,254,154.53
Phase 10 - Sta 1134+00 to 1240+00	LS	1.0000	5,625,097.45	2,559,885.89	8,228,183.85	1,293,227.37	2,132,543.28	11,653,954.49
Lands and Damages	LS	1.0000	0.00	0.00	43,200.51	0.00	8,169.22	51,369.73
Levees and Floodwalls	LS	1.0000	5,112,452.78	1,842,183.35	6,954,636.14	1,098,832.51	1,522,910.92	9,576,379.57
Planning Engineering and Design	LS	1.0000	187,736.77	262,831.47	450,568.24	71,189.78	208,755.39	730,513.41
Construction Management	LS	1.0000	324,907.90	454,871.06	779,778.96	123,205.08	392,707.76	1,295,691.79
Phase 11 - Sta 1240+00 to 1355+00	LS	1.0000	5,560,788.18	2,536,713.16	8,146,407.58	1,279,405.21	2,351,261.08	11,777,073.87
Lands and Damages	LS	1.0000	0.00	0.00	48,906.24	0.00	10,221.40	59,127.64
Levees and Floodwalls	LS	1.0000	5,048,143.52	1,819,010.63	6,867,154.14	1,085,010.35	1,673,135.41	9,625,299.91
Planning Engineering and Design	LS	1.0000	187,736.77	262,831.47	450,568.24	71,189.78	232,756.25	754,514.28
Construction Management	LS	1.0000	324,907.90	454,871.06	779,778.96	123,205.08	435,148.01	1,338,132.04
Phase 12 - Sta 1355+00 to 1432+00	LS	1.0000	5,491,354.98	2,511,694.11	8,034,430.60	1,264,481.76	2,643,566.02	11,942,478.37

Description	UOM	Quantity	CostToPrime	PrimeCMU	ContractCost	Contingency	Escalation	ProjectCost
Lands and Damages	LS	1.0000	0.00	0.00	31,381.50	0.00	7,606.88	38,988.38
Relocations	LS	1.0000	1,791,685.25	645,602.59	2,437,287.84	385,091.48	684,144.75	3,506,524.06
Levees and Floodwalls	LS	1.0000	3,187,025.06	1,148,388.99	4,335,414.06	684,995.42	1,216,947.26	6,237,356.74
Planning Engineering and Design	LS	1.0000	187,736.77	262,831.47	450,568.24	71,189.78	257,278.88	779,036.91
Construction Management	LS	1.0000	324,907.90	454,871.06	779,778.96	123,205.08	477,588.26	1,380,572.29
Phase 13 - Sta 1432+00 to 1539+00	LS	1.0000	5,517,023.67	2,520,943.38	8,081,575.11	1,269,998.79	2,823,856.37	12,175,430.27
Lands and Damages	LS	1.0000	0.00	0.00	43,608.06	0.00	11,115.69	54,723.75
Levees and Floodwalls	LS	1.0000	5,004,379.00	1,803,240.84	6,807,619.85	1,075,603.94	2,009,433.74	9,892,657.53
Planning Engineering and Design	LS	1.0000	187,736.77	262,831.47	450,568.24	71,189.78	282,375.44	804,133.47
Construction Management	LS	1.0000	324,907.90	454,871.06	779,778.96	123,205.08	520,931.49	1,423,915.53
Phase 14 - Sta 1539+00 to 1643+00	LS	1.0000	5,343,073.08	2,458,263.31	7,843,721.81	1,232,611.15	2,992,943.67	12,069,276.63
Lands and Damages	LS	1.0000	0.00	0.00	42,385.41	0.00	11,745.00	54,130.41
Levees and Floodwalls	LS	1.0000	4,830,428.42	1,740,560.78	6,570,989.20	1,038,216.29	2,108,510.84	9,717,716.33
Planning Engineering and Design	LS	1.0000	187,736.77	262,831.47	450,568.24	71,189.78	307,419.83	829,177.85
Construction Management	LS	1.0000	324,907.90	454,871.06	779,778.96	123,205.08	565,268.01	1,468,252.04
Phase 15 - Sta 1643+00 to 1750+00	LS	1.0000	5,327,140.56	2,452,522.31	7,823,270.93	1,229,186.73	3,234,008.44	12,286,466.10
Lands and Damages	LS	1.0000	0.00	0.00	43,608.06	0.00	13,099.86	56,707.92
Levees and Floodwalls	LS	1.0000	4,814,495.89	1,734,819.77	6,549,315.67	1,034,791.88	2,278,265.91	9,862,373.45
Planning Engineering and Design	LS	1.0000	187,736.77	262,831.47	450,568.24	71,189.78	333,038.15	854,796.17
Construction Management	LS	1.0000	324,907.90	454,871.06	779,778.96	123,205.08	609,604.52	1,512,588.56
Phase 16 - Sta 1750+00 to 1910+00	LS	1.0000	8,628,931.20	3,642,265.08	12,336,404.59	1,938,849.01	5,174,583.64	19,449,837.25
Lands and Damages	LS	1.0000	0.00	0.00	65,208.32	0.00	21,107.93	86,316.25
Levees and Floodwalls	LS	1.0000	8,116,286.53	2,924,562.54	11,040,849.07	1,744,454.15	4,138,602.65	16,923,905.88
Planning Engineering and Design	LS	1.0000	187,736.77	262,831.47	450,568.24	71,189.78	359,126.05	880,884.07
Construction Management	LS	1.0000	324,907.90	454,871.06	779,778.96	123,205.08	655,747.01	1,558,731.04
Phase 17 - Sta 1910+00 to 2030+00	LS	1.0000	5,035,617.55	2,347,477.07	7,432,000.86	1,166,528.95	3,577,884.71	12,176,414.51
Lands and Damages	LS	1.0000	0.00	0.00	48,906.24	0.00	16,970.47	65,876.71
Levees and Floodwalls	LS	1.0000	4,522,972.88	1,629,774.53	6,152,747.42	972,134.09	2,472,333.88	9,597,215.39
Planning Engineering and Design	LS	1.0000	187,736.77	262,831.47	450,568.24	71,189.78	385,787.88	907,545.91
Construction Management	LS	1.0000	324,907.90	454,871.06	779,778.96	123,205.08	702,792.47	1,605,776.51

Description	UOM	Quantity	CostToPrime	PrimeCMU	ContractCost	Contingency	Escalation	ProjectCost
Phase 18 - Sta 2030+00 to 2122+00	**LS**	**1.0000**	**4,899,107.64**	**2,298,288.10**	**7,234,890.52**	**1,137,188.53**	**3,742,407.82**	**12,114,486.86**
Lands and Damages	**LS**	**1.0000**	**0.00**	**0.00**	**37,494.78**	**0.00**	**13,921.81**	**51,416.59**
Levees and Floodwalls	**LS**	**1.0000**	**4,386,462.97**	**1,580,585.56**	**5,967,048.54**	**942,793.67**	**2,565,624.41**	**9,475,466.62**
Planning Engineering and Design	**LS**	**1.0000**	**187,736.77**	**262,831.47**	**450,568.24**	**71,189.78**	**413,023.65**	**934,781.68**
Construction Management	**LS**	**1.0000**	**324,907.90**	**454,871.06**	**779,778.96**	**123,205.08**	**749,837.94**	**1,652,821.98**
Phase 19 - Sta 2122+00 to 2210+00	**LS**	**1.0000**	**4,839,309.84**	**2,276,741.00**	**7,151,915.42**	**1,124,336.03**	**3,956,295.55**	**12,232,547.01**
Lands and Damages	**LS**	**1.0000**	**0.00**	**0.00**	**35,864.58**	**0.00**	**14,223.89**	**50,088.47**
Levees and Floodwalls	**LS**	**1.0000**	**4,326,665.17**	**1,559,038.47**	**5,885,703.64**	**929,941.18**	**2,703,084.73**	**9,518,729.55**
Planning Engineering and Design	**LS**	**1.0000**	**187,736.77**	**262,831.47**	**450,568.24**	**71,189.78**	**440,207.25**	**961,965.27**
Construction Management	**LS**	**1.0000**	**324,907.90**	**454,871.06**	**779,778.96**	**123,205.08**	**798,779.68**	**1,701,763.71**
Phase 20 - Sta 2210+00 to 2271+00	**LS**	**1.0000**	**7,544,569.24**	**3,251,534.13**	**10,820,964.04**	**1,705,784.33**	**6,000,054.11**	**18,526,802.48**
Lands and Damages	**LS**	**1.0000**	**0.00**	**0.00**	**24,860.67**	**0.00**	**10,488.72**	**35,349.39**
Levees and Floodwalls	**LS**	**1.0000**	**7,031,924.58**	**2,533,831.59**	**9,565,756.17**	**1,511,389.47**	**4,673,447.75**	**15,750,593.39**
Planning Engineering and Design	**LS**	**1.0000**	**187,736.77**	**262,831.47**	**450,568.24**	**71,189.78**	**468,486.53**	**990,244.56**
Construction Management	**LS**	**1.0000**	**324,907.90**	**454,871.06**	**779,778.96**	**123,205.08**	**847,631.11**	**1,750,615.15**

San Acacia Levee Improvements

Phasing Features Matrix

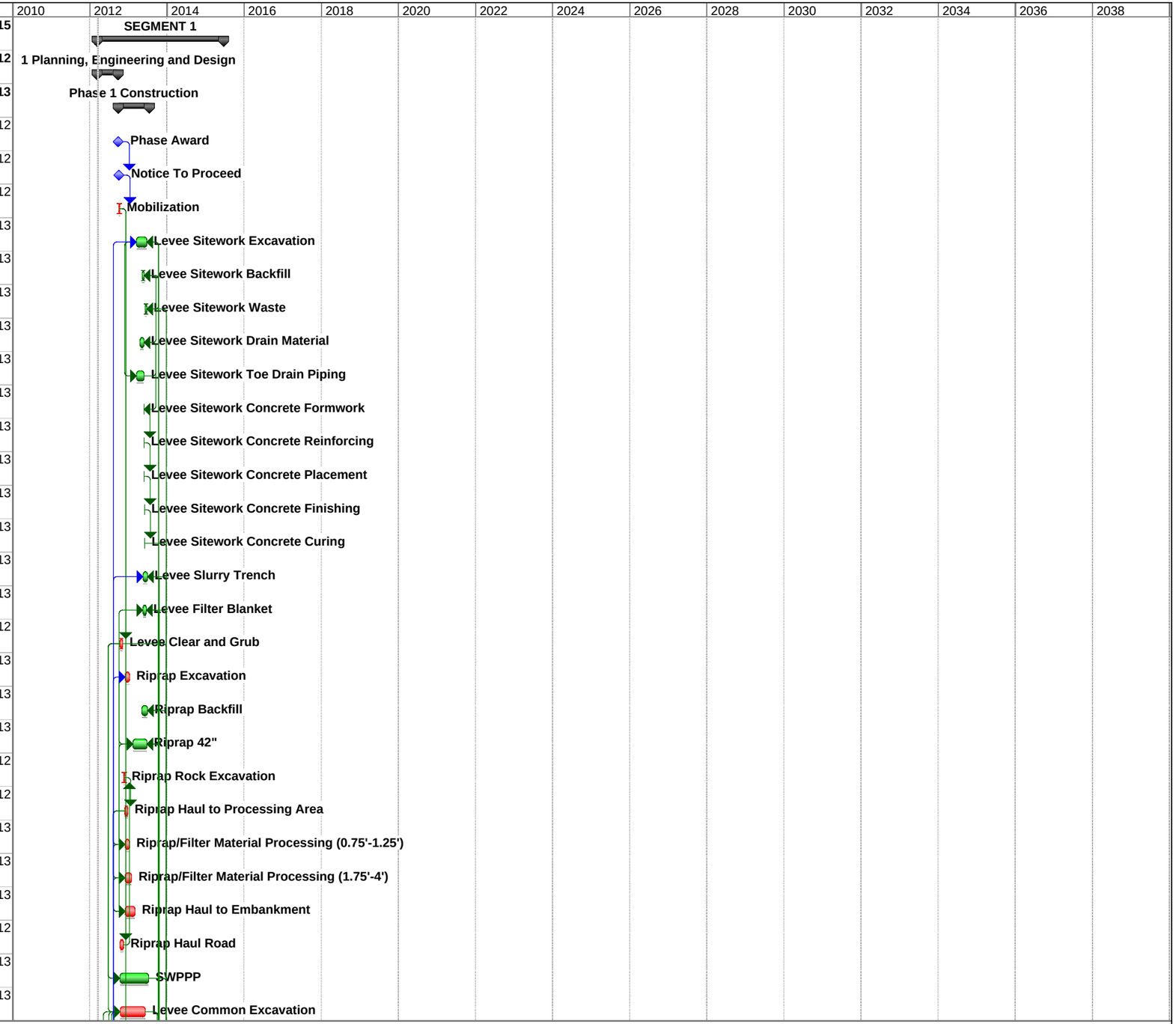
	SEGMENT 1			SEGMENT 2				SEGMENT 3	SEGMENT 4	
Description	**PHASE 1** 645+00-800+00	**PHASE 2** 800+00-950+00	**PHASE 3** 950+00-1030+00	**PHASE 4** 145+00-262+00	**PHASE 5** 262+00-319+00	**PHASE 6** 319+00-479+00	**PHASE 7** 479+00-640+00	**PHASE 8** 68+00-145+00 SADD Improve	**PHASE 9** 1030+00-1134+00	**PHASE 10** 1134+00-1240+00
Channel Construction										
Clearing and Grubbing								X		
Excavation, Common								X		
Waste								X		
Haul Road								X		
Levee Construction										
Drainage										
Drain Material	X	X	X	X	X	X	X	X	X	X
Piping, Toe Drain	X	X	X	X	X	X	X	X	X	X
Care and Diversion of Water										
Portable Cofferdam	X	X	X	X	X	X	X	X	X	X
Dewatering	X		X		X			X		
Associated General Items										
Site Work										
Slurry Trench	X	X	X	X	X	X	X	X	X	X
Filter Blanket	X	X	X	X	X	X	X	X	X	X
Clearing and Grubbing	X	X	X	X	X	X	X	X	X	X
Riprap										
Excavation, Common [Riprap]	X		X	X	X			X	X	X
Backfill [Riprap]	X			X	X				X	X
Haul Excess Excavation Waste	X		X	X				X	X	X
9 Inch (0.75') Thick Riprap										X
15 Inch (1.25') Thick Riprap										
21 Inch (1.75') Thick Riprap			X						X	
30 Inch (2.50') Thick Riprap			X							
42 Inch (3.50') Thick Riprap	X							X		
48 Inch (4.00') Thick Riprap					X					
Launchable Riprap			X		X			X		
Rock Excavation	X	X	X	X	X	X	X	X	X	X
Riprap Processing	X	X	X	X	X	X	X	X	X	X
Levee Earthwork Alt. A (100yr + 4ft)										
Excavation, Common (Haul to Processing Stockpile includes quantity	X	X	X	X	X	X	X	X	X	X
Screening Operation	X	X	X	X	X	X	X	X	X	X
Levee Construction	X	X	X	X	X	X	X	X	X	X
Haul spoils to land side of Levee	X	X	X	X	X	X	X	X	X	X
Sta. 80+00 to 325+00 Hauling				X	X			X		
Sta. 325+00 to 575+00 Hauling						X	X			
Sta. 575+00 to 825+00 Hauling	X	X				X	X			
Sta. 825+00 to 985+00 Hauling		X	X							
Sta. 985+00 to 1230+00 Hauling			X						X	X
Sta. 1230+00 to 1480+00 Hauling										X
Sta. 1480+00 to 1730+00 Hauling										
Sta. 1730+00 to 1980+00 Hauling										
Sta. 1980+00 to 2263+97 Hauling										
Upstream Construction										
Soil Cement								X		
Roller Compacted Concrete Armoring								X		
Floodwall								X		
Irrigation Bridge Box Cover								X		
Culvert Extensions								X		
Mob / Demob Batching Plant								X		
Brown Arroyo										
Flood Wall Structure			X							
Other Items										
Levee Tie Back, San Lorenzo Arroyo				X				X		
Levee Tie Back, Socorro Arroyo	X						X			
Utility Relocation										

San Acacia Levee Improvements

Phasing Features Matrix

		SEGMENT 5					SEGMENT 6			
Description	**PHASE 11** 1240+00-1355+00	**PHASE 12** 1355+00-1432+00	**PHASE 13** 1432+00-1539+00	**PHASE 14** 1539+00-1643+00	**PHASE 15** 1643+00-1750+00	**PHASE 16** 1750+00-1910+00	**PHASE 17** 1910+00-2030+00	**PHASE 18** 2030+00-2122+00	**PHASE 19** 2122+00-2210+00	**PHASE 20** 2210+00-2271+00
Channel Construction										
Clearing and Grubbing										
Excavation, Common										
Waste										
Haul Road										
Levee Construction										
Drainage										
Drain Material	X	X	X	X	X	X	X	X	X	X
Piping, Toe Drain	X	X	X	X	X	X	X	X	X	X
Care and Diversion of Water										
Portable Cofferdam	X	X	X	X	X	X	X	X	X	X
Dewatering										X
Associated General Items										
Site Work										
Slurry Trench	X	X	X	X	X	X	X	X	X	X
Filter Blanket	X	X	X	X	X	X	X	X	X	X
Clearing and Grubbing	X	X	X	X	X	X	X	X	X	X
Riprap										
Excavation, Common [Riprap]	X	X		X		X				X
Backfill [Riprap]	X	X		X		X				X
Haul Excess Excavation Waste	X	X		X		X				X
9 Inch (0.75') Thick Riprap	X	X		X		X				
15 Inch (1.25') Thick Riprap										X
21 Inch (1.75') Thick Riprap										
30 Inch (2.50') Thick Riprap										
42 Inch (3.50') Thick Riprap										
48 Inch (4.00') Thick Riprap										
Launchable Riprap										X
Rock Excavation	X	X	X	X	X	X	X	X	X	X
Riprap Processing	X	X	X	X	X	X	X	X	X	X
Levee Earthwork Alt. A (100yr + 4ft)										
Excavation, Common (Haul to Processing Stockpile includes quantity	X	X	X	X	X	X	X	X	X	X
Screening Operation	X	X	X	X	X	X	X	X	X	X
Levee Construction	X	X	X	X	X	X	X	X	X	X
Haul spoils to land side of Levee	X								X	
Sta. 80+00 to 325+00 Hauling										
Sta. 325+00 to 575+00 Hauling										
Sta. 575+00 to 825+00 Hauling										
Sta. 825+00 to 985+00 Hauling										
Sta. 985+00 to 1230+00 Hauling										
Sta. 1230+00 to 1480+00 Hauling	X	X	X							
Sta. 1480+00 to 1730+00 Hauling			X	X	X					
Sta. 1730+00 to 1980+00 Hauling					X	X	X			
Sta. 1980+00 to 2263+97 Hauling							X	X	X	
Upstream Construction										
Soil Cement										
Roller Compacted Concrete Armoring										
Floodwall										
Irrigation Bridge Box Cover										
Culvert Extensions										
Mob / Demob Batching Plant										
Brown Arroyo										
Flood Wall Structure										
Other Items										
Levee Tie Back, San Lorenzo Arroyo										
Levee Tie Back, Socorro Arroyo										
Utility Relocation		X								

ID	Task Name	Duration	Early Start	Early Finish
1	**SEGMENT 1**	**825 days**	**Tue 3/13/12**	**Tue 6/23/15**
2	**Phase 1 Planning, Engineering and Design**	**140 days**	**Tue 3/13/12**	**Thu 9/27/12**
4	**Phase 1 Construction**	**202 days**	**Fri 9/28/12**	**Fri 7/19/13**
5	Phase Award	0 days	Fri 9/28/12	Fri 9/28/12
6	Notice To Proceed	0 days	Thu 10/4/12	Thu 10/4/12
7	Mobilization	5 days	Fri 10/5/12	Fri 10/12/12
8	Levee Sitework Excavation	68 days	Wed 3/20/13	Mon 6/24/13
9	Levee Sitework Backfill	13 days	Mon 5/13/13	Thu 5/30/13
10	Levee Sitework Waste	11 days	Mon 6/10/13	Mon 6/24/13
11	Levee Sitework Drain Material	27 days	Mon 4/22/13	Wed 5/29/13
12	Levee Sitework Toe Drain Piping	49 days	Thu 3/21/13	Wed 5/29/13
13	Levee Sitework Concrete Formwork	2 days	Tue 5/28/13	Wed 5/29/13
14	Levee Sitework Concrete Reinforcing	1 day	Thu 5/30/13	Thu 5/30/13
15	Levee Sitework Concrete Placement	1 day	Fri 5/31/13	Fri 5/31/13
16	Levee Sitework Concrete Finishing	1 day	Mon 6/3/13	Mon 6/3/13
17	Levee Sitework Concrete Curing	1 day	Tue 6/4/13	Tue 6/4/13
18	Levee Slurry Trench	28 days	Wed 5/22/13	Mon 7/1/13
19	Levee Filter Blanket	24 days	Mon 5/20/13	Fri 6/21/13
20	Levee Clear and Grub	19 days	Mon 10/15/12	Thu 11/8/12
21	Riprap Excavation	27 days	Tue 12/4/12	Fri 1/11/13
22	Riprap Backfill	36 days	Fri 5/10/13	Mon 7/1/13
23	Riprap 42"	92 days	Fri 2/15/13	Wed 6/26/13
24	Riprap Rock Excavation	6 days	Mon 11/19/12	Tue 11/27/12
25	Riprap Haul to Processing Area	20 days	Wed 11/28/12	Wed 12/26/12
26	Riprap/Filter Material Processing (0.75'-1.25')	28 days	Mon 12/3/12	Fri 1/11/13
27	Riprap/Filter Material Processing (1.75'-4')	41 days	Mon 12/3/12	Thu 1/31/13
28	Riprap Haul to Embankment	61 days	Tue 12/4/12	Mon 3/4/13
29	Riprap Haul Road	24 days	Mon 10/15/12	Fri 11/16/12
30	SWPPP	187 days	Mon 10/15/12	Fri 7/12/13
31	Levee Common Excavation	161 days	Thu 10/18/12	Mon 6/10/13



Project: San Acacia Alt A Base + 4
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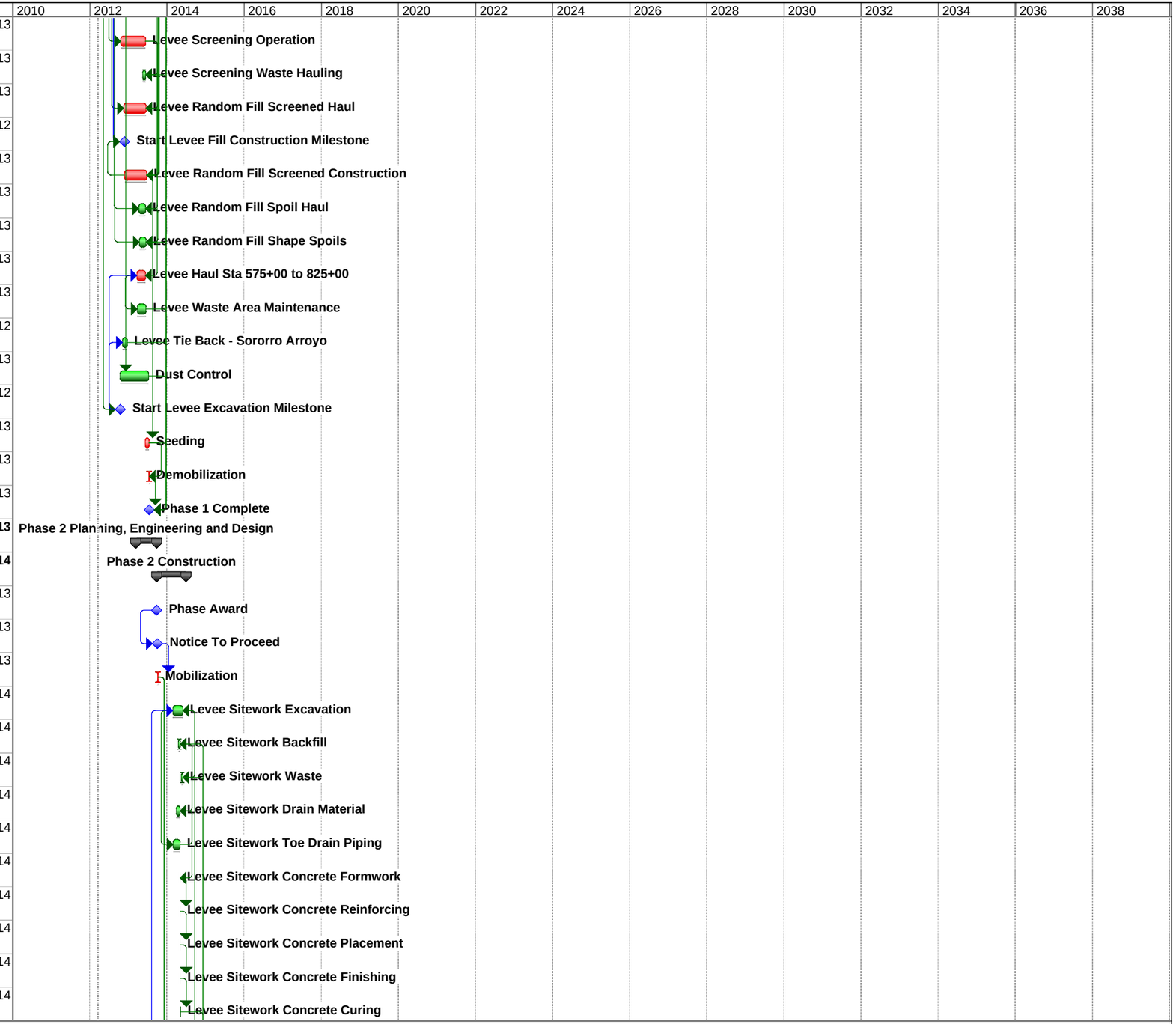
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
32	Levee Screening Operation	161 days	Tue 10/23/12	Thu 6/13/13
33	Levee Screening Waste Hauling	20 days	Fri 5/17/13	Fri 6/14/13
34	Levee Random Fill Screened Haul	145 days	Mon 11/19/12	Mon 6/17/13
35	Start Levee Fill Construction Milestone	0 days	Tue 11/27/12	Tue 11/27/12
36	Levee Random Fill Screened Construction	145 days	Tue 11/27/12	Mon 6/24/13
37	Levee Random Fill Spoil Haul	44 days	Fri 4/12/13	Thu 6/13/13
38	Levee Random Fill Shape Spoils	44 days	Wed 4/17/13	Tue 6/18/13
39	Levee Haul Sta 575+00 to 825+00	57 days	Mon 3/25/13	Wed 6/12/13
40	Levee Waste Area Maintenance	57 days	Thu 3/28/13	Mon 6/17/13
41	Levee Tie Back - Sororro Arroyo	30 days	Thu 11/8/12	Fri 12/21/12
42	Dust Control	187 days	Mon 10/15/12	Fri 7/12/13
43	Start Levee Excavation Milestone	0 days	Thu 10/18/12	Thu 10/18/12
44	Seeding	26 days	Tue 6/11/13	Wed 7/17/13
45	Demobilization	5 days	Mon 7/15/13	Fri 7/19/13
46	Phase 1 Complete	0 days	Fri 7/19/13	Fri 7/19/13
47	**Phase 2 Planning, Engineering and Design**	**140 days**	**Wed 3/13/13**	**Fri 9/27/13**
49	**Phase 2 Construction**	**190 days**	**Sat 9/28/13**	**Wed 7/2/14**
50	Phase Award	0 days	Sat 9/28/13	Sat 9/28/13
51	Notice To Proceed	0 days	Fri 10/4/13	Fri 10/4/13
52	Mobilization	5 days	Mon 10/7/13	Fri 10/11/13
53	Levee Sitework Excavation	66 days	Fri 2/28/14	Mon 6/2/14
54	Levee Sitework Backfill	13 days	Mon 4/21/14	Wed 5/7/14
55	Levee Sitework Waste	10 days	Mon 5/19/14	Mon 6/2/14
56	Levee Sitework Drain Material	26 days	Tue 4/1/14	Tue 5/6/14
57	Levee Sitework Toe Drain Piping	47 days	Mon 3/3/14	Tue 5/6/14
58	Levee Sitework Concrete Formwork	2 days	Mon 5/5/14	Tue 5/6/14
59	Levee Sitework Concrete Reinforcing	1 day	Wed 5/7/14	Wed 5/7/14
60	Levee Sitework Concrete Placement	1 day	Thu 5/8/14	Thu 5/8/14
61	Levee Sitework Concrete Finishing	1 day	Fri 5/9/14	Fri 5/9/14
62	Levee Sitework Concrete Curing	1 day	Mon 5/12/14	Mon 5/12/14



Project: San Acacia Alt A Base + 4
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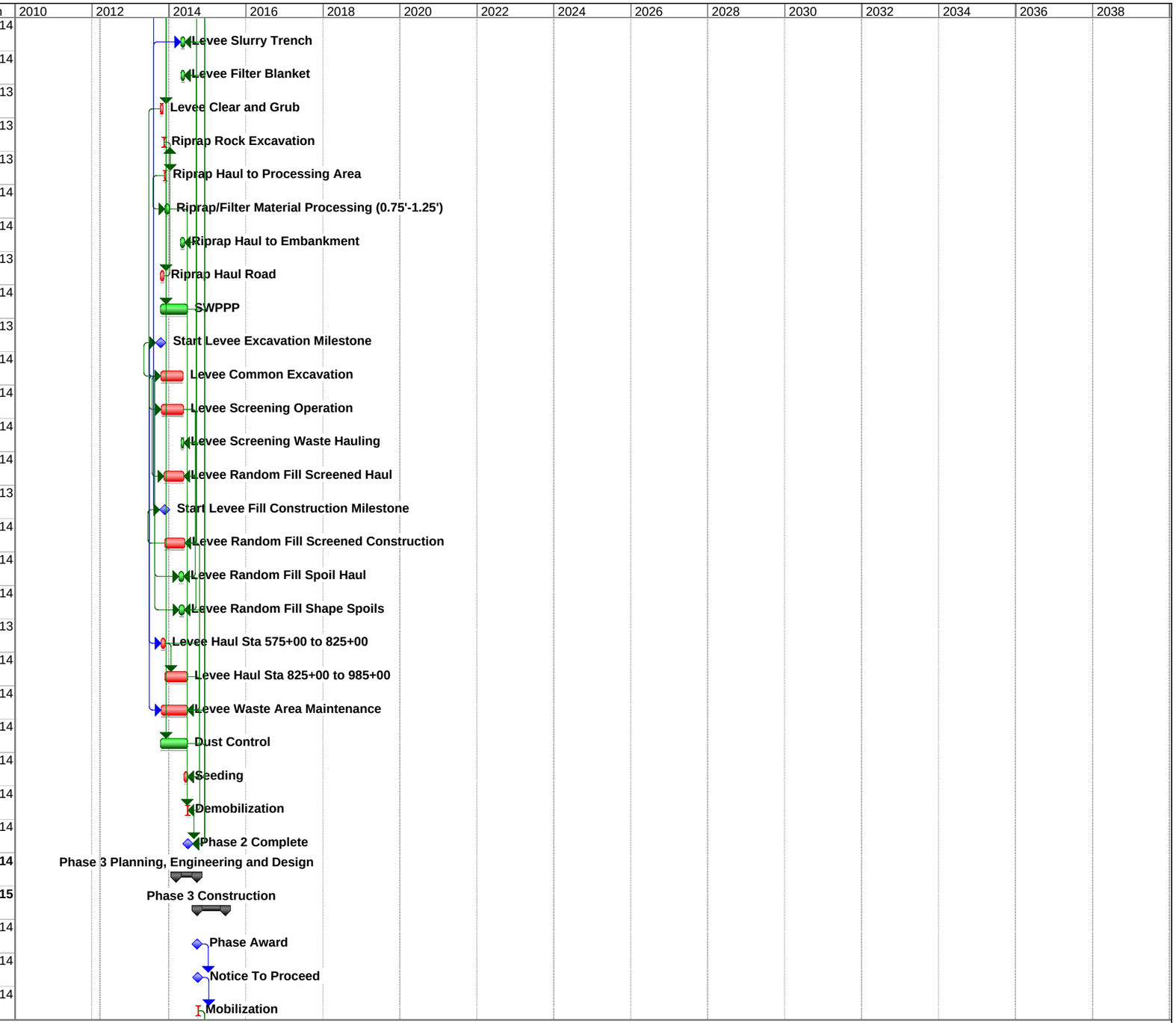
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
63	Levee Slurry Trench	26 days	Fri 4/25/14	Mon 6/2/14
64	Levee Filter Blanket	24 days	Mon 4/28/14	Fri 5/30/14
65	Levee Clear and Grub	18 days	Tue 10/15/13	Thu 11/7/13
66	Riprap Rock Excavation	3 days	Mon 11/18/13	Wed 11/20/13
67	Riprap Haul to Processing Area	9 days	Thu 11/21/13	Wed 12/4/13
68	Riprap/Filter Material Processing (0.75'-1.25')	27 days	Tue 11/26/13	Mon 1/6/14
69	Riprap Haul to Embankment	27 days	Wed 4/23/14	Fri 5/30/14
70	Riprap Haul Road	23 days	Tue 10/15/13	Fri 11/15/13
71	SWPPP	177 days	Tue 10/15/13	Fri 6/27/14
72	Start Levee Excavation Milestone	0 days	Fri 10/18/13	Fri 10/18/13
73	Levee Common Excavation	145 days	Fri 10/18/13	Fri 5/16/14
74	Levee Screening Operation	145 days	Wed 10/23/13	Wed 5/21/14
75	Levee Screening Waste Hauling	18 days	Tue 4/29/14	Thu 5/22/14
76	Levee Random Fill Screened Haul	130 days	Mon 11/18/13	Fri 5/23/14
77	Start Levee Fill Construction Milestone	0 days	Mon 11/25/13	Mon 11/25/13
78	Levee Random Fill Screened Construction	130 days	Mon 11/25/13	Mon 6/2/14
79	Levee Random Fill Spoil Haul	33 days	Mon 4/7/14	Wed 5/21/14
80	Levee Random Fill Shape Spoils	33 days	Thu 4/10/14	Tue 5/27/14
81	Levee Haul Sta 575+00 to 825+00	26 days	Mon 10/21/13	Tue 11/26/13
82	Levee Haul Sta 825+00 to 985+00	147 days	Wed 11/27/13	Fri 6/27/14
83	Levee Waste Area Maintenance	172 days	Tue 10/22/13	Fri 6/27/14
84	Dust Control	177 days	Tue 10/15/13	Fri 6/27/14
85	Seeding	25 days	Tue 5/27/14	Mon 6/30/14
86	Demobilization	5 days	Thu 6/26/14	Wed 7/2/14
87	Phase 2 Complete	0 days	Wed 7/2/14	Wed 7/2/14
88	**Phase 3 Planning, Engineering and Design**	**140 days**	**Wed 3/12/14**	**Fri 9/26/14**
90	**Phase 3 Construction**	**184 days**	**Sun 9/28/14**	**Tue 6/23/15**
91	Phase Award	0 days	Sun 9/28/14	Sun 9/28/14
92	Notice To Proceed	0 days	Fri 10/3/14	Fri 10/3/14
93	Mobilization	5 days	Mon 10/6/14	Fri 10/10/14



Project: San Acacia Alt A Base + 4
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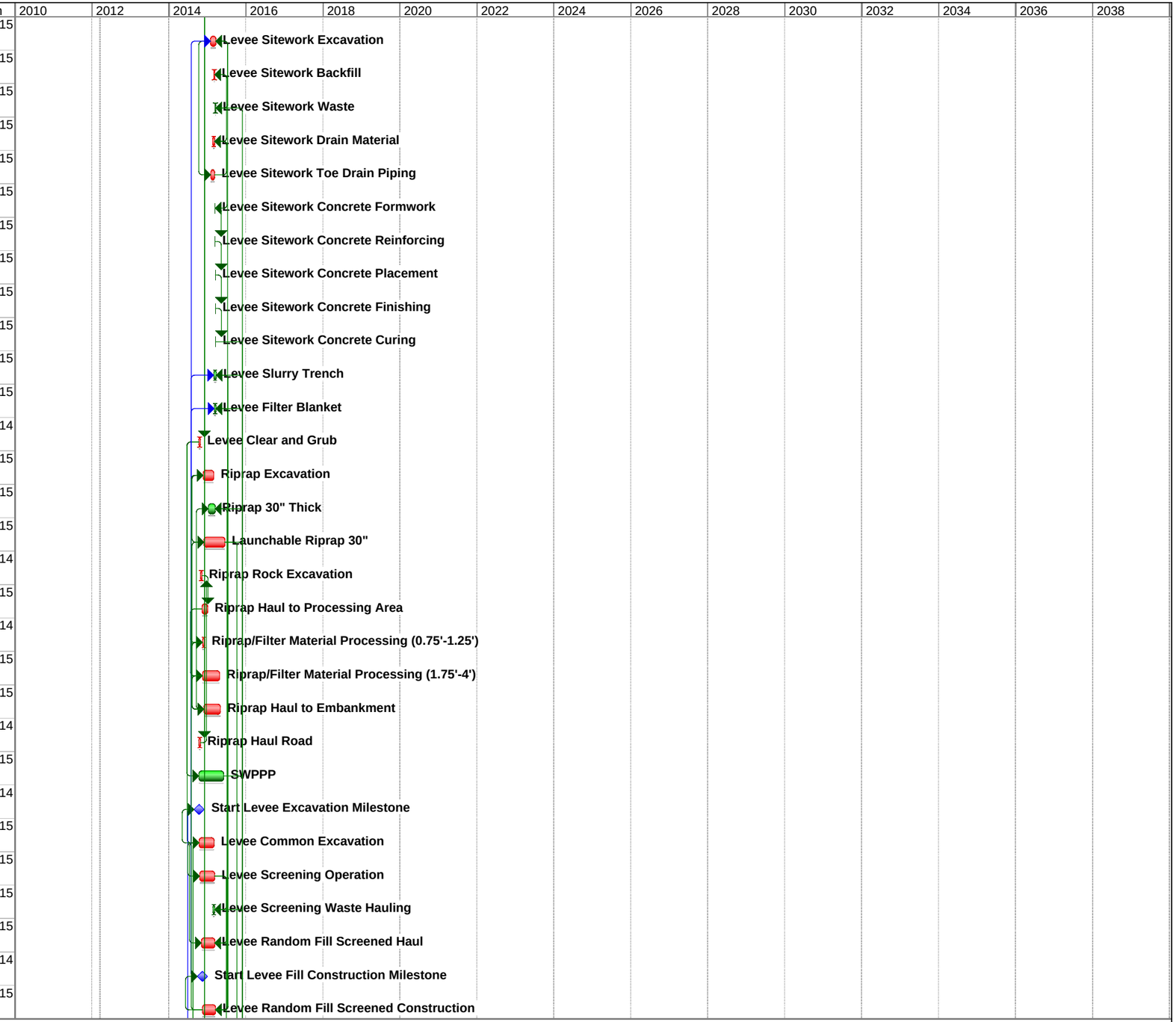
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
94	Levee Sitework Excavation	35 days	Mon 2/2/15	Mon 3/23/15
95	Levee Sitework Backfill	7 days	Thu 3/5/15	Fri 3/13/15
96	Levee Sitework Waste	6 days	Mon 3/16/15	Mon 3/23/15
97	Levee Sitework Drain Material	14 days	Mon 2/23/15	Thu 3/12/15
98	Levee Sitework Toe Drain Piping	25 days	Wed 2/4/15	Wed 3/11/15
99	Levee Sitework Concrete Formwork	1 day	Tue 3/17/15	Tue 3/17/15
100	Levee Sitework Concrete Reinforcing	1 day	Wed 3/18/15	Wed 3/18/15
101	Levee Sitework Concrete Placement	1 day	Thu 3/19/15	Thu 3/19/15
102	Levee Sitework Concrete Finishing	1 day	Fri 3/20/15	Fri 3/20/15
103	Levee Sitework Concrete Curing	1 day	Mon 3/23/15	Mon 3/23/15
104	Levee Slurry Trench	17 days	Thu 3/5/15	Fri 3/27/15
105	Levee Filter Blanket	13 days	Mon 3/9/15	Wed 3/25/15
106	Levee Clear and Grub	10 days	Tue 10/14/14	Mon 10/27/14
107	Riprap Excavation	67 days	Mon 11/24/14	Tue 3/3/15
108	Riprap 30" Thick	45 days	Mon 1/12/15	Tue 3/17/15
109	Launchable Riprap 30"	137 days	Tue 12/2/14	Wed 6/17/15
110	Riprap Rock Excavation	9 days	Thu 10/30/14	Wed 11/12/14
111	Riprap Haul to Processing Area	35 days	Thu 11/13/14	Mon 1/5/15
112	Riprap/Filter Material Processing (0.75'-1.25')	15 days	Tue 11/18/14	Tue 12/9/14
113	Riprap/Filter Material Processing (1.75'-4')	111 days	Tue 11/18/14	Tue 4/28/15
114	Riprap Haul to Embankment	107 days	Tue 12/2/14	Tue 5/5/15
115	Riprap Haul Road	12 days	Tue 10/14/14	Wed 10/29/14
116	SWPPP	162 days	Tue 10/14/14	Fri 6/5/15
117	Start Levee Excavation Milestone	0 days	Fri 10/17/14	Fri 10/17/14
118	Levee Common Excavation	95 days	Fri 10/17/14	Fri 3/6/15
119	Levee Screening Operation	95 days	Wed 10/22/14	Wed 3/11/15
120	Levee Screening Waste Hauling	12 days	Wed 2/25/15	Thu 3/12/15
121	Levee Random Fill Screened Haul	85 days	Fri 11/7/14	Fri 3/13/15
122	Start Levee Fill Construction Milestone	0 days	Mon 11/17/14	Mon 11/17/14
123	Levee Random Fill Screened Construction	85 days	Mon 11/17/14	Fri 3/20/15



Project: San Acacia Alt A Base + 4
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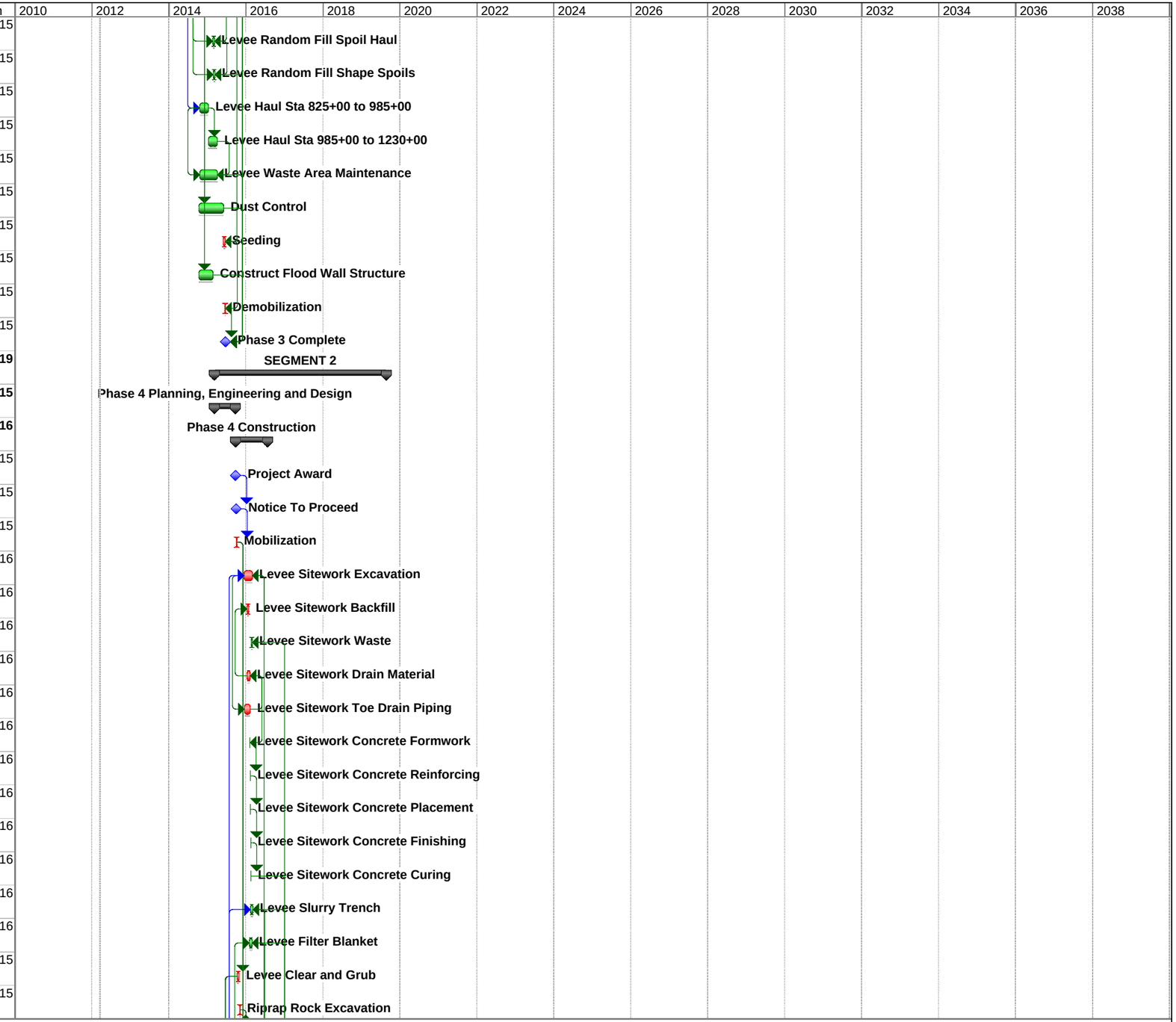
Task | Critical Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Early Start	Early Finish
124	Levee Random Fill Spoil Haul	12 days	Tue 2/24/15	Wed 3/11/15
125	Levee Random Fill Shape Spoils	12 days	Fri 2/27/15	Mon 3/16/15
126	Levee Haul Sta 825+00 to 985+00	55 days	Wed 10/22/14	Mon 1/12/15
127	Levee Haul Sta 985+00 to 1230+00	58 days	Tue 1/13/15	Mon 4/6/15
128	Levee Waste Area Maintenance	113 days	Thu 10/23/14	Tue 4/7/15
129	Dust Control	162 days	Tue 10/14/14	Fri 6/5/15
130	Seeding	14 days	Tue 6/2/15	Fri 6/19/15
131	Construct Flood Wall Structure	90 days	Tue 10/14/14	Tue 2/24/15
132	Demobilization	5 days	Wed 6/17/15	Tue 6/23/15
133	Phase 3 Complete	0 days	Tue 6/23/15	Tue 6/23/15
134	**SEGMENT 2**	**1124 days**	**Wed 3/11/15**	**Wed 8/28/19**
135	**Phase 4 Planning, Engineering and Design**	**140 days**	**Wed 3/11/15**	**Fri 9/25/15**
137	**Phase 4 Construction**	**209 days**	**Mon 9/28/15**	**Wed 7/27/16**
138	Project Award	0 days	Mon 9/28/15	Mon 9/28/15
139	Notice To Proceed	0 days	Fri 10/2/15	Fri 10/2/15
140	Mobilization	5 days	Mon 10/5/15	Fri 10/9/15
141	Levee Sitework Excavation	51 days	Fri 12/18/15	Thu 3/3/16
142	Levee Sitework Backfill	10 days	Fri 1/15/16	Fri 1/29/16
143	Levee Sitework Waste	8 days	Tue 2/23/16	Thu 3/3/16
144	Levee Sitework Drain Material	21 days	Thu 1/14/16	Fri 2/12/16
145	Levee Sitework Toe Drain Piping	37 days	Mon 12/21/15	Fri 2/12/16
146	Levee Sitework Concrete Formwork	2 days	Thu 2/11/16	Fri 2/12/16
147	Levee Sitework Concrete Reinforcing	1 day	Tue 2/16/16	Tue 2/16/16
148	Levee Sitework Concrete Placement	1 day	Wed 2/17/16	Wed 2/17/16
149	Levee Sitework Concrete Finishing	1 day	Thu 2/18/16	Thu 2/18/16
150	Levee Sitework Concrete Curing	1 day	Fri 2/19/16	Fri 2/19/16
151	Levee Slurry Trench	18 days	Tue 2/16/16	Thu 3/10/16
152	Levee Filter Blanket	18 days	Fri 2/5/16	Wed 3/2/16
153	Levee Clear and Grub	14 days	Tue 10/13/15	Fri 10/30/15
154	Riprap Rock Excavation	2 days	Fri 11/6/15	Mon 11/9/15



Project: San Acacia Alt A Base + 4
Date: Wed 3/14/12

Task | Critical Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Early Start	Early Finish
155	Riprap Haul to Processing Area	7 days	Tue 11/10/15	Thu 11/19/15
156	Riprap/Filter Material Processing (0.75'-1.25')	21 days	Mon 11/16/15	Tue 12/15/15
157	Riprap Haul to Embankment	21 days	Tue 11/17/15	Wed 12/16/15
158	Riprap Haul Road	18 days	Tue 10/13/15	Thu 11/5/15
159	SWPPP	175 days	Tue 10/13/15	Wed 6/22/16
160	Start Levee Excavation Milestone	0 days	Fri 10/16/15	Fri 10/16/15
161	Levee Common Excavation	84 days	Fri 10/16/15	Thu 2/18/16
162	Levee Screening Operation	84 days	Wed 10/21/15	Tue 2/23/16
163	Levee Screening Waste Hauling	11 days	Tue 2/9/16	Wed 2/24/16
164	Levee Random Fill Screened Haul	76 days	Wed 11/4/15	Thu 2/25/16
165	Start Levee Fill Construction Milestone	0 days	Thu 11/12/15	Thu 11/12/15
166	Levee Random Fill Screened Construction	76 days	Thu 11/12/15	Thu 3/3/16
167	Levee Random Fill Spoil Haul	9 days	Wed 2/10/16	Tue 2/23/16
168	Levee Random Fill Shape Spoils	9 days	Tue 2/16/16	Fri 2/26/16
169	Levee Haul Sta 80+00 to 325+00	173 days	Mon 10/19/15	Fri 6/24/16
170	Levee Waste Area Maintenance	173 days	Mon 10/19/15	Fri 6/24/16
171	Dust Control	175 days	Tue 10/13/15	Wed 6/22/16
172	Levee Tie Back - San Lorenzo Arroyo	30 days	Tue 10/13/15	Tue 11/24/15
173	Seeding	20 days	Mon 6/27/16	Mon 7/25/16
174	Demobilization	5 days	Thu 7/21/16	Wed 7/27/16
175	Phase 4 Complete	0 days	Wed 7/27/16	Wed 7/27/16
176	**Phase 5 Planning, Engineering and Design**	**140 days**	**Fri 3/11/16**	**Tue 9/27/16**
178	**Phase 5 Construction**	**257 days**	**Wed 9/28/16**	**Thu 10/5/17**
179	Phase Award	0 days	Wed 9/28/16	Wed 9/28/16
180	Notice To Proceed	0 days	Tue 10/4/16	Tue 10/4/16
181	Mobilization	5 days	Wed 10/5/16	Wed 10/12/16
182	Levee Sitework Excavation	25 days	Tue 11/1/16	Wed 12/7/16
183	Levee Sitework Backfill	5 days	Fri 11/25/16	Thu 12/1/16
184	Levee Sitework Waste	4 days	Fri 12/2/16	Wed 12/7/16
185	Levee Sitework Drain Material	10 days	Wed 11/16/16	Wed 11/30/16

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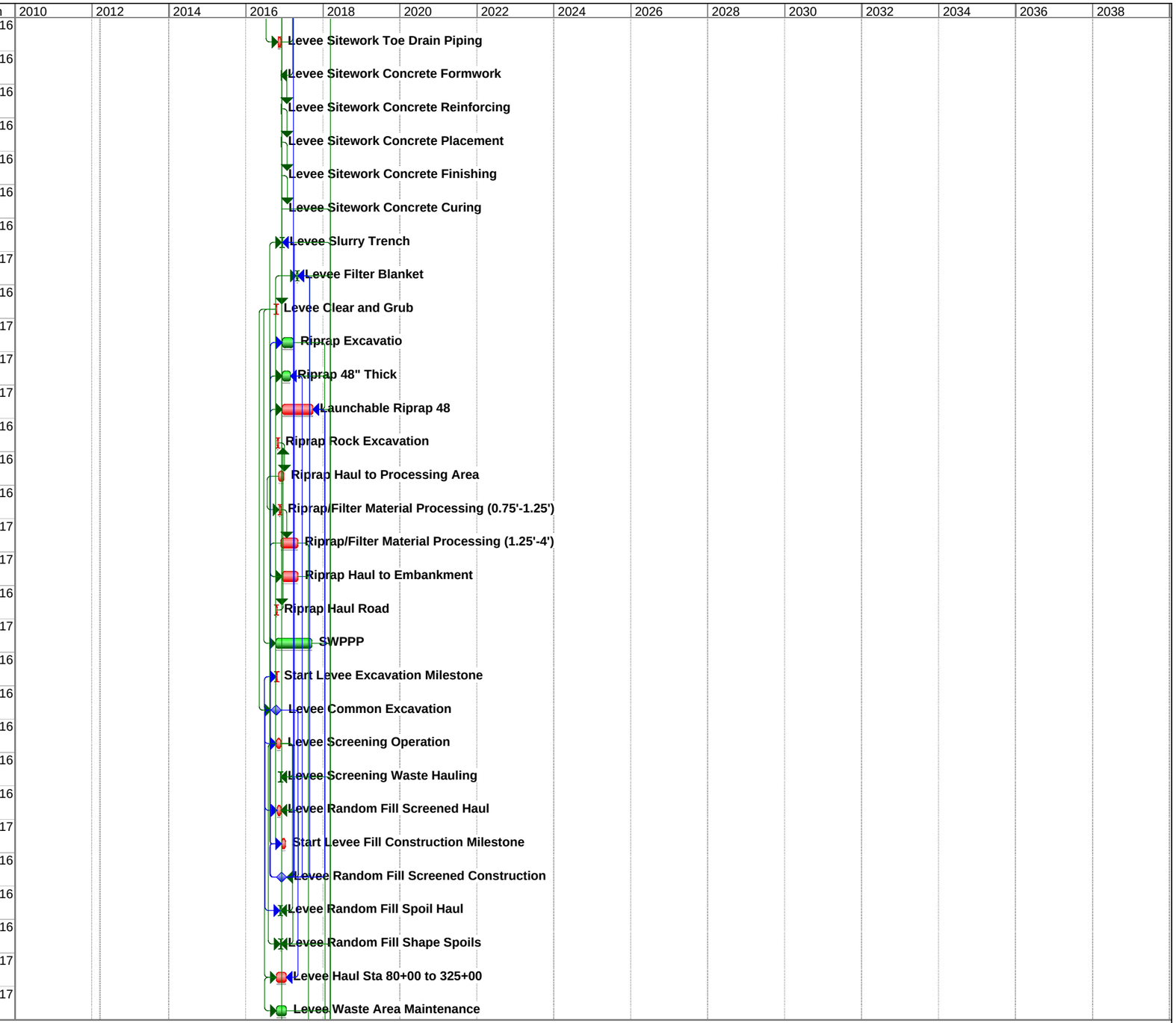
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
186	Levee Sitework Toe Drain Piping	18 days	Thu 11/3/16	Wed 11/30/16
187	Levee Sitework Concrete Formwork	1 day	Wed 11/30/16	Wed 11/30/16
188	Levee Sitework Concrete Reinforcing	1 day	Thu 12/1/16	Thu 12/1/16
189	Levee Sitework Concrete Placement	1 day	Fri 12/2/16	Fri 12/2/16
190	Levee Sitework Concrete Finishing	1 day	Mon 12/5/16	Mon 12/5/16
191	Levee Sitework Concrete Curing	1 day	Tue 12/6/16	Tue 12/6/16
192	Levee Slurry Trench	6 days	Thu 12/8/16	Thu 12/15/16
193	Levee Filter Blanket	9 days	Fri 4/28/17	Wed 5/10/17
194	Levee Clear and Grub	7 days	Thu 10/13/16	Fri 10/21/16
195	Riprap Excavatio	70 days	Thu 12/15/16	Tue 3/28/17
196	Riprap 48" Thick	50 days	Thu 12/15/16	Tue 2/28/17
197	Launchable Riprap 48	201 days	Wed 12/14/16	Fri 9/29/17
198	Riprap Rock Excavation	9 days	Wed 10/26/16	Mon 11/7/16
199	Riprap Haul to Processing Area	34 days	Tue 11/8/16	Wed 12/28/16
200	Riprap/Filter Material Processing (0.75'-1.25')	11 days	Mon 11/14/16	Tue 11/29/16
201	Riprap/Filter Material Processing (1.25'-4')	111 days	Wed 11/30/16	Tue 5/9/17
202	Riprap Haul to Embankment	102 days	Wed 12/14/16	Wed 5/10/17
203	Riprap Haul Road	9 days	Thu 10/13/16	Tue 10/25/16
204	SWPPP	235 days	Thu 10/13/16	Tue 9/19/17
205	Start Levee Excavation Milestone	6 days	Tue 10/18/16	Tue 10/25/16
206	Levee Common Excavation	0 days	Mon 10/17/16	Mon 10/17/16
207	Levee Screening Operation	25 days	Fri 10/21/16	Mon 11/28/16
208	Levee Screening Waste Hauling	3 days	Fri 11/25/16	Tue 11/29/16
209	Levee Random Fill Screened Haul	23 days	Thu 10/27/16	Wed 11/30/16
210	Start Levee Fill Construction Milestone	23 days	Thu 12/8/16	Wed 1/11/17
211	Levee Random Fill Screened Construction	0 days	Wed 12/7/16	Wed 12/7/16
212	Levee Random Fill Spoil Haul	5 days	Mon 11/21/16	Mon 11/28/16
213	Levee Random Fill Shape Spoils	5 days	Fri 11/25/16	Thu 12/1/16
214	Levee Haul Sta 80+00 to 325+00	62 days	Wed 10/19/16	Thu 1/19/17
215	Levee Waste Area Maintenance	62 days	Thu 10/20/16	Fri 1/20/17



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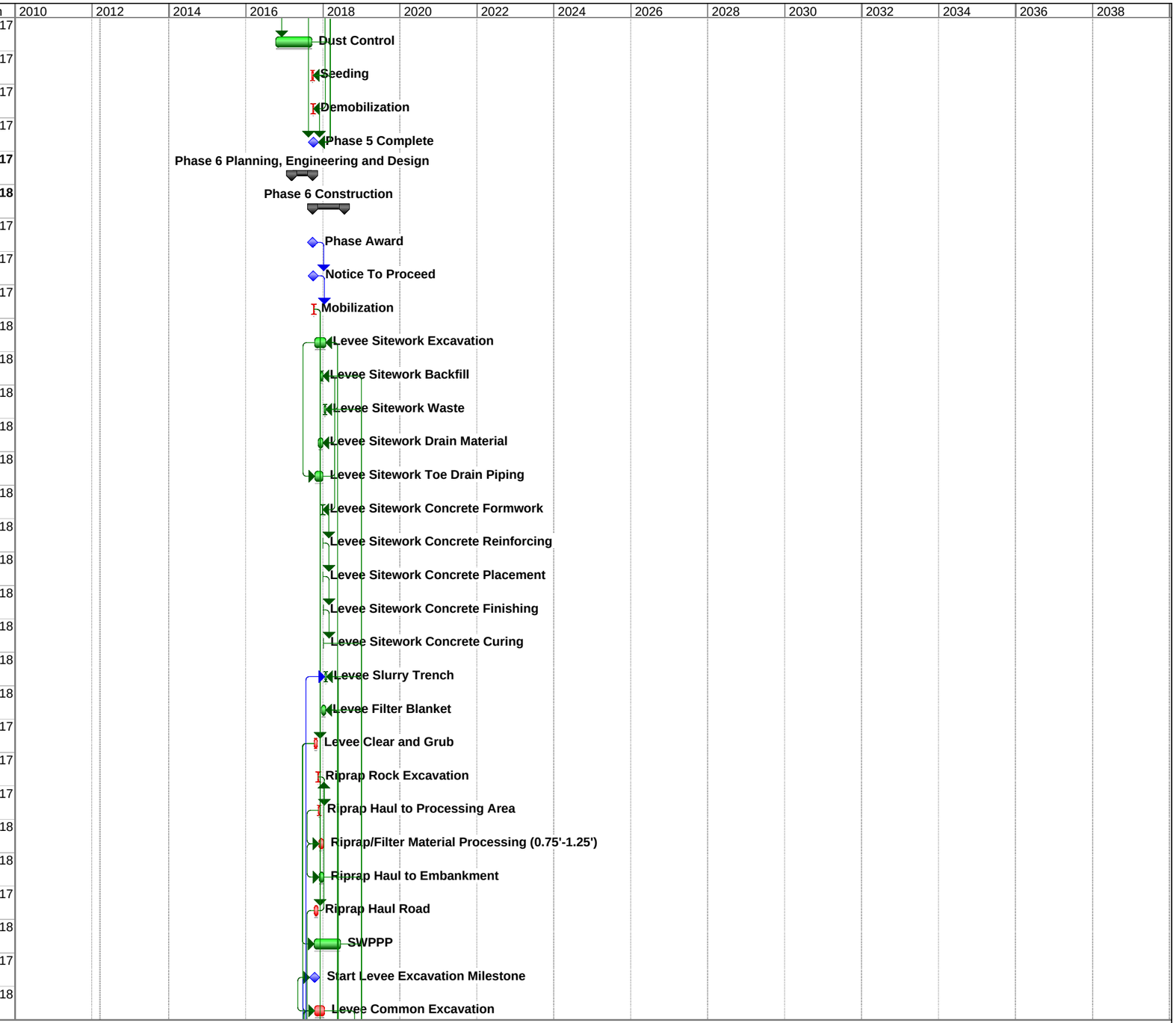
Task | Critical Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Early Start	Early Finish
216	Dust Control	235 days	Thu 10/13/16	Tue 9/19/17
217	Seeding	10 days	Wed 9/20/17	Tue 10/3/17
218	Demobilization	5 days	Fri 9/29/17	Thu 10/5/17
219	Phase 5 Complete	0 days	Thu 10/5/17	Thu 10/5/17
220	**Phase 6 Planning, Engineering and Design**	**140 days**	**Mon 3/13/17**	**Wed 9/27/17**
222	**Phase 6 Construction**	**207 days**	**Thu 9/28/17**	**Thu 7/26/18**
223	Phase Award	0 days	Thu 9/28/17	Thu 9/28/17
224	Notice To Proceed	0 days	Wed 10/4/17	Wed 10/4/17
225	Mobilization	5 days	Thu 10/5/17	Thu 10/12/17
226	Levee Sitework Excavation	70 days	Wed 10/18/17	Tue 1/30/18
227	Levee Sitework Backfill	14 days	Wed 12/13/17	Wed 1/3/18
228	Levee Sitework Waste	11 days	Tue 1/16/18	Tue 1/30/18
229	Levee Sitework Drain Material	28 days	Tue 11/21/17	Tue 1/2/18
230	Levee Sitework Toe Drain Piping	50 days	Thu 10/19/17	Tue 1/2/18
231	Levee Sitework Concrete Formwork	2 days	Fri 12/29/17	Tue 1/2/18
232	Levee Sitework Concrete Reinforcing	1 day	Wed 1/3/18	Wed 1/3/18
233	Levee Sitework Concrete Placement	1 day	Thu 1/4/18	Thu 1/4/18
234	Levee Sitework Concrete Finishing	1 day	Fri 1/5/18	Fri 1/5/18
235	Levee Sitework Concrete Curing	1 day	Mon 1/8/18	Mon 1/8/18
236	Levee Slurry Trench	12 days	Mon 1/22/18	Tue 2/6/18
237	Levee Filter Blanket	25 days	Thu 12/21/17	Mon 1/29/18
238	Levee Clear and Grub	19 days	Fri 10/13/17	Wed 11/8/17
239	Riprap Rock Excavation	3 days	Fri 11/17/17	Tue 11/21/17
240	Riprap Haul to Processing Area	10 days	Wed 11/22/17	Wed 12/6/17
241	Riprap/Filter Material Processing (0.75'-1.25')	29 days	Tue 11/28/17	Tue 1/9/18
242	Riprap Haul to Embankment	29 days	Wed 11/29/17	Wed 1/10/18
243	Riprap Haul Road	24 days	Fri 10/13/17	Thu 11/16/17
244	SWPPP	170 days	Fri 10/13/17	Mon 6/18/18
245	Start Levee Excavation Milestone	0 days	Wed 10/18/17	Wed 10/18/17
246	Levee Common Excavation	60 days	Wed 10/18/17	Tue 1/16/18



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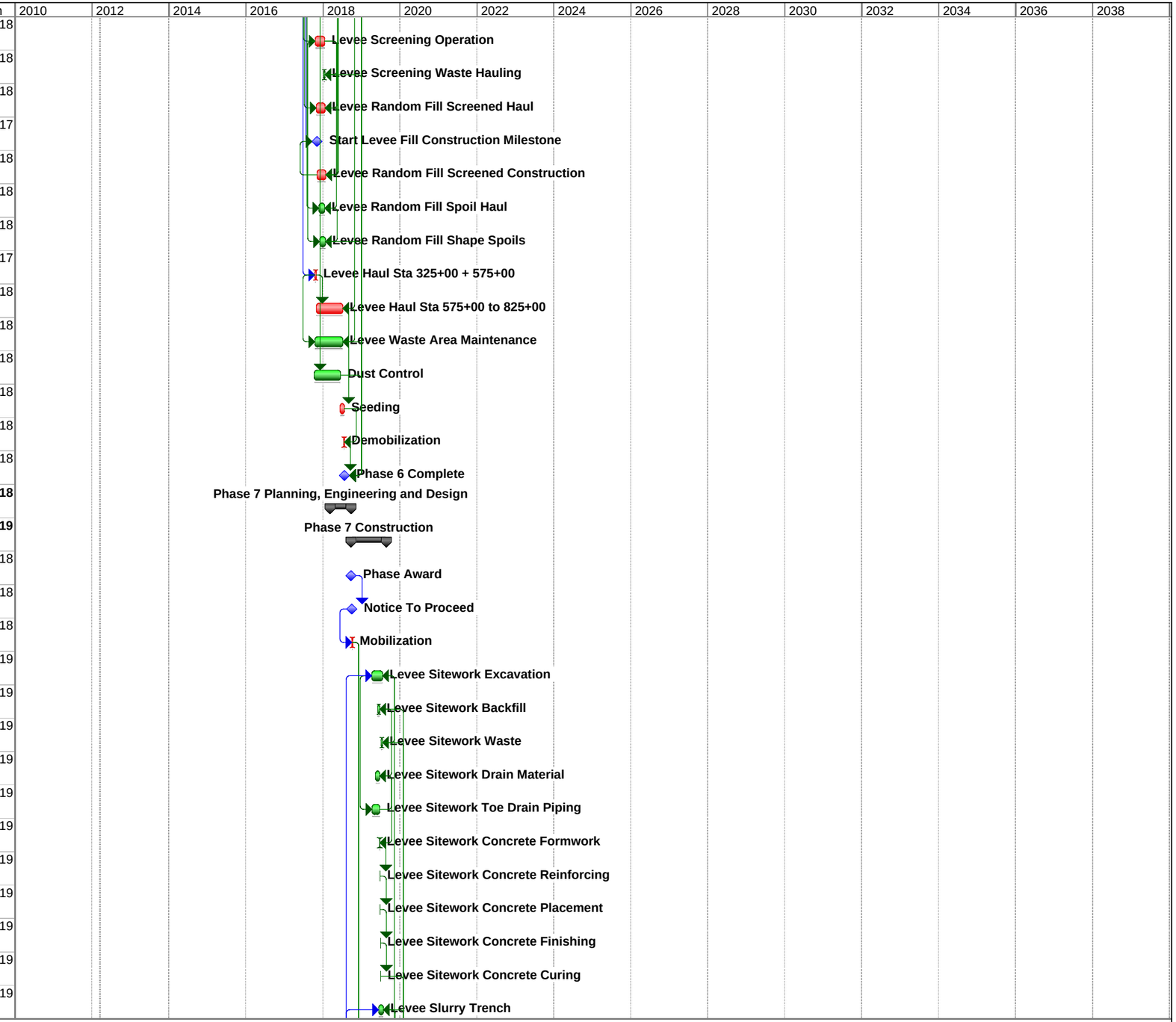
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
247	Levee Screening Operation	60 days	Mon 10/23/17	Fri 1/19/18
248	Levee Screening Waste Hauling	8 days	Wed 1/10/18	Mon 1/22/18
249	Levee Random Fill Screened Haul	54 days	Thu 11/2/17	Tue 1/23/18
250	Start Levee Fill Construction Milestone	0 days	Thu 11/9/17	Thu 11/9/17
251	Levee Random Fill Screened Construction	54 days	Thu 11/9/17	Tue 1/30/18
252	Levee Random Fill Spoil Haul	37 days	Mon 11/27/17	Fri 1/19/18
253	Levee Random Fill Shape Spoils	37 days	Mon 12/4/17	Fri 1/26/18
254	Levee Haul Sta 325+00 + 575+00	10 days	Thu 10/19/17	Wed 11/1/17
255	Levee Haul Sta 575+00 to 825+00	171 days	Thu 11/2/17	Tue 7/10/18
256	Levee Waste Area Maintenance	181 days	Thu 10/19/17	Tue 7/10/18
257	Dust Control	170 days	Fri 10/13/17	Mon 6/18/18
258	Seeding	27 days	Fri 6/15/18	Tue 7/24/18
259	Demobilization	5 days	Fri 7/20/18	Thu 7/26/18
260	Phase 6 Complete	0 days	Thu 7/26/18	Thu 7/26/18
261	**Phase 7 Planning, Engineering and Design**	**140 days**	**Tue 3/13/18**	**Thu 9/27/18**
263	**Phase 7 Construction**	**230 days**	**Fri 9/28/18**	**Wed 8/28/19**
264	Phase Award	0 days	Fri 9/28/18	Fri 9/28/18
265	Notice To Proceed	0 days	Thu 10/4/18	Thu 10/4/18
266	Mobilization	5 days	Fri 10/5/18	Fri 10/12/18
267	Levee Sitework Excavation	71 days	Fri 4/12/19	Tue 7/23/19
268	Levee Sitework Backfill	14 days	Fri 6/7/19	Wed 6/26/19
269	Levee Sitework Waste	11 days	Tue 7/9/19	Tue 7/23/19
270	Levee Sitework Drain Material	28 days	Thu 5/16/19	Tue 6/25/19
271	Levee Sitework Toe Drain Piping	51 days	Mon 4/15/19	Tue 6/25/19
272	Levee Sitework Concrete Formwork	3 days	Wed 6/26/19	Fri 6/28/19
273	Levee Sitework Concrete Reinforcing	1 day	Mon 7/1/19	Mon 7/1/19
274	Levee Sitework Concrete Placement	1 day	Tue 7/2/19	Tue 7/2/19
275	Levee Sitework Concrete Finishing	1 day	Wed 7/3/19	Wed 7/3/19
276	Levee Sitework Concrete Curing	1 day	Fri 7/5/19	Fri 7/5/19
277	Levee Slurry Trench	31 days	Mon 6/17/19	Tue 7/30/19



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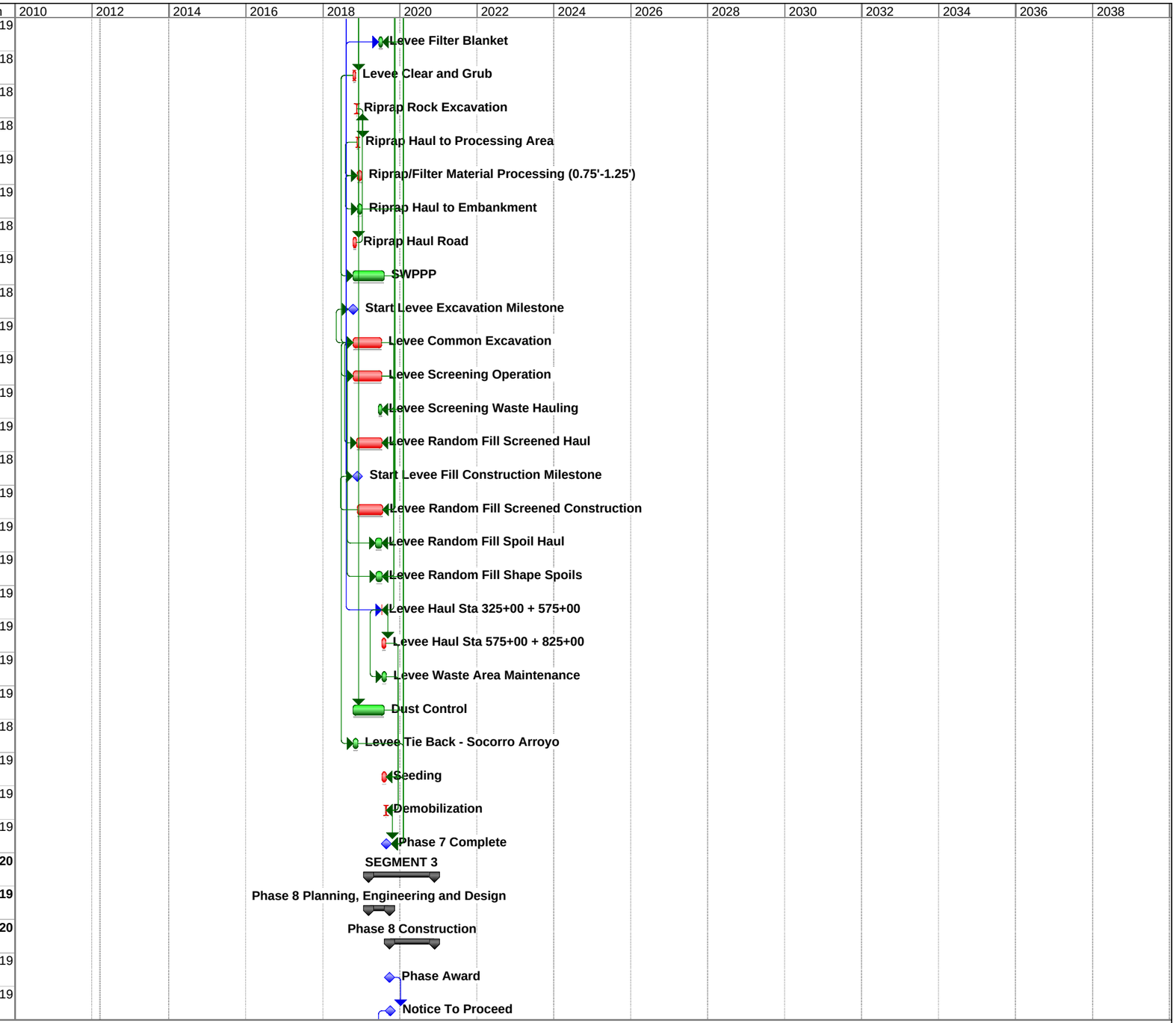
Task | Critical Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Early Start	Early Finish
278	Levee Filter Blanket	25 days	Mon 6/17/19	Mon 7/22/19
279	Levee Clear and Grub	19 days	Mon 10/15/18	Thu 11/8/18
280	Riprap Rock Excavation	3 days	Mon 11/19/18	Wed 11/21/18
281	Riprap Haul to Processing Area	10 days	Fri 11/23/18	Thu 12/6/18
282	Riprap/Filter Material Processing (0.75'-1.25')	29 days	Mon 11/26/18	Mon 1/7/19
283	Riprap Haul to Embankment	29 days	Tue 11/27/18	Tue 1/8/19
284	Riprap Haul Road	24 days	Mon 10/15/18	Fri 11/16/18
285	SWPPP	205 days	Mon 10/15/18	Wed 8/7/19
286	Start Levee Excavation Milestone	0 days	Thu 10/18/18	Thu 10/18/18
287	Levee Common Excavation	184 days	Thu 10/18/18	Fri 7/12/19
288	Levee Screening Operation	184 days	Fri 10/19/18	Mon 7/15/19
289	Levee Screening Waste Hauling	23 days	Thu 6/13/19	Tue 7/16/19
290	Levee Random Fill Screened Haul	165 days	Mon 11/19/18	Tue 7/16/19
291	Start Levee Fill Construction Milestone	0 days	Tue 11/27/18	Tue 11/27/18
292	Levee Random Fill Screened Construction	165 days	Tue 11/27/18	Tue 7/23/19
293	Levee Random Fill Spoil Haul	40 days	Fri 5/17/19	Mon 7/15/19
294	Levee Random Fill Shape Spoils	40 days	Wed 5/22/19	Thu 7/18/19
295	Levee Haul Sta 325+00 + 575+00	1 day	Tue 7/16/19	Tue 7/16/19
296	Levee Haul Sta 575+00 + 825+00	27 days	Wed 7/17/19	Thu 8/22/19
297	Levee Waste Area Maintenance	28 days	Fri 7/19/19	Tue 8/27/19
298	Dust Control	205 days	Mon 10/15/18	Wed 8/7/19
299	Levee Tie Back - Socorro Arroyo	30 days	Thu 10/18/18	Fri 11/30/18
300	Seeding	27 days	Fri 7/19/19	Mon 8/26/19
301	Demobilization	5 days	Thu 8/22/19	Wed 8/28/19
302	Phase 7 Complete	0 days	Wed 8/28/19	Wed 8/28/19
303	**SEGMENT 3**	**432 days**	**Wed 3/13/19**	**Fri 11/27/20**
304	**Phase 8 Planning, Engineering and Design**	**140 days**	**Wed 3/13/19**	**Fri 9/27/19**
306	**Phase 8 Construction**	**292 days**	**Sat 9/28/19**	**Fri 11/27/20**
307	Phase Award	0 days	Sat 9/28/19	Sat 9/28/19
308	Notice To Proceed	0 days	Fri 10/4/19	Fri 10/4/19



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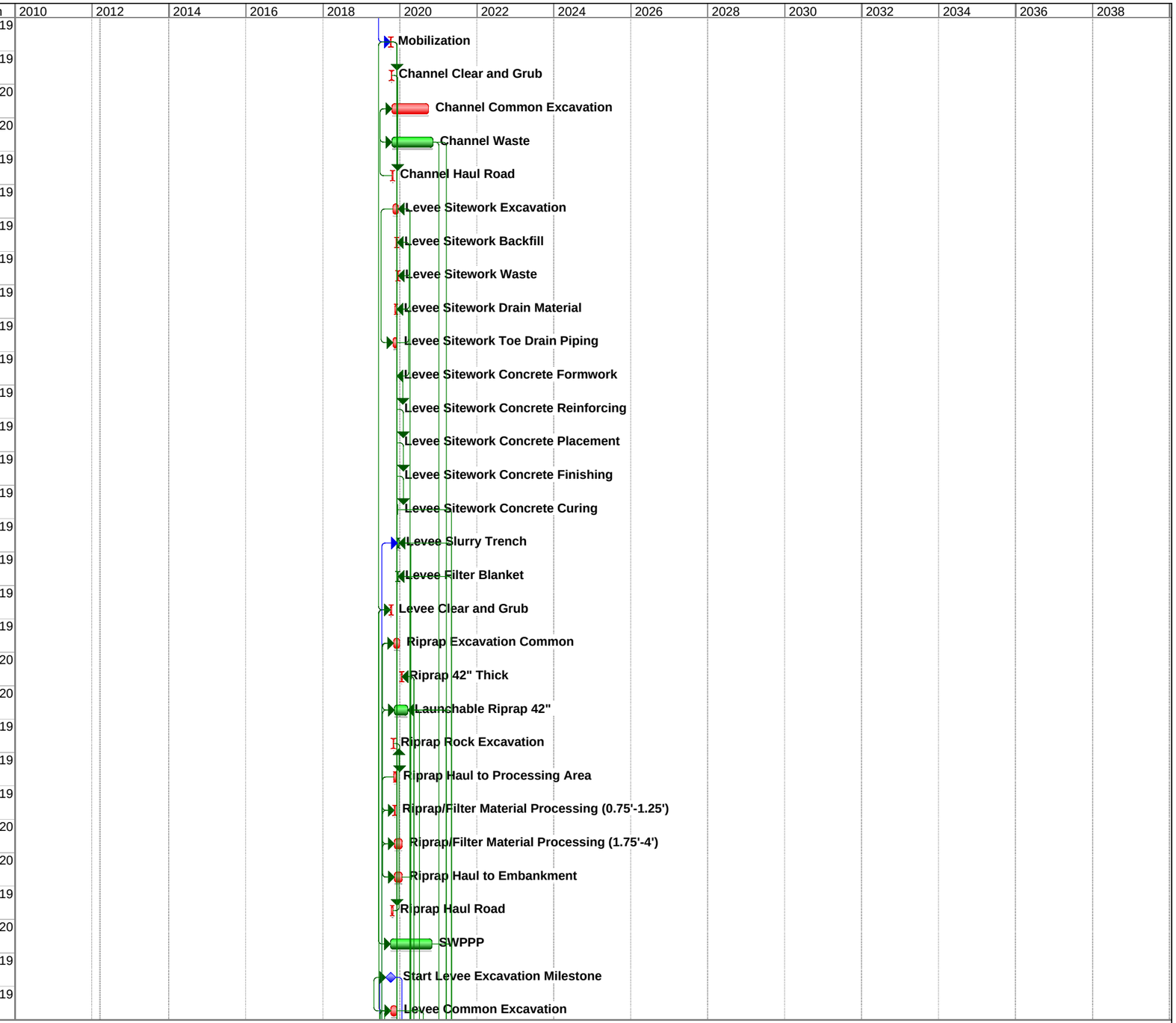
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
309	Mobilization	5 days	Mon 10/7/19	Fri 10/11/19
310	Channel Clear and Grub	4 days	Tue 10/15/19	Fri 10/18/19
311	Channel Common Excavation	239 days	Mon 10/21/19	Wed 9/30/20
312	Channel Waste	268 days	Mon 10/21/19	Thu 11/12/20
313	Channel Haul Road	8 days	Mon 10/21/19	Wed 10/30/19
314	Levee Sitework Excavation	34 days	Wed 10/30/19	Wed 12/18/19
315	Levee Sitework Backfill	7 days	Fri 11/29/19	Mon 12/9/19
316	Levee Sitework Waste	5 days	Thu 12/12/19	Wed 12/18/19
317	Levee Sitework Drain Material	14 days	Mon 11/18/19	Fri 12/6/19
318	Levee Sitework Toe Drain Piping	25 days	Thu 10/31/19	Fri 12/6/19
319	Levee Sitework Concrete Formwork	1 day	Fri 12/6/19	Fri 12/6/19
320	Levee Sitework Concrete Reinforcing	1 day	Mon 12/9/19	Mon 12/9/19
321	Levee Sitework Concrete Placement	1 day	Tue 12/10/19	Tue 12/10/19
322	Levee Sitework Concrete Finishing	1 day	Wed 12/11/19	Wed 12/11/19
323	Levee Sitework Concrete Curing	1 day	Thu 12/12/19	Thu 12/12/19
324	Levee Slurry Trench	10 days	Thu 12/12/19	Thu 12/26/19
325	Levee Filter Blanket	6 days	Tue 12/10/19	Tue 12/17/19
326	Levee Clear and Grub	9 days	Mon 10/7/19	Fri 10/18/19
327	Riprap Excavation Common	36 days	Thu 11/7/19	Tue 12/31/19
328	Riprap 42" Thick	6 days	Thu 1/16/20	Fri 1/24/20
329	Launchable Riprap 42"	85 days	Wed 11/13/19	Tue 3/17/20
330	Riprap Rock Excavation	4 days	Thu 10/31/19	Tue 11/5/19
331	Riprap Haul to Processing Area	16 days	Wed 11/6/19	Fri 11/29/19
332	Riprap/Filter Material Processing (0.75'-1.25')	7 days	Tue 11/12/19	Wed 11/20/19
333	Riprap/Filter Material Processing (1.75'-4')	49 days	Tue 11/12/19	Thu 1/23/20
334	Riprap Haul to Embankment	48 days	Wed 11/13/19	Thu 1/23/20
335	Riprap Haul Road	12 days	Tue 10/15/19	Wed 10/30/19
336	SWPPP	270 days	Mon 10/7/19	Mon 11/2/20
337	Start Levee Excavation Milestone	0 days	Thu 10/10/19	Thu 10/10/19
338	Levee Common Excavation	37 days	Thu 10/10/19	Wed 12/4/19



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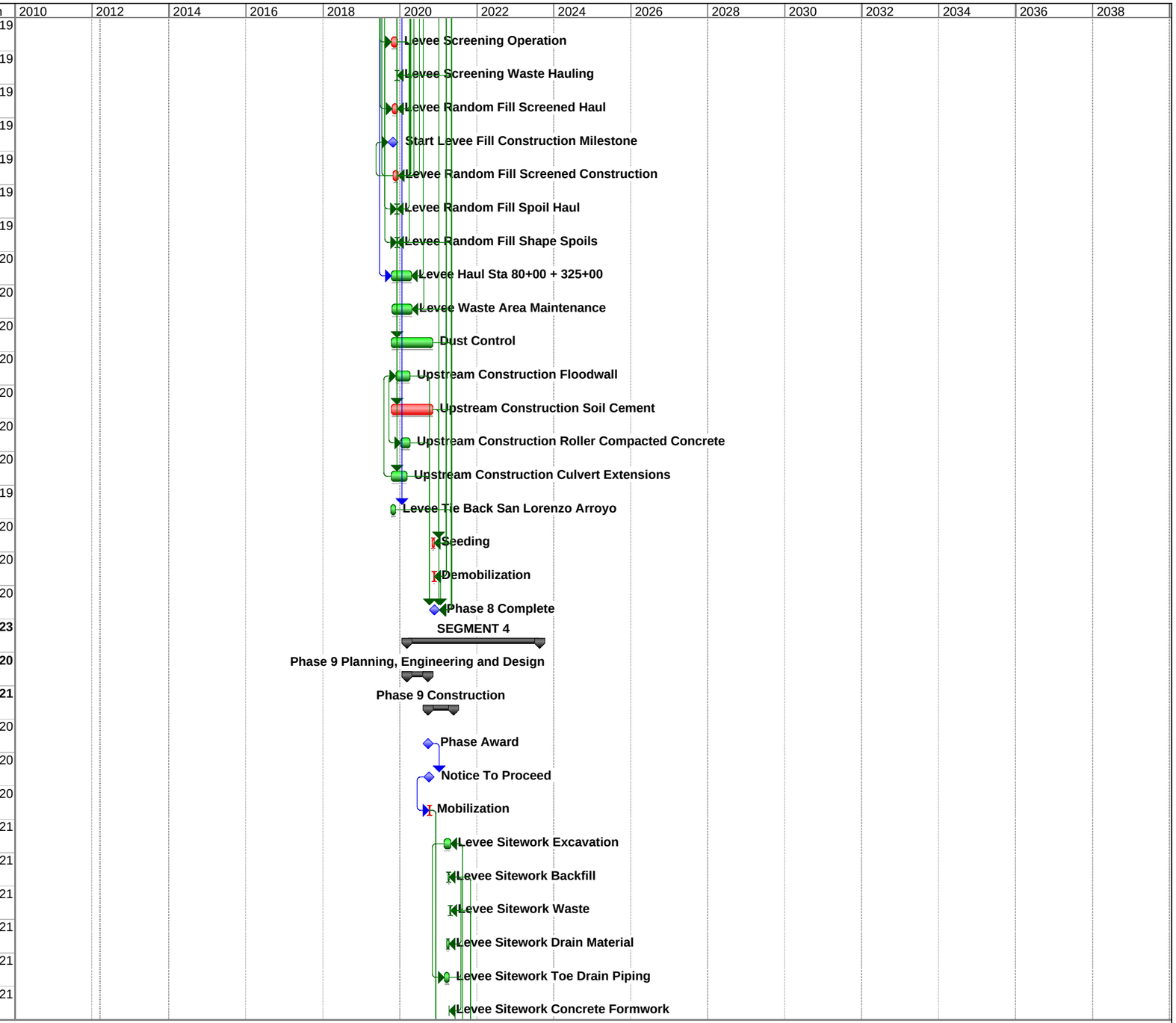
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
339	Levee Screening Operation	37 days	Wed 10/16/19	Mon 12/9/19
340	Levee Screening Waste Hauling	5 days	Wed 12/4/19	Tue 12/10/19
341	Levee Random Fill Screened Haul	33 days	Thu 10/24/19	Wed 12/11/19
342	Start Levee Fill Construction Milestone	0 days	Thu 10/31/19	Thu 10/31/19
343	Levee Random Fill Screened Construction	33 days	Thu 10/31/19	Wed 12/18/19
344	Levee Random Fill Spoil Haul	5 days	Tue 12/3/19	Mon 12/9/19
345	Levee Random Fill Shape Spoils	5 days	Fri 12/6/19	Thu 12/12/19
346	Levee Haul Sta 80+00 + 325+00	130 days	Wed 10/16/19	Wed 4/22/20
347	Levee Waste Area Maintenance	130 days	Mon 10/21/19	Mon 4/27/20
348	Dust Control	270 days	Tue 10/15/19	Mon 11/9/20
349	Upstream Construction Floodwall	90 days	Wed 11/27/19	Tue 4/7/20
350	Upstream Construction Soil Cement	270 days	Tue 10/15/19	Mon 11/9/20
351	Upstream Construction Roller Compacted Concrete	60 days	Mon 1/13/20	Tue 4/7/20
352	Upstream Construction Culvert Extensions	100 days	Tue 10/15/19	Tue 3/10/20
353	Levee Tie Back San Lorenzo Arroyo	30 days	Thu 10/10/19	Fri 11/22/19
354	Seeding	13 days	Thu 11/5/20	Tue 11/24/20
355	Demobilization	5 days	Fri 11/20/20	Fri 11/27/20
356	Phase 8 Complete	0 days	Fri 11/27/20	Fri 11/27/20
357	**SEGMENT 4**	**869 days**	**Wed 3/11/20**	**Wed 8/23/23**
358	**Phase 9 Planning, Engineering and Design**	**140 days**	**Wed 3/11/20**	**Fri 9/25/20**
360	**Phase 9 Construction**	**167 days**	**Mon 9/28/20**	**Thu 5/27/21**
361	Phase Award	0 days	Mon 9/28/20	Mon 9/28/20
362	Notice To Proceed	0 days	Tue 10/6/20	Tue 10/6/20
363	Mobilization	5 days	Wed 10/7/20	Wed 10/14/20
364	Levee Sitework Excavation	46 days	Fri 2/26/21	Fri 4/30/21
365	Levee Sitework Backfill	9 days	Mon 4/5/21	Thu 4/15/21
366	Levee Sitework Waste	7 days	Thu 4/22/21	Fri 4/30/21
367	Levee Sitework Drain Material	18 days	Mon 3/22/21	Wed 4/14/21
368	Levee Sitework Toe Drain Piping	33 days	Mon 3/1/21	Wed 4/14/21
369	Levee Sitework Concrete Formwork	2 days	Tue 4/13/21	Wed 4/14/21



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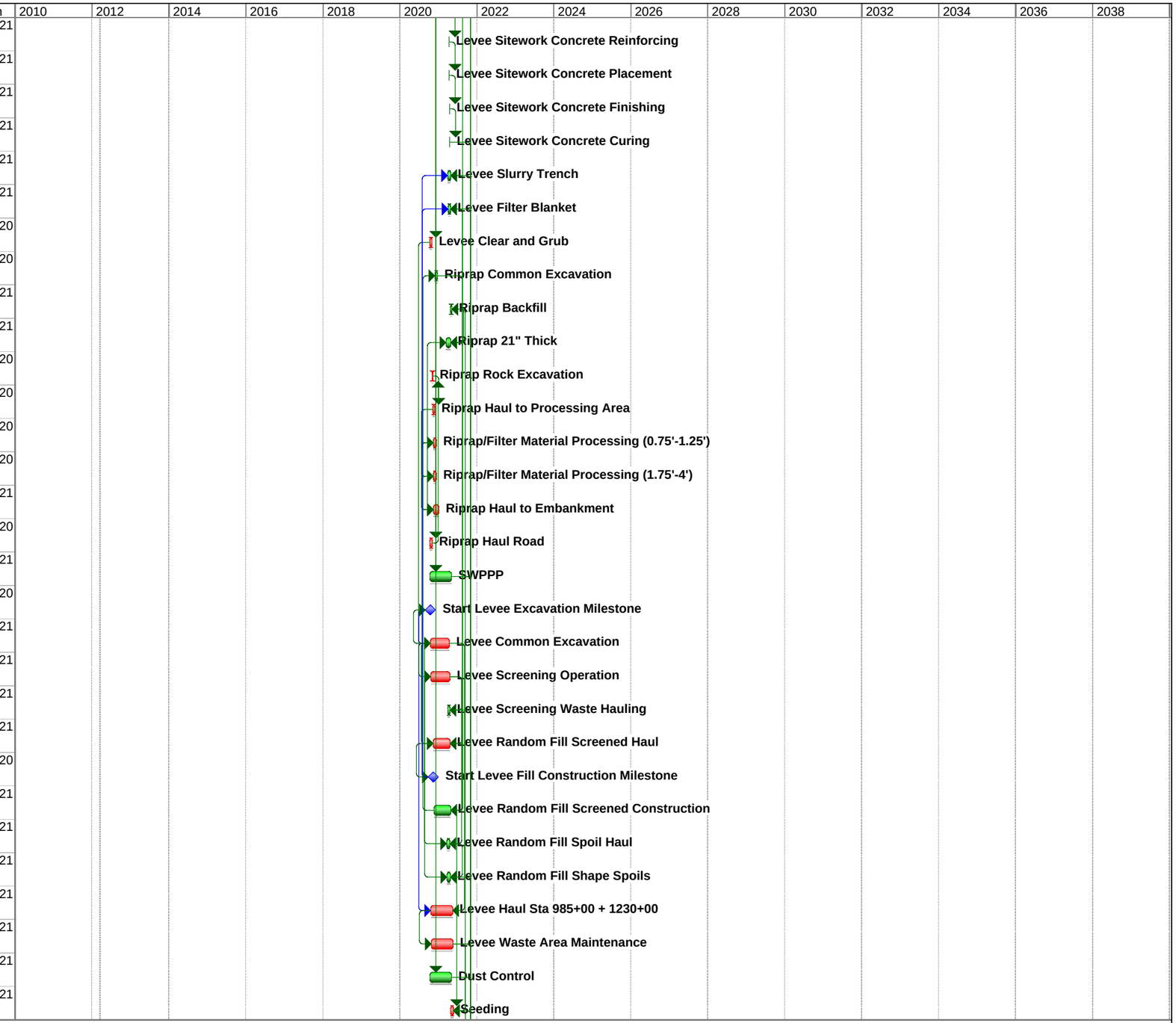
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
370	Levee Sitework Concrete Reinforcing	1 day	Thu 4/15/21	Thu 4/15/21
371	Levee Sitework Concrete Placement	1 day	Fri 4/16/21	Fri 4/16/21
372	Levee Sitework Concrete Finishing	1 day	Mon 4/19/21	Mon 4/19/21
373	Levee Sitework Concrete Curing	1 day	Tue 4/20/21	Tue 4/20/21
374	Levee Slurry Trench	22 days	Thu 4/1/21	Fri 4/30/21
375	Levee Filter Blanket	17 days	Tue 4/6/21	Wed 4/28/21
376	Levee Clear and Grub	13 days	Thu 10/15/20	Mon 11/2/20
377	Riprap Common Excavation	18 days	Tue 12/1/20	Thu 12/24/20
378	Riprap Backfill	10 days	Wed 4/28/21	Tue 5/11/21
379	Riprap 21" Thick	33 days	Wed 3/17/21	Fri 4/30/21
380	Riprap Rock Excavation	3 days	Fri 11/6/20	Tue 11/10/20
381	Riprap Haul to Processing Area	11 days	Thu 11/12/20	Fri 11/27/20
382	Riprap/Filter Material Processing (0.75'-1.25')	19 days	Tue 11/17/20	Mon 12/14/20
383	Riprap/Filter Material Processing (1.75'-4')	19 days	Tue 11/17/20	Mon 12/14/20
384	Riprap Haul to Embankment	34 days	Wed 11/18/20	Thu 1/7/21
385	Riprap Haul Road	16 days	Thu 10/15/20	Thu 11/5/20
386	SWPPP	140 days	Thu 10/15/20	Thu 5/6/21
387	Start Levee Excavation Milestone	0 days	Tue 10/20/20	Tue 10/20/20
388	Levee Common Excavation	123 days	Tue 10/20/20	Fri 4/16/21
389	Levee Screening Operation	123 days	Fri 10/23/20	Wed 4/21/21
390	Levee Screening Waste Hauling	15 days	Fri 4/2/21	Thu 4/22/21
391	Levee Random Fill Screened Haul	110 days	Mon 11/16/20	Fri 4/23/21
392	Start Levee Fill Construction Milestone	0 days	Mon 11/16/20	Mon 11/16/20
393	Levee Random Fill Screened Construction	110 days	Mon 11/23/20	Fri 4/30/21
394	Levee Random Fill Spoil Haul	22 days	Tue 3/23/21	Wed 4/21/21
395	Levee Random Fill Shape Spoils	22 days	Fri 3/26/21	Mon 4/26/21
396	Levee Haul Sta 985+00 + 1230+00	142 days	Fri 10/23/20	Tue 5/18/21
397	Levee Waste Area Maintenance	142 days	Wed 10/28/20	Fri 5/21/21
398	Dust Control	140 days	Thu 10/15/20	Thu 5/6/21
399	Seeding	18 days	Fri 4/30/21	Tue 5/25/21



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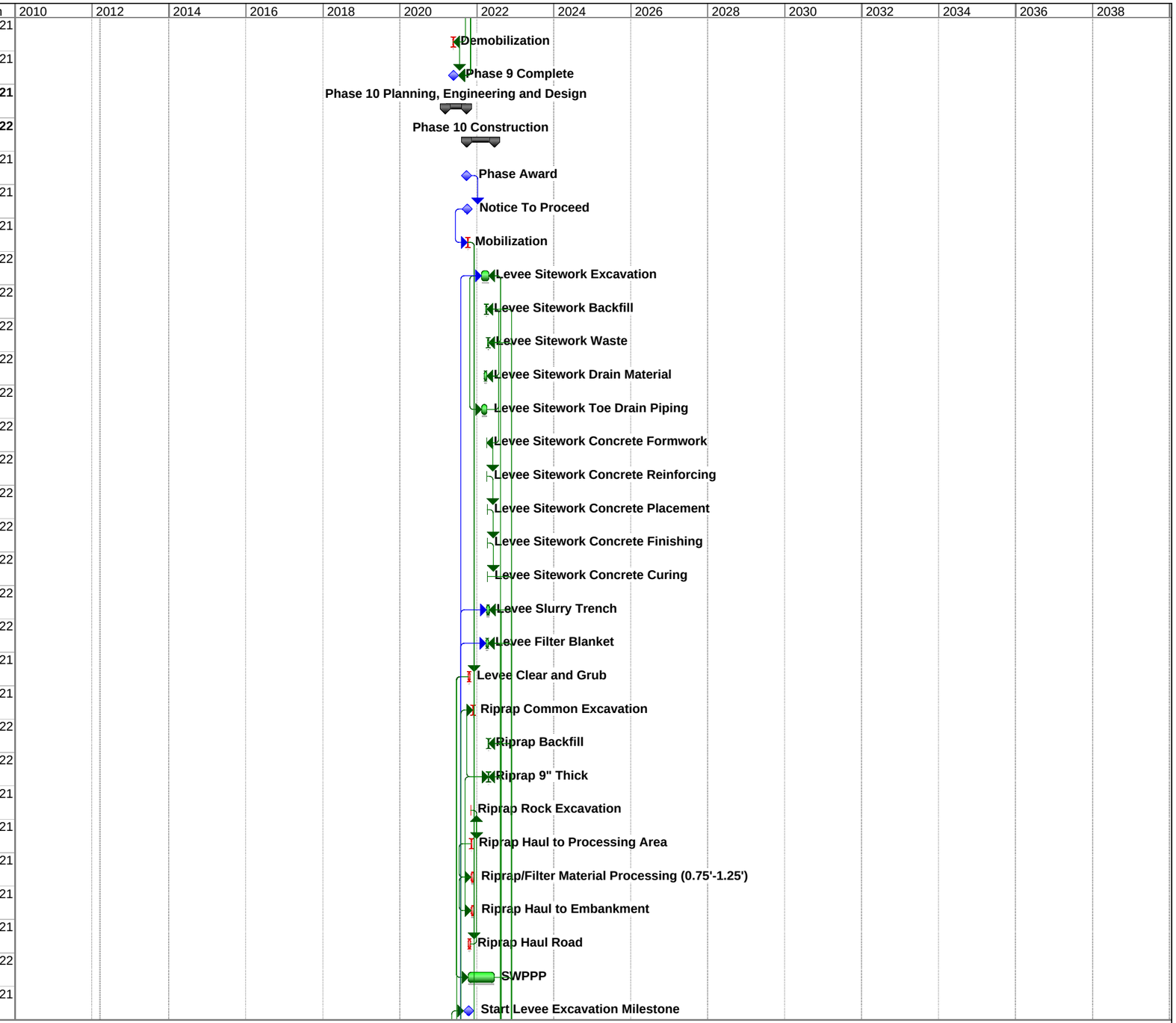
Task		Split		Milestone		Project Summary		External Milestone
Critical Task		Progress		Summary		External Tasks		Deadline

ID	Task Name	Duration	Early Start	Early Finish
400	Demobilization	5 days	Fri 5/21/21	Thu 5/27/21
401	Phase 9 Complete	0 days	Thu 5/27/21	Thu 5/27/21
402	**Phase 10 Planning, Engineering and Design**	**140 days**	**Thu 3/11/21**	**Mon 9/27/21**
404	**Phase 10 Construction**	**182 days**	**Tue 9/28/21**	**Mon 6/20/22**
405	Phase Award	0 days	Tue 9/28/21	Tue 9/28/21
406	Notice To Proceed	0 days	Mon 10/4/21	Mon 10/4/21
407	Mobilization	5 days	Tue 10/5/21	Tue 10/12/21
408	Levee Sitework Excavation	47 days	Thu 2/17/22	Mon 4/25/22
409	Levee Sitework Backfill	9 days	Tue 3/29/22	Fri 4/8/22
410	Levee Sitework Waste	7 days	Fri 4/15/22	Mon 4/25/22
411	Levee Sitework Drain Material	19 days	Mon 3/14/22	Thu 4/7/22
412	Levee Sitework Toe Drain Piping	34 days	Fri 2/18/22	Thu 4/7/22
413	Levee Sitework Concrete Formwork	2 days	Wed 4/6/22	Thu 4/7/22
414	Levee Sitework Concrete Reinforcing	1 day	Fri 4/8/22	Fri 4/8/22
415	Levee Sitework Concrete Placement	1 day	Mon 4/11/22	Mon 4/11/22
416	Levee Sitework Concrete Finishing	1 day	Tue 4/12/22	Tue 4/12/22
417	Levee Sitework Concrete Curing	1 day	Wed 4/13/22	Wed 4/13/22
418	Levee Slurry Trench	20 days	Tue 4/5/22	Mon 5/2/22
419	Levee Filter Blanket	17 days	Thu 3/31/22	Fri 4/22/22
420	Levee Clear and Grub	13 days	Wed 10/13/21	Fri 10/29/21
421	Riprap Common Excavation	3 days	Fri 11/26/21	Tue 11/30/21
422	Riprap Backfill	5 days	Wed 4/20/22	Tue 4/26/22
423	Riprap 9" Thick	3 days	Thu 4/21/22	Mon 4/25/22
424	Riprap Rock Excavation	2 days	Thu 11/4/21	Fri 11/5/21
425	Riprap Haul to Processing Area	7 days	Mon 11/8/21	Wed 11/17/21
426	Riprap/Filter Material Processing (0.75'-1.25')	21 days	Tue 11/9/21	Thu 12/9/21
427	Riprap Haul to Embankment	21 days	Wed 11/10/21	Fri 12/10/21
428	Riprap Haul Road	16 days	Wed 10/13/21	Wed 11/3/21
429	SWPPP	170 days	Wed 10/13/21	Thu 6/16/22
430	Start Levee Excavation Milestone	0 days	Mon 10/18/21	Mon 10/18/21



Project: San Acacia Alt A Base + 4
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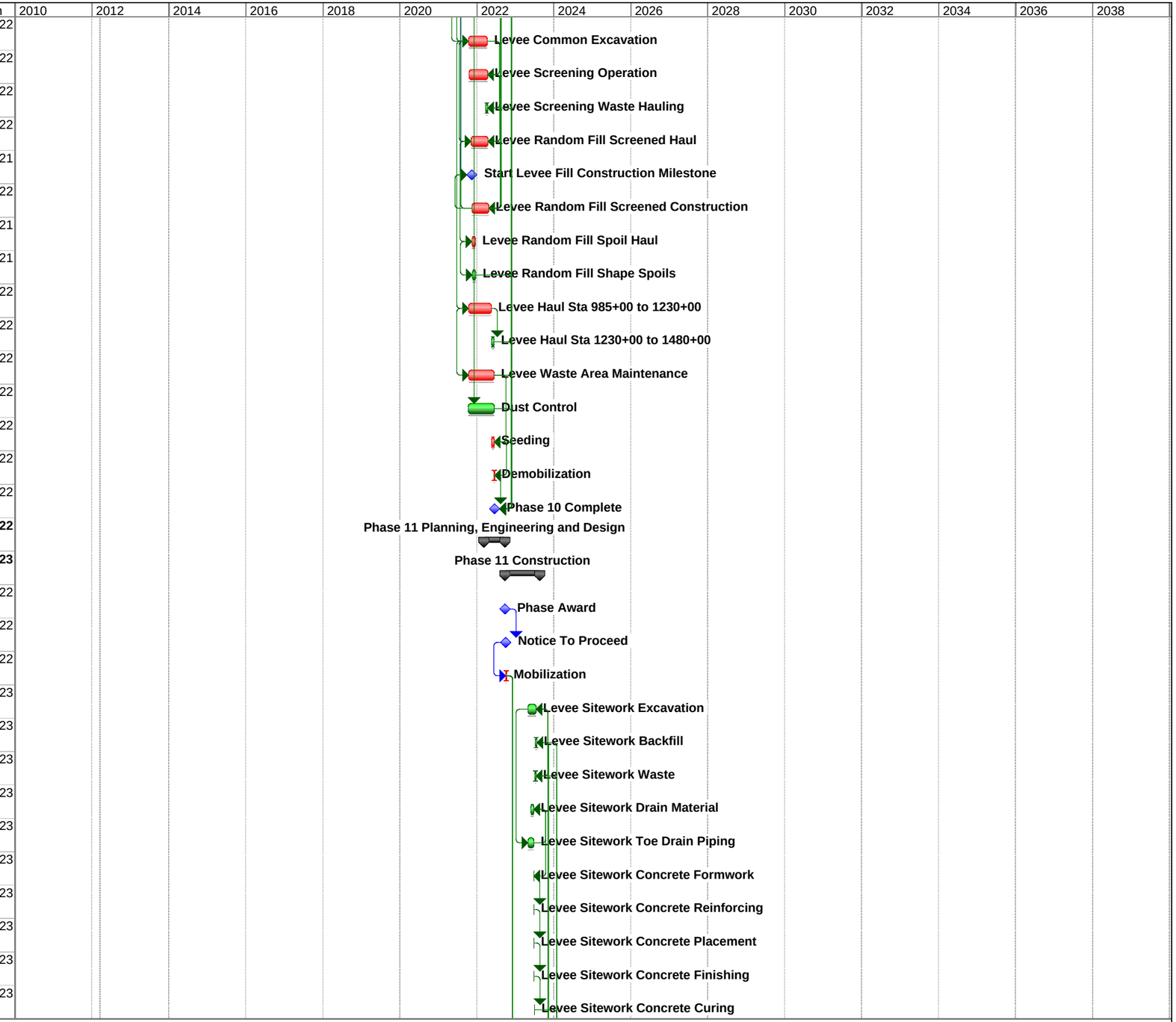
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
431	Levee Common Excavation	120 days	Mon 10/18/21	Mon 4/11/22
432	Levee Screening Operation	120 days	Thu 10/21/21	Thu 4/14/22
433	Levee Screening Waste Hauling	15 days	Mon 3/28/22	Fri 4/15/22
434	Levee Random Fill Screened Haul	108 days	Wed 11/10/21	Mon 4/18/22
435	Start Levee Fill Construction Milestone	0 days	Thu 11/18/21	Thu 11/18/21
436	Levee Random Fill Screened Construction	108 days	Thu 11/18/21	Mon 4/25/22
437	Levee Random Fill Spoil Haul	22 days	Thu 11/18/21	Mon 12/20/21
438	Levee Random Fill Shape Spoils	22 days	Mon 11/22/21	Wed 12/22/21
439	Levee Haul Sta 985+00 to 1230+00	149 days	Mon 10/18/21	Fri 5/20/22
440	Levee Haul Sta 1230+00 to 1480+00	16 days	Mon 5/23/22	Tue 6/14/22
441	Levee Waste Area Maintenance	165 days	Mon 10/18/21	Tue 6/14/22
442	Dust Control	170 days	Wed 10/13/21	Thu 6/16/22
443	Seeding	18 days	Mon 5/23/22	Thu 6/16/22
444	Demobilization	5 days	Tue 6/14/22	Mon 6/20/22
445	Phase 10 Complete	0 days	Mon 6/20/22	Mon 6/20/22
446	**Phase 11 Planning, Engineering and Design**	**140 days**	**Fri 3/11/22**	**Tue 9/27/22**
448	**Phase 11 Construction**	**227 days**	**Wed 9/28/22**	**Wed 8/23/23**
449	Phase Award	0 days	Wed 9/28/22	Wed 9/28/22
450	Notice To Proceed	0 days	Tue 10/4/22	Tue 10/4/22
451	Mobilization	5 days	Wed 10/5/22	Wed 10/12/22
452	Levee Sitework Excavation	53 days	Wed 5/3/23	Tue 7/18/23
453	Levee Sitework Backfill	11 days	Wed 7/12/23	Wed 7/26/23
454	Levee Sitework Waste	8 days	Fri 7/7/23	Tue 7/18/23
455	Levee Sitework Drain Material	21 days	Tue 5/30/23	Tue 6/27/23
456	Levee Sitework Toe Drain Piping	38 days	Thu 5/4/23	Tue 6/27/23
457	Levee Sitework Concrete Formwork	2 days	Mon 6/26/23	Tue 6/27/23
458	Levee Sitework Concrete Reinforcing	1 day	Wed 6/28/23	Wed 6/28/23
459	Levee Sitework Concrete Placement	1 day	Thu 6/29/23	Thu 6/29/23
460	Levee Sitework Concrete Finishing	1 day	Fri 6/30/23	Fri 6/30/23
461	Levee Sitework Concrete Curing	1 day	Mon 7/3/23	Mon 7/3/23



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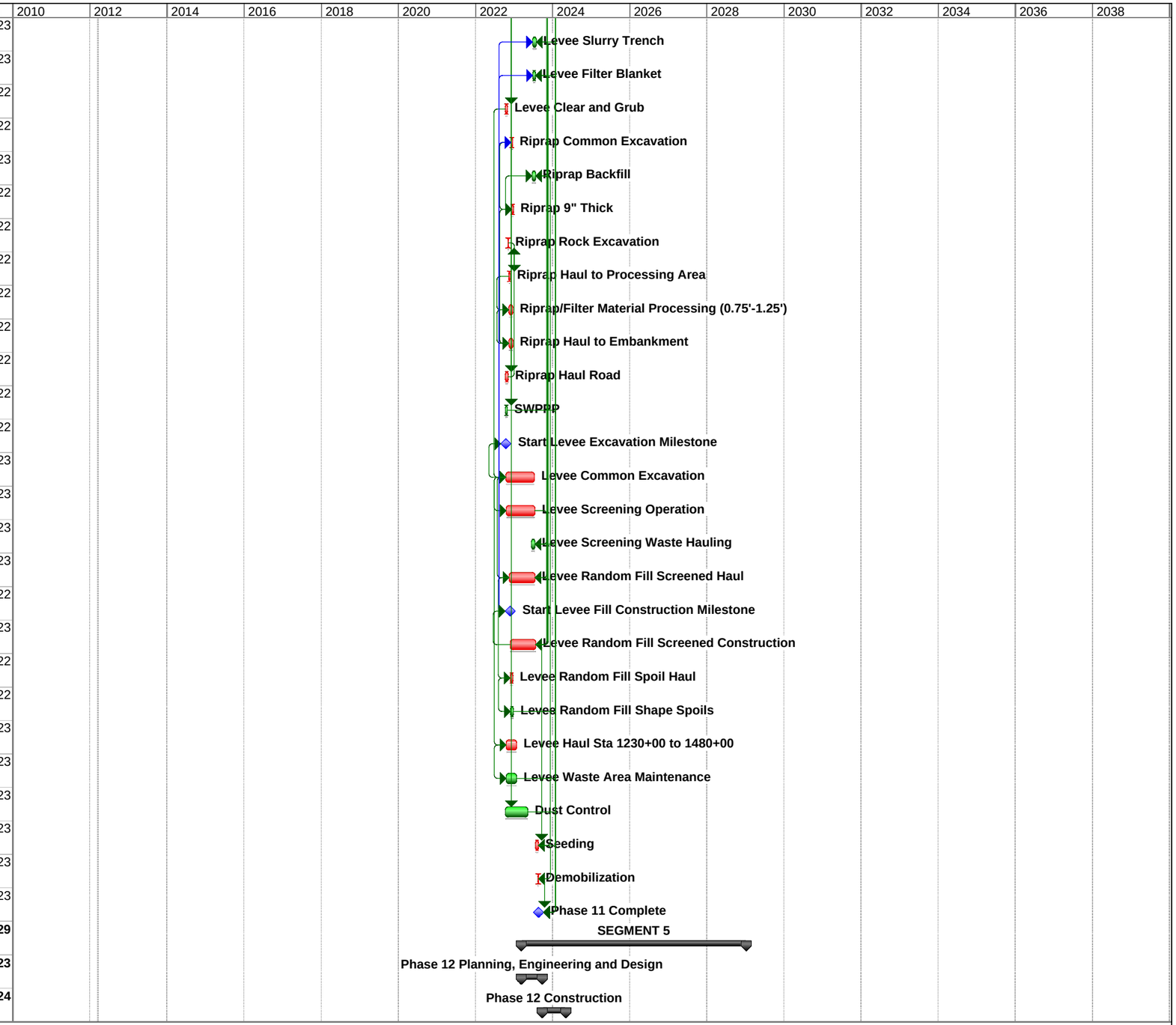
Task | Critical Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Early Start	Early Finish
462	Levee Slurry Trench	25 days	Wed 6/28/23	Wed 8/2/23
463	Levee Filter Blanket	18 days	Thu 6/29/23	Tue 7/25/23
464	Levee Clear and Grub	14 days	Thu 10/13/22	Tue 11/1/22
465	Riprap Common Excavation	12 days	Mon 12/5/22	Tue 12/20/22
466	Riprap Backfill	23 days	Fri 6/23/23	Wed 7/26/23
467	Riprap 9" Thick	12 days	Mon 12/12/22	Wed 12/28/22
468	Riprap Rock Excavation	3 days	Tue 11/8/22	Thu 11/10/22
469	Riprap Haul to Processing Area	9 days	Mon 11/14/22	Fri 11/25/22
470	Riprap/Filter Material Processing (0.75'-1.25')	27 days	Tue 11/15/22	Thu 12/22/22
471	Riprap Haul to Embankment	27 days	Wed 11/16/22	Fri 12/23/22
472	Riprap Haul Road	18 days	Thu 10/13/22	Mon 11/7/22
473	SWPPP	13 days	Thu 10/13/22	Mon 10/31/22
474	Start Levee Excavation Milestone	0 days	Tue 10/18/22	Tue 10/18/22
475	Levee Common Excavation	185 days	Tue 10/18/22	Thu 7/13/23
476	Levee Screening Operation	185 days	Fri 10/21/22	Tue 7/18/23
477	Levee Screening Waste Hauling	23 days	Fri 6/16/23	Wed 7/19/23
478	Levee Random Fill Screened Haul	167 days	Fri 11/18/22	Wed 7/19/23
479	Start Levee Fill Construction Milestone	0 days	Mon 11/28/22	Mon 11/28/22
480	Levee Random Fill Screened Construction	167 days	Mon 11/28/22	Wed 7/26/23
481	Levee Random Fill Spoil Haul	19 days	Mon 11/28/22	Thu 12/22/22
482	Levee Random Fill Shape Spoils	19 days	Wed 11/30/22	Tue 12/27/22
483	Levee Haul Sta 1230+00 to 1480+00	65 days	Fri 10/21/22	Thu 1/26/23
484	Levee Waste Area Maintenance	65 days	Fri 10/21/22	Thu 1/26/23
485	Dust Control	146 days	Thu 10/13/22	Fri 5/12/23
486	Seeding	20 days	Tue 7/25/23	Mon 8/21/23
487	Demobilization	5 days	Thu 8/17/23	Wed 8/23/23
488	Phase 11 Complete	0 days	Wed 8/23/23	Wed 8/23/23
489	**SEGMENT 5**	**1465 days**	**Mon 3/13/23**	**Wed 1/10/29**
490	**Phase 12 Planning, Engineering and Design**	**140 days**	**Mon 3/13/23**	**Wed 9/27/23**
492	**Phase 12 Construction**	**152 days**	**Thu 9/28/23**	**Tue 5/7/24**



Project: San Acacia Alt A Base + 4
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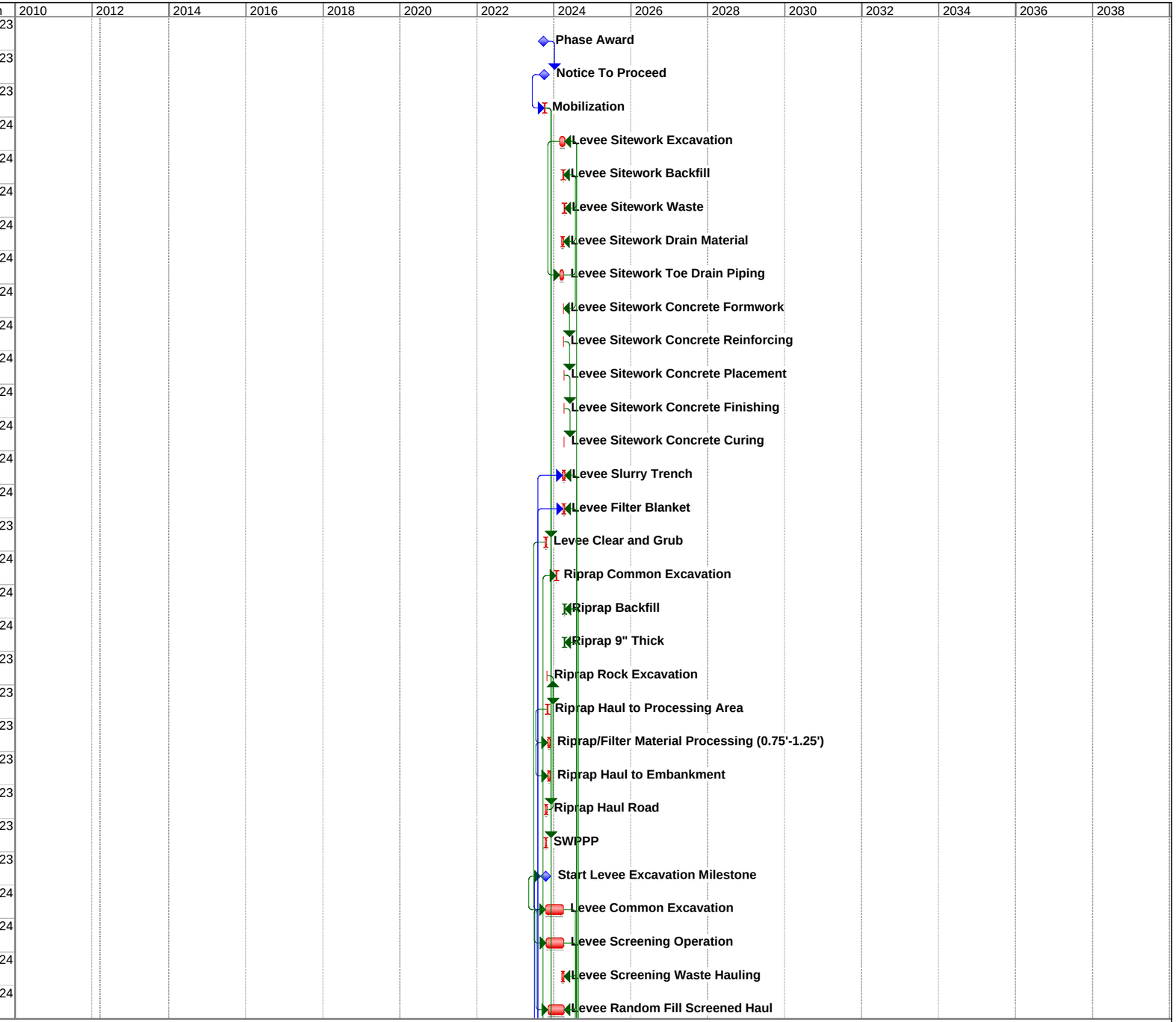
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
493	Phase Award	0 days	Thu 9/28/23	Thu 9/28/23
494	Notice To Proceed	0 days	Wed 10/4/23	Wed 10/4/23
495	Mobilization	5 days	Thu 10/5/23	Thu 10/12/23
496	Levee Sitework Excavation	34 days	Thu 2/29/24	Tue 4/16/24
497	Levee Sitework Backfill	7 days	Thu 3/28/24	Fri 4/5/24
498	Levee Sitework Waste	5 days	Wed 4/10/24	Tue 4/16/24
499	Levee Sitework Drain Material	14 days	Mon 3/18/24	Thu 4/4/24
500	Levee Sitework Toe Drain Piping	25 days	Fri 3/1/24	Thu 4/4/24
501	Levee Sitework Concrete Formwork	1 day	Thu 4/4/24	Thu 4/4/24
502	Levee Sitework Concrete Reinforcing	1 day	Fri 4/5/24	Fri 4/5/24
503	Levee Sitework Concrete Placement	1 day	Mon 4/8/24	Mon 4/8/24
504	Levee Sitework Concrete Finishing	1 day	Tue 4/9/24	Tue 4/9/24
505	Levee Sitework Concrete Curing	1 day	Wed 4/10/24	Wed 4/10/24
506	Levee Slurry Trench	16 days	Wed 3/27/24	Wed 4/17/24
507	Levee Filter Blanket	12 days	Fri 3/29/24	Mon 4/15/24
508	Levee Clear and Grub	9 days	Fri 10/13/23	Wed 10/25/23
509	Riprap Common Excavation	4 days	Fri 1/26/24	Wed 1/31/24
510	Riprap Backfill	7 days	Tue 4/9/24	Wed 4/17/24
511	Riprap 9" Thick	4 days	Thu 4/11/24	Tue 4/16/24
512	Riprap Rock Excavation	2 days	Tue 10/31/23	Wed 11/1/23
513	Riprap Haul to Processing Area	5 days	Thu 11/2/23	Wed 11/8/23
514	Riprap/Filter Material Processing (0.75'-1.25')	16 days	Tue 11/7/23	Thu 11/30/23
515	Riprap Haul to Embankment	16 days	Wed 11/8/23	Fri 12/1/23
516	Riprap Haul Road	12 days	Fri 10/13/23	Mon 10/30/23
517	SWPPP	9 days	Fri 10/13/23	Wed 10/25/23
518	Start Levee Excavation Milestone	0 days	Wed 10/18/23	Wed 10/18/23
519	Levee Common Excavation	114 days	Wed 10/18/23	Tue 4/2/24
520	Levee Screening Operation	114 days	Mon 10/23/23	Fri 4/5/24
521	Levee Screening Waste Hauling	14 days	Wed 3/20/24	Mon 4/8/24
522	Levee Random Fill Screened Haul	102 days	Fri 11/10/23	Tue 4/9/24



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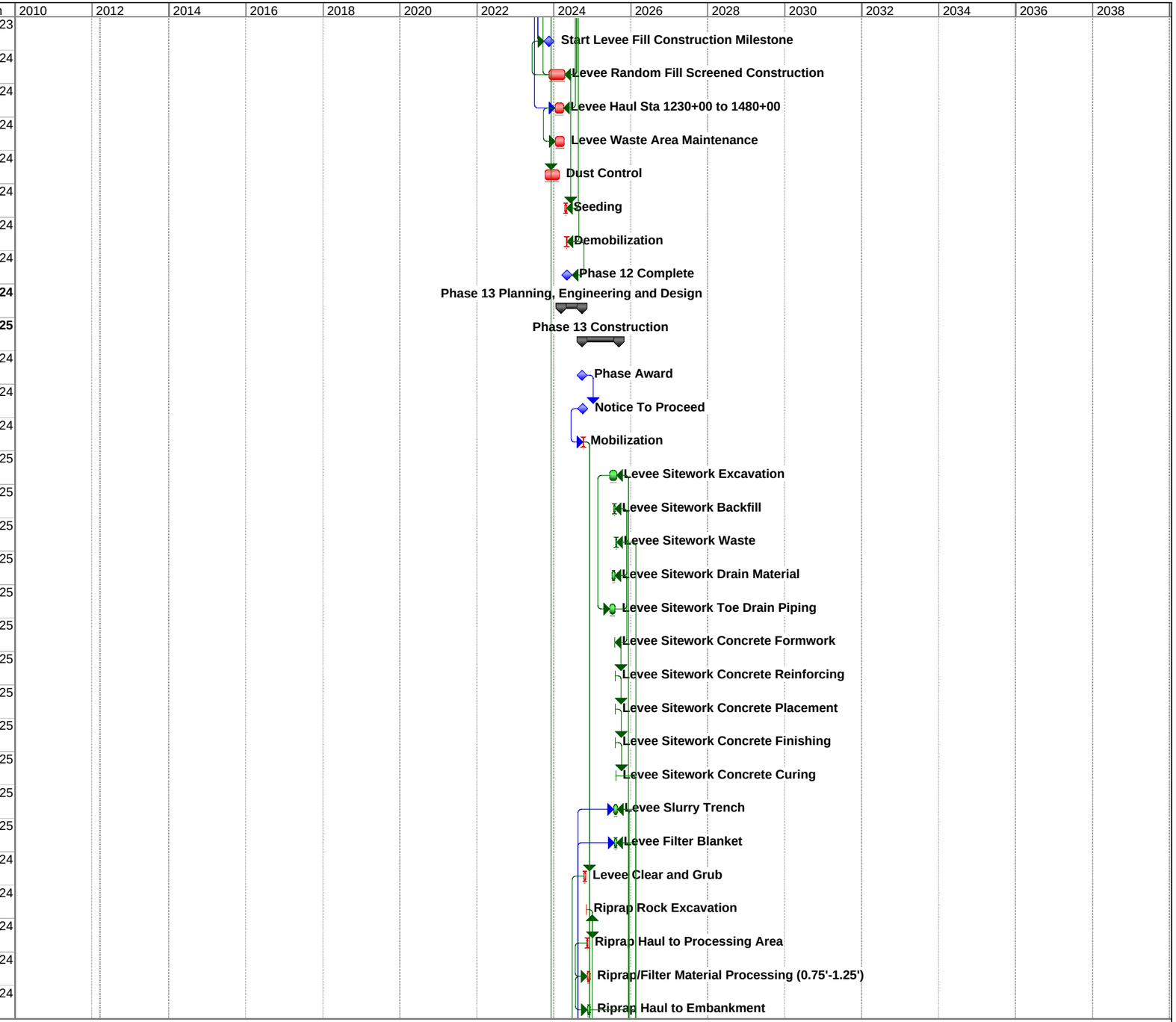
Task | Critical Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Early Start	Early Finish
523	Start Levee Fill Construction Milestone	0 days	Mon 11/20/23	Mon 11/20/23
524	Levee Random Fill Screened Construction	102 days	Mon 11/20/23	Tue 4/16/24
525	Levee Haul Sta 1230+00 to 1480+00	57 days	Tue 1/16/24	Thu 4/4/24
526	Levee Waste Area Maintenance	57 days	Fri 1/19/24	Tue 4/9/24
527	Dust Control	90 days	Fri 10/13/23	Fri 2/23/24
528	Seeding	13 days	Wed 4/17/24	Fri 5/3/24
529	Demobilization	5 days	Wed 5/1/24	Tue 5/7/24
530	Phase 12 Complete	0 days	Tue 5/7/24	Tue 5/7/24
531	**Phase 13 Planning, Engineering and Design**	**140 days**	**Wed 3/13/24**	**Fri 9/27/24**
533	**Phase 13 Construction**	**240 days**	**Sat 9/28/24**	**Fri 9/12/25**
534	Phase Award	0 days	Sat 9/28/24	Sat 9/28/24
535	Notice To Proceed	0 days	Fri 10/4/24	Fri 10/4/24
536	Mobilization	5 days	Mon 10/7/24	Fri 10/11/24
537	Levee Sitework Excavation	47 days	Tue 6/17/25	Thu 8/21/25
538	Levee Sitework Backfill	9 days	Fri 7/25/25	Wed 8/6/25
539	Levee Sitework Waste	7 days	Wed 8/13/25	Thu 8/21/25
540	Levee Sitework Drain Material	19 days	Thu 7/10/25	Tue 8/5/25
541	Levee Sitework Toe Drain Piping	34 days	Wed 6/18/25	Tue 8/5/25
542	Levee Sitework Concrete Formwork	2 days	Tue 8/5/25	Wed 8/6/25
543	Levee Sitework Concrete Reinforcing	1 day	Thu 8/7/25	Thu 8/7/25
544	Levee Sitework Concrete Placement	1 day	Fri 8/8/25	Fri 8/8/25
545	Levee Sitework Concrete Finishing	1 day	Mon 8/11/25	Mon 8/11/25
546	Levee Sitework Concrete Curing	1 day	Tue 8/12/25	Tue 8/12/25
547	Levee Slurry Trench	25 days	Fri 7/25/25	Thu 8/28/25
548	Levee Filter Blanket	17 days	Thu 7/31/25	Fri 8/22/25
549	Levee Clear and Grub	13 days	Tue 10/15/24	Thu 10/31/24
550	Riprap Rock Excavation	2 days	Thu 11/7/24	Fri 11/8/24
551	Riprap Haul to Processing Area	7 days	Tue 11/12/24	Wed 11/20/24
552	Riprap/Filter Material Processing (0.75'-1.25')	19 days	Fri 11/15/24	Thu 12/12/24
553	Riprap Haul to Embankment	19 days	Mon 11/18/24	Fri 12/13/24



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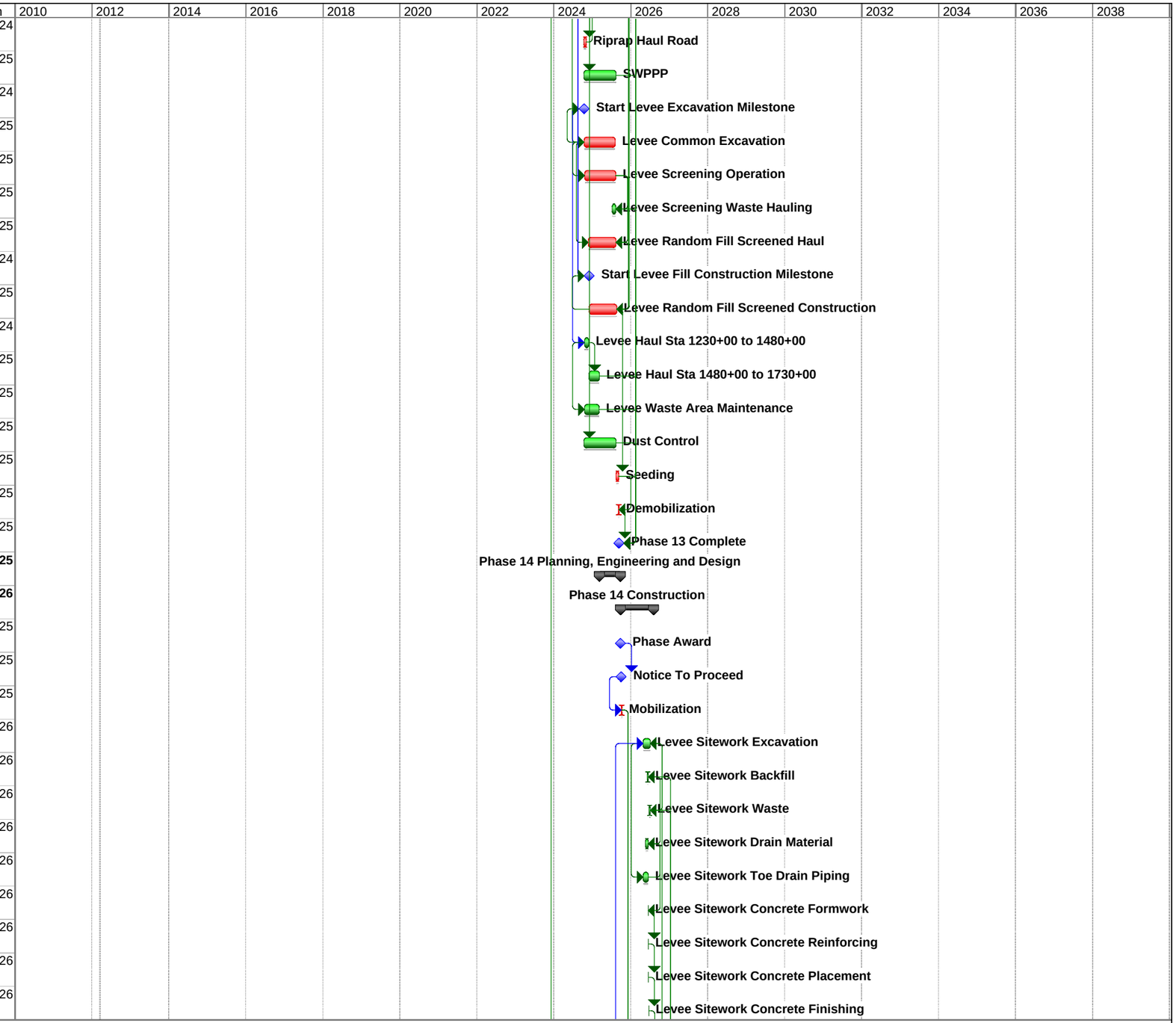
Task | Critical Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Early Start	Early Finish
554	Riprap Haul Road	17 days	Tue 10/15/24	Wed 11/6/24
555	SWPPP	211 days	Tue 10/15/24	Fri 8/15/25
556	Start Levee Excavation Milestone	0 days	Fri 10/18/24	Fri 10/18/24
557	Levee Common Excavation	202 days	Fri 10/18/24	Thu 8/7/25
558	Levee Screening Operation	202 days	Wed 10/23/24	Tue 8/12/25
559	Levee Screening Waste Hauling	25 days	Thu 7/10/25	Wed 8/13/25
560	Levee Random Fill Screened Haul	181 days	Tue 11/26/24	Thu 8/14/25
561	Start Levee Fill Construction Milestone	0 days	Wed 12/4/24	Wed 12/4/24
562	Levee Random Fill Screened Construction	181 days	Wed 12/4/24	Thu 8/21/25
563	Levee Haul Sta 1230+00 to 1480+00	28 days	Mon 10/21/24	Fri 11/29/24
564	Levee Haul Sta 1480+00 to 1730+00	67 days	Mon 12/2/24	Mon 3/10/25
565	Levee Waste Area Maintenance	94 days	Mon 10/21/24	Fri 3/7/25
566	Dust Control	211 days	Tue 10/15/24	Fri 8/15/25
567	Seeding	18 days	Fri 8/15/25	Wed 9/10/25
568	Demobilization	5 days	Mon 9/8/25	Fri 9/12/25
569	Phase 13 Complete	0 days	Fri 9/12/25	Fri 9/12/25
570	**Phase 14 Planning, Engineering and Design**	**140 days**	**Wed 3/12/25**	**Fri 9/26/25**
572	**Phase 14 Construction**	**216 days**	**Sun 9/28/25**	**Fri 8/7/26**
573	Phase Award	0 days	Sun 9/28/25	Sun 9/28/25
574	Notice To Proceed	0 days	Fri 10/3/25	Fri 10/3/25
575	Mobilization	5 days	Mon 10/6/25	Fri 10/10/25
576	Levee Sitework Excavation	46 days	Thu 4/30/26	Mon 7/6/26
577	Levee Sitework Backfill	9 days	Mon 6/8/26	Thu 6/18/26
578	Levee Sitework Waste	7 days	Thu 6/25/26	Mon 7/6/26
579	Levee Sitework Drain Material	18 days	Fri 5/22/26	Wed 6/17/26
580	Levee Sitework Toe Drain Piping	33 days	Fri 5/1/26	Wed 6/17/26
581	Levee Sitework Concrete Formwork	2 days	Tue 6/16/26	Wed 6/17/26
582	Levee Sitework Concrete Reinforcing	1 day	Thu 6/18/26	Thu 6/18/26
583	Levee Sitework Concrete Placement	1 day	Fri 6/19/26	Fri 6/19/26
584	Levee Sitework Concrete Finishing	1 day	Mon 6/22/26	Mon 6/22/26



Project: San Acacia Alt A Base + 4
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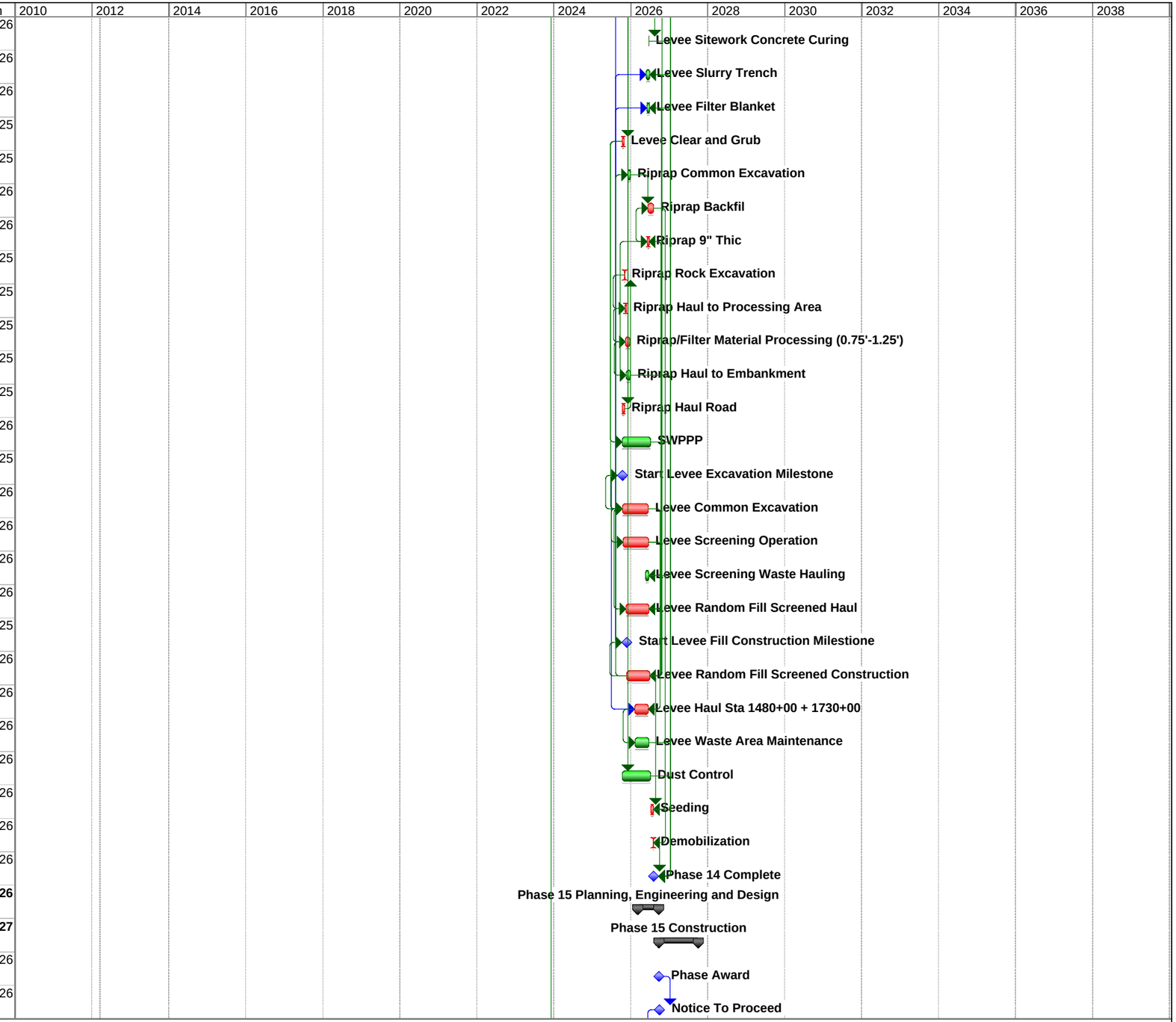
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
585	Levee Sitework Concrete Curing	1 day	Tue 6/23/26	Tue 6/23/26
586	Levee Slurry Trench	25 days	Thu 5/28/26	Wed 7/1/26
587	Levee Filter Blanket	17 days	Fri 6/5/26	Mon 6/29/26
588	Levee Clear and Grub	13 days	Tue 10/14/25	Thu 10/30/25
589	Riprap Common Excavation	19 days	Thu 12/4/25	Wed 12/31/25
590	Riprap Backfil	37 days	Mon 6/15/26	Wed 8/5/26
591	Riprap 9" Thic	14 days	Mon 6/8/26	Thu 6/25/26
592	Riprap Rock Excavation	3 days	Wed 11/5/25	Fri 11/7/25
593	Riprap Haul to Processing Area	9 days	Mon 11/10/25	Fri 11/21/25
594	Riprap/Filter Material Processing (0.75'-1.25')	27 days	Fri 11/14/25	Tue 12/23/25
595	Riprap Haul to Embankment	27 days	Fri 11/21/25	Wed 12/31/25
596	Riprap Haul Road	16 days	Tue 10/14/25	Tue 11/4/25
597	SWPPP	184 days	Tue 10/14/25	Wed 7/8/26
598	Start Levee Excavation Milestone	0 days	Fri 10/17/25	Fri 10/17/25
599	Levee Common Excavation	166 days	Fri 10/17/25	Tue 6/16/26
600	Levee Screening Operation	166 days	Wed 10/22/25	Fri 6/19/26
601	Levee Screening Waste Hauling	21 days	Fri 5/22/26	Mon 6/22/26
602	Levee Random Fill Screened Haul	149 days	Wed 11/19/25	Tue 6/23/26
603	Start Levee Fill Construction Milestione	0 days	Wed 11/26/25	Wed 11/26/25
604	Levee Random Fill Screened Construction	149 days	Wed 11/26/25	Tue 6/30/26
605	Levee Haul Sta 1480+00 + 1730+00	90 days	Tue 2/10/26	Wed 6/17/26
606	Levee Waste Area Maintenance	90 days	Fri 2/13/26	Mon 6/22/26
607	Dust Control	184 days	Tue 10/14/25	Wed 7/8/26
608	Seeding	18 days	Mon 7/13/26	Wed 8/5/26
609	Demobilization	5 days	Mon 8/3/26	Fri 8/7/26
610	Phase 14 Complete	0 days	Fri 8/7/26	Fri 8/7/26
611	**Phase 15 Planning, Engineering and Design**	**140 days**	**Wed 3/11/26**	**Fri 9/25/26**
613	**Phase 15 Construction**	**258 days**	**Mon 9/28/26**	**Wed 10/6/27**
614	Phase Award	0 days	Mon 9/28/26	Mon 9/28/26
615	Notice To Proceed	0 days	Fri 10/2/26	Fri 10/2/26



Project: San Acacia Alt A Base + 4
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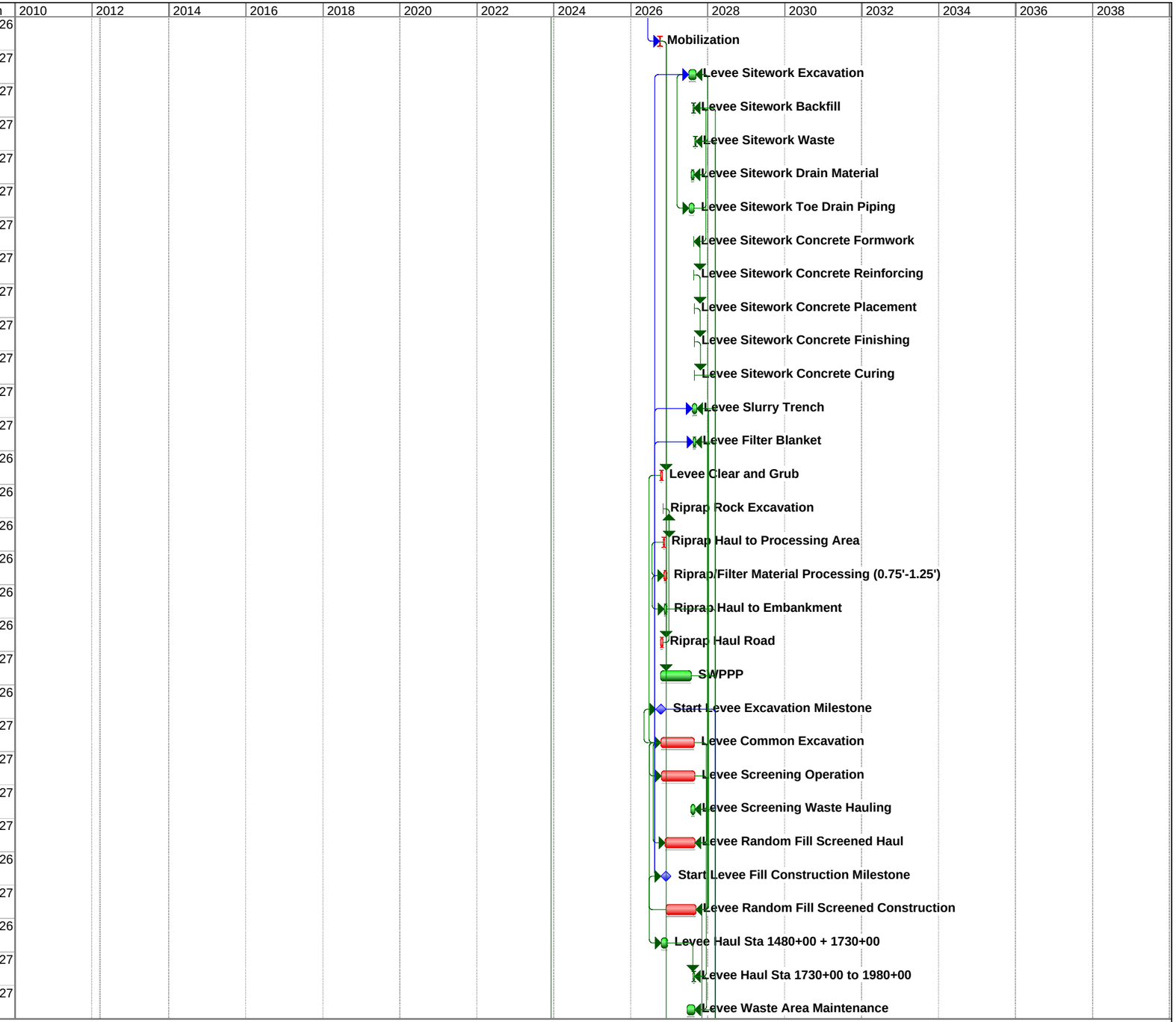
Task | Split | Milestone | Project Summary | External Milestone
Critical Task | Progress | Summary | External Tasks | Deadline

ID	Task Name	Duration	Early Start	Early Finish
616	Mobilization	5 days	Mon 10/5/26	Fri 10/9/26
617	Levee Sitework Excavation	47 days	Thu 7/8/27	Mon 9/13/27
618	Levee Sitework Backfill	9 days	Mon 8/16/27	Thu 8/26/27
619	Levee Sitework Waste	7 days	Thu 9/2/27	Mon 9/13/27
620	Levee Sitework Drain Material	19 days	Fri 7/30/27	Wed 8/25/27
621	Levee Sitework Toe Drain Piping	34 days	Fri 7/9/27	Wed 8/25/27
622	Levee Sitework Concrete Formwork	2 days	Tue 8/24/27	Wed 8/25/27
623	Levee Sitework Concrete Reinforcing	1 day	Thu 8/26/27	Thu 8/26/27
624	Levee Sitework Concrete Placement	1 day	Fri 8/27/27	Fri 8/27/27
625	Levee Sitework Concrete Finishing	1 day	Mon 8/30/27	Mon 8/30/27
626	Levee Sitework Concrete Curing	1 day	Tue 8/31/27	Tue 8/31/27
627	Levee Slurry Trench	29 days	Tue 8/10/27	Mon 9/20/27
628	Levee Filter Blanket	17 days	Wed 8/18/27	Fri 9/10/27
629	Levee Clear and Grub	13 days	Tue 10/13/26	Thu 10/29/26
630	Riprap Rock Excavation	2 days	Thu 11/5/26	Fri 11/6/26
631	Riprap Haul to Processing Area	7 days	Mon 11/9/26	Wed 11/18/26
632	Riprap/Filter Material Processing (0.75'-1.25')	19 days	Fri 11/13/26	Thu 12/10/26
633	Riprap Haul to Embankment	19 days	Mon 11/16/26	Fri 12/11/26
634	Riprap Haul Road	17 days	Tue 10/13/26	Wed 11/4/26
635	SWPPP	201 days	Tue 10/13/26	Fri 7/30/27
636	Start Levee Excavation Milestone	0 days	Fri 10/16/26	Fri 10/16/26
637	Levee Common Excavation	218 days	Fri 10/16/26	Fri 8/27/27
638	Levee Screening Operation	218 days	Wed 10/21/26	Wed 9/1/27
639	Levee Screening Waste Hauling	27 days	Wed 7/28/27	Thu 9/2/27
640	Levee Random Fill Screened Haul	196 days	Wed 11/25/26	Fri 9/3/27
641	Start Levee Fill Construction Milestone	0 days	Thu 12/3/26	Thu 12/3/26
642	Levee Random Fill Screened Construction	196 days	Thu 12/3/26	Mon 9/13/27
643	Levee Haul Sta 1480+00 + 1730+00	41 days	Mon 10/19/26	Wed 12/16/26
644	Levee Haul Sta 1730+00 to 1980+00	11 days	Mon 8/16/27	Mon 8/30/27
645	Levee Waste Area Maintenance	51 days	Mon 6/21/27	Tue 8/31/27



Project: San Acacia Alt A Base + 4
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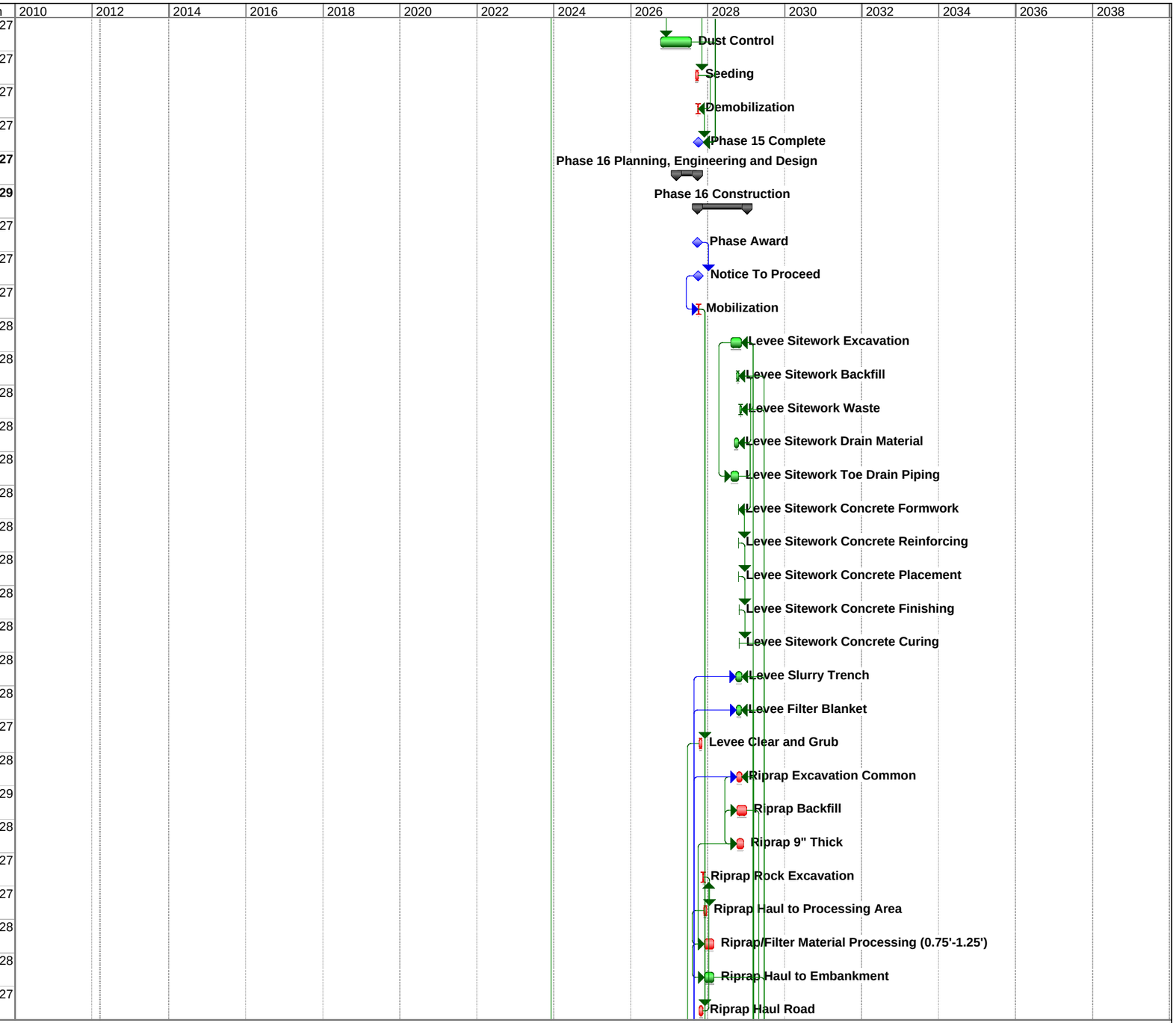
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
646	Dust Control	201 days	Tue 10/13/26	Fri 7/30/27
647	Seeding	18 days	Thu 9/9/27	Mon 10/4/27
648	Demobilization	5 days	Thu 9/30/27	Wed 10/6/27
649	Phase 15 Complete	0 days	Wed 10/6/27	Wed 10/6/27
650	**Phase 16 Planning, Engineering and Design**	**140 days**	**Thu 3/11/27**	**Mon 9/27/27**
652	**Phase 16 Construction**	**322 days**	**Tue 9/28/27**	**Wed 1/10/29**
653	Phase Award	0 days	Tue 9/28/27	Tue 9/28/27
654	Notice To Proceed	0 days	Mon 10/4/27	Mon 10/4/27
655	Mobilization	5 days	Tue 10/5/27	Tue 10/12/27
656	Levee Sitework Excavation	70 days	Wed 8/9/28	Fri 11/17/28
657	Levee Sitework Backfill	14 days	Tue 10/3/28	Mon 10/23/28
658	Levee Sitework Waste	11 days	Thu 11/2/28	Fri 11/17/28
659	Levee Sitework Drain Material	28 days	Tue 9/12/28	Fri 10/20/28
660	Levee Sitework Toe Drain Piping	50 days	Thu 8/10/28	Fri 10/20/28
661	Levee Sitework Concrete Formwork	2 days	Thu 10/19/28	Fri 10/20/28
662	Levee Sitework Concrete Reinforcing	1 day	Mon 10/23/28	Mon 10/23/28
663	Levee Sitework Concrete Placement	1 day	Tue 10/24/28	Tue 10/24/28
664	Levee Sitework Concrete Finishing	1 day	Wed 10/25/28	Wed 10/25/28
665	Levee Sitework Concrete Curing	1 day	Thu 10/26/28	Thu 10/26/28
666	Levee Slurry Trench	38 days	Tue 9/26/28	Mon 11/20/28
667	Levee Filter Blanket	32 days	Mon 10/2/28	Thu 11/16/28
668	Levee Clear and Grub	19 days	Wed 10/13/27	Mon 11/8/27
669	Riprap Excavation Common	32 days	Wed 10/4/28	Mon 11/20/28
670	Riprap Backfill	61 days	Fri 10/6/28	Fri 1/5/29
671	Riprap 9" Thick	42 days	Thu 10/5/28	Wed 12/6/28
672	Riprap Rock Excavation	6 days	Wed 11/17/27	Wed 11/24/27
673	Riprap Haul to Processing Area	20 days	Fri 11/26/27	Thu 12/23/27
674	Riprap/Filter Material Processing (0.75'-1.25')	60 days	Wed 12/1/27	Mon 2/28/28
675	Riprap Haul to Embankment	60 days	Thu 12/2/27	Tue 2/29/28
676	Riprap Haul Road	24 days	Wed 10/13/27	Tue 11/16/27



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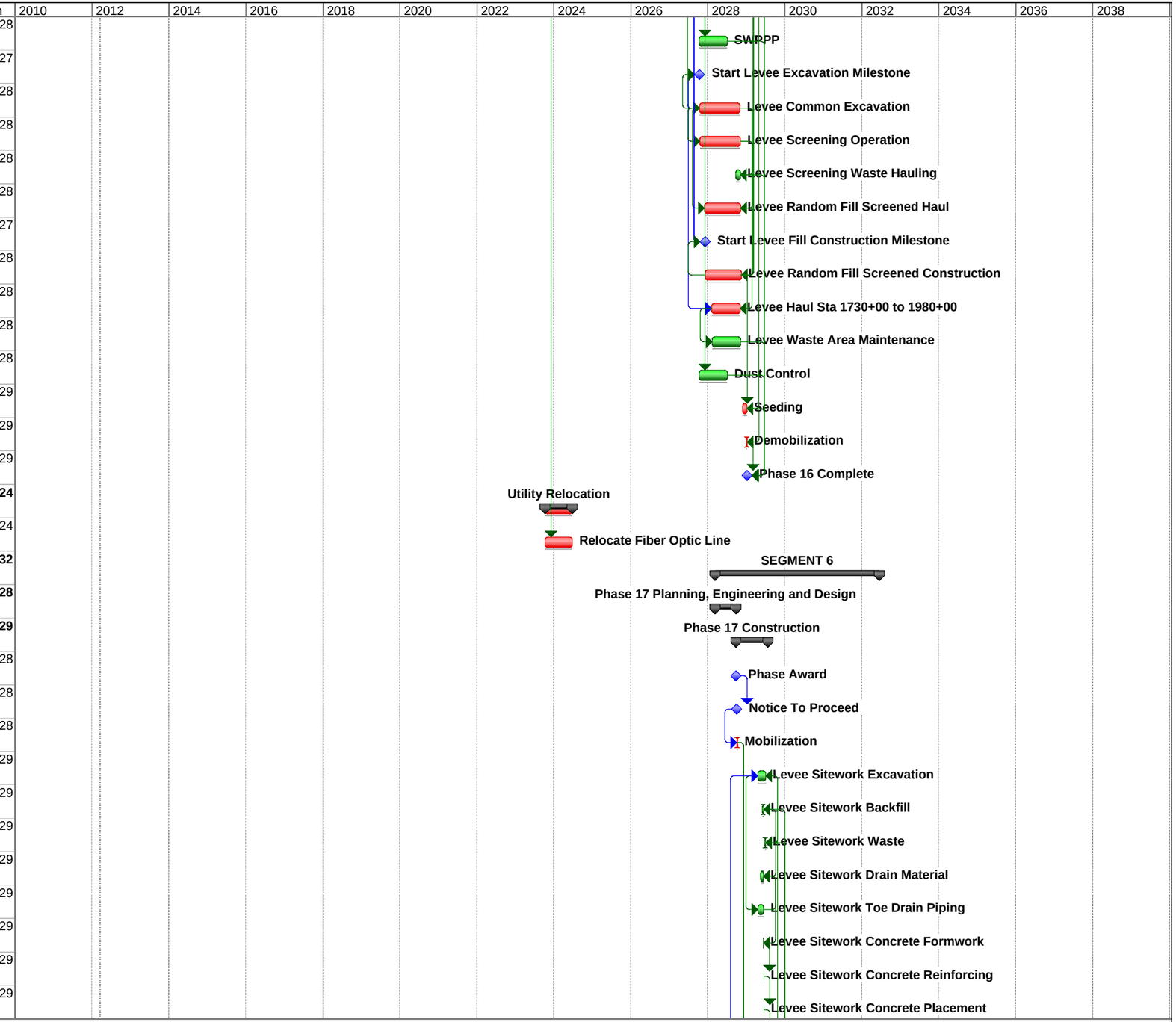
Task		Split		Milestone		Project Summary		External Milestone
Critical Task		Progress		Summary		External Tasks		Deadline

ID	Task Name	Duration	Early Start	Early Finish
677	SWPPP	184 days	Wed 10/13/27	Thu 7/6/28
678	Start Levee Excavation Milestone	0 days	Mon 10/18/27	Mon 10/18/27
679	Levee Common Excavation	264 days	Mon 10/18/27	Thu 11/2/28
680	Levee Screening Operation	264 days	Thu 10/21/27	Tue 11/7/28
681	Levee Screening Waste Hauling	32 days	Mon 9/25/28	Wed 11/8/28
682	Levee Random Fill Screened Haul	237 days	Fri 12/3/27	Thu 11/9/28
683	Start Levee Fill Construction Milestone	0 days	Fri 12/10/27	Fri 12/10/27
684	Levee Random Fill Screened Construction	237 days	Fri 12/10/27	Fri 11/17/28
685	Levee Haul Sta 1730+00 to 1980+00	188 days	Thu 2/10/28	Mon 11/6/28
686	Levee Waste Area Maintenance	188 days	Tue 2/15/28	Thu 11/9/28
687	Dust Control	184 days	Wed 10/13/27	Thu 7/6/28
688	Seeding	27 days	Wed 11/29/28	Mon 1/8/29
689	Demobilization	5 days	Thu 1/4/29	Wed 1/10/29
690	Phase 16 Complete	0 days	Wed 1/10/29	Wed 1/10/29
849	**Utility Relocation**	**176 days**	**Fri 10/13/23**	**Tue 6/25/24**
850	Relocate Fiber Optic Line	176 days	Fri 10/13/23	Tue 6/25/24
691	**SEGMENT 6**	**1074 days**	**Mon 3/13/28**	**Fri 6/18/32**
692	**Phase 17 Planning, Engineering and Design**	**140 days**	**Mon 3/13/28**	**Wed 9/27/28**
694	**Phase 17 Construction**	**208 days**	**Thu 9/28/28**	**Fri 7/27/29**
695	Phase Award	0 days	Thu 9/28/28	Thu 9/28/28
696	Notice To Proceed	0 days	Wed 10/4/28	Wed 10/4/28
697	Mobilization	5 days	Thu 10/5/28	Thu 10/12/28
698	Levee Sitework Excavation	53 days	Mon 4/23/29	Fri 7/6/29
699	Levee Sitework Backfill	11 days	Mon 6/4/29	Mon 6/18/29
700	Levee Sitework Waste	8 days	Tue 6/26/29	Fri 7/6/29
701	Levee Sitework Drain Material	21 days	Thu 5/17/29	Fri 6/15/29
702	Levee Sitework Toe Drain Piping	38 days	Tue 4/24/29	Fri 6/15/29
703	Levee Sitework Concrete Formwork	2 days	Thu 6/14/29	Fri 6/15/29
704	Levee Sitework Concrete Reinforcing	1 day	Mon 6/18/29	Mon 6/18/29
705	Levee Sitework Concrete Placement	1 day	Tue 6/19/29	Tue 6/19/29



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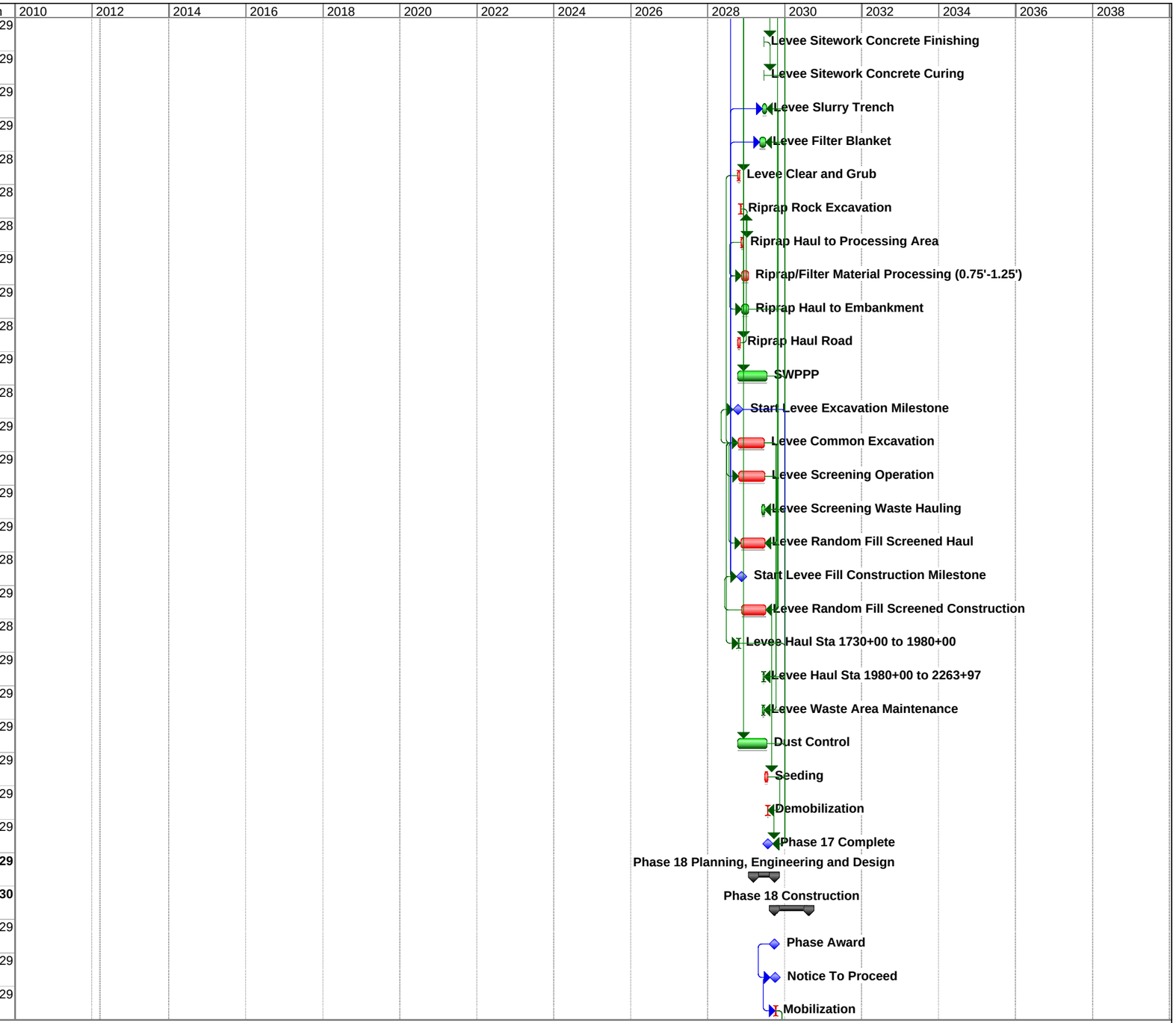
Task | Critical Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Early Start	Early Finish
706	Levee Sitework Concrete Finishing	1 day	Wed 6/20/29	Wed 6/20/29
707	Levee Sitework Concrete Curing	1 day	Thu 6/21/29	Thu 6/21/29
708	Levee Slurry Trench	27 days	Wed 6/6/29	Fri 7/13/29
709	Levee Filter Blanket	38 days	Fri 5/11/29	Thu 7/5/29
710	Levee Clear and Grub	14 days	Fri 10/13/28	Wed 11/1/28
711	Riprap Rock Excavation	4 days	Wed 11/8/28	Tue 11/14/28
712	Riprap Haul to Processing Area	14 days	Wed 11/15/28	Tue 12/5/28
713	Riprap/Filter Material Processing (0.75'-1.25')	43 days	Mon 11/20/28	Tue 1/23/29
714	Riprap Haul to Embankment	43 days	Tue 11/21/28	Wed 1/24/29
715	Riprap Haul Road	18 days	Fri 10/13/28	Tue 11/7/28
716	SWPPP	190 days	Fri 10/13/28	Tue 7/17/29
717	Start Levee Excavation Milestone	0 days	Wed 10/18/28	Wed 10/18/28
718	Levee Common Excavation	170 days	Wed 10/18/28	Thu 6/21/29
719	Levee Screening Operation	170 days	Mon 10/23/28	Tue 6/26/29
720	Levee Screening Waste Hauling	22 days	Tue 5/29/29	Wed 6/27/29
721	Levee Random Fill Screened Haul	157 days	Tue 11/14/28	Thu 6/28/29
722	Start Levee Fill Construction Milestone	0 days	Tue 11/21/28	Tue 11/21/28
723	Levee Random Fill Screened Construction	157 days	Tue 11/21/28	Fri 7/6/29
724	Levee Haul Sta 1730+00 to 1980+00	5 days	Thu 10/19/28	Wed 10/25/28
725	Levee Haul Sta 1980+00 to 2263+97	9 days	Mon 6/11/29	Thu 6/21/29
726	Levee Waste Area Maintenance	13 days	Tue 6/5/29	Thu 6/21/29
727	Dust Control	190 days	Fri 10/13/28	Tue 7/17/29
728	Seeding	20 days	Wed 6/27/29	Wed 7/25/29
729	Demobilization	5 days	Mon 7/23/29	Fri 7/27/29
730	Phase 17 Complete	0 days	Fri 7/27/29	Fri 7/27/29
731	**Phase 18 Planning, Engineering and Design**	**140 days**	**Tue 3/13/29**	**Thu 9/27/29**
733	**Phase 18 Construction**	**224 days**	**Fri 9/28/29**	**Tue 8/20/30**
734	Phase Award	0 days	Fri 9/28/29	Fri 9/28/29
735	Notice To Proceed	0 days	Thu 10/4/29	Thu 10/4/29
736	Mobilization	5 days	Fri 10/5/29	Fri 10/12/29



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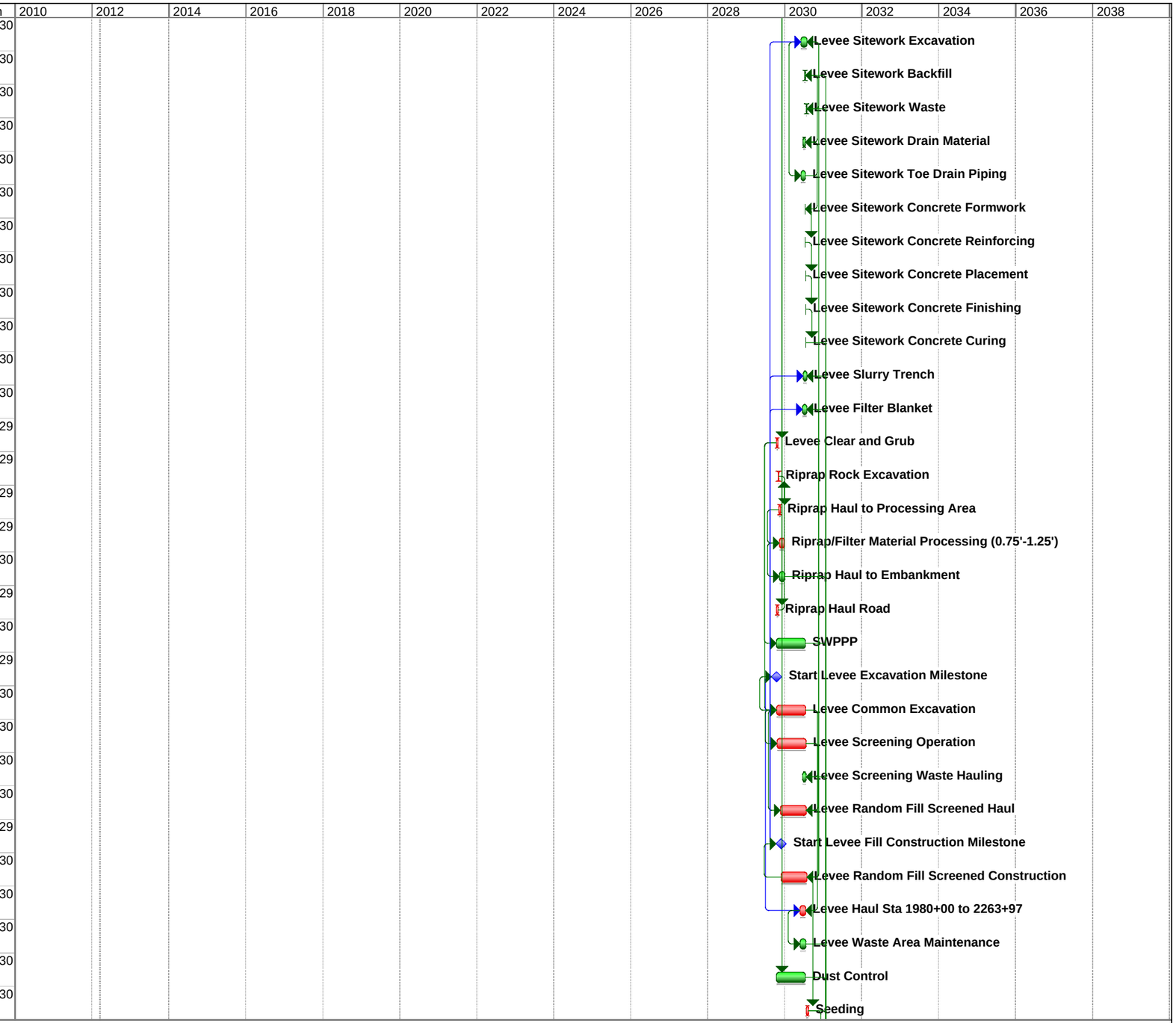
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
737	Levee Sitework Excavation	41 days	Wed 6/5/30	Thu 8/1/30
738	Levee Sitework Backfill	8 days	Tue 7/9/30	Thu 7/18/30
739	Levee Sitework Waste	6 days	Thu 7/25/30	Thu 8/1/30
740	Levee Sitework Drain Material	16 days	Tue 6/25/30	Wed 7/17/30
741	Levee Sitework Toe Drain Piping	29 days	Thu 6/6/30	Wed 7/17/30
742	Levee Sitework Concrete Formwork	2 days	Tue 7/16/30	Wed 7/17/30
743	Levee Sitework Concrete Reinforcing	1 day	Thu 7/18/30	Thu 7/18/30
744	Levee Sitework Concrete Placement	1 day	Fri 7/19/30	Fri 7/19/30
745	Levee Sitework Concrete Finishing	1 day	Mon 7/22/30	Mon 7/22/30
746	Levee Sitework Concrete Curing	1 day	Tue 7/23/30	Tue 7/23/30
747	Levee Slurry Trench	25 days	Thu 6/27/30	Thu 8/1/30
748	Levee Filter Blanket	29 days	Thu 6/20/30	Wed 7/31/30
749	Levee Clear and Grub	11 days	Mon 10/15/29	Mon 10/29/29
750	Riprap Rock Excavation	3 days	Fri 11/2/29	Tue 11/6/29
751	Riprap Haul to Processing Area	11 days	Wed 11/7/29	Fri 11/23/29
752	Riprap/Filter Material Processing (0.75'-1.25')	33 days	Tue 11/13/29	Mon 12/31/29
753	Riprap Haul to Embankment	33 days	Wed 11/14/29	Wed 1/2/30
754	Riprap Haul Road	14 days	Mon 10/15/29	Thu 11/1/29
755	SWPPP	190 days	Mon 10/15/29	Wed 7/17/30
756	Start Levee Excavation Milestone	0 days	Thu 10/18/29	Thu 10/18/29
757	Levee Common Excavation	188 days	Thu 10/18/29	Thu 7/18/30
758	Levee Screening Operation	188 days	Tue 10/23/29	Tue 7/23/30
759	Levee Screening Waste Hauling	23 days	Fri 6/21/30	Wed 7/24/30
760	Levee Random Fill Screened Haul	169 days	Fri 11/23/29	Thu 7/25/30
761	Start Levee Fill Construction Milestone	0 days	Fri 11/30/29	Fri 11/30/29
762	Levee Random Fill Screened Construction	169 days	Fri 11/30/29	Thu 8/1/30
763	Levee Haul Sta 1980+00 to 2263+97	38 days	Tue 5/28/30	Fri 7/19/30
764	Levee Waste Area Maintenance	38 days	Wed 5/29/30	Mon 7/22/30
765	Dust Control	190 days	Mon 10/15/29	Wed 7/17/30
766	Seeding	16 days	Fri 7/26/30	Fri 8/16/30



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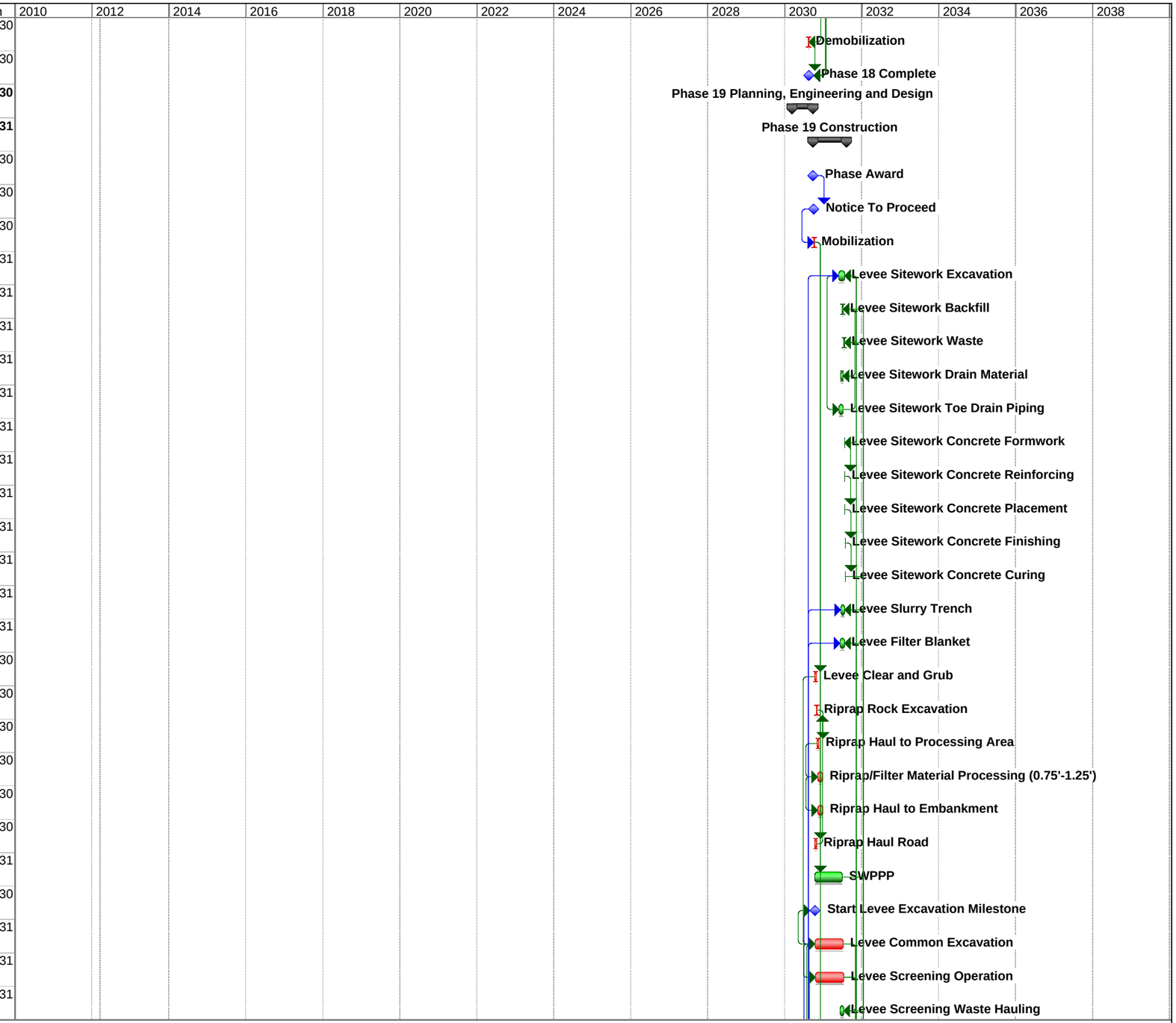
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
767	Demobilization	5 days	Wed 8/14/30	Tue 8/20/30
768	Phase 18 Complete	0 days	Tue 8/20/30	Tue 8/20/30
769	**Phase 19 Planning, Engineering and Design**	**140 days**	**Wed 3/13/30**	**Fri 9/27/30**
771	**Phase 19 Construction**	**217 days**	**Sat 9/28/30**	**Mon 8/11/31**
772	Phase Award	0 days	Sat 9/28/30	Sat 9/28/30
773	Notice To Proceed	0 days	Fri 10/4/30	Fri 10/4/30
774	Mobilization	5 days	Mon 10/7/30	Fri 10/11/30
775	Levee Sitework Excavation	39 days	Fri 5/30/31	Thu 7/24/31
776	Levee Sitework Backfill	8 days	Tue 7/1/31	Fri 7/11/31
777	Levee Sitework Waste	6 days	Thu 7/17/31	Thu 7/24/31
778	Levee Sitework Drain Material	16 days	Wed 6/18/31	Thu 7/10/31
779	Levee Sitework Toe Drain Piping	28 days	Mon 6/2/31	Thu 7/10/31
780	Levee Sitework Concrete Formwork	2 days	Wed 7/23/31	Thu 7/24/31
781	Levee Sitework Concrete Reinforcing	1 day	Fri 7/25/31	Fri 7/25/31
782	Levee Sitework Concrete Placement	1 day	Mon 7/28/31	Mon 7/28/31
783	Levee Sitework Concrete Finishing	1 day	Tue 7/29/31	Tue 7/29/31
784	Levee Sitework Concrete Curing	1 day	Wed 7/30/31	Wed 7/30/31
785	Levee Slurry Trench	24 days	Fri 6/20/31	Thu 7/24/31
786	Levee Filter Blanket	28 days	Fri 6/13/31	Wed 7/23/31
787	Levee Clear and Grub	11 days	Tue 10/15/30	Tue 10/29/30
788	Riprap Rock Excavation	3 days	Fri 11/1/30	Tue 11/5/30
789	Riprap Haul to Processing Area	11 days	Wed 11/6/30	Thu 11/21/30
790	Riprap/Filter Material Processing (0.75'-1.25')	32 days	Tue 11/12/30	Fri 12/27/30
791	Riprap Haul to Embankment	32 days	Wed 11/13/30	Mon 12/30/30
792	Riprap Haul Road	13 days	Tue 10/15/30	Thu 10/31/30
793	SWPPP	180 days	Tue 10/15/30	Wed 7/2/31
794	Start Levee Excavation Milestone	0 days	Fri 10/18/30	Fri 10/18/30
795	Levee Common Excavation	182 days	Fri 10/18/30	Thu 7/10/31
796	Levee Screening Operation	182 days	Wed 10/23/30	Tue 7/15/31
797	Levee Screening Waste Hauling	23 days	Fri 6/13/31	Wed 7/16/31



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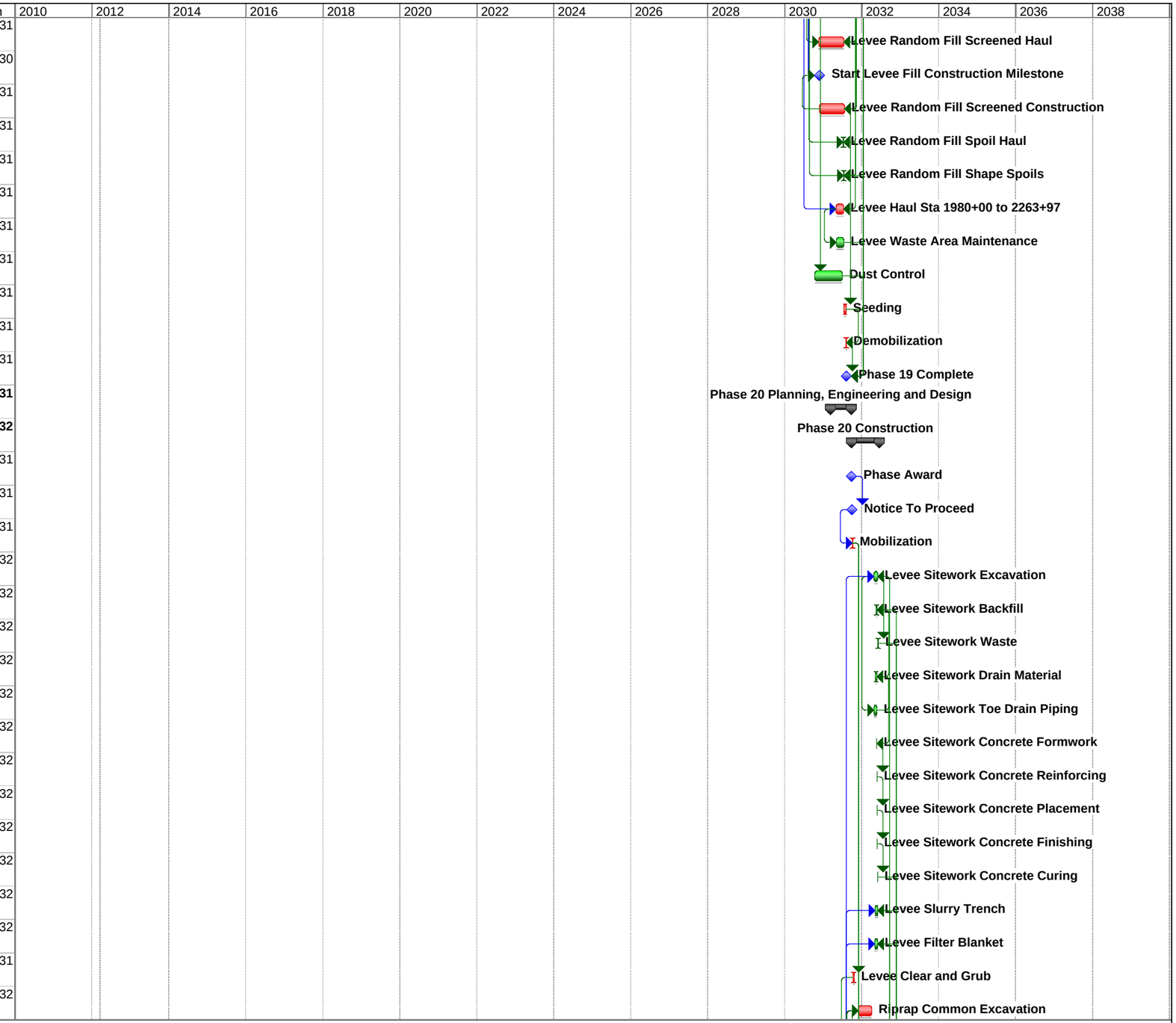
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
798	Levee Random Fill Screened Haul	164 days	Thu 11/21/30	Thu 7/17/31
799	Start Levee Fill Construction Milestone	0 days	Fri 11/29/30	Fri 11/29/30
800	Levee Random Fill Screened Construction	164 days	Fri 11/29/30	Thu 7/24/31
801	Levee Random Fill Spoil Haul	4 days	Thu 7/10/31	Tue 7/15/31
802	Levee Random Fill Shape Spoils	4 days	Tue 7/15/31	Fri 7/18/31
803	Levee Haul Sta 1980+00 to 2263+97	49 days	Mon 5/5/31	Mon 7/14/31
804	Levee Waste Area Maintenance	49 days	Thu 5/8/31	Thu 7/17/31
805	Dust Control	180 days	Tue 10/15/30	Wed 7/2/31
806	Seeding	15 days	Fri 7/18/31	Thu 8/7/31
807	Demobilization	5 days	Tue 8/5/31	Mon 8/11/31
808	Phase 19 Complete	0 days	Mon 8/11/31	Mon 8/11/31
809	**Phase 20 Planning, Engineering and Design**	**140 days**	**Wed 3/12/31**	**Fri 9/26/31**
811	**Phase 20 Construction**	**182 days**	**Sun 9/28/31**	**Fri 6/18/32**
812	Phase Award	0 days	Sun 9/28/31	Sun 9/28/31
813	Notice To Proceed	0 days	Fri 10/3/31	Fri 10/3/31
814	Mobilization	5 days	Mon 10/6/31	Fri 10/10/31
815	Levee Sitework Excavation	27 days	Tue 4/27/32	Thu 6/3/32
816	Levee Sitework Backfill	6 days	Wed 5/19/32	Wed 5/26/32
817	Levee Sitework Waste	4 days	Fri 6/4/32	Wed 6/9/32
818	Levee Sitework Drain Material	11 days	Tue 5/11/32	Tue 5/25/32
819	Levee Sitework Toe Drain Piping	20 days	Wed 4/28/32	Tue 5/25/32
820	Levee Sitework Concrete Formwork	1 day	Tue 5/25/32	Tue 5/25/32
821	Levee Sitework Concrete Reinforcing	1 day	Wed 5/26/32	Wed 5/26/32
822	Levee Sitework Concrete Placement	1 day	Thu 5/27/32	Thu 5/27/32
823	Levee Sitework Concrete Finishing	1 day	Fri 5/28/32	Fri 5/28/32
824	Levee Sitework Concrete Curing	1 day	Tue 6/1/32	Tue 6/1/32
825	Levee Slurry Trench	18 days	Mon 5/10/32	Thu 6/3/32
826	Levee Filter Blanket	19 days	Thu 5/6/32	Wed 6/2/32
827	Levee Clear and Grub	8 days	Tue 10/14/31	Thu 10/23/31
828	Riprap Common Excavation	87 days	Tue 12/2/31	Tue 4/6/32



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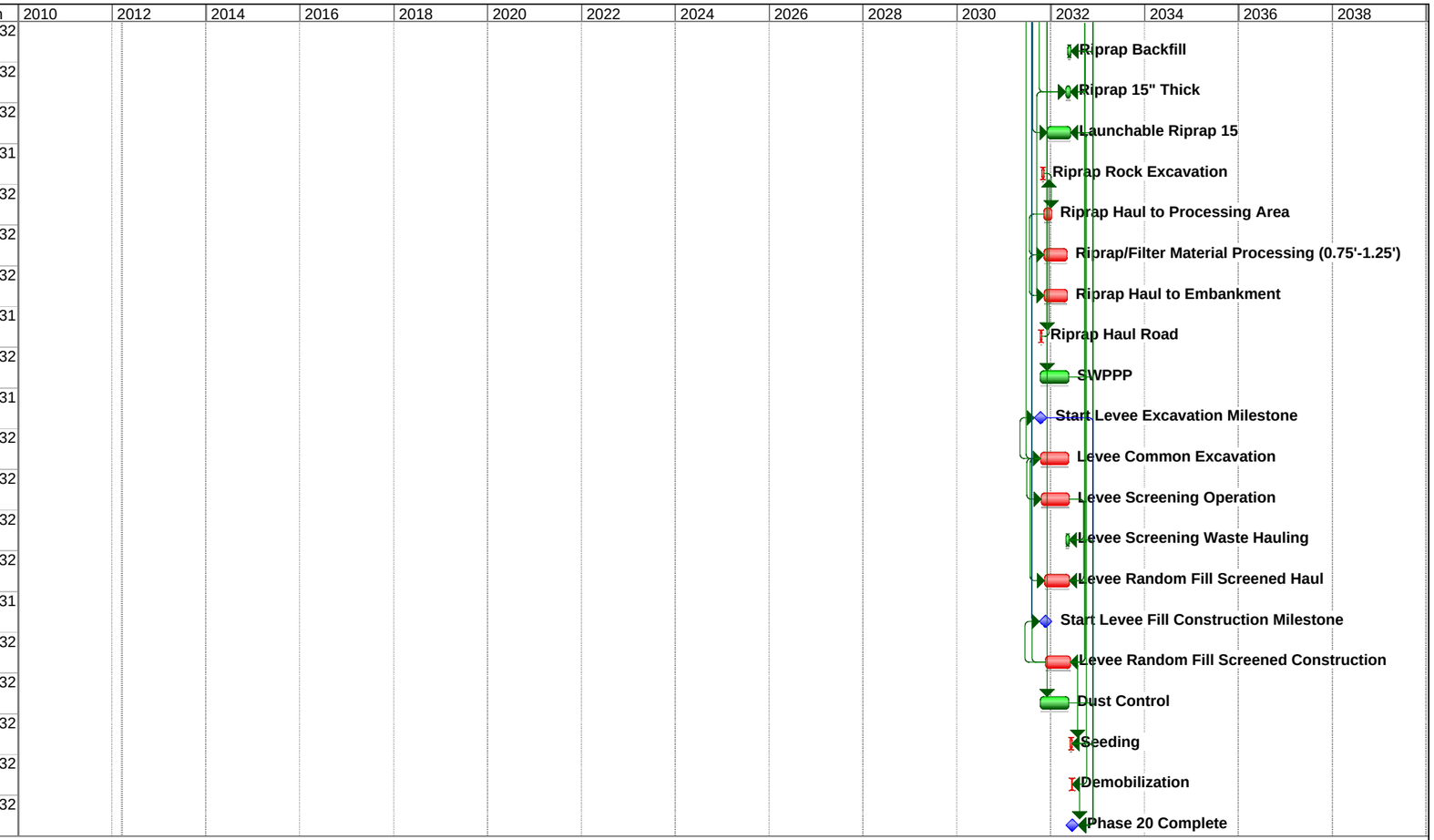
Task | Split | Milestone | Project Summary | External Milestone
Critical Task | Progress | Summary | External Tasks | Deadline

ID	Task Name	Duration	Early Start	Early Finish
829	Riprap Backfill	17 days	Fri 5/14/32	Tue 6/8/32
830	Riprap 15" Thick	25 days	Thu 4/29/32	Thu 6/3/32
831	Launchable Riprap 15	125 days	Mon 12/8/31	Fri 6/4/32
832	Riprap Rock Excavation	11 days	Mon 10/27/31	Mon 11/10/31
833	Riprap Haul to Processing Area	40 days	Wed 11/12/31	Fri 1/9/32
834	Riprap/Filter Material Processing (0.75'-1.25')	122 days	Thu 11/13/31	Fri 5/7/32
835	Riprap Haul to Embankment	122 days	Fri 11/14/31	Mon 5/10/32
836	Riprap Haul Road	9 days	Tue 10/14/31	Fri 10/24/31
837	SWPPP	153 days	Tue 10/14/31	Fri 5/21/32
838	Start Levee Excavation Milestone	0 days	Fri 10/17/31	Fri 10/17/31
839	Levee Common Excavation	148 days	Fri 10/17/31	Wed 5/19/32
840	Levee Screening Operation	148 days	Wed 10/22/31	Mon 5/24/32
841	Levee Screening Waste Hauling	18 days	Fri 4/30/32	Tue 5/25/32
842	Levee Random Fill Screened Haul	133 days	Mon 11/17/31	Wed 5/26/32
843	Start Levee Fill Construction Milestone	0 days	Mon 11/24/31	Mon 11/24/31
844	Levee Random Fill Screened Construction	133 days	Mon 11/24/31	Thu 6/3/32
845	Dust Control	153 days	Tue 10/14/31	Fri 5/21/32
846	Seeding	11 days	Wed 6/2/32	Wed 6/16/32
847	Demobilization	5 days	Mon 6/14/32	Fri 6/18/32
848	Phase 20 Complete	0 days	Fri 6/18/32	Fri 6/18/32



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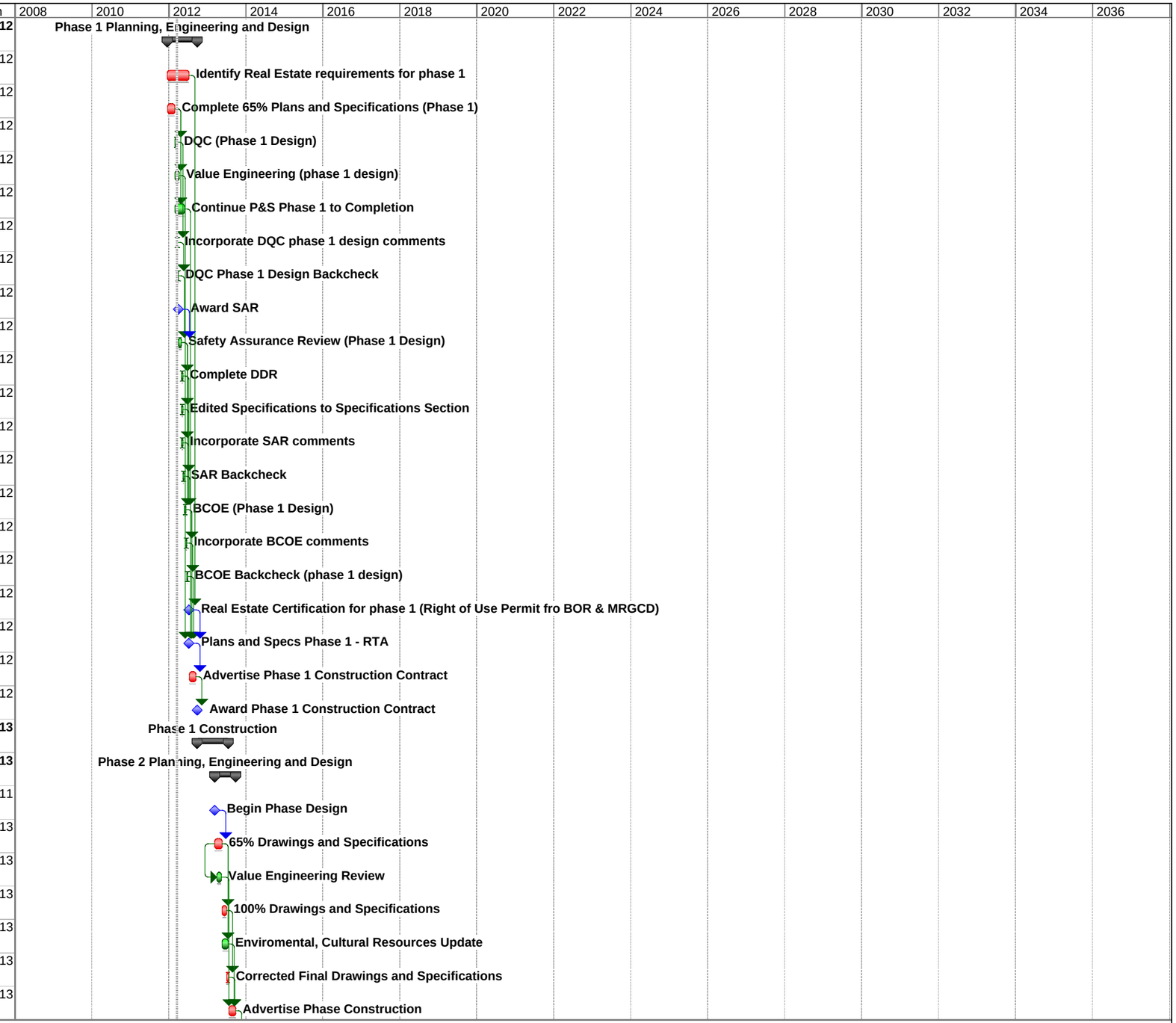
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

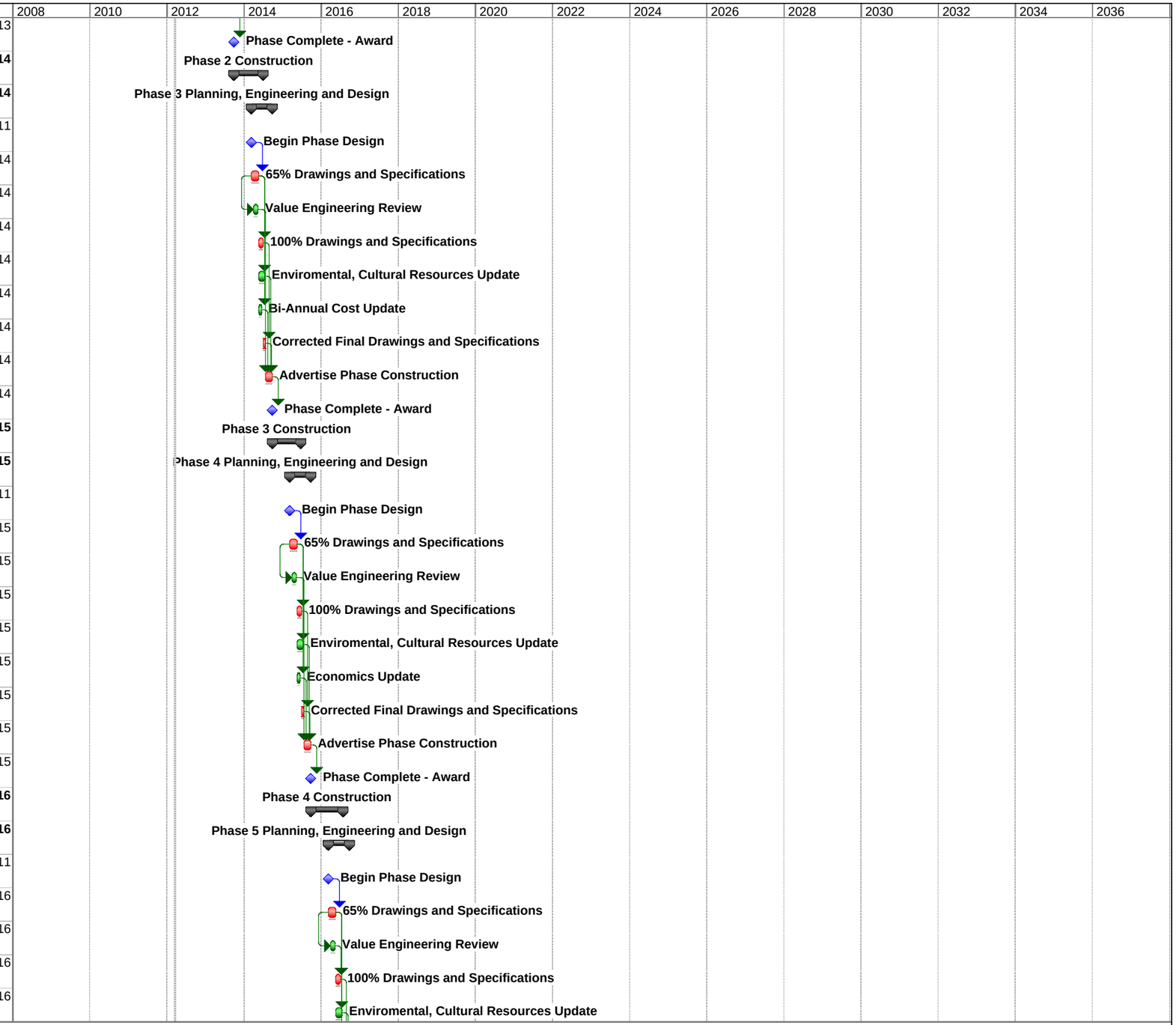
ID	Task Name	Duration	Early Start	Early Finish
1	**Phase 1 Planning, Engineering and Design**	**199 days**	**Mon 12/19/11**	**Fri 9/28/12**
2	Identify Real Estate requirements for phase 1	143 days	Mon 12/19/11	Wed 7/11/12
3	Complete 65% Plans and Specifications (Phase 1)	45 days	Fri 12/23/11	Tue 2/28/12
4	DQC (Phase 1 Design)	14 days	Wed 2/29/12	Mon 3/19/12
5	Value Engineering (phase 1 design)	30 days	Wed 2/29/12	Tue 4/10/12
6	Continue P&S Phase 1 to Completion	65 days	Wed 2/29/12	Wed 5/30/12
7	Incorporate DQC phase 1 design comments	5 days	Tue 3/20/12	Mon 3/26/12
8	DQC Phase 1 Design Backcheck	5 days	Tue 3/27/12	Mon 4/2/12
9	Award SAR	0 days	Tue 4/3/12	Tue 4/3/12
10	Safety Assurance Review (Phase 1 Design)	20 days	Tue 4/3/12	Mon 4/30/12
11	Complete DDR	10 days	Tue 5/1/12	Mon 5/14/12
12	Edited Specifications to Specifications Section	10 days	Tue 5/1/12	Mon 5/14/12
13	Incorporate SAR comments	10 days	Tue 5/1/12	Mon 5/14/12
14	SAR Backcheck	9 days	Tue 5/15/12	Fri 5/25/12
15	BCOE (Phase 1 Design)	10 days	Tue 5/29/12	Mon 6/11/12
16	Incorporate BCOE comments	7 days	Tue 6/12/12	Wed 6/20/12
17	BCOE Backcheck (phase 1 design)	7 days	Thu 6/21/12	Fri 6/29/12
18	Real Estate Certification for phase 1 (Right of Use Permit fro BOR & MRGCD)	0 days	Wed 7/11/12	Wed 7/11/12
19	Plans and Specs Phase 1 - RTA	0 days	Wed 7/11/12	Wed 7/11/12
20	Advertise Phase 1 Construction Contract	44 days	Mon 7/16/12	Fri 9/14/12
21	Award Phase 1 Construction Contract	0 days	Fri 9/28/12	Fri 9/28/12
22	**Phase 1 Construction**	**202 days**	**Fri 9/28/12**	**Fri 7/19/13**
24	**Phase 2 Planning, Engineering and Design**	**140 days**	**Wed 3/13/13**	**Fri 9/27/13**
25	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
26	65% Drawings and Specifications	50 days	Wed 3/13/13	Tue 5/21/13
30	Value Engineering Review	30 days	Wed 4/3/13	Tue 5/14/13
27	100% Drawings and Specifications	30 days	Wed 5/22/13	Wed 7/3/13
31	Enviromental, Cultural Resources Update	40 days	Wed 5/22/13	Thu 7/18/13
28	Corrected Final Drawings and Specifications	15 days	Fri 7/5/13	Thu 7/25/13
29	Advertise Phase Construction	45 days	Fri 7/26/13	Fri 9/27/13



Project: San Acacia Alt A Base + 4
Date: Wed 3/14/12

Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

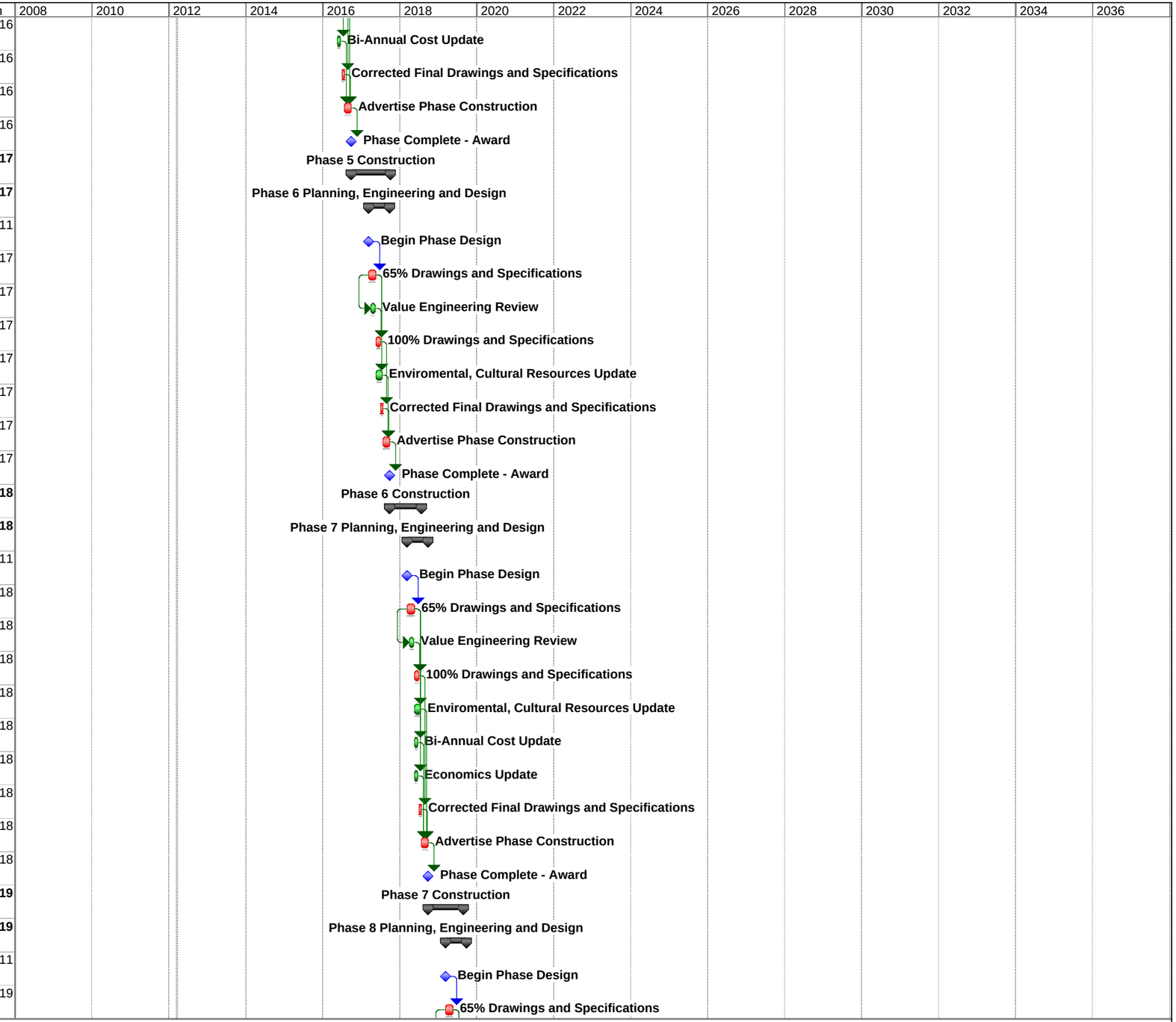
ID	Task Name	Duration	Early Start	Early Finish
32	Phase Complete - Award	0 days	Fri 9/27/13	Fri 9/27/13
33	**Phase 2 Construction**	**190 days**	**Sat 9/28/13**	**Wed 7/2/14**
35	**Phase 3 Planning, Engineering and Design**	**140 days**	**Wed 3/12/14**	**Fri 9/26/14**
36	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
37	65% Drawings and Specifications	50 days	Wed 3/12/14	Tue 5/20/14
38	Value Engineering Review	30 days	Wed 4/2/14	Tue 5/13/14
39	100% Drawings and Specifications	30 days	Wed 5/21/14	Wed 7/2/14
40	Enviromental, Cultural Resources Update	40 days	Wed 5/21/14	Thu 7/17/14
41	Bi-Annual Cost Update	20 days	Wed 5/21/14	Wed 6/18/14
42	Corrected Final Drawings and Specifications	15 days	Thu 7/3/14	Thu 7/24/14
43	Advertise Phase Construction	45 days	Fri 7/25/14	Fri 9/26/14
44	Phase Complete - Award	0 days	Fri 9/26/14	Fri 9/26/14
45	**Phase 3 Construction**	**184 days**	**Sun 9/28/14**	**Tue 6/23/15**
47	**Phase 4 Planning, Engineering and Design**	**140 days**	**Wed 3/11/15**	**Fri 9/25/15**
48	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
49	65% Drawings and Specifications	50 days	Wed 3/11/15	Tue 5/19/15
50	Value Engineering Review	30 days	Wed 4/1/15	Tue 5/12/15
51	100% Drawings and Specifications	30 days	Wed 5/20/15	Wed 7/1/15
52	Enviromental, Cultural Resources Update	40 days	Wed 5/20/15	Thu 7/16/15
53	Economics Update	20 days	Wed 5/20/15	Wed 6/17/15
54	Corrected Final Drawings and Specifications	15 days	Thu 7/2/15	Thu 7/23/15
55	Advertise Phase Construction	45 days	Fri 7/24/15	Fri 9/25/15
56	Phase Complete - Award	0 days	Fri 9/25/15	Fri 9/25/15
57	**Phase 4 Construction**	**209 days**	**Mon 9/28/15**	**Wed 7/27/16**
59	**Phase 5 Planning, Engineering and Design**	**140 days**	**Fri 3/11/16**	**Tue 9/27/16**
60	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
61	65% Drawings and Specifications	50 days	Fri 3/11/16	Thu 5/19/16
62	Value Engineering Review	30 days	Fri 4/1/16	Thu 5/12/16
63	100% Drawings and Specifications	30 days	Fri 5/20/16	Fri 7/1/16
64	Enviromental, Cultural Resources Update	40 days	Fri 5/20/16	Mon 7/18/16



Project: San Acacia Alt A Base + 4
Date: Wed 3/14/12

Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

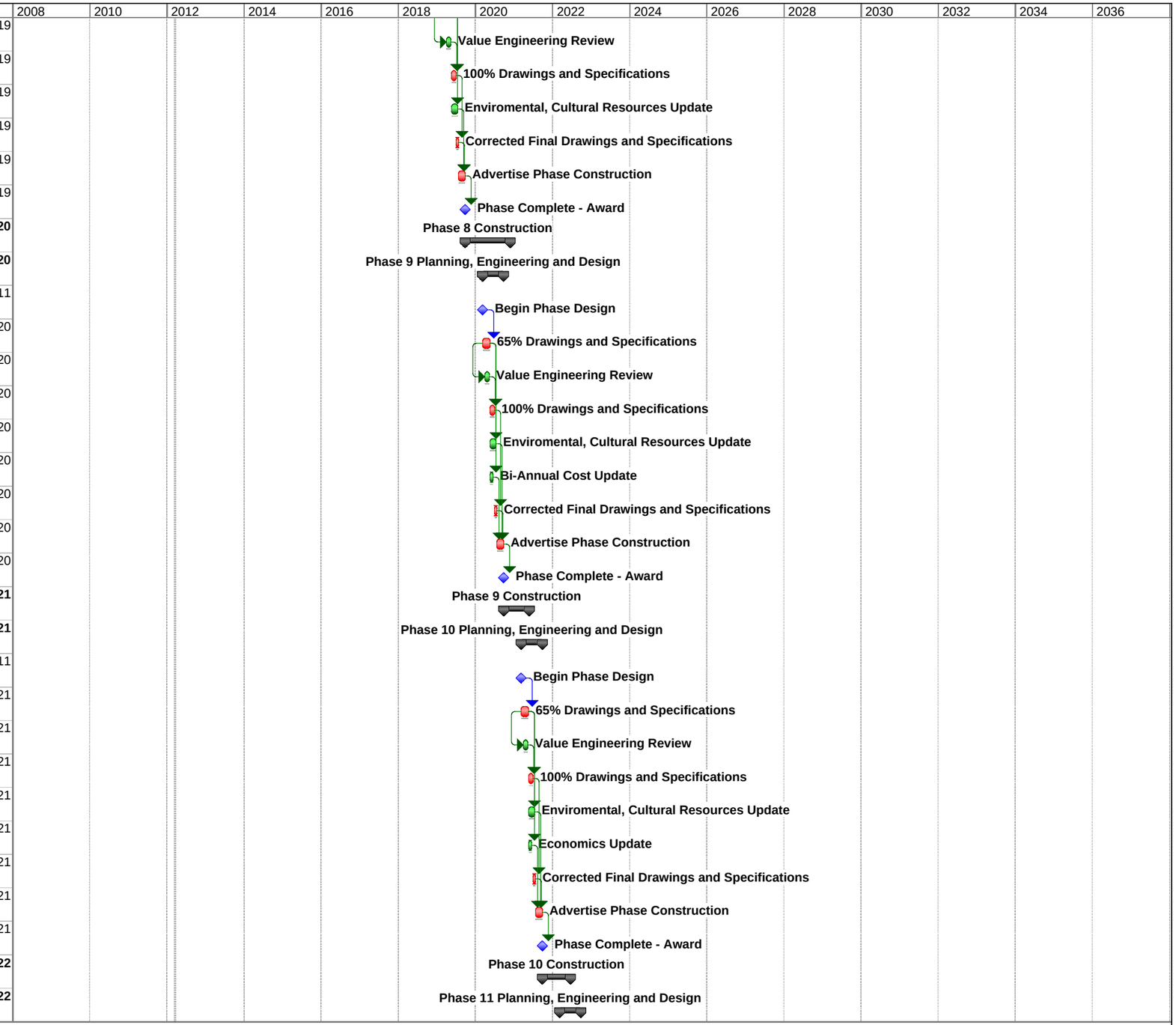
ID	Task Name	Duration	Early Start	Early Finish
65	Bi-Annual Cost Update	20 days	Fri 5/20/16	Fri 6/17/16
66	Corrected Final Drawings and Specifications	15 days	Tue 7/5/16	Mon 7/25/16
67	Advertise Phase Construction	45 days	Tue 7/26/16	Tue 9/27/16
68	Phase Complete - Award	0 days	Tue 9/27/16	Tue 9/27/16
69	**Phase 5 Construction**	**257 days**	**Wed 9/28/16**	**Thu 10/5/17**
71	**Phase 6 Planning, Engineering and Design**	**140 days**	**Mon 3/13/17**	**Wed 9/27/17**
72	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
73	65% Drawings and Specifications	50 days	Mon 3/13/17	Fri 5/19/17
74	Value Engineering Review	30 days	Mon 4/3/17	Fri 5/12/17
75	100% Drawings and Specifications	30 days	Mon 5/22/17	Mon 7/3/17
76	Enviromental, Cultural Resources Update	40 days	Mon 5/22/17	Tue 7/18/17
77	Corrected Final Drawings and Specifications	15 days	Wed 7/5/17	Tue 7/25/17
78	Advertise Phase Construction	45 days	Wed 7/26/17	Wed 9/27/17
79	Phase Complete - Award	0 days	Wed 9/27/17	Wed 9/27/17
80	**Phase 6 Construction**	**207 days**	**Thu 9/28/17**	**Thu 7/26/18**
82	**Phase 7 Planning, Engineering and Design**	**140 days**	**Tue 3/13/18**	**Thu 9/27/18**
83	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
84	65% Drawings and Specifications	50 days	Tue 3/13/18	Mon 5/21/18
85	Value Engineering Review	30 days	Tue 4/3/18	Mon 5/14/18
86	100% Drawings and Specifications	30 days	Tue 5/22/18	Tue 7/3/18
87	Enviromental, Cultural Resources Update	40 days	Tue 5/22/18	Wed 7/18/18
88	Bi-Annual Cost Update	20 days	Tue 5/22/18	Tue 6/19/18
89	Economics Update	20 days	Tue 5/22/18	Tue 6/19/18
90	Corrected Final Drawings and Specifications	15 days	Thu 7/5/18	Wed 7/25/18
91	Advertise Phase Construction	45 days	Thu 7/26/18	Thu 9/27/18
92	Phase Complete - Award	0 days	Thu 9/27/18	Thu 9/27/18
93	**Phase 7 Construction**	**230 days**	**Fri 9/28/18**	**Wed 8/28/19**
95	**Phase 8 Planning, Engineering and Design**	**140 days**	**Wed 3/13/19**	**Fri 9/27/19**
96	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
97	65% Drawings and Specifications	50 days	Wed 3/13/19	Tue 5/21/19



Project: San Acacia Alt A Base + 4
Date: Wed 3/14/12

Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

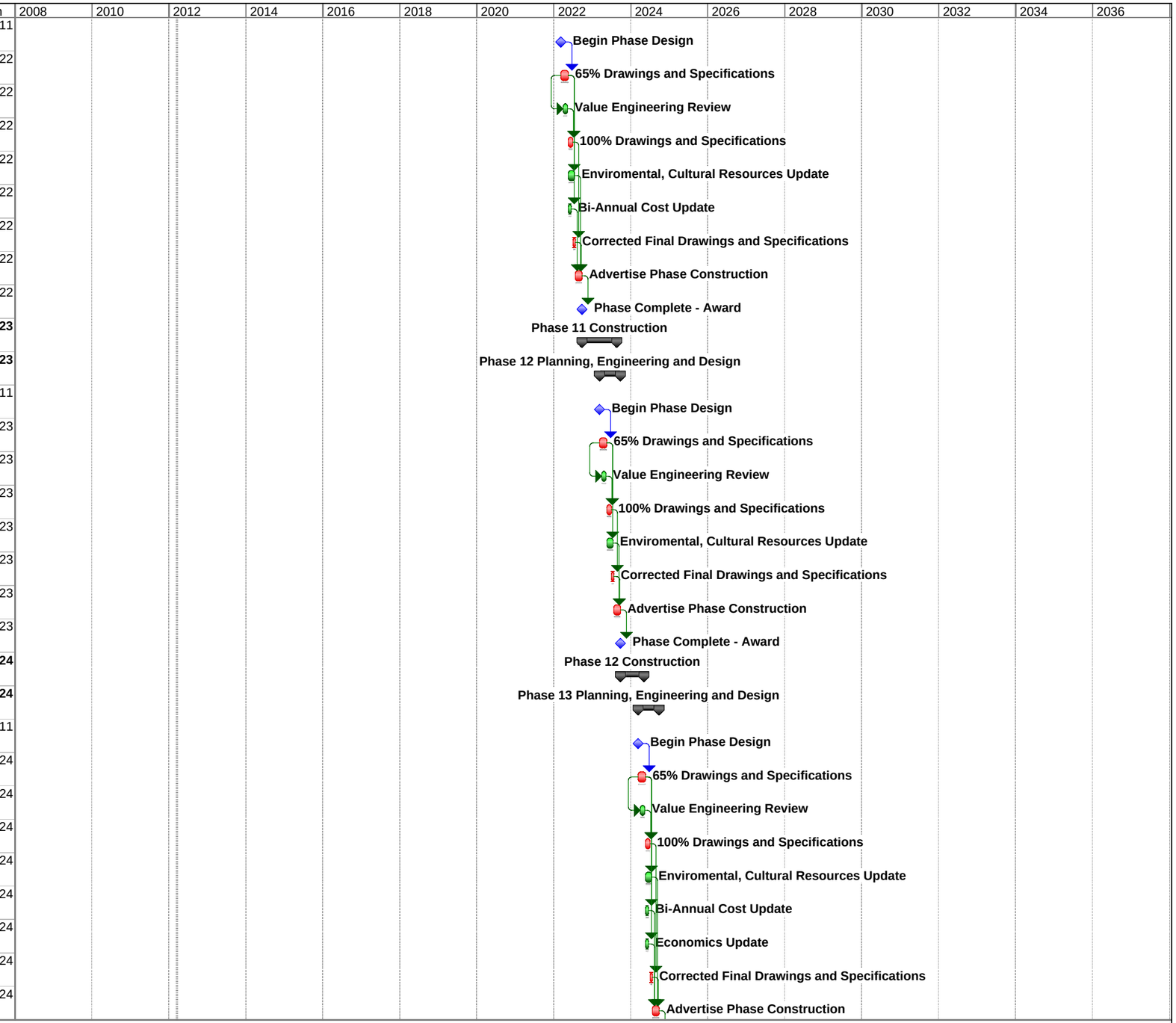
ID	Task Name	Duration	Early Start	Early Finish
98	Value Engineering Review	30 days	Wed 4/3/19	Tue 5/14/19
99	100% Drawings and Specifications	30 days	Wed 5/22/19	Wed 7/3/19
100	Enviromental, Cultural Resources Update	40 days	Wed 5/22/19	Thu 7/18/19
101	Corrected Final Drawings and Specifications	15 days	Fri 7/5/19	Thu 7/25/19
102	Advertise Phase Construction	45 days	Fri 7/26/19	Fri 9/27/19
103	Phase Complete - Award	0 days	Fri 9/27/19	Fri 9/27/19
104	**Phase 8 Construction**	**292 days**	**Sat 9/28/19**	**Fri 11/27/20**
106	**Phase 9 Planning, Engineering and Design**	**140 days**	**Wed 3/11/20**	**Fri 9/25/20**
107	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
108	65% Drawings and Specifications	50 days	Wed 3/11/20	Tue 5/19/20
109	Value Engineering Review	30 days	Wed 4/1/20	Tue 5/12/20
110	100% Drawings and Specifications	30 days	Wed 5/20/20	Wed 7/1/20
111	Enviromental, Cultural Resources Update	40 days	Wed 5/20/20	Thu 7/16/20
112	Bi-Annual Cost Update	20 days	Wed 5/20/20	Wed 6/17/20
113	Corrected Final Drawings and Specifications	15 days	Thu 7/2/20	Thu 7/23/20
114	Advertise Phase Construction	45 days	Fri 7/24/20	Fri 9/25/20
115	Phase Complete - Award	0 days	Fri 9/25/20	Fri 9/25/20
116	**Phase 9 Construction**	**167 days**	**Mon 9/28/20**	**Thu 5/27/21**
118	**Phase 10 Planning, Engineering and Design**	**140 days**	**Thu 3/11/21**	**Mon 9/27/21**
119	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
120	65% Drawings and Specifications	50 days	Thu 3/11/21	Wed 5/19/21
121	Value Engineering Review	30 days	Thu 4/1/21	Wed 5/12/21
122	100% Drawings and Specifications	30 days	Thu 5/20/21	Thu 7/1/21
123	Enviromental, Cultural Resources Update	40 days	Thu 5/20/21	Fri 7/16/21
124	Economics Update	20 days	Thu 5/20/21	Thu 6/17/21
125	Corrected Final Drawings and Specifications	15 days	Fri 7/2/21	Fri 7/23/21
126	Advertise Phase Construction	45 days	Mon 7/26/21	Mon 9/27/21
127	Phase Complete - Award	0 days	Mon 9/27/21	Mon 9/27/21
128	**Phase 10 Construction**	**182 days**	**Tue 9/28/21**	**Mon 6/20/22**
130	**Phase 11 Planning, Engineering and Design**	**140 days**	**Fri 3/11/22**	**Tue 9/27/22**



Project: San Acacia Alt A Base + 4
Date: Wed 3/14/12

Task		Split		Milestone		Project Summary	External Milestone
Critical Task		Progress		Summary		External Tasks	Deadline

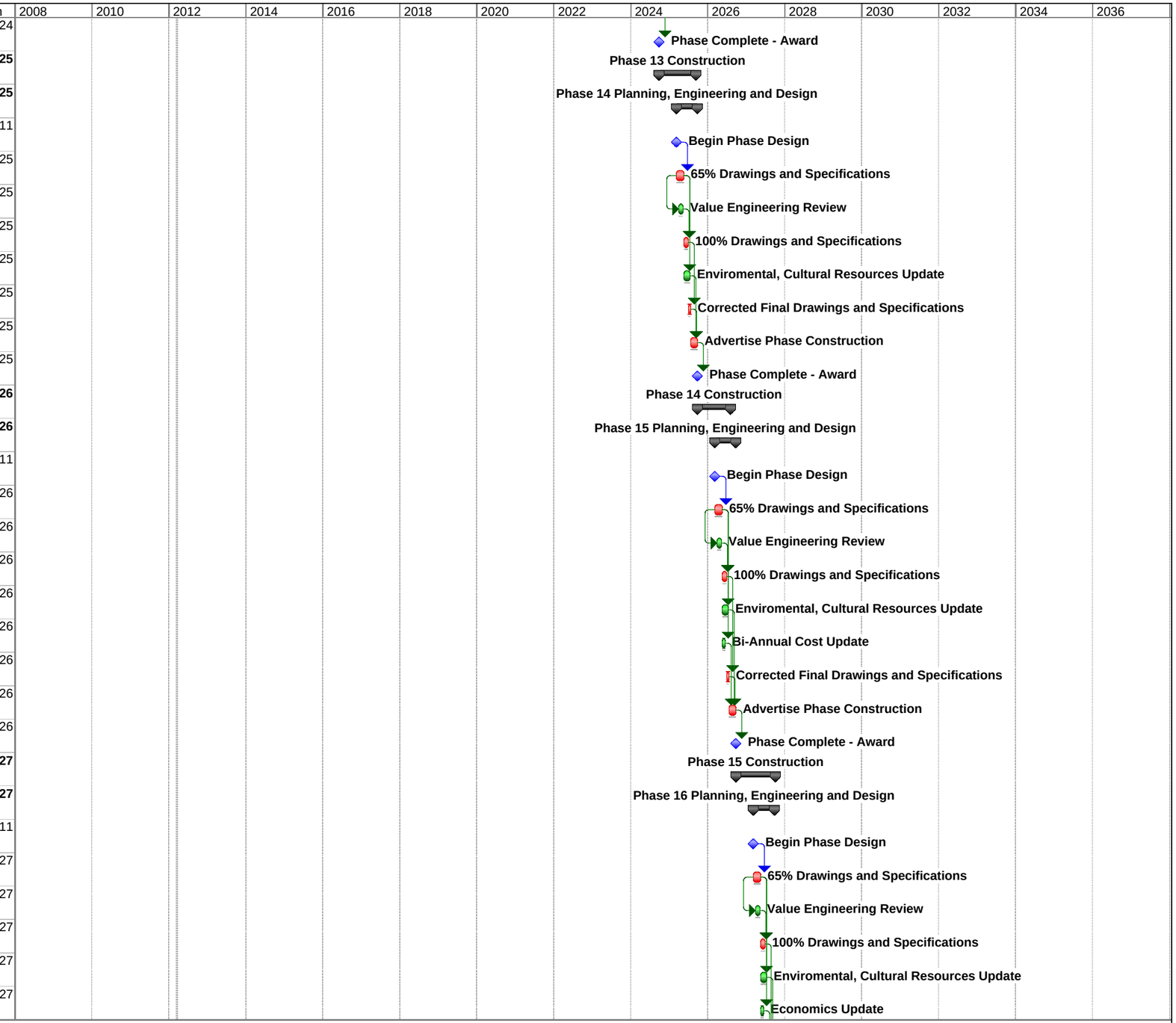
ID	Task Name	Duration	Early Start	Early Finish
131	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
132	65% Drawings and Specifications	50 days	Fri 3/11/22	Thu 5/19/22
133	Value Engineering Review	30 days	Fri 4/1/22	Thu 5/12/22
134	100% Drawings and Specifications	30 days	Fri 5/20/22	Fri 7/1/22
135	Enviromental, Cultural Resources Update	40 days	Fri 5/20/22	Mon 7/18/22
136	Bi-Annual Cost Update	20 days	Fri 5/20/22	Fri 6/17/22
137	Corrected Final Drawings and Specifications	15 days	Tue 7/5/22	Mon 7/25/22
138	Advertise Phase Construction	45 days	Tue 7/26/22	Tue 9/27/22
139	Phase Complete - Award	0 days	Tue 9/27/22	Tue 9/27/22
140	**Phase 11 Construction**	**227 days**	**Wed 9/28/22**	**Wed 8/23/23**
142	**Phase 12 Planning, Engineering and Design**	**140 days**	**Mon 3/13/23**	**Wed 9/27/23**
143	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
144	65% Drawings and Specifications	50 days	Mon 3/13/23	Fri 5/19/23
145	Value Engineering Review	30 days	Mon 4/3/23	Fri 5/12/23
146	100% Drawings and Specifications	30 days	Mon 5/22/23	Mon 7/3/23
147	Enviromental, Cultural Resources Update	40 days	Mon 5/22/23	Tue 7/18/23
148	Corrected Final Drawings and Specifications	15 days	Wed 7/5/23	Tue 7/25/23
149	Advertise Phase Construction	45 days	Wed 7/26/23	Wed 9/27/23
150	Phase Complete - Award	0 days	Wed 9/27/23	Wed 9/27/23
151	**Phase 12 Construction**	**152 days**	**Thu 9/28/23**	**Tue 5/7/24**
153	**Phase 13 Planning, Engineering and Design**	**140 days**	**Wed 3/13/24**	**Fri 9/27/24**
154	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
155	65% Drawings and Specifications	50 days	Wed 3/13/24	Tue 5/21/24
156	Value Engineering Review	30 days	Wed 4/3/24	Tue 5/14/24
157	100% Drawings and Specifications	30 days	Wed 5/22/24	Wed 7/3/24
158	Enviromental, Cultural Resources Update	40 days	Wed 5/22/24	Thu 7/18/24
159	Bi-Annual Cost Update	20 days	Wed 5/22/24	Wed 6/19/24
160	Economics Update	20 days	Wed 5/22/24	Wed 6/19/24
161	Corrected Final Drawings and Specifications	15 days	Fri 7/5/24	Thu 7/25/24
162	Advertise Phase Construction	45 days	Fri 7/26/24	Fri 9/27/24



Project: San Acacia Alt A Base + 4
Date: Wed 3/14/12

Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

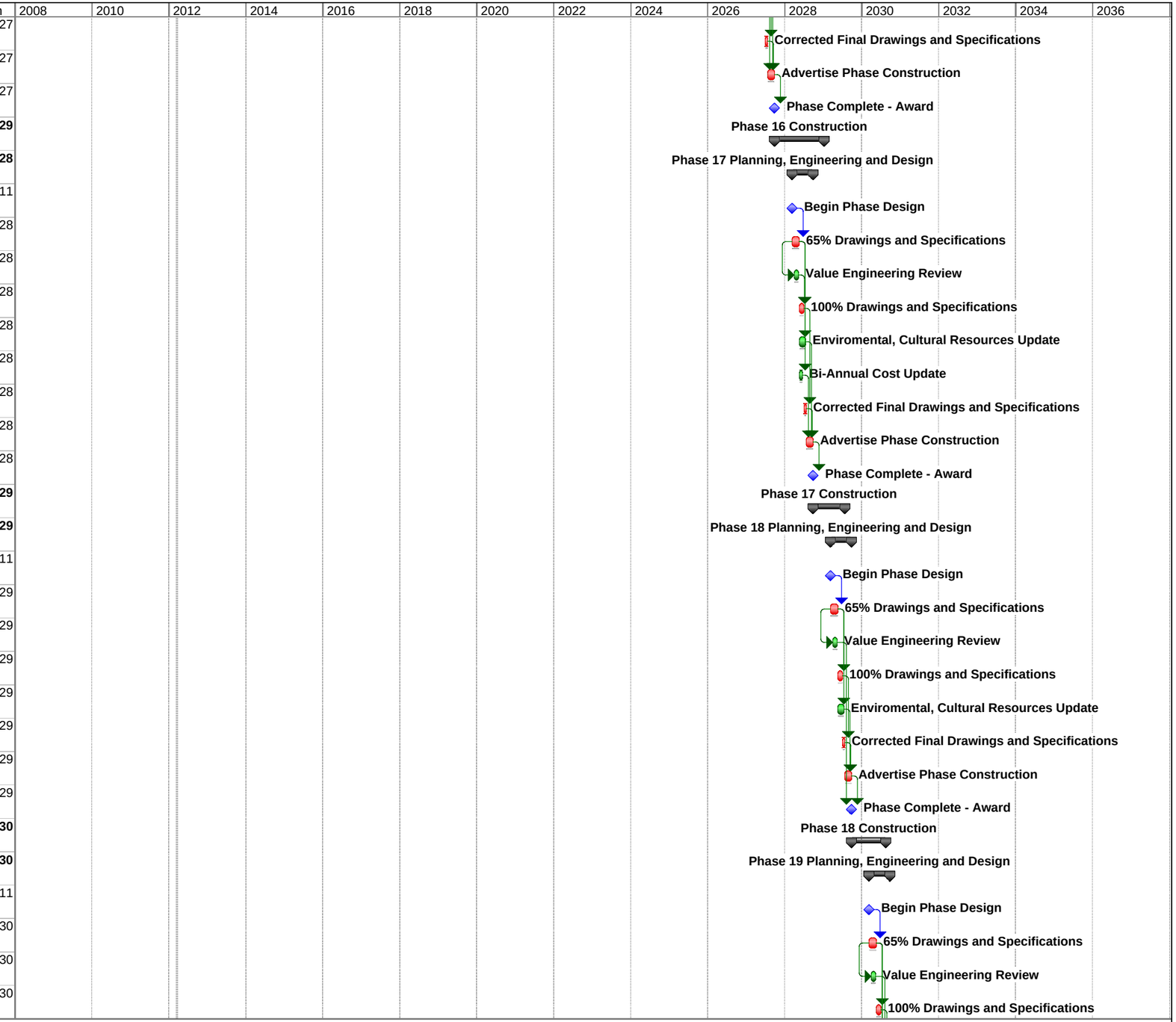
ID	Task Name	Duration	Early Start	Early Finish
163	Phase Complete - Award	0 days	Fri 9/27/24	Fri 9/27/24
164	**Phase 13 Construction**	**240 days**	**Sat 9/28/24**	**Fri 9/12/25**
166	**Phase 14 Planning, Engineering and Design**	**140 days**	**Wed 3/12/25**	**Fri 9/26/25**
167	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
168	65% Drawings and Specifications	50 days	Wed 3/12/25	Tue 5/20/25
169	Value Engineering Review	30 days	Wed 4/2/25	Tue 5/13/25
170	100% Drawings and Specifications	30 days	Wed 5/21/25	Wed 7/2/25
171	Enviromental, Cultural Resources Update	40 days	Wed 5/21/25	Thu 7/17/25
172	Corrected Final Drawings and Specifications	15 days	Thu 7/3/25	Thu 7/24/25
173	Advertise Phase Construction	45 days	Fri 7/25/25	Fri 9/26/25
174	Phase Complete - Award	0 days	Fri 9/26/25	Fri 9/26/25
175	**Phase 14 Construction**	**216 days**	**Sun 9/28/25**	**Fri 8/7/26**
177	**Phase 15 Planning, Engineering and Design**	**140 days**	**Wed 3/11/26**	**Fri 9/25/26**
178	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
179	65% Drawings and Specifications	50 days	Wed 3/11/26	Tue 5/19/26
180	Value Engineering Review	30 days	Wed 4/1/26	Tue 5/12/26
181	100% Drawings and Specifications	30 days	Wed 5/20/26	Wed 7/1/26
182	Enviromental, Cultural Resources Update	40 days	Wed 5/20/26	Thu 7/16/26
183	Bi-Annual Cost Update	20 days	Wed 5/20/26	Wed 6/17/26
184	Corrected Final Drawings and Specifications	15 days	Thu 7/2/26	Thu 7/23/26
185	Advertise Phase Construction	45 days	Fri 7/24/26	Fri 9/25/26
186	Phase Complete - Award	0 days	Fri 9/25/26	Fri 9/25/26
187	**Phase 15 Construction**	**258 days**	**Mon 9/28/26**	**Wed 10/6/27**
189	**Phase 16 Planning, Engineering and Design**	**140 days**	**Thu 3/11/27**	**Mon 9/27/27**
190	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
191	65% Drawings and Specifications	50 days	Thu 3/11/27	Wed 5/19/27
192	Value Engineering Review	30 days	Thu 4/1/27	Wed 5/12/27
193	100% Drawings and Specifications	30 days	Thu 5/20/27	Thu 7/1/27
194	Enviromental, Cultural Resources Update	40 days	Thu 5/20/27	Fri 7/16/27
195	Economics Update	20 days	Thu 5/20/27	Thu 6/17/27



Project: San Acacia Alt A Base + 4
Date: Wed 3/14/12

Task		Split		Milestone		Project Summary		External Milestone
Critical Task		Progress		Summary		External Tasks		Deadline

ID	Task Name	Duration	Early Start	Early Finish
196	Corrected Final Drawings and Specifications	15 days	Fri 7/2/27	Fri 7/23/27
197	Advertise Phase Construction	45 days	Mon 7/26/27	Mon 9/27/27
198	Phase Complete - Award	0 days	Mon 9/27/27	Mon 9/27/27
199	**Phase 16 Construction**	**322 days**	**Tue 9/28/27**	**Wed 1/10/29**
201	**Phase 17 Planning, Engineering and Design**	**140 days**	**Mon 3/13/28**	**Wed 9/27/28**
202	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
203	65% Drawings and Specifications	50 days	Mon 3/13/28	Fri 5/19/28
204	Value Engineering Review	30 days	Mon 4/3/28	Fri 5/12/28
205	100% Drawings and Specifications	30 days	Mon 5/22/28	Mon 7/3/28
206	Enviromental, Cultural Resources Update	40 days	Mon 5/22/28	Tue 7/18/28
207	Bi-Annual Cost Update	20 days	Mon 5/22/28	Mon 6/19/28
208	Corrected Final Drawings and Specifications	15 days	Wed 7/5/28	Tue 7/25/28
209	Advertise Phase Construction	45 days	Wed 7/26/28	Wed 9/27/28
210	Phase Complete - Award	0 days	Wed 9/27/28	Wed 9/27/28
211	**Phase 17 Construction**	**208 days**	**Thu 9/28/28**	**Fri 7/27/29**
213	**Phase 18 Planning, Engineering and Design**	**140 days**	**Tue 3/13/29**	**Thu 9/27/29**
214	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
215	65% Drawings and Specifications	50 days	Tue 3/13/29	Mon 5/21/29
216	Value Engineering Review	30 days	Tue 4/3/29	Mon 5/14/29
217	100% Drawings and Specifications	30 days	Tue 5/22/29	Tue 7/3/29
218	Enviromental, Cultural Resources Update	40 days	Tue 5/22/29	Wed 7/18/29
219	Corrected Final Drawings and Specifications	15 days	Thu 7/5/29	Wed 7/25/29
220	Advertise Phase Construction	45 days	Thu 7/26/29	Thu 9/27/29
221	Phase Complete - Award	0 days	Thu 9/27/29	Thu 9/27/29
222	**Phase 18 Construction**	**224 days**	**Fri 9/28/29**	**Tue 8/20/30**
224	**Phase 19 Planning, Engineering and Design**	**140 days**	**Wed 3/13/30**	**Fri 9/27/30**
225	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
226	65% Drawings and Specifications	50 days	Wed 3/13/30	Tue 5/21/30
227	Value Engineering Review	30 days	Wed 4/3/30	Tue 5/14/30
228	100% Drawings and Specifications	30 days	Wed 5/22/30	Wed 7/3/30



Project: San Acacia Alt A Base + 4
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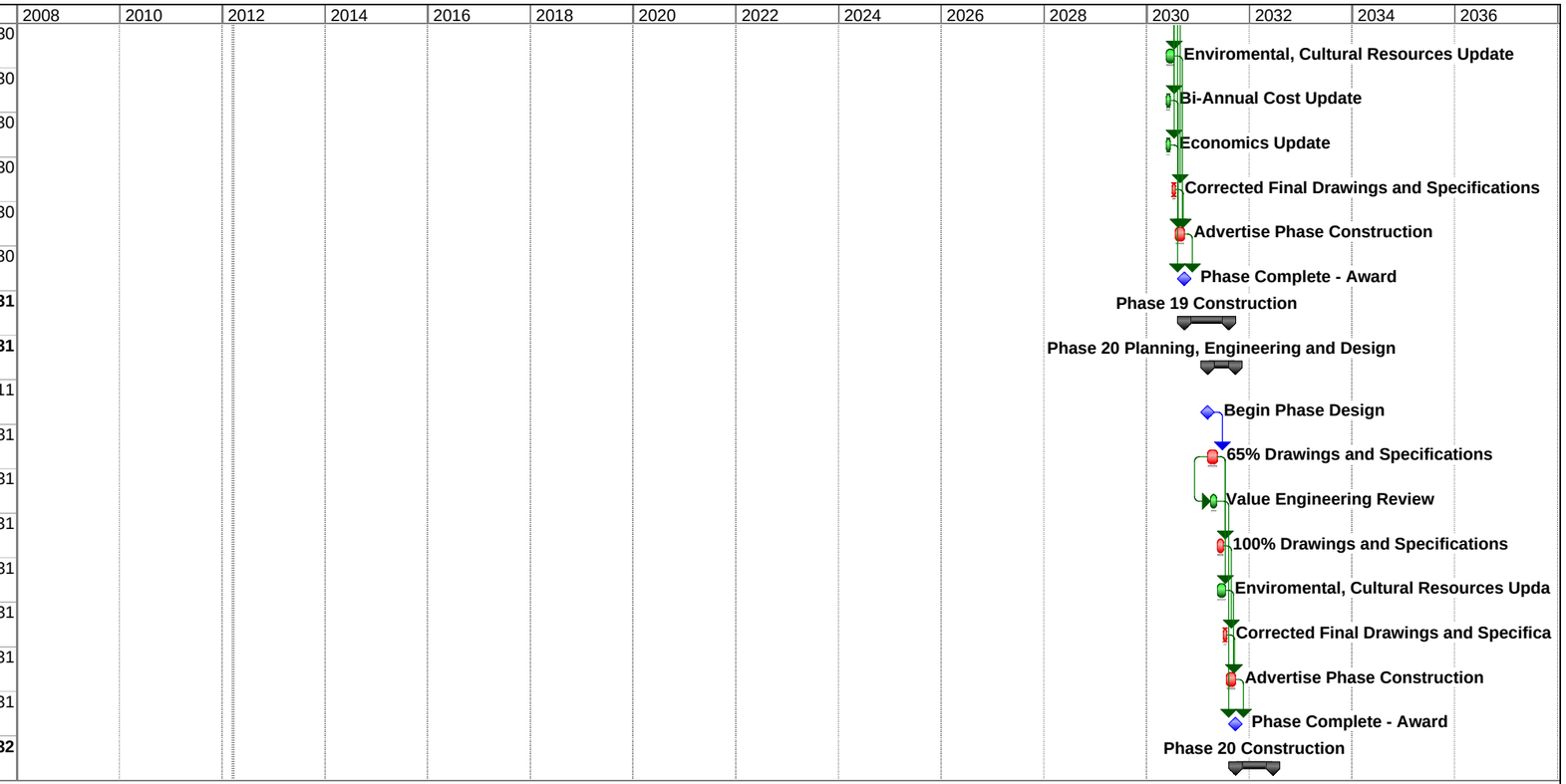
Task		Split		Milestone		Project Summary		External Milestone	
Critical Task		Progress		Summary		External Tasks		Deadline	

ID	Task Name	Duration	Early Start	Early Finish
229	Enviromental, Cultural Resources Update	40 days	Wed 5/22/30	Thu 7/18/30
230	Bi-Annual Cost Update	20 days	Wed 5/22/30	Wed 6/19/30
231	Economics Update	20 days	Wed 5/22/30	Wed 6/19/30
232	Corrected Final Drawings and Specifications	15 days	Fri 7/5/30	Thu 7/25/30
233	Advertise Phase Construction	45 days	Fri 7/26/30	Fri 9/27/30
234	Phase Complete - Award	0 days	Fri 9/27/30	Fri 9/27/30
235	**Phase 19 Construction**	**217 days**	**Sat 9/28/30**	**Mon 8/11/31**
237	**Phase 20 Planning, Engineering and Design**	**140 days**	**Wed 3/12/31**	**Fri 9/26/31**
238	Begin Phase Design	0 days	Fri 10/14/11	Fri 10/14/11
239	65% Drawings and Specifications	50 days	Wed 3/12/31	Tue 5/20/31
240	Value Engineering Review	30 days	Wed 4/2/31	Tue 5/13/31
241	100% Drawings and Specifications	30 days	Wed 5/21/31	Wed 7/2/31
242	Enviromental, Cultural Resources Update	40 days	Wed 5/21/31	Thu 7/17/31
243	Corrected Final Drawings and Specifications	15 days	Thu 7/3/31	Thu 7/24/31
244	Advertise Phase Construction	45 days	Fri 7/25/31	Fri 9/26/31
245	Phase Complete - Award	0 days	Fri 9/26/31	Fri 9/26/31
246	**Phase 20 Construction**	**182 days**	**Sun 9/28/31**	**Fri 6/18/32**



Project: San Acacia Alt A Base + 4
Date: Wed 3/14/12

Task		Split		Milestone		Project Summary	External Milestone
Critical Task		Progress		Summary		External Tasks	Deadline

DRAFT

GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-8

Cultural Resources

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

March 21, 2012

94140

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

RECEIVED
MAR 22 2012
Bob
HISTORIC PRESERVATION DIVISION

Ms. Jan Biella
Interim State Historic Preservation Officer
New Mexico Department of Cultural Affairs
Historic Preservation Division
Bataan Memorial Building
407 Galisteo Street, Suite 236
Santa Fe, New Mexico 87501

Rec'd 4-19-2012
GDE

Re: HPD Consultation Numbers 054201, 054093, 088135, 092670

Dear Ms. Biella:

Pursuant to 36 CFR Part 800, the U.S. Army Corps of Engineers (Corps), Albuquerque District, in cooperation with the project Sponsor, the Middle Rio Grande Conservancy District (MRGCD), is continuing our consultation regarding the proposed levee rehabilitation project for the San Acacia to Bosque del Apache reach of the Rio Grande Floodway in Socorro County, New Mexico. The Recommended Plan consists of rehabilitation of the existing non-engineered spoil-bank levee by constructing a structurally sound, engineered earthen levee extending approximately 43 miles along the west bank of the Rio Grande, from the San Acacia Diversion Dam to Tiffany Junction. The Corps seeks your concurrence in our determinations regarding three elements of this project:

1) A determination of **no historic properties affected** for the construction of a floodwall and levee tie-in to high ground near the San Acacia Diversion Dam;
2) A determination of **no adverse effect to historic properties** by rehabilitation of U.S. Bureau of Reclamation (BOR) facilities near the San Acacia Diversion Dam;
3) A determination of **no historic properties affected** for the use of the northern portion of the Tiffany Basin for an earthen spoil/waste disposal area.

Each of these elements is described below, along with explanations of our determinations. A draft of the Supplemental Environmental Impact Statement for the project will be posted to the Corps' Albuquerque District web page (http://www.spa.usace.army.mil/fonsi/) in the near future.

Floodwall and Levee Tie-In

One part of the Recommended Plan calls for the construction of a concrete floodwall and levee tie-in to a hillside immediately adjacent to the BNSF railway grade and northeast of the 1930s San Acacia Diversion Dam (Enclosures 1 and 2). On February 29, Corps archaeologists Gregory Everhart, Jonathan Van Hoose, Jeremy Decker, Ariane Pinson, and Christopher Parrish conducted a site visit to the area immediately adjacent to and northeast of the San Acacia Diversion Dam and BNSF railway grade, where the levee and new concrete floodwall will tie in to the hillside. The site visit verified that this area was previously disturbed by quarrying and construction activities. The Corps is of the opinion that construction of the headwall and levee tie-in to high ground will result in **no historic properties affected.** The Corps seeks your concurrence with this determination.

Rehabilitation of BOR Facilities

Construction activities near the San Acacia Diversion Dam also include the in-kind replacement of the Bureau of Reclamation's (BOR's) five existing seven-by-seven-foot CBC Conveyance Channel headworks that divert river water to the Low Flow Conveyance (LFC) Channel (Enclosures 1 and 2). These features were constructed in the 1950s by the BOR for managing irrigation water flows diverted from the river. Construction will also add one five-foot-diameter arch corrugated metal pipe extension, 65 feet in length, to the headworks of the Socorro Main Canal. The APE for the floodwall and the rehabilitation of both headworks is approximately 2.7 acres in size. The Corps is of the opinion that the proposed in-kind replacement of BOR's five LFC Channel headworks and the addition of a pipe extension to Socorro Main Canal headworks will result in **no adverse effect to historic properties.** The Corps seeks your concurrence with this determination.

Use of Tiffany Basin as Spoil Area

During planning for the proposed project, Corps engineers determined that approximately 302 acres would be necessary for disposal of excess earthen materials during construction of the proposed engineered levee, and have preliminarily chosen a

location in the Tiffany Basin for sediment disposal. This proposed project area is located in the northern portion of this low basin area that sits lower than the (perched) Rio Grande channel. The proposed project area is approximately 302 acres; the APE is approximately 377 acres (Enclosure 3).

On February 28, 2012, prior to the field survey, a search of the Archaeological Records Management Section's (ARMS) database found no historic properties documented within the area; however, no archaeological surveys had been conducted in the area. On February 29 and March 1, 2012, Corps archaeologists conducted a pedestrian archaeological survey of the proposed spoil area. Survey of this area was problematic due to the extremely high density of tamarisk vegetation covering large portions of the project area; as a result, only 183 acres (or 49 percent) of the 377-acre APE could be surveyed, and ground surface visibility in this area was often restricted (Enclosure 4).

Corps personnel discovered no historic properties during the course of the survey, with the exception of three isolated occurrences (IOs), which were recorded in the field: 1) one small scatter of rocks; 2) one small standing, thin-walled metal pipe; and 3) one historic Clorox bleach bottle. The Corps determines that these three IOs are not eligible for nomination to the National Register of Historic Places and that no further work is necessary.

While vegetation and visibility made it impossible to survey 100 percent of the APE, other available lines of evidence suggest that the vast majority (and possibly all) of the APE is unlikely to contain undisturbed sediments and intact cultural deposits. Utilizing a series of historic maps and aerial imagery, the Corps investigation determined that the majority of the APE was significantly disturbed within the last 100 years by two processes: the existence of the Rio Grande active river channel and floodplain within the current APE, and intensive ground disturbance through farming, BOR construction activities between 1951-1959, and other subsequent blading / bulldozing. By delineating the visible boundaries of both the river channel and human ground disturbance on maps from 1918 and aerial imagery from 1935 and 1962, the Corps determined that a minimum of 248 acres (66 percent of the APE) has been heavily disturbed in the last century (Enclosure 5). When combined with the 183 acres surveyed (some of which overlapped the known disturbance areas), the Corps determines that 309 acres (82 percent) of the APE is

highly unlikely to contain historic properties. Further, the geographic extent of recent disturbance is a conservative estimate; given the fact that the entire APE was once active floodplain, the likelihood of any intact historic properties in the remainder of the APE is low. The Corps is therefore of the opinion that use of the area as a waste sediment disposal area would result in **no historic properties affected**. The Corps seeks your concurrence with this determination.

Reconstruction of the 43-mile levee is planned to be conducted in phases over approximately 14 to 20 years, dependent upon the availability of funding. While use of the Tiffany Basin Spoil Area is part of the current plan, as planning and project design for each phase is formalized, the Corps will seek other, less costly locations for the disposal of excess earthen materials. Possibilities would include existing gravel quarry areas on the gravel terraces above the floodplain all along the river valley. If such areas are identified and determined viable for disposal, the Corps will consult with the SHPO on those locations at that time.

Please find enclosed for your review, our archaeological survey report entitled *A Site Visit to the San Acacia Diversion Dam and a Cultural Resources Inventory of Approximately 377 Acres for the Proposed Tiffany Basin Spoil Area, San Acacia to Bosque del Apache Levee Rehabilitation Project, Socorro County, New Mexico* (Corps Report No. USACE-ABQ-2012-001; NMCRIS No. 123307).

Pursuant to 36 CFR 800.2, consulting parties in the Section 106 process identified for the proposed San Acacia to Bosque del Apache Levee Rehabilitation Project (Undertaking) include the Corps, the MRGCD, the BOR, the U.S. Fish and Wildlife Service, Sevilleta National Wildlife Refuge, and your office. Consistent with the Department of Defense's American Indian and Alaska Native Policy, signed by Secretary of Defense William S. Cohen on October 20, 1998, and based on the State of New Mexico Indian Affairs Department and Historic Preservation Division's 2012 Native American Consultations List, Native American tribes that have indicated they have concerns in Socorro County have been sent scoping letters regarding the proposed project activities near the San Acacia Diversion Dam and the Tiffany Basin waste disposal area. The Corps has previously submitted scoping letters to Tribal entities on various aspects of this project in August 2002, February 2006, and July 2011. To date, the Corps has received no indication of tribal concerns regarding this project. No Traditional Cultural Properties and no Indian Trust

Assets are known to occur within or adjacent to the proposed project area.

In summary and pursuant to 36 CFR 800, the Corps seeks your concurrence with our determinations of **no historic properties affected**, **no adverse effect to historic properties**, and **no historic properties affected** by the three actions described above.

Should previously undiscovered artifacts or features be unearthed during construction, work will be stopped in the immediate vicinity of the find, a determination of significance made, and the Corps will consult with your office and with Native American tribes that may have concerns in the project area as to the best course of action.

If you have questions or require additional information regarding the Recommended Plan for the proposed 43-mile San Acacia to Bosque del Apache Levee Rehabilitation Project, please contact Gregory Everhart, archaeologist, at (505) 342-3352 or myself at (505) 342-3281.

Sincerely,

Julie Alcon
Chief, Environmental
Resources Section

17-April-2012
Date

I CONCUR for

JAN BIELLA
INTERIM NEW MEXICO STATE
HISTORIC PRESERVATION OFFICER

Enclosures

Copies furnished with Enclosures:

Mr. Ray Gomez P.E.
Assistant Engineer
Middle Rio Grande Conservancy District
PO Box 581
Albuquerque, New Mexico 87103

Ms. Cheryl Rolland
Manager
U.S. Bureau of Reclamation
Albuquerque Area Office
Facilities and Lands Division
555 Broadway Boulevard NE, Suite 100
Albuquerque, New Mexico 87102

Mr. Mark Hungerford
Archaeologist
U.S. Bureau of Reclamation
Albuquerque Area Office
Facilities and Lands Division
555 Broadway Boulevard NE, Suite 100
Albuquerque, New Mexico 87102

Ms. Kathy Granillo
Refuge Manager
U.S. Fish and Wildlife Service
Sevilleta National Wildlife Refuge
PO Box 1248
Socorro, New Mexico 87801

Ysleta del Sur Pueblo

Tribal Council – Javier Loera – (War Captain/Tribal Historic and Preservation Officer) E-mail jloera@ydsp-nsn.gov

119 South Old Pueblo Road * P.O. Box 17579 * El Paso, Texas 79917 * (915) 859-8053 * Fax: (915) 859-4252

April 10, 2012

Rec'd 4-13-2012
GDE

Mr. Gregory D. Everhart
Archaeologist
Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section
Department of the Army
Albuquerque District, Corps of Engineers
4101 Jefferson Plaza NE
Albuquerque, NM 87109-3435

Dear Mr. Everhart:

This letter is in response to the correspondence received in our office in which you provide the Ysleta del Sur Pueblo the opportunity to comment on the U.S. Army Corps of Engineers (Corps), Albuquerque District, in cooperation with the project sponsor, the Middle Rio Grande Conservancy District's (MRGCD) proposed planning of a levee rehabilitation project for a portion of the Rio Grande Floodway in Socorro County, New Mexico.

While we do not have any comments on the proposed undertaking and believe that this project will not adversely affect traditional, religious or culturally significant sites of our Pueblo and have no opposition to it; we would like to request consultation should any human remains or artifacts unearthed during this project be determined to fall under the Native American Graves Protection and Repatriation Act (NAGPRA) guidelines. Copies of our Pueblo's Cultural Affiliation Position Paper and Consultation Policy are available upon request.

Thank you for allowing us the opportunity to comment on the proposed project.

Sincerely,

Javier Loera

Javier Loera
War Captain/Tribal Historic and Preservation Officer
Ysleta del Sur Pueblo

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

March 27, 2012

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

RECEIVED
APR 02 2012
BY: CPO

Honorable Leroy Shingoitewa
Chairman, Hopi Tribal Council
Post Office Box 123
Kykotsmovi, Arizona 86039

Rec'd 4-5-2012
GDE

Dear Chairman Shingoitewa:

The U.S. Army Corps of Engineers (Corps), Albuquerque District, in cooperation with the project sponsor, the Middle Rio Grande Conservancy District (MRGCD), is planning a levee rehabilitation project for a portion of the Rio Grande Floodway in Socorro County, New Mexico. The existing levee is located along the west side of the Rio Grande in what is known as the San Acacia to Bosque del Apache reach of the Rio Grande Floodway. The Recommended Plan consists of an earthen levee extending approximately 43 miles along the west bank of the Rio Grande, from the San Acacia Diversion Dam to Tiffany Junction. San Acacia is located at the north end of the project area; Tiffany Junction is located at the south end of the project area, approximately 3 miles north of the San Marcial BNSF Railroad Bridge (Enclosure 1). The Corps provided a description of the Recommended Plan in our July 2011 Socorro County tribal scoping letter regarding this project (Enclosure 2).

This scoping letter is to notify tribes with concerns in Socorro County about three new elements of the Recommended Plan:

Floodwall and Levee Tie-in

One part of the Recommended Plan calls for the construction of a concrete floodwall and levee tie-in to a hillside immediately adjacent to the BNSF railway grade and northeast of the 1930s San Acacia Diversion Dam (Enclosures 3 and 4). On February 29, 2012, Corps archaeologists conducted a site visit to the area immediately adjacent to and northeast of the San Acacia Diversion Dam and BNSF railway grade, where the levee and new concrete floodwall will tie in to the hillside. The site visit verified that this area was previously disturbed by quarrying and construction activities.

Rehabilitation of U.S. Bureau of Reclamation (BOR) Facilities

Construction activities near the San Acacia Diversion Dam also include the in-kind replacement of the BOR's five existing 7' by 7' CBC Conveyance Channel headworks that divert river water to the Low Flow Conveyance Channel (Enclosures 3 and 4). To the best of our knowledge, these features were constructed in the 1950s by the BOR to manage river flow to Elephant Butte for compact deliveries. Construction will add

one 5′ diameter arch corrugated metal pipe extension, 65 feet in length, to the headworks of the Socorro Main Canal. This entire area has been previously disturbed. The Area of Potential Effect (APE) for the floodwall and the rehabilitation of both headworks is approximately 2.7 acres in size. Both the San Acacia Diversion Dam and the Low Flow Conveyance Channel are historic structures.

Use of Tiffany Basin as Spoil Area

The existing spoil bank levee contains more earthen materials than is necessary to the construct the new engineered levee, therefore, the excess earthen materials need to be removed. During planning for the proposed project, Corps engineers determined that approximately 302 acres would be necessary for disposal of excess earthen materials, and have preliminarily chosen a location known as the Tiffany Basin for sediment disposal. This proposed project area, located in the northern portion of Tiffany Basin, is a low basin adjacent to the river that sits lower than the Rio Grande channel. The proposed spoil area is approximately 302 acres; the APE is approximately 377 acres (Enclosure 5).

On February 29, 2012 and March 1, 2012, the Corps archaeologists conducted a pedestrian archaeological survey of the Tiffany Basin Spoil Area. No historic properties were observed during the Corps survey with the exception of three isolated occurrences, which were recorded in the field: 1) one small scatter of rocks; 2) one small standing, thin-walled metal pipe; and 3) one historic clorox bleach bottle. The Corps determined these three isolated occurrences are not eligible for nomination to the National Register of Historic Places.

Utilizing a series of historic maps and aerial imagery, the Corps investigation determined that the majority of the APE was significantly disturbed within the last 100 years by two processes: the existence of the Rio Grande active river channel and floodplain within the current APE, and intensive ground disturbance through farming, BOR construction activities between 1951-1959, and other subsequent blading and bulldozing.

Reconstruction of the 43-mile levee is planned to be conducted in phases over approximately 14 to 20 years, dependent upon the availability of funding. While use of the Tiffany Basin Spoil Area is part of the current plan, as planning and project design for each phase is formalized, the Corps will seek other less costly locations for the disposal of excess earthen materials. Possibilities would include existing gravel quarry areas on the gravel terraces above the floodplain all along the river valley.

Since the proposed construction area for the floodwall and levee tie-in near the San Acacia Diversion Dam has been previously disturbed, the Corps is of the opinion that construction of this part of the project will result in no historic properties affected. The proposed rehabilitation of the BOR facilities has also been previously disturbed, and the Corps is of the opinion that rehabilitation of these facilities

will result in no adverse effect to historic properties. Based on the negative results of the Corps archaeological survey and investigation of historic mapping and aerial imagery, the Corps is of the opinion that the use of the Tiffany Basin Spoil Area would result in no historic properties affected.

The Corps is seeking input for consideration during planning of the project. The purpose of this scoping letter is to provide you with the opportunity to submit concerns or comments you may have regarding potential effects for the proposed project. Specifically, any concerns you may have regarding the environment such as natural, biological, or cultural resources; wildlife, vegetation, and special status species; air, water, or sound quality; aesthetics; health and safety; or Indian Trust Assets that may occur within or adjacent to the project area. Your input will be used in preparing an environmental impact statement to comply with the National Environmental Policy Act. In the near future, a draft of the Supplemental Environmental Impact Statement for the project will be posted to the Corps' Albuquerque District web page http://www.spa.usace.army.mil/fonsi/.

Please provide written comments at the address above regarding environmental concerns to William DeRagon, Biologist, and comments regarding cultural resources to Gregory D. Everhart, Archaeologist.

If you have any questions or require additional information on the San Acacia to Bosque del Apache Levee Rehabilitation project, please contact Mr. DeRagon at (505) 342-3358 or at william.deragon@usace.army.mil, Mr. Everhart at (505) 342-3352 or at gregory.d.everhart@usace.army.mil or myself at (505) 342-3281 or at julie.a.alcon@usace.army.mil.

Sincerely,

Julie Alcon
Acting Chief, Environmental Resources Section

Enclosures

Copy Furnished w/Enclosures:

Mr. Leigh Kuwanwisiwma
Hopi Tribal Council
Director, Cultural Preservation Office
Post Office Box 123
Kykotsmovi, Arizona 86039

Concur
for Kuwanwisiwma
4-2-12

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

March 27, 2012

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

Honorable Frank Paiz
Governor, Pueblo of Ysleta del Sur
P.O. Box 17579, Ysleta Station
El Paso, Texas 79917

Dear Governor Paiz:

The U.S. Army Corps of Engineers (Corps), Albuquerque District, in cooperation with the project sponsor, the Middle Rio Grande Conservancy District (MRGCD), is planning a levee rehabilitation project for a portion of the Rio Grande Floodway in Socorro County, New Mexico. The existing levee is located along the west side of the Rio Grande in what is known as the San Acacia to Bosque del Apache reach of the Rio Grande Floodway. The Recommended Plan consists of an earthen levee extending approximately 43 miles along the west bank of the Rio Grande, from the San Acacia Diversion Dam to Tiffany Junction. San Acacia is located at the north end of the project area; Tiffany Junction is located at the south end of the project area, approximately 3 miles north of the San Marcial BNSF Railroad Bridge (Enclosure 1). The Corps provided a description of the Recommended Plan in our July 2011 Socorro County tribal scoping letter regarding this project (Enclosure 2).

This scoping letter is to notify tribes with concerns in Socorro County about three new elements of the Recommended Plan:

Floodwall and Levee Tie-in

One part of the Recommended Plan calls for the construction of a concrete floodwall and levee tie-in to a hillside immediately adjacent to the BNSF railway grade and northeast of the 1930s San Acacia Diversion Dam (Enclosures 3 and 4). On February 29, 2012, Corps archaeologists conducted a site visit to the area immediately adjacent to and northeast of the San Acacia Diversion Dam and BNSF railway grade, where the levee and new concrete floodwall will tie in to the hillside. The site visit verified that this area was previously disturbed by quarrying and construction activities.

Rehabilitation of U.S. Bureau of Reclamation (BOR) Facilities

Construction activities near the San Acacia Diversion Dam also include the in-kind replacement of the BOR's five existing 7' by 7' CBC Conveyance Channel headworks that divert river water to the Low Flow Conveyance Channel (Enclosures 3 and 4). To the best of our knowledge, these features were constructed in the 1950s by the BOR to manage river flow to Elephant Butte for compact deliveries. Construction will add one 5' diameter arch corrugated metal pipe extension, 65 feet in length,

to the headworks of the Socorro Main Canal. This entire area has been previously disturbed. The Area of Potential Effect (APE) for the floodwall and the rehabilitation of both headworks is approximately 2.7 acres in size. Both the San Acacia Diversion Dam and the Low Flow Conveyance Channel are historic structures.

Use of Tiffany Basin as Spoil Area

The existing spoil bank levee contains more earthen materials than is necessary to the construct the new engineered levee, therefore, the excess earthen materials need to be removed. During planning for the proposed project, Corps engineers determined that approximately 302 acres would be necessary for disposal of excess earthen materials, and have preliminarily chosen a location known as the Tiffany Basin for sediment disposal. This proposed project area, located in the northern portion of Tiffany Basin, is a low basin adjacent to the river that sits lower than the Rio Grande channel. The proposed spoil area is approximately 302 acres; the APE is approximately 377 acres (Enclosure 5).

On February 29, 2012 and March 1, 2012, the Corps archaeologists conducted a pedestrian archaeological survey of the Tiffany Basin Spoil Area. No historic properties were observed during the Corps survey with the exception of three isolated occurrences, which were recorded in the field: 1) one small scatter of rocks; 2) one small standing, thin-walled metal pipe; and 3) one historic clorox bleach bottle. The Corps determined these three isolated occurrences are not eligible for nomination to the National Register of Historic Places.

Utilizing a series of historic maps and aerial imagery, the Corps investigation determined that the majority of the APE was significantly disturbed within the last 100 years by two processes: the existence of the Rio Grande active river channel and floodplain within the current APE, and intensive ground disturbance through farming, BOR construction activities between 1951-1959, and other subsequent blading and bulldozing.

Reconstruction of the 43-mile levee is planned to be conducted in phases over approximately 14 to 20 years, dependent upon the availability of funding. While use of the Tiffany Basin Spoil Area is part of the current plan, as planning and project design for each phase is formalized, the Corps will seek other less costly locations for the disposal of excess earthen materials. Possibilities would include existing gravel quarry areas on the gravel terraces above the floodplain all along the river valley.

Since the proposed construction area for the floodwall and levee tie-in near the San Acacia Diversion Dam has been previously disturbed, the Corps is of the opinion that construction of this part of the project will result in no historic properties affected. The proposed rehabilitation of the BOR facilities has also been previously disturbed, and the Corps is of the opinion that rehabilitation of these facilities will result in no adverse effect to historic properties. Based on the negative results of the Corps archaeological survey and investigation of

historic mapping and aerial imagery, the Corps is of the opinion that the use of the Tiffany Basin Spoil Area would result in no historic properties affected.

The Corps is seeking input for consideration during planning of the project. The purpose of this scoping letter is to provide you with the opportunity to submit concerns or comments you may have regarding potential effects for the proposed project. Specifically, any concerns you may have regarding the environment such as natural, biological, or cultural resources; wildlife, vegetation, and special status species; air, water, or sound quality; aesthetics; health and safety; or Indian Trust Assets that may occur within or adjacent to the project area. Your input will be used in preparing an environmental impact statement to comply with the National Environmental Policy Act. In the near future, a draft of the Supplemental Environmental Impact Statement for the project will be posted to the Corps' Albuquerque District web page http://www.spa.usace.army.mil/fonsi/.

Please provide written comments at the address above regarding environmental concerns to William DeRagon, Biologist, and comments regarding cultural resources to Gregory D. Everhart, Archaeologist.

If you have any questions or require additional information on the San Acacia to Bosque del Apache Levee Rehabilitation project, please contact Mr. DeRagon at (505) 342-3358 or at william.deragon@usace.army.mil, Mr. Everhart at (505) 342-3352 or at gregory.d.everhart@usace.army.mil or myself at (505) 342-3281 or at julie.a.alcon@usace.army.mil.

Sincerely,

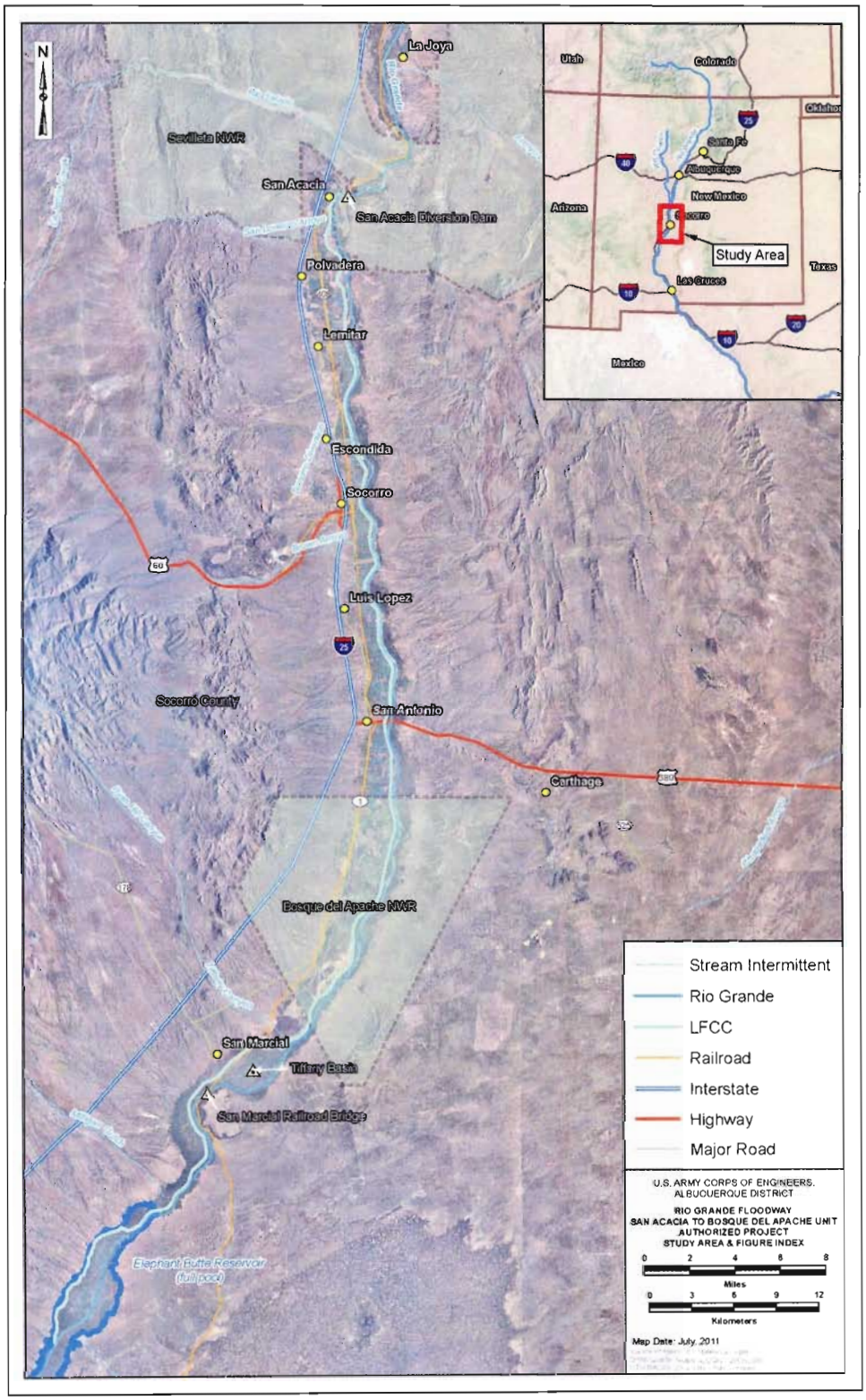
Julie Alcon
Chief, Environmental Resources
Section

Enclosures

Copy Furnished w/Enclosures:

Mr. Javier Loera
NAGPRA Representative
Pueblo of Ysleta del Sur
P.O. Box 17579, Ysleta Station
El Paso, Texas 79917

Enclosure 1: San Acacia to Bosque del Apache Study Area.



Enclosure 2: 2011 Tribal Scoping letter.

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

July 5, 2011

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Division

Honorable Ben Shelly
President, Navajo Nation
Post Office Box 9000
Window Rock, Arizona 86515

Dear President Shelly:

The U.S. Army Corps of Engineers (Corps), Albuquerque District, is planning a levee rehabilitation project for a portion of the Rio Grande Floodway in Socorro County, New Mexico. The existing levee is located along the west side of the Rio Grande in what is known as the San Acacia to Bosque del Apache reach of the Rio Grande Floodway. The Preliminary Preferred Plan consists of an earthen levee extending approximately 43 miles along the west bank of the Rio Grande, from the San Acacia Diversion Dam to Tiffany Junction. Tiffany Junction is approximately 3 miles north of the San Marcial BNSF Railroad Bridge (See Enclosure 1, Map Figure 1.1). The plan consists of reconstructing the existing spoil bank (non-engineered) levee to form a structurally sound levee paralleling the U.S. Bureau of Reclamation's (Reclamation) Low Flow Conveyance Channel (LFCC). The local sponsor, the Middle Rio Grande Conservancy District (MRGCD), supports the Preliminary Preferred Plan. A draft of the Supplemental Environmental Impact Statement will be posted to the Corps' Albuquerque District web page (http://www.spa.usace.army.mil/fonsi/) in the near future.

The study area of the current project, San Acacia to Bosque Del Apache Unit, is one unit within the comprehensive plan of development for flood control in the Rio Grande Basin, New Mexico that was authorized by the Flood Control Acts of 1948 (P.L. 80-858, Section 203) and 1950 (P.L. 81-516), in accordance with the recommendations of the Chief of Engineers, as found in House Document No. 243, 81st Congress, 1st Session, dated April 5, 1948. The Authority provided a comprehensive plan for coordinated development, by the Corps and Bureau of Reclamation, of water resource and flood risk management on the Rio Grande commencing near Truth or Consequences at about river mile 123 extending upstream to the lower end of the Rio Grande Canyon 14 miles upstream from Española, New Mexico at about river mile 394. The comprehensive plan included channel rectification, improvement of irrigation works, dredging, construction of three reservoirs and levee

enlargement and construction. A November 1947 agreement delegated responsibility for channel rectification and maintenance to the Bureau of Reclamation and facilities for local flood protection to the Corps of Engineers.

As described in the 1948 report, levees had been constructed by local interests through parts of the Espanola and Middle Valley of the Rio Grande. The levees were not uniform as to grade, section or standard of construction and it was proposed to modify and supplement the existing levees. Since authorized in 1948, no levee rehabilitation projects have been constructed in the San Acacia to Bosque del Apache reach.

In 1997, the Corps contracted with the University of New Mexico's Office of Contract Archeology to conduct archaeological surveys of the levee alignment and other areas of the recommended plan's construction area. With the exception of the existing, historic 1930s MRGCD irrigation system, levee, and Reclamation's LFCC, completed in 1959, no archaeological sites, historic properties, or features were identified within the proposed levee reconstruction zone or access routes. No Traditional Cultural Properties are known to occur within or adjacent to the project area. As a part of planning for this project, the Corps, with our letter dated August 16, 2002, has previously submitted tribal scoping letters to tribes with concerns within Socorro County regarding the drilling of groundwater monitoring wells (copy attached for your convenience, Enclosure 2). With our tribal scoping letter dated February 21, 2006, the Corps informed tribes with concerns in Socorro County about studying the feasibility of constructing a new railroad bridge and the relocation of approximately 4 miles of track for the proposed railroad-Rio Grande crossing near San Marcial (copy attached for your convenience, Enclosure 3). Responses were received from the Pueblo of Isleta, the White Mountain Apache Tribe, the Comanche Tribe, and the Hopi Tribe. All of these stated they had no concerns regarding construction work for the San Marcial railroad crossing.

Based on the results of the Corps' archaeological investigations of the San Acacia to San Marcial reach, the Corps is of the opinion that reconstruction of the 43-mile levee would result in no historic properties affected. On November 5, 1997, the NM State Historic Preservation Officer (SHPO) concurred with the Corps determination of no effect for the then recommended alternative which followed the same alignment as the presently recommended plan (SHPO Consultation No. 054093). The Corps has previously submitted additional documentation to the SHPO for mitigation of effects to the MRGCD irrigation system, levee, and Reclamation's LFCC (Berry and Lewis 1997; Van Citters 2000; Dodge and Santillanes 2007). The SHPO has also concurred that it is

highly unlikely that historic properties or cultural materials of significant antiquity or archaeological integrity would occur within areas of the Rio Grande's historic active channel.

There are two important aspects of the proposed project. The first is that the on-going modeling of river flows and projected volumes of water during flood events indicate that the proposed engineered levee may be smaller in both height and width than the existing spoil-bank levee. The second is that the material in the spoil-bank levee would be used in the rehabilitation of the proposed engineered levee. Therefore, all of the construction will occur in areas originally disturbed during construction of the levee and the low-flow conveyance channel, and no new quarry areas for fill would be required. Access for construction already exists on a network of paved and dirt roads, and to the extent possible, staging locations for equipment will be in previously disturbed locations. There are no archaeological sites within these disturbed areas.

Subsequent to the 1997 SHPO concurrence of no effect for the 43-mile levee rehabilitation project, Corps' engineers determined that as a new element of the Preliminary Preferred Plan, bank protection work would need to be constructed on the river bend immediately downstream of the San Acacia Diversion Dam. The San Acacia Diversion Dam is located at the upstream end of the 43-mile levee project. The Rio Grande channel on this river bend is significantly degraded. Proposed work in this San Acacia Overbank Lowering Area (see Enclosure 1, Map Figures 2 and 3) would include the placement of protective rock rip-rap on the outside of the river bend (northwest) adjacent to the BNSF railroad grade, and lowering and shaping the overbank area on the inside of the river bend (southeast). The light blue area shown in Map Figure 3 represents the sand bank that would be excavated to the depth of the existing river channel; the light green area would be excavated on a 1 to 10 slope. All work would be confined to the river channel and sand bank. This excavation would reduce river flow velocity around the river bend; thereby providing flood protection to the BNSF railway grade, Reclamation's LFCC, and the community of San Acacia and adjacent farm land.

On May 26, 2011, Corps archaeologists conducted a site visit to the San Acacia Overbank Lowering Area to verify the location of known archaeological resources in relation to the proposed construction area. Supported with information gathered from archival records, the Corps' site visit found that archaeological resources in the area are of sufficient distance away from the project area that they would not be affected. The Corps is of the opinion that improvements to the river channel would result in no effect to historic properties. This San Acacia project area is on land managed by the U.S. Fish and Wildlife Service, Sevilleta National Wildlife Refuge.

The Corps is seeking input for consideration during planning of the project. The purpose of this scoping letter is to provide you with the opportunity to submit concerns or comments you may have regarding potential effects for the proposed project. Specifically, any concerns you may have regarding the environment such as natural, biological, or cultural resources; wildlife, vegetation, and special status species; air, water, or sound quality; aesthetics; health and safety; or Indian Trust Assets that may occur in the project area. Your input will be used in preparing an environmental impact statement to comply with the National Environmental Policy Act.

Please provide written comments regarding environmental concerns to William DeRagon, Biologist (William.deragon@usace.army.mil); and, comments regarding cultural resources to Gregory D. Everhart, Archaeologist (Gregory.d.everhart@usace.army.mil), at the above address. If you have any questions or require additional information on the San Acacia to Bosque del Apache levee rehabilitation project, please contact Mr. DeRagon at (505) 342-3358, Mr. Everhart at (505) 342-3352, or myself at (505) 342-3281.

Sincerely,

for Andrea Hummel

Julie Alcon
Chief, Environmental Resources
Section

Enclosures

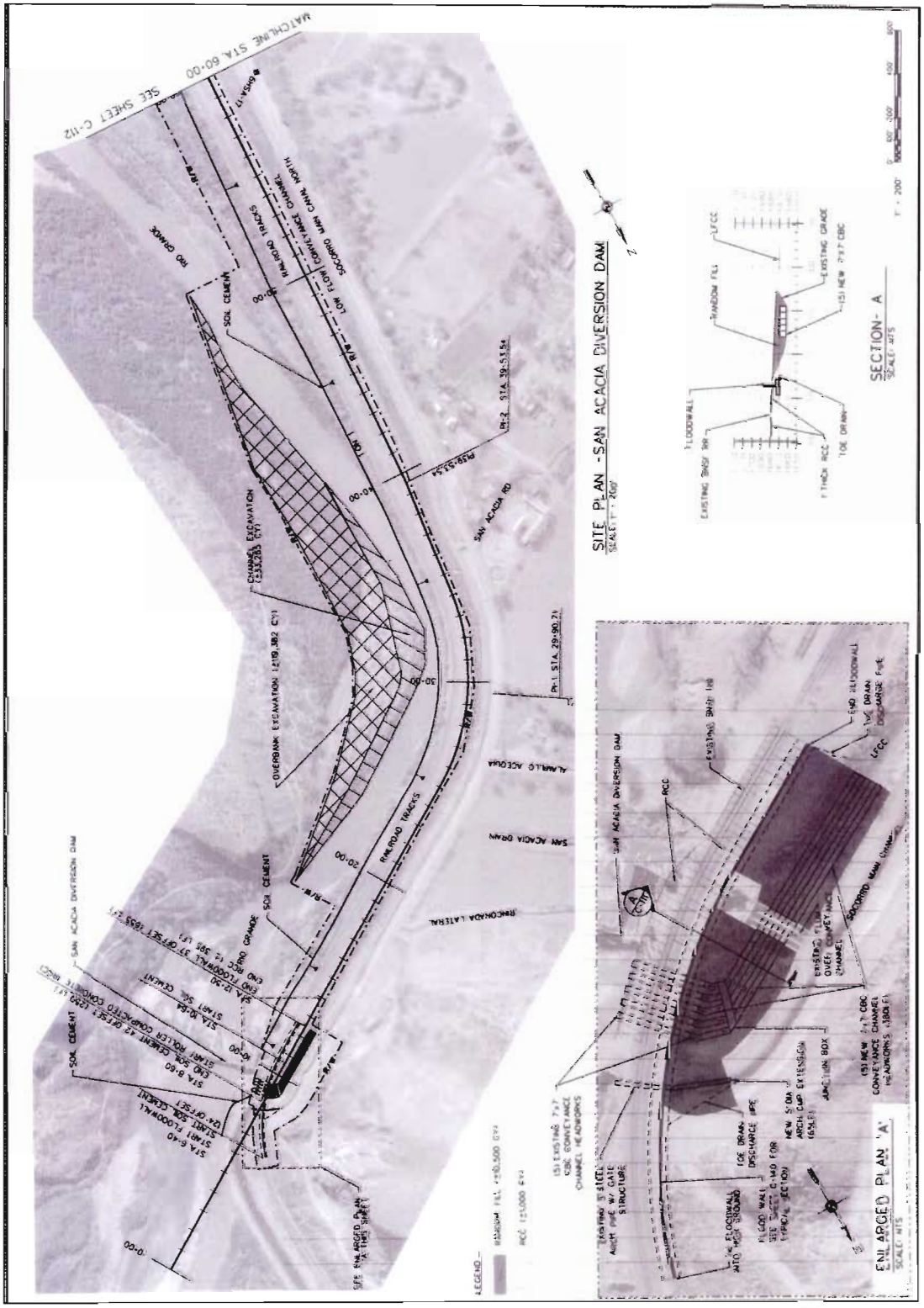
Copy furnished w/Encl:

2011 - Tribal mailing list - Socorro County, NM
American Indian tribes that have indicated that they have cultural resources concerns in Socorro County.

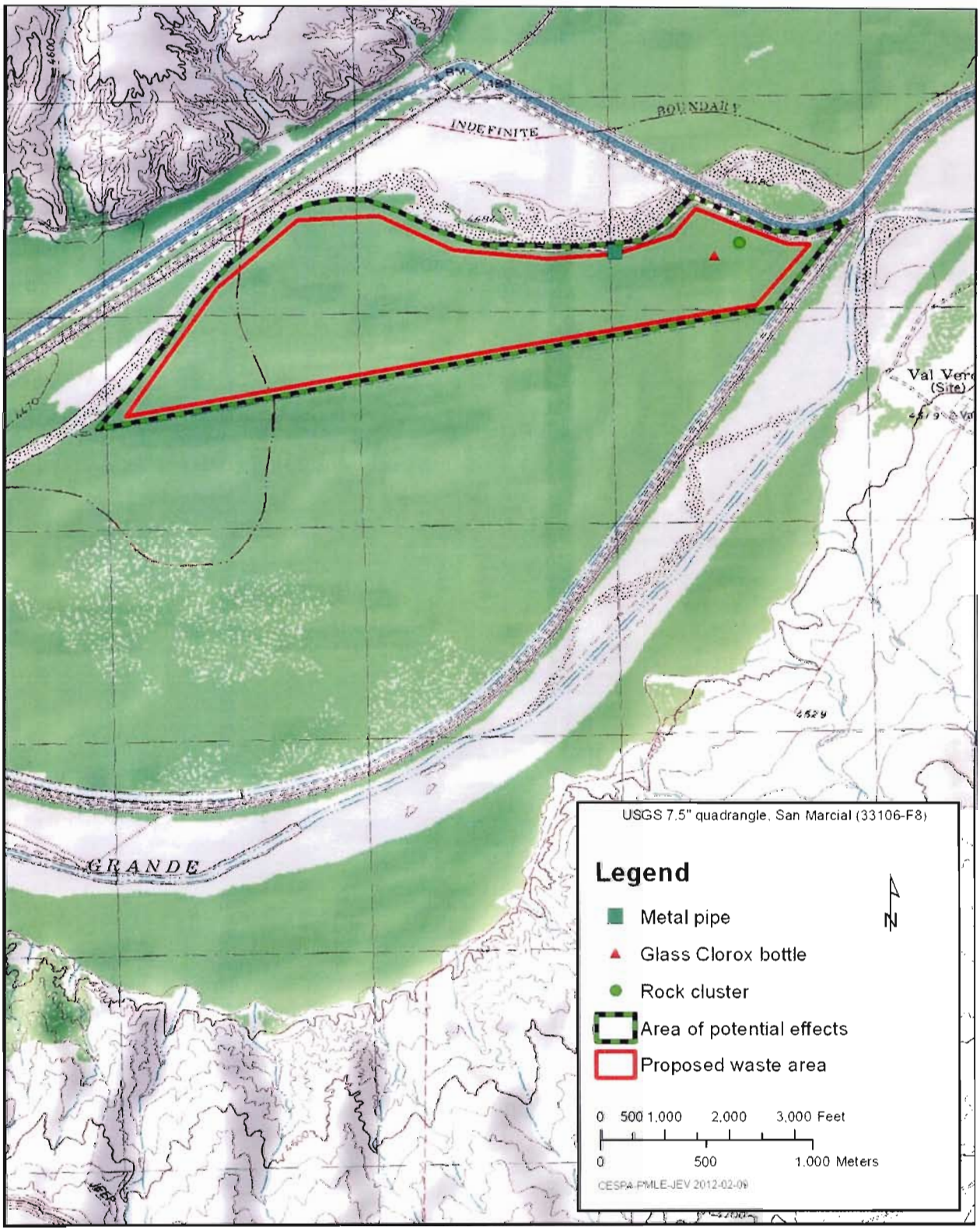
Pueblo of Acoma
Comanche Indian Tribe
Fort Sill Apache Tribe
Hopi Tribe
Pueblo of Isleta
Kiowa Tribe
Mescalero Apache Tribe
Navajo Nation
White Mountain Apache Tribe

Enclosure 3: Location of levee tie-in area and Bureau of Reclamation Low Flow Conveyance Channel headworks (to be replaced in kind).

Enclosure 4: San Acacia to Bosque del Apache Unit, Engineer Drawing, Site Plan - San Acacia Diversion Dam, (draft) Sheet No. C-111.



Enclosure 5: Tiffany Basin Spoil Area and APE with locations of Isolated occurrences (USGS 7.5-Minute Quadrangle map: San Marcial [33106-F8]).



2012 – Tribal Contacts/Mailing List – Socorro County, NM
Native American tribes that have indicated they have cultural concerns in Socorro County, NM.

Pueblo of Acoma
Comanche Indian Tribe
Fort Sill Apache Tribe
Hopi Tribe
Pueblo of Isleta
Kiowa Tribe
Mescalero Apache Tribe
Navajo Nation
White Mountain Apache Tribe
Ysleta del Sur Pueblo

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Director, Historic Preservation Office
Pueblo of Acoma
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Chairman, Comanche Nation of Oklahoma
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Tribal Historic Preservation Officer
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Jame Eskew
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Pueblo of Ysleta del Sur
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El Paso, Texas 79917

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

March 21, 2012

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

Ms. Jan Biella
Interim State Historic Preservation Officer
New Mexico Department of Cultural Affairs
Historic Preservation Division
Bataan Memorial Building
407 Galisteo Street, Suite 236
Santa Fe, New Mexico 87501

Re: HPD Consultation Numbers 054201, 054093, 088135, 092670

Dear Ms. Biella:

Pursuant to 36 CFR Part 800, the U.S. Army Corps of Engineers (Corps), Albuquerque District, in cooperation with the project Sponsor, the Middle Rio Grande Conservancy District (MRGCD), is continuing our consultation regarding the proposed levee rehabilitation project for the San Acacia to Bosque del Apache reach of the Rio Grande Floodway in Socorro County, New Mexico. The Recommended Plan consists of rehabilitation of the existing non-engineered spoil-bank levee by constructing a structurally sound, engineered earthen levee extending approximately 43 miles along the west bank of the Rio Grande, from the San Acacia Diversion Dam to Tiffany Junction. The Corps seeks your concurrence in our determinations regarding three elements of this project:

1) A determination of **no historic properties affected** for the construction of a floodwall and levee tie-in to high ground near the San Acacia Diversion Dam;
2) A determination of **no adverse effect to historic properties** by rehabilitation of U.S. Bureau of Reclamation (BOR) facilities near the San Acacia Diversion Dam;
3) A determination of **no historic properties affected** for the use of the northern portion of the Tiffany Basin for an earthen spoil/waste disposal area.

Each of these elements is described below, along with explanations of our determinations. A draft of the Supplemental Environmental Impact Statement for the project will be posted to the Corps' Albuquerque District web page (http://www.spa.usace.army.mil/fonsi/) in the near future.

Floodwall and Levee Tie-In

One part of the Recommended Plan calls for the construction of a concrete floodwall and levee tie-in to a hillside immediately adjacent to the BNSF railway grade and northeast of the 1930s San Acacia Diversion Dam (Enclosures 1 and 2). On February 29, Corps archaeologists Gregory Everhart, Jonathan Van Hoose, Jeremy Decker, Ariane Pinson, and Christopher Parrish conducted a site visit to the area immediately adjacent to and northeast of the San Acacia Diversion Dam and BNSF railway grade, where the levee and new concrete floodwall will tie in to the hillside. The site visit verified that this area was previously disturbed by quarrying and construction activities. The Corps is of the opinion that construction of the headwall and levee tie-in to high ground will result in **no historic properties affected**. The Corps seeks your concurrence with this determination.

Rehabilitation of BOR Facilities

Construction activities near the San Acacia Diversion Dam also include the in-kind replacement of the Bureau of Reclamation's (BOR's) five existing seven-by-seven-foot CBC Conveyance Channel headworks that divert river water to the Low Flow Conveyance (LFC) Channel (Enclosures 1 and 2). These features were constructed in the 1950s by the BOR for managing irrigation water flows diverted from the river. Construction will also add one five-foot-diameter arch corrugated metal pipe extension, 65 feet in length, to the headworks of the Socorro Main Canal. The APE for the floodwall and the rehabilitation of both headworks is approximately 2.7 acres in size. The Corps is of the opinion that the proposed in-kind replacement of BOR's five LFC Channel headworks and the addition of a pipe extension to Socorro Main Canal headworks will result in **no adverse effect to historic properties**. The Corps seeks your concurrence with this determination.

Use of Tiffany Basin as Spoil Area

During planning for the proposed project, Corps engineers determined that approximately 302 acres would be necessary for disposal of excess earthen materials during construction of the proposed engineered levee, and have preliminarily chosen a

location in the Tiffany Basin for sediment disposal. This proposed project area is located in the northern portion of this low basin area that sits lower than the (perched) Rio Grande channel. The proposed project area is approximately 302 acres; the APE is approximately 377 acres (Enclosure 3).

On February 28, 2012, prior to the field survey, a search of the Archaeological Records Management Section's (ARMS) database found no historic properties documented within the area; however, no archaeological surveys had been conducted in the area. On February 29 and March 1, 2012, Corps archaeologists conducted a pedestrian archaeological survey of the proposed spoil area. Survey of this area was problematic due to the extremely high density of tamarisk vegetation covering large portions of the project area; as a result, only 183 acres (or 49 percent) of the 377-acre APE could be surveyed, and ground surface visibility in this area was often restricted (Enclosure 4).

Corps personnel discovered no historic properties during the course of the survey, with the exception of three isolated occurrences (IOs), which were recorded in the field: 1) one small scatter of rocks; 2) one small standing, thin-walled metal pipe; and 3) one historic Clorox bleach bottle. The Corps determines that these three IOs are not eligible for nomination to the National Register of Historic Places and that no further work is necessary.

While vegetation and visibility made it impossible to survey 100 percent of the APE, other available lines of evidence suggest that the vast majority (and possibly all) of the APE is unlikely to contain undisturbed sediments and intact cultural deposits. Utilizing a series of historic maps and aerial imagery, the Corps investigation determined that the majority of the APE was significantly disturbed within the last 100 years by two processes: the existence of the Rio Grande active river channel and floodplain within the current APE, and intensive ground disturbance through farming, BOR construction activities between 1951-1959, and other subsequent blading / bulldozing. By delineating the visible boundaries of both the river channel and human ground disturbance on maps from 1918 and aerial imagery from 1935 and 1962, the Corps determined that a minimum of 248 acres (66 percent of the APE) has been heavily disturbed in the last century (Enclosure 5). When combined with the 183 acres surveyed (some of which overlapped the known disturbance areas), the Corps determines that 309 acres (82 percent) of the APE is

highly unlikely to contain historic properties. Further, the geographic extent of recent disturbance is a conservative estimate; given the fact that the entire APE was once active floodplain, the likelihood of any intact historic properties in the remainder of the APE is low. The Corps is therefore of the opinion that use of the area as a waste sediment disposal area would result in **no historic properties affected**. The Corps seeks your concurrence with this determination.

Reconstruction of the 43-mile levee is planned to be conducted in phases over approximately 14 to 20 years, dependent upon the availability of funding. While use of the Tiffany Basin Spoil Area is part of the current plan, as planning and project design for each phase is formalized, the Corps will seek other, less costly locations for the disposal of excess earthen materials. Possibilities would include existing gravel quarry areas on the gravel terraces above the floodplain all along the river valley. If such areas are identified and determined viable for disposal, the Corps will consult with the SHPO on those locations at that time.

Please find enclosed for your review, our archaeological survey report entitled *A Site Visit to the San Acacia Diversion Dam and a Cultural Resources Inventory of Approximately 377 Acres for the Proposed Tiffany Basin Spoil Area, San Acacia to Bosque del Apache Levee Rehabilitation Project, Socorro County, New Mexico* (Corps Report No. USACE-ABQ-2012-001; NMCRIS No. 123307).

Pursuant to 36 CFR 800.2, consulting parties in the Section 106 process identified for the proposed San Acacia to Bosque del Apache Levee Rehabilitation Project (Undertaking) include the Corps, the MRGCD, the BOR, the U.S. Fish and Wildlife Service, Sevilleta National Wildlife Refuge, and your office. Consistent with the Department of Defense's American Indian and Alaska Native Policy, signed by Secretary of Defense William S. Cohen on October 20, 1998, and based on the State of New Mexico Indian Affairs Department and Historic Preservation Division's 2012 Native American Consultations List, Native American tribes that have indicated they have concerns in Socorro County have been sent scoping letters regarding the proposed project activities near the San Acacia Diversion Dam and the Tiffany Basin waste disposal area. The Corps has previously submitted scoping letters to Tribal entities on various aspects of this project in August 2002, February 2006, and July 2011. To date, the Corps has received no indication of tribal concerns regarding this project. No Traditional Cultural Properties and no Indian Trust

Assets are known to occur within or adjacent to the proposed project area.

In summary and pursuant to 36 CFR 800, the Corps seeks your concurrence with our determinations of **no historic properties affected**, **no adverse effect to historic properties**, and **no historic properties affected** by the three actions described above.

Should previously undiscovered artifacts or features be unearthed during construction, work will be stopped in the immediate vicinity of the find, a determination of significance made, and the Corps will consult with your office and with Native American tribes that may have concerns in the project area as to the best course of action.

If you have questions or require additional information regarding the Recommended Plan for the proposed 43-mile San Acacia to Bosque del Apache Levee Rehabilitation Project, please contact Gregory Everhart, archaeologist, at (505) 342-3352 or myself at (505) 342-3281.

Sincerely,

Julie Alcon
Chief, Environmental
Resources Section

_____ I CONCUR _____
Date JAN BIELLA
INTERIM NEW MEXICO STATE
HISTORIC PRESERVATION OFFICER

Enclosures

Copies furnished with Enclosures:

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Facilities and Lands Division
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Mr. Mark Hungerford
Archaeologist
U.S. Bureau of Reclamation
Albuquerque Area Office
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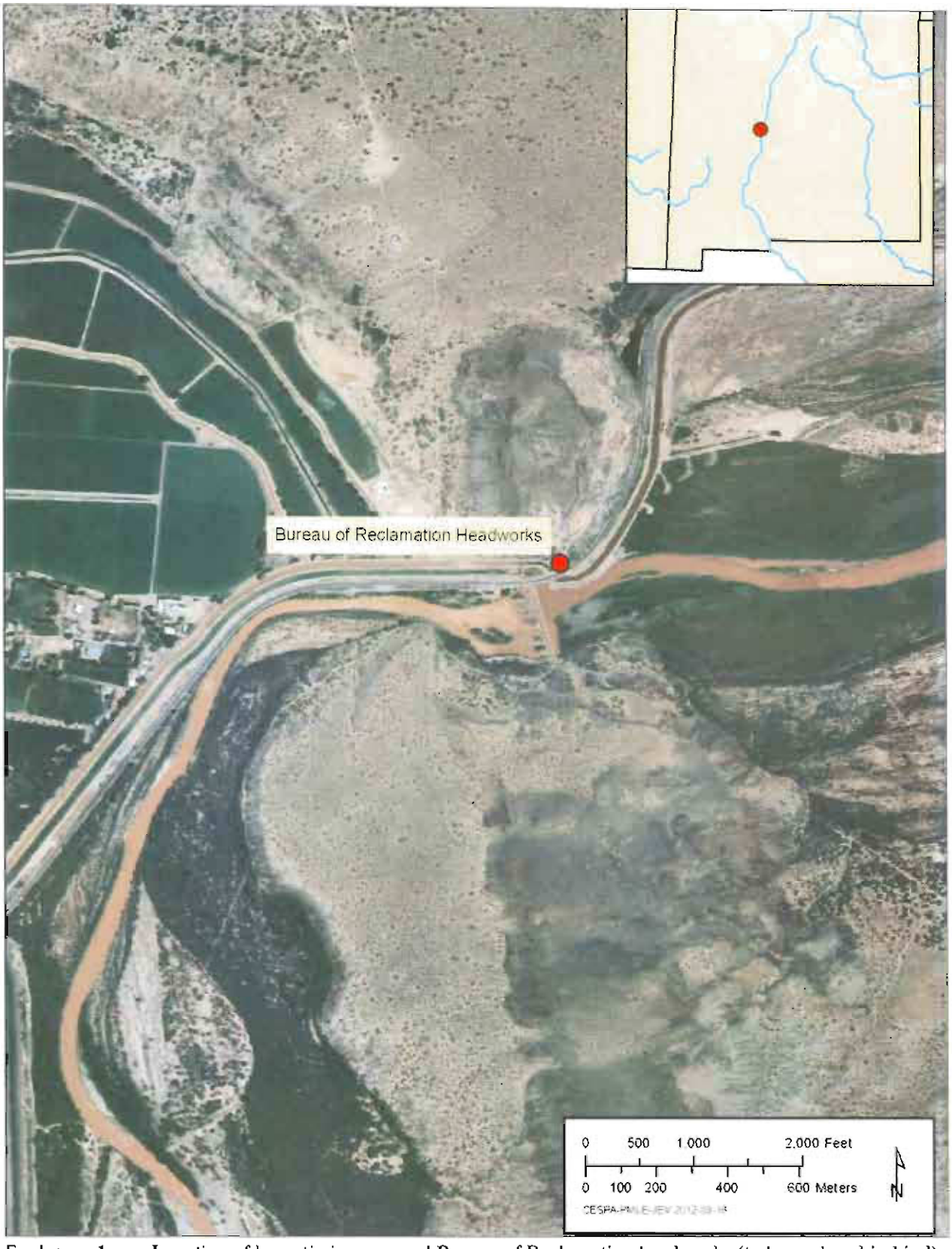
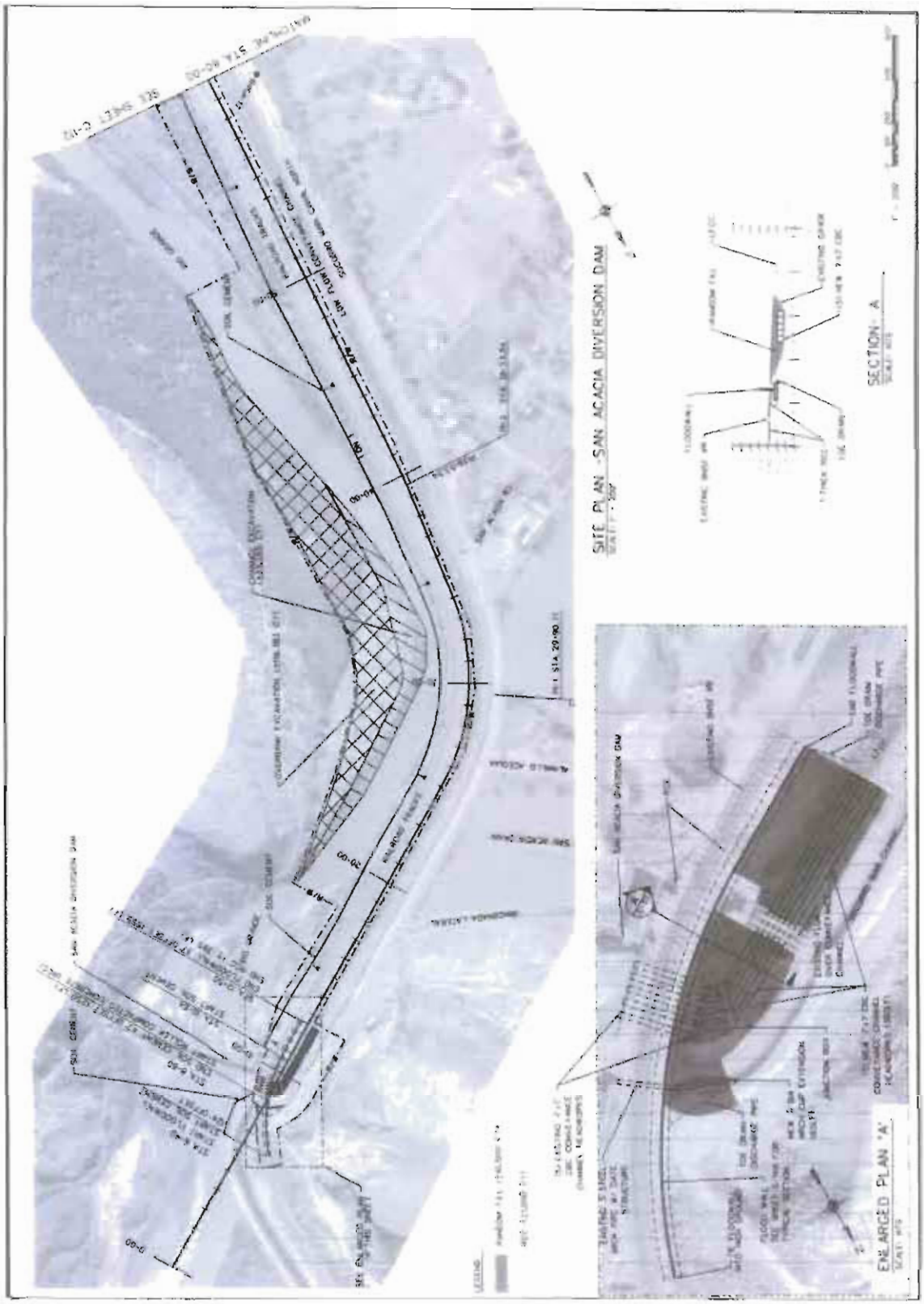
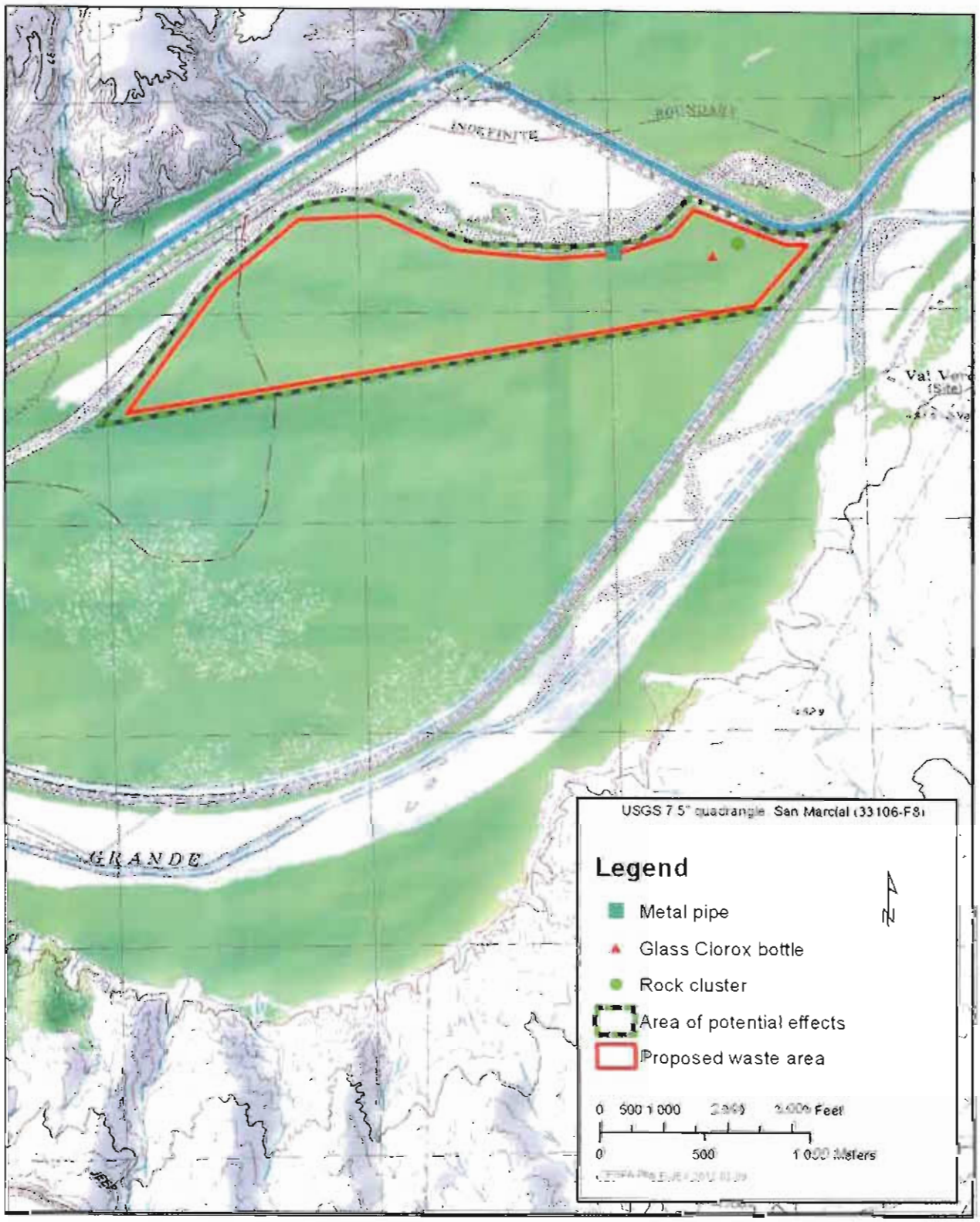
Ms. Kathy Granillo
Refuge Manager
U.S. Fish and Wildlife Service
Sevilleta National Wildlife Refuge
PO Box 1248
Socorro, New Mexico 87801



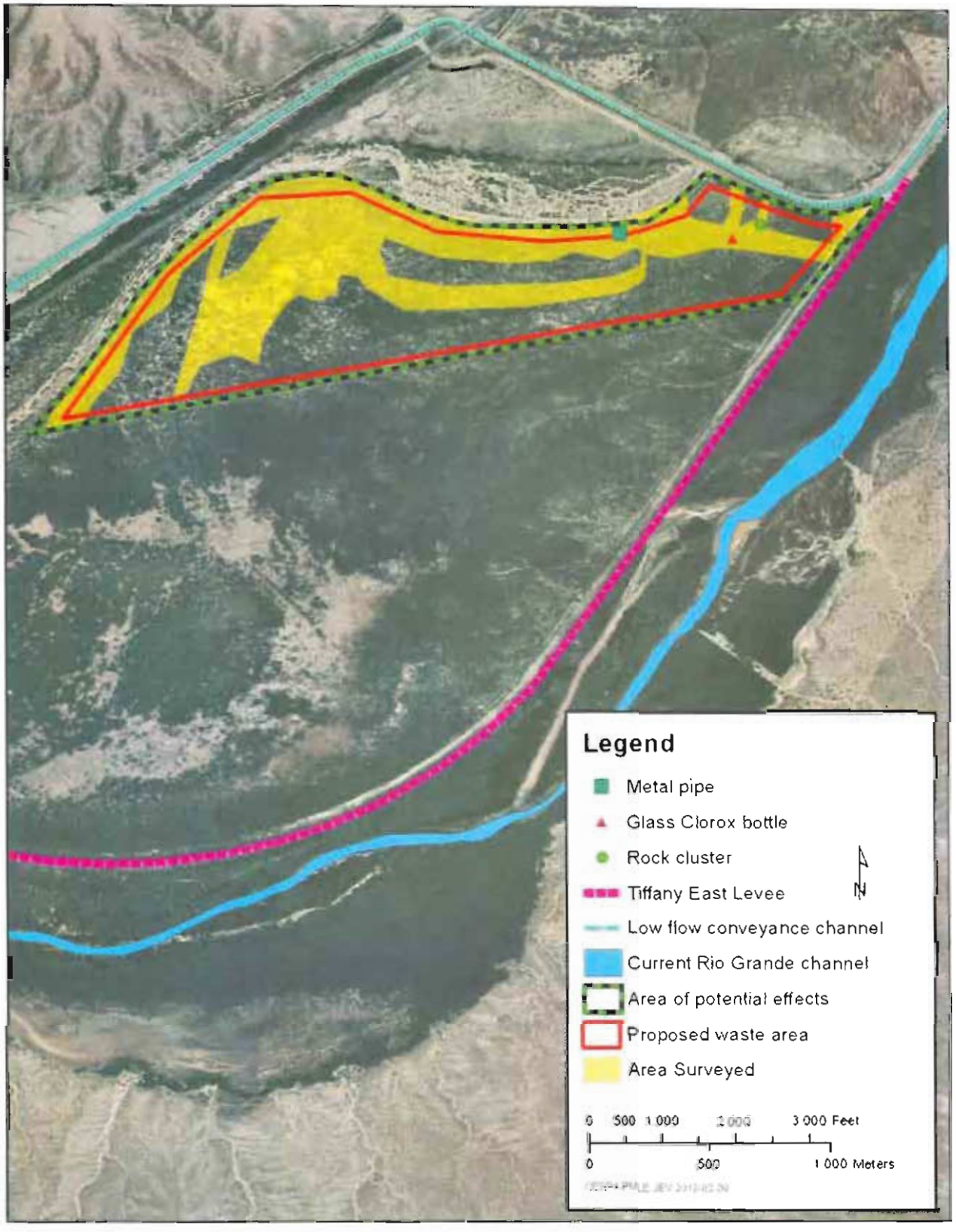
Enclosure 1. Location of levee tie-in area, and Bureau of Reclamation headworks (to be replaced in kind).



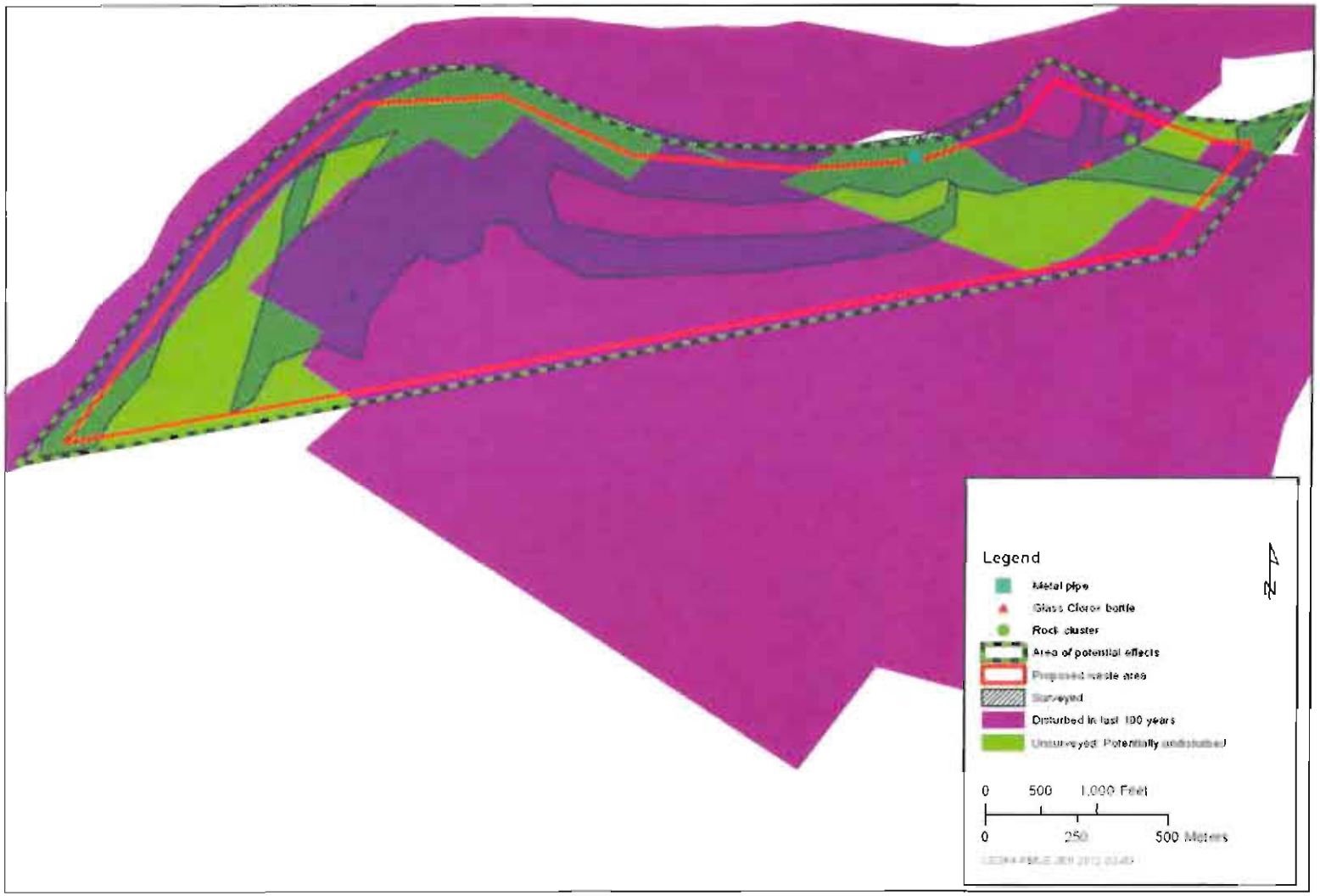
Enclosure 2. San Acacia to Bosque del Apache Unit, Engineer Drawing, Site Plan – San Acacia Diversion Dam, (draft) Sheet No. C-111.



Enclosure 3. Project Area and APE with locations of IO's (USGS 7.5-Minute Quadrangle map: San Marcial [33106-F8]).



Enclosure 4. Project Area, APE, and archaeological survey area (2009 NAIP Imagery).



Enclosure 5. This map is a composite that shows project area, APE, and area covered by the Corps 2012 archaeological survey. It also shows the areas of previous ground disturbance (purple), which includes the location of the active river channel, 1917-1918 farm fields, 1935 farm fields, and 1962 blading. It also shows the unsurveyed portions of the project area for which recent disturbance could not be confirmed (green).

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

92670

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AUG - 4 2011
HISTORIC PRESERVATION DIVISION

August 2, 2011

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

Ms. Jan Biella
Interim State Historic Preservation Officer
New Mexico Department of Cultural Affairs
Historic Preservation Division
Bataan Memorial Building
407 Galisteo Street, Suite 236
Santa Fe, New Mexico 87501

Re: HPD Consultation No's. 054201, 054093, 088135

Dear Ms. Biella:

The U.S. Army Corps of Engineers (Corps), Albuquerque District, is planning a levee rehabilitation project for a portion of the Rio Grande Floodway in Socorro County, New Mexico. The existing levee is located along the west side of the Rio Grande in what is known as the San Acacia to Bosque del Apache reach of the Rio Grande Floodway (Enclosure No. 1). The Preliminary Preferred Plan consists of rehabilitation of the existing spoil-bank levee (non-engineered) by constructing a structurally sound, engineered earthen levee extending approximately 43 miles along the west bank of the Rio Grande, from the San Acacia Diversion Dam to Tiffany Junction(Enclosure No. 1). The Corps is seeking your concurrence in our determination of "No Historic Properties Affected" for a new element of the Preliminary Preferred Plan, identified as the San Acacia Overbank Lowering Area, as described below.

The engineered levee would follow the alignment of the existing spoil-bank levee that parallels the U.S. Bureau of Reclamation's (Reclamation) Low Flow Conveyance Channel (LFCC). The local sponsor, the Middle Rio Grande Conservancy District (MRGCD), supports the Preliminary Preferred Plan. A draft of the Supplemental Environmental Impact Statement will be posted to the Corps' Albuquerque District web page (http://www.spa.usace.army.mil/fonsi/) in the near future.

The study area of the current project, called the San Acacia to Bosque Del Apache Unit, is one unit within the comprehensive plan of development for flood control in the Rio Grande Basin, New Mexico that was authorized by the Flood Control Acts of 1948 (P.L. 80-858, Section 203) and 1950 (P.L. 81-516), in accordance with the recommendations of the Chief of Engineers, as found in House Document No. 243, 81st Congress, 1st Session, dated April 5, 1948. The Authority provided a

comprehensive plan for coordinated development of water resource and flood risk management on the Rio Grande, by the Corps and Bureau of Reclamation, commencing near Truth or Consequences at about river mile 123 extending upstream to the lower end of the Rio Grande Canyon 14 miles upstream from Española, New Mexico at about river mile 394. The comprehensive plan included channel rectification, improvement of irrigation works, dredging, construction of three reservoirs and levee enlargement and construction. A November 1947 agreement delegated responsibility for channel rectification and maintenance to the Bureau of Reclamation and facilities for local flood protection to the Corps of Engineers.

As described in the 1948 report, levees had previously been constructed by local interests through parts of the Espanola and Middle Valley of the Rio Grande. The levees were not uniform as to grade, section or standard of construction and it was proposed to modify and supplement the existing levees. Since authorized in 1948, no levee rehabilitation projects have been constructed in the San Acacia to Bosque del Apache reach.

Pursuant to 36 CFR 800.2, consulting parties in the Section 106 process identified for the proposed San Acacia to Bosque del Apache Levee Rehabilitation Project (Undertaking) include the Corps, the U.S. Bureau of Reclamation, the MRGCD, and your office. Consistent with the Department of Defense's American Indian and Alaska Native Policy, signed by Secretary of Defense William S. Cohen on October 20, 1998, and based on the State of New Mexico Indian Affairs Department and Historic Preservation Division's 2011 Native American Consultations List, on July 5, 2011, Native American tribes that have indicated they have concerns in Socorro County were sent scoping letters regarding the proposed project. The Corps has previously submitted scoping letters to this tribal list on various aspects of this project in August of 2002 and February of 2006. To date, the Corps has received no indication of tribal concerns regarding this project. No Traditional Cultural Properties are known to occur within or adjacent to the proposed project area.

The Corps has previously consulted with the New Mexico State Historic Preservation Officer (SHPO) regarding various aspects of the proposed Undertaking. On November 3, 1997, your office concurred that there would be no adverse effect to historic properties for the proposed removal/relocation of the historic 1930s BNSF railway bridge located near San Marcial (HPD Consultation No. 054201; Enclosure No. 2). Although bridge removal was considered during initial planning, the Corps subsequently determined that they had no authority to pursue any activity regarding the bridge; therefore, bridge removal is no longer a project alternative. On November 5, 1997, your office concurred that there would be no adverse effect to historic properties for the proposed reconstruction of 45 miles of the existing spoil bank levee within the existing alignment and for several access roads (HPD Consultation No. 054093; Enclosure No. 3). The current Preliminary Preferred Plan includes approximately 43 miles of levee

rehabilitation. On November 10, 2009, your office concurred that there would be no adverse effect to historic properties for proposed geologic drilling along the existing alignment and on the existing spoil bank levee (HPD Consultation No. 088135; Enclosure No. 4).

In support of those Section 106 consultation letters, the Corps submitted two archaeological survey reports and other related documentation for mitigation of the adverse effect to MRGCD's historic 1930s levee and irrigation water delivery system. Those reports include the following: Berry and Lewis 1997; Doleman 1997; Van Citters 2000; Chapman and Actis 2007; and Dodge and Santillanes 2007 (Enclosure No. 5).

Of the 210 archaeological sites that are known to occur in the vicinity of the 43 mile project area, approximately 40 archaeological sites along the west-side and 37 archaeological sites along the east side of the Rio Grande channel, located within or immediately adjacent to the flood plain, have been subjected to or have the potential to have been affected by some unknown amount of historic flooding related effects. The Future Without Project and the Future With Project Alternatives, including the Preliminary Preferred Alternative, would not change the potential for effects from future flooding to these sites.

Now, pursuant to 36 CFR Part 800, the Corps is seeking your concurrence in our determination of "No Historic Properties Affected" for a new element of the Preliminary Preferred Plan. The new construction element, identified as the San Acacia Overbank Lowering Area, is located on the river bend immediately downstream of the San Acacia Diversion Dam. The San Acacia Diversion Dam is located at the upstream end of the 43-mile levee project. On this river bend, the Rio Grande channel is significantly degraded. Proposed work would include the placement of protective rock rip-rap on the outside of the river bend (northwest) adjacent to the BNSF railroad grade, and lowering and shaping the overbank area on the inside of the river bend (southeast) (Enclosures 6 and 7).

Pursuant to 36 CFR 800.4, the Area of Potential Effects (APE) for the San Acacia Overbank Lowering Area is approximately 17.4 acres. As shown in Enclosures No. 7, the light blue area represents the sand bank that would be excavated to the depth of the existing river channel; the light green area would be excavated and shaped on a 1 to 10 (vertical to horizontal) slope. All work would be confined to the river channel and sand bank. This excavation would reduce river flow velocity around the river bend, thereby providing flood protection to the BNSF railway grade, Reclamation's LFCC, and the community of San Acacia and adjacent farm land.

Pursuant to 36 CFR 800.4(b), on May 26, 2011, Corps archaeologists conducted a site visit to the San Acacia Overbank Lowering Area to verify the location of known archaeological resources in relation to the proposed construction area. The San Acacia

Overbank Lowering Area is located on land managed by the U.S. Fish and Wildlife Service's Sevilleta National Wildlife Refuge. Prior to the site visit, an archival literature search, and searches of the New Mexico Archaeological Records Management Section (ARMS) database, the State Register of Cultural Properties, and the National Register of Historic Places (NRHP) were completed. Supported with information gathered from archival records, the Corps' site visit found that two archaeological sites located in the area (LA 31705 and LA 31706) are approximately 250 feet or more away from the project area and therefore of sufficient distance that they would not be affected. The limit of surface artifacts observed during the site visit occur along the gravel terrace above the floodplain as generally shown along the red line shown on Enclosure No 7. The Corps site visit verified that no archaeological resources occur on the river sand bank and per previous discussions with your office, that it is highly unlikely that historic properties or cultural materials of significant antiquity or that would retain archaeological integrity would occur within areas of the Rio Grande's historic active channel that include the sand bank in the San Acacia Overbank Lowering Area. The Corps is of the opinion that improvements to the river channel would result in no historic properties affected. The Corps seeks you concurrence with this determination.

In summary, the Corps has previously consulted with your office regarding reconstruction of 45 miles of earthen levee extending along the west bank of the Rio Grande in the San Acacia to Bosque del Apache reach of the Rio Grande Floodway. The Preliminary Preferred Plan now consists of 43 miles of levee reconstruction. An archaeological survey of the levee alignment was conducted and no archaeological sites are located within or adjacent to the existing levee. The Preliminary Preferred Plan will stay within the existing levee alignment and will use existing access roads and preapproved staging areas that have been disturbed and used for similar purposes in the past. The 1930s MRGCD levee and irrigation system is considered to be historic; therefore, the Corps has previously submitted documentation as mitigation (as noted above in HPD Consultation Letter No. 054093 [Enclosure No. 3] and listed in Enclosure No. 5). Geologic drilling was previously accomplished along and on the existing levee. Your office has concurred with the Corps' determination of no adverse effect to historic properties for this levee reconstruction work (as noted above in HPD Consultation Letter No. 088135 [Enclosure No. 4]).

The Corps is currently seeking your concurrence in our determination of "No Historic Properties Affected" for the new construction element of the Preliminary Preferred Plan, identified as the San Acacia Overbank Lowering Area.

Should previously undiscovered artifacts or features be unearthed during construction, work will be stopped in the immediate vicinity of the find, a determination of significance made, and the Corps will consult with your office and with American Indian tribes that may have concerns in the project area as to the best course of action.

If you have questions or require additional information regarding the Preliminary Preferred Plan for the proposed 43-mile San Acacia to Bosque del Apache Levee Rehabilitation Project, please contact Gregory Everhart, archaeologist, at (505) 342-3352 or myself at (505) 342-3281.

Sincerely,

Julie Alcon
Chief, Environmental
Resources Section

9. 12. 2011
Date

I CONCUR John R Eaton For
JAN BIELLA
INTERIM NEW MEXICO STATE
HISTORIC PRESERVATION OFFICER

Enclosures

Copies furnished w/ enclosures:

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U.S. Bureau of Reclamation
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Archaeologist
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Mr. Ray Gomez P.E.
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Ms. Kathy Granillo
Refuge Manager
U.S. Fish and Wildlife Service
Sevilleta National Wildlife Refuge
PO Box 1248
Socorro, New Mexico 87801

THE NAVAJO NATION

BEN SHELLY
PRESIDENT

REX LEE JIM
VICE-PRESIDENT

September 6, 2010 — [sic]

Rec'd 9-20-2011
GDE

Julie Alcon, Chief
Environmental Resources Sec.
Department of the Army
Albuquerque District
4101 Jefferson Plaza NE
Albuquerque, NM 87109-3435

Dear Ms. Alcon:

The Navajo Nation Historic Preservation Department – Traditional Culture Program (NNHPD-TCP) is in receipt of the proposed project where the US Army Corps of Engineers (Corps), Albuquerque District, is planning a levee rehabilitation project for a portion of the Rio Grande Floodway in Socorro County, NM.

After reviewing your consultation documents, NNHPD-TCP has concluded the proposed undertaking/project area **will not impact** Navajo traditional cultural resources. The NNHPD-TCP, on behalf of the Navajo Nation has no concerns at this time.

However, the determination made by the NNHPD-TCP does not necessarily mean that the Navajo Nation has no interest or concerns with the proposed project. If the proposed project inadvertently discovers habitation site, plant gathering areas, human remains and objects of cultural patrimony the NNHPD-TCP request that we be notified respectively in accordance with the Native American Graves Protection and Repatriation Act (NAGPRA).

The NNHPD-TCP appreciates the Department of the Army's consultation efforts, pursuant to 36 CFR Pt. 800.1 (c)(2)(iii). Should you have any additional concerns and/or questions, do not hesitate to contact me electronically at tony@navajohistoricpreservation.org or telephone at 928-871-7750.

Sincerely,

Tony H. Joe, Jr., Supervisory Anthropologist *(Section 106 Consultations)*
Historic Preservation Department – Traditional Culture Program

TCP 11-362
CC: Office File/Chrono

Ysleta del Sur Pueblo

Tribal Council – Javier Loera – (War Captain/Tribal Historic Preservation Officer) E-mail jloera@ydsp-nsn.gov

119 South Old Pueblo Road * P.O. Box 17579 * El Paso, Texas 79917 * (915) 859-8053 * Fax: (915) 859-4252

August 24, 2011

Rec'd 9-2-2011
GDE

Julie Alarcon
Department of the Army
Albuquerque District, Corps of Engineers
4101 Jefferson Plaza N.E.
Albuquerque, NM 87109

Dear Ms. Alarcon:

This letter is in response to the correspondence received in our office in which you provide Ysleta del Sur Pueblo the opportunity to comment on the Levee Rehabilitation project for a portion of the Rio Grande Floodway in Socorro County, New Mexico.

While we do not have any comments on the Levee Rehabilitation project for a portion of the Rio Grande Floodway in Socorro County, New Mexico we believe that this project will not adversely affect Traditional, Religious, or culturally significant sites of our Pueblo and have no opposition to it; However, we would like to request consultation should any Human remains of Artifacts unearthed during this project be determined to fall under NAGPRA guidelines. Copies of our Pueblo's Cultural Affiliation Position Paper and Consultation Policy are available upon request.

Thank you for allowing us the opportunity to comment on this project.

Sincerely,

Javier Loera

Javier Loera
War Captain/Tribal Historic Preservation Officer
Ysleta del Sur Pueblo
E-mail: jloera@ydsp-nsn.gov

OFFICE OF THE GOVERNOR

505 869-3111 / 6333
FAX: 505 869-4236

PUEBLO OF ISLETA
P. O. BOX 1270, ISLETA, NM 87022

Rec'd 8-4-2011
CDE

August 2, 2011

Julie Alcon
Chief, Environmental Resources
Department of the Army
Albuquerque District, Corps of Engineers
4101 Jefferson Plaza NE
Albuquerque, NM 87109-3435

Dear Ms. Alcon:

This letter is in response to your letter regarding the proposed levee rehabilitation in Socorro County, New Mexico. I am pleased to inform you that this project will not have an impact on religious or cultural sites affiliated with the Pueblo of Isleta.

However, in the event that discoveries are found during construction, we would appreciate being advised of such findings. Please forward all environmental assessment plans to our office.

Thank you for your consideration in contacting this office to express our concerns.

Sincerely,

PUEBLO OF ISLETA

Lt. Gov.

Frank Lujan,
Governor

THE NAVAJO NATION

BEN SHELLY
PRESIDENT

REX LEE JIM
VICE-PRESIDENT

July 25, 2010

Rec'd 8-24-2010
GDE

Julie Alcon, Chief
Environmental Resource Section
Department of the Army
Albuquerque district
4101 Jefferson Plaza NE
Albuquerque, NM 87109

Dear Ms. Alcon:

Our apology for an oversight and missing the deadline date of your request, and that the Navajo Nation Historic Preservation Department – Traditional Culture Program (NNHPD-TCP) is in receipt of the proposed project where the US Army Corps of Engineers, Albuquerque District, is planning a levee rehabilitation project for a portion of the Rio Grande Floodway in Socorro County, New Mexico.

After reviewing your consultation documents, NNHPD-TCP has concluded the proposed undertaking/project area **will not impact** Navajo traditional cultural resources. The NNHPD-TCP, on behalf of the Navajo Nation has concerns at this time.

However, the determination made by the NNHPD-TCP does not necessarily mean that the Navajo Nation has no interest or concerns with the proposed project. If the proposed project inadvertently discovers habitation site, plant gathering areas, human remains and objects of cultural patrimony the NNHPD-TCP request that we be notified respectively in accordance with the Native American Graves Protection and Repatriation Act (NAGPRA).

The NNHPD-TCP appreciates the US Army's consultation efforts, pursuant to 36 CFR Pt. 800.1 (c)(2)(iii). Should you have any additional concerns and/or questions, do not hesitate to contact me electronically at tony@navajohistoricpreservation.org or telephone at 928-871-7750.

Sincerely,

Tony H. Joe, Jr., Supervisory Anthropologist *(Section 106 Consultations)*
Historic Preservation Department – Traditional Culture Program

TCP 11-295
CC: Office File/Chrono

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

July 5, 2011

RECEIVED
JUL 11 2011
BY:

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Division

Honorable Leroy Shingoitewa
Chairman, Hopi Tribal Council
Post Office Box 123
Kykotsmovi, Arizona 86039

Rec'd 7-14-2011
GDE

Dear Chairman Shingoitewa:

The U.S. Army Corps of Engineers (Corps), Albuquerque District, is planning a levee rehabilitation project for a portion of the Rio Grande Floodway in Socorro County, New Mexico. The existing levee is located along the west side of the Rio Grande in what is known as the San Acacia to Bosque del Apache reach of the Rio Grande Floodway. The Preliminary Preferred Plan consists of an earthen levee extending approximately 43 miles along the west bank of the Rio Grande, from the San Acacia Diversion Dam to Tiffany Junction. Tiffany Junction is approximately 3 miles north of the San Marcial BNSF Railroad Bridge (See Enclosure 1, Map Figure 1.1). The plan consists of reconstructing the existing spoil bank (non-engineered) levee to form a structurally sound levee paralleling the U.S. Bureau of Reclamation's (Reclamation) Low Flow Conveyance Channel (LFCC). The local sponsor, the Middle Rio Grande Conservancy District (MRGCD), supports the Preliminary Preferred Plan. A draft of the Supplemental Environmental Impact Statement will be posted to the Corps' Albuquerque District web page (http://www.spa.usace.army.mil/fonsi/) in the near future.

The study area of the current project, San Acacia to Bosque Del Apache Unit, is one unit within the comprehensive plan of development for flood control in the Rio Grande Basin, New Mexico that was authorized by the Flood Control Acts of 1948 (P.L. 80-858, Section 203) and 1950 (P.L. 81-516), in accordance with the recommendations of the Chief of Engineers, as found in House Document No. 243, 81st Congress, 1st Session, dated April 5, 1948. The Authority provided a comprehensive plan for coordinated development, by the Corps and Bureau of Reclamation, of water resource and flood risk management on the Rio Grande commencing near Truth or Consequences at about river mile 123 extending upstream to the lower end of the Rio Grande Canyon 14 miles upstream from Española, New Mexico at about river mile 394. The comprehensive plan included channel rectification, improvement of irrigation works, dredging, construction of three reservoirs and levee

enlargement and construction. A November 1947 agreement delegated responsibility for channel rectification and maintenance to the Bureau of Reclamation and facilities for local flood protection to the Corps of Engineers.

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In 1997, the Corps contracted with the University of New Mexico's Office of Contract Archeology to conduct archaeological surveys of the levee alignment and other areas of the recommended plan's construction area. With the exception of the existing, historic 1930s MRGCD irrigation system, levee, and Reclamation's LFCC, completed in 1959, no archaeological sites, historic properties, or features were identified within the proposed levee reconstruction zone or access routes. No Traditional Cultural Properties are known to occur within or adjacent to the project area. As a part of planning for this project, the Corps, with our letter dated August 16, 2002, has previously submitted tribal scoping letters to tribes with concerns within Socorro County regarding the drilling of groundwater monitoring wells (copy attached for your convenience, Enclosure 2). With our tribal scoping letter dated February 21, 2006, the Corps informed tribes with concerns in Socorro County about studying the feasibility of constructing a new railroad bridge and the relocation of approximately 4 miles of track for the proposed railroad-Rio Grande crossing near San Marcial (copy attached for your convenience, Enclosure 3). Responses were received from the Pueblo of Isleta, the White Mountain Apache Tribe, the Comanche Tribe, and the Hopi Tribe. All of these stated they had no concerns regarding construction work for the San Marcial railroad crossing.

Based on the results of the Corps' archaeological investigations of the San Acacia to San Marcial reach, the Corps is of the opinion that reconstruction of the 43-mile levee would result in no historic properties affected. On November 5, 1997, the NM State Historic Preservation Officer (SHPO) concurred with the Corps determination of no effect for the then recommended alternative which followed the same alignment as the presently recommended plan (SHPO Consultation No. 054093). The Corps has previously submitted additional documentation to the SHPO for mitigation of effects to the MRGCD irrigation system, levee, and Reclamation's LFCC (Berry and Lewis 1997; Van Citters 2000; Dodge and Santillanes 2007). The SHPO has also concurred that it is

highly unlikely that historic properties or cultural materials of significant antiquity or archaeological integrity would occur within areas of the Rio Grande's historic active channel.

There are two important aspects of the proposed project. The first is that the on-going modeling of river flows and projected volumes of water during flood events indicate that the proposed engineered levee may be smaller in both height and width than the existing spoil-bank levee. The second is that the material in the spoil-bank levee would be used in the rehabilitation of the proposed engineered levee. Therefore, all of the construction will occur in areas originally disturbed during construction of the levee and the low-flow conveyance channel, and no new quarry areas for fill would be required. Access for construction already exists on a network of paved and dirt roads, and to the extent possible, staging locations for equipment will be in previously disturbed locations. There are no archaeological sites within these disturbed areas.

Subsequent to the 1997 SHPO concurrence of no effect for the 43-mile levee rehabilitation project, Corps' engineers determined that as a new element of the Preliminary Preferred Plan, bank protection work would need to be constructed on the river bend immediately downstream of the San Acacia Diversion Dam. The San Acacia Diversion Dam is located at the upstream end of the 43-mile levee project. The Rio Grande channel on this river bend is significantly degraded. Proposed work in this San Acacia Overbank Lowering Area (see Enclosure 1, Map Figures 2 and 3) would include the placement of protective rock rip-rap on the outside of the river bend (northwest) adjacent to the BNSF railroad grade, and lowering and shaping the overbank area on the inside of the river bend (southeast). The light blue area shown in Map Figure 3 represents the sand bank that would be excavated to the depth of the existing river channel; the light green area would be excavated on a 1 to 10 slope. All work would be confined to the river channel and sand bank. This excavation would reduce river flow velocity around the river bend; thereby providing flood protection to the BNSF railway grade, Reclamation's LFCC, and the community of San Acacia and adjacent farm land.

On May 26, 2011, Corps archaeologists conducted a site visit to the San Acacia Overbank Lowering Area to verify the location of known archaeological resources in relation to the proposed construction area. Supported with information gathered from archival records, the Corps' site visit found that archaeological resources in the area are of sufficient distance away from the project area that they would not be affected. The Corps is of the opinion that improvements to the river channel would result in no effect to historic properties. This San Acacia project area is on land managed by the U.S. Fish and Wildlife Service, Sevilleta National Wildlife Refuge.

The Corps is seeking input for consideration during planning of the project. The purpose of this scoping letter is to provide you with the opportunity to submit concerns or comments you may have regarding potential effects for the proposed project. Specifically, any concerns you may have regarding the environment such as natural, biological, or cultural resources; wildlife, vegetation, and special status species; air, water, or sound quality; aesthetics; health and safety; or Indian Trust Assets that may occur in the project area. Your input will be used in preparing an environmental impact statement to comply with the National Environmental Policy Act.

Please provide written comments regarding environmental concerns to William DeRagon, Biologist (William.deragon@usace.army.mil); and, comments regarding cultural resources to Gregory D. Everhart, Archaeologist (Gregory.d.everhart@usace.army.mil), at the above address. If you have any questions or require additional information on the San Acacia to Bosque del Apache levee rehabilitation project, please contact Mr. DeRagon at (505) 342-3358, Mr. Everhart at (505) 342-3352, or myself at (505) 342-3281.

Sincerely,

Andrea Hummel

for Julie Alcon
Chief, Environmental Resources
Section

Enclosures

No historic properties
significant to the
Hopi Tribe affected
Margaret
for Kwamoldewma
7-12-11

Copy furnished w/Encl:

2011 - Tribal mailing list - Socorro County, NM
American Indian tribes that have indicated that they have cultural resources concerns in Socorro County.

Pueblo of Acoma
Comanche Indian Tribe
Fort Sill Apache Tribe
Hopi Tribe
Pueblo of Isleta
Kiowa Tribe
Mescalero Apache Tribe
Navajo Nation
White Mountain Apache Tribe

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

July 5, 2011

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Division

Honorable Ben Shelly
President, Navajo Nation
Post Office Box 9000
Window Rock, Arizona 86515

Dear President Shelly:

The U.S. Army Corps of Engineers (Corps), Albuquerque District, is planning a levee rehabilitation project for a portion of the Rio Grande Floodway in Socorro County, New Mexico. The existing levee is located along the west side of the Rio Grande in what is known as the San Acacia to Bosque del Apache reach of the Rio Grande Floodway. The Preliminary Preferred Plan consists of an earthen levee extending approximately 43 miles along the west bank of the Rio Grande, from the San Acacia Diversion Dam to Tiffany Junction. Tiffany Junction is approximately 3 miles north of the San Marcial BNSF Railroad Bridge (See Enclosure 1, Map Figure 1.1). The plan consists of reconstructing the existing spoil bank (non-engineered) levee to form a structurally sound levee paralleling the U.S. Bureau of Reclamation's (Reclamation) Low Flow Conveyance Channel (LFCC). The local sponsor, the Middle Rio Grande Conservancy District (MRGCD), supports the Preliminary Preferred Plan. A draft of the Supplemental Environmental Impact Statement will be posted to the Corps' Albuquerque District web page (http://www.spa.usace.army.mil/fonsi/) in the near future.

The study area of the current project, San Acacia to Bosque Del Apache Unit, is one unit within the comprehensive plan of development for flood control in the Rio Grande Basin, New Mexico that was authorized by the Flood Control Acts of 1948 (P.L. 80-858, Section 203) and 1950 (P.L. 81-516), in accordance with the recommendations of the Chief of Engineers, as found in House Document No. 243, 81st Congress, 1st Session, dated April 5, 1948. The Authority provided a comprehensive plan for coordinated development, by the Corps and Bureau of Reclamation, of water resource and flood risk management on the Rio Grande commencing near Truth or Consequences at about river mile 123 extending upstream to the lower end of the Rio Grande Canyon 14 miles upstream from Española, New Mexico at about river mile 394. The comprehensive plan included channel rectification, improvement of irrigation works, dredging, construction of three reservoirs and levee

enlargement and construction. A November 1947 agreement delegated responsibility for channel rectification and maintenance to the Bureau of Reclamation and facilities for local flood protection to the Corps of Engineers.

As described in the 1948 report, levees had been constructed by local interests through parts of the Espanola and Middle Valley of the Rio Grande. The levees were not uniform as to grade, section or standard of construction and it was proposed to modify and supplement the existing levees. Since authorized in 1948, no levee rehabilitation projects have been constructed in the San Acacia to Bosque del Apache reach.

In 1997, the Corps contracted with the University of New Mexico's Office of Contract Archeology to conduct archaeological surveys of the levee alignment and other areas of the recommended plan's construction area. With the exception of the existing, historic 1930s MRGCD irrigation system, levee, and Reclamation's LFCC, completed in 1959, no archaeological sites, historic properties, or features were identified within the proposed levee reconstruction zone or access routes. No Traditional Cultural Properties are known to occur within or adjacent to the project area. As a part of planning for this project, the Corps, with our letter dated August 16, 2002, has previously submitted tribal scoping letters to tribes with concerns within Socorro County regarding the drilling of groundwater monitoring wells (copy attached for your convenience, Enclosure 2). With our tribal scoping letter dated February 21, 2006, the Corps informed tribes with concerns in Socorro County about studying the feasibility of constructing a new railroad bridge and the relocation of approximately 4 miles of track for the proposed railroad-Rio Grande crossing near San Marcial (copy attached for your convenience, Enclosure 3). Responses were received from the Pueblo of Isleta, the White Mountain Apache Tribe, the Comanche Tribe, and the Hopi Tribe. All of these stated they had no concerns regarding construction work for the San Marcial railroad crossing.

Based on the results of the Corps' archaeological investigations of the San Acacia to San Marcial reach, the Corps is of the opinion that reconstruction of the 43-mile levee would result in no historic properties affected. On November 5, 1997, the NM State Historic Preservation Officer (SHPO) concurred with the Corps determination of no effect for the then recommended alternative which followed the same alignment as the presently recommended plan (SHPO Consultation No. 054093). The Corps has previously submitted additional documentation to the SHPO for mitigation of effects to the MRGCD irrigation system, levee, and Reclamation's LFCC (Berry and Lewis 1997; Van Citters 2000; Dodge and Santillanes 2007). The SHPO has also concurred that it is

highly unlikely that historic properties or cultural materials of significant antiquity or archaeological integrity would occur within areas of the Rio Grande's historic active channel.

There are two important aspects of the proposed project. The first is that the on-going modeling of river flows and projected volumes of water during flood events indicate that the proposed engineered levee may be smaller in both height and width than the existing spoil-bank levee. The second is that the material in the spoil-bank levee would be used in the rehabilitation of the proposed engineered levee. Therefore, all of the construction will occur in areas originally disturbed during construction of the levee and the low-flow conveyance channel, and no new quarry areas for fill would be required. Access for construction already exists on a network of paved and dirt roads, and to the extent possible, staging locations for equipment will be in previously disturbed locations. There are no archaeological sites within these disturbed areas.

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On May 26, 2011, Corps archaeologists conducted a site visit to the San Acacia Overbank Lowering Area to verify the location of known archaeological resources in relation to the proposed construction area. Supported with information gathered from archival records, the Corps' site visit found that archaeological resources in the area are of sufficient distance away from the project area that they would not be affected. The Corps is of the opinion that improvements to the river channel would result in no effect to historic properties. This San Acacia project area is on land managed by the U.S. Fish and Wildlife Service, Sevilleta National Wildlife Refuge.

The Corps is seeking input for consideration during planning of the project. The purpose of this scoping letter is to provide you with the opportunity to submit concerns or comments you may have regarding potential effects for the proposed project. Specifically, any concerns you may have regarding the environment such as natural, biological, or cultural resources; wildlife, vegetation, and special status species; air, water, or sound quality; aesthetics; health and safety; or Indian Trust Assets that may occur in the project area. Your input will be used in preparing an environmental impact statement to comply with the National Environmental Policy Act.

Please provide written comments regarding environmental concerns to William DeRagon, Biologist (William.deragon@usace.army.mil); and, comments regarding cultural resources to Gregory D. Everhart, Archaeologist (Gregory.d.everhart@usace.army.mil), at the above address. If you have any questions or require additional information on the San Acacia to Bosque del Apache levee rehabilitation project, please contact Mr. DeRagon at (505) 342-3358, Mr. Everhart at (505) 342-3352, or myself at (505) 342-3281.

Sincerely,

for Andrea Hummel

Julie Alcon
Chief, Environmental Resources Section

Enclosures

Copy furnished w/Encl:

2011 - Tribal mailing list - Socorro County, NM
American Indian tribes that have indicated that they have cultural resources concerns in Socorro County.

Pueblo of Acoma
Comanche Indian Tribe
Fort Sill Apache Tribe
Hopi Tribe
Pueblo of Isleta
Kiowa Tribe
Mescalero Apache Tribe
Navajo Nation
White Mountain Apache Tribe

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

July 29, 2011

Planning, Project and Program Management Division
Planning Branch, Environmental Resources Section

Honorable Frank K. Paiz
Governor, Ysleta del Sur Pueblo
117 S. Old Pueblo Road
El Paso, Texas 79907

Dear Governor Paiz:

The U.S. Army Corps of Engineers (Corps), Albuquerque District, is planning a levee rehabilitation project for a portion of the Rio Grande Floodway in Socorro County, New Mexico. The existing levee is located along the west side of the Rio Grande in what is known as the San Acacia to Bosque del Apache reach of the Rio Grande Floodway. The Preliminary Preferred Plan consists of an earthen levee extending approximately 43 miles along the west bank of the Rio Grande, from the San Acacia Diversion Dam to Tiffany Junction. Tiffany Junction is approximately 3 miles north of the San Marcial BNSF Railroad Bridge (See Enclosure 1, Map Figure 1.1). The plan consists of reconstructing the existing spoil bank (non-engineered) levee to form a structurally sound levee paralleling the U.S. Bureau of Reclamation's (Reclamation) Low Flow Conveyance Channel (LFCC). The local sponsor, the Middle Rio Grande Conservancy District (MRGCD), supports the Preliminary Preferred Plan. A draft of the Supplemental Environmental Impact Statement will be posted to the Corps' Albuquerque District web page (http://www.spa.usace.army.mil/fonsi/) in the near future.

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Please provide written comments regarding environmental concerns to William DeRagon, Biologist (William.Deragon@usace.army.mil) and, comments regarding cultural resources to Gregory D. Everhart, Archaeologist (Gregory.d.everhart@usace.army.mil), at the address above.

If you have any questions or require additional information on the San Acacia to Bosque del Apache levee rehabilitation project, please contact Mr. DeRagon at (505) 342-3358, Mr. Everhart at (505) 342-3352 or myself at (505) 342-3281.

Sincerely,

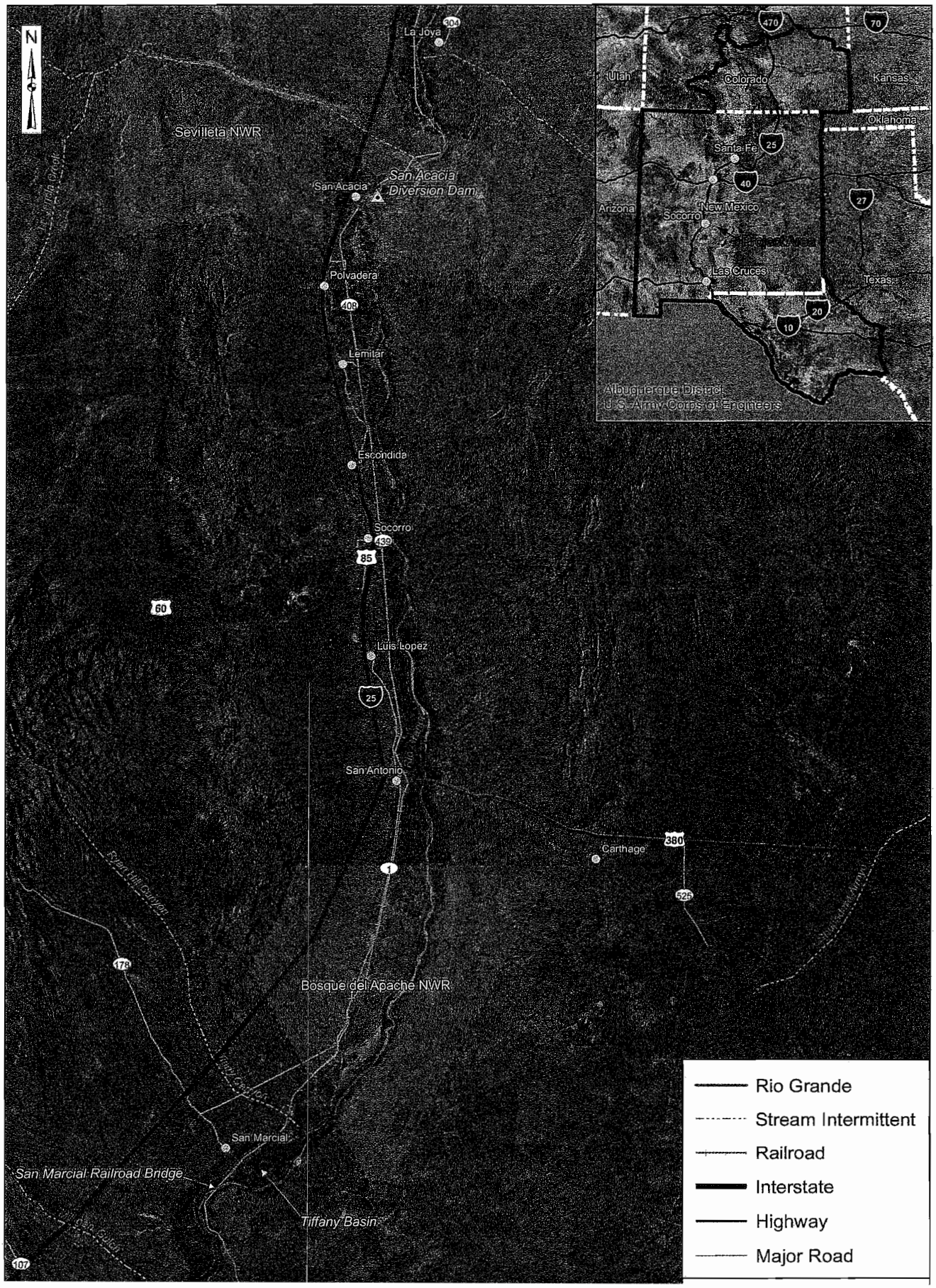
Julie Alcon
Chief, Environmental Resources Section

Enclosures

Copy furnished w/Encl:
Javier Loera, Tribal Historic Preservation Officer

Enclosure 1, Figure 1

Figure 1.1 Study Area



Enclosure 1, Figure 2

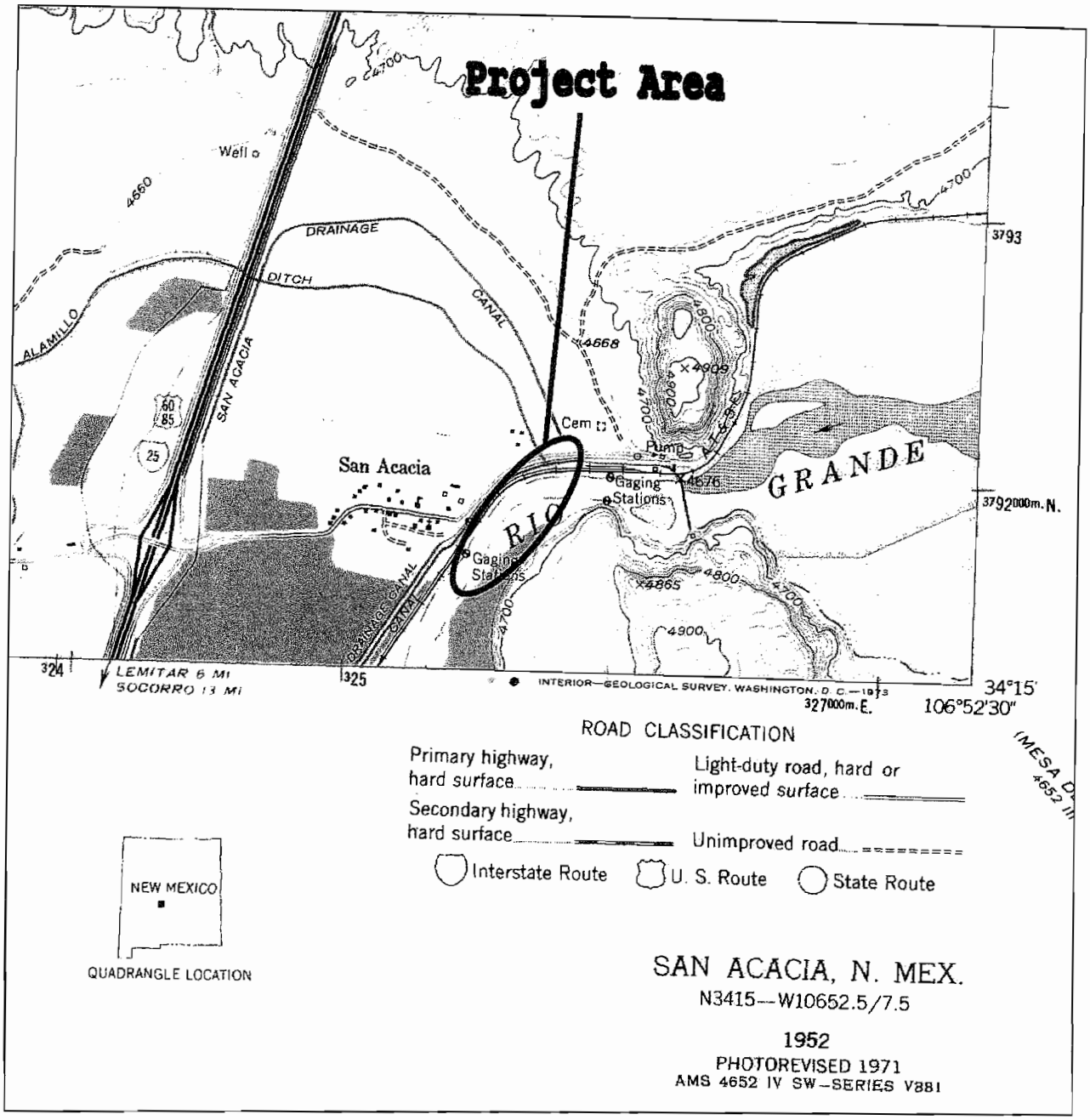
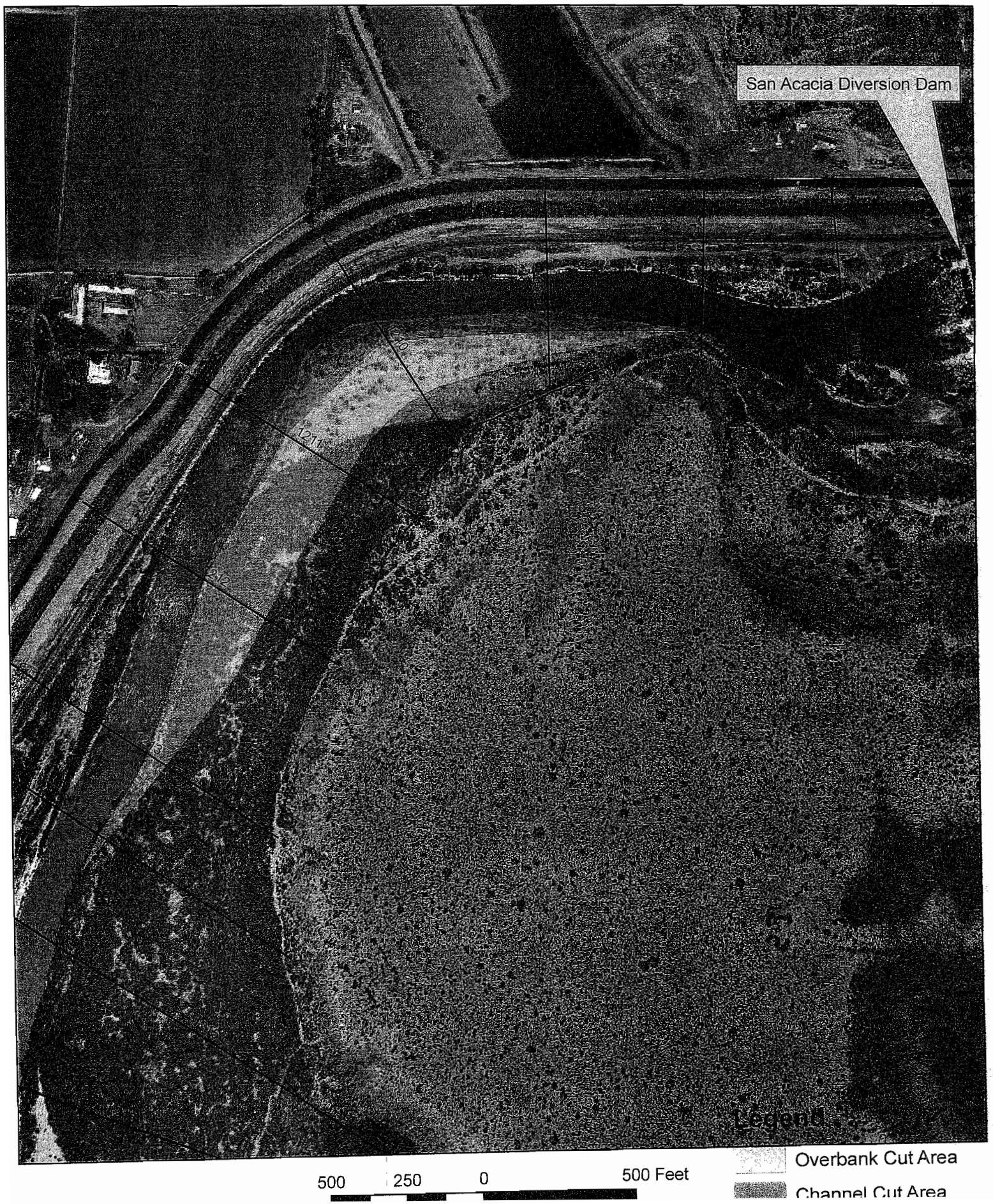


Figure 2: Approximate Location of San Acacia Overbank Lowering Project Area. Adapted from USGS 7.5-Minute Quadrangle Map: San Acacia, NM (34106-c8; 1952, PhotoRevised 1971). Prepared by Corps archaeologist, Gregory D. Everhart, June 30, 2011.

Enclosure 1, Figure 3

San Acacia Overbank Excavation



Enclosure 2

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA, NE
ALBUQUERQUE, NEW MEXICO 87109-3435
FAX (505) 342-3199

Reply to Attention of:

AUG 16 2002

Engineering and Construction Division
Environmental Resources Branch

Mr. Wayne Taylor, Jr., Chairman
Hopi Tribe
P.O. Box 123
Kykotsmovi, Arizona 86039

Dear Mr. Taylor:

In conjunction with the proposed San Acacia Surface Water/Groundwater Investigation, the New Mexico Interstate Stream Commission (NMISC) and the U.S. Army Corps of Engineers (Corps), Albuquerque District, are proposing to install up to 80 boreholes and 25 staff gauges along seven transects across the Low Flow Conveyance Channel between San Acacia Diversion Dam and the delta of Elephant Butte Reservoir. Within this river reach, competing demands for water, including agriculture, municipal use, wildlife habitat, and Rio Grande compact delivery requirements, necessitate a better understanding of the water budget. The purpose of the investigation is to collect data required to better understand the interactions between surface water and groundwater in this river reach. The entire project area lies within the historic floodplain of the Rio Grande.

Each well will be monitored monthly for three years. There will be one aquifer pumping test on each transect during the first year. The proposed transects are shown on the enclosed figure. Whenever possible, the transects have been located within or adjacent to disturbed areas and existing roads. Some previously undisturbed areas are also included. Due to the nature of the investigation, there is some latitude for placement of the wells and environmentally or culturally sensitive locations will be avoided. Inventories to identify and evaluate environmental, archaeological, and historic resources have been conducted by SWCA Environmental Consultants (SWCA), and the reports are in preparation. An Environmental Assessment is being prepared, and you will receive a draft for your review and comment. SWCA will provide you copies of the reports as they are completed and information regarding project impacts on identified resources, should you so request.

We are contacting the Hopi Tribe to gather information on tribal concerns about traditional cultural properties or other issues within the proposed project locations. You may provide information in writing or, at your request, a meeting with personnel from the Corps, NMISC, or SWCA staff can be arranged to discuss any concerns you may

F:\USER\ECLACK\JOHN\TAYLOR + each respective name

have about this project. We will maintain strict confidentiality with regard to certain types of information concerning traditional religious and/or cultural historic properties that may be affected by this proposed undertaking. We would also appreciate suggestions about other groups that we should contact regarding this project.

A response within 30 days from date of receipt would be appreciated. Please feel free to contact John D. Schelberg, (505) 342-3359, john.d.schelberg@usace.army.mil; or Mary Quirolo, SWCA Ethnographer, 1(800) 828-8499, mquirolo@swca.com if you have questions or need additional information.

I have also furnished a copy of this letter to Leigh J. Kuwanwisiwma, Director, Cultural Preservation Office, of your organization.

Sincerely,

Dana R. Hurst
Lieutenant Colonel, EN
District Engineer

Enclosure

Mr. Wayne Taylor, Jr., Chairman
Hopi Tribe
P.O. Box 123
Kykotsmovi, AZ 86039

Mr. Leigh J. Kuwansisiwma, Director
Cultural Preservation Office
Hopi Tribe
P.O. Box 123
Kykotsmovi, AZ 86039

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Navajo Nation
P.O. Box 4950
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Honorable Alvino Lucero
Pueblo of Isleta
P.O. Box 1270
Isleta, NM 87022

Mr. Jim Piatt, Environmental Officer
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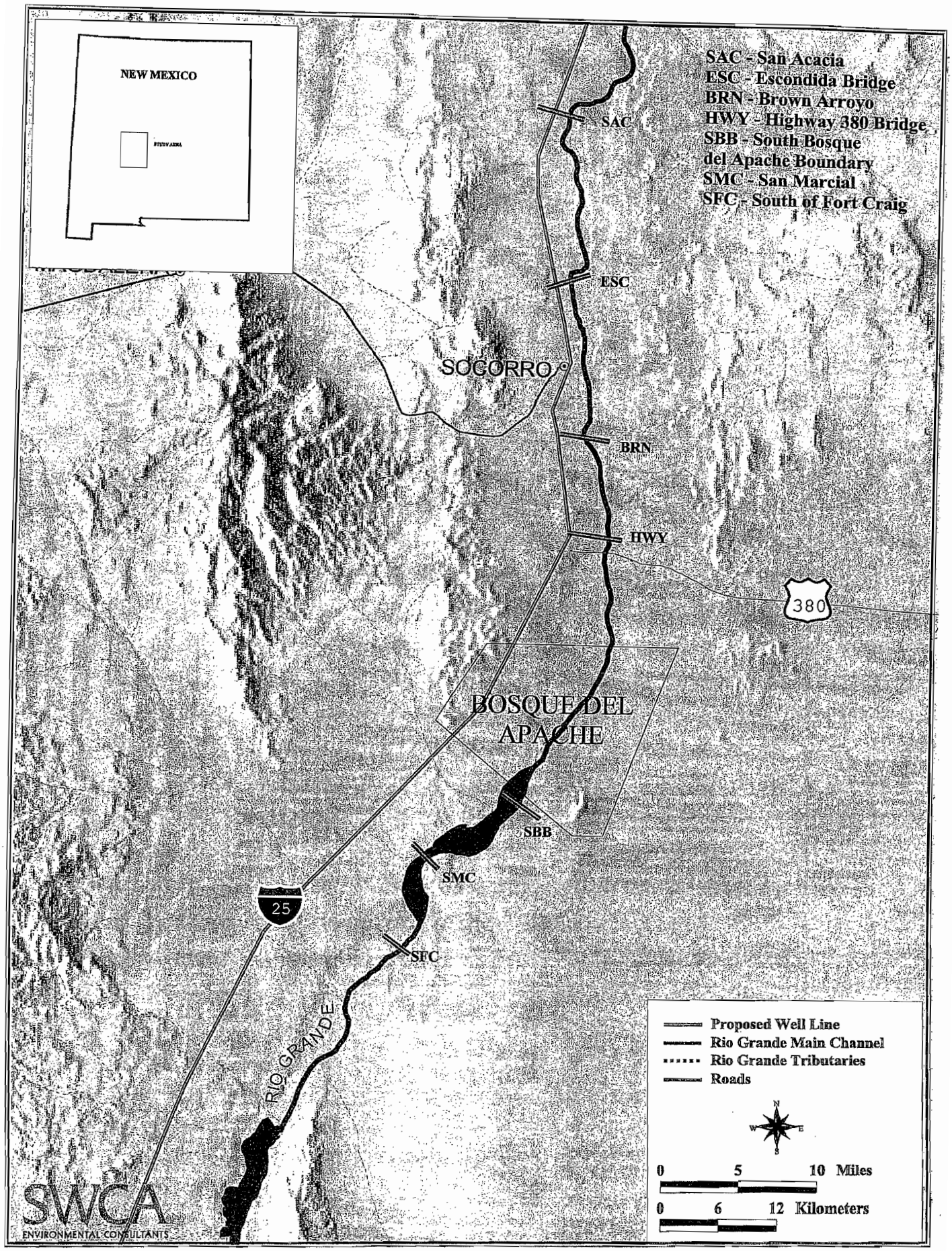


Figure 1. Proposed Well Lines for Below San Acacia Surface Water/ Groundwater Investigation

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

Enclosure 3.

February 21, 2006

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

Honorable Jason Johnson
Governor, Acoma Pueblo
P.O. Box 309
Acoma, New Mexico 87034

Dear Governor Johnson:

The U.S. Army Corps of Engineers (Corps), Albuquerque District is studying the feasibility of constructing a new railroad bridge over the Rio Grande and relocating a four-mile segment of the Burlington Northern Santa Fe (BNSF) Railroad at San Marcial, Socorro County, New Mexico. Due to the existing BNSF bridge's proximity to the headwaters of Elephant Butte Reservoir, the bridge's constriction of the river, and the consequent slowing of the river, sediment deposition is increasing and the elevation of the riverbed is rising. The proposed project is located on an unplatted portion of the San Marcial, New Mexico USGS quadrangle map (Pedro Armendaires Grant No. 33) and an unplatted portion of the Ft. Craig USGS quadrangle map (Pedro Armendaires Grant No. 34). A map showing the project area is enclosed for your review.

A variety of ground-disturbing activities may occur as the feasibility study progresses. Initially, a series of six-inch diameter holes will be drilled in order to define the geological substrate. If construction is approved, the proposed right-of-way will be cleared of vegetation, and the track and a new bridge will be built. The existing bridge will be removed.

The Corps is offering you the opportunity to bring to our attention any concerns or comments regarding the potential effects of this project on Indian Trust assets, traditional cultural properties, sacred sites, biological resources, and any other significant issues that you may have regarding the proposed railroad realignment.

Please provide written comments by March 25, 2006. If you have any questions or require more information regarding the Railroad Relocation at San Marcial, please contact John Schelberg Ph.D., archaeologist, at (505) 342-3359. Thank you for your attention to this matter.

Sincerely,

Julie A. Hall, Chief
Environmental Resources Section

Enclosure

2006 – Tribal mailing list – Socorro County, NM
American Indian tribes that have indicated that they have cultural resources concerns in Socorro County.

Pueblo of Acoma
Comanche Indian Tribe
Fort Sill Apache Tribe
Hopi Tribe
Pueblo of Isleta
Kiowa Tribe
Mescalero Apache Tribe
Navajo Nation
White Mountain Apache Tribe

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

July 29, 2011

Planning, Project and Program Management Division
Planning Branch, Environmental Resources Section

Honorable Frank K. Paiz
Governor, Ysleta del Sur Pueblo
117 S. Old Pueblo Road
El Paso, Texas 79907

Dear Governor Paiz:

The U.S. Army Corps of Engineers (Corps), Albuquerque District, is planning a levee rehabilitation project for a portion of the Rio Grande Floodway in Socorro County, New Mexico. The existing levee is located along the west side of the Rio Grande in what is known as the San Acacia to Bosque del Apache reach of the Rio Grande Floodway. The Preliminary Preferred Plan consists of an earthen levee extending approximately 43 miles along the west bank of the Rio Grande, from the San Acacia Diversion Dam to Tiffany Junction. Tiffany Junction is approximately 3 miles north of the San Marcial BNSF Railroad Bridge (See Enclosure 1, Map Figure 1.1). The plan consists of reconstructing the existing spoil bank (non-engineered) levee to form a structurally sound levee paralleling the U.S. Bureau of Reclamation's (Reclamation) Low Flow Conveyance Channel (LFCC). The local sponsor, the Middle Rio Grande Conservancy District (MRGCD), supports the Preliminary Preferred Plan. A draft of the Supplemental Environmental Impact Statement will be posted to the Corps' Albuquerque District web page (http://www.spa.usace.army.mil/fonsi/) in the near future.

The study area of the current project, San Acacia to Bosque Del Apache Unit, is one unit within the comprehensive plan of development for flood control in the Rio Grande Basin, New Mexico that was authorized by the Flood Control Acts of 1948 (P.L. 80-858, Section 203) and 1950 (P.L. 81-516), in accordance with the recommendations of the Chief of Engineers, as found in House Document No. 243, 81st Congress, 1st Session, dated April 5, 1948. The Authority provided a comprehensive plan for coordinated development, by the Corps and Bureau of Reclamation, of water resource and flood risk management on the Rio Grande commencing near Truth or Consequences at about river mile 123 extending

upstream to the lower end of the Rio Grande Canyon 14 miles upstream from Española, New Mexico at about river mile 394. The comprehensive plan included channel rectification, improvement of irrigation works, dredging, construction of three reservoirs and levee enlargement and construction. A November 1947 agreement delegated responsibility for channel rectification and maintenance to the Bureau of Reclamation and facilities for local flood protection to the Corps of Engineers.

As described in the 1948 report, levees had been constructed by local interests through parts of the Espanola and Middle Valley of the Rio Grande. The levees were not uniform as to grade, section or standard of construction and it was proposed to modify and supplement the existing levees. Since authorized in 1948, no levee rehabilitation projects have been constructed in the San Acacia to Bosque del Apache reach.

In 1997, the Corps contracted with the University of New Mexico's Office of Contract Archeology to conduct archaeological surveys of the levee alignment and other areas of the recommended plan's construction area. With the exception of the existing, historic 1930s MRGCD irrigation system, levee, and Reclamation's LFCC, completed in 1959, no archaeological sites, historic properties, or features were identified within the proposed levee reconstruction zone or access routes. No Traditional Cultural Properties are known to occur within or adjacent to the project area. As a part of planning for this project, the Corps, with our letter dated August 16, 2002, has previously submitted tribal scoping letters to tribes with concerns within Socorro County regarding the drilling of groundwater monitoring wells (copy attached for your convenience, Enclosure 2). With our tribal scoping letter dated February 21, 2006, the Corps informed tribes with concerns in Socorro County about studying the feasibility of constructing a new railroad bridge and the relocation of approximately 4 miles of track for the proposed railroad-Rio Grande crossing near San Marcial (copy attached for your convenience, Enclosure 3). Responses were received from the Pueblo of Isleta, the White Mountain Apache Tribe, the Comanche Tribe, and the Hopi Tribe. All of these stated they had no concerns regarding construction work for the San Marcial railroad crossing.

Based on the results of the Corps' archaeological investigations of the San Acacia to San Marcial reach, the Corps is of the opinion that reconstruction of the 43-mile levee would result in no effects to historic properties. On November 5, 1997,

the NM State Historic Preservation Officer (SHPO) concurred with the Corps determination of no effect for the then recommended alternative which followed the same alignment as the presently recommended plan (SHPO Consultation No. 054093). The Corps has previously submitted additional documentation to the SHPO for mitigation of effects to the MRGCD irrigation system, levee, and Reclamation's LFCC (Berry and Lewis 1997; Van Citters 2000; Dodge and Santillanes 2007). The SHPO has also concurred that it is highly unlikely that historic properties or cultural materials of significant antiquity or archaeological integrity would occur within areas of the Rio Grande's historic active channel.

There are two important aspects of the proposed project. The first is that the on-going modeling of river flows and projected volumes of water during flood events indicate that the proposed engineered levee may be smaller in both height and width than the existing spoil-bank levee. The second is that the material in the spoil-bank levee would be used in the rehabilitation of the proposed engineered levee. Therefore, all of the construction will occur in areas originally disturbed during construction of the levee and the low-flow conveyance channel, and no new quarry areas for fill would be required. Access for construction already exists on a network of paved and dirt roads, and to the extent possible, staging locations for equipment will be in previously disturbed locations. There are no archaeological sites within these disturbed areas.

Subsequent to the 1997 SHPO concurrence of no effect for the 43-mile levee rehabilitation project, Corps' engineers determined that as a new element of the Preliminary Preferred Plan, bank protection work would need to be constructed on the river bend immediately downstream of the San Acacia Diversion Dam. The San Acacia Diversion Dam is located at the upstream end of the 43-mile levee project. The Rio Grande channel on this river bend is significantly degraded. Proposed work in this San Acacia Overbank Lowering Area (see Enclosure 1, Map Figures 2 and 3) would include the placement of protective rock rip-rap on the outside of the river bend (northwest) adjacent to the BNSF railroad grade, and lowering and shaping the overbank area on the inside of the river bend (southeast). The light blue area shown in Map Figure 3 represents the sand bank that would be excavated to the depth of the existing river channel; the light green area would be excavated on a 1 to 10 slope. All work would be confined to the river channel and sand bank. This excavation would reduce river flow velocity around the river bend; thereby providing flood

protection to the BNSF railway grade, Reclamation's LFCC, and the community of San Acacia and adjacent farm land.

On May 26, 2011, Corps archaeologists conducted a site visit to the San Acacia Overbank Lowering Area to verify the location of known archaeological resources in relation to the proposed construction area. Supported with information gathered from archival records, the Corps' site visit found that archaeological resources in the area are of sufficient distance away from the project area that they would not be affected. The Corps is of the opinion that improvements to the river channel would result in no effect to historic properties. This San Acacia project area is on land managed by the U.S. Fish and Wildlife Service, Sevilleta National Wildlife Refuge.

The Corps is seeking input for consideration during planning of the project. The purpose of this scoping letter is to provide you with the opportunity to submit concerns or comments you may have regarding potential effects for the proposed project. Specifically, any concerns you may have regarding the environment such as natural, biological, or cultural resources; wildlife, vegetation, and special status species; air, water, or sound quality; aesthetics; health and safety; or Indian Trust Assets that may occur in the project area. Your input will be used in preparing an environmental impact statement to comply with the National Environmental Policy Act.

Please provide written comments regarding environmental concerns to William DeRagon, Biologist (William.Deragon@usace.army.mil) and, comments regarding cultural resources to Gregory D. Everhart, Archaeologist (Gregory.d.everhart@usace.army.mil), at the address above.

If you have any questions or require additional information on the San Acacia to Bosque del Apache levee rehabilitation project, please contact Mr. DeRagon at (505) 342-3358, Mr. Everhart at (505) 342-3352 or myself at (505) 342-3281.

Sincerely,

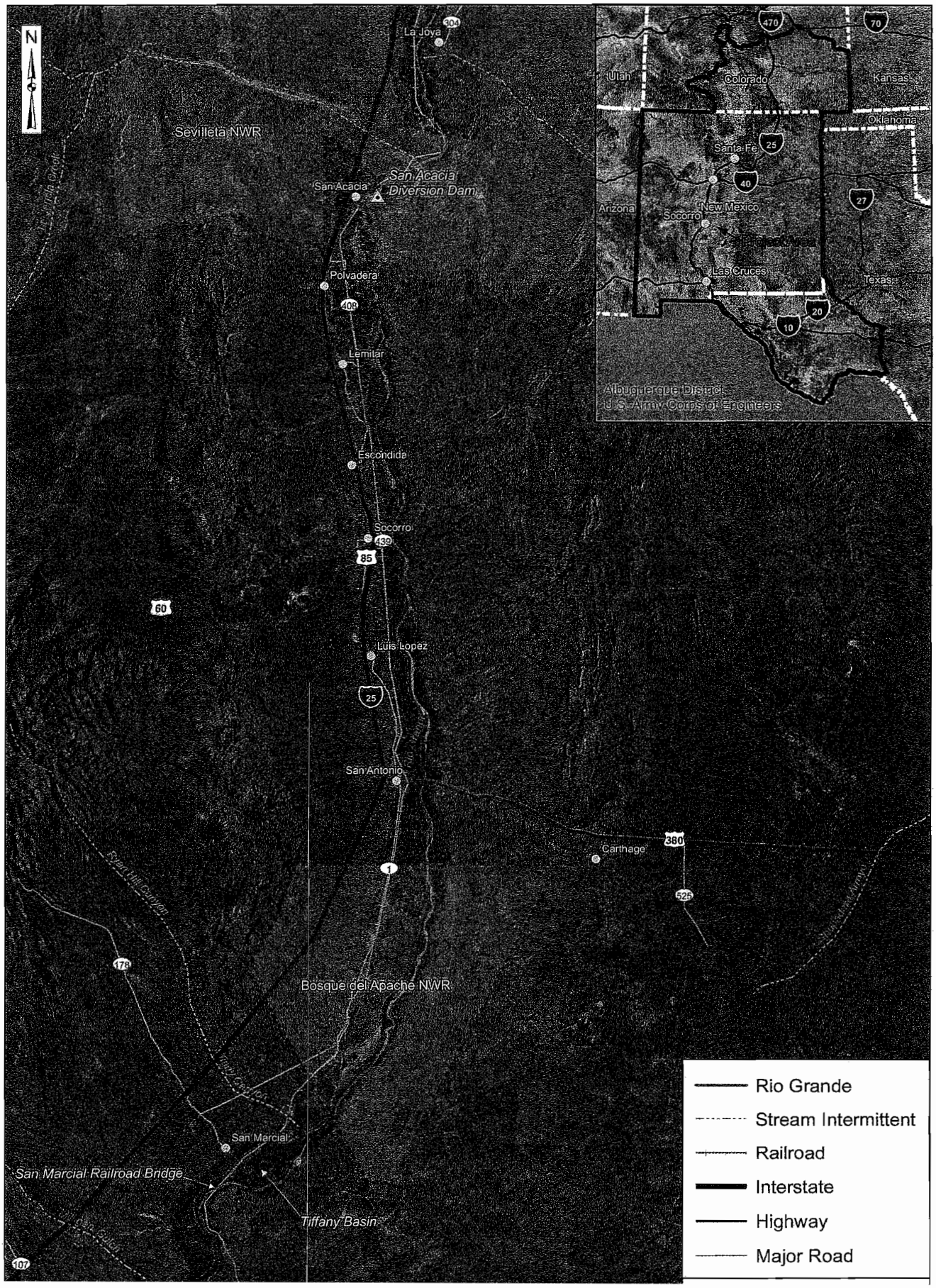
Julie Alcon
Chief, Environmental Resources Section

Enclosures

Copy furnished w/Encl:
Javier Loera, Tribal Historic Preservation Officer

Enclosure 1, Figure 1

Figure 1.1 Study Area



Enclosure 1, Figure 2

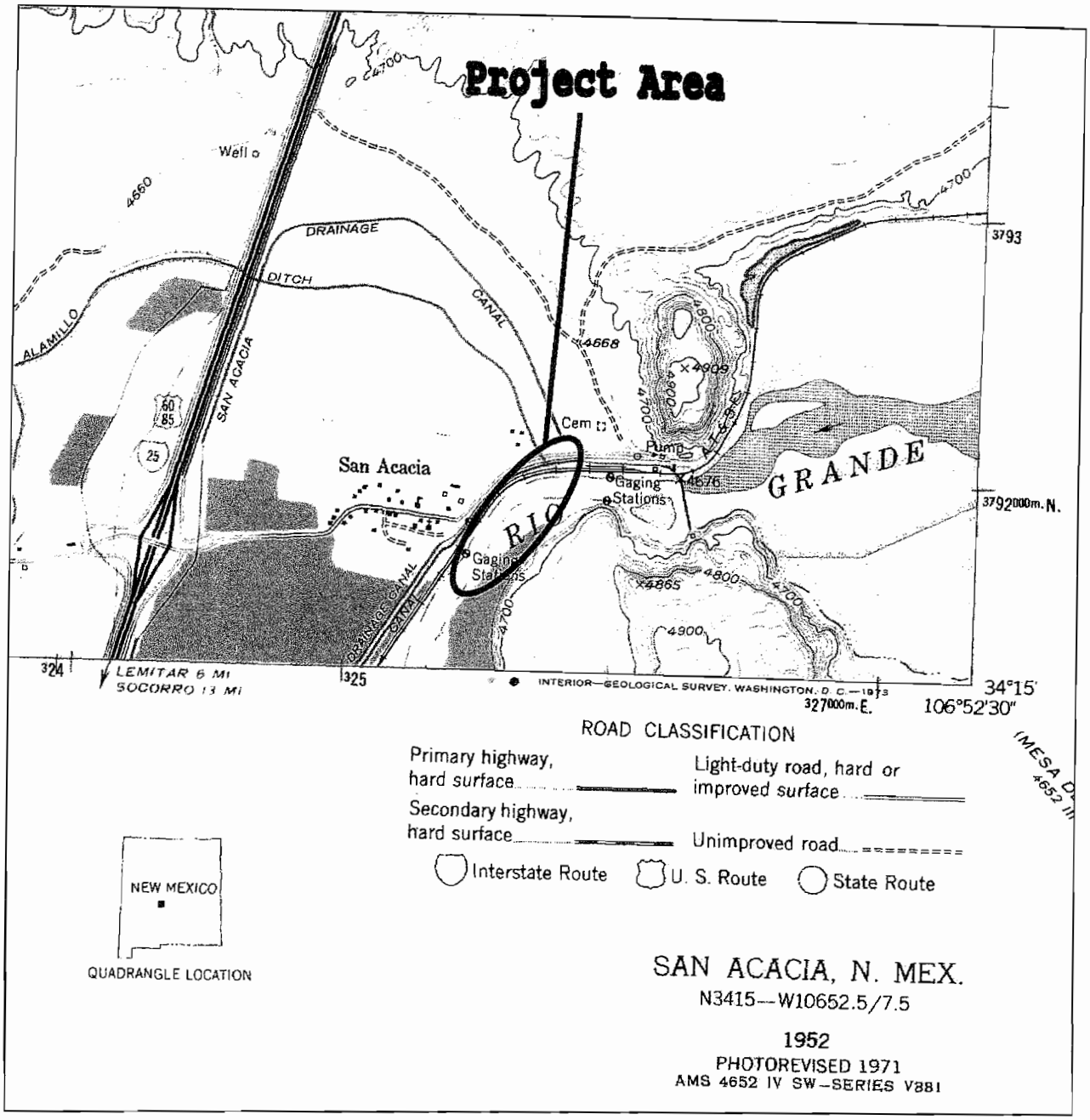
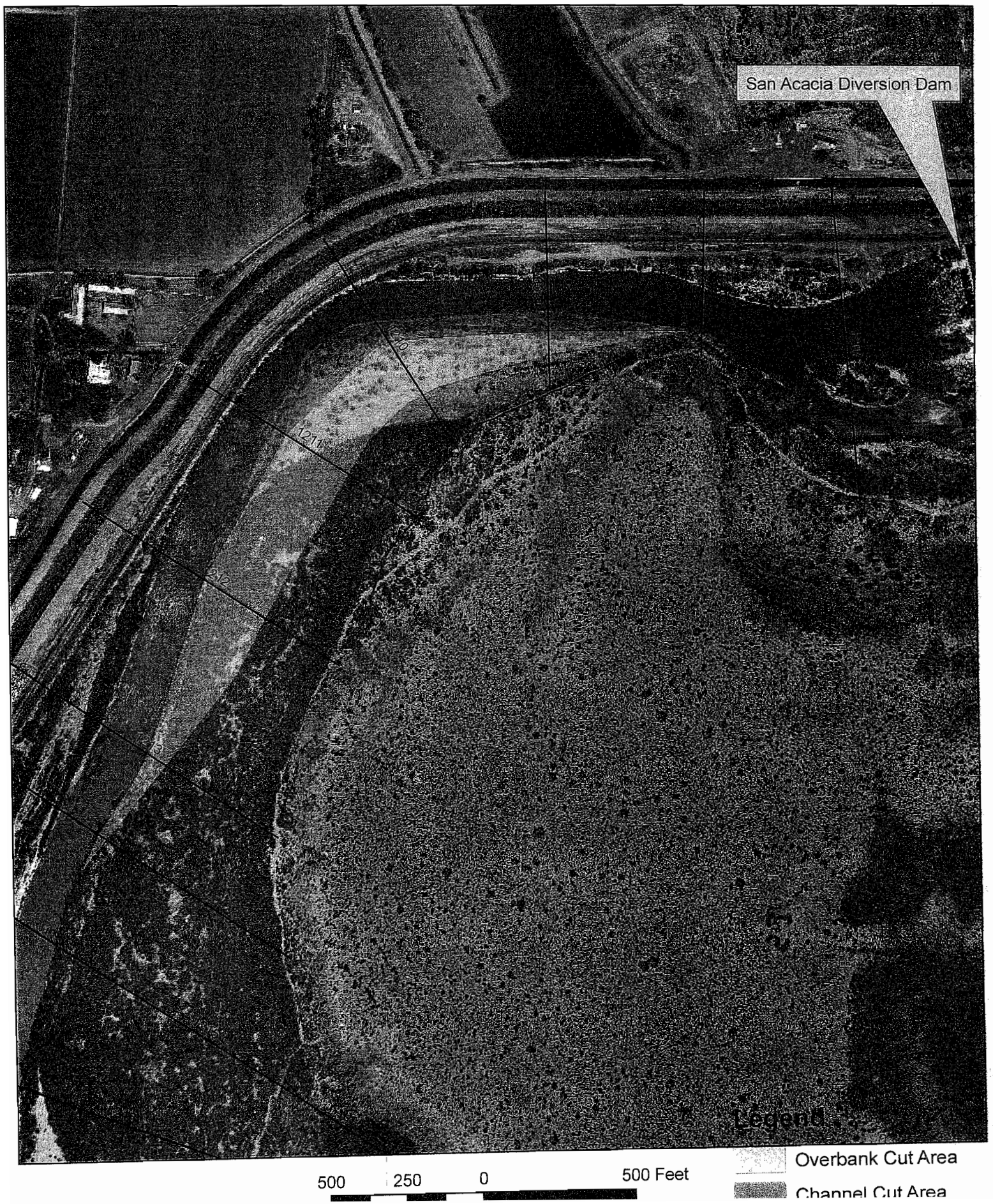


Figure 2: Approximate Location of San Acacia Overbank Lowering Project Area. Adapted from USGS 7.5-Minute Quadrangle Map: San Acacia, NM (34106-c8; 1952, PhotoRevised 1971). Prepared by Corps archaeologist, Gregory D. Everhart, June 30, 2011.

Enclosure 1, Figure 3

San Acacia Overbank Excavation



Enclosure 2

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA, NE
ALBUQUERQUE, NEW MEXICO 87109-3435
FAX (505) 342-3199

Reply to Attention of:

AUG 16 2002

Engineering and Construction Division
Environmental Resources Branch

Mr. Wayne Taylor, Jr., Chairman
Hopi Tribe
P.O. Box 123
Kykotsmovi, Arizona 86039

Dear Mr. Taylor:

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A response within 30 days from date of receipt would be appreciated. Please feel free to contact John D. Schelberg, (505) 342-3359, john.d.schelberg@usace.army.mil; or Mary Quirolo, SWCA Ethnographer, 1(800) 828-8499, mquirolo@swca.com if you have questions or need additional information.

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District Engineer

Enclosure

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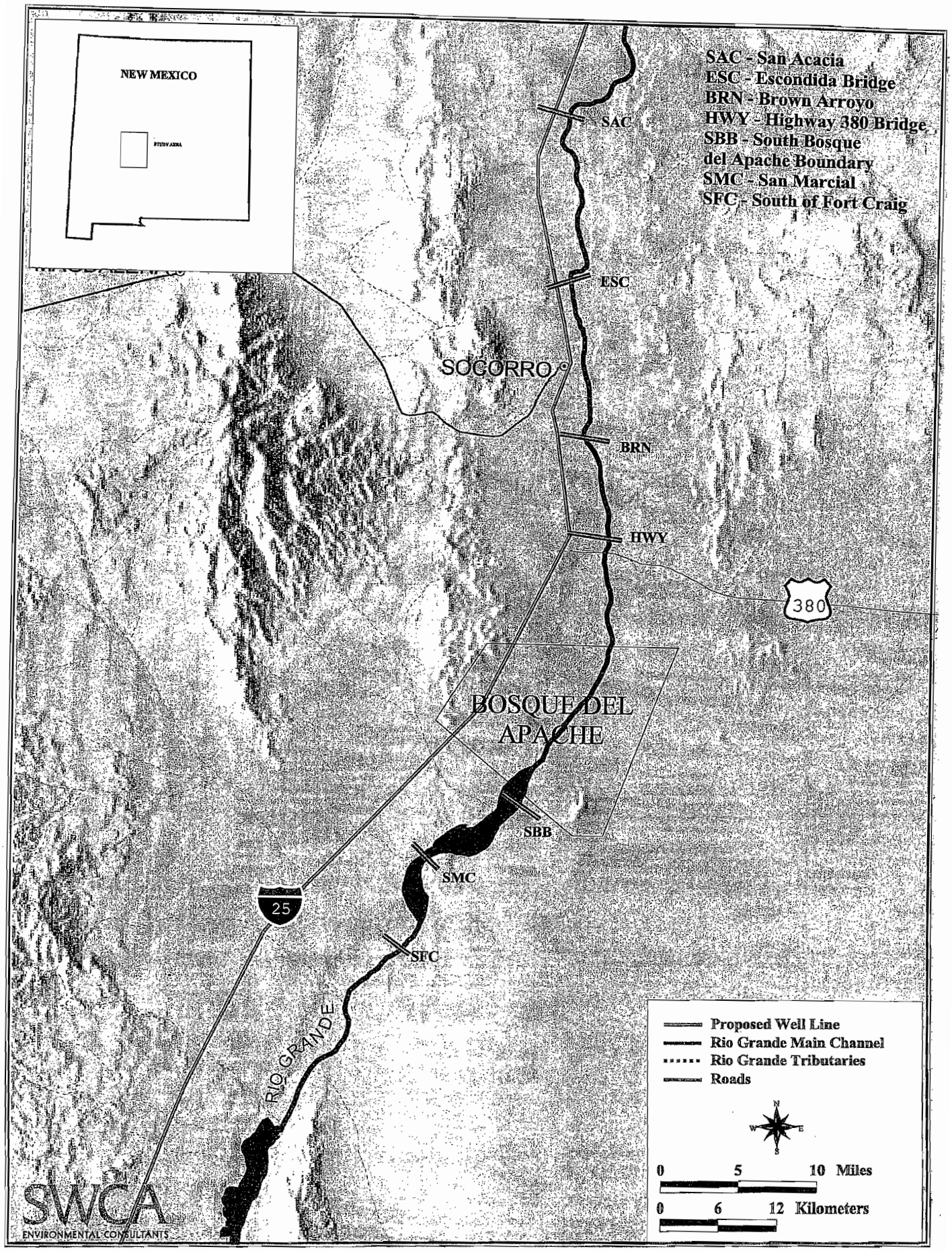

Figure 1. Proposed Well Lines for Below San Acacia Surface Water/ Groundwater Investigation

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

Enclosure 3.

February 21, 2006

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

Honorable Jason Johnson
Governor, Acoma Pueblo
P.O. Box 309
Acoma, New Mexico 87034

Dear Governor Johnson:

The U.S. Army Corps of Engineers (Corps), Albuquerque District is studying the feasibility of constructing a new railroad bridge over the Rio Grande and relocating a four-mile segment of the Burlington Northern Santa Fe (BNSF) Railroad at San Marcial, Socorro County, New Mexico. Due to the existing BNSF bridge's proximity to the headwaters of Elephant Butte Reservoir, the bridge's constriction of the river, and the consequent slowing of the river, sediment deposition is increasing and the elevation of the riverbed is rising. The proposed project is located on an unplatted portion of the San Marcial, New Mexico USGS quadrangle map (Pedro Armendaires Grant No. 33) and an unplatted portion of the Ft. Craig USGS quadrangle map (Pedro Armendaires Grant No. 34). A map showing the project area is enclosed for your review.

A variety of ground-disturbing activities may occur as the feasibility study progresses. Initially, a series of six-inch diameter holes will be drilled in order to define the geological substrate. If construction is approved, the proposed right-of-way will be cleared of vegetation, and the track and a new bridge will be built. The existing bridge will be removed.

The Corps is offering you the opportunity to bring to our attention any concerns or comments regarding the potential effects of this project on Indian Trust assets, traditional cultural properties, sacred sites, biological resources, and any other significant issues that you may have regarding the proposed railroad realignment.

Please provide written comments by March 25, 2006. If you have any questions or require more information regarding the Railroad Relocation at San Marcial, please contact John Schelberg Ph.D., archaeologist, at (505) 342-3359. Thank you for your attention to this matter.

Sincerely,

Julie A. Hall, Chief
Environmental Resources Section

Enclosure

2006 – Tribal mailing list – Socorro County, NM
American Indian tribes that have indicated that they have cultural resources concerns in Socorro County.

Pueblo of Acoma
Comanche Indian Tribe
Fort Sill Apache Tribe
Hopi Tribe
Pueblo of Isleta
Kiowa Tribe
Mescalero Apache Tribe
Navajo Nation
White Mountain Apache Tribe

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

November 9, 2009

088135

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

Ms. Jan Biella
Interim State Historic Preservation Officer
New Mexico Department of Cultural Affairs
Historic Preservation Division
Bataan Memorial Building
407 Galisteo Street, Suite 236
Santa Fe, New Mexico 87501

NOV 10 2009

Dear Ms. Biella:

Pursuant to 36 CFR Part 800, the U.S. Army Corps of Engineers (Corps), Albuquerque District, in cooperation with the Bureau of Reclamation (BOR), is seeking your concurrence in our determination of "no adverse effect to historic properties" for geological drilling associated with the Rio Grande Floodway, San Acacia to Bosque del Apache Unit, Socorro County, New Mexico. This project is focusing on the levee system from the diversion dam at San Acacia to the BNSF railroad bridge across the Rio Grande at San Marcial. The project will only occur on the levees on the west side of the Rio Grande. The proposed project is funded for 18.5 miles; however, we are seeking your concurrence for the total project length of approximately 44 miles north-to-south as we are anticipating additional funding and the drilling will be exactly the same. The Corps authority to conduct the project is provided by the Flood Control Act on 1948. Funding for the project is provided by the American Recovery and Reinvestment Act.

This drilling project is identical to the Bernalillo to Belen project discussed in our letter of August 20, 2009, (HPD log number 087510, copy enclosed). The long-term project consists of the reconstruction of the non-engineered spoil-bank levees to improve flood damage reduction along the Rio Grande from Bernalillo to the headwaters of Elephant Butte Reservoir. The levee is divided into units for the purpose of hydraulic investigations, funding, and other Corps management considerations.

The purpose of the proposed drilling and the sampling protocols are identical to those described in the August 20, 2009 letter (HPD Log 087510). Approximately 700 bore holes are required over the 44 mile-long project area. Three holes are planned every 1,000 feet: one in the maintenance road on the land side; one in the levee; and one in the river side. Fewer holes may be drilled due to dense stands of vegetation or other impediments to vehicular access on the levee's river side. Post-Katrina levee protocol allows for the relocation of a hole or even not drilling in an area of cultural or biological concern. There will be no blading or other ground disturbance in order to facilitate vehicular access.

The levee itself is historic, built in the 1930s by the Middle Rio Grande Conservancy District (MRGCD) and rehabilitated and expanded by the Corps and Bureau of Reclamation in the 1950s. As an artificial earthen spoil-bank feature, the Corps finds that drilling in the levee will not adversely affect those elements of the levee that make it eligible for listing on the National Register of Historic Places (NRHP). Access and staging for the project will use existing roads and facilities.

The levee is a spoil-bank levee constructed using nearby sediment. A maintenance road parallels the levee on the landward side and the drilling will occur within this maintenance road. The river side has been subject to construction-related disturbance and frequent channel modifications and the drilling will be within 15 to 20 feet of the levee toe. A Corps archaeologist and biologist will conduct a site visit of proposed locations to ensure that the proposed drilling areas have been previously disturbed, and, if not, will move those locations to disturbed areas or recommend no drilling for that specific segment. This project is very low impact; on similar projects, bore holes are not visible even a few months after drilling. The Corps finds that there will be no adverse effect to historic properties caused by drilling on either side of the levee.

An on-line records check of the New Mexico Cultural Resources Information System (NMCRIS) database was conducted by Lance Lundquist in December, 2007. Within the entire west-side flood plain (from the rivers edge to the bluffs an area vastly larger than the project area), 44 historic properties have been identified. Of these, 75 percent (33 sites) date to the historic period, 14 percent (six sites) date to the prehistoric period, one has both prehistoric and historic components, and four are of unknown temporal affiliation. With the exception of the

levee itself, there are no know historic properties within 50 meters of the currently proposed drilling locations

There are no known tribal concerns associated with this project based on the 2007 Upper Rio Grande Water Operations Environmental Impact Statement.

The concurrence request specified in this letter is specific to the drilling, which the Corps considers to have no adverse effect to historic properties. If this project moves forward, the Corps will fulfill its Section 106 of the NHPA duties for those phases. It is anticipated that due to the historic nature of the levee, as well as the impacts associated with staging and construction on other potential historic properties, replacing the existing 44 mile levee system would involve adverse effects to historic properties. As the planning phase continues, we will continue to involve your office and consult as required by Section 106.

Pursuant to 36 CFR 800.13, should previously unknown historic properties be encountered during drilling, work would cease in the immediate vicinity of the resource. A determination of significance would be made, and further consultation would be conducted with your office and with American Indian Tribes that have cultural concerns in the area.

In sum, we seek your concurrence in our determination of "no adverse effect to historic properties" related to geologic drilling for this project. If you have questions regarding the Rio Grande Floodway, San Acacia to Bosque del Apache Unit, Socorro County, New Mexico project, please contact John D. Schelberg, archaeologist, at (505) 342-3359 or Lance Lundquist, archaeologist, at (505) 342-3671.

Sincerely,

Julie Alcon
Chief, Environmental Resources Section

11/10/09
Date

I CONCUR
FOR Jan Biella
New Mexico State Historic Preservation Officer

Enclosures

1. Project Location Map
2. New Mexico State Historic Preservation Office letter

Copy furnished w/Enclosures:

Mr. Mark Hungerford, Archaeologist
U.S. Bureau of Reclamation
Albuquerque Area Office
555 Broadway Blvd., NE
Suite 100
Albuquerque, NM 87102-2352

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

August 20, 2009

AUG 21 2009
NN

087510

Rec'd 8/21/09 via email
LAC

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

Ms. Jan Biella
Interim State Historic Preservation Officer
New Mexico Department of Cultural Affairs
Historic Preservation Division
Bataan Memorial Building
407 Galisteo Street, Suite 236
Santa Fe, New Mexico 87501

Dear Ms. Biella:

Pursuant to 36 CFR Part 800, the U.S. Army Corps of Engineers (Corps), Albuquerque District, in cooperation with the Bureau of Reclamation (BOR), and Isleta Pueblo, is seeking your concurrence in our determination of "no adverse effect to historic properties" for geological drilling associated with the Middle Rio Grande Flood Protection, Bernalillo to Belen, New Mexico project. This project is focusing on the levee system from the Albuquerque's South Diversion Channel (approximately 1.3 miles south of Rio Bravo Blvd) to 3.5 miles south of the BNSF railroad bridge in Belen, or approximately 5 miles south of New Mexico Highway 309. The total project length is approximately 29 miles north-to-south, with approximately 53.5 miles of levee (on both sides of the river) under examination (see Enclosure 1). The Corps authority to conduct the project is provided by the Water Resource Development Act of 1986, Section 401. Funding for the project is federal, provided by the American Recovery and Reinvestment Act of 2009 (ARRA).

The long-term project consists of the reconstruction of the non-engineered spoil-bank levees to improve flood damage reduction along the Rio Grande. The purpose of the proposed drilling and sampling is to characterize foundation materials and earthen levees for this future effort. To accomplish this, the Corps is planning to conduct 6-inch diameter test boring approximately every 1,000 feet along the levee to a depth of approximately 30 feet. In addition, 6-inch diameter bore holes will be placed on either side of the levee, located approximately 15-20 feet from the levee toe. These bore holes

will be drilled to a depth of approximately 15 feet deep. Approximately 850 bore holes are required over the 53.5-mile project area.

The levee itself is historic, built in the 1930s by the Middle Rio Grande Conservancy District (MRGCD) and rehabilitated and expanded by the Corps and the BOR in the 1950s. As an artificial earthen spoil-bank feature, the Corps finds that drilling in the levee will not adversely affect those elements of the levee that make it eligible for listing on the National Register of Historic Places (NRHP). Access and staging for the project will use existing roads and facilities.

The levee is a spoil-bank levee, and was constructed using nearby sediment, especially those removed in the creation of the riverside drain. As such, the area surrounding the levee has also been highly disturbed. In addition, a maintenance road parallels the levee on the land-ward side. The bore holes on this side will be located in the existing maintenance road. The river side has been subject to construction-related disturbance and frequent channel modifications. A Corps archaeologist and biologist will conduct a site visit of proposed locations to ensure that the proposed drilling areas have been previously disturbed, and, if not, will move those locations to disturbed areas or recommend no drilling for that specific segment. Post-Katrina levee protocol allows for the relocation of a hole or even not drilling in an area of cultural or biological concern. No jetty jacks will be disturbed during this project, and no vegetation will be bladed. This project is very low impact; on similar projects, bore holes are not visible even a few months after drilling. The Corps finds that there will be no adverse effect to historic properties caused by drilling on either side of the levee.

An on-line records check of the New Mexico Cultural Resources Information System (NMCRIS) database was conducted by Lance Lundquist on September 8, 2008. Within 100 feet of the levees (larger than the project area), 10 historic properties have been identified (see Table 1). Of these, 80 percent (eight sites) date to the historic period, one dates to the Pueblo III/IV period, and one dates to the Archaic period. Most of the historic sites within the project area contain features relating to irrigation, with about 60 percent being small (less than one acre) and 40 percent large (over one acre). Of the sites listed in Table 1, three have been determined by your office as eligible to the NRHP, three have been determined as not

eligible, and the remainder have not been evaluated. Of those that have not been evaluated, all but one should be considered eligible because they are acequias. The levees themselves were previously determined as eligible. This project will not have an adverse effect on any of these properties.

Table 1: Site Information for Sites within the Project Area

LA No.	Features Present?	Occupation	Site Size	Site Type	NRHP Eligible
100485	Yes	Historic	0-1 acre	Atrisco Riverside Drain	Yes, Criterion A[1]
108653	Yes	Prehistoric	1-5 acres	Large Archaic Period site	Yes, Criterion D[2]
108654	Yes	Historic	5+ acres	Agricultural field (recent)	No[2]
108655	Yes	Prehistoric	0-1 acre	Pueblo III/IV hearth and a few ceramic sherds	No[2]
111616	Yes	Historic	0-1 acre	San Juan Feeder Canal	Yes, Criterion A[1]
111617	Yes	Historic	0-1 acre	Lower Belen Riverside Drain	Yes, Criterion A[1]
145560	Yes	Historic	5+ acres	Los Padillas Acequia/Drain	Yes, Criterion D[2]
148365	Yes	Historic	0-1 acre	Feeder ditch from Los Padillas Acequia/Drain	No[2]
153624	Yes	Historic	1-5 acres	Water control dike	Yes, Criterion D[2]
153625	Yes	Historic	0-1 acre	Foot bridge across Atrisco Riverside Drain	Not Determined[2]

[1] Assumed eligible – all acequias in New Mexico are considered NRHP-eligible
[2] Determination made by the New Mexico SHPO

Part of this project is on Isleta Pueblo land. The Corps has closely coordinated with the Pueblo, and the Pueblo supports the project. Enclosure 2 is a letter from the Governor indicating the Pueblo's support of this project. There are no known tribal concerns associated with this project.

The concurrence request specified in this letter is specific to the drilling, which the Corps considers to have no adverse effect to historic properties. If this project moves forward, the Corps will fulfill its Section 106 of the NHPA duties for those phases. It is anticipated that due to the historic nature of the levee, as well as the impacts associated with staging and construction on other potential historic properties, that replacing the existing 50+ mile levee system would involve adverse effects to historic properties. As the planning phase continues, we will continue to involve your office and consult as required by Section 106.

Pursuant to 36 CFR 800.13, should previously unknown historic properties be encountered during drilling, work would cease in the immediate vicinity of the resource. A

determination of significance would be made, and further consultation would be conducted with your office and with American Indian Tribes that have cultural concerns in the area.

In sum, we seek your concurrence in our determination of "no adverse effect to historic properties" related to geologic drilling for this project. If you have questions or require additional information regarding the Middle Rio Grande Flood Protection, Bernalillo to Belen, New Mexico project, please contact Mr. Lance Lundquist, archaeologist, at (505) 342-3671.

Sincerely,

Julie Alcon
Chief, Environmental Resources Section

8/21/09
Date

I CONCUR
Jan Biella
FOR New Mexico State Historic Preservation Officer

Enclosures

Copy furnished w/Enclosures:

Honorable J. Robert Benavides
Governor, Pueblo of Isleta
Post Office Box 1270
Isleta, New Mexico 87022

Mr. Mark Hungerford, Archaeologist
U.S. Bureau of Reclamation
Albuquerque Area Office
555 Broadway Blvd., NE
Suite 100
Albuquerque, NM 87102-2352

Dr. Bruce Harrell
Regional Archaeologist
Southwest Regional Office
Bureau of Indian Affairs
Post Office Box 26567
Albuquerque, New Mexico 87125-6567

THE HOPI TRIBE

Ivan L. Sidney, Sr.
Chairman

Todd D. Honyaoma, Sr.
Vice Chairman

March 13, 2006

Department of the Army
Albuquerque District, Corps of Engineers PMLE
4101 Jefferson Plaza, NE
Albuquerque, New Mexico 87109

Dear Sir/Madam:

Your department had submitted to our Cultural Preservation Office of the Hopi Tribal Government a feasibility study of constructing a new railroad bridge over several location areas. I am forwarding this information to you that include their findings, opinions, and comments concerning your project.

If you have any questions or concerns regarding the contents, please feel free to call me at any time. I can be reached at my office at 928-734-3114. Thank you.

Sincerely,

Art Batala, Chief Executive Assistant
Office of the Vice Chairman

xc: Lyle J. Balenquah, Arch. Program Mgr., Hopi CPO
File

COMANCHE TRIBE

NAGPRA

March 13, 2006

Julie Hall, Chief
Department of the Army
Albuquerque District, Corps of Engineers
Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section
4101 Jefferson Plaza NE
Albuquerque, NM 87109-3435

Re: Consultation regarding the construction of a new railroad bridge over the Rio Grande and relocating a four-mile segment of the Burlington Northern Santa Fe Railroad at San Marcial, Socorro County, NM

Dear Ms. Hall:

Thank you for your letter of February 21st regarding the planned project as referenced above.

At this time, the Comanche Nation has no immediate concerns or issues regarding the project; however, please keep us informed of the project progress. We also would like to receive any archaeological reports and findings for the project area.

If in the process of the project human remains or archaeological items are discovered, we request that you immediately cease the project work and notify us so that we may discuss appropriate disposition with you and the other Tribal Nations that may be affected by such discoveries.

We look forward to your reports as activities proceed.

Sincerely,

Fred Nahwooksy

Fred Nahwooksy, NAGPRA Coordinator

PO Box 908 • Lawton, Oklahoma 73502 • PHONE: (580) 492-3740 • FAX: (580) 492-3745

Fogle, Cheryl SPA

From: Mark Altaha [markaltaha@wmat.nsn.us]
Sent: Tuesday, March 07, 2006 1:46 PM
To: Fogle, Cheryl SPA
Subject: Rio Grande Bridge / Relocating of BNSF

Please forward to John Schelberg Ph.D. Archaeologist.

Mr.Schelburg,

Please be advised the White Mountain Apache tribe feels there is no threat to potential Tradtional Cultural Properties and/or sacred places that may occur in the Area of Potential Effect and the proposed project may proceed as planned. Should there be further concerns regarding the said project please do not hesitate to contact our office for further assistance.

Thank you,

Mark T. Altaha
White Mountain Apache Tribe
Historic Preservation Office

OFFICE OF THE GOVERNOR

505-869-3111 / 6333
FAX: 505-869-4236

PUEBLO OF ISLETA
P.O. BOX 1270 ISLETA, NM 87022

March 3, 2006

Julie A. Hall, Chief
Environmental Resources Section
Department of the Army
Albuquerque District, Corps of Engineers
4101 Jefferson Plaza NE
Albuquerque, NM 87109-3435

Dear Ms. Hall:

This letter is in response to your correspondence dated February 21, 2006, regarding the proposed construction of a new railroad bridge over the Rio Grande and relocation of a four-mile segment of the Burlington Northern Santa Fe Railroad at San Marcial, Socorro County, New Mexico.

I am pleased to inform you that this project will not have an impact on religious or cultural sites affiliated with the Pueblo of Isleta. However, in the event that discoveries are found during construction, we would appreciate being advised of such findings.

Thank you for your consideration in contacting this office to express your concerns.

Sincerely,

PUEBLO OF ISLETA

Robert Benavides
Governor

cc: files

Copy

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

February 21, 2006

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

Honorable Jason Johnson
Governor, Acoma Pueblo
P.O. Box 309
Acoma, New Mexico 87034

Dear Governor Johnson:

The U.S. Army Corps of Engineers (Corps), Albuquerque District is studying the feasibility of constructing a new railroad bridge over the Rio Grande and relocating a four-mile segment of the Burlington Northern Santa Fe (BNSF) Railroad at San Marcial, Socorro County, New Mexico. Due to the existing BNSF bridge's proximity to the headwaters of Elephant Butte Reservoir, the bridge's constriction of the river, and the consequent slowing of the river, sediment deposition is increasing and the elevation of the riverbed is rising. The proposed project is located on an unplatted portion of the San Marcial, New Mexico USGS quadrangle map (Pedro Armendaires Grant No. 33) and an unplatted portion of the Ft. Craig USGS quadrangle map (Pedro Armendaires Grant No. 34). A map showing the project area is enclosed for your review.

A variety of ground-disturbing activities may occur as the feasibility study progresses. Initially, a series of six-inch diameter holes will be drilled in order to define the geological substrate. If construction is approved, the proposed right-of-way will be cleared of vegetation, and the track and a new bridge will be built. The existing bridge will be removed.

The Corps is offering you the opportunity to bring to our attention any concerns or comments regarding the potential effects of this project on Indian Trust assets, traditional cultural properties, sacred sites, biological resources, and any other significant issues that you may have regarding the proposed railroad realignment.

Please provide written comments by March 25, 2006. If you have any questions or require more information regarding the Railroad Relocation at San Marcial, please contact John Schelberg Ph.D., archaeologist, at (505) 342-3359. Thank you for your attention to this matter.

Sincerely,

Julie A. Hall, Chief
Environmental Resources Section

Enclosure

2006 – Tribal mailing list – Socorro County, NM
American Indian tribes that have indicated that they have cultural resources concerns in Socorro County.

Pueblo of Acoma
Comanche Indian Tribe
Fort Sill Apache Tribe
Hopi Tribe
Pueblo of Isleta
Kiowa Tribe
Mescalero Apache Tribe
Navajo Nation
White Mountain Apache Tribe

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA, NE
ALBUQUERQUE, NEW MEXICO 87109-3435
FAX (505) 342-3199

Reply to
Attention of:

AUG 16 2002

Engineering and Construction Division
Environmental Resources Branch

Mr. Wayne Taylor, Jr., Chairman
Hopi Tribe
P.O. Box 123
Kykotsmovi, Arizona 86039

Dear Mr. Taylor:

In conjunction with the proposed San Acacia Surface Water/Groundwater Investigation, the New Mexico Interstate Stream Commission (NMISC) and the U.S. Army Corps of Engineers (Corps), Albuquerque District, are proposing to install up to 80 boreholes and 25 staff gauges along seven transects across the Low Flow Conveyance Channel between San Acacia Diversion Dam and the delta of Elephant Butte Reservoir. Within this river reach, competing demands for water, including agriculture, municipal use, wildlife habitat, and Rio Grande compact delivery requirements, necessitate a better understanding of the water budget. The purpose of the investigation is to collect data required to better understand the interactions between surface water and groundwater in this river reach. The entire project area lies within the historic floodplain of the Rio Grande.

Each well will be monitored monthly for three years. There will be one aquifer pumping test on each transect during the first year. The proposed transects are shown on the enclosed figure. Whenever possible, the transects have been located within or adjacent to disturbed areas and existing roads. Some previously undisturbed areas are also included. Due to the nature of the investigation, there is some latitude for placement of the wells and environmentally or culturally sensitive locations will be avoided. Inventories to identify and evaluate environmental, archaeological, and historic resources have been conducted by SWCA Environmental Consultants (SWCA), and the reports are in preparation. An Environmental Assessment is being prepared, and you will receive a draft for your review and comment. SWCA will provide you copies of the reports as they are completed and information regarding project impacts on identified resources, should you so request.

We are contacting the Hopi Tribe to gather information on tribal concerns about traditional cultural properties or other issues within the proposed project locations. You may provide information in writing or, at your request, a meeting with personnel from the Corps, NMISC, or SWCA staff can be arranged to discuss any concerns you may

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have about this project. We will maintain strict confidentiality with regard to certain types of information concerning traditional religious and/or cultural historic properties that may be affected by this proposed undertaking. We would also appreciate suggestions about other groups that we should contact regarding this project.

A response within 30 days from date of receipt would be appreciated. Please feel free to contact John D. Schelberg,(505) 342-3359, john.d.schelberg@usace.army.mil; or Mary Quirolo, SWCA Ethnographer, 1(800) 828-8499, mquirolo@swca.com if you have questions or need additional information.

I have also furnished a copy of this letter to Leigh J. Kuwanwisiwma, Director, Cultural Preservation Office, of your organization.

Sincerely,

Dana R. Hurst
Lieutenant Colonel, EN
District Engineer

Enclosure

Mr. Wayne Taylor, Jr., Chairman
Hopi Tribe
P.O. Box 123
Kykotsmovi, AZ 86039

Mr. Leigh J. Kuwansisiwma, Director
Cultural Preservation Office
Hopi Tribe
P.O. Box 123
Kykotsmovi, AZ 86039

Mr. Kelsey A. Begaye, President
Navajo Nation
P.O. Box 4950
Window Rock, AZ 86515

Alan S. Downer, Ph.D.
Navajo Nation Historic Preservation Department
P.O. Box 4950
Window Rock, AZ 86515

Ms. Ruey Darrow, Chairwoman
Fort Sill Apache Tribe
Route 2, Box 121
Apache, OK 73006

Mr. Michael Darrow
Tribal Historian
Route 2, Box 121
Apache, OK 73006

Ms. Sara Misquez, President
Mescalero Apache Tribe
P.O. Box 227
Mescalero, NM 88340

Ms. Donna Stern-McFadden
Resource Management and Protection
P.O. Box 227
Mescalero, NM 88340

Mr. Dallas Massey, Sr., Chairman
White Mountain Apache Tribe
P.O. Box 587
Whiteriver, AZ 85941

Mr. John Welch
Tribal Historic Preservation Officer
White Mountain Apache Tribe
P.O. Box 587
Whiteriver, AZ 85941

Honorable Alvino Lucero
Pueblo of Isleta
P.O. Box 1270
Isleta, NM 87022

Mr. Jim Piatt, Environmental Officer
Pueblo of Isleta
P.O. Box 1270
Isleta, NM 87022

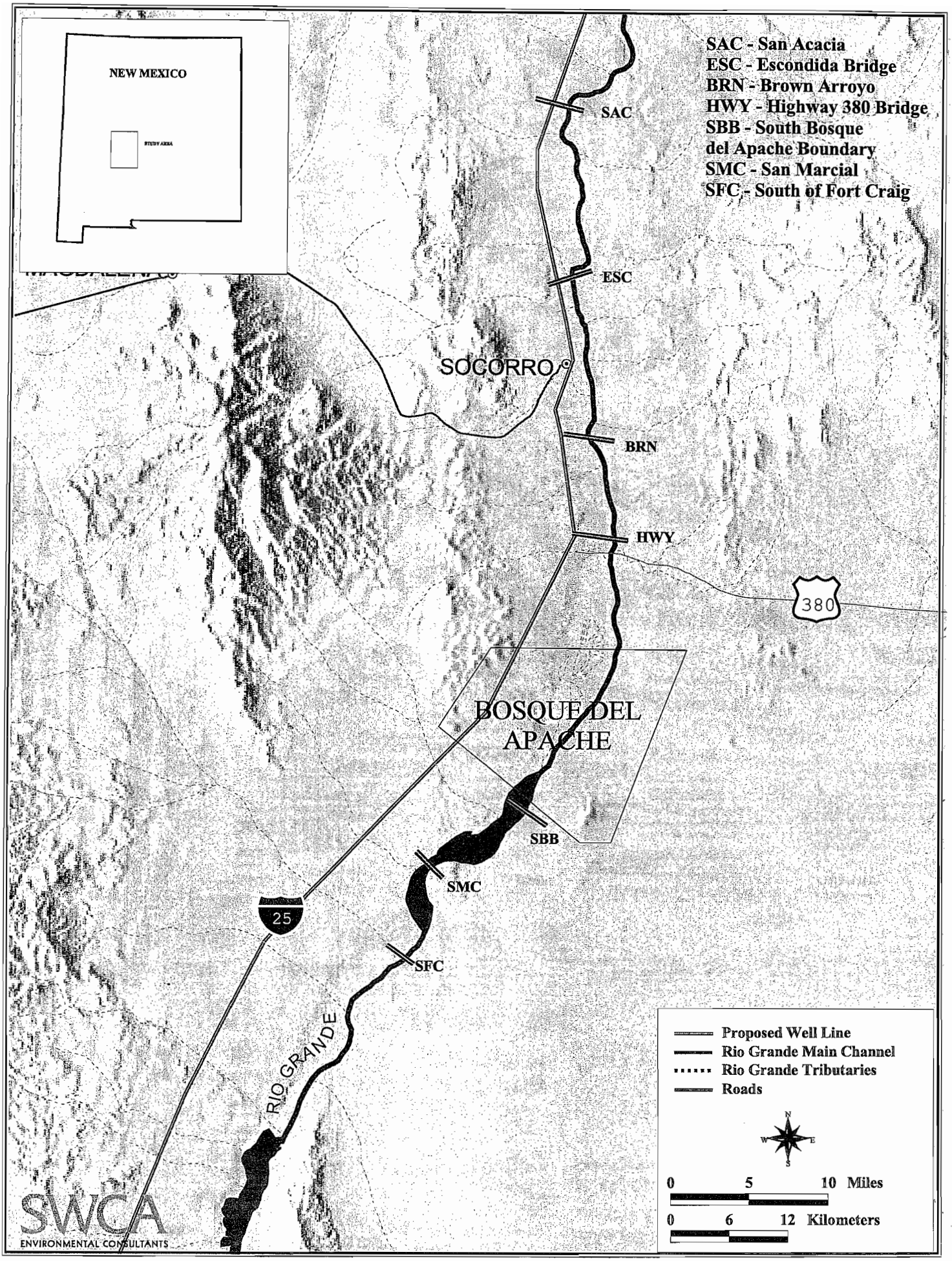

Figure 1. Proposed Well Lines for Below San Acacia Surface Water/ Groundwater Investigation

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA, NE
ALBUQUERQUE, NEW MEXICO 87109-3435
FAX (505) 342-3199

Reply to Attention of:

054093

October 3, 1997

RECEIVED
OCT 10 1997
HISTORIC PRESERVATION DIVISION

Engineering and Technical
Services Division
Planning and Environment
Branch

Lynne Sebastian, Ph.D.
State Historic Preservation
Officer
State Historic Preservation
Bureau
228 East Palace Avenue, Room 101
Santa Fe, New Mexico 87503

Dear Dr. Sebastian:

In accordance with 36 CFR 800.5, the Substitution Agreement between your office and the Advisory Council on Historic Preservation (under 36 CFR 800.7) and the Programmatic Memorandum of Agreement for our levee rehabilitation program, the U.S. Army Corps of Engineers (Corps), Albuquerque District, is providing to your office information regarding our cultural resources and historic properties investigations associated with the rehabilitation of the Middle Rio Grande levee system. We seek your concurrence with our determinations regarding portions of this undertaking and their potential effects on historic and cultural resources.

The Corps has conducted a cultural resources inventory of the alignment of the San Acacia to San Marcial Reach of the Middle Rio Grande levee system. In addition, resource inventories were conducted along access routes to ten "Habitat Improvement Features" (HIFs) located in the Rio Grande flood plain. We have previously consulted with Mr. Dan Riley of your office regarding these habitat features by telephone. As a result of this conversation, it was agreed that survey within the flood plain would be counter-productive and uninformative and that our inventory should focus on access routes to HIFs. The results of this inventory are provided in the enclosed letter report from our contractor, the Office of Contract Archaeology - University of New Mexico.

In summary, no historic properties or features and only two isolated artifacts were identified along the 45 miles of the existing spoilbank levee, the area to be directly impacted by construction activities. The Corps believes that the two separate isolated artifacts, lacking spatial context and integrity, do not meet the criteria for eligibility to the National Register of

Historic Places. The Corps has provided to your office our documentation of the existing spoilbank levee and its attendant historic context under separate cover (Historical Documentation of Middle Rio Grande Flood Protection Projects, K. Lynn Berry and Karen Lewis, 1997). Given that no historic or cultural properties or features have been identified along the construction area and that the existing spoilbank has been adequately documented to mitigate its rehabilitation, the Corps is of the opinion that actual construction activities will have no effect on the historic resources of the region.

As noted, the inventory also included proposed access routes to areas identified for habitat improvement. Construction activities in these HIFs will consist of excavation of a channel from the Rio Grande into areas that are only marginally exposed to periodic inundation under current conditions. Because of their location in the Rio Grande flood plain, it is extremely unlikely that cultural or historic resources would be found there. Survey of the access routes into these areas, however, identified numerous historic properties. As cited in the enclosed report, access to all ten of the proposed HIFs will primarily be along an unnumbered and unpaved road that parallels the Rio Grande on its eastern or left-hand margin. Numerous historic properties have been previously documented along this road and were confirmed by our inventory. Access from this artery into the bosque HIF locations can also be attained along existing unpaved roads in five instances. Access to the five remaining HIFs will necessitate traversing previously undisturbed areas. Surveys of these undisturbed areas found that two proposed access routes would impact previously unrecorded historic properties (LA 119574 and LA 119575). Both of these sites are large, complex, multi-component artifact scatters that have the potential for structural feature remains. As such, the Corps considers them eligible for inclusion on the National Register of Historic Places.

Given the density and size of historic properties associated with access to the HIF areas, the Corps believes that the most prudent action to take is to avoid the properties involved. To ensure no impacts to these properties, the Corps proposes a three-fold avoidance plan. First, prior to construction, the Corps shall clearly demarcate access routes that detour around all identified historic properties and ensure contractor adherence to their use. Second, the Corps shall employ minimal efforts to improve existing roadways, including the preclusion of improvements along existing roads through known properties. Third, the Corps shall undertake extensive monitoring by qualified archaeological professionals of construction activities as they occur to ensure rapid identification and protection of any previously unrecorded historic properties. Therefore, because limited use of existing roads without improvements should not affect historic properties to an extent any greater than that already produced by road construction and the implementation of a rigorous avoidance plan, the Corps is

of the opinion that construction activities associated with habitat improvement will have no effect on the historic and cultural resources of the region.

We shall continue to coordinate with your office as construction plans continue to mature. We look forward to our continuing consultations regarding this extensive undertaking. Please contact Dr. Ronald Kneebone at (505) 342-3355 with any questions or comments that you may have.

Sincerely,

John D. Schelberg
for Mark C. Harberg
Chief, Environmental Section

Enclosure

Copy Furnished (w/o enclosure):

Claudia Nissley, Director
Western Office of Project Review
Advisory Council on Historic
Preservation
730 Simms Street, Room 401
Golden, Colorado 80401

I CONCUR _____ 11-5-97
for LYNNE SEBASTIAN, PH.D.
NEW MEXICO STATE HISTORIC PRESERVATION OFFICER

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA, NE
ALBUQUERQUE, NEW MEXICO 87109-3435
FAX (505) 342-3199

Reply to Attention of:

ET-PW
11/5/97

054201

October 24, 1997

Engineering and Planning Division
Planning Branch

RECEIVED
OCT 28 1997

Lynne Sebastian, Ph.D.
State Historic Preservation Officer
State Historic Preservation Bureau
228 East Palace Avenue, Room 101
Santa Fe, New Mexico 87503

Dear Dr. Sebastian:

In accordance with 36 CFR 800.5, the Substitution Agreement between your office and the Advisory Council on Historic Preservation (under 36 CFR 800.7) and the Programmatic Memorandum of Agreement for our levee rehabilitation program, the U.S. Army Corps of Engineers, Albuquerque District (Corps), is providing to your office information regarding our cultural resources and historic properties investigations associated with the rehabilitation of the Middle Rio Grande Levee system. We seek your concurrence with our determinations regarding portions of this undertaking and their potential effects on historic and cultural resources.

Recent design changes for the San Acacia Reach of the Middle Rio Grande Levee Rehabilitation Project call for the removal of an existing railroad bridge near San Marcial, Socorro County, New Mexico. The bridge is located in UTM Zone 13 at 3728300 N and 315290 E. The bridge is currently in use by the Burlington Northern Santa Fe Railway, the bridge's owner. The bridge was originally constructed circa 1930. Although the bridge has been raised a total of 18 feet as a result of aggradation of the local river bed, the superstructure remains essentially unchanged since its construction. The bridge is a "Warren Through-Truss" design. The bridge is composed of five 149-foot long steel trusses on timber and concrete piers. The total length of the structure is 853 feet.

The Corps has evaluated the structure using the system developed by the New Mexico State Highway and Transportation Department (SHD) in consultation with your office. The bridge scored 72 points out of the 108 points possible, placing it in the top one-third of the rating. This value appears to be consistent with those ratings given similar highway structures. Given the structure's age, relative rarity as an engineering feature, and its long-term historic function in south central New Mexican commerce, the Corps believes the bridge to be eligible for inclusion on the National Register of Historic Places.

The San Marcial Railroad Bridge is situated such that it produces a severe constriction in the Rio Grande River floodway during periods of high flows. The negative effects of the current situation are increased water surface elevations upstream of the structure requiring more extensive levee construction and impaired water resource operations throughout the Middle Rio Grande Valley. Limited flexibility in water operations in turn has a deleterious impact on riparian and riverine ecosystems along the Rio Grande. Replacement of the bridge with a more modern structure on a different site is considered crucial to effective flood control, efficient and beneficial water operations, and habitat improvement for endangered species. These widespread environmental benefits considerably offset adverse impacts to the historic context of the area through the loss of the structure.

The Corps proposes to market the structure for reuse in another location and the recordation of the structure according to Level II standards of the Historic American Engineering Record. A considerable amount of documentation in the form of engineered drawings and photography are available for the structure and an historic narrative shall be produced to complete the documentation package. With your concurrence on our determination, we shall begin consultation with your office on the content, extent, and distribution of the final mitigation document.

We shall continue to coordinate with your office as construction plans continue to mature. We look forward to our continuing consultations regarding this extensive undertaking. Please contact Dr. Ronald Kneebone at (505) 342-3355 with any questions or comments that you may have.

Sincerely,

Mark C. Harberg

Mark C. Harberg
Chief, Environmental Section

Enclosure

Copy Furnished: (w/o enclosure)
Don Klima, Director
Advisory Council on Historic Preservation
Office of Planning and Review
12136 W Bayaud Ave. #330
Lakewood, CO 80228-2115

I CONCUR Ly Sebastian 11-3-97
LYNNE SEBASTIAN, PH.D.
NEW MEXICO STATE HISTORIC PRESERVATION OFFICER

The University of New Mexico

Office of Contract Archeology
1717 Lomas Blvd. NE
Albuquerque, NM 87131
Telephone (505) 277-5853
FAX (505) 277-6726

October 14, 1997

Dr. Ron Kneebone
US Army Corps of Engineers
Albuquerque District
4010 Jefferson Plaza NE
Albuquerque, NM 87109

Dear Ron:

This letter serves as the final letter report for "Cultural Resources Survey Isleta to Belen and San Acacia to San Marcial" conducted by the University of New Mexico Office of Contract Archeology (OCA) in August and September, 1997, pursuant to Corps of Engineers Solicitation DACW-D-94-0019, Delivery Order 13 (UNM/OCA Proposal nos. 185-606 and 185-606a). The present project is the first of two cultural resource surveys to be conducted under Delivery Order 13. The other survey will involve levee alignments between Isleta Pueblo and Belen, and OCA proposes ultimately to combine the letter reports prepared for both surveys into a single bound and published final report.

This letter also serves to convey to you deliverables specified in the Revised Scope of Services: *(a)* the daily field logs (1 copy), *(b)* the remainder of the data compendium, consisting of the completed Laboratory of Anthropology (ARMS/NMCRIS) site forms and related documentation (3 copies), *(c)* the photographic note book, and *(d)* a DOS-compatible disk containing relevant project computer files that is certified virus-free. Also attached under the heading "Part 2" is a separate report on OCA's use of Global Positioning System (GPS) equipment to locate salient survey features, such as archeological sites and access routes, in the field.

Under separate cover (September 23, 1997), OCA submitted two sets of maps that comprised the first part of the data compendium. One map set consists of the "blueline" orthophoto maps (scale 1 inch:400 feet) provided by your office (the "CoE maps", sheet numbers 53-79, see below). These maps are annotated with the locations of surveyed archeological sites, other known sites, surveyed proposed habitat improvement area (HIA) access routes, and other pertinent HIA access information. The other maps set consists of 19 copies of portions of ARMS/NMCRIS 7.5 min USGS maps, which show known Laboratory of Anthropology site locations within the entire project corridor. The ARMS/NMCRIS Project/activity number for the present project is 58373.

Project Activities

Between August 25 and September 12, 1997, the University of New Mexico Office of Contract Archeology (OCA) conducted an archeological survey of approximately 45 miles of levee along the west bank of the Rio Grande in Socorro County between the San Acacia diversion dam in the north and the railroad bridge across the Rio Grande ca. 0.5 mi south of old San Marcial, NM for the US Army Corps of Engineers, Albuquerque District (CoE). Figures 1 and 2 show the project area together with the plotted locations of known archeological sites within the project corridor (see below). In addition, the levee that lies east of the AT&SF railroad bed for some 3.5 mi north of the railroad bridge and the east-west levee segment that connects this levee with the main levee were surveyed as well. An attempt was made to survey the proposed railroad realignment south of old San Marcial, but the area involved is choked with thick, high (20-30 ft) bosque vegetation (mostly willow and tamarisk) and is essentially impassable and can not be surveyed without sophisticated equipment (see example slides in the photographic notebook). Finally, reconnaissance survey of potential access to a total of 10 *habitat improvement areas* (HIAs) was conducted, including four proposed access roads across undisturbed areas. Two archeological sites were located during this portion of the survey and were recorded on Laboratory of Anthropology (ARMS/NMCRIS) site forms.

Survey Results

Survey of the existing levee alignments yielded a total of two isolated lithic artifacts, none of which could be associated with an existing site. Per specifications in the scope of services, these artifacts were neither recorded nor collected. No prehistoric or historic archeological sites were encountered. One previously recorded site (LA 755, a large, Pueblo III site with extensive structural remains) was encountered during reconnaissance of existing access to the proposed HIAs (HIA 95, north end). In addition, two previously unrecorded sites were discovered along the proposed access routes to HIAs 82 and 77. The two new sites were recorded and mapped using Laboratory of Anthropology (ARMS/NMCRIS) forms and standard OCA analysis forms. Two other new sites were noted near HIA 82 but were not recorded (see below).

Results of the reconnaissance survey of access into the ten HIAs indicated on the CoE maps is summarized in Table 1. Access via existing dirt roads was confirmed for five of the HIAs. Two sites were found along existing roads that access HIA 95, and a 400x100-ft corridor connecting the southeast corner of HIA 95 and an existing road was surveyed and found to be free of sites (see CoE map 62). Four proposed access routes through undisturbed areas were also surveyed for HIAs 100, 99, 82, and 77. Archeological sites were found along two of these routes (HIAs 82, 77). Surveyed beginning points for each of the HIA access routes, as well as the mapping datums established at each of the two recorded archeological sites were marked with 14-inch rebar stakes and aluminum caps stamped with identifying HIA or site numbers. GPS-based locational data for these stakes are provided in Table 2 (see attached Part 2 of the report for an explanation of the derivation of these data).

Site Description: LA 119574 (OCA:606-1). LA 119574 is an extensive artifact scatter that was found along the proposed access to HIA 82 (Figure 3). The site is located on and around the high point of an old point bar on the eastern side of the Rio Grande floodplain (possibly a Holocene-age terrace). Corps of Engineers aerial photos show older meander loops to the east. The site sits 1-2 m above the current floodplain. Surface artifact density is highest around the center (high point) of the site but extends ca. 100 m to the north and south, 120 m to the east, and ca. 50 m to the west, where the terrain slopes downward gently to the edge of the floodplain and thick bosque vegetation. Only the central portion of the site was flagged and recorded, and the site's boundary was only loosely defined (other artifact concentrations -- presumably representing other sites were observed ca. 450-600 m to the south).

Surface deposits are characterized by an eolian sand sheet (estimated at 20-30 cm thick) overlying alluvial sands and gravel, which are locally exposed in blowouts. Artifacts are more common in the blowouts, suggesting that buried cultural materials are likely common. Ceramic and lithic artifacts (including ground stone) are present in roughly equal amounts ~~the~~ and number in the hundreds. Small numbers of fire-cracked rock (mostly quartzite) were also observed. No architecture or features were observed, but their presence can not be precluded, given the nature of the surface deposits.

Socorro B/W, Elmendorf B/W, Chupadero B/W, and three varieties of White Mtn. Redware (Wingate and St. John's B/R, St. John's poly) all indicate a distinct late Pueblo-III occupation, ca. AD 1100-1300. Despite the absence of obvious residential features, the site's lithic artifact assemblage (numerous chipped stone tools and some ground stone observed), together with occasional FCR indicates a variety of possibly residential activities. The most popular lithic material is a distinct red/brown orthoquartzite. In addition, the site's setting is quite similar to that of Qualacu Pueblo, located some 700 m to the north, and the site is considered eligible to the NHRP.
NRHP

Two other probable prehistoric sites were encountered during reconnaissance of HIA 82, but were not recorded. They lie south of LA 119574 north of the end of an existing dirt road that leads to an apiary. Two ARMS/NMCRIS sites (LA 8743 and LA 8748) lie just the south of these sites (see sheet number 68). There is some confusion concerning if LA 8743 and LA 8748 are properly located and/or represent two separate sites. ARMS/NMCRIS personnel are investigating. It is possible that one or both of the two unrecorded sites mentioned above are actually the same as either or both LA 8743 and LA 8748. The location plotted for LA 8743 on CoE map 68 is based on the location indicated on the ARMS/NMCRIS map, while that for LA 8748 is based on converted coordinates supplied by CoE.

Site Description: LA 119575 (OCA:606-2). LA 119575 consists of a well-defined artifact scatter that was found along the proposed access to HIA 77. This route occupies a low ridge or tongue of alluvial gravel that extends northwest onto the current Rio Grande floodplain from the bordering terrace to the east. The tongue slopes gently down from the southeast. The terrace scrub-grassland gives way to thick bosque vegetation some 250 m to the southeast of the site, and with the exception of the site area proper, this thicket extends to the edge of the present-day river bed. The site itself is curiously devoid of all but the occasional tamarisk and mesquite and exhibits grasses and unidentified forbs that occupy ca. 50 % of the surface. Surface deposits

are mostly alluvial sand and gravel with a thin eolian veneer. The ridge slopes gently to the northwest, and slightly more steeply to the southwest and northeast where the sand and gravel merge with floodplain silts and clays. Aerial photos indicate the low ridge separates two old river meanders.

The site was given the name "Temple of Doom" on the basis of three factors: (1) the nearly impassable jungle of tamarisk, Russian olive, and other thorny trees must be traversed to reach the site; (2) the site's rich artifact assemblage and probable Archaic age; and (3) the fact that the site was guarded by a hovering horde of blood-sucking insects.

107 lithic artifacts, including numerous chipped stone tools and three one-hand manos were recorded and represent 50-80% of the site's surface assemblage. One brownware sherd was also noted but is presumed to be intrusive. Although no projectile points were found, the site exhibits several characteristics that suggest an Archaic period occupation, despite various warnings against the use of such criteria: bifaces and evidence of biface manufacture, one-hand manos, abundant fire-cracked rock, and high lithic raw material variety, including probable non-local materials (e.g., the raw material assemblage differs markedly from that observed at OCA:606-1 some 4 km to the north). Several well-made scrapers were observed, including an endscraper and a circular (or end) scraper made of possible Alibates chert (collected). As noted, lithic raw materials exhibited considerable variety, including several separate cherts and chalcedonies, as well as rhyolite and some of the orthoquartzite observed at OCA:606-2. All stags of reduction are represented in the lithic assemblage, as is evidence of tool use. The site's abundant fire-cracked rock assemblage was not consistently recorded, but it is dominated by quartzite and non-basalt volcanics.

One probable hearth feature (Feature 1) was observed in the southwestern portion of the site. Internal differentiation of the site's artifact density and activities was also noted (see artifact concentration on map [many artifact in this locale were of rhyolite]). The site's hearth feature, together with the chipped and ground stone tools present suggest that the site was used for at least temporary residential purposes, possibly in conjunction with exploitation of riparian resources. Thus the site may represent a valuable example of Archaic period use of the Rio Grande's rich riparian resources, and, as such, the site is considered eligible to the NHRP.

Use of Extant Archeological Records to Assess Project Impact

As called for in the scope of services, data from ARMS/NMCRIS were used to determine if any known archeological sites lie within the project area, or within or near any of the HIAs or proposed access routes. ARMS/NMCRIS site numbers and coordinate data supplied by the Corps of Engineers were used in conjunction with copies of relevant portions of the master ARMS/NMCRIS USGS maps to plot known site boundaries (or locations) on the CoE maps. The area encompassed by these maps (excluding map numbers 76-79, which lie outside the present survey area) was used to define the "project right-of-way.

This component of OCA's work involved two steps. First, known site boundaries and LA numbers were transferred to the CoE maps from USGS map portions provided by

ARMS/NMCRIS via fax. The two sites recorded by OCA at HIAs 82 and 77 were also marked on the CoE maps. During this process, as known sites were plotted, they were checked off on the project corridor list provided by CoE. Second, the coordinates of any sites not checked off were then evaluated to determine if they do in fact fall within the CoE map limits. A few sites were added on this basis, including two sites whose coordinates indicate that they lie in the middle of the current river bed, suggesting that the coordinate data may contain errors. Finally, a few sites, whose coordinates place them at locations lacking sites on the ARMS/NMCRIS maps were plotted, and personnel at ARMS/NMCRIS were notified of possible problems with location/coordinate information. To the best of our knowledge, all ARMS/NMCRIS listed sites that fall within the project limits -- as defined by the CoE maps -- have been plotted on the CoE maps. As noted above, also attached are the 7.5 min USGS map portions faxed to our office by ARMS/NMCRIS that show all mapped Laboratory of Anthropology sites within the entire project vicinity. No ARMS/NMCRIS sites fall on or immediately adjacent to the surveyed levee segments or within HIAs as marked on the CoE maps.

Of the known sites plotted on the CoE maps, seven may be most likely to be impacted by access to proposed HIAs. These are LA 755 (HIA 95); LA 119574 and two unrecorded sites to the south, LA 8743, and LA 8748 (HIA 82), and LA 119575 (HIA 77). A number of sites that lie along the north-south running access road on the east side of the Rio Grande within the Bosque del Apache National Wildlife Refuge may also be affected by access to the various HIAs in this area (see maps). The latter sites are LA 757, LA 758, LA 771, LA 80057, LA 54001-LA 54010, and LA 54013.

In addition, although not plotted on the ARMS/NMCRIS maps, the Civil War Val Verde Battlefield lies in the vicinity of the village of old San Marcial and includes areas affected by two proposed CoE activities: *(a)* the proposed realignment of the southern portion of the existing levee to coincide with the existing railroad alignment east of San Marcial and north of the railroad bridge, and *(b)* the proposed railroad realignment in the area south of old San Marcial and west of the bridge (not surveyed, see above). Whether or not this location -- the site of one of two major Civil War battles fought in New Mexico (see Figure 5) -- is on the NHRP, is currently unknown, but it is obviously a site of considerable historic significance. No evidence of the battlefield was encountered during the levee survey conducted in this area, however.

The Battle of Val Verde took place February 13-21, 1862, and was one of two major Civil War engagements between US and Confederate forces that took place in in New Mexico; the Battle of Glorieta Pass was the other. The Battle of Val Verde is documented in a manuscript entitled *The Prudent Soldier, the Rash Old Fighter, and the Walking Whiskey Keg*, by C. Kirkpatrick and C. Crane, on file at OCA).

It has been our pleasure to aid the Corps of Engineers Albuquerque District in managing cultural resources. If you have any questions, please feel free to contact me.

Sincerely,
William H. Doleman
Project Director

DRAFT

GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-9

Ecological Resources

APPENDIX F-9
ECOLOGICAL RESOURCES

1. PRELIMINARY EFFECTS DETERMINATION, SCREENING OF ALTERNATIVES (January 2008)

Thirteen with-project alternatives (Alternatives A - K) were evaluated for potential beneficial or adverse effects, and requirements for mitigation. Four basic ecological resources were recognized for evaluation purposes: riverine aquatic habitat, riparian habitat, the Federally endangered Rio Grande silvery minnow (*Hybognathus amarus*), and the Federally endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*). For convenience, this evaluation groups effects into two broad categories: those related to changes in inundation, and those related to construction and the required footprints of features.

INUNDATION

Adverse ecological affects likely to result from flood events includes the physical destruction of vegetation from high flow velocities, soil erosion, and/or sediment deposition; the temporary displacement of non-aquatic animals; and the death (primarily through drowning) of non-arboreal mammals and reptiles. Because little information exists to quantify and predict impacts to animal populations, the following discussion of ecological effects focuses on vegetation communities and areal extent of inundation as constituents of wildlife habitat quality. No attempt has been made to monetarily quantify the discussed effects. Specific habitat effects are discussed for two endangered species: the Rio Grande silvery minnow and the Southwestern Willow Flycatcher.

1%-chance Floodplain

Specific impacts were not quantified for this relatively rare event. Qualitatively, it is believed that this event is sufficiently severe to result in overall adverse effects to plant and animal communities.

Without Project

Without project, ecological damage from the 1%-chance flood event is to be expected both within the current floodway and throughout the floodplain west of the levee or railroad alignment. Affected plant communities in the floodplain include: rural and suburban yards; agricultural fields and edges; upland Chihuahuan desertscrub; and wetland and riparian communities managed at Bosque del Apache NWR.

With Project (Levee Alternatives)

For the with-project condition, ecological damages in the floodplain west of the levee alignment are essentially eliminated; however, adverse impacts would still occur within the riparian and aquatic communities in the floodway. Adverse effects would be extensive, yet similar to the without-project condition. Although inundation, scouring and sediment accretion are natural processes of sand-bed rivers such as the Rio Grande, the recovery of plant and animal communities from the 1%-chance flood would be slow.

Differences in effects among the various levee heights evaluated are a matter of degree, with increasing protection of floodplain communities and increasing potential damage to floodway communities. Considering the relatively rare occurrence of the 1%-chance and larger events, the economic damages that

are prevented constitute a more important parameter for levee-height determination than the differential ecological damages.

10%-chance Floodplain

For the more probable 10%-chance event, some specific effects can be quantified. This event would most likely result from rainstorm activity; therefore inundation would be of short-duration.

Without Project

Generally, without the project, levee failure would result in inundation both within the current floodway and throughout the floodplain. Breached or damaged spoil bank levees would likely be quickly repaired or rebuilt along the existing alignment.

Although periodic floodplain inundation outside of the existing levee alignment has the potential for providing allocthonous material to the Rio Grande, historic and existing land uses west of the levee also present potential hazards to water quality. Following a levee breach, floodwaters would likely be of low quality and could result in the introduction of contaminants (sewage, POLs) to the river, and, therefore, would not be considered beneficial to aquatic habitat and organisms.

With Project

With the proposed levee replacement, the event would be contained within the current floodway. The differences in depths and velocities of the with- and without-project 10%-chance events are nominal; therefore, the extent of adverse effects would be similarly small. The magnitude of the event (approx. 10,000 cfs) is within the range of unregulated snowmelt and thunderstorm flows recorded in the Middle Rio Grande over the past 100 years, and well within the flow regime that the predominant riparian species (cottonwood, willow) have adapted.

With levee replacement, potentially adverse flooding impacts to approximately 15,000 to 20,000 acres (depending on alternative) of Chihuahuan desertscrub and agricultural habitat (and their attendant animal populations) would be prevented (Table 1).

Table 1. 10%-chance floodplain acreages for with- and without-project alternatives.

Alternative	Inundated area (ac.)	Difference from Without-project (ac.)	
10-yr Future cond., Without project	36,200	--	
10-yr Future cond., With project:			
Alts. E - F	36,200	0	
Alts. A - D (levee to Tiffany Jct.)	21,100	-15,100	Upland & undeveloped historic riparian areas removed from inundation area.
Alts. G - I (Additional levee west of Tiffany Basin)	15,400	-20,800	An additional ~5,000 acres of undeveloped historic riparian area west of LFCC is removed from inundation area.
Alts. J - K (Additional levee east of Tiffany Basin)	13,400	-22,800	A yet additional 2,000 riparian acres removed from inundation (Tiff. Basin).

Levee height alternatives: Levee height does not affect the behavior of the 10-yr event.

Rio Grande silvery minnow (RGSM) are small fish that cannot swim against high velocities for extended periods. With-levee-project depths and velocities within the 10-year floodplain were reviewed to evaluate potential effects on RGSM. Average with-project water depth in the overbank area increases by 1 to 2 feet, and extensive shallow (2 feet or less) areas still occur. Likewise, representative with-project cross-sections (e.g., Figs. 1 through 3) indicate that relatively slow-flowing (<2 ft/sec) areas are extensive enough to provide refugia for the RGSM. Summarizing, sufficient slackwater areas would remain after levee replacement to avoid flushing RGSM from the San Acacia reach.

Southwestern Willow Flycatchers (SWFLs) regularly nest in the riparian zone from Tiffany Junction downstream into the headwaters of Elephant Butte Reservoir. Upstream to San Acacia Diversion Dam, scattered, individual territories are established in some years. The slightly increased inundation area of the 10-% chance flood would benefit riparian habitat, including suitable and potentially suitable breeding habitat for the SWFL. With-project surface water elevations of the 10%-chance event would increase slightly, or decrease, in the downstream end of the study reach (Fig. 4), and would not result in the increased inundation of SWFL nests (if the event were to occur in June or July).

Tiffany Sediment Basin

Inundating the 2,000 acre Tiffany Basin would dramatically increase riverine aquatic habitat in the Middle Rio Grande. After sufficient sediment accumulates in the basin to reduce the possibility of mainstem headcutting, the Tiffany east spoil bank levee could be removed, opening the entire area to "run-of-the-river" flows. With sedimentation over time, the habitat would progress from aquatic habitat to a riparian plant community. Expected accumulation of sediment in the Tiffany Basin — rather than in Elephant Butte Reservoir — is on the order of 15,000 acre-feet.

The present plan proposed to introduce sediment into Tiffany Basin through a weir inlet, and evacuate water from the basin into the Low Flow Conveyance Channel through a screened outlet. Rio Grande silvery minnow would, therefore, become trapped in the Tiffany Basin in large numbers, and expire as the basin seasonally dried. Screening the inlet to prevent RGSM passage through the weir would also exclude the majority of bed material, defeating its purpose. To date, no other design solution has been formulated to resolve this issue.

Despite the potential for large ecological benefits, implementation of the Tiffany Sediment Basin also entails potentially significant adverse impacts for the RGSM which, at this time, could not be mitigated. For these reasons, the Tiffany Basin feature should not be included in the recommended plan for the San Acacia to Bosque del Apache flood damage reduction project.

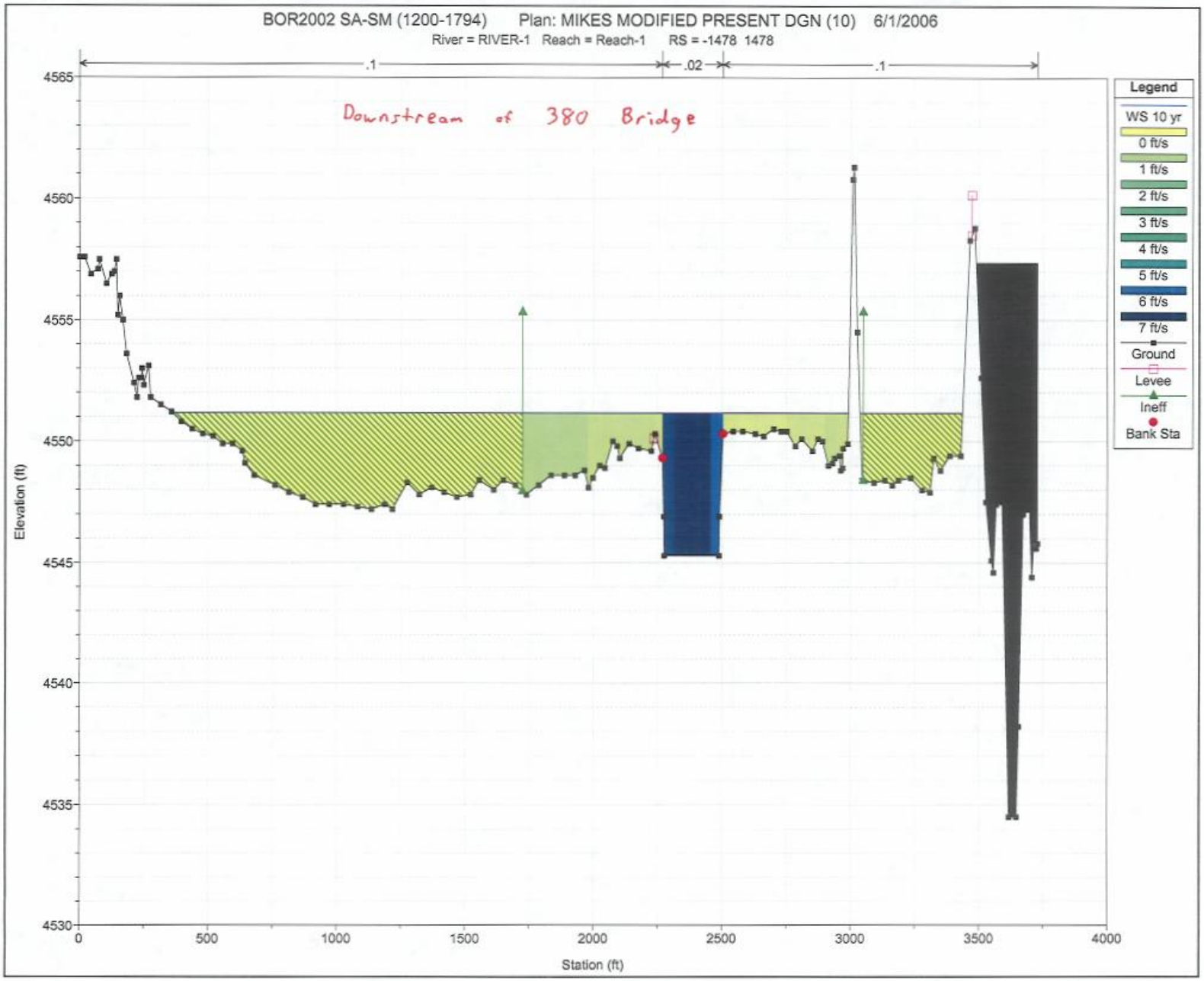

Figure 1. 10%-chance event velocities near Hwy 380 bridge.

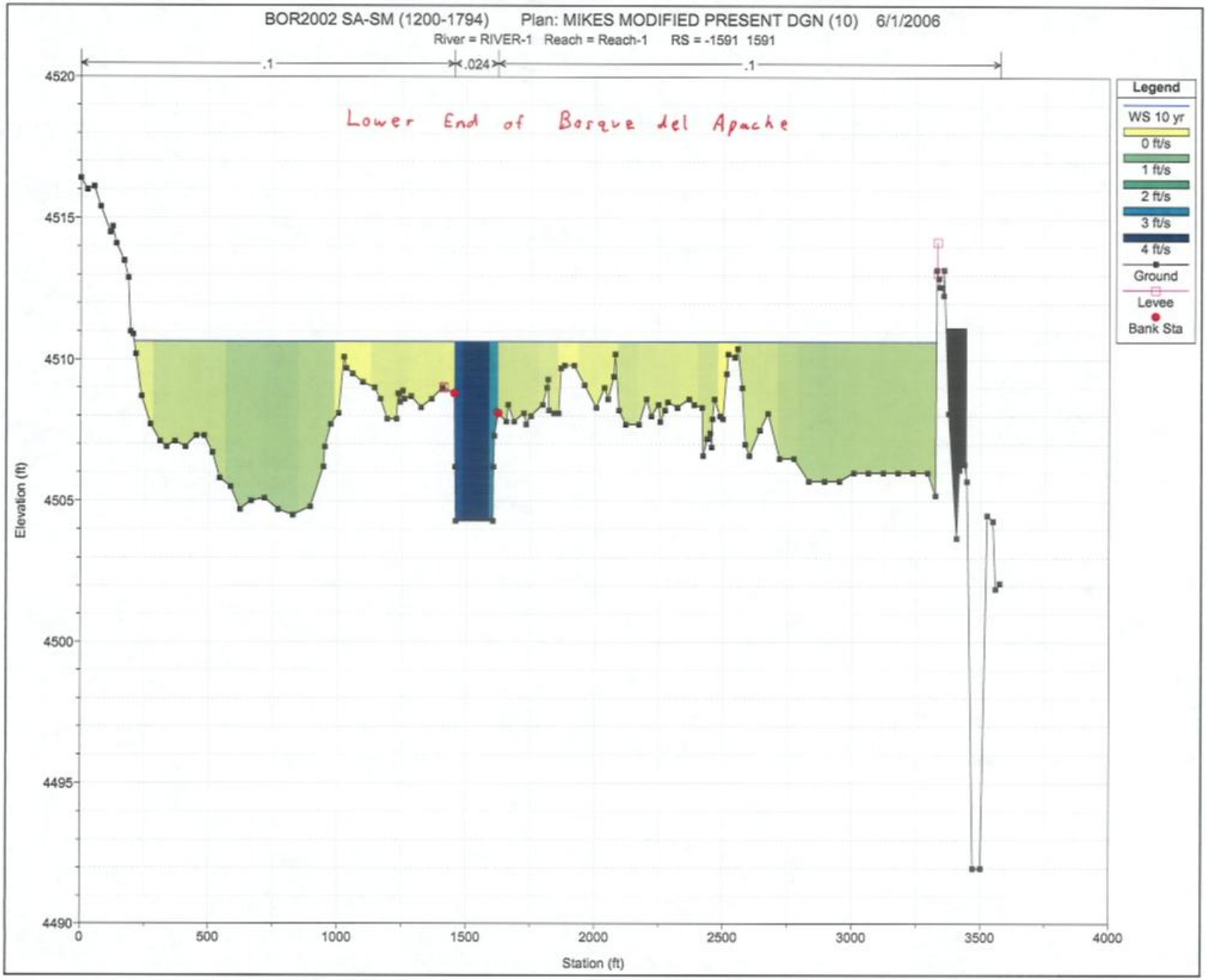

Figure 2. 10%-chance event velocities near Bosque del Apache.

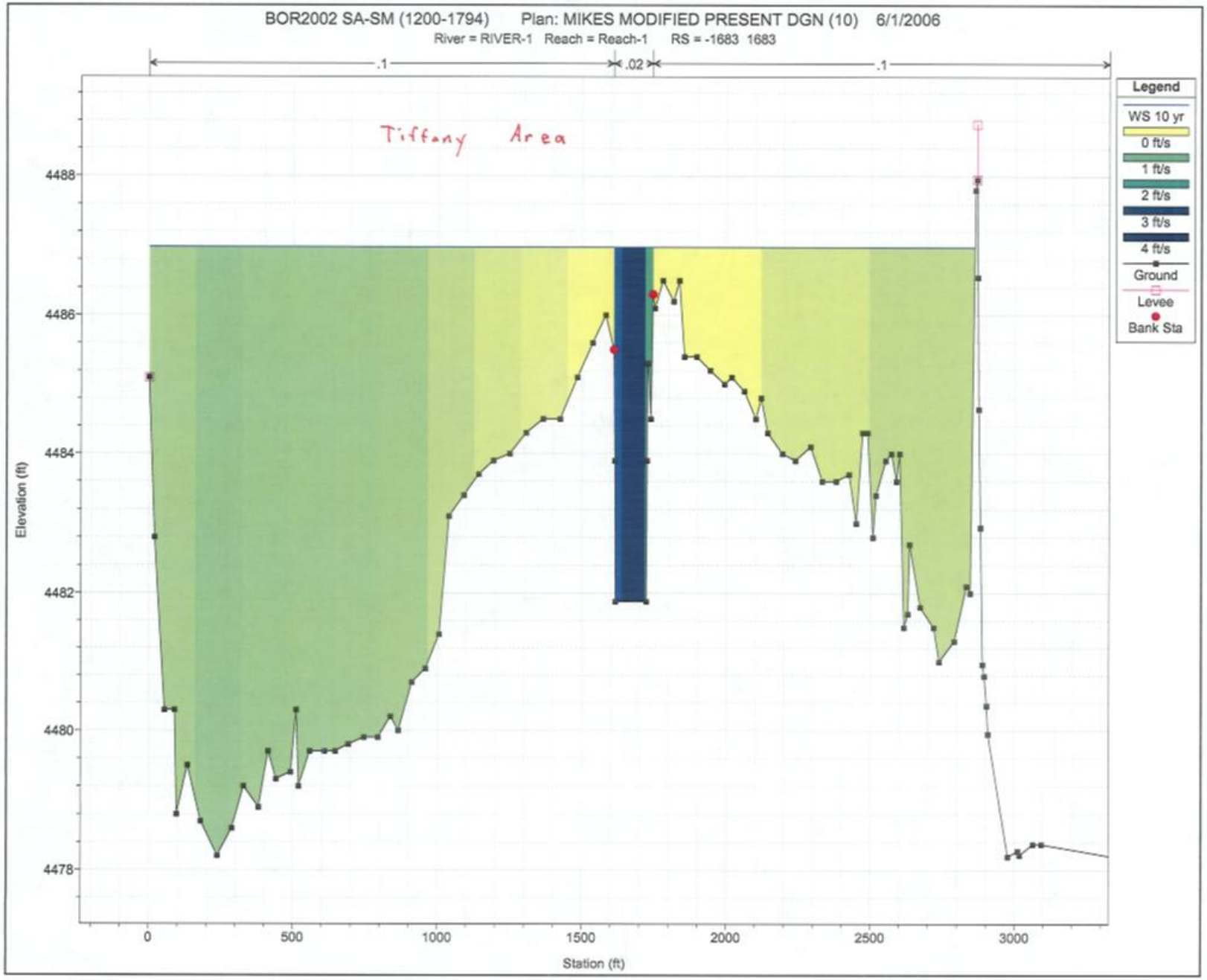

Figure 3. 10%-chance event velocities near Tiffany Basin.

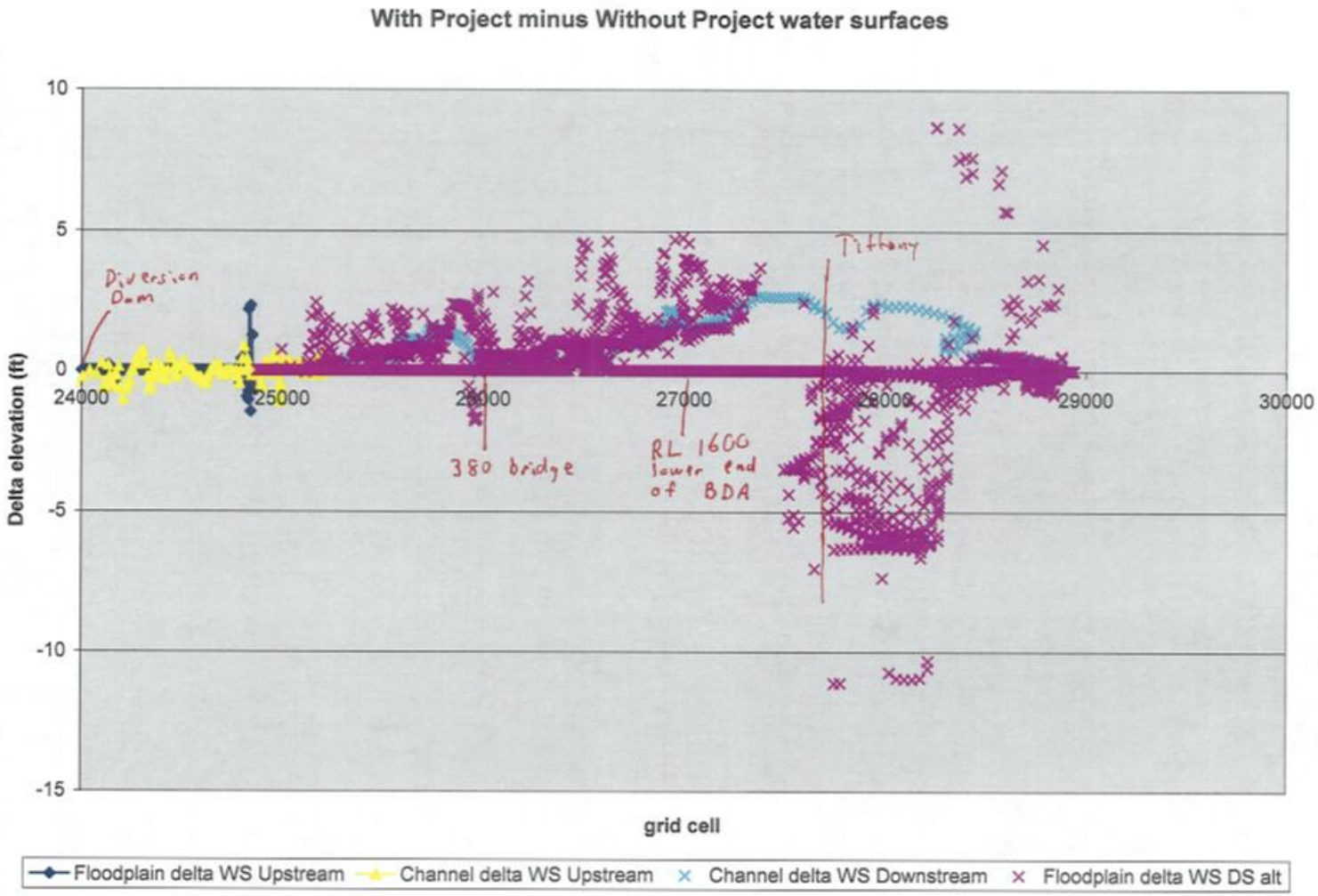

Figure 4. 10%-chance event, with-project water surface change.

FEATURE FOOTPRINTS

Alternative A (Primary Levee from San Acacia to Tiffany Junction)

Levee Heights and Footprints

Five levee height alternatives were included in plan formulation and NED analysis. These were based on the 100-yr water surface elevation, and increased in one-foot increments to the 100-yr + 4-feet water surface elevation.

Templates of the 100-yr and 100-yr+4ft levee cross-sections superimposed on existing topography (see examples in Figs. 5 through 7) were reviewed to estimate potential effects on riparian vegetation bordering the riverward toe of the levee. Between stations 08+00 and 1300+00, proposed levee base widths are less than the existing spoilbank width (by 50 feet or more) for all levee height alternatives. From about 1300+00 to 1900+00, the 100yr+4ft base width equals the existing width, and all other height options are less than the existing width. From about 1900+00 to 2264+00, the 100-yr base width equals the existing, and the 100yr+4ft width exceeds the existing width by approximately 30 feet.

Therefore, removal of riparian vegetation would be required in the downstream 7 to 18 miles of the proposed 46.7-mile-long primary levee. However, because the proposed levee (whatever the height) would be significantly narrower than the existing spoil bank in the upstream 30 to 40 miles, there will be a net increase to the floodway area following construction. Sufficient "newly exposed" acreage would be available for the planting of riparian trees and shrubs to offset vegetation losses at the downstream end of the levee.

Potential areas of riparian vegetation removal would not affect recent territories of breeding Southwestern Willow Flycatchers for the Alternative A segment.

Summarizing, there is no environmental preference among the 5 height alternatives analyzed for the primary levee. Although a levee with a larger cross-section would potentially require more mitigative plantings, the cost of those plantings would be more than offset by the inherent decreased cost of waste haul and disposal.

Vegetation-Free Zone

EM 1110-2-301 requires that no vegetation (except grasses) be allowed to grow within 15 feet of the riverward toe of new levees. Based on the discussion of levee base widths above, this would require the removal of existing riparian vegetation in the downstream 7 to 18 miles of the alignment. The respective areas of potential vegetation removal are 13 to 33 acres.

Again, the significantly narrower proposed levee (whatever its height) in the upstream 30 to 40 miles of the alignment would result in more than sufficient area (perhaps, 150 acres) for mitigative planting.

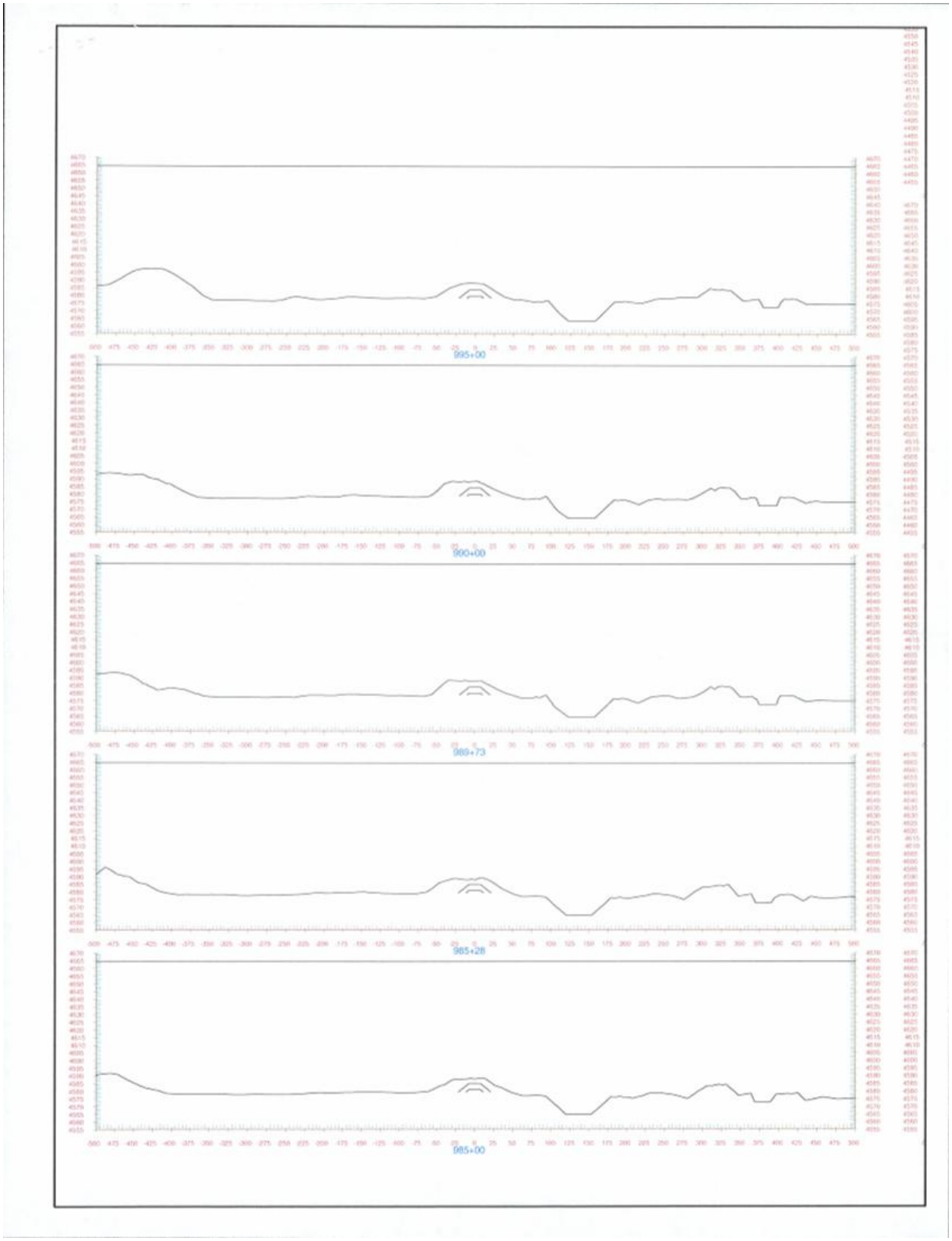

Figure 5. Example levee cross-section template.

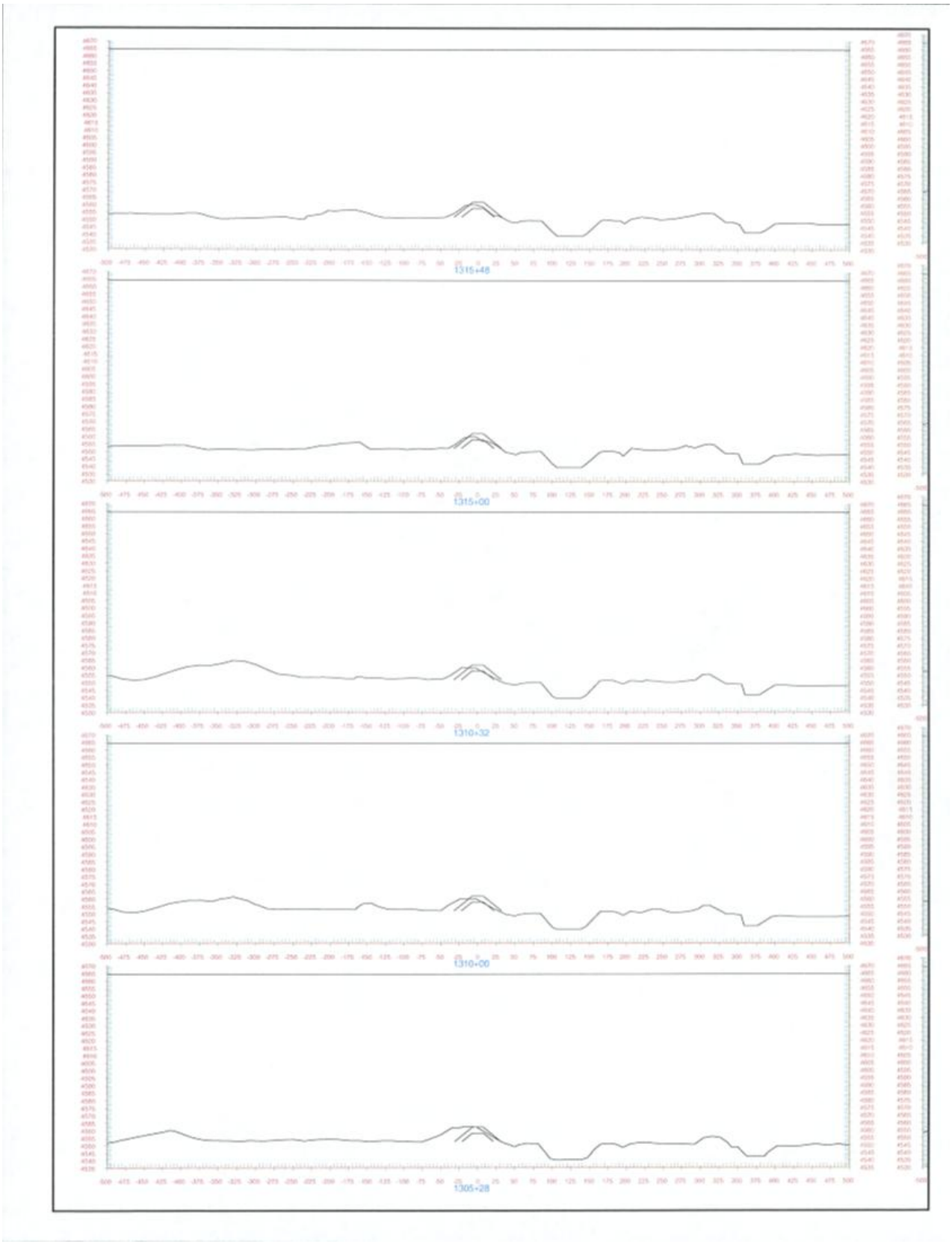

Figure 6. Example levee cross-section template.

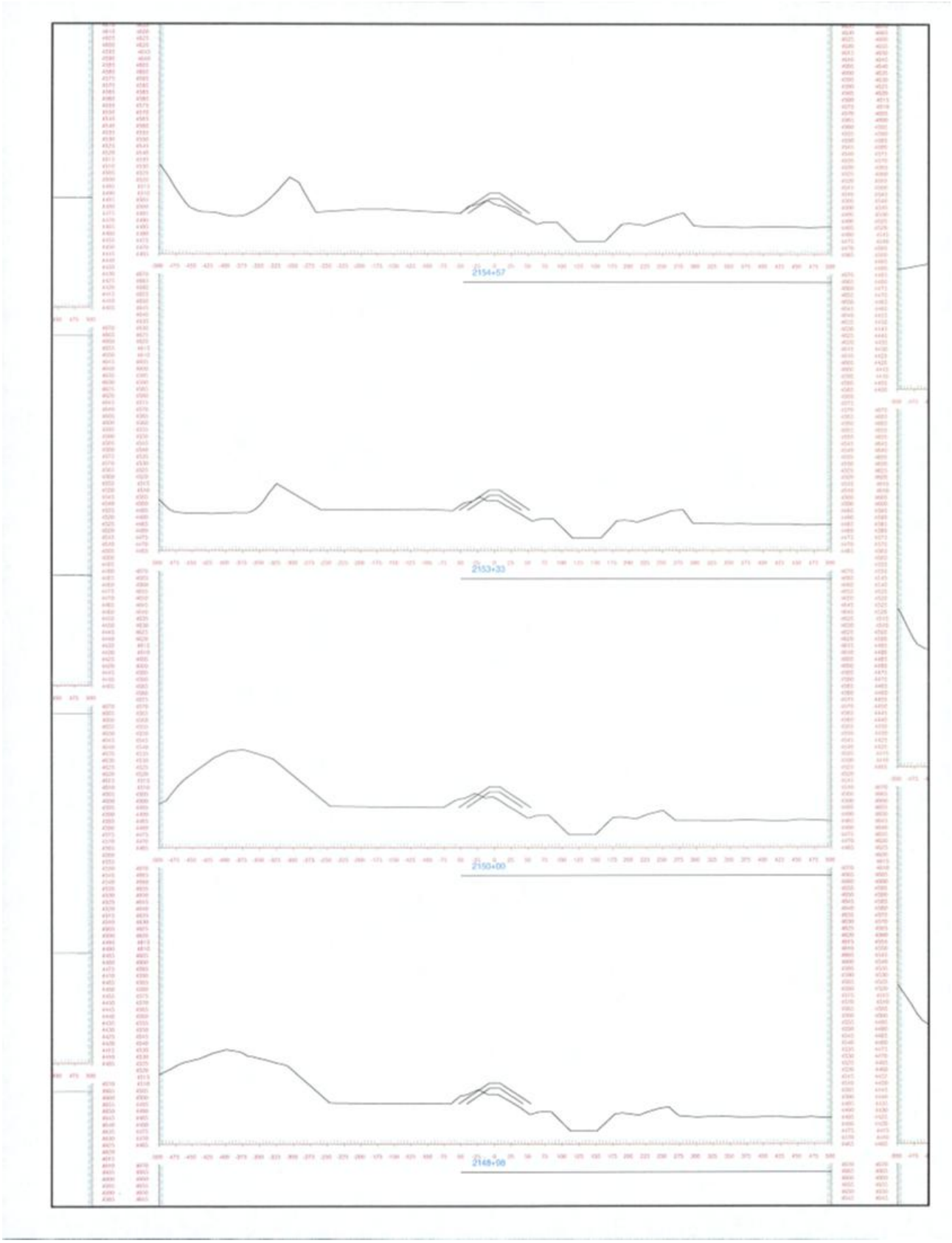

Figure 7. Example levee cross-section template.

Alternatives G - I (Tiffany Levee, West Side)

Dimensions for the alternative levee segments below Tiffany Junction and the new bridge approach were not explicitly provided, and therefore were estimated for the 1%-chance event (Table 2). These dimensions (and associated effects) may increase with increasing levee height.

A new levee abutting the existing railroad track on the west side of Tiffany Basin would displace approximately 15 acres of riparian vegetation. The required vegetation-free zone would convert about 5 acres of mixed riparian shrubs to grassland.

Table 2. Estimated dimensions of alternative features downstream from Tiffany Junction.

Features	Proposed base width (ft)	Existing base width (ft)	Difference in base width (ft)w	Length (ft)	Length (mi)	New footprint area (ac)	Vegetation-free area (ac)
Alts. G-I (Tiffany west)	45	0	45	14,942	2.83	15.44	5.15
Alts. J-K (Tiffany east)	100	60	40	21,384	4.05	19.64	14.73[a]
San Marcial bridge approach	140	0	140	7,300	1.38	23.46	3.31[b]

[a] A vegetation-free zone would be maintained on both sides of the new levee.
[b] A vegetation-free zone would be maintained on both sides of a portion of the new approach.

Alternatives J - K (Tiffany Levee, East Side)

An engineered levee would replace the existing spoil bank between the Tiffany Basin and the active Rio Grande floodway. Approximately 20 acres of riparian vegetation would be displaced by the proposed footprint (Table 3). A vegetation-free zone would be required on both sides of this levee segment, and would replace about 15 acres of riparian shrubs.

Suitable, and frequently occupied, Southwestern Willow Flycatcher breeding habitat borders the riverward side of this levee segment. Adverse impacts to SWFL habitat can be avoided if the new levee footprint does not extend eastward of the existing riverward toe of the spoil bank.

San Marcial Railroad Bridge Approach

The approach to a new San Marcial Railroad Bridge would include a realigned railroad bed and an engineered levee abutting the bed on the riverward side. The estimated areas of riparian vegetation displaced by the footprint and vegetation-free zone would be approximately 24 and 3 acres, respectively (Table 3). This includes the highest-quality riparian vegetation along the entire San Acacia levee alignment. Breeding SWFL are regularly known to occupy this area. This adverse effect may be offset by increased riparian inundation over 163 river-miles facilitated by a new bridge.

Tiffany Sediment Basin

The footprints of the weir and outlet structures associated with this feature are minimal. The benefit of the 2.000-acre "footprint" of the basin itself was addressed in the Inundation portion of this analysis.

RANKING OF ALTERNATIVES

Given the variety of ecological resources evaluated, there is no index of habitat value that is common to all. Therefore, overall effects to ecological resources were evaluated based on the following relative scale:

+3	Significant beneficial
+2	Moderate beneficial
+1	Minor beneficial
0	No effect, or no net effect
-1	Minor adverse
-2	Moderate adverse
-3	Significant adverse

These numeric values are relative and are not intended to be arithmetically summed when evaluating the overall effect of a specific alternative.

Table 4 summarizes the ecological resource rankings of the 13 evaluated alternatives. Generally, potential impacts related to levee features are minor to moderate, and can be mitigated through avoidance or replacement plantings. The unavoidable significant adverse effect to Rio Grande silvery minnow associated with the Tiffany Sediment Basin feature strongly influences the low ranking of all alternatives that include that feature. Conversely, the relatively large and extensive beneficial flooding effects associated with San Marcial Railroad Bridge replacement are a positive influence on the ratings of alternatives including that feature.

The three most favorable alternatives based on the least impact to ecological resources are:

Alt. I - Primary levee, Tiffany west levee, and San Marcial Railroad Bridge.

Alt. C - Primary levee and San Marcial Railroad Bridge (railroad is still susceptible to flood damage)

Alt. A - Primary levee.

Table 4. Relative ranking of alternatives.

Alterna-tive	Features in Alternatives					Ecological Resources				Overall Ecological Resource ranking
	San Acacia to Tiffany Jct. levee	Tiffany Jct. to San Marcial levee – West	Tiffany Jct. to San Marcial levee – East	San Marcial Railroad Bridge	Tiffany Sediment Basin	Aquatic Habitat	Rio Grande silvery minnow	Riparian Habitat	South-western Willow Fly-catcher	
A	X					+1 inund'n	0 inund'n	0 inund'n -1 footprint	0 inund'n 0 footprint	**+1**
B	X				X	+2 inund'n	-3 inund'n	0 inund'n -1 footprint	0 inund'n 0 footprint	-3
C	X			X		+1 inund'n	0 inund'n	+2 inund'n -1 footprint	+2 inund'n -1 footprint	**+2**
D	X			X	X	+2 inund'n	-3 inund'n	+2 inund'n -1 footprint	+2 inund'n -1 footprint	-3
E				X		0 inund'n	0 inund'n	+2 inund'n -1 footprint	+2 inund'n -1 footprint	+2 But no flood risk reduction
F					X	+2 inund'n	-3 inund'n	0 inund'n 0 footprint	0 inund'n	-3 No flood risk reduction
G	X	X		X	X	+2 inund'n	-3 inund'n	+2 inund'n -1 footprint	+2 inund'n -1 footprint	-3
H	X	X			X	+2 inund'n	-3 inund'n	-1 inund'n -1 footprint	0 inund'n 0 footprint	-3
I	X	X		X		+1 inund'n	0 inund'n	+2 inund'n -1 footprint	+2 inund'n -1 footprint	**+2**
J	X		X	X		+1 inund'n	0 inund'n	+1 inund'n -1 footprint	-1 inund'n -1 footprint	-1
K	X		X			+1 inund'n	0 inund'n	-2 inund'n -1 footprint	-1 inund'n -1 footprint	-1

2. BACKGROUND MATERIAL FOR FINAL EFFECTS DETERMINATIONS (March 2012)

Construction activities and the post-project footprint of the proposed / alternative earthen levees are primary factors of potential ecological effects. Geo-referenced basal extents of the both the 1%-chance-event and the 1%-chance-event+4-ft levees were superimposed on digital aerial photography from 2010, and on riparian vegetation coverage mapped in 2007 (Parametrix, 2008). These layers were analyzed to estimate potential changes to the floodway area and riparian vegetation bordering the riverward toe of the levee.

The position of the riverside toe of the new levee was determined relative to that of the existing soil bank at numerous locations along the 43-mile alignment. At each location, this offset (whether landward or riverward), and the ensuing affected area, determined the potential changes in floodway area and riparian vegetation.

Two levee height alternatives were analyzed: at the 1%-chance-event water surface elevation, and four feet taller than the 1%-chance-event water surface elevation (proposed plan). Due to its additional height, the 1%-chance-event+4-ft levee would be 20 to 24 feet wider than the 1%-chance-event levee, depending on whether the side slopes are 2.5:1 or 3:1, respectively.

Throughout the project area, the Rio Grande occupies a physically well-defined channel; however, flows regularly reach a magnitude to inundate portions of the overbank area adjacent to the channel. Therefore, for the purposes of this evaluation, the Ordinary High Water Mark (OHWM) was defined as the extent of the 50%-exceedance discharge. This discharge — 5,660 cfs — was determined by Tetra Tech, Inc. (described in Parametrix [2008][1]), and was based on mean daily discharge values at the San Acacia streamflow gage for the period 1974 through 2002. The Parametrix (2008) investigation also modeled and mapped these flows using the two-dimensional, FLO2-D hydraulic model. The mapped extent of inundation for the attenuated 5,660-cfs discharge at San Acacia served as the basis for determining the OHWM in the evaluation of effects.

The following tables depict the spreadsheet calculations that were used to quantify effects described in the GRR/SEIS.

[1] Parametrix. 2008. Restoration Analysis and Recommendations for the San Acacia Reach of the Middle Rio Grande, NM. Prepared for the U.S. Bureau of reclamation, Albuquerque, and the Middle Rio Grande Endangered Species Collaborative Program.

Spreadsheet 1. Change in floodway area: Alt. A + 4 ft Levee.

			Alt. A + 4ft Levee							
			Acres of floodway lost (-) or gained (+) due to project features				Within the gained floodway area … area suitable for woody plantings (i.e., outside of VFZ)			
Label or note	Station (+00)	Station as ft	New riverward toe is x ft from old riverward toe (- = landward; + = riverward)	Acres of floodway lost (-)	Acres of floodway gained (+)	Subtotal (net) by reach	Width (ft)	Acres	OHWM?	NWR?
Start (10+63) to 67+50				-1.99	3.08	1.09		0.00		
69+00 to Escondida Br				0.00	35.28	35.28		18.20		
Escondida Br to Hwy 380 Br				0.00	38.75	38.75		15.66		
Hwy 380 Br to BDANWR				0.00	7.19	7.19		1.30		
BDANWR				-8.71	0.57	-8.14		0.00		
BDANWR to 2213+00				0.00	0.76	0.76		0.28		
2213+00 to 2271+00				-1.36	0.12	-1.24		0.03		
NET or SUM				**-12.06**	**85.75**	**73.69**		**35.47**		
EASTSIDE:										
Channel cut		--		0.00	3.08	**3.08**			OHWM	Sevilleta
WESTSIDE:										
Start (10+63)										
soil cement	10.63	1063	0	0.00	0.00	**-1.99**				
soil cement	12.8	1280	0	0.00	0.00					Sevilleta
soil cement	27	2700	18	-0.08	0.00					Sevilleta
soil cement	29	2900	20	-0.05	0.00					Sevilleta
soil cement	30	3000	30	-0.28	0.00				-0.56 ac OW below OHWM	Sevilleta
soil cement	34	3400	30	-0.41	0.00					Sevilleta
soil cement	40	4000	20	-0.41	0.00					Sevilleta
soil cement	49	4900	30	-0.76	0.00					Sevilleta
soil cement	60	6000	0	0.00	0.00					
soil cement	67.5	6750	0	0.00	0.00					
	56.87	5687								
Earthen Levee begins										
	69	6900	-20	0.00	0.51	**35.28**	5	0.13		
	80	8000	-20	0.00	0.92		5	0.23		
	100	10000	-30	0.00	0.28		15	0.14		
San Lorenzo	104	10400	-60	0.00	5.58		45	4.18		
San Lorenzo	144.5	14450	0	0.00	0.00					
	145.5	14550	-70	0.00	0.08		55	0.06		
	146	14600	-80	0.00	7.35		65	5.97		
	186	18600	-50	0.00	0.46		35	0.32		
	190	19000	-35	0.00	0.64		20	0.37		
	198	19800	-20	0.00	0.09		5	0.02		
	200	20000	-15	0.00	0.07		0	0.00		
	202	20200	-25	0.00	1.61		10	0.64		
	230	23000	-15	0.00	0.86					
	255	25500	-30	0.00	0.34		15	0.17		
	260	26000	-60	0.00	3.44		45	2.58		
	285	28500	-50	0.00	0.11		35	0.08		
	286	28600	-30	0.00	0.62		15	0.31		
	295	29500	-20	0.00	1.61		5	0.40		
	330	33000	-25	0.00	2.30		10	0.92		
	370	37000	-20	0.00	0.23		5	0.06		
	375	37500	-20	0.00	0.46		5	0.11	OHWM	
	385	38500	-20	0.00	2.98		5	0.75	OHWM	
	450	45000	-15	0.00	1.72		0	0.00		
	500	50000	-20	0.00	3.03		5	0.76		
	566	56600								
Escondida Bridge	566	56600	-7	0.00	0.22	**2.26**	0	0.00		

Spreadsheet 1. Change in floodway area: Alt. A + 4 ft Levee. (continued)

			Alt. A + 4ft Levee							
			Acres of floodway lost (-) or gained (+) due to project features				Within the gained floodway area … area suitable for woody plantings (i.e., outside of VFZ)			
Label or note	Station (+00)	Station as ft	New riverward toe is x ft from old riverward toe (- = landward; + = riverward)	Acres of floodway lost (-)	Acres of floodway gained (+)	Subtotal (net) by reach	Width (ft)	Acres	OHWM?	NWR?
	580	58000	-10	0.00	0.14		0	0.00		
	586	58600	-15	0.00	1.89		0	0.00		
	641	64100								
Socorro North Channel	647	64700	0	0.00	0.00	**22.36**	0			
	649	64900	-5	0.00	0.22		0			
	668	66800	-5	0.00	0.20		0		OHWM	
	685	68500	-23	0.00	0.26		8	0.09	OHWM	
	690	69000	-45	0.00	1.14		30	0.76	OHWM	
	701	70100	-45	0.00	2.07		30	1.38	OHWM	
	721	72100	-27	0.00	1.18		12	0.52		
	740	74000	-15	0.00	1.38		0	0.00		
	780	78000	-17	0.00	0.55		2	0.06		
	794	79400	-30	0.00	0.41		15	0.21		
	800	80000	-30	0.00	0.69		15	0.34		
	810	81000	-45	0.00	1.45		30	0.96		
	824	82400	-30	0.00	2.48		15	1.24		
	860	86000	-15	0.00	1.14		0	0.00		
	893	89300	-23	0.00	0.11		8	0.04		
	895	89500	-30	0.00	2.07		15	1.03		
	925	92500	-32	0.00	0.88		17	0.47		
	937	93700	-45	0.00	1.03		30	0.69		
	947	94700	-30	0.00	3.65		15	1.83		
	1000	100000	-27	0.00	0.31		12	0.14		
	1005	100500	-30	0.00	0.83		15	0.41		
	1017	101700	-15	0.00	0.34		0	0.00		
	1027	102700								
Brown Arroyo	1029	102900	-15	0.00	0.38	**14.13**	0	0.00		
	1040	104000	-30	0.00	2.07		15	1.03		
	1070	107000	-28	0.00	0.84		13	0.39		
	1083	108300	-15	0.00	0.59		0	0.00		
	1100	110000	-30	0.00	0.14		15	0.07		
	1102	110200	-15	0.00	1.14		0	0.00		
	1135	113500	-25	0.00	0.40		10	0.16		
	1142	114200	-30	0.00	1.10		15	0.55		
	1158	115800	-40	0.00	0.37		25	0.23		
	1162	116200	-15	0.00	0.76		0	0.00		
	1184	118400	-39	0.00	1.70		24	1.05		
	1203	120300	-35	0.00	1.37		20	0.78		
	1220	122000	-25	0.00	1.03		10	0.41		
2.5:1 slope	1238	123800	-42	0.00	0.19		27	0.12		
transitioning	**1240**	124000	-42	0.00	0.19		27	0.12		
transitioning	**1242**	124200	-42	0.00	0.29		27	0.19		
transitioning	**1245**	124500	-42	0.00	0.29		27	0.19		
3:1 slope	**1248**	124800	-42	0.00	0.19		27	0.12		
	1250	125000	-30	0.00	0.14		15	0.07		
	1252	125200	-15	0.00	0.96		0	0.00		
	1280	128000	0	0.00	0.00					
riprap	1310	131000	0	0.00	0.00					
riprap	1317.59	131759	0	0.00	0.00					
	1337.07	133707	0	0.00	0.00					
	1350	135000	0	0.00	0.00					
	1352	135200	0	0.00	0.00					
	1354	135400								

Spreadsheet 1. Change in floodway area: Alt. A + 4 ft Levee. (continued)

				Alt. A + 4ft Levee							
				Acres of floodway lost (-) or gained (+) due to project features				Within the gained floodway area … area suitable for woody plantings (i.e., outside of VFZ)			
Label or note		Station (+00)	Station as ft	New riverward toe is x ft from old riverward toe (- = landward; + = riverward)	Acres of floodway lost (-)	Acres of floodway gained (+)	Subtotal (net) by reach	Width (ft)	Acres	OHWM?	NWR?
Hwy 60 Bridge		1355	135500	0	0.00	0.00	**7.19**				
		1361	136100	-10	0.00	0.07					
		1364	136400	-30	0.00	0.41		15	0.21		
	riprap	1370	137000	-15	0.00	0.02		0	0.00		
	riprap	1370.57	137057	-15	0.00	0.39		0	0.00		
		1381.85	138185	-15	0.00	0.25		0	0.00		
		1389	138900	-20	0.00	0.23		5	0.06		
		1394	139400	-15	0.00	1.96		0	0.00		
		1451	145100	-15	0.00	1.79		0	0.00	OHWM	
		1503	150300	-30	0.00	2.07		15	1.03	OHWM	
		1533	153300	0						OHWM	
BdA north boundary		1533	153300	0	0.00	0.00	**-8.14**			OHWM	BdA
		1600	160000	0	0.00	0.00				OHWM	BdA
		1610	161000	0	0.00	0.00				OHWM	BdA
		1620	162000	0	0.00	0.00				OHWM	BdA
		1660	166000	0	0.00	0.00				OHWM	BdA
		1692	169200	0	0.00	0.00				OHWM	BdA
		1700	170000	0	0.00	0.00				OHWM	BdA
		1710	171000	0	0.00	0.00				OHWM	BdA
	riprap	1729.68	172968	0	0.00	0.00				OHWM	BdA
	riprap	1733	173300	0	0.00	0.00				OHWM	BdA
	riprap	1738	173800	0	0.00	0.00				OHWM	BdA
	riprap	1777	177700	10	-0.56	0.00				OHWM	BdA
	riprap	1801.42	180142	10	-0.36	0.00				OHWM	BdA
		1817	181700	5	-0.03	0.00				OHWM	BdA
		1820	182000	0	0.00	0.00				OHWM	BdA
		1830	183000	0	0.00	0.00				OHWM	BdA
		1840	184000	5	-0.11	0.00				OHWM	BdA
		1850	185000	0	0.00	0.00				OHWM	BdA
		1860	186000	-10	0.00	0.16				OHWM	BdA
		1867	186700	-15	0.00	0.28				OHWM	BdA
		1875	187500	-5	0.00	0.14				OHWM	BdA
		1887	188700	0	0.00	0.00				OHWM	BdA
		1907	190700	10	-0.11	0.00				OHWM	BdA
		1912	191200	15	-0.28	0.00				OHWM	BdA
		1920	192000	10	-0.16	0.00				OHWM	BdA
		1927	192700	5	-0.15	0.00				OHWM	BdA
		1940	194000	10	-0.28	0.00				OHWM	BdA
		1952	195200	15	-0.28	0.00				OHWM	BdA
		1960	196000	20	-0.09	0.00				OHWM	BdA
		1962	196200	25	-0.46	0.00				OHWM	BdA
		1970	197000	20	-0.23	0.00				OHWM	BdA
		1975	197500	25	-0.29	0.00				OHWM	BdA
		1980	198000	18	-0.21	0.00				OHWM	BdA
		1985	198500	23	-0.11	0.00				OHWM	BdA
		1987	198700	30	-0.21	0.00				OHWM	BdA
		1990	199000	40	-0.46	0.00				OHWM	BdA
		1995	199500	30	-1.72	0.00				OHWM	BdA
		2020	202000	30	-1.38	0.00				OHWM	BdA
		2040	204000	15	-0.28	0.00				OHWM	BdA
		2048	204800	20	-0.09	0.00				OHWM	BdA
		2050	205000	15	-0.28	0.00				OHWM	BdA
		2058	205800	0	0.00	0.00				OHWM	BdA

Spreadsheet 1. Change in floodway area: Alt. A + 4 ft Levee. (concluded)

			Alt. A + 4ft Levee							
			Acres of floodway lost (-) or gained (+) due to project features				Within the gained floodway area … area suitable for woody plantings (i.e., outside of VFZ)			
Label or note	Station (+00)	Station as ft	New riverward toe is x ft from old riverward toe (- = landward; + = riverward)	Acres of floodway lost (-)	Acres of floodway gained (+)	Subtotal (net) by reach	Width (ft)	Acres	OHWM?	NWR?
	2060	206000	5	-0.06	0.00				OHWM	BdA
	2065	206500	10	-0.11	0.00				OHWM	BdA
	2070	207000	5	-0.06	0.00				OHWM	BdA
	2075	207500	0	0.00	0.00				OHWM	BdA
	2092	209200	0	0.00	0.00				OHWM	BdA
	2103	210300	0	0.00	0.00				OHWM	BdA
	2108	210800	0	0.00	0.00				OHWM	BdA
	2120	212000	15	-0.38	0.00				OHWM	BdA
	2131	213100							OHWM	BdA
BdA south boundary (gap here - disturbed)									OHWM	BdA
	2133	213300	0	0.00	0.00	**0.76**			OHWM	
	2170	217000	0	0.00	0.00				OHWM	
	2184	218400	-15	0.00	0.21				OHWM	
	2190	219000	-30	0.00	0.34		15	0.17	OHWM	
	2195	219500	-30	0.00	0.21		15	0.10	OHWM	
	2198	219800	0	0.00	0.00				OHWM	
	2213	221300							OHWM	
Levee curves to west; leaves floodway						The value below is the 10-yr floodplain				
10yr	2213	221300	0	0.00	0.00	**-1.24**				
10yr	2220	222000	15	-0.34	0.00					
10yr	2230	223000	0	0.00	0.00					
10yr	2240	224000	15	-0.34	0.00					
10yr	2250	225000	15	-0.34	0.00					
10yr	2260	226000	12	-0.08	0.00					
10yr	2263	226300	0	0.00	0.00					
10yr	2264	226400	-15	0.00	0.03					
10yr	2265	226500	-30	0.00	0.07		15	0.03		
10yr	2266	226600	-7	0.00	0.02					
10yr	2267	226700	15	-0.03	0.00					
10yr	2268	226800	15	-0.03	0.00					
10yr	2269	226900	30	-0.07	0.00					
10yr	2270	227000	45	-0.10	0.00					
10yr	2271	227100	0							
RR embankment (terminus)										

1%+4ft Levee: Acres (net) below OHWM --

OHWM is defined as the 2-yr flow (i.e., 5,660 cfs at San Acacia & 4,170 at San Marcial [Parametrix 2008]). The source doc also maps these discharges.

Location or Station	Lost (ac.)	Gained (ac.)	Net (ac.)	Length ft	Length mi
East channel cut	0.00	3.08	3.08	1,950	0.37
Soil cemernt	-0.56	0.00	-0.56	1,100	0.21
375+00 - 385+00	0.00	3.44	3.44	1,000	0.19
668+00 - 701+00	0.00	3.66	3.66	3,300	0.63
1451+00 - 2213+00	-8.71	5.19	-3.53	76,000	14.39
Subtotal	-9.27	15.37	**6.10**	81,400	15.42

Spreadsheet 2. Change in floodway area: Alt. A Levee.

			Alt. A Levee							
			Acres of floodway lost (-) or gained (+) due to project features				area … area suitable for woody plantings (i.e., outside of VFZ)			
Label or note	Station (+00)	Station as ft	New riverward toe is x ft from old riverward toe (- = landward; + = riverward)	Acres of floodway lost (-)	Acres of floodway gained (+)	Subtotal (net) by reach	Width (ft)	Acres	OHWM?	NWR?
Start (10+63) to 69+00				-1.99	3.08	1.09		0.00		
69+00 to Escondida Br				0.00	58.06	58.06		40.89		
Escondida Br to Hwy 380 Br				0.00	99.29	99.29		72.43		
Hwy 60 Br to BDANWR				0.00	16.99	16.99		10.86		
BDANWR				-0.87	25.68	24.81		8.45		
BDANWR to 2213+00				0.00	5.17	5.17		2.41		
2213+00 to 2271+00				-0.06	2.02	1.96		0.00		
NET or SUM				-2.92	210.29	**207.36**		**135.05**		
EASTSIDE:										
Channel cut		--		0.00	3.08	**3.08**			OHWM	Sevilleta
WESTSIDE:										
Start (10+63) [This is the same as for the "+4-ft" levee.]										
soil cement	10.63	1063	0	0.00	0.00	**-1.99**				
soil cement	12.8	1280	0	0.00	0.00					Sevilleta
soil cement	27	2700	18	-0.08	0.00					Sevilleta
									-056 ac OW below OHWM	
soil cement	29	2900	20	-0.05	0.00					Sevilleta
soil cement	30	3000	30	-0.28	0.00					Sevilleta
soil cement	34	3400	30	-0.41	0.00					Sevilleta
soil cement	40	4000	20	-0.41	0.00					Sevilleta
soil cement	49	4900	30	-0.76	0.00					Sevilleta
soil cement	60	6000	0	0.00	0.00					
soil cement	67.5	6750	0							
Earthen Levee begins										
	69	6900	-40	0.00	1.01	**58.06**	25	0.63		
	80	8000	-20	0.00	0.00		5	0.00		
	80	8000	-40	0.00	1.84		25	1.15		
	100	10000	-50	0.00	0.46		35	0.32		
	104	10400	-80	0.00	7.44		65	6.04		
San Lorenzo	144.5	14450	0	0.00	0.00					
San Lorenzo	145.5	14550	-90	0.00	0.10					
	146	14600	-100	0.00	9.18		85	7.81		
	186	18600	-70	0.00	0.64		55	0.51		
	190	19000	-55	0.00	1.01		40	0.73		
	198	19800	-40	0.00	0.18		25	0.11		
	200	20000	-35	0.00	0.16		20	0.09		
	202	20200	-45	0.00	2.89		30	1.93		
	230	23000	-35	0.00	2.01		20	1.15		
	255	25500	-50	0.00	0.57		35	0.40		
	260	26000	-80	0.00	4.59		65	3.73		
	285	28500	-70	0.00	0.16		55	0.13		
	286	28600	-50	0.00	1.03		35	0.72		
	295	29500	-40	0.00	3.21		25	2.01		
	330	33000	-45	0.00	4.13		30	2.75		
	370	37000	-40	0.00	7.35		25	4.59		
	450	45000	-35	0.00	4.02		20	2.30		
	500	50000	-40	0.00	6.06		25	3.79		

Spreadsheet 2. Change in floodway area: Alt. A Levee. (continued)

			Alt. A Levee							
			Acres of floodway lost (-) or gained (+) due to project features				area … area suitable for woody plantings (i.e., outside of VFZ)			
Label or note	Station (+00)	Station as ft	New riverward toe is x ft from old riverward toe (- = landward; + = riverward)	Acres of floodway lost (-)	Acres of floodway gained (+)	Subtotal (net) by reach	Width (ft)	Acres	OHWM?	NWR?
	566	56600	-20				5	-6.50		
Escondida Bridge										
	566	56600	-35	0.00	1.12	**7.99**	20	0.64		
	580	58000	-40	0.00	0.55		25	0.34		
	586	58600	-50	0.00	6.31		35	4.42		
	641	64100								
Socorro North Channel										
	647	64700	-35	0.00	0.16	**53.15**	20	0.09		
	649	64900	-45	0.00	3.72		30	2.48		
	685	68500	-60	0.00	0.69		45	0.52		
	690	69000	-80	0.00	5.69		65	4.63		
	721	72100	-62	0.00	2.70		47	2.05		
	740	74000	-65	0.00	5.97		50	4.59		
	780	78000	-62	0.00	1.99		47	1.51		
	794	79400	-50	0.00	0.69		35	0.48		
	800	80000	-65	0.00	1.49		50	1.15		
	810	81000	-80	0.00	2.57		65	2.09		
	824	82400	-65	0.00	5.37		50	4.13		
	860	86000	-50	0.00	3.79		35	2.65		
	893	89300	-60	0.00	0.28		45	0.21		
	895	89500	-65	0.00	4.48		50	3.44		
	925	92500	-72	0.00	1.98		57	1.57		
	937	93700	-80	0.00	1.84		65	1.49		
	947	94700	-50	0.00	6.08		35	4.26		
	1000	100000	-62	0.00	0.71		47	0.54		
	1005	100500	-65	0.00	1.79		50	1.38		
	1017	101700	-50	0.00	1.15		35	0.80		
	1027	102700								
Brown Arroyo										
	1029	102900	-50	0.00	1.26	**38.16**	35	0.88		
	1040	104000	-65	0.00	4.48		50	3.44		
	1070	107000	-58	0.00	1.73		43	1.28		
	1083	108300	-50	0.00	1.95		35	1.37		
	1100	110000	-65	0.00	0.30		50	0.23		
	1102	110200	-50	0.00	3.79		35	2.65		
	1135	113500	-60	0.00	0.96		45	0.72		
	1142	114200	-65	0.00	2.39		50	1.84		
	1158	115800	-75	0.00	0.69		60	0.55		
	1162	116200	-50	0.00	2.53		35	1.77		
	1184	118400	-74	0.00	3.23		59	2.57		
	1203	120300	-70	0.00	2.73		55	2.15		
	1220	122000	-50	0.00	2.07		35	1.45		
	1238	123800	-62	0.00	0.28		47	0.22		
2.5:1 slope	1240	124000	**-62**	0.00	0.28		47	0.22		
transitioning	1242	124200	**-63**	0.00	0.43		48	0.33		
transitioning	1245	124500	**-64**	0.00	0.44		49	0.34		
transitioning	1248	124800	**-65**	0.00	0.30		50	0.23		
3:1 slope	1250	125000	**-54**	0.00	0.25		39	0.18		
	1252	125200	-39	0.00	2.51		24	1.54		
	1280	128000	-24	0.00	1.65		9	0.62		
	1310	131000	-39	0.00	0.68		24	0.42		

Spreadsheet 2. Change in floodway area: Alt. A Levee. (continued)

			Alt. A Levee							
			Acres of floodway lost (-) or gained (+) due to project features				area … area suitable for woody plantings (i.e., outside of VFZ)			
Label or note	Station (+00)	Station as ft	New riverward toe is x ft from old riverward toe (- = landward; + = riverward)	Acres of floodway lost (-)	Acres of floodway gained (+)	Subtotal (net) by reach	Width (ft)	Acres	OHWM?	NWR?
riprap	1317.59	131759	-39	0.00	1.74		24	1.07		
riprap	1337.07	133707	-39	0.00	1.16		24	0.71		
	1350	135000	-47	0.00	0.22		32	0.15		
	1352	135200	-24	0.00	0.11		9	0.04		
	1354	135400								
Hwy 60 Bridge										
	1355	135500	-24	0.00	0.33	**16.99**	9	0.12		
	1361	136100	-34	0.00	0.23		19	0.13		
	1364	136400	-54	0.00	0.74		39	0.54		
	1370	137000	-39	0.00	0.05		24	0.03		
riprap	1370.57	137057	-39	0.00	1.01		24	0.62		
riprap	1381.85	138185	-39	0.00	0.64		24	0.39		
	1389	138900	-44	0.00	0.51		29	0.33		
	1394	139400	-39	0.00	5.10		24	3.14		
	1451	145100	-39	0.00	4.66		24	2.87	OHWM	
	1503	150300	-54	0.00	3.72		39	2.69	OHWM	
	1533	153300	-24						OHWM	
									OHWM	
BdA north boundary									OHWM	
	1533	153300	-24	0.00	3.69	**24.81**	9	1.38	OHWM	BdA
	1600	160000	-24	0.00	0.55		9	0.21	OHWM	BdA
	1610	161000	-24	0.00	0.55		9	0.21	OHWM	BdA
	1620	162000	-24	0.00	2.20		9	0.83	OHWM	BdA
	1660	166000	-24	0.00	1.76		9	0.66	OHWM	BdA
	1692	169200	-24	0.00	0.44		9	0.17	OHWM	BdA
	1700	170000	-24	0.00	0.55		9	0.21	OHWM	BdA
	1710	171000	-24	0.00	1.08		9	0.41	OHWM	BdA
riprap	1729.68	172968	-24	0.00	0.18		8.5	0.06	OHWM	BdA
riprap	1733	173300	-24	0.00	0.28		8.5	0.10	OHWM	BdA
riprap	1738	173800	-24	0.00	2.15		8.5	0.76	OHWM	BdA
riprap	1777	177700	-14	0.00	0.78				OHWM	BdA
riprap	1801.42	180142	-14	0.00	0.50				OHWM	BdA
	1817	181700	-19	0.00	0.13		4	0.03	OHWM	BdA
	1820	182000	-24	0.00	0.55		9	0.21	OHWM	BdA
	1830	183000	-24	0.00	0.55		9	0.21	OHWM	BdA
	1840	184000	-19	0.00	0.44		4	0.09	OHWM	BdA
	1850	185000	-24	0.00	0.55		9	0.21	OHWM	BdA
	1860	186000	-34	0.00	0.55		19	0.31	OHWM	BdA
	1867	186700	-39	0.00	0.72		24	0.44	OHWM	BdA
	1875	187500	-29	0.00	0.80		14	0.39	OHWM	BdA
	1887	188700	-24	0.00	1.10		9	0.41	OHWM	BdA
	1907	190700	-14	0.00	0.16				OHWM	BdA
	1912	191200	-9	0.00	0.17				OHWM	BdA
	1920	192000	-14	0.00	0.22				OHWM	BdA
	1927	192700	-19	0.00	0.57		4	0.12	OHWM	BdA
	1940	194000	-14	0.00	0.39				OHWM	BdA
	1952	195200	-9	0.00	0.17				OHWM	BdA
	1960	196000	-4	0.00	0.02				OHWM	BdA
	1962	196200	1	-0.02	0.00				OHWM	BdA
	1970	197000	-4	0.00	0.05				OHWM	BdA

Spreadsheet 2. Change in floodway area: Alt. A Levee. (concluded)

			Alt. A Levee							
			Acres of floodway lost (-) or gained (+) due to project features				area … area suitable for woody plantings (i.e., outside of VFZ)			
Label or note	Station (+00)	Station as ft	New riverward toe is x ft from old riverward toe (- = landward; + = riverward)	Acres of floodway lost (-)	Acres of floodway gained (+)	Subtotal (net) by reach	Width (ft)	Acres	OHWM?	NWR?
	1975	197500	1	-0.01	0.00				OHWM	BdA
	1980	198000	-6	0.00	0.07				OHWM	BdA
	1985	198500	-1	0.00	0.00				OHWM	BdA
	1987	198700	6	-0.04	0.00				OHWM	BdA
	1990	199000	16	-0.18	0.00				OHWM	BdA
	1995	199500	6	-0.34	0.00				OHWM	BdA
	2020	202000	6	-0.28	0.00				OHWM	BdA
	2040	204000	-9	0.00	0.17				OHWM	BdA
	2048	204800	-4	0.00	0.02				OHWM	BdA
	2050	205000	-9	0.00	0.17				OHWM	BdA
	2058	205800	-24	0.00	0.11		9	0.04	OHWM	BdA
	2060	206000	-19	0.00	0.22		4	0.05	OHWM	BdA
	2065	206500	-14	0.00	0.16				OHWM	BdA
	2070	207000	-19	0.00	0.22		4	0.05	OHWM	BdA
	2075	207500	-24	0.00	0.94		9	0.35	OHWM	BdA
	2092	209200	-24	0.00	0.61		9	0.23	OHWM	BdA
	2103	210300	-24	0.00	0.28		9	0.10	OHWM	BdA
	2108	210800	-24	0.00	0.66		9	0.25	OHWM	BdA
	2120	212000	-9	0.00	0.23				OHWM	BdA
	2131	213100							OHWM	BdA
BdA south boundary (gap here - disturbed)									OHWM	
	2133	213300	-24	0.00	2.04	**5.17**	9	0.76	OHWM	
	2170	217000	-24	0.00	0.77		9	0.29	OHWM	
	2184	218400	-39	0.00	0.54		24	0.33	OHWM	
	2190	219000	-54	0.00	0.62		39	0.45	OHWM	
	2195	219500	-54	0.00	0.37		39	0.27	OHWM	
	2198	219800	-24	0.00	0.83		9	0.31	OHWM	
	2213	221300							OHWM	
Levee curves to west; leaves floodway										
10yr	2213	221300	-24	0.00	0.39	**1.96**	0	0.00		
10yr	2220	222000	-9	0.00	0.21		0	0.00		
10yr	2230	223000	-24	0.00	0.55		0	0.00		
10yr	2240	224000	-9	0.00	0.21		0	0.00		
10yr	2250	225000	-9	0.00	0.21		0	0.00		
10yr	2260	226000	-12	0.00	0.08		0	0.00		
10yr	2263	226300	-24	0.00	0.06		0	0.00		
10yr	2264	226400	-39	0.00	0.09		0	0.00		
10yr	2265	226500	-54	0.00	0.12		0	0.00		
10yr	2266	226600	-31	0.00	0.07		0	0.00		
10yr	2267	226700	-9	0.00	0.02		0	0.00		
10yr	2268	226800	-9	0.00	0.02		0	0.00		
10yr	2269	226900	6	-0.01	0.00		0	0.00		
10yr	2270	227000	21	-0.05	0.00		0	0.00		
10yr	2271	227100								
RR embankment (terminus)										
Net acres (gained) below OHWM:				-1.43	42.30	**40.87**		16.41		
				Filled	Exposed	Net				

Spreadsheet 3. Vegetation type change due to 15-ft-wide Vegetation-free Zone and buried riprap.

		100yr+4							100yr				
		Width needed (ft)							Width needed (ft)				
Station (+00)	Station as ft	Due to levee toe	Additional for riprap (where needed)	Length (ft)	Acres of vegetation type change	Veg. type (H&O 2007 by Px)	OHWM?	NWR?	Due to levee toe	Additional for riprap (where needed)	Length (ft)	Acres of vegetation type change	Veg. type (H&O 2007 by Px)
69+00 to Escondida Br				0	0.00						0	0.00	
Escondida Br to Hwy 380 Br				13,200	4.35						0	0.00	
Hwy 380 Br to BdA				2,028	0.58						0	0.00	
BDANWR				59,800	21.58						23,374	3.40	
BDANWR to 2213+00				6,600	2.27						0	0.00	
Subtotal (floodway)				**81,628**	**28.78**						**23,374**	**3.40**	
"Tiff Corner" to RR [10-yr-fldpln]				5,600	1.91						3,600	0.50	
SUM				**87,228**	**30.70**						**26,974**	**3.90**	
				16.52	mi.						5.11	mi.	
69+00 to Escondida Br: No veg. type change due to VFZ													
Escondida Bridge													
566	56600	8		660	0.12	OP			0			0	
572.6	57260	8		740	0.14	SC-ATX5			0			0	
580	58000	5		600	0.07	SC-ATX5			0			0	
586	58600	0			0				0			0	
641	64100												
Socorro North Channel													
647	64700	15		200	0.07	SC5			0			0	
649	64900	10		1900	0.44	SC5			0			0	
668	66800	10		950	0.22	SC5	OHWM		0			0	
677.5	67750	10		750	0.17	C2	OHWM		0			0	
685	68500	0			0		OHWM		0			0	
690	69000	0			0		OHWM		0			0	
721	72100	0			0				0			0	
740	74000	0			0				0			0	
780	78000	0			0				0			0	
794	79400	0			0				0			0	
800	80000	0			0				0			0	
810	81000	0			0				0			0	
824	82400	0			0				0			0	
860	86000	0			0				0			0	
893	89300	0			0				0			0	
895	89500	0			0				0			0	
925	92500	0			0				0			0	
937	93700	0			0				0			0	
947	94700	0			0				0			0	
1000	100000	0			0				0			0	
1005	100500	0			0				0			0	
1017	101700	0			0				0			0	
1027	102700								0			0	
Brown Arroyo									0			0	
1029	102900	0			0				0			0	
1040	104000	0			0				0			0	
1070	107000	0			0				0			0	
1083	108300	0			0				0			0	
1100	110000	0			0				0			0	
1102	110200	0			0				0			0	
1135	113500	0			0				0			0	
1142	114200	0			0				0			0	
1158	115800	0			0				0			0	
1162	116200	0			0				0			0	
1184	118400	0			0				0			0	
1203	120300	0			0				0			0	
1220	122000	0			0				0			0	
1238	123800	0			0				0			0	
2.5:1 slope **1240**	124000	0			0				0			0	
transitioning **1242**	124200	0			0				0			0	
transitioning **1245**	124500	0			0				0			0	
transitioning **1248**	124800	0			0				0			0	
3:1 slope 1250	125000	0			0				0			0	
1252	125200	0			0				0			0	
1280	128000	15		600	0.21	RO-C/SC3			0			0	
1286	128600	15		2400	0.83	SC5F			0			0	
1310	131000	15		759	0.26	C-RO/SC3			0			0	
riprap 1317.59	131759	15	13	1181	0.76	SC5S			0	0		0	
riprap 1329.4	132940	15	13	360	0.23	SC5S			0	0		0	
riprap 1333	133300	15	13	407	0.26	C/SC-B-SBM-NMO1			0	0		0	
riprap 1337.07	133707	15		1293	0.45	C/SC-B-SBM-NMO1			0			0	
1350	135000	15		200	0.07	C/SC-B-SBM-NMO1			0			0	
1352	135200	15		200	0.07	C/SC-B-SBM-NMO1			0			0	
1354	135400												
Hwy 380 Bridge													
1355	135500	15		100	0.03	OP			0			0	

Spreadsheet 3. Vegetation type change due to 15-ft-wide Vegetation-free Zone and buried riprap, (continued)

			100yr+4							100yr				
			Width needed (ft)							Width needed (ft)				
	Station (+00)	Station as ft	Due to levee toe	Additional for riprap (where needed)	Length (ft)	Acres of vegetation type change	Veg. type (H&O 2007 by Px)	OHWM?	NWR?	Due to levee toe	Additional for riprap (where needed)	Length (ft)	Acres of vegetation type change	Veg. type (H&O 2007 by Px)
	1356	135600	15		500	0.17	C/SC3S			0			0	
	1361	136100	5		300	0.03	C/SC3S			0			0	
	1364	136400	0			0	C/SC3S			0			0	
	1370	137000	0			0	C/SC3			0			0	
riprap	1370.57	137057	0	13	1128	0.34	C/SC3			0	0		0	
riprap	1381.85	138185	0			0				0			0	
	1389	138900	0			0				0			0	
	1394	139400	0			0				0			0	
	1451	145100	0			0		OHWM		0			0	
	1503	150300	0			0		OHWM		0			0	
	1533	153300						OHWM						
BDANWR north boundary								OHWM						
	1533	153300	15		2200	0.76	OPt	OHWM	BdA	0			0	
	1555	155500	15		1400	0.48	SC/SC3	OHWM	BdA	0			0	
	1569	156900	15		2800	0.96	SC-RO-B5	OHWM	BdA	0			0	
	1597	159700	15		300	0.10	C/SC1	OHWM	BdA	0			0	
	1600	160000	15		1000	0.34	C/SC1	OHWM	BdA	0			0	
	1610	161000	15		1000	0.34	C/SC1	OHWM	BdA	0			0	
	1620	162000	15		1300	0.45	C/SC1	OHWM	BdA	0			0	
	1633	163300	15		200	0.07	SC-B5	OHWM	BdA	0			0	
	1635	163500	15		2500	0.86	SC-TW-C/SC-B3	OHWM	BdA	0			0	
	1660	166000	15		3200	1.10	SC-TW-C/SC-B3	OHWM	BdA	0			0	
	1692	169200	15		800	0.28	SC-TW-C/SC-B3	OHWM	BdA	0			0	
	1700	170000	15		1000	0.34	SC-TW-C/SC-B3	OHWM	BdA	0			0	
	1710	171000	15		1500	0.52	SC-TW-C/SC-B3	OHWM	BdA	0			0	
	1725	172500	15		468	0.16	SC5	OHWM	BdA	0			0	
riprap	1729.68	172968	15	9.5	332	0.19	SC5	OHWM	BdA	0	0.5	332	0.004	SC5
riprap	1733	173300	15	9.5	500	0.28	SC5	OHWM	BdA	0	0.5	500	0.006	SC5
riprap	1738	173800	15	9.5	420	0.24	C/SC1	OHWM	BdA	0	0.5	420	0.005	C/SC1
riprap	1742.2	174220	15	9.5	1930	1.09	SC5	OHWM	BdA	0	0.5	1930	0.022	SC5
riprap	1761.5	176150	15	9.5	700	0.39	C/SC-RO1	OHWM	BdA	0	0.5	700	0.008	C/SC-RO1
riprap	1768.5	176850	15	9.5	850	0.48	SC5	OHWM	BdA	0	0.5	850	0.010	SC5
riprap	1777	177700	15	9.5	2300	1.29	C/SC-RO1	OHWM	BdA	0	0.5	2300	0.026	C/SC-RO1
riprap	1800	180000	15	9.5	142	0.08	SC/SC-CW3	OHWM	BdA	0	0.5	142	0.002	SC/SC-CW3
riprap	1801.42	180142	15		1558	0.54	SC/SC-CW3	OHWM	BdA	0			0	
	1817	181700	15		200	0.07	SC/SC-CW3	OHWM	BdA	0			0	
	1819	181900	15		100	0.03	C5	OHWM	BdA	0			0	
	1820	182000	15		120	0.04	C5	OHWM	BdA	0			0	
	1821.2	182120	15		880	0.30	C/SC-C3F	OHWM	BdA	0			0	
	1830	183000	15		560	0.19	C/SC-C3F	OHWM	BdA	0			0	
	1835.6	183560	15		440	0.15	SC5F	OHWM	BdA	0			0	
	1840	184000	15		1000	0.34	SC5F	OHWM	BdA	0			0	
	1850	185000	15		1000	0.34	SC5F	OHWM	BdA	0			0	
	1860	186000	5		700	0.08	SC5F	OHWM	BdA	0			0	
	1867	186700	0		800	0	SC5F	OHWM	BdA	0			0	
	1875	187500	10		1200	0.28	SC5F	OHWM	BdA	0			0	
	1887	188700	15		1650	0.57	SC5F	OHWM	BdA	0			0	
	1903.5	190350	15		130	0.04	Bare (OW)	OHWM	BdA	0			0	
	1904.8	190480	15		220	0.08	SC5F	OHWM	BdA	0			0	
	1907	190700	15		500	0.17	SC5F	OHWM	BdA	1		500	0.01	SC5F
	1912	191200	15		800	0.28	SC5F	OHWM	BdA	6		800	0.11	SC5F
	1920	192000	15		700	0.24	SC5F	OHWM	BdA	1		700	0.02	SC5F
	1927	192700	15		1300	0.45	SC5F	OHWM	BdA	0		1300	0	
	1940	194000	15		1200	0.41	SC5F	OHWM	BdA	1		1200	0.03	SC5F
	1952	195200	15		20	0.01	SC5F	OHWM	BdA	6		20	0.00	SC5F
	1952.2	195220	15		80	0.03	OP	OHWM	BdA	6		80	0.01	OP
	1953	195300	15		700	0.24	SC4	OHWM	BdA	6		700	0.10	SC4
	1960	196000	15		200	0.07	SC4	OHWM	BdA	11		200	0.05	SC4
	1962	196200	15		800	0.28	SC4	OHWM	BdA	15		800	0.28	SC4
	1970	197000	15		500	0.17	SC4	OHWM	BdA	11		500	0.13	SC4
	1975	197500	15		500	0.17	SC4	OHWM	BdA	15		500	0.17	SC4
	1980	198000	15		500	0.17	SC4	OHWM	BdA	9		500	0.10	SC4
	1985	198500	15		200	0.07	SC4	OHWM	BdA	14		200	0.06	SC4
	1987	198700	15		300	0.10	SC4	OHWM	BdA	15		300	0.10	SC4
	1990	199000	15		500	0.17	SC4	OHWM	BdA	15		500	0.17	SC4
	1995	199500	15		2500	0.86	SC4	OHWM	BdA	15		2500	0.86	SC4
	2020	202000	15		2000	0.69	SC4	OHWM	BdA	15		2000	0.69	SC4
	2040	204000	15		800	0.28	SC4	OHWM	BdA	6		800	0.11	SC4
	2048	204800	15		200	0.07	SC4	OHWM	BdA	9		200	0.04	SC4
	2050	205000	15		800	0.28	SC4	OHWM	BdA	6		800	0.11	SC4
	2058	205800	15		200	0.07	SC4	OHWM	BdA	0			0	
	2060	206000	15		500	0.17	SC4	OHWM	BdA	0			0	
	2065	206500	15		500	0.17	SC4	OHWM	BdA	1			0.01	SC4
	2070	207000	15		500	0.17	SC4	OHWM	BdA	0			0	
	2075	207500	15		400	0.14	SC4	OHWM	BdA	0			0	
	2079	207900	15		700	0.24	OP	OHWM	BdA	0			0	
	2086	208600	15		600	0.21	C-SC/C-SC3	OHWM	BdA	0			0	
	2092	209200	15		1100	0.38	C-SC/C-SC3	OHWM	BdA	0			0	
	2103	210300	15		500	0.17	C-SC/C-SC3	OHWM	BdA	0			0	

Spreadsheet 3. Vegetation type change due to 15-ft-wide Vegetation-free Zone and buried riprap, (continued)

		100yr+4							100yr				
		Width needed (ft)							Width needed (ft)				
Station (+00)	Station as ft	Due to levee toe	Additional for riprap (where needed)	Length (ft)	Acres of vegetation type change	Veg. type (H&O 2007 by Px)	OHWM?	NWR?	Due to levee toe	Additional for riprap (where needed)	Length (ft)	Acres of vegetation type change	Veg. type (H&O 2007 by Px)
2108	210800	15		1200	0.41	C-SC/C-SC3	OHWM	BdA	0			0	
2120	212000	15		140	0.05	C-SC/C-SC3	OHWM	BdA	6		140	0.02	C-SC/C-SC3
2121.4	212140	15		960	0.33	SC4	OHWM	BdA	6		960	0.13	SC4
2131	213100					SC4	OHWM	BdA					
BDANWR south boundary (gap here - disturbed)							OHWM						
2133	213300	15		250	0.09	[OP]	OHWM		0			0	
2135.5	213550	15		3450	1.19	SC4							
2170	217000	15		1400	0.48	SC4	OHWM		0			0	
2184	218400	0			0	SC4	OHWM		0			0	
2190	219000	0			0	SC4	OHWM		0			0	
2195	219500	0			0	SC4	OHWM		0			0	
2198	219800	15		1500	0.52	SC4	OHWM		0			0	
2213	221300	15					OHWM						
2213+00 (levee curves to west, leaves floodway)													
10yr-fldplain 2213	221300	15		700	0.24	SC6bt			0			0	
10yr-fldplain 2220	222000	15		1000	0.34	SC6bt			6		1000	0.14	SC6bt
10yr-fldplain 2230	223000	15		800	0.28	SC6bt			0			0	
10yr-fldplain 2238	223800	15		200	0.07	OPbt			6		200	0.03	OPbt
10yr-fldplain 2240	224000	15		1000	0.34	OPbt			6		1000	0.14	OPbt
10yr-fldplain 2250	225000	15		1000	0.34	OPbt			6		1000	0.14	OPbt
10yr-fldplain 2260	226000	15		300	0.10	OPbt			3		300	0.02	OPbt
10yr-fldplain 2263	226300	15		100	0.03	OPbt			0			0	
10yr-fldplain 2264	226400	0			0	OPbt			0			0	
10yr-fldplain 2265	226500	0			0	OPbt			0			0	
10yr-fldplain 2266	226600	8		100	0.02	OPbt			0			0	
10yr-fldplain 2267	226700	15		100	0.03	OPbt			0			0	
10yr-fldplain 2268	226800	15		100	0.03	OPbt			0			0	
10yr-fldplain 2269	226900	15		100	0.03	OPbt			15		100	0.03	OPbt
10yr-fldplain 2270	227000	15		100	0.03	OPbt			15				
10yr-fldplain 2271	227100					OPbt							
RR embankment (end)													

SUMMARY BY REACH:

	100yr+4			100yr		
Reach	Subtotal by reach	Acres of vegetation removal	Veg. type (H&O 2007 by Px)	Subtotal by reach	Acres of vegetation removal	Veg. type (H&O 2007 by Px)
69+00 to Escondida Br	0	0		0	0	
Escondida Br to Hwy 380	4.35	0.84	C/SC-B-SBM-NMO1	0.00	0	C/SC-B-SBM-NMO1
		0.17	C2		0	C2
		0.12	OP		0	OP
		0.47	RO-C/SC3		0	RO-C/SC3
		0.72	SC5		0	SC5
		1.82	SC5F		0	SC5F
		0.20	SC-ATX5		0	SC-ATX5
Hwy 380 to BDANWR	0.58	0.03	OP	0.00	0	OP
		0.54	C/SC3S		0	C/SC3S
BDANWR	21.58	0.04	Bare (OP)	3.40	0.011	(OP)
		1.48	C/SC1		0.005	C/SC1
		0.50	C/SC-C3F		0	C/SC-C3F
		1.69	C/SC-RO1		0.034	C/SC-RO1
		0.08	C5		0	C5
		1.22	C-SC/C-SC3		0.019	C-SC/C-SC3
		0.27	OP		0	OP
		0.76	OPt		0	OPt
		0.48	SC/SC3		0	SC/SC3
		0.69	SC/SC-CW3		0.002	SC/SC-CW3
		4.67	SC4		3.119	SC4
		2.19	SC5		0.041	SC5
		3.40	SC5F		0.168	SC5F
		0.07	SC-B5		0	SC-B5
		0.96	SC-RO-B5		0	SC-RO-B5
		3.10	SC-TW-C/SC-B3		0	SC-TW-C/SC-B3
BDANWR to 2213+00	2.28	0.09	[OP]	0		OW (pump channel)
		2.19	SC4			
Subtotal	28.79	28.79		3.40	3.40	
2213+00 to RR	1.91	0.86	SC6bt	0.50	0.14	SC6bt
		1.05	OPbt		0.36	OPbt
Subtotal		1.91			0.50	

Spreadsheet 3. Vegetation type change due to 15-ft-wide Vegetation-free Zone and buried riprap, (concluded)

		100yr+4							100yr				
		Width needed (ft)							Width needed (ft)				
Station (+00)	Station as ft	Due to levee toe	Additional for riprap (where needed)	Length (ft)	Acres of vegetation type change	Veg. type (H&O 2007 by Px)	OHWM?	NWR?	Due to levee toe	Additional for riprap (where needed)	Length (ft)	Acres of vegetation type change	Veg. type (H&O 2007 by Px)

SUMMARY (entire reach):

	100yr+4						100yr					
	Acres of vegetation removal	Veg. type (H&O 2007 by Px)	Native dominated	Mixed	Non-native dominated	OP	Acres of veg removal	Veg. type (H&O 2007 by Px)	Native dominated	Mixed	Non-native dominated	OP
Riparian (floodway):	1.32	**(OP)**				1.3	0.011	**OP**				0.011
	1.48	**C/SC1**		1.5			0.005	**C/SC1**		0.005		
	0.54	**C/SC3S**		0.5								
	0.84	**C/SC-B-SBM-NMO1**	0.8									
	0.50	**C/SC-C3F**	0.5									
	1.69	**C/SC-RO1**		1.7			0.034	**C/SC-RO1**		0.034		
	0.17	**C2**	0.2									
	0.08	**C5**	0.1									
	1.22	**C-SC/C-SC3**	1.2				0.019	**C-SC/C-SC3**	0.019			
	0.47	**RO-C/SC3**			0.5							
	0.48	**SC/SC3**			0.5							
	0.69	**SC/SC-CW3**			0.7		0.002	**SC/SC-CW3**			0.002	
	5.67	**SC4**			5.7		3.119	**SC4**			3.119	
	2.92	**SC5**			2.9		0.041	SC5			0.041	
	5.21	**SC5F**			5.2		0.168	**SC5F**			0.168	
	0.20	**SC-ATX5**			0.2							
	0.07	**SC-B5**			0.1							
	0.96	**SC-RO-B5**			1.0							
	3.10	**SC-TW-C/SC-B3**			3.1							
Sum	27.60		2.8	3.7	19.8	1.3	3.40		0.02	0.04	3.33	0.01
Percentage			10.2%	13.4%	71.6%	4.8%			0.6%	1.2%	98.0%	0.3%
10-yr floodplain (Tiffany Basin):	0.86	**SC6bt**			0.9		0.14	**SC6bt**			0.1	
	1.05	**OPbt**				1.1	0.36	**OPbt**				0.4
Sum	1.91				0.86	1.05	0.50				0.1	0.4
Percentage					45.0%	55.0%					27.8%	72.2%

Spreadsheet 4. Vegetation permanently removed due to footprint of features.

			100yr+4 levee					100yr levee		
	Station (+00)	Station as ft	New toe is x ft from old toe (- = landward; + = riverward)	Acres of vegetation removed	Vegetation type (H&O 2007 by Px): Black = Upland Green = Riparian	OHWM?	NWR?	New toe is x ft from old toe (- = landward; + = riverward)	Acres of vegetation removed	Vegetation type (H&O 2007 by Px): Black = Upland Green = Riparian
EASTSIDE:										
Channel cut				0.82	CW5	no	Sevilleta		0.82	CW5
Channel cut				2.00	SC6S	no	Sevilleta		2.00	SC6S
Channel cut				0.28	SC5	no	Sevilleta		0.28	SC5
Overbank cut				4.04	SC6S		Sevilleta		4.04	SC6S
Overbank cut				5.23	SC5		Sevilleta		5.23	SC5
WESTSIDE:										
floodwall	6.40	640	--					--		
floodwall	7.70	770	--	0.05	HMQ-ATX			--	0.05	HMS-ATX
floodwall + soil cement	10.63	1063	--	0.11	Bare OP			--	0	Bare OP
floodwall + soil cement	12.30	1230	--	0.09	C-TW2			--	0.09	C-TW2
floodwall + soil cement	12.50	1250		0.03	C/TW2				0.3	C/TW2
soil cem.	12.90	1290	--	0.02	C/TW2		Sevilleta	--	0.2	C/TW2
soil cem.	13.70	1370	--	0.67	SC5 Temp: 0.34 CW5S		Sevilleta	--	0.67	SC5 (0.67) Temp: 0.34 CW5S
soil cem.	21	2100	--	0.12	SC5 *Temp: 0.11 SC5*		Sevilleta	--	0.12	SC5 *Temp: 0.11 SC5*
soil cem.	23.5	2350	--	0.26	SC5 (0.22) CW-B5S (0.04) *Temp: 0.15 SC5* *Temp: 0.03 CW-B5S*		Sevilleta	--	0.22	SC5 (0.22) CW-B5S (0.04) Temp: 0.15 SC5 Temp: 0.03 CW-B5S
soil cem.	29	2900	--	0.34	0.34 SC-B5 +0.56 OW	not veg; just OW	Sevilleta	--	2.01	SC-B5 +0.56 OW
soil cem.	40	4000	--	.04+	SC-B5 *Temp: 0.46 SC-B5*		Sevilleta	--	1.43	SC-B5
soil cem.	50	5000	--	2.28	SC4 *Temp: 0.80 SC4*		Sevilleta	--		
soil cem.	67.5	6750	--					--	3.08	SC4
BDANWR north boundary										
	1533	153300	0		--	OHWM	BdA			
riprap	1777	177700	10	0.17	SC5	OHWM	BdA			
riprap	1784.5	178450	10	0.36	C/SC-RO1	OHWM	BdA			
riprap	1800	180000	10	0.03	SC/SC-CW3	OHWM	BdA			
riprap	1801.42	180142	10	0.36	SC/SC-CW3	OHWM	BdA			
	1817	181700	5	0.02	SC/SC-CW3	OHWM	BdA			
	1819	181900	5	0.01	C5	OHWM	BdA			
	1820	182000	0		C5	OHWM	BdA			
	1821.2	182120	0		C/SC-C3F	OHWM	BdA			
	1830	183000	0		C/SC-C3F	OHWM	BdA			
	1835.6	183560	0		SC5F	OHWM	BdA			
	1840	184000	5	0.11	SC5F	OHWM	BdA			
	1850	185000	0		SC5F	OHWM	BdA			
	1860	186000	-10		SC5F	OHWM	BdA			
	1867	186700	-15		SC5F	OHWM	BdA			
	1875	187500	-5		SC5F	OHWM	BdA			
	1887	188700	0		SC5F	OHWM	BdA			
	1903.5	190350	0		(OP)	OHWM	BdA			
	1904.8	190480	0		SC5F	OHWM	BdA			
	1907	190700	10	0.11	SC5F	OHWM	BdA			
	1912	191200	15	0.28	SC5F	OHWM	BdA			
	1920	192000	10	0.16	SC5F	OHWM	BdA			
	1927	192700	5	0.15	SC5F	OHWM	BdA			
	1940	194000	10	0.28	SC5F	OHWM	BdA			
	1952	195200	15	0.01	SC5F	OHWM	BdA			
	1952.2	195220	15	0.03	OP	OHWM	BdA			
	1953	195300	15	0.24	SC4	OHWM	BdA			
	1960	196000	20	0.09	SC4	OHWM	BdA	-4		
	1962	196200	25	0.46	SC4	OHWM	BdA	1	0.02	SC4

Spreadsheet 4. Vegetation permanently removed due to footprint of features. (continued)

			100yr+4 levee					100yr levee		
	Station (+00)	Station as ft	New toe is x ft from old toe (- = landward; + = riverward)	Acres of vegetation removed	Vegetation type (H&O 2007 by Px): Black = Upland Green = Riparian	OHWM?	NWR?	New toe is x ft from old toe (- = landward; + = riverward)	Acres of vegetation removed	Vegetation type (H&O 2007 by Px): Black = Upland Green = Riparian
	1970	197000	20	0.23	SC4	OHWM	BdA	-4		SC4
	1975	197500	25	0.29	SC4	OHWM	BdA	1	0.01	SC4
	1980	198000	18	0.21	SC4	OHWM	BdA	-6		SC4
	1985	198500	23	0.11	SC4	OHWM	BdA	-1		SC4
	1987	198700	30	0.21	SC4	OHWM	BdA	6	0.04	SC4
	1990	199000	40	0.46	SC4	OHWM	BdA	16	0.18	SC4
	1995	199500	30	1.52	SC4	OHWM	BdA	6	0.30	SC4
	2017	201700	30	0.21	SC4	OHWM	BdA	6	0.04	SC4
	2020	202000	30	1.38	SC4	OHWM	BdA	6	0.28	SC4
	2040	204000	15	0.28	SC4	OHWM	BdA	-9		
	2048	204800	20	0.09	SC4	OHWM	BdA			
	2050	205000	15	0.28	SC4	OHWM	BdA			
	2058	205800	0		SC4	OHWM	BdA			
	2060	206000	5	0.06	SC4	OHWM	BdA			
	2065	206500	10	0.11	SC4	OHWM	BdA			
	2070	207000	5	0.06	SC4	OHWM	BdA			
	2075	207500	0		SC4	OHWM	BdA			
	2079	207900	0		OP	OHWM	BdA			
	2086	208600	0		C-SC/C-SC3	OHWM	BdA			
	2092	209200	0		C-SC/C-SC3	OHWM	BdA			
	2103	210300	0		C-SC/C-SC3	OHWM	BdA			
	2108	210800	0		C-SC/C-SC3	OHWM	BdA			
	2120	212000	15	0.05	C-SC/C-SC3	OHWM	BdA			
	2121.4	212140	15	0.30	SC4	OHWM	BdA			
	2130	213000	15	0.03	SC4	OHWM	BdA			
	2131	213100			end of BdA	OHWM	BdA			
BDANWR south boundary (gap here - disturbed)						OHWM				
	2133	213300	0		[OP]	OHWM				
	2135.5	213550	0		SC4	OHWM				
	2170	217000	0		SC4	OHWM				
	2184	218400	-15		SC4	OHWM				
	2190	219000	-30		SC4	OHWM				
	2195	219500	-30		SC4	OHWM				
	2198	219800	0		SC4	OHWM				
	2210	221000	0		C2	OHWM				
	2213	221300				OHWM				
2213+00 (levee curves to west, leaves floodway)										
10yr-fp	2213	221300	0		SC5 [BOR2010]					
10yr-fp	2220	222000	15	0.34	SC5 [BOR2010]					
10yr-fp	2230	223000	0		SC5 [BOR2010]					
10yr-fp	2235	223500	0		SC6 [BOR2010]					
10yr-fp	2237	223700	0		SC5 [BOR2010]					
10yr-fp	2238	223800	0		OPbt					
10yr-fp	2240	224000	15	0.34	OPbt					
10yr-fp	2250	225000	15	0.34	OPbt					
10yr-fp	2260	226000	12	0.08	OPbt					
10yr-fp	2263	226300	0	0.00	OPbt					
10yr-fp	2264	226400	-15		OPbt					
10yr-fp	2265	226500	-30		OPbt					
10yr-fp	2266	226600	-7		OPbt					
10yr-fp	2267	226700	15	0.03	OPbt					
10yr-fp	2268	226800	15	0.03	OPbt					
10yr-fp	2269	226900	30	0.07	OPbt					
10yr-fp	2270	227000	45	0.10	OPbt					
10yr-fp	2271	227100	0		OPbt					
RR embankment										

Spreadsheet 4. Vegetation permanently removed due to footprint of features. (concluded)

		100yr+4 levee					100yr levee		
Station (+00)	Station as ft	New toe is x ft from old toe (- = landward; + = riverward)	Acres of vegetation removed	Vegetation type (H&O 2007 by Px): Black = Upland Green = Riparian	OHWM?	NWR?	New toe is x ft from old toe (- = landward; + = riverward)	Acres of vegetation removed	Vegetation type (H&O 2007 by Px): Black = Upland Green = Riparian

Non-riparian veg'n lost to footprint

Type	Acres	Native dominated	Non-native (SC) dominated	OP
SC6S	6.04		6.04	
SC5	6.52		6.52	
SC4	2.28		2.28	
HMQ-ATX	0.05	0.05		
C-TW2	0.09	0.09		
C/TW2	0.05	0.05		
	15.03	0.19	14.84	0
		1.26%	98.74%	

Riparian (floodway) veg'n lost to footprint

Type	Acres	Native dominated	Non-native dominated	OP
North end (10+63 to 69+00):				
CW5S	0.82	0.82		
CW-B5S	0.04	0.04		
SC-B5	3.44		3.44	
Subtotal (reach)	4.30	0.86	3.44	
		20.0%	80.0%	
BDANWR:				
C/SC-RO1	0.36		0.36	
C5	0.01	0.01		
C-SC/C-SC3	0.05	0.05		
OP	0.03			0.03
SC/SC-CW3	0.41		0.41	
SC4	6.59		6.59	
SC5	0.17		0.17	
SC5F	1.10		1.10	
Subtotal (reach)	8.71	0.06	8.63	0.03
		0.7%	99.0%	0.3%
Subtotal: All riparian (floodway):				
	13.01	*0.92*	*12.07*	*0.03*
		7.07%	*92.72%*	*0.21%*

In 10-yr-floodplain (Tiffany Basin):

OPbt	1.01			1.01
SC5	0.34		0.34	
Sum	**1.36**		0.34	1.01
			25.4%	74.6%
Offsetting gain	0.12			

Temp. riparian disturbance (soil cement)

CW5S	0.34	0.34		
CW-B5S	0.07	0.07		
SC-B5	0.46		0.46	
SC5	0.15		0.15	
SC4	0.80		0.80	
Sum	**1.82**	0.41	1.41	0.00

Subtotal (floodway)	**0.87**	**SC4**

*Note: Net floodway acres = 0.87 lost & 25.68 gained = 24.81 net gain on BDANWR.

10-year floodplain (Tiffany Basin):

Corner to RR (10-yr fldpln)	0.06	**OPbt**
Offsetting gain in reach =	0.00	
Net	-0.06	

DRAFT

GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-10

Economics

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F-01 Areas of Consideration:

The study area comprises a stretch of the Rio Grande extending from the town of San Acacia south past the Bosque Del Apache Wildlife Refuge to the former village of San Marcial, which lies north of the Bureau of Reclamation's Elephant Butte Reservoir. The study area is entirely contained within Socorro County, New Mexico. The City of Socorro, NM is the largest population center within the county. The 2010 U.S. Census determined that 9,051 of the county's 17,866 people lived within that city. The two main industries of the study area are education and research. The two largest employers within Socorro County are the New Mexico Institute of Mining and Technology and the National Radio Astronomy Observatory.

Figure F-1 - Study area

The study area is comprised of low, flat, and wide floodplains situated along both banks of the Rio Grande, which is perched. A typical perched channel cross section follows:

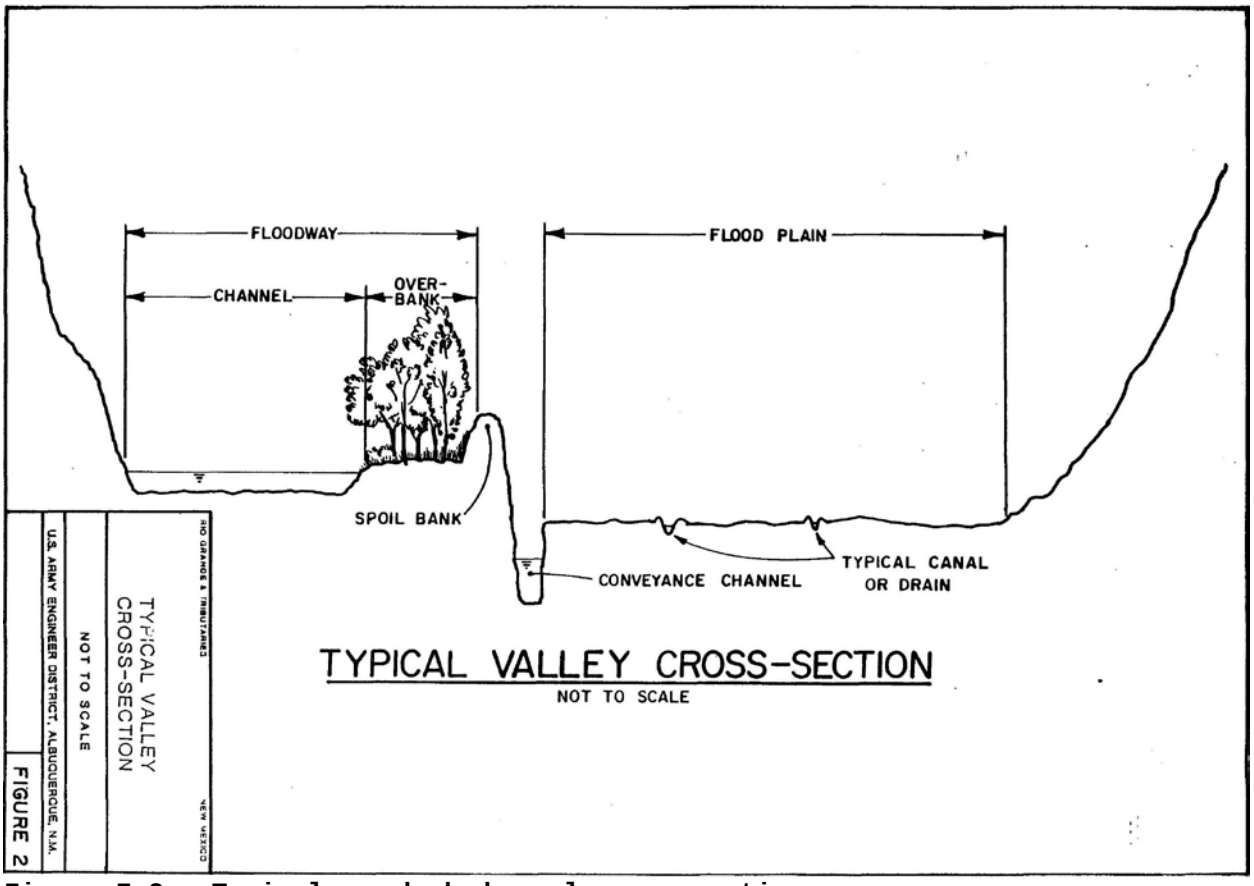

Figure F-2 - Typical perched channel cross-section

This differs from the typical cross-section of an incised river channel and the adjacent lands, diagrammed here:

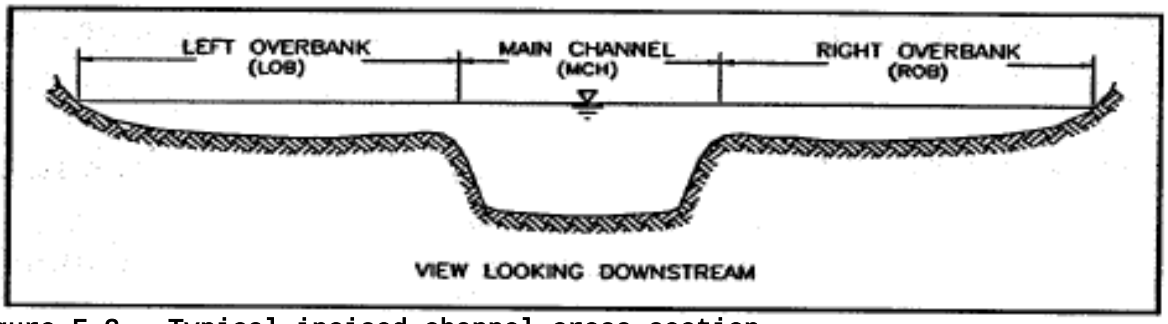

Figure F-3 - Typical incised channel cross-section

The perched channel provided additional modeling challenges to the study team. For one, the rating curves that were

developed for the floodway differ from each overbank. Second, where flood waters leave the floodway and enter into the overbank, those waters may continue in the OVERBANK area for miles before reuniting with the floodway. Further discussion of modeling perched channels follows in this appendix.

The study area has an extensive history of flooding. Much of that flood threat has been mitigated with the construction of Cochiti Dam, but a substantial residual risk exists from uncontrolled drainages downstream of the dam, as well as the risk of a substantial spring snowmelt runoff. Over the past 30 years, numerous levee patrols have been conducted to monitor controlled releases from Cochiti Reservoir that threaten the spoilbank levees. Further, the Bureau of Reclamation has estimated it spends $2 million annually on levee maintenance to maintain performance in the areas proximate to the Bosque Del Apache National Wildlife Refuge. Finally, the Interstate Stream Commission has spent $11.3 million over the past 9 years to dredge and maintain a pilot channel through the main stem of the Rio Grande to mitigate sediment accumulation at the headwaters of the Elephant Butte Reservoir, at the southern extent of the study area (Albuquerque Journal, ‘‘Building a River’’, February 14, 2010, Page B1).

F-02 General Computational Procedures:

The assumptions and procedures used to analyze and quantify the economic variables are presented in this section. The hydro-economic model used to develop expected annual damages is based on discharge-frequency, stage-frequency, and depth-percent damage curves used to develop a damage-frequency curve. Depth-percent damage curves express dollar damages resulting from varying depths of water based on a percentage of the value of structure and contents.

Each surveyed property is assigned to a category (e.g., commercial, residential, public, apartment, transportation facilities, utilities, and vehicles) with as many subcategories (e.g., contents) as necessary, and details of ground and first floor elevations are noted. Each category has an associated depth-damage relationship expressed as a cumulative percentage of value for each foot of inundation. The depth-damage relationships were derived from historical data obtained from insurance companies, a recent commercial content survey conducted by the Albuquerque District, the Flood Insurance Administration, and prior Corps of Engineers experience. Note that the 2003 residential curves developed by the Institute of Water Resources (IWR) were used; thus, the residential content damages are a direct relationship to structure value. Table F-1 depicts the depth-damage

relationships used in this study. Tables F-2A to F-2C display the without-project rating curves used in this study.

The elevation of each property (determined from GIS-based topographic maps and field investigations) is aggregated by location and structure type to compute the vertical distribution of damageable property at that location. Each property category is then tabulated in terms of the number of units, average value per unit and aggregate value, within consecutive inundation depth ranges for each location. That inventory is set into The Hydrologic Engineering Center's Flood Damage Analysis (FDA) ver. 1.2.5a to compute expected annual and Equivalent Annual Damages.

This report contains descriptive tables (number of structures subject to flooding by event, value of damageable property by property type and event, and single occurrence damages associated with specific frequency events) that were generated as a reality check of the FDA analysis. The study area's floodplain is fairly wide and flat, such that structure first floor height has a tremendous bearing on start of damages and damages attributable to specific events. To compute the number of structures in a given floodplain, the FDA_StrucDetail.out file was consulted, which computes number of structures, value of damageable property, and single occurrence damages. This computation occurs ''without-risk'' but serves as a consistency check on EAD and equivalent annual benefit calculations.

Tables F-3A and F-3B display the number of damageable property units by floodplain, in the present and the future hydraulic conditions. Tables F-4A and F-4B present the depreciated replacement values of those properties, by floodplain and hydraulic condition. As a quality check, these tables also display average value per structure, which is computed by dividing the number of structures in Tables F-4A to F-4B by the corresponding values in Tables F-3A to F-3B. The 2010 Census indicates the average household size in Socorro County is 2.46 persons. Multiplying this figure by the number residential and apartment structures in the 1% chance and 0.2% chance floodplains suggest that the study area has a Population at Risk (PAR) of 1,395 persons from the 1% chance flood and 1,823 persons from the 0.2% chance flood.

Section 308 of the Water Resources Development Act of 1990 states ''The Secretary shall not include in the benefit base for justifying Federal flood damage reduction projects...any new or substantially improved structure...built in the 100-year flood plain with a first floor elevation less than the 100-year flood elevation after July 1,1991.'' To comply with that requirement, the latest Flood Insurance Rate Maps

(FIRM) of the study area were consulted and compared to identified study floodplains. (http://msc.fema.gov/webapp/wcs/stores/servlet/CategoryDisplay?storeId=10001&catalogId=10001&langId=-1&categoryId=12001&parent_category_rn=12001&type=CAT_MAPPANEL&stateId=13038&countyId=14814&communityId=349932&stateName=NEW+MEXICO&countyName=SOCORRO+COUNTY&communityName=SOCORRO%2CCTY%2FSOCORRO+CO&dfirm_kit_id=&future=false&dfirmCatId=null&isCountySelected=&isCommSelected=&userType=G&urlUserType=G&sfc=0&cat_state=13038&cat_county=14814&cat_community=349932 accessed3/23/2011)

The latest applicable FIRM mapping has an effective date of 5/17/1988 and applies only to the incorporated portions of the Town of Socorro. 1446 structures were identified by comparing FIRM coverage with study floodplains. Of those structures, 1138 were elevated clear of the FIRM-identified 1% ACE water surface elevation, leaving a remainder of 308 structures subject to the Section 308 exclusion. Of those structures, only 13 were determined to be built after July 1,1991. Table F-3C presents the results of this analysis.

These 13 structures were largely comprised of single-story, detached residences and mobile homes of fairly average value. The remainder was material storage sheds and farm equipment storage buildings. The damages and benefit calculations were performed prior to this analysis, but the properties subject to exclusion by Section 308 are so few and minor in value relative to the scope of the flooding issues facing the Middle Rio Grande Valley, the study team thought it unwise to recompute damage and benefit calculations removing those properties. Sensitivity analyses indicate excluding these properties would have no material impact on EAD, project benefits, project sizing to identify the NED plan, or project cost-sharing.

For each category, the aggregate value of property at each flood depth is combined with the depth-damage relationship to compute total, single event damages for each level of flooding. Tables F-5A and F-5B display the single occurrence damages by category for the floodplain evaluated. This is combined with the discharge-frequencies of the reference floods to produce damage-frequency relationships. Damage-frequency relationships provide probable average annual damages for each category under the conditions of each reference flood, and can then be compared to the hydrologic, hydraulic, and economic data analyzed within HEC-FDA. Tables F-6A to F-6C present the average annual damages computation from the HEC-FDA analysis.

Residual, average annual damages for each alternative, including the without project alternative, are obtained through consecutive iterations of the above computations for each alternative. The difference between damages in the

without-project alternative and the residual damages for each alternative is the value of the benefits (inundation reduction) for each alternative. The following figure demonstrates the integration of hydrology, hydraulic data, and the economic information developed in this appendix is integrated to generate the Equivalent Annual Damages (EAD) computation:

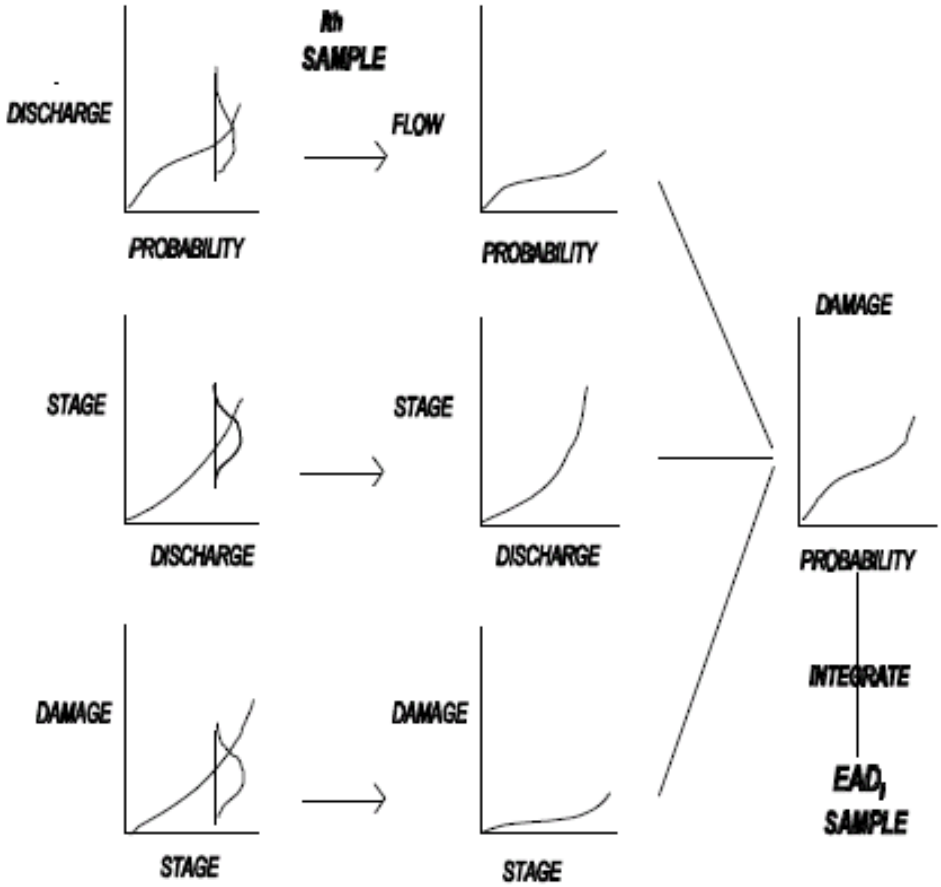

Figure F-4 - EAD Development Methodology

F-03 Value of Property:

A survey of structures within the floodplain was initially conducted in 2005, to evaluate the flood threat to the area. The property examined was categorized into residential, commercial, and public buildings, as well as, vehicles, streets and utilities, and outbuildings (sheds and detached garages). The field survey gathered primary data such as structure description (quality of construction, construction

materials, number of floors, presence of basements), an estimate of effective age for depreciation purposes, occupancy type, elevation above grade, an estimate of structure size in square feet, and the number of nearby structures that share these attributes. Tables F-3A and F-4A show number of property units and value of damageable property affected by the 10-percent, 2-percent, 1-percent and 0.2 percent chance flood events, respectively. Tables F-3B and F-4B show number of property units and value of damageable property affected by the 10-percent, 2-percent, 1-percent and 0.2 percent chance flood events, respectively, in the future hydraulic condition. These tables were generated using HEC-FDA's FDA_StrucDetail.out file for descriptive purposes only, to better understand the nature of the damages reported by HEC-FDA.

Depreciated, replacement residential structure values were computed using the factors and methods described in the Real Estate Cost Handbook, published by the Marshall and Swift Company. Corps regulations require cost-benefit evaluations use depreciated replacement costs. Replacement cost is the cost of physically replacing (reconstructing) the structure. Depreciation accounts for deterioration occurring prior to flooding, and variation in remaining useful life of structures. Depreciated replacement cost computations include factors such as construction type (wood, masonry) and quality, effective age (for depreciation purposes), and local market prices that bring the value of the structure to what we'd expect to spend on a ''replacement in kind'' structure in the study area. That computation was then verified in the field through interviews with local Realtors, and insurance agents to verify structure ages and replacement costs of structures in the floodplain. A windshield survey of all structures was also conducted to establish average first floor elevation above grade of structures in each damage reach. That ''elevation above grade'' was added to the ground surface elevation DTM data used in the hydraulic model to tie the economic inventory to the floodplain model. Commercial, public and apartment structures were inventoried in the field survey using the Marshall and Swift Valuation Service.

Content values were estimated from several sources. Residential content values were held at 50% of the structure value. Insurers contacted estimated content values are greater than 55% of structure value. (Where the IWR 2001 and 2003 structure and content depth-percent damage relationships were used, content damages are expressed as a percentage of structure value.) Commercial and public content values were computed using CCI, developed by Marshall and Swift/Boeckh, which estimated content and inventory values based upon factors like SIC code for the property, size of the property in square feet.

Vehicle estimates were determined using in-house data and published surveys. Total vehicles in the floodplain depicted are for residential structures and apartments. The typical household in Socorro County has 1.74 vehicles. It is assumed that one of these vehicles is driven out of the floodplain before any flood event. The remaining vehicles were distributed to the residential and apartment structures located within the 0.2 percent chance exceedance flood plain. It was assumed that all business-related vehicles were already evacuated from the floodplain.

Streets were measured from floodplain maps to determine quantities susceptible to flooding for each event. Streets, roads within the floodplain were elevated to a median elevation for each particular flood event for which floodplains were generated, and were ‘‘damaged’’ per elevation-damage relationships produced by the Galveston District (displayed in Table F-1). The resulting damages per event were then probability-adjusted per the likelihood of the event, and summed to compute equivalent annual damages. A sample of that calculation follows:

Roads Present				
freq	interval	value	single occ	total
0		36,715,390.98		
	0.002		36,715,390.98	73,430.78
0.002		36,715,390.98		
	0.008		30,868,198.44	246,945.59
0.01		25,021,005.91		
	0.01		23,370,744.67	233,707.45
0.02		21,720,483.42		
	0.08		16,093,455.23	1,287,476.42
0.1		10,466,427.03		
	0.01		5,233,213.52	52,332.14
0.11		0.00		
sum				1,893,892.37

Figure F-5 - Sample Event-Damage Calculation

Construction costs for roads were obtained from the City of Alamogordo, NM (http://ci.alamogordo.nm.us/Assets/COA+Document/City+Clerk/Minutes/04-08-2008+Regular+Minutes.pdf, accessed 10/30/2009) and the Arkansas State Highway and Transportation Department (http://www.arkansashighways.com/roadway_design_division/Cost_per_Mile_JULY_2009.pdf, accessed 10/30/2009). It was assumed that utility quantities (expressed in linear feet) were identical to paved street quantities. Utility construction costs were obtained from the Arizona and Texas Departments of Transportation. Damage estimates were calculated from published data provided by the Galveston District. Emergency costs were derived from locations that have had similar flood characteristics (Carlsbad, NM).

Agricultural acreage was measured using aerial photography of the floodplains used in this study. Agricultural valuation and damage assessment for crops within the study area was calculated using crop budgets from the NMSU Cooperative Extension Service for the study area. Using the same hydrologic data developed for recreation damage assessment, the crop budget was applied to a typical calendar year to calculate sunk costs if the flood event were to occur before the harvest. The long duration events predicted suggest a total loss of that year's crop if the event occurs before the harvest. Flood events occurring after harvest activities were conservatively assumed not to damage the value of the agricultural land, since the crop was already harvested. Officials at the Natural Resources Conservation Service provided estimates of crop composition (alfalfa hay, wheat, green chile, corn) and relative distribution.

The Bureau of Reclamation operates and maintains a Low Flow Conveyance Channel (LFCC). The channel was constructed in 1959 as a diversion running parallel to the Rio Grande that could divert water from the main channel and reduce evaporative water losses for the Rio Grande between the San Acacia diversion dam and Elephant Butte Reservoir to the south. The LFCC hasn’t actively diverted water from the Rio Grande since the 1980s, but does deliver water to the Middle Rio Grande Conservancy District’s Socorro Diversion as well as to wetlands in the Bosque Del Apache NWR. The LFCC currently provides valley drainage, (Page 1-8 of the main report), irrigation return flows and shallow groundwater interception (Page 1-21), and water for use by Bosque Del Apache NWR and MRGCD irrigators (Page 1-9). It is the valley drainage/groundwater intercept functions alone that keep the LFCC full for much of the year. Bureau of Reclamation estimates that water is diverted from the LFCC, used, and return flows captured 4 times between the San Acacia diversion dam and the downstream end of the LFCC. Those functions are not part of the original design, but have evolved over the course of the LFCC’s life. The LFCC is also recognized by the IBWC as a critical component in meeting Rio Grande Compact water delivery requirements to Texas and Mexico. The Fish and Wildlife Service also recognizes the LFCC as providing water to habitat critical to the Southwest Willow Flycatcher (an endangered species). Those functions have a value, which has not been captured in this analysis. The ‘‘Avoided Water Losses’’ benefit category captures the water that DIDN’T evaporate in a wider channel or pond due to intercept and delivery by the LFCC, but it’s clear THAT benefit (no NED benefits claimed in this analysis) doesn’t totally capture the impact of the structure. The Bureau of Reclamation has indicated they will continue to operate the LFCC without diverting flows from the Rio Grande in a Record of Decision for the Upper Rio Grande Basin Water Operations Review Final EIS (Page 1-

21.). The existing channel was shortened to 58 miles, as sediment filled in the LFCC downstream of San Marcial (Page 1-9) which is the source of the ‘‘channel must be rehabilitated’’ statements in the report. In the event the LFCC were rendered inoperable, MRGCD irrigators would not receive their water, and neither would the Bosque Del Apache NWR. Local runoff would not return to the Rio Grande (which is perched above the floodplain) and would be impounded in the floodplain until evaporated or reabsorbed into the groundwater. New Mexico would fall further behind in Rio Grande Water Compact deliveries, and habitat critical to the Southwestern Willow Flycatcher would lose a key water source. Bureau of Reclamation representatives affirmed that the December 1993 construction cost for the LFCC was $87,620,000. Based upon the most recent expert solicitation, the Corps has estimated the LFCC’s replacement cost in the study area at $125 million. Bureau of Reclamation personnel have stated as recently as 2007 in a Record of Decision that they the LFCC will continue to be operated as a passive drain with zero diversion from the Rio Grande. Savings in O&M of existing structures provided represent a benefit of the proposed project. Tables in this appendix do not reflect this savings, because it is uncertain what portion of that maintenance budget is attributed to the levee or the LFCC, or whether the Bureau of Reclamation would be able to reduce or halt its maintenance costs of the LFCC with the proposed project in place. Bureau of Reclamation personnel provided the event-%damage relationship used in this evaluation, as well as estimates of LFCC downtime following flooding and sedimentation within the diversion. The Bureau of Reclamation has indicated that they annually maintain the LFCC to protect it against underseepage from the main channel, under the existing spoilbank levee (which has no foundation) and erodes the LFCC sidewalls. An expanded discussion of the flood threats to the LFCC can be found in the Geotechnical appendix. A more detailed discussion of the flood threat to the LFCC and the benefits provided by the proposed project can be found in Paragraph F-11 of this appendix.

F-04 Sources of Uncertainty:

The major sources of economic uncertainty include many of the same variables identified above in the damage estimate analysis and others noted as follows:

1. Value of property;
2. Value of property contents;
3. Flood stage at which damage begins;
4. First floor elevations of structures;

5. Responses to flood forecasts and warnings;
6. Flood fighting efforts;
7. Cleanup costs;
8. Business losses;
9. Depth-percent damage curves;
10. Estimate of the stage associated with a given discharge;
11. Estimate of damage for a given flood stage; and
12. Estimate of future land use

Principal sources of error affecting the stage-damage relationship were examined in a risk and uncertainty framework. Those sources of error are 1) errors associated with the damageable property elevation, 2) errors associated with the values of structures in the floodplain inventory, 3) errors associated with values of structure contents in the floodplain inventory, 4) errors associated with the damage functions used against the floodplain inventory.

There are numerous factors which affect the frequency distributions as well as the rating curves for the study area's hydraulic reaches. Those factors are discussed in detail in Appendix E.

Elevation of damageable property:

A standard deviation of 0.4 feet was used to account for the uncertainty associated with the elevation of damageable property. In the study area, the flooding depths are relatively shallow and the flood plains are large and flat; therefore, an elevation difference of one foot could potentially double the damages associated with a given stage. The 0.4 feet standard deviation was used for three reasons. First, since the economic inventory was conducted by a visual windshield inspection, the first floor elevations of structures were estimated rather than measured. Second, the digital terrain model (DTM) used to develop specific frequency event floodplains introduces a source of uncertainty relative to elevation. Sensitivity analyses also indicated that the flat overbank flooding areas was overstating the impact of relatively frequent flooding, so a more conservative start of damages condition was established in HEC-FDA to minimize this impact. Para. F-05 of this appendix discusses how the start of damages condition was modeled in HEC-FDA.

Structure value:

It was assumed that the estimated structure value, which was derived from sales information and a field inventory, has a standard deviation of 15 percent of the structure value. That 15 percent standard deviation comes from prior

Albuquerque District studies, and prior experience of the Ft. Worth District, which developed that estimate from interviews with various County Assessor's offices.

The structure inventory values and associated error distribution were then evaluated to compute floodplain inventory that incorporates errors concerning structure value. It was assumed that the estimated structure value (derived from field inventory and consultations with Realtors, insurance agents) could be off by 15% of the structure value. The floodplain inventory was then assessed using these assumptions, dropping all values more than three standard deviations from the reported (mean) value. The resulting distribution of structure values with error would contain 99% of possible values given the assumptions above.

Content value:

The error distribution associated with content value varied by structure type. In terms of average annual damages for residential contents the damage curves relate to the structure value rather than the content value.

The content value error distribution varied by structure type. Corps guidance stipulates residential content values should be held to no more than 50% of structure values, though local insurers note that contents are valued at 55-60% of structure value, or more. Residential and apartment content value distributions with error were fixed to the error distributions associated with residential and apartment structures. New depth-percent damage relationships published by IWR in 2001 and 2003 compute content damages as a percentage of structure value. Content valuation in this appendix is for illustrative purposes only, and content damages for residences use the IWR methods. Commercial and public contents used standard deviations that were equal to the content value to develop the content value with error. All content relationships were truncated to eliminate the possibility of negative values.

Stage-percent damage relationship:

Depth-percent damage curves are among the most important and least exact data in benefit estimation. Depth-percent damage curves express dollar damages resulting from varying depths of water based on a percentage of the value of structure and contents. Errors associated with the depth-percent damage functions were applied after the structure and content values were determined. The errors associated with the stage-percent damage relationship were evaluated for structures and contents of all occupancy types. The

standard deviations used were those estimated by IWR for residential and apartment structures and contents.

The errors associated with the stage-%damage relationship were evaluated for structures and contents of commercial and public occupancy types. It was assumed that the damage value used +/- 40% of that value would contain the true damages for a given stage 95% of the time. The 40% standard deviation came from prior Albuquerque District studies, stage-%damage relationships developed by Galveston and Albuquerque Districts through post-flood surveys of property owners, and interviews with local business owners. Residential and apartment structures and contents use the IWR stage-percent damage relationships, which include errors for each stage presented. Errors associated with the depth-percent damage functions used were applied after the uncertain structure and content values were determined.

F-05 HEC-FDA Use

Consistent with the requirements set forth in EC 1105-2-412, ‘‘Assuring Quality of Planning Models’’ HEC-FDA version 1.2.5a was used to compute average annual and equivalent annual damages (EAD). Corps guidance stipulates that the plan which reasonably maximizes net national economic development benefits, consistent with the Federal objective, be identified. Project benefits for flood risk management measures are identified through successive iterations of existing and future without-project scenarios, changing key hydrologic and/or hydraulic variables as the measures warrant. HEC-FDA is the only model certified for formulation and evaluation of flood risk management plans using risk analysis methods, and was used in this study. Damages are computed in August, 2010 price levels using the fiscal year 2010 Federal discount rate of 4.375%. The period of analysis is 50 years.

There were special conditions in the Middle Rio Grande study area that required changes to how HEC-FDA performs its analysis. First, HEC-FDA is set up expecting an incised channel with overbank flooding areas higher than the channel. The Rio Grande River is perched in many portions of the study area, meaning the river sits higher within its banks than many of the lower spots in the overbank areas. A typical effect of perched channels is severe events can have LOWER stages than less severe, more frequent events, as the river breaks through its banks and rushes into the expansive (and lower) overbanks. A second consequence of the perched channel is different banks of the same damage reach can have different water surface elevations for the same event.

The study team developed ‘‘virtual’’ channels to address HEC-FDA’s limitations to handle perched channels. For each

damage reach, hydraulic water surface elevations were computed for the main channel, the left (east) overbank and the right (west) overbank locations. The HEC-FDA model contains three streams for purposes of analysis, identified in this appendix as the ‘‘Rio Grande’’, the ‘‘Rio Grande LOB’’ (left overbank, east of the channel), and the ‘‘Rio Grande ROB’’ (right overbank, west of the channel). Each stream has its own water surface profiles, exceedance-probability functions, and stage-discharge functions. The economic inventory was assigned to either the left or right overbank ‘‘stream.’’

A second issue created by perched channels is an exaggeration of the damages associated with frequent, though relatively not severe, events. The hydraulics appendix notes that there is considerable concern over the quality of the existing levees, such that upstream dam releases are kept to below 7,000 cfs, which corresponds to somewhere between the 20% and 10%-chance events in this study. The geotechnical appendix also notes the LFCC receives damages due to river water seeping under the existing levee (that doesn’t have a foundation) and collapsing the LFCC sidewall. The HEC-RAS model showed overbank depths with the 50% and 20%-chance events, which didn’t seem reasonable for this evaluation. Therefore, a beginning damage depth was applied in HEC-FDA corresponding to the present condition, 10%-chance water surface elevation. This ensures that events more frequent than the 10%-chance event doesn’t damage the floodplain inventory, as the flows are expected to be contained within the banks of the Rio Grande. The PDT feels this assumption is conservative, as it assumes the existing spoil bank levees provide some degree of protection, though history shows those levees do not survive water against them. Absent the starting damage elevations, average annual damages were more than double what is presented here. Tables F-2A and F-2B display the rating curves used in this evaluation.

F-06 Potential Flood Damages:

It is currently estimated that the mean 1-percent chance exceedance flood would cause damages of about $98.4 million in the study area. Tables F-5A and F-5B presents the single occurrence damages associated with the 10%, 2%, 1%, and 0.2% chance flows in the assorted floodplains. These tables were generated using the @RISK application for descriptive purposes only, to better understand the nature of the damages reported by HEC-FDA. HEC-FDA was used to compute average and equivalent annual damages for structures and their contents only. Other damage categories were evaluated by identifying damages associated with the same event frequencies, as described below. This study’s hydrology and hydraulic evaluations assume that flood events of a

magnitude greater than the 20% chance event damage structures, contents, and vehicles in the flooding areas analyzed. It should be noted that many intangible damages (such as loss of life, disruption to community services, and increased health risks) that could occur because of flooding are not represented in these damage values.

Several damage categories (agriculture, roads, utilities, railroads, irrigation drains) were evaluated outside HEC-FDA using the following method: Within each floodplain, quantities (in acres for agriculture, in lineal feet for other categories) of each property type were measured in GIS. The 10% chance floodplain inventory represents all property falling within the 10% floodplain polygon. The 2% chance floodplain represents the entire inventory in the 10% chance floodplain, plus the measurements in the floodplain polygon between the 10% and 2% chance floodplain boundaries. The 1% floodplain represents the contents in the 10% floodplain, the floodplains between the 10% and 2% chance boundaries, plus the polygon bounded by the 2% and 1% chance floodplain boundaries. Finally, the 0.2% chance floodplain represents the sum of the 10% chance polygon, plus the polygon bounded by the 10% and 2% floodplain boundaries, plus the polygon bounded by the 2% and 1% floodplain boundaries, and finally, the polygon bounded by the 1% and 0.2% chance floodplain boundaries.

Streets, roads, utility lines, railroads, and irrigation drains within each floodplain were elevated to a median elevation for each particular flood for which floodplains were generated. Therefore, for the first floodplain a particular stretch of road is inundated, the first inundation event stage is equal to half the marginal stage between identified floodplain and the prior event or start of damages (for the 10% chance floodplain). Subsequently more severe flood stages have the effect of damaging more property, as the floodplains grow, and providing even more inundation depths for properties located within lesser floodplains.

Agricultural valuation and damage assessment for crops within the study area was calculated using crop budgets from the NMSU Cooperative Extension Service for the study area. GIS data and the floodplain boundaries were used to determine the acreage subject to flooding by specific events. Using the hydrologic data to determine the likelihood of precipitation in a given month, the crop budget was applied to a typical calendar year to calculate sunk costs if the flood event were to occur before the harvest. The long duration events predicted suggest a total loss of that year's crop if the event occurs before the harvest, therefore crop surface elevations were not necessary. Flood events occurring after harvest activities were conservatively assumed not to damage the value of the

agricultural land, since the crop was already harvested. Officials at the Natural Resources Conservation Service provided estimates of crop composition (alfalfa hay, wheat, green chile, corn) and relative distribution.

Construction costs for roads and interstates were obtained from the Arkansas Department of Transportation and the City of Alamogordo, NM. Utility construction costs were obtained from the Arizona and Texas Departments of Transportation. Depth-percent damage relationships were calculated from published data provided by the Galveston District as well as prior Albuquerque District studies.

Estimated damages for the Bureau of Reclamation's Low Flow Conveyance Channel (LFCC) were developed by applying depth-percent damage relationships provided by the Bureau of Reclamation to the length of channel in each floodplain (determined by measurement of aerial floodplain photos). This was the more conservative method of assessing damages, as elevation of the LFCC on 5' contour interval aerial photos, with appurtenant uncertainty distributions, increased average annual damages using depth-damage relationships 25-40%. The stage-% damage relationship used is identified in Table 1. Paragraph F-11 of this appendix describes sensitivity studies conducted that used 5 separate depth-% damage relationships on the LFCC and their impacts.

Enumerated damages derived for the Bosque Del Apache National Wildlife Refuge represent the value of recreational opportunity lost for one year in the year that the flood event occurs. In addition to calculating values and damages to physical assets contained within the refuge, it was assumed that floods generate adverse changes to the specialized recreation values for the facility during the winter, when the site is visited by a variety of migratory waterfowl. During the summer flood events would negatively impact general recreation values for the Bosque Del Apache NWR. Hydrologic data was provided to estimate when during a typical year a significant flood event would occur, and specialized and general recreational values were developed per Economic Guidance Memorandum 10-3. A probability distribution of event occurrence in any given month was developed, and it was assumed that recreation opportunities would not be available for the remainder of the year if the Bosque Del Apache NWR were flooded, given the long duration events predicted and the loss of recreation facilities to that event. The probability distributed results for the various flood events are presented in the tables within this appendix.

The general and specialized recreation values were estimated through interviews with Corps, Bureau of Reclamation and Bosque Del Apache NWR biologists, who looked at the quality of the recreation experience, the availability of the

recreation opportunity, the carrying capacity of the refuge and its facilities, the accessibility of the refuge, and the general esthetic condition. Each respondent provided a point estimate for the general recreation experience as well as the specialized recreation experience per Economic Guidance Memorandum (EGM) 07-03. Specialized recreation values were computed to cover the months when the Sandhill Crane and other migratory waterfowl visit in the winter. An arithmetic mean of the general recreation values was used to compute the value per general recreation day; the same computation was developed for specialized recreation values.

Agricultural acreage was measured using aerial photography of the floodplains used in this study. Agricultural valuation and damage assessment for crops within the study area was calculated using crop budgets from the NMSU Cooperative Extension Service for the study area. Using the same hydrologic data developed for recreation damage assessment, the crop budget was applied to a typical calendar year to calculate sunk costs if the flood event were to occur before the harvest. The long duration events predicted suggest a total loss of that year's crop if the event occurs before the harvest. Flood events occurring after harvest activities were conservatively assumed not to damage the value of the agricultural land, since the crop was already harvested. Officials at the Natural Resources Conservation Service provided estimates of crop composition (alfalfa hay, wheat, green chile, corn) and relative distribution.

Emergency costs include the costs of evacuation, reoccupation, disaster relief, cleanup and debris removal, and other similar expenses. The emergency costs incurred are dependent upon factors including number of residences damaged, evacuated, etc. Factors used in this study are based upon historical flooding in Carlsbad, NM and interviews with American Red Cross personnel.

Future flood damages resulting from basin development or growth in the floodplain have not been included, but are not expected to be significant for several reasons. 1) Local Realtors contacted noted that growth in Socorro and the surrounding area has been flat and may remain stagnant in the future. 2) Local Realtors have noted that most recent development in the study area has occurred outside the floodplain.

Future flood damages to existing properties are expected to increase in parts of the study area due to sediment aggradation within the Rio Grande. Generally, areas north of the Town of Socorro were expected to degrade, while areas south of Socorro were expected to aggrade. Any project evaluated in this light will have to account for the increased stages caused by sediment deposition in selected

areas along the Rio Grande. Several tables in this appendix show existing conditions information, information for conditions 50 years hence. Tables F-6A to F-6C present Expected Annual Equivalent damages and benefits, discounting future values to present value for purposes of selecting the NED plan.

F-07 Average Annual Damages:

Risk and uncertainty analysis was used to derive average annual damages. Hydrologic and hydraulic uncertainty was combined through Monte Carlo simulations within HEC-FDA. When flooding from all sources is considered, the study area presently faces the risk of approximately $8.0 million in average annual damages to structures and contents. Sediment deposition over the proposed project's life is expected to increase those damages, which has been discounted to present value, summed, and amortized over the project life. Tables F-6A to F-6C presents the average annual damages that could occur from flooding in the study area without any flood protection, by land use category and floodplain. Table F-6C discounts the future damages to present values, and presents the Equivalent Annual Damages (EAD).

A major damage category for the study area outside of structures and their contents is damage to the Low Flow Conveyance Channel. The Water Resources Development Act of 1992 (PL 102-580) authorizes the Corps to identify the portion of project benefits attributable to Federal properties. Tables F-6A and F-6B display the Average Annual Damages for the present and future hydraulic conditions. Table F-6C discounts the future damages to present values, and presents the Equivalent Annual Damages (EAD) and EAD attributable to Federal properties.

F-08 Analysis of Existing Levees:

A reliability assessment of the existing system of spoilbank levees was performed to determine applicable Probable Non-Failure and Probable Failure Points (PNP and PFP, respectively). The results of that evaluation are presented in the Geotechnical Appendix of this GRR. In it, the conditions under which the levees fail are limited to foundation seepage, piping, and sloughing of the land side low flow conveyance channel (LFCC), which would occur before flows break out of the river channel. This is largely due to the existing levee's lack of foundation, and occurs as often as the 50% chance event. Further discussion of the LFCC's vulnerability to flows in the Rio Grande can be found in the Geotechnical appendix, and in Paragraph F-11 of this appendix.

As a result of the subsurface investigations and interviews with Bureau of Reclamation personnel, the Probable Non-Failure Point (PNP) was determined to be some point within the Rio Grande channel. The Probable Failure Point (PFP) was determined to be the toe of the existing levee just above the point where water first breaks out of the river channel. For purposes of determining damages and benefits for this appendix, the existing spoilbank levee provides no protection from any of the flood events evaluated.

A geo-technical evaluation was performed for the existing system of spoilbank levees from San Acacia to Bosque Del Apache. The geo-technical analysis that appears in Appendix E notes that the existing levees are constructed of uncompacted materials and are not adequate to withstand water against or near the levees from the Rio Grande or the Low Flow Conveyance Channel (LFCC). Moreover, Bureau of Reclamation personnel said that extensive flood fighting had been performed in the past to prevent levee failure. Previous iterations of this report did not consider the protective value of the existing system of spoilbank levees, and no adjustment of the benefits provided by those levees is necessary.

F-09 Levee Sizes Considered:

Several alternative levee heights, with sizes corresponding to the mean 1% chance exceedance event stage to about four feet greater than the mean 1% chance exceedance event stage, were evaluated in a framework incorporating elements of risk and uncertainty in hydrology, hydraulics and economics. Any analysis of alternatives must include the no action alternative. If no action is taken, the floodplains defined by the study will continue to suffer damages described in Tables F-6A to F-6C. Each height uses the same real estate footprint and will substantially replace existing spoilbank levees so alternative alignments were not considered for this analysis.

The table which follows describes how the alternative levee sizes were selected to contain specific flood events. Given the Risk and Uncertainty framework used in plan selection, it is inappropriate to describe an alternative in terms of "level of protection." The terms ("Base levee", "Base + 1 ft. levee", etc...) describe a height that corresponds to a mean event stage. Project performance measurements (formerly known as Reliability) are discussed in paragraph F-16.

ALTERNATIVE LEVEE HEIGHTS EVALUATED

Alternative	Description
Base Levee	Approximately the mean 1% chance exceedance flood

	stage, present conditions
Base Levee+ 1 ft	Base levee plus 1.0 foot of levee height
Base Levee+ 2 ft	Base levee plus 2.0 foot of levee height
Base Levee+ 3 ft	Base levee plus 3.0 foot of levee height
Base Levee+ 4 ft	Base levee plus 4.0 foot of levee height

The exterior-interior relationship defines a relationship between the water surface stage on the river or exterior side of the levee versus the stage in the floodplain or the interior side of the levee. This relationship is necessary if the stage in the interior will not reach the same stage that is overtopping the levee. This may be due to floods that results in stages near the top of the levee overtopping as designed in a safe, controlled manner, or a flood hydrograph volume not sufficient to fill the floodplain to the stage equal to the top of the levee. For this project, there is insufficient volume to fill the floodplain once the flows are contained within one levee. In either case, the relationship must be developed from hydrologic or hydraulic analyses external to the FDA program. If the relationship is not specified, the assumption is that the floodplain fills to the stage in the river (represented by the exterior stage-discharge function for the reach) for all events that result in stages that cause levee failure or are above the top of levee. Because the levee cuts off portions of the floodplain, the remaining water is ‘‘stacked’’ in a smaller cross section and areal extent. The exterior relationships are expected to be somewhat higher than the corresponding interior rating curve.

To capture the benefits of the proposed levees, the study team evaluated the beneficial effects of flood protection for the virtual ‘‘Right Overbank (ROB)’’ channel as an interior rating curve in the main channel. In the without-project and without-project, future conditions, the main channel and the right overbank ‘‘virtual channel’’ have significantly different hydrology and hydraulic properties. However, the with-project conditions have identical properties for both the main channel (which is perched several feet over the overbank areas) and the right overbank. Several attempts were made to create a proxy for main channel levee height in the right overbank, but were not successful. The economic inventory of the right overbank was relocated to the main channel to most effectively capture the effect of channel aggradation in the main channel, which was not modeled over the period of analysis in the with-project condition. The main channel and the virtual ‘‘Left Overbank (LOB)’’ channels used the exterior rating curves to model the impact of a levee. The

main channel uses the exterior rating curve to measure the project performance and capture data like annual exceedance probability, cumulative risk of failure, and likelihood of capturing key events of specific magnitudes, such as the 1% chance event. The left overbank uses the exterior rating curves to measure any induced damages that could be caused by putting a levee on only the right bank of the Rio Grande.

The levee heights analyzed started at the height corresponding to the mean 1% chance stage for each damage reach. Incremental heights of one foot were analyzed, up to the 1% annual chance exceedance (ACE) stage + 4’ design heights. Across all reaches, that final levee height exceeds the mean 0.2% chance event stage, so the team was assured of analyzing alternatives that would include capturing almost all events. New rating curves were developed by Corps hydraulic engineers to define the with-project (exterior) relationships for the main channel and the left overbank, and are presented in Table F-2C. Since the Right Overbank’s damageable property would be afforded flood protection by any proposed levee, the same rating curves developed for the without project condition in the Right Overbank were placed in HEC-FDA’s levee interior-exterior relationships as the ‘‘interior’’ relationship in the with-project and the with-project, future condition. That relationship was used to evaluate the benefits of the levee alternatives.

F-10 Evaluation of Induced Flooding on East Bank and Downstream Areas:

Infrared aerials of the Rio Grande east bank were examined to determine the extent, if any, of induced damages that would be caused by placement of the proposed levee on the west bank. Those properties identified were then evaluated in the field for structure value and first floor elevation, using the methods described in Paragraph F-02, above. During the field inventory, attempts were made to locate any newer structures built since the time of the aerial mapping, but none were found. A lack of eastern bank growth was confirmed by the Socorro City Planner and officials at the Natural Resources Conservation Service. Forty-seven residential and commercial structures were located within the 1% annual chance exceedance (ACE) floodplain. Table F-7 describes the inventory of damageable properties on the east bank, by floodplain. The inventory on the east bank was evaluated using the methods described in Paragraphs F-03 to F-07, above, to compute EAD in the without-project and with-project condition, for both the present and future condition.

Table F-7

NUMBER OF STRUCTURES
WITHOUT PROJECT CONDITIONS (PRESENT)
SAN ACACIA TO BOSQUE DEL APACHE EAST BANK FLOODPLAIN

Land Use Category	EVENT							
	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	13.00		17.00		19.00		21.00	
Commercial	1.00		1.00		1.00		1.00	
Public	0.00		0.00		0.00		0.00	
Apartments	0.00		0.00		0.00		0.00	
Outbuildings	27.00		27.00		27.00		34.00	
TOTAL STR.	**41.00**		**45.00**		**47.00**		**56.00**	

The east bank inventory was generally aggregated into two geographic areas. The first area on the east bank is the small community of Pueblito, immediately upstream of Socorro, which sits upon the west bank. The second area is northeast of the Village of San Antonio, consisting of residential and commercial structures along Bosquecito Road.

Different hydraulic models were used for the without-project condition (FLO-2D) and the with-project condition (HEC-RAS), making a direct, one-to-one comparison of WSEL difficult. Therefore, this discussion will center on impacts the proposed levee on the west bank of the Rio Grande has on flooding on the east bank. The additional increment of induced flooding is minor at cross sections containing damageable property (1327, 1433, and 1483), which is roughly 0.5’ at the 10% chance exceedance event for properties along Bosquecito Road in the future hydraulic condition. In the present, with-project condition the levee on the west bank on the Rio Grande showed no water surface increase until the 2% chance exceedence event. The events that will produce induced flooding begin at the 10% chance exceedance event and end at the 1% chance exceedance event plus 4.0’, where any proposed project's capacity is exceeded on the west bank. The following tables (Tables F-8 and F-9) describe the impact of west bank levee construction to east bank stages for specific events in the present and future conditions:

Table F-8						
10-YR WSEL CHANGES						
XSEC	10-yr WSEL, present			10-yr WSEL, future		
	w/o project	w/ project	Change	w/o project	w/ project	Change
1312	4620.76	4620.76	0	4619.59	4620.77	1.18
1327	4610.52	4610.67	0.154	4610.52	4610.674	0.154
1433	4567.66	4567.66	0	4568.435	4568.59	0.155
1483	4549.77	4549.25	-0.52	4549.77	4550.31	0.54
1491	4545.39	4546.86	1.47	4546.79	4548.32	1.53

Negative values ignored in residual EAD calculation.

Table F-9						
50-YR WSEL CHANGES						
XSEC	50-yr WSEL, present			50-yr WSEL, future		
	w/o project	w/ project	Change	w/o project	w/ project	Change
1312	4621.26	4623.36	2.1	4621.26	4622.88	1.62
1327	4613.16	4611.1	-2.06	4612.30	4612.064	-0.236
1433	4567.94	4568.39	0.45	4568.64	4569.34	0.7
1483	4549.97	4550.02	0.05	4549.97	4551.08	1.11
1491	4545.92	4547.58	1.66	4547.32	4549.04	1.72

Negative values ignored in residual EAD calculation.

Ignoring the negative values in water surface elevation changes (due to different hydraulic models) it's clear the impact of the levee is most felt in the future condition. There are two reasons for this; the general aggradation of sediment within the Rio Grande projected over the project life, and the increased error measurement, expressed in the standard deviation around the 1% chance event's water surface elevation. The standard deviation around the 1% chance event in the present condition is 1.3', and in the future condition is 2.26'. The net effect of the higher standard deviation accounts for approximately 1/3 of the increase in EAD.

Aerial photos of floodplains downstream of the downstream extent of the proposed project were examined to determine the extent of induced flooding downstream attributable to the project. No properties were found, which was verified during field investigations. Additionally, downstream flooding is more likely to occur because of change in the Elephant Butte Reservoir stage rather than the Rio Grande flood stage.

Pre- and post-project floodplains on the east bank were evaluated to determine the change in equivalent annual damages (EAD) attributable to the proposed project. The start of damages was assumed to be the 10% chance exceedance event. The proposed levee projects do not have a measurable impact to the damageable property in the present condition,

but a minor impact in the future. The without project EAD for the without-project condition is $272,000 whereas with-project EAD is $275,000. The results indicate that the EAD induced by the proposed project is approximately $3,000. The damage analysis is limited to 22 existing structures.

F-11 Evaluation of the Bureau of Reclamation's Low Flow Conveyance Channel (LFCC)

1. History and description of the LFCC

The Bureau of Reclamation constructed, operates and maintains the Low Flow Conveyance Channel (LFCC). The earthen and rock-lined channel was constructed in 1959 as a diversion running parallel to and west of the Rio Grande that could divert water from the main channel and reduce evaporative water losses for the Rio Grande between the San Acacia Diversion Dam and Elephant Butte Reservoir to the south. The LFCC had a design carrying capacity of 2,000 cfs and extended approximately 75 miles from the San Acacia Diversion Dam to the ''narrows'' in Elephant Butte Reservoir.
A series of high spring runoffs and high Elephant Butte reservoir conditions from 1979 to 1987 repeatedly damaged the LFCC. Making diversions from the Rio Grande would further damage the structure, especially in the lowest 15 miles, south of the San Marcial railroad bridge crossing, where sedimentation completely filled the LFCC. The Bureau of Reclamation evaluated their options for the LFCC with various planning studies and EIS from 1996 to 2007, to include relocating the LFCC to the East bank of the Rio Grande downstream of San Marcial. Reclamation continues their operations and maintenance activities downstream of the railroad crossing, and repurposed the LFCC to serve as a passive drain to intercept and convey shallow groundwater and irrigation return flows downstream to Elephant Butte Reservoir. However, the uncertainty over the LFCC's location and purpose downstream of the San Marcial railroad bridge has prompted the Corps to drop the segment of the LFCC downstream of the San Marcial railroad bridge from evaluation in this flood risk management study. Reclamation continues to operate and maintain the entirety of the LFCC as required. The residual length of the channel (50 miles from the San Acacia Diversion Dam to the San Marcial railroad crossing) serves as the focus of this evaluation. The LFCC is minimally protected by a spoil bank embankment. This spoil bank, located east of the LFCC and west of the main Rio Grande channel, was built using material that was excavated to create the LFCC. Subsequent maintenance and rehabilitation activities have also provided material to create the embankment. It extends the entire length of the

LFCC and varies in size, largely due to convenience and availability of material. Being a non-engineered structure, the spoil bank lacks features common in levees, such as soil compaction, appropriate side slopes, an impervious core and foundation, toe protection, etc…

2. Uses and outputs of the LFCC

The LFCC's role in the study area has evolved since its construction. The LFCC hasn't actively diverted water from the Rio Grande since the 1985, but the shorter channel length in its present configuration does deliver water to the Middle Rio Grande Conservancy District's Socorro Diversion as well as to wetlands in the Bosque Del Apache NWR. The original intent of the LFCC was to minimize evaporative water losses by diverting Rio Grande flows into a channel with a narrower topwidth. From construction to 1985, evaporative water loss savings were between 30,000 and 40,000 acre-feet annually. That savings is not claimed in this current analysis.

The LFCC functions as a riverside drain, and provides valley drainage, (Page 1-8 of the main report), irrigation return flows and shallow groundwater interception (Page 1-21), and water for use by Bosque Del Apache NWR and MRGCD irrigators (Page 1-9). It is the valley drainage/groundwater intercept functions alone that keep the LFCC full for much of the year (The LFCC and the valley sit below the perched Rio Grande). Bureau of Reclamation estimates that water is diverted from the LFCC, used, and return flows captured 4 times between the San Acacia diversion dam and the downstream end of the LFCC. Those functions are not part of the original design, but have evolved over the course of the LFCC's life. The LFCC is also recognized by the IBWC as a critical component in meeting Rio Grande Compact water delivery requirements to Texas and Mexico. The Fish and Wildlife Service also recognizes the LFCC as providing water to habitat critical to the Southwest Willow Flycatcher (an endangered species). Those functions have value to the region and the environment, which has not been captured in this analysis. Without the Low Flow Conveyance channel, life in the study area would be different. According to the Bureau of Reclamation, ''Land use practices and their economic values for the agricultural community and BDANWR [Bosque del Apache National Wildlife Refuge] would be diminished without the LFCC drainage facility. There would be the potential for increased groundwater levels due to surface water irrigation of lands and increased alkalinity in the soils due to the groundwater rising and fluctuations near the root zones. These alkalinity problems due to lack of valley drainage would also impact fish and wildlife, vegetation, wetlands, and endangered species functions on the BDANWR.'' Groundwater replacement sources may be available to replace the needed water but the Bureau has indicated that groundwater levels are continually declining as it is, and

further use would accelerate that depletion, potentially being an unsustainable solution. Absent the LFCC, stormwater and irrigation runoff has no means to return to the perched Rio Grande, meaning the State of New Mexico will have a harder time making water deliveries to Texas and Mexico per the Rio Grande Compact.

3. Nature of the flood threat and nature of damages

a. Spoil bank and underseepage

As previously stated, the LFCC is minimally protected from the Rio Grande by a non-engineered spoil bank levee. The most common threat to the LFCC occurs with annual channel flows. The Bureau of Reclamation has indicated that they annually maintain the LFCC to protect it against under seepage from the main channel, under the existing spoil bank levee (which has no foundation), which erodes the LFCC sidewalls. Reclamation has historically performed river and spoil bank levee maintenance during the Corps' flood control operations (above the mean annual peak flow or long duration periods at or above the mean annual peak flow) in the study area. These flows occur during the spring runoff or monsoonal thunderstorm events. Work on the river has been comprised of constructing pilot channels through sediment deposits (after flows recede) or widening, raising, and repairing the levee in the San Acacia Reach. This work occurs prior to the annual spring runoff, when the snowpack is very large, or during the spring runoff. The success rate of this preparatory work is spotty at best, as Reclamation indicates that there have been ''many cases of near failure due to either overtopping or seepage/piping.''

Aside from the underseepage threat, the LFCC faces a threat of sedimentation closing off channel capacity. The Bureau of Reclamation spends $150,000-$700,000 annually to maintain the LFCC, which includes sediment removal, and lining vulnerable portions of the channel with rock. Small flows, to include annual flows, present a threat of under seepage. Larger flows threaten to erode the spoil bank levee, and deposit sediment and levee materials within the LFCC, which sits below the perched Rio Grande.

b. Flood fight history

The study area has an extensive history of flooding. Much of that flood threat has been mitigated with the construction of Cochiti Dam, but a substantial residual risk exists from uncontrolled drainages downstream of the dam, as well as the risk of a substantial spring snowmelt runoff. Over the past 30 years, numerous levee patrols have been conducted to monitor controlled releases from Cochiti Reservoir that threaten the spoil bank levees. Significant flood fighting efforts took place in 1966, 1969, 1973, 1984, 1989, 1991. The important thing to note about each of these events is the flows were less severe than the 10% chance

event, and the more recent events (1989, 1991) were less severe than the 50% chance event. The last event in the study area that is considered more severe than the 10% chance exceedance in the study area was in 1986.

The Bureau of Reclamation has estimated it spends $150,000-$700,000 annually on LFCC maintenance to maintain performance in the areas proximate to the Bosque Del Apache National Wildlife Refuge. Even more work is done to maintain the Rio Grande main channel with the goal of managing sediment accumulation, and to maintain and repair the spoil bank levees. The Interstate Stream Commission has spent $11.3 million over the past 9 years to dredge and maintain a pilot channel through the main stem of the Rio Grande to mitigate sediment accumulation at the headwaters of the Elephant Butte Reservoir, at the southern extent of the study area (Albuquerque Journal, ‘‘Building a River’’, February 14, 2010, Page B1). Reclamation has also spent $2.25 million in 2009-2010 to repair 4 miles of the spoil bank levee at the northern edge of the Bosque Del Apache National Wildlife refuge. In 2005-2008, Reclamation spent $7 million for spoil bank levee repairs.

c. Benefits afforded by existing levees

A reliability assessment of the existing system of spoilbank levees was performed to determine applicable Probable Non-Failure and Probable Failure Points (PNP and PFP, respectively). The results of that evaluation are presented in the Geotechnical Appendix of this GRR. In it, the conditions under which the levees fail are limited to foundation seepage, piping, and sloughing of the land side low flow conveyance channel (LFCC), which would occur before flows break out of the river channel. This is largely due to the existing levee’s lack of foundation, and occurs as often as the 50% chance event. Further discussion of the LFCC’s vulnerability to flows in the Rio Grande can be found in the Geotechnical appendix.

As a result of the subsurface investigations and interviews with Bureau of Reclamation personnel, the Probable Non-Failure Point (PNP) was determined to be some point within the Rio Grande channel. The Probable Failure Point (PFP) was determined to be the toe of the existing levee just above the point where water first breaks out of the river channel. For purposes of determining damages and benefits for this appendix, the existing spoilbank levee provides no protection from any of the flood events evaluated.

A geo-technical evaluation was performed for the existing system of spoilbank levees from San Acacia to Bosque Del Apache. The geo-technical analysis that appears in Appendix E notes that the existing levees are constructed of uncompacted materials and are not adequate to withstand water against or near the levees from the Rio Grande or the Low Flow Conveyance Channel (LFCC). Moreover, Bureau of Reclamation personnel said that extensive flood fighting had

been performed in the past to prevent levee failure. Previous iterations of this report did not consider the protective value of the existing system of spoilbank levees, and no adjustment of the benefits provided by those levees is necessary.

d. Alternative means to flood fight (operate Cochiti)

Aside from flood fighting as flows threaten the spoil bank levee and the LFCC behind it, there are few other options available to the Bureau of Reclamation to mitigate the damages. Cochiti dam and reservoir is roughly 120 miles upstream of the study area, and changing operations at Cochiti does not have an impact in the study area for three days. Galisteo and Jemez dams are also upstream, but do not contribute materially to flows within the study area. The hydrology for the region indicates that events in unregulated watersheds downstream of Cochiti dam generate the most severe flows in the study hydrology. However, spring snowmelt runoff floods provide longer durations which further threatens to the fragile spoil bank levees. At the downstream end of the study area is the San Marcial railroad bridge, which is described extensively elsewhere as facing both a flood threat and a sediment accumulation threat. That bridge represents a choke point for operating Cochiti Dam releases, as the Federal government cannot cause flood damage to the structure through its operations. When the Bureau of Reclamation manages sediment accumulations in the Rio Grande, one of the results is maintained channel flows under the bridge.

4. Modeling the flood damages in HEC-FDA.

The LFCC was modeled in the Hydrologic Engineering Center’s Flood Damage Analysis (HEC-FDA) package using the same information (frequency distributions, rating curves, virtual channels, interior-exterior relationships for the proposed levees, changes in H&H in the future without and with-project condition due to sediment aggradation, beginning depth-damage) that was used to model structures and their contents, described elsewhere in this GRR, except as noted here. For each hydraulic cross section, a length of the channel was assigned, keying the property elevation to the height at grade at the cross section. The Bureau of Reclamation provided a range of values for the replacement cost of the LFCC. At the low end, there is $1 million per mile, and at the high end, $1,395 per foot. This results in a replacement cost of the LFCC between $50 million and $368 million. The Corps subsequently created its own estimate to predict replacement cost of a typical length of channel ($473 per lineal foot) which puts the entire LFCC’s replacement cost at roughly $125 million. For purposes of this evaluation, the low and high LFCC values, as well as the Corps’ valuation was used to evaluate the impacts of LFCC replacement cost on damages and benefits.

The Bureau of Reclamation did indicate there are some reaches where the channel is in a degraded position or may have a shortened remaining life, but was unable to provide sufficient information to apply depreciation to this replacement cost. Per ER 1105-2-100, Para. E-19. k. (4) (a), depreciation, "accounts for deterioration occurring prior to flooding, and variation in remaining useful life of structures." Neither Bureau of Reclamation nor Corps personnel could identify any deterioration in the portion of the LFCC protected by the proposed levees (channel capacity remains the same as the designed capacity) nor variability in the channel's remaining useful life. Further, re-alignment and extensive repairs have been made to the LFCC by Reclamation during the last few years. Therefore, there was no depreciation factor applied to the replacement cost of the LFCC protected by the proposed project. While the Bureau of Reclamation did indicate reaches of the LFCC that were in a deteriorated condition, it’s a reasonable assumption that those reaches would receive priority in the current or next year’s maintenance activities. The main report refer to necessary and extensive repairs required to restore LFCC operations as an active diversion. Those repairs are to portions of the LFCC downstream of the San Marcial railroad bridge, which is downstream of the southern extent of the study area. The analysis of the flood risk and benefits of the proposed levees only deal with the Low Flow Conveyance Channel between the San Acacia Diversion Dam and the San Marcial railroad bridge.

There is a dearth of available depth-damage curves applicable to the LFCC or other irrigation channels throughout the Corps. Existing published reports frequently do not display the curves used for damage categories other than structures or contents, and studies that include ‘‘Farm’’ or ‘‘Crop’’ damages frequently ignore the irrigation infrastructure. The Bureau of Reclamation didn’t have any information more recently than 1995. However, the District had several depth-% damage relationships available to model the impact of flooding on the LFCC. All five curves were applied to the three values of the LFCC to determine whether curve selection would materially impact damages and benefits, and are listed within the following table:

Table F-10

DEPTH-DAMAGE RELATIONSHIPS

(EXPRESSED AS PERCENT OF LFCC VALUE)

	Depth (ft.)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RGMCC curve, identified in May, 1995 solicitation	0	67	100													
RGMCC curve, 1990 FIRM rate reivew	0	7	14	21	28	35	42	49	56	63	70	77	84	91	95	95
Canals, ditches depth-damage relationship	0	11	22	33	44	55	66	77	88	95	100					
Earthen feeder ditches	0	20	40	60	80	100										
Concrete feeder ditches	0	1	14	21	28	35	42	49	56	63	70	77	84	91	95	

The first curve was developed based upon a 1995 expert elicitation of local Bureau of Reclamation personnel. The second curve is based upon an earlier solicitation, although it appears that the curve was also supported by the FIA. The final three curves were developed by the Albuquerque District, Corps of Engineers, and used in other studies. The LFCC is heavily damaged on a regular basis by under seepage from the perched Rio Grande, under the existing spoil bank levee, but has yet to encounter a more traditional flood where the existing levee is breached, and flood water and sediment inundates the channel. As a means to test whether modeling existing levee performance would have an impact on LFCC damages and benefits, two scenarios were developed to model in HEC-FDA. A beginning damage depth was applied in HEC-FDA corresponding to the present condition, 20%-chance water surface elevation. This ensures that events more frequent than the 20%-chance event doesn't damage the floodplain inventory, as the flows are expected to be contained within the banks of the Rio Grande. A second beginning damage depth was applied to the LFCC corresponding to the present condition, 10%-chance water surface elevation, to evaluate the impact of the start of damages condition on LFCC damages and benefits.

5. Project benefits

The scenarios and their impact on EAD is presented within the following table:

Table F-11						
WITHOUT PROJECT CONDITION, 10 YR START OF DAMAGES, LFCC EAD						
LFCC replacement cost		**Damage Curve selection**				
		RGMCC curve, identified in May, 1995 solicitation	RGMCC curve, 1990 FIRM rate reivew	Canals, ditches depth-damage relationship	Earthen feeder ditches	Concrete feeder ditches
Low	$1 million/mile	8,660.53	2,339.88	3,690.95	6,190.58	2,346.68
Likely	$ 473/foot	21,634.33	5,843.72	9,217.91	15,464.24	5,860.69
High	$1395/foot	63,808.49	17,234.71	27,189.79	45,611.78	17,284.71

WITHOUT PROJECT CONDITION, 5 YR START OF DAMAGES, LFCC EAD						
LFCC replacement cost		**Damage Curve selection**				
		RGMCC curve, identified in May, 1995 solicitation	RGMCC curve, 1990 FIRM rate reivew	Canals, ditches depth-damage relationship	Earthen feeder ditches	Concrete feeder ditches
Low	$1 million/mile	9,320.19	2,549.29	4,020.61	6,704.08	2,554.99
Likely	$ 473/foot	23,278.74	6,366.73	10,041.21	16,742.35	6,380.93
High	$1395/foot	68,658.27	18,777.20	29,617.47	49,381.26	18,819.04

The Water Resources Development Act of 1992 (Public Law 102-580) has a provision to adjust the non-Federal contribution to project costs to more equitably reflect the non-Federal benefits in relation to the total benefits of the project. The law requires the Corps to identify the benefits of any flood control project that are attributable to Federal properties, but also states that Federal property benefits may not exceed 50% of total project benefits. Table F-47-A-5 of the Economics appendix to the GRR contains the equivalent annual damages and benefits attributable to the NED plan, which is Alternative A at the 100-yr + 4’ levee height. That table is repeated here for convenience.

Table F-50-A-5								
	EQUIVALENT ANNUAL BENEFITS BY LAND USE CATEGORY							
	100 yr levee + 4 ft							
LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
	EAD	Residual Damages	Benefits					
Residential	2,198.80	22.72	2176.08					
Commercial	5,593.65	46.84	5546.81					
Public	119.94	12.90	107.04					
Apartments	1.49	0.04	1.45					
Outbuildings	77.40	0.87	76.53					
Subtotal - Structures and	7,991.28	83.37	7907.91					
Streets, roads	1,893.89	126.73	1767.16					
Utilities	60.73	4.06	56.66					
Railroad	193.28	12.93	180.35					
Vehicles	343.28	27.84	315.43					
Agriculture	101.00	6.15	94.86	*Federal Benefits*		*Federal Benefits*		
Irr. Drains	36.01	2.41	33.60					
LFCC	6,366.73	72.26	6294.46	*6294.46*		*7731.81*		
Avoided Water Losses	0.00	0.00	0.00	*0.00*		*0.00*		
Recreation	822.84	9.93	812.91	*812.91*		*812.91*		
East Bank	272.25	274.89	-2.64					
Emergency Costs	157.59	2.87	154.72		*Federal % of Total*		*Federal % of Total*	
TOTAL	**18,238.87**	**623.45**	**17,615.42**	***7107.37***	***40.70%***	***8544.72***	***50.00%***	

The table indicates the current proportion of Federal benefits to total benefits, plus identifies the maximum allowable Federal benefits under PL 102-580. This figure is important when evaluating the variables surrounding the LFCC's damage and benefit analysis. Holding the Recreation benefits to $812,910 on an equivalent annual basis, the 50% benefit cap for Federal properties is $8,545,000. Applying the 50% cap to the matrix of 30 different scenarios that handle assumptions such as replacement cost, start of damages, depth-% damage curve selection provides a useful boundary for analysis where some assumptions alone or in concert exceed the 50% benefit cap.

The following tables present the benefits of the proposed levee to the LFCC, at the 100-yr + 4' height, both in dollar values and as a percentage of total benefits, keeping in mind the benefit cap of $8,545,000.

Table F-12A

BASE+4' PROJECT CONDITION, 10 YR START OF DAMAGES

LFCC EQUIVALENT ANNUAL BENEFITS

LFCC replacement cost		**Damage Curve selection**				
		RGMCC curve, identified in May, 1995 solicitation	RGMCC curve, 1990 FIRM rate reivew	Canals, ditches depth-damage relationship	Earthen feeder ditches	Concrete feeder ditches
Low	$1 million/mile	8,619.34	2,330.63	3,676.70	6,166.01	2,337.42
Likely	$ 473/foot	21,531.46	5,820.61	9,182.32	15,402.89	5,837.57
High	$1395/foot	63,504.59	17,166.58	27,084.84	45,430.87	17,216.51

BASE+4' PROJECT CONDITION, 5 YR START OF DAMAGES

LFCC EQUIVALENT ANNUAL BENEFITS

LFCC replacement cost		**Damage Curve selection**				
		RGMCC curve, identified in May, 1995 solicitation	RGMCC curve, 1990 FIRM rate reivew	Canals, ditches depth-damage relationship	Earthen feeder ditches	Concrete feeder ditches
Low	$1 million/mile	9,195.82	2,520.36	3,976.32	6,628.91	2,526.05
Likely	$ 473/foot	22,968.12	6,294.46	9,930.61	16,554.60	6,308.64
High	$1395/foot	67,741.80	18,564.10	29,291.30	48,827.57	18,605.86

Table F-12B						
BASE+4' PROJECT CONDITION, 10 YR START OF DAMAGES						
LFCC EQUIVALENT ANNUAL BENEFITS EXPRESSED AS % OF TOTAL BENEFITS						
LFCC replacement cost		Damage Curve selection				
		RGMCC curve, identified in May, 1995 solicitation	RGMCC curve, 1990 FIRM rate reivew	Canals, ditches depth-damage relationship	Earthen feeder ditches	Concrete feeder ditches
Low	$1 million/mile	47.67%	23.29%	30.25%	40.27%	23.33%
Likely	$ 473/foot	68.34%	39.05%	49.12%	61.03%	39.11%
High	$1395/foot	86.13%	63.46%	72.93%	81.71%	63.52%

BASE+4' PROJECT CONDITION, 5 YR START OF DAMAGES						
LFCC EQUIVALENT ANNUAL BENEFITS EXPRESSED AS % OF TOTAL BENEFITS						
LFCC replacement cost		Damage Curve selection				
		RGMCC curve, identified in May, 1995 solicitation	RGMCC curve, 1990 FIRM rate reivew	Canals, ditches depth-damage relationship	Earthen feeder ditches	Concrete feeder ditches
Low	$1 million/mile	49.15%	24.35%	31.63%	41.82%	24.39%
Likely	$ 473/foot	69.67%	40.70%	50.92%	62.65%	40.75%
High	$1395/foot	86.88%	65.18%	74.41%	82.74%	65.22%

It's important to note that none of these scenarios alters the NED plan selection process. Alternative A is still the recommended alternative, and the Base + 4' levee height is the height which maximizes net benefits. The same alternative at the same levee height would be presented if there were NO Federal properties in the study area, would have a benefit/cost ratio in excess of 1.0 and would generate maximum net benefits. The purpose of the remaining portion of this examination is to determine the impact of key assumptions on the proportion of benefits attributable to Federal properties.

a. Scenarios where Federal benefits exceed 50%

From the previous tables, it's clear that some assumptions, if adopted, clearly indicate damages and benefits attributable to Federal properties in excess of the statutory limit of 50% of total project benefits. The

Bureau of Reclamation presented the replacement cost of the LFCC as a range of values between $50 million and $368 million. Adopting the high value produced high damages and benefits in all scenarios, pushing Federal benefits over the 50% statutory cap. Also, using the depth-damage curve provided by the Bureau of Reclamation in 1995 generated high damages and benefits. This isn't surprising given that curve has 100% damage at 2' of inundation. Any scenario that uses either the high dollar cost or the 1995 curve pushes benefits to Federal properties over 50%.

b. Sensitivity of project damages to input variables

So what of the remaining scenarios? What can be said of the other variables and their impact on the benefits attributable to the LFCC? It would appear that the single most important variable in determining the benefits is the value of the LFCC. The Bureau of Reclamation was able to provide a range of values between $50 and $368 million, but presented that information as a minimum and maximum, with no ''likely'' value, nor an error distribution around that value. The PDT quick cost estimate was developed to provide a likely construction cost, which follows:

San Acacia - Estimate of LFCC Cost

Assumptions:

LFCC is a trapezoidal channel with a 40' wide earthen bottom, 2h:1v side slopes with 1' rip rap armoring and a 80' top width. Depth is approximately 10'. LFCC is excavated and the spoil material is utilized close to the excavation, spoil bank or wasted.

Costs taken from San Acacia project which involves large volume excavation and rip rap and is located in the same area as the LFCC.

Cost is for a 1000' length of LFCC

Item Description	Quantity	Unit	Unit Cost	Extended
Construction Staking	1	day	$ 1,800.00	$ 1,800.00
Clear and Grub	5.74	acre	$ 2,723.00	$ 15,630.02
Excavation	24000	cy	$ 2.81	$ 67,440.00
Fine Grading	9333	sy	$ 1.06	$ 9,892.98
Rip Rap	1630	cy	$ 45.00	$ 73,350.00
Spoil/Fill Material	26880	cy	$ 4.50	$ 120,960.00
Dust Control	24000	cy	$ 0.38	$ 9,120.00
SWPPP	1000	lf	$ 2.94	$ 2,940.00
Site Access Road	1000	lf	$ 3.78	$ 3,780.00
				$ 304,913.00
Planning, Engineering and Design @ 6%				$ 18,294.78
Construction Management @ 9%				$ 27,442.17
				$ 350,649.95
Contingency / Misc Structures @ 35%				$ 122,727.48
Grand Total 2012 dollars				**$ 473,377.43**
			per lf	**$ 473.38**

Distributed over the 50 mile length of channel in the study area, that puts the replacement cost of the LFCC at around $125 million. Cost engineering has indicated that channel REPLACEMENT involves additional activities, such as clearing sediment from damaged portions as needed, which would drive this cost up. The $368 million cost has the impact of

pushing Federal benefits over 50% in all scenarios. The $50 million cost estimate was considered too low, given the Corps' own cost estimate, for serious consideration. Further discussion of the LFCC will focus on the ''Likely'' LFCC cost of approximately $125 million (2012 dollars). Surprisingly, limiting the beginning damage depth in HEC-FDA had little impact on the benefit percentages. In FDA, a depth corresponding to a specific event frequency can be set for the economic inventory, such that events that produce less depth can simply be ignored. It's a means to set a start of damages condition, and was used to model the 20% and 10% chance events, described in the hydraulics appendix. The net effect of adjusting the start of damages to a lower recurrence interval event, which would model the existing levee holding until a 10% chance event (which has no basis in historical experience or technical judgment), was to lower the benefit percentage 1-2%. The difference in water surface elevation at just about every cross section evaluated in the study area was 0.1'.

There were 5 depth-% damage curves selected for this evaluation. The first curve was based upon a 1995 Bureau of Reclamation solicitation, and has the impact of placing Federal benefits over 50%, regardless of start of damages or LFCC replacement cost. That curve was considered an outlier in this analysis. At the other extreme, the Albuquerque district, Corps of Engineers has some historic, and locally developed curves that have been used in other studies. Using the ''Concrete feeder ditches'' curve provided the lowest damages and benefits, and was considered another outlier, as the LFCC is an earthen and rip-rap lined channel, rather than a concrete one. The remaining curves are based upon a 1990 FIRM rate review of the study area and a couple other historic curves used by the Albuquerque district, Corps of Engineers. Two of those curves, when selected, push Federal benefits over the 50% threshold. The final curve, identified as the ''RGMCC curve, 1990 FIRM rate review'' produces Federal benefits between 42 and 44 percent, depending on the start of damages condition modeled.

Considering all the assumptions and all the scenarios above, it would appear that Federal benefits of the proposed levee at the Base + 4' levee height will be between 40-50% of total benefits. None of the above assumptions changed alternative selection or levee height, and excluding Federal benefits does not jeopardize the project's benefit-cost ratio. What remains is to determine what the Federal benefits are to compute the non-Federal cost share of the project costs. There are uncaptured NED benefits which would increase Federal benefits, but were not quantified. When the proposed levee is constructed, the Bureau of Reclamation no longer has responsibility to maintain the existing spoil bank levee, and NED costs attributable to levee OMRR&R are expected to go down significantly. Because the LFCC is no longer damaged annually by under seepage,

Reclamation will save LFCC OMRR&R costs (estimated in the without project condition at $150,000-$700,000), but was unable to provide a figure for the with-project condition. Another unquantified benefit of the LFCC is the riverside drain function, which ensures surface water runoff is transported downstream. Absent the LFCC, New Mexico is impounding water and has an even more difficult time meeting water delivery targets to Texas and Mexico per the Rio Grande Compact.

6. Limitations of study

There are some things that couldn't be done in this evaluation, due to time or technological limitations. We can only answer the question, ''What valuation of the LFCC coupled with the 10-year start of damages and the third depth-damage relationship would create Federal benefits over 50%?'' if we agree that damages and replacement cost are proportional. The ''Likely'' value of the LFCC would need to be 33% greater than $125 million, or $166 million, for greater than 50% Federal benefits regardless of curve selection, with a 10% chance start of damages. For a 20% start of damages, Federal benefits exceed 50% when LFCC costs roughly $153 million (22% more than $125 million) to obviate the need to select a damage curve.

Damage curve selection becomes a greater issue only if the value of the LFCC goes down from the ''Likely'' $125 million replacement value. More on this point later, in the discussion of prior condition of the LFCC in any given analysis year.

One assumption that was not modeled in this analysis was the notion of a localized failure in one damage reach alleviating the flood risk in other damage reaches. The study area contains 22 damage reaches with damageable property, with the project affecting the all but the 2 damage reaches located furthest downstream. In theory, an upstream breach would lower the flood threat to the spoil bank levee, but since the LFCC represents the low point in the floodplain adjacent to the perched Rio Grande, inundation damage occurs to the LFCC in terms of channel capacity exceedance, sediment and trash deposition, and sidewall washouts. Upstream flows would eventually find their way into the LFCC and create the inundation related damages along its length, without coming in through the existing spoil bank levee. The same conditions would hold with any proposed levee project.

The HEC-FDA model assumes the LFCC is intact and functioning prior to flooding in any given year, which doesn't match the assumptions the Bureau of Reclamation gave the Corps in the most recent solicitation. The Bureau assumes that in the event the LFCC were destroyed, it could take 5 years to replace. It's HIGHLY likely that a 10% or 20% event could happen in the 5 years between the first damaging event, and the subsequent one. Without modeling the gap between the

first and second damaging event, one cannot know how much of the prior event's damage was repaired. Without knowing the nature of that prior event's damage to the LFCC, which could dictate how long it would take to rebuild the damage to the LFCC, the equivalent annual flood risk could be misstated, as well as the benefits of the proposed levees. HEC-FDA assumes that modeled damages in one year are repaired by the next year, which may not hold in this case.

There are also uncaptured benefits which would increase Federal benefits. First, the Bureau of Reclamation claims that LFCC maintenance is $150,000 to $700,000 a year. The LFCC's greatest threat, and therefore use of the OMRR&R dollars, is the under seepage from the Rio Grande under the spoil bank levee, to the LFCC. A new levee would have an impervious foundation, which would result in indeterminate savings in those maintenance costs. Further, a proposed levee would have a non-Federal owner, which results in significant, and uncaptured, savings to the Bureau of Reclamation to repair the existing spoil bank. Finally, the Bureau of Reclamation has indicated that those OMRR&R funds NOT spent on the LFCC or the spoil bank levee could be applied toward channel maintenance, which may limit the sediment accumulations relative to what's modeled in this study, and making the proposed levee more effective in the future, with-project condition.

7. Conclusions

The General Reevaluation Report has identified Alternative A, at the Base + 4' levee height, as the alternative and height which maximizes net NED benefits. Excluding the benefits attributable to Federal properties does not change alternative selection nor levee height. The Water Resources Development Act of 1992 (Public Law 102-580) has a provision to adjust the non-Federal contribution to project costs to more equitably reflect the non-Federal benefits in relation to the total benefits of the project. The law requires the Corps to identify the benefits of any flood control project that are attributable to Federal properties, but also states that Federal property benefits may not exceed 50% of total project benefits. Using a reasonable ''Likely'' value for the replacement cost of the LFCC, the Federal property benefits are somewhere between 40 and 50% of total project benefits.

Bureau of Reclamation’s response to the Corps’ information request:

Reclamation Responses to
USACE Questions Regarding the Proposed San Acacia Levee Project
(February 6, 2012)

1. Historical Flooding and Flood Fighting Efforts: What historic flood events are you aware of **in the study area? Where did they occur? What was the estimated flow? Stage? Recurrence interval?**

   Reclamation is aware of multiple hydrologic and flood frequency analyses the Corps has done for their San Acacia Levee Project. Reclamation believes that this technical question is best addressed by the Corps of Engineers' Hydrology and Hydraulics experts. Reclamation understands that the scope of their investigations in the San Acacia reach is focused on flood control protection.

   Reclamation's Denver Technical Service Center has the following recent reports that review and quantify the various flood frequency values for the subject reach:

   > Dworak, F. April, 2009. Middle Rio Grande Review of Hydrology Studies. Flood Hydrology and Emergency Management Group, Bureau of Reclamation, Technical Service Center, U.S. Department of the Interior, Denver Colorado 80225
   > Wright, J.M. October 2010. The Middle Rio Grande Peak Discharge Frequency Study. Flood Hydrology and Emergency Management Group, Bureau of Reclamation, Technical Service Center, U.S. Department of the Interior, Denver Colorado 80225

   Reclamation also suggests that the Corps review the following USGS Web site for the recorded historical values for peak flows at gages in the subject reach: http://waterdata.usgs.gov/nm/nwis/nwis

2. **What actions did Reclamation take to fight the flood?**

   Given the broad and general context of this question, this question will be answered in the same context. Reclamation has historically performed river and spoil bank levee maintenance during the Corps' Flood Control Operations (above the mean annual peak flow or long duration periods at or above the mean annual peak flow) in the subject reach. These flows occur during the spring runoff or monsoonal thunderstorm events. Work on the river has been comprised of pilot channels through sediment deposits (after flows recede) or widening, raising, and repairing the levee in the San Acacia Reach. This work occurred prior to the annual spring runoff when the snowpack is very large or during the spring runoff.

3. **Was it successful?**

   Work to maintain the existing spoil levee during flood events has been successful to date with many cases of near failures due to either overtopping or seepage/piping.

4. **Any post-flood repair work to the levee or the LFCC?**
   Yes, work has been done during and after flood events in the river and LFCC as described above. Also, Reclamation constructed two LFCC setback relocation projects in the period between 2005 and 2009. These projects are located at sites where large meander bends and their migration threatened the spoil bank levee and LFCC.

5. **How much did those efforts (flood fight/flood repair) cost?**
   Please see Reclamation's response below to this question. It is unknown exactly what the percentage of work involved dealt with dealing with condition that are above flood flows and what normal (work to convey the mean annual peak flows and less) river maintenance related work.

6. **Does Reclamation perceive some stretches of the existing levee system as more susceptible to flooding than others**? Yes. In some sub-reaches, there is more susceptibility and risk to public health and safety: public and private infrastructure; homes and businesses: the local agriculture and tourism(the BDANWR is a nationally renowned bird and wildlife viewing refuge) economy; basin water delivery, and fish and wildlife including endangered species.

Channel and LFCC Operations:

7. **What activities does Reclamation participate in the Rio Grande to maintain the river channel? The LFCC?**
   [*Answer for River only*] Maintenance of the river channel includes infrastructure relocation or setback, channel modification (includes pilot channel, channel realignment, secondary channel work, floodplain work), bank protection/stabilization, habitat improvements and mitigation: and the aforementioned spoil bank levee maintenance and protection work to pass the mean annual peak flow events and less.
   [*Answer for LFCC only*] Maintenance of the LFCC consists of mowing, aquatic vegetation removal, road maintenance, sediment removal, and debris removal. Annual costs for this maintenance range from $150,000 to $700,000.

8. **How much is spent on each of these efforts?**
   Annual costs have varied on the amount of work done for repair and maintenance in the subject reach. At an appraisal, feasibility grade estimated costs have varied from $0 in extremely dry drought years where no runoff has occurred to about $2.25M in 2009-10 with American Recovery and Reinvestment Act work being done on in a 4-mile reach of the northern Bosque Del Apache National Wildlife Refuge (BDANWR). The LFCC setback relocation projects at RM 114, RM 113, and RM 111 had an appraisal/feasibility grade estimated total cost of about $7M for work done in the period of 2005-2008. At the RM 114 and RM 113 locations at the crossing of the San Lorenzo arroyo, a reinforced concrete pipe siphon, and sheet-pile drop structure were also constructed as part of the costs.

Reclamation advises the Corps of Engineers to review the Calendar Year Reports submitted to the Rio Grande Compact Commission and Engineer Advisors for a detailed summary of river maintenance and water salvage related works that are done by Reclamation in the subject reach. Reclamation has been submitting these reports on its efforts in the subject reach for an extensive time period.

The above cost variability is a function of the hydrologic and the river channel conditions which are highly dynamic. In considering this response, the Corps is asked to give major consideration to the temporal nature of river maintenance work. During very wet and high flow periods, work cannot be safely performed in the active river channel and only on the spoil bank levee. During dry periods, concerning flooding and river maintenance needs, the perceived conditions by the lay person are such that no apparent maintenance issues exist with the exception of water conveyance. At this time, access to the active river channel is safer and more stable. The maintenance during the advantageous, drier periods allow for reducing maintenance work to improve river conditions during the periods when mean annual peak flow and larger events occur. Working in a fluvial environment, such as a river channel and floodplain, is difficult given the river flow's annual and seasonal variability in inundated areas.

9. **Should the proposed levee be constructed, do you foresee any changes to these activities, such as reduced spending in one activity or another?** No. Reclamation foresees that the authorized maintenance work of the river channel and LFCC will continue at existing levels given tendencies of maintenance needs to develop for both systems.

   Given the non-existent current state of flood control in the reach and its limited authority for such works, Reclamation's position is that it does not have liability for any flood related damages should they occur. Reclamation does foresee a reduction in the emergency related works performed by Reclamation during the spring runoff and monsoonal flood control operational periods (above the mean annual peak flow or long duration periods at or above the mean annual peak flow) with the proposed flood control levee infrastructure and appurtenances. Reduced spending by Reclamation would be realized for these activities to protect its investment of the LFCC and continue its maintenance of the river channel elsewhere.

10. **Will shifting resources improve maintenance efficacy?** Yes. Resources and efforts would be shifted to maintenance activities that are preventative or recurring, rather than emergency in nature. Resources would also be shifted to environmental mitigation related activities.

11. **Prior iterations of this study have used an "avoided water losses" benefit category, where water diverted INTO the LFCC is saved from evaporation by running through a channel with a narrower topwidth than the Rio Grande. Does this benefit**

computation still make sense? No. This would apply to surface water flows that were diverted into the LFCC at the San Acacia Diversion Dam historically between the 1950's to 1985.

12. **Surface water diversions into the LFCC are no longer occurring. What would you estimate to be the annual water SAVINGS to be?** Reclamation is not aware of any quantification of the annual amount of water salvaged of the current pre-described operation of the LFCC. Given the preceding explanation, various water supply needs are being met by the LFCC in this reach. These would be measured and quantified differently than the historic surface water deliveries by the river and the surface diversion operation of the LFCC.

    Related to water salvaged in the valley by the current operation of the LFCC, Reclamation recommends that the Corps do a water budget analysis with the URGWOM model and look at the surface and groundwater relationships and evaluate the water lost to evapotranspiration and local infiltration storage by non-permeable barriers to downstream flow. This analysis could be done for two scenarios—with and without the LFCC in place—to determine the effect of the LFCC.

    Reclamation is aware of some work done by Dr. Nabil Shafike and S.S. Papadopulos & Associates Inc. for the New Mexico Interstate Stream Commission and New Mexico Mining and Technology in Socorro related to quantifying the surface and groundwater relationships in the subject reach. Reclamation is aware of the USGS LFCC surface water gage at San Marcial that has daily and annual volumes of surface water that goes through the subject reach. This information is quantified and located at the USGS website. Reclamation believes this would provide information on the current drainage and irrigation return flow operational water deliveries of the LFCC. Analysis could also be done to compare values with the amount of water that is delivered in the river channel and LFCC system.
13. **Since the LFCC doesn't presently divert water from the Rio Grande, do you see this savings differently?** Yes. The LFCC has and continues to serve multiple water resource related purposes that include providing effective valley drainage; being a wasteway for irrigation return flows; serving as a water source for four pumping locations to deliver water back to the river for Endangered Species flow needs; and providing irrigation diversion for the Middle Rio Grande Conservancy's Socorro Division, Bosque Del Apache National Wildlife Refuge, and the Armendaris (Turner) Ranch.

The LFCC:

14. What is your best estimate of the replacement cost of the LFCC from San Acacia diversion dam to the San Marcial railroad bridge? Do you have any uncertainties about that cost estimate, such as a contingency? Perhaps a low value, best guess, high value? We're looking to capture any uncertainties around cost estimates. How long would it take for Reclamation to replace the LFCC should it be destroyed? In the event portions of the LFCC are damaged, what would you estimate to be the

annual replacement rate, such as "We could replace N miles of that channel in a year." Reclamation has not developed a comprehensive cost estimate for replacing the LFCC. For levee setback river maintenance projects encompassing one to two miles of LFCC, Reclamation uses an appraisal-level estimate of $1395.14 per foot of channel to relocate the LFCC and spoil levee. In applying this estimate to the approximately 50-mile-long reach of the LFCC between San Acacia and San Marcial, this results in a cost estimate of $368,316,960, which is obviously toward the high end of the potential cost range. A very rough estimate of the lowest replacement cost is $50,000,000, which assumes costs of $1,000,000 per mile. These cost estimates are subject to a high level of uncertainty. It is difficult, however, to imagine a scenario in which the entire LFCC would be destroyed. Furthermore, it is extremely unlikely that the LFCC would be replaced if it was somehow destroyed in its entirety. In 1995, Reclamation estimated that complete replacement of the LFCC would take about 5 years, but this estimate has not been reevaluated since then. With adequate budget and lead time to establish construction contracts, Reclamation could probably replace about 10 miles of LFCC per year. Using force account crews only, about 1 mile per year could be replaced.

15. The original project was designed and constructed to divert from San Acacia diversion dam to headwaters of Elephant Butte Reservoir. Current Corps study recommends a levee from San Acacia diversion dam to upstream end of Tiffany Basin. Does a downstream cutoff just north of Tiffany leave a residual threat to the LFCC function? (e.g. continued maintenance of levee past Tiffany) Yes. Reclamation would continue maintenance of the levee to protect the current function of the LFCC and various infrastructure like access roads. Other non-Reclamation infrastructure such as the railroad would also be at risk. **What would the impact of extending the levees to the San Marcial railroad bridge? (e.g. avoided levee maintenance, avoided flood fighting).** Since the levee would be a flood control levee, Reclamation would not assume responsibility for its maintenance. Therefore, there would be a reduction in maintenance operations performed by Reclamation. Reclamation would provide consideration for doing reimbursable work as part of a future maintenance program.

The LFCC was designed to divert water out of the Rio Grande from the San Acacia diversion dam to the headwaters of Elephant Butte reservoir. That diversion hasn't taken place since when? Normal operation of the LFCC has not occurred since 1985. What role does the LFCC play in the region today? **Does Reclamation see the present function of the LFCC as a subset of the channel's role when authorized for construction?** The LFCC functions as a riverside drain. It is a source of water for ESA-related pumping into the Rio Grande. It also provides some water for agricultural purposes and is the primary source of water to Bosque del Apache National Wildlife Refuge. Furthermore, it supports wetlands near the upstream end of Elephant Butte Reservoir. The drainage function was a part of the original intent of the LFCC's authorization, but it was a secondary function, rather than a primary one. **Is the channel's present configuration and role cheaper than the Authorized design and role?** If the LFCC had been constructed for drainage purposes only, it would have been smaller and would have had much less riprap lining. Obviously, it would have been less expensive to construct. Operational costs are lower now than when the LFCC was in full

operation because less maintenance is required. **Does the present channel maintain the same capabilities as the Authorized and constructed design?** The LFCC is currently not operable as originally intended because of extensive sediment deposition at the downstream end. Also, when parts of the LFCC were moved as part of two of Reclamation's recent levee setback projects, the riprap lining was installed only to the 500-cfs water surface, rather than to the 2000-cfs water surface. **Does the channel have the same life expectancy as it does when originally constructed?** The channel cannot currently be operated as it was originally intended. In addition to the problems caused by sediment deposition in the LFCC itself, ongoing sediment deposition in the Rio Grande floodway continues to reduce the sustainable lifespan of the floodway and LFCC system. **Are there stretches that are "worn" more than others?** The downstream portion of the LFCC has extensive sediment deposition problems that are not present in sections farther upstream. **Are there any sources of depreciation between the channel when originally constructed and what exists today?** Sediment deposition is the main source of damage to the channel. ESA-related concerns greatly reduce the probability that the LFCC would be operated according to its original intent, even if such operation was technically feasible. **Please describe how the LFCC is susceptible to flooding from the Rio Grande.** The LFCC is currently protected from the river flows by a spoil levee made from material excavated from the LFCC during its construction. Because the levee is a spoil levee any ponding (or hydraulic head of any duration) of water against the levee poses a risk to the levee**. Is the channel facing scour threats?** The main threat to the LFCC is the potential breaching of the spoil levee. **Does it risk filling with sediment?** In the event of levee breach the channel would be at risk. **How would you describe the LFCC's susceptibility (e.g. as a depth-% damage relationship, as an event-$ damage relationship)?** Again, since the levee protecting the LFCC is not an engineered levee any ponding of water against the levee would pose risk for levee failure and therefore damage to the LFCC. Since Reclamation cannot be certain of the levee makeup along the whole length of the levee, determining any type of relationship with regard to depth of water and damage would be a wild guess at this point.

16. What would Reclamation's response be should the LFCC be damaged or destroyed? Reclamation's current answers to this and the following related questions are conceptual/hypothetical, Since they have not been thoroughly evaluated in the context of Reclamation's management priorities. Assuming that the damage or destruction is resulting from a catastrophic flood, Reclamation would need to evaluate the situation first. There are different implications (e.g. public health and safety, economic damage, water delivery, etc.) depending upon where in the reach impacts would occur. Reclamation would most likely seek to reconstruct the LFCC facility where the damage occurs. Various efforts would be undertaken to engage with local and regional stakeholders to assisting in funding and cost sharing on this effort. Special attention would be given to those who receive the most benefits from the current operation of the facility.

17. What is the impact to Reclamation and the region should the LFCC be damaged or destroyed? The implications and the scope of the impact to the region if the LFCC were damaged or destroyed have been explained in preceding and subsequent answers herein.

18. **What is life like in the region without the LFCC?** Reclamation recommends that the Corps consult with the Middle Rio Grande Conservancy District, the local community farmers, residents, and BNANWR refuge staff and tourism visitors regarding this matter. Also recommend consulting with a socio-economic scientist from the area. Land use practices and their economic values for the agricultural community and BDANWR would be diminished without the LFCC drainage facility. There would be the potential for increased groundwater levels due to surface water irrigation of lands and increased alkalinity in the soils due to the groundwater rising and fluctuations near the root zones. These alkalinity problems due to lack of valley drainage would also impact fish and wildlife, vegetation, wetlands, and endangered species functions on the BDANWR. Reclamation would recommend that some work be done to quantify the economic loss due to these conditions without the drainage function of LFCC.

19. **Are there available substitutes for water users in the region in the event the LFCC was destroyed?** At a hypothetical level, Reclamation would assume that some groundwater water pumping could be performed to meet water user needs in the subject reach. There does exist in the Middle Rio Grande area questions of the long term sustainability of this practice due to declining groundwater levels from continued pumping.

20. **Is there anything else the Corps should consider when evaluating the flood threat to the LFCC and existing levee system?**

    It might be good to get the local perspective of the LFCC and its function and value to the valley. BDANWR perspective might be of use.

    Reclamation understands that the potential failure modes of levee overtopping and geotechnical and piping failure will be better controlled by the flood control infrastructure and its appurtenances (i.e. seepage control and drains) with the proposed project. Reclamation through its operation and maintenance program for water and sediment delivery is aware of flood control benefits that are derived currently by the local project sponsors, community, and the Corps. Reclamation requests future, formal acknowledgement of flood control benefits of work done by Reclamation and the New Mexico Interstate Stream Commission going back to the original 1950's river and LFCC works.

    Reclamation also recommends that the Corps extend their Flood Control Levee down to the San Marcial Railroad Bridge Crossing. Reclamation considers this area at risk due to the presence of the BN&SF railroad line. In the event of a catastrophic flood, Reclamation believes there is the potential for public health and safety risks to the railroad workers and operators in the event a train is derailed due to failure of their embankment.

    If a catastrophic breach of the current spoil levee occurred (causing the river to go into the western portion of the valley) in the reach below the San Marcial railroad bridge crossing, Reclamation would consider reconstructing a single channel system downstream of this location with a new LFCC outfall to the river. The new LFCC outfall would also be

downstream of the railroad bridge crossing. Given the regional drought and lowered reservoir pool elevations since the early 2000's, Reclamation and New Mexico Interstate Stream Commission have been very successful in maintaining a sustainable single channel system in the reservoir delta. Reclamation recognizes that this success can change if the reservoir pool rises dramatically or a full pool condition re-occurs at the upstream end of the reservoir in the future.

Lastly, Reclamation strongly supports the Corps position to move ahead with construction of this project with the first phase beginning in Federal Fiscal Year 2012.

NOTE: The Corps should be aware that the broad scope and hypothetical nature of these questions render Reclamation's responses as unofficial. Many of Reclamation's answers should not be regarded as definitive statements. Reclamation understands that the Corps has been planning and evaluating this flood control project as part of its mission on the Middle Rio Grande going back to the 1980's. Reclamation believes answers to a lot of the questions should be the responsibility of the Corps.

F-12 Inclusion of Additional Features to Flood Control Alternatives:

Features were evaluated with the project design to meet objectives other than flood control (sediment management, infrastructure benefits to the railroad, travel detour cost savings, Rio Grande operations improvements). These additional features can be divided into two distinct categories: the acquisition and rehabilitation of 2,053 acres within the Tiffany area and the reconstruction of a railroad bridge at San Marcial.
The following figure shows the features and their combinations that served as the basis for each of the alternatives:

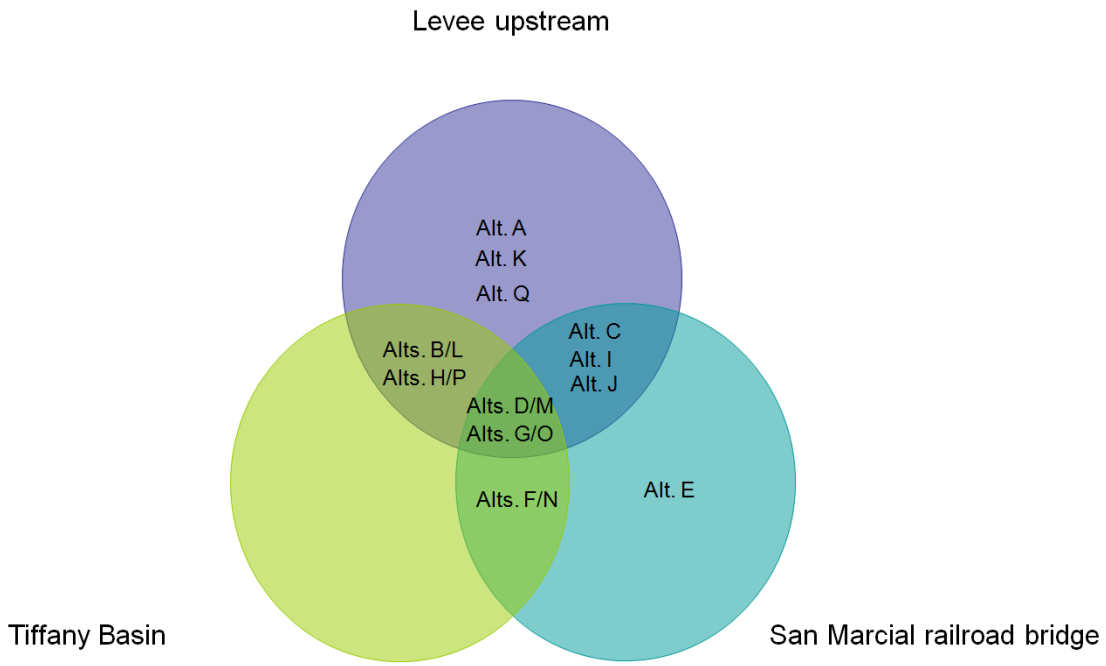

Figure F-6 - Alternatives and Their Features

The railroad bridge replacement at San Marcial is located south of the 2,053 acres comprising the Tiffany area modification, and derives much of its benefits from flood damage reduction to the railroad, and avoided train reroutes, as well as improvements in operations of the Rio Grande. Given that addition or deletion of the new bridge does not affect performance of 43 river miles of levees proposed, the railroad bridge is a separable element per ER 1105-2-100 (Para. 6-5.e.) and EC 1165-2-155. The currently designed railroad bridge modification cost $22,519,000 (August, 2010 dollars) depending upon bridge height, levee size upstream, and number of bays under the bridge. Flood control benefits for replacing the existing bridge come in avoided transportation costs to route traffic around the flooded bridge. Preliminary calculations estimating a start of damages condition, projected cost/ton-mile, detour routes and daily tonnage provided by the Burlington Northern Santa Fe railroad indicate that there may be sufficient benefits to justify bridge modifications on flood control alone. Additional benefits for bridge modification from pecuniary savings associated with a change in Rio Grande operations could be added to the flood control benefits.

The Tiffany Basin was considered during alternative formulation as a means to control sediment aggradation within the Rio Grande. Over the project life, sediment accumulations within the Tiffany Basin would elevate the basin floor even to the Rio Grande (currently perched about 10’ over the Basin floor). Sediment accumulations over the project life would mitigate the need for the Bureau of

Reclamation to remove sediment from the Rio Grande. There are also benefits afforded to the environment by bringing more land into service for endangered species.

Enumeration of Railroad Bridge Benefits:

Infrastructure benefits and transportation benefits were calculated for the San Marcial railroad bridge using the following assumptions:

1) There are three critical events that need to be evaluated for the existing and proposed bridge for both the present conditions (with and without the proposed levee project) and 50 years hence (without project year 50 and with project year 50).

2) The first critical event (the ''Closure Event'') occurs when floodwaters touch the low chord of the bridge. According to the BNSF railroad, the bridge will be closed for 36 hours, incurring the expense of diverting 30,000 daily estimated tonnage through a detour of 105 miles at a marginal cost of $0.025/ton-mile. On a per event basis, the closure event costs $118,125. These closure event losses cover all events equal to or greater than the closure event, but less than the damaging event, described below.

3) The second critical event (the ''Damage Event'', also described by BNSF railroad personnel) occurs when flood waters rise 1' above the low chord of the bridge. The bridge is assumed to be damaged, and will cost $3,000,000 to repair the existing bridge, and will take 30 days to effect repairs. During that repair time, 30,000 daily tons is rerouted 105 miles at a marginal cost of $0.025/ton-mile, giving us a damaging event transportation detour loss of $5,362,500. These damaging event losses cover all events equal to or greater than the bridge damaging event, but less than the failure event, described below.

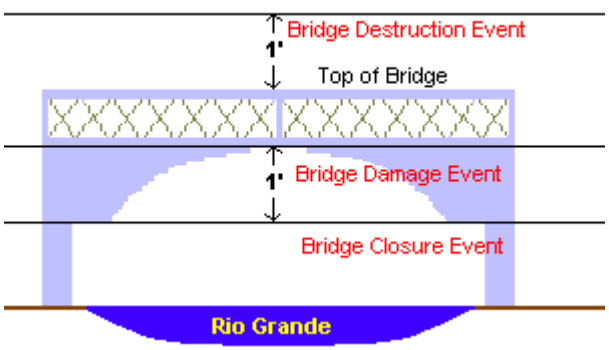

Figure F-7 - Bridge Critical Failure Points

4) The third critical event (the ‘‘Destruction Event’’, described by BNSF railroad personnel) occurs when flood waters rise 1' above the top of the bridge. The bridge is assumed to be destroyed, and will cost $23 million to replace with the proposed bridge and will take one year to replace with the proposed bridge. During that repair time, 30,000 daily tons is rerouted 105 miles at a marginal cost of $0.025/ton-mile, generating failure event transportation detour losses of $45,990,000. These failure event losses cover all events equal to or greater than the bridge failure event.

5) Bureau of Reclamation officials have assured the study team that their sediment removal events will continue as long as the current railroad bridge exists. With the replacement of that bridge, those sediment removal activities may cease. Therefore, it is important to measure the replacement bridge's performance over the project life (50 years).

The replacement bridge is designed to withstand flows up to the .002 event at which point it would be destroyed. It would sustain damages at a 0.0037 flood event, such that repair costs would be approximately $3,000,000 and time out of service would be one month. A 0.0039 flood event would cause transportation reroutes for approximately 1 day. The following table describes bridge performance in the various scenarios described:

Table F-13

PROBABILITY THAT FLOOD EVENT AFFECTS CURRENT AND REPLACEMENT BRIDGE

	Scenario Evaluated					
	A	B	C	D	E	F
	Existing Bridge/ Without Project	Existing Bridge/ Without Project Year 50	Existing Bridge/ Levee Project Year 1[1]	Existing Bridge/ Levee Project Year 50[1]	Replacement Bridge/ Levee Project Year 1	Replacement Bridge/ Levee Project Year 50
Destruction Event	**0.002**	**0.99**	**0.005**	**0.99**	**0.002**	**0.01**
Damage Event	**0.76**	**0.99**	**0.76**	**0.99**	**0.0037**	**0.019**
Closure Event	**0.977**	**0.99**	**0.977**	**0.99**	**0.0039**	**0.02**

[1]Bureau of Reclamation officials will continue sediment removal efforts as long as the existing bridge remains.

Over the life of the proposed levee and bridge project there is a cumulative probability that one or more of these damaging events occurs. There is a legitimate, though small, probability that a closure or damage event could occur each year over the levee project's life, but the bridge failure event could only occur once over the project life. After the failure event, we assume the railroad replaces their lost structure with a new bridge with identical performance characteristics as the currently

proposed project bridge.

The benefit and loss calculations incorporate these probabilities to monetize flood effects. The following table (Table F-14) outlines cumulative probabilities of these significant flood events for several time periods:

The Bureau of Reclamation will continue to remove sediment accumulations as long as the existing bridge remains at San Marcial, which is why columns A and B are identical, as well as columns C and D. When the proposed levee project is built, attenuation losses induce floodwaters to the San Marcial railroad bridge. On this table, this is represented by column C being greater for every event and every time period than column A. The same observation holds for columns D and B.

The replacement of the San Marcial railroad bridge lessens the cumulative probabilities of flooding events, which can be gleaned by noting that all values in column E are significantly smaller than corresponding values in column A. However, because the replacement bridge has improved performance over the project life, the Bureau will cease their sediment removal activities. As represented above, sediment accumulations over 50 years cause values in column F to be somewhat greater than corresponding values in column E. Therefore, the values in columns E and F are still greater than their counterparts in columns A and B. Table F-10 describes the annual risk of damaging flood events to the existing and proposed San Marcial bridge. A discussion of the source of those probabilities is in Appendix E.

The with-project condition for the existing bridge was estimated by measuring the area under the damage-frequency curve. After a closure or damaging event the bridge was assumed to be restored to its original condition. After a destruction event we assume the railroad replaces their bridge with the proposed bridge.

Under the without project condition, the damaging events occur with the same frequency. The replacement of the bridge would cause all damages from the time of replacement to be less than with than those with existing bridge. Therefore, over the life of the project (50 years), there are 51 different scenarios. Each relates to the year the bridge is destroyed. For instance, if the bridge is destroyed in year 4, during the first 3 years there are probabilities of damages costs to transportation and infrastructure based on the probabilities of the existing bridge being closed or damaged. Then from years 5 to 50, there are different sets of probabilities for each level of damage based on the new bridge. The areas under the curve were measured for each of the 51 possible scenarios. Note that the 51st scenario is one in which the existing bridge is never destroyed. The results were then combined based on probability of occurrence (the probability that the bridge had not been destroyed previously x the probability that the bridge would be destroyed in a given year).

The results of that analysis are contained within the following table (Table F-15):

Table F-15

AVERAGE ANNUAL LOSSES TO CURRENT AND REPLACEMENT BRIDGE (x $1,000 August, 2010 price level)						
	Scenario Evaluated					
	A	B	C	D	E	F
	Existing Bridge/ Without Project	Existing Bridge/ Without Project Year 50	Existing Bridge/ Levee Project Year 1[1]	Existing Bridge/ Levee Project Year 50[1]	Replacement Bridge/ Levee Project Year 1	Replacement Bridge/ Levee Project Year 50
Destruction Event	174.14	174.14	241.51	241.51	0.00	0.00
Damage Event	3,765.77	3,765.77	4,048.69	4,048.69	9.12	78.14
Closure Event	23.75	23.75	25.63	25.63	0.02	0.17
Total	3,963.66	3,963.66	4,315.84	4,315.84	9.14	78.31

To reiterate, because BuRec will continue sediment removal efforts as long as the railroad bridge remains, Columns A and B are identical, as are Columns C & D. Column F represents 50 years of sediment accumulations that occurs when those activities end with the construction of the new bridge with the proposed levee project.

The induced likelihood of flooding has already been described. Table F-16 describes what those probabilities mean in terms of dollars.

Table F-16

INDUCED AVERAGE ANNUAL LOSSES TO CURRENT BRIDGE BY PROPOSED PROJECT (x $1,000 August, 2010 price level)			
	Scenario Evaluated		
	A	C	
	Existing Bridge/ Without Project	Existing Bridge/ Levee Project Year 1[1]	Induced Damages
Destruction Event	$174	$242	$67
Damage Event	$3,766	$4,049	$283
Closure Event	$24	$26	$2
Total	$3,964	$4,316	$352

With the new levee project alone, increased likelihood of flooding is minimal will cause over $352,000 in damages on an average annual basis. Avoidance of induced damages can support over $7 million in new construction to build a bridge with the same performance characteristics as the existing bridge. Table F-17 describes the benefits of replacing the San Marcial railroad bridge.

Table F-17

AVERAGE ANNUAL BENEFITS OF REPLACEMENT BRIDGE TO CURRENT AND POST-PROJECT CONDITIONS (x $1,000 August, 2010 price level)					
	Scenario Evaluated				
	A	B	C	D	E
	Replacement Bridge/ Levee Project Year 1	Existing Bridge/ Without Project	Average Annual Benefits	Existing Bridge/ Levee Project Year 1	Average Annual Benefits + Induced Damages Prevented
Total	$9	$3,964	$3,955	$4,316	$4,307

Enumeration of Tiffany Area Benefits:

The benefits from including the Tiffany Basin come from decreasing sediment deposition in the upstream reaches of the Rio Grande. Alternatives containing the Tiffany Sediment Basin have lower future, with project stages than alternatives not containing this feature, but the calculations indicate those benefits are most appreciable to the smaller project sizes. At the NED plan size (Base + 4 feet), the equivalent annual benefits of including the Tiffany Basin, discounting future benefits to present values, are roughly $429,000. At the margin, the benefits do not justify the additional costs of the Tiffany Sediment feature. There is also a small unquantified benefit of rerouting sediment into the Tiffany Basin, saving Bureau of Reclamation personnel the cost of removing that sediment from the Rio Grande over the 37 years it takes to fill the basin.

At the NED plan size (Base + 4 feet), the equivalent annual benefits of including the Tiffany Basin, discounting future benefits to present values, is roughly $429,000.

F-13 Alternatives Considered:

The project features described above, such as the levee along the west bank of the Rio Grande, a replacement railroad bridge at the San Marcial river crossing, and the Tiffany Basin, were evaluated in isolation and in concert with each other to capture the effects of project features upon other project features and to evaluate the performance of the features in combination and alone in meeting the stated goals of the project. What follows is a discussion of the matrix development, and a discussion of each alternative considered, and a discussion of the effects of

each project alternative.

The following diagram outlines the methods by which each alternative was evaluated. All alternatives were screened by identifying the benefit/cost ratio (BCR) but many alternatives were evaluated by examining the marginal benefits and the marginal cost of the added feature. Evaluating alternatives in this fashion would make explicit any external benefits, cost efficiencies or inefficiencies, and any potential network effects of implementing multiple project features. Where two alternatives perform the same function, this analysis identifies the least-cost alternative.

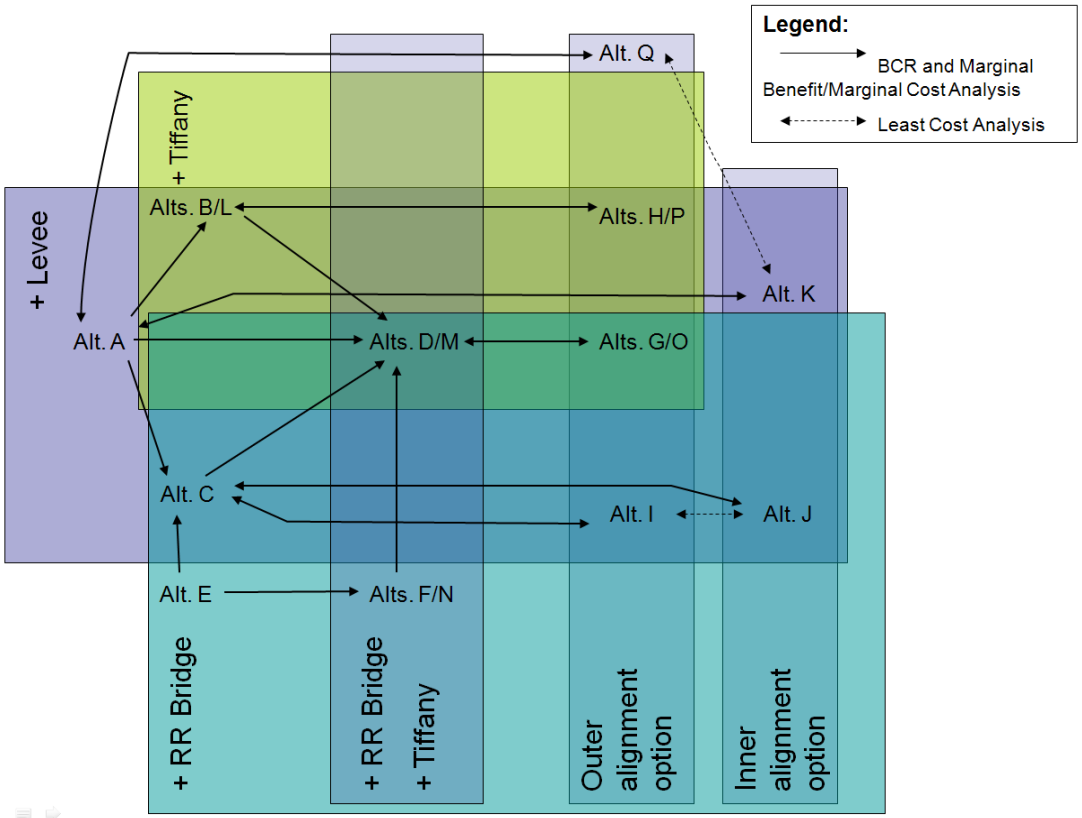

Figure F-8 - Alternatives Analysis Methods

Alternative A Evaluation

Alternative A is essentially the roughly 43 river miles of levee to the upstream extent of the Tiffany area. The NED plan, which maximizes net benefits, is the largest of the levees analyzed, at mean Base levee + 4 feet. Costs and benefits follow (Table F-18):

Table F-18

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR ALT. A

SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

	Base levee	Base levee + 1 ft	Base levee + 2 ft	Base levee + 3 ft	Base levee + 4 ft
Construction Costs (x $1,000)					
Levee	110,145.06	114,726.99	119,546.83	121,731.53	123,389.22
Overbank lowering/LFCC Channel Berm	4,989.60	4,989.60	4,989.60	4,989.60	4,989.60
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	4,854.00	4,854.00	4,854.00	4,854.00	4,854.00
PED	8,046.56	8,046.56	8,046.56	8,046.56	8,046.56
Construction Management	20,297.94	20,297.94	20,297.94	20,297.94	20,297.94
Mitigation	1,385.15	1,421.11	1,457.06	1,493.02	1,528.98
Total First Cost	149,718.31	154,336.19	159,191.99	161,412.65	163,106.30
IDC, Construction (168 months, 4-3/8%)*	55,367.00	57,074.73	58,870.44	59,691.66	60,317.99
Total, Interest During Construction	55,367.00	57,074.73	58,870.44	59,691.66	60,317.99
Total Investment	205,085.31	211,410.93	218,062.43	221,104.31	223,424.28
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	10,167.55	10,481.15	10,810.92	10,961.72	11,076.74
OMRR&R					
Total Avg. Ann. Cost	10,167.55	10,481.15	10,810.92	10,961.72	11,076.74
Project Benefits (x $1,000)					
Levee	11,780.59	14,643.38	16,120.77	16,990.98	17,615.42
Tiffany Basin (RR and reroutes)	379.35	379.35	379.35	379.35	379.35
RR Bridge					
Equivalent Avg. Ann. Benefits	12,159.94	15,022.72	16,500.12	17,370.32	17,994.77
Benefit/Cost Ratio	1.20	1.43	1.53	1.58	1.62
Net Benefits	1,992.39	4,541.57	5,689.20	6,408.60	6,918.03

Alternative B Evaluation

Alternative B is Alternative A plus the addition of the Tiffany sediment deposition feature. By including the Tiffany area to the project, we expect some savings to take place in project costs. First, additional toe protection to the project levee upstream may not be needed to the extent it's necessary in Alt. A, as sediment deposition over the 30+ years Tiffany is expected to fill will eliminate the risk of a headcut situation. The effects of the Tiffany Basin alone are not analyzed . Table F-19 identifies the costs and benefits of various size levees in concert with the Tiffany Sediment Basin feature. Table F-20 compares the marginal benefits and marginal costs of Alternative B to Alternative A, to highlight the impact of adding the Tiffany Sediment Basin to the upstream levees.

Alternative B Costs:

Those savings are eaten up by additional project costs. The cost of the NED levee identified in Alt. A increases by approximately $1.1 million. The Tiffany Basin feature itself costs $6.8 million. ISC officials have noted a concern that flows through the Tiffany Basin increase evaporative losses, which was a significant benefit (roughly 30,000-40,000 acre-feet/year when the diversion was active) attributable to the Low Flow Conveyance Channel. That loss would increase the costs attributable to the Tiffany Basin project feature, but as yet has been unquantified.

Alternative B Benefits:

The benefits from including the Tiffany Basin come from decreasing sediment deposition in the upstream reaches of the Rio Grande. Alt. B has lower future, with project stages than Alt. A, but the calculations indicate those benefits are most appreciable to the smaller project sizes. At the NED plan size (Base levee + 4 feet), the equivalent annual benefits of including the Tiffany Basin, discounting future benefits to present values, is roughly $429,000 ($50,000 at the margin). At the margin, the benefits do not justify the additional costs of the Tiffany Sediment feature. There is also a small unquantified benefit of rerouting sediment into the Tiffany Basin, saving Bureau of Reclamation personnel the cost of removing that sediment from the Rio Grande over the 10 years it takes to fill the basin.

At the NED plan size (Base levee + 4 feet), the equivalent annual benefits of including the Tiffany Basin, discounting future benefits to present values, is roughly $429,000. At the margin, the benefits do not justify the additional costs of the Tiffany Sediment feature.

Potential rationale for Alternative B plan selection:

It might be possible to justify the Tiffany Basin through a combination of NED and NER benefits (such as a multipurpose project or through mitigation). To do that, an incremental cost analysis showing that an expenditure of approximately $14,450,000 at Tiffany is an efficient and effective means to achieve the NER goal.

Table F-19

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR ALT. B

SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

	Base levee	Base levee + 1 ft	Base levee + 2 ft	Base levee + 3 ft	Base levee + 4 ft
Construction Costs (x $1,000)					
Levee	111,131.38	116,170.15	120,848.41	122,931.56	124,515.64
Overbank lowering/LFCC Channel Berm	4,989.60	4,989.60	4,989.60	4,989.60	4,989.60
Tiffany Basin	6,845.08	6,845.08	6,845.08	6,845.08	6,845.08
RR Bridge	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	4,854.00	4,854.00	4,854.00	4,854.00	4,854.00
PED	8,046.56	8,046.56	8,046.56	8,046.56	8,046.56
Construction Management	20,297.94	20,297.94	20,297.94	20,297.94	20,297.94
Total First Cost	156,164.55	161,203.32	165,881.58	167,964.73	169,548.82
IDC, Construction (168 months, 4-3/8%)*	57,750.87	59,614.25	61,344.31	62,114.67	62,700.48
Total, Interest During Construction	57,750.87	59,614.25	61,344.31	62,114.67	62,700.48
Total Investment	213,915.43	220,817.57	227,225.88	230,079.41	232,249.29
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	10,605.32	10,947.51	11,265.21	11,406.68	11,514.26
OMRR&R					
Total Avg. Ann. Cost	10,605.32	10,947.51	11,265.21	11,406.68	11,514.26
Project Benefits (x $1,000)					
Levee	11,919.14	14,648.88	16,119.75	17,007.45	17,267.09
Tiffany Basin (RR and reroutes)	429.16	429.16	429.16	429.16	429.16
RR Bridge					
Equivalent Avg. Ann. Benefits	12,348.31	15,078.05	16,548.91	17,436.61	17,696.25
Benefit/Cost Ratio	1.16	1.38	1.47	1.53	1.54
Net Benefits	1,742.99	4,130.54	5,283.70	6,029.93	6,181.99

Table F-20

MARGINAL COSTS, COMPARING ALTERNATIVE B TO ALTERNATIVE A (X $1,000)					
Levee	986.32	1,443.16	1,301.58	1,200.03	1,126.42
Overbank lowering/LFCC Channel Berm	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	6,845.08	6,845.08	6,845.08	6,845.08	6,845.08
RR Bridge	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	0.00	0.00	0.00	0.00	0.00
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	6,446.24	6,867.13	6,689.59	6,552.08	6,442.52
IDC, Construction (168 months, 4-3/8%)*	2,383.87	2,539.52	2,473.86	2,423.01	2,382.49
Total, Interest During Construction	2,383.87	2,539.52	2,473.86	2,423.01	2,382.49
Total Investment	8,830.11	9,406.65	9,163.45	8,975.09	8,825.01
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	437.77	466.35	454.30	444.96	437.52
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	437.77	466.35	454.30	444.96	437.52
Marginal Benefits (x $1,000)					
Levee	138.55	5.51	-1.02	16.47	-348.34
Tiffany Basin	49.82	49.82	49.82	49.82	49.82
RR Bridge	0.00	0.00	0.00	0.00	0.00
Equivalent Avg. Ann. Benefits	188.37	55.32	48.80	66.29	-298.52
Benefit/Cost Ratio	0.43	0.12	0.11	0.15	-0.68
Net Benefits	-249.41	-411.03	-405.50	-378.67	-736.04

Alternative C Evaluation

Alternative C is Alternative A plus the addition of the San Marcial railroad bridge feature. The effects of constructing the San Marcial railroad bridge alone are analyzed in Alternative E. Table F-21 identifies the costs and benefits of various size levees in concert with the replacement railroad bridge. Table F-22 compares the marginal benefits and marginal costs of Alternative C to Alternative A, to highlight the impact of adding the replacement railroad bridge to the upstream levees.

Alternative C Costs:

A major expense attributed to the upstream levees had to do with hauling material to a disposal site. By including the railroad bridge and appurtenant approaches, disposal costs for the levee (captured in Alt. A costs), and borrow costs for the railroad bridge approaches (captured in Alt. E costs) become a transfer within the project. In previous iterations of this analysis, the inclusion of the railroad bridge lowers NED levee costs by $8.3 million. The most recent cost estimate (August, 2010) does not have that savings, and borrow/fill savings appear no longer to be a factor in estimating construction costs. The railroad bridge size has been optimized for a specific horizontal alignment, a specific height, and specific features (7 bay bridge, concrete). The railroad bridge inclusion represents a $23 million additional feature to the project.

Alternative C Benefits:

As described in the economics appendix, the railroad bridge represents a service that, in the without project condition, is threatened with interruption. The benefit calculations consider the likelihood of traffic reroutes, tonnage and distance of the reroutes, and the likelihood of needing to repair or replace the existing bridge. Those benefits amount to roughly $4.3 million on an average annual basis. Those benefits come from a higher bridge deck and marginally higher railroad approaches on either side of the new river crossing. Bureau of Reclamation officials have indicated they spend roughly $2 million annually to remove sediment from nearby reaches of the Rio Grande, and altering the railroad bridge to convey more water, *ceteris paribus*, does not appear to alter that in the with project condition.

Potential rationale for Alternative C plan selection:

Alternative C, at the Base levee + 4 feet size, provides roughly $9.8 million in net average annual benefits. This is more than the NED project size identified in Alternative A ($6.8 million). Unfortunately, hydraulic analyses have indicated that constructing the levees (Alternative A) several miles upstream of the railroad bridge has no

material impact on flows at the bridge. The current legal opinion is that, absent that hydraulic link between the proposed levee and the existing bridge, the Corps has no authority to reconstruct the railroad bridge.

Table F-21

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR ALT. C

SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

	Base levee	Base levee + 1 ft	Base levee + 2 ft	Base levee + 3 ft	Base levee + 4 ft
Construction Costs (x $1,000)					
Levee	110,145.06	114,726.99	119,546.83	121,731.53	123,389.22
Overbank lowering/LFCC Channel Berm	4,989.60	4,989.60	4,989.60	4,989.60	4,989.60
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	23,000.07	23,000.07	23,000.07	23,000.07	23,000.07
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	4,854.00	4,854.00	4,854.00	4,854.00	4,854.00
PED	8,046.56	8,046.56	8,046.56	8,046.56	8,046.56
Construction Management	20,297.94	20,297.94	20,297.94	20,297.94	20,297.94
Total First Cost	171,333.23	175,915.16	180,735.00	182,919.70	184,577.39
IDC, Construction (168 months, 4-3/8%)*	63,360.37	65,054.80	66,837.22	67,645.14	68,258.17
Total, Interest During Construction	63,360.37	65,054.80	66,837.22	67,645.14	68,258.17
Total Investment	234,693.60	240,969.96	247,572.22	250,564.84	252,835.56
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	11,635.44	11,946.61	12,273.93	12,422.29	12,534.87
OMRR&R					
Total Avg. Ann. Cost	11,635.44	11,946.61	12,273.93	12,422.29	12,534.87
Project Benefits (x $1,000)					
Levee	11,780.59	14,643.38	16,120.77	16,990.98	17,615.42
Tiffany Basin (RR and reroutes)	569.09	569.09	569.09	569.09	569.09
RR Bridge	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70
Equivalent Avg. Ann. Benefits	16,656.38	19,519.16	20,996.55	21,866.76	22,491.21
Benefit/Cost Ratio	1.43	1.63	1.71	1.76	1.79
Net Benefits	5,020.93	7,572.55	8,722.62	9,444.47	9,956.34

Table F-22

MARGINAL COSTS, COMPARING ALTERNATIVE C TO ALTERNATIVE A (X $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Overbank lowering/LFCC Channel Berm	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	23,000.07	23,000.07	23,000.07	23,000.07	23,000.07
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	0.00	0.00	0.00	0.00	0.00
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	21,614.92	21,578.97	21,543.01	21,507.05	21,471.10
Sediment Collection System	7,993.37	7,980.07	7,966.77	7,953.48	7,940.18
IDC, Construction (168 months, 4-3/8%)*	7,993.37	7,980.07	7,966.77	7,953.48	7,940.18
Total Investment	29,608.29	29,559.04	29,509.78	29,460.53	29,411.28
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	1,467.89	1,465.45	1,463.01	1,460.57	1,458.13
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	1,467.89	1,465.45	1,463.01	1,460.57	1,458.13
Marginal Benefits (x $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	189.74	189.74	189.74	189.74	189.74
RR Bridge	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70
Equivalent Avg. Ann. Benefits	4,496.44	4,496.44	4,496.44	4,496.44	4,496.44
Benefit/Cost Ratio	3.06	3.07	3.07	3.08	3.08
Net Benefits	3,028.54	3,030.98	3,033.42	3,035.87	3,038.31

Alternative D Evaluation

Alternative D is Alternative A plus the addition of the San Marcial railroad bridge, described in Alternative C, and the Tiffany Basin feature. The Tiffany Basin was not analyzed in isolation, but its performance and cost was deemed independent of other project features, and did not need an alternative developed in isolation. Table F-23 identifies the costs and benefits of various size levees in concert with the Tiffany Sediment Basin and replacement railroad bridge features. Table F-24 compares the marginal benefits and marginal costs of Alternative D to Alternative A, to highlight the impact of adding the Tiffany Sediment Basin and the replacement railroad bridge to the upstream levees. Table F-25 compares the marginal benefits and marginal costs of Alternative D to Alternative C, to highlight the impact of adding the Tiffany Sediment Basin to Alternative A (upstream levee + railroad bridge). Table F-26 compares the marginal benefits and marginal costs of Alternative D to Alternative B, to highlight the impact of adding the replacement railroad bridge to Alternative B (upstream levee + Tiffany Sediment Basin).

Alternative D Costs:

This feature represents the combination of the upstream levee, railroad bridge, and the Tiffany basin. This feature represents the combination of the Alt. B and the Alt. C additions to Alt. A. Many of the assertions made in the discussions of Alts. B and C are still valid here. For example, the railroad bridge feature cost $23.0 million across all alternatives. The Tiffany Basin costs approximately $6.8 million across all alternatives. Minor cost changes across the alternatives come from changes to the Levee feature costs.

Comparing this Alternative to Alt. A (levee only), we note that the project incurs fixed and specific costs ($6.8 million for the Tiffany Basin, $23.0 million for the railroad), and incurred no savings in levee construction costs. Adding the basin and railroad bridge saved no money in levee construction costs for the NED plan. The NED plan size was still Base levee + 4 feet. The Tiffany Basin still serves as a drag on the project benefits, and expected cost savings on other features by including Tiffany did not materialize here.

A major expense attributed to the upstream levees had to do with hauling material to a disposal site. By including the railroad bridge and appurtenant approaches, disposal costs for the levee (captured in Alt. A costs), and borrow costs for the railroad bridge approaches (captured in Alt. E costs) become a transfer within the project. In previous

analyses (September, 2007) the inclusion of the railroad bridge lowered NED levee costs by $3.4 million. That savings is not present in this analysis. Because the railroad bridge size has been optimized at a specific horizontal alignment, a specific height, and specific features (7 bay bridge, concrete) the railroad bridge inclusion represents a $23.0 million additional feature to the project.

Tables which follow show marginal cost and marginal benefit comparisons between Alt. D and previously analyzed alternatives. Some interesting relationships developed. For one, adding the Tiffany Basin feature to Alt. C (levee plus RR bridge) INCREASED levee construction costs. Adding the RR bridge to Alt. B (levee plus Tiffany) decreased levee construction costs by less than $1 million. It appears that including the Tiffany Basin increases levee construction costs, which further makes it difficult to justify the Tiffany Basin.

Alternative D Benefits:

As described in the economics appendix, the railroad bridge represents a service that, in the without project condition, is threatened with interruption. The benefit calculations consider the likelihood of traffic reroutes, tonnage and distance of the reroutes, and the likelihood of needing to repair or replace the existing bridge. Those benefits amount to roughly $4.3 million on an average annual basis. Bureau of Reclamation officials have indicated they spend roughly $2 million annually to remove sediment from nearby reaches of the Rio Grande, and altering the railroad bridge to convey more water, *ceteris paribus*, does not appear to alter that in the with project condition.

Potential rationale for Alternative D plan selection:

Alternative C, at the Base levee + 4 feet size, provides roughly $8.8 million in net average annual benefits. This is more than the NED project size identified in Alternative A ($6.8 million). Unfortunately, hydraulic analyses have indicated that constructing the levees (Alternative A) several miles upstream of the railroad bridge has no material impact on flows at the bridge. The current legal opinion is that, absent that hydraulic link between the proposed levee and the existing bridge, the Corps has no authority to reconstruct the railroad bridge.

Even if a levee and railroad bridge were justified, including the Tiffany Basin will decrease levee construction costs by roughly $617,000, comparing Alternative D to Alternative B. There are uncaptured benefits (avoidance of sediment removal costs) and uncaptured costs (increased evaporative losses of water through the Tiffany Basin). The Tiffany Basin inclusion no longer provides construction

savings for other project features, and will be difficult to justify.

Table F-23

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR ALT. D

SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

	Base levee	Base levee + 1 ft	Base levee + 2 ft	Base levee + 3 ft	Base levee + 4 ft
Construction Costs (x $1,000)					
Levee	110,959.88	115,533.27	120,211.17	122,304.66	123,899.09
Overbank lowering/LFCC Channel Berm	4,982.88	4,982.88	4,982.88	4,982.88	4,982.88
Tiffany Basin	6,842.25	6,842.25	6,842.25	6,842.25	6,842.25
RR Bridge	22,977.07	22,977.07	22,977.07	22,977.07	22,977.07
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	4,854.00	4,854.00	4,854.00	4,854.00	4,854.00
PED	8,044.43	8,044.43	8,044.43	8,044.43	8,044.43
Construction Management	20,297.94	20,297.94	20,297.94	20,297.94	20,297.94
Total First Cost	178,958.44	183,531.83	188,209.73	190,303.22	191,897.65
IDC, Construction (168 months, 4-3/8%)*	66,180.23	67,871.51	69,601.43	70,375.62	70,965.25
Total, Interest During Construction	66,180.23	67,871.51	69,601.43	70,375.62	70,965.25
Total Investment	245,138.67	251,403.34	257,811.16	260,678.84	262,862.90
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	12,153.28	12,463.86	12,781.55	12,923.72	13,032.00
OMRR&R					
Total Avg. Ann. Cost	12,153.28	12,463.86	12,781.55	12,923.72	13,032.00
Project Benefits (x $1,000)					
Levee	11,919.14	14,648.88	16,119.75	17,007.45	17,267.09
Tiffany Basin (RR and reroutes)	420.37	420.37	420.37	420.37	420.37
RR Bridge	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70
Equivalent Avg. Ann. Benefits	16,646.21	19,375.95	20,846.82	21,734.52	21,994.16
Benefit/Cost Ratio	1.37	1.55	1.63	1.68	1.69
Net Benefits	4,492.93	6,912.09	8,065.27	8,810.80	8,962.16

Table F-24

MARGINAL COSTS, COMPARING ALTERNATIVE D TO ALTERNATIVE A (X $1,000)					
Levee	814.82	806.28	664.34	573.13	509.86
Overbank lowering/LFCC Channel Berm	-6.72	-6.72	-6.72	-6.72	-6.72
Tiffany Basin	6,842.25	6,842.25	6,842.25	6,842.25	6,842.25
RR Bridge	22,977.07	22,977.07	22,977.07	22,977.07	22,977.07
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	-2.13	-2.13	-2.13	-2.13	-2.13
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	29,240.13	29,195.64	29,017.74	28,890.57	28,791.35
Sediment Collection System	10,813.23	10,796.78	10,730.99	10,683.96	10,647.27
IDC, Construction (168 months, 4-3/8%)*	10,813.23	10,796.78	10,730.99	10,683.96	10,647.27
Total Investment	40,053.36	39,992.41	39,748.73	39,574.53	39,438.62
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	1,985.73	1,982.71	1,970.63	1,961.99	1,955.25
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	1,985.73	1,982.71	1,970.63	1,961.99	1,955.25
Marginal Benefits (x $1,000)					
Levee	138.55	5.51	-1.02	16.47	-348.34
Tiffany Basin	41.03	41.03	41.03	41.03	41.03
RR Bridge	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70
Equivalent Avg. Ann. Benefits	4,486.27	4,353.23	4,346.70	4,364.19	3,999.39
Benefit/Cost Ratio	2.26	2.20	2.21	2.22	2.05
Net Benefits	2,500.54	2,370.52	2,376.07	2,402.20	2,044.13

Table F-25

MARGINAL COSTS, COMPARING ALTERNATIVE D TO ALTERNATIVE C (X $1,000)					
Levee	814.82	806.28	664.34	573.13	509.86
Overbank lowering/LFCC Channel Berm	-6.72	-6.72	-6.72	-6.72	-6.72
Tiffany Basin	6,842.25	6,842.25	6,842.25	6,842.25	6,842.25
RR Bridge	-23.01	-23.01	-23.01	-23.01	-23.01
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	-2.13	-2.13	-2.13	-2.13	-2.13
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	7,625.21	7,616.67	7,474.73	7,383.51	7,320.25
Sediment Collection System	2,819.86	2,816.71	2,764.21	2,730.48	2,707.09
IDC, Construction (168 months, 4-3/8%)*	2,819.86	2,816.71	2,764.21	2,730.48	2,707.09
Total Investment	10,445.07	10,433.38	10,238.94	10,114.00	10,027.34
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	517.84	517.26	507.62	501.42	497.13
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	517.84	517.26	507.62	501.42	497.13
Marginal Benefits (x $1,000)					
Levee	138.55	5.51	-1.02	16.47	-348.34
Tiffany Basin	-148.71	-148.71	-148.71	-148.71	-148.71
RR Bridge	0.00	0.00	0.00	0.00	0.00
Equivalent Avg. Ann. Benefits	-10.16	-143.21	-149.73	-132.24	-497.05
Benefit/Cost Ratio	-0.02	-0.28	-0.29	-0.26	-1.00
Net Benefits	-528.00	-660.46	-657.35	-633.67	-994.18

Table F-26

MARGINAL COSTS, COMPARING ALTERNATIVE D TO ALTERNATIVE B (X $1,000)					
Levee	-171.50	-636.88	-637.24	-626.90	-616.56
Overbank lowering/LFCC Channel Berm	-6.72	-6.72	-6.72	-6.72	-6.72
Tiffany Basin	-2.83	-2.83	-2.83	-2.83	-2.83
RR Bridge	22,977.07	22,977.07	22,977.07	22,977.07	22,977.07
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	-2.13	-2.13	-2.13	-2.13	-2.13
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	22,793.88	22,328.51	22,328.15	22,338.49	22,348.83
Sediment Collection System	8,429.36	8,257.26	8,257.13	8,260.95	8,264.77
IDC, Construction (168 months, 4-3/8%)*	8,429.36	8,257.26	8,257.13	8,260.95	8,264.77
Total Investment	31,223.24	30,585.77	30,585.28	30,599.43	30,613.60
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	1,547.96	1,516.36	1,516.33	1,517.03	1,517.74
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	1,547.96	1,516.36	1,516.33	1,517.03	1,517.74
Marginal Benefits (x $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	-8.79	-8.79	-8.79	-8.79	-8.79
RR Bridge	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70
Equivalent Avg. Ann. Benefits	4,297.91	4,297.91	4,297.91	4,297.91	4,297.91
Benefit/Cost Ratio	2.78	2.83	2.83	2.83	2.83
Net Benefits	2,749.95	2,781.55	2,781.57	2,780.87	2,780.17

Alternative E Evaluation

Alternative E is the San Marcial railroad bridge without the levee or the Tiffany Basin. Table F-27 identifies the costs and benefits of the railroad bridge. Previous analyses have already established the optimum characteristics of the replacement bridge and its approaches. The format of the table permits addition of the railroad bridge feature to other Alternatives.

Alternative E Costs:

This feature represents the cost of the railroad bridge in isolation. The railroad bridge feature cost $23.0 million across all alternatives. The railroad bridge and approaches are for a specified height, span (7 bay) and concrete construction, optimized in the economics appendix.

Alternative E Benefits:

As described throughout the economics appendix, the railroad bridge represents a service that, in the without project condition, is threatened with interruption. The benefit calculations consider the likelihood of traffic reroutes, tonnage and distance of the reroutes, and the likelihood of needing to repair or replace the existing bridge. Those benefits amount to roughly $4.3 million on an average annual basis. Those benefits come from a higher bridge deck and marginally higher railroad approaches on either side of the new river crossing. Bureau of Reclamation officials have indicated they spend roughly $2 million annually to remove sediment from nearby reaches of the Rio Grande, and altering the railroad bridge to convey more water, *ceteris paribus*, does not appear to alter that in the with project condition.

Potential rationale for Alternative E plan selection:

Alternative E provides roughly $3.4 million in net average annual benefits. Unfortunately, hydraulic analyses have indicated that constructing the levees (Alternative A) several miles upstream of the railroad bridge has no material impact on flows at the bridge. The current legal opinion is that, absent that hydraulic link between the proposed levee and the existing bridge, the Corps has no authority to reconstruct the railroad bridge.

Were USACE authorized to construct a railroad bridge, it would be justified through the NED analysis. The purpose of this alternative evaluation, however, concedes that there is no authority to construct the railroad bridge, and attempts to evaluate the range of alternatives on an NED basis, to identify tradeoffs, and efficiencies where possible.

Table F-27

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR ALT. E

SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

	Base levee	Base levee + 1 ft	Base levee + 2 ft	Base levee + 3 ft	Base levee + 4 ft
Construction Costs (x $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Overbank lowering/LFCC Channel Berm	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	23,026.39	23,026.39	23,026.39	23,026.39	23,026.39
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	1,150.04	1,150.04	1,150.04	1,150.04	1,150.04
Construction Management	2,899.71	2,899.71	2,899.71	2,899.71	2,899.71
Total First Cost	27,076.14	27,076.14	27,076.14	27,076.14	27,076.14
IDC, Construction (30 months, 4-3/8%)*	1,502.41	1,502.41	1,502.41	1,502.41	1,502.41
Total, Interest During Construction	1,502.41	1,502.41	1,502.41	1,502.41	1,502.41
Total Investment	28,578.54	28,578.54	28,578.54	28,578.54	28,578.54
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	1,416.84	1,416.84	1,416.84	1,416.84	1,416.84
OMRR&R					
Total Avg. Ann. Cost	1,416.84	1,416.84	1,416.84	1,416.84	1,416.84
Project Benefits (x $1,000)					
Levee					
Tiffany Basin (RR and reroutes)	479.45	479.45	479.45	479.45	479.45
RR Bridge	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70
Equivalent Avg. Ann. Benefits	4,786.15	4,786.15	4,786.15	4,786.15	4,786.15
Benefit/Cost Ratio	3.38	3.38	3.38	3.38	3.38
Net Benefits	3,369.30	3,369.30	3,369.30	3,369.30	3,369.30

Alternative F Evaluation

Alternative F is the San Marcial railroad bridge plus the Tiffany Basin without the levee. It is essentially Alternative E plus Tiffany. The Tiffany Basin was not evaluated in isolation. Table F-28 identifies the costs and benefits of the railroad bridge and the Tiffany Sediment Basin. Previous analyses have already established the optimum characteristics of the replacement bridge and its approaches. The format of the table permits addition of the railroad bridge feature to other Alternatives. Table F-29 compares the marginal benefits and marginal costs of Alternative F to Alternative E, to highlight the impact of adding the Tiffany Sediment Basin and the replacement railroad bridge to the upstream levees. Table F-30 compares the marginal benefits and marginal costs of Alternative F to Alternative D, to highlight the impact of adding the upstream levees to a combination of the Tiffany Sediment Basin and the replacement railroad bridge.

Alternative F Costs:

This feature represents the combination of the railroad bridge and the Tiffany basin. This feature represents the combination of the Tiffany Basin to Alt. E. Many of the assertions made in the discussions of Alt. E and the Tiffany Basin are still valid here. For example, the railroad bridge feature cost $23.0 million across all alternatives. The Tiffany Basin costs increased slightly to $7.2 million in this alternative. There were no cost changes across the alternatives but the absence of the levee feature appears to have impacted Tiffany in an unexpected fashion.

Tables which follow show marginal cost and marginal benefit comparisons between Alt. F and Alternative E (railroad bridge only). This alternative is somewhat different from other alternatives including the Tiffany Basin in that the Tiffany feature costs are roughly $300,000 higher here. The Tiffany Basin still represents a ‘‘drag’’ on the project benefit calculations. Comparing this Alternative to Alternative D, which comprises the levee plus Tiffany plus the RR bridge enables us to evaluate the LEVEE against the two other potential project features (Table 27). As expected, projects including the upstream levee provide greater net benefits than projects without the upstream levee.

Alternative F Benefits:

As described in the economics appendix, the railroad bridge represents a service that, in the without project condition, is threatened with interruption. The benefit calculations consider the likelihood of traffic reroutes, tonnage and distance of the reroutes, and the likelihood of needing to

repair or replace the existing bridge. Those benefits amount to roughly $4.3 million on an average annual basis. Bureau of Reclamation officials have indicated they spend roughly $2 million annually to remove sediment from nearby reaches of the Rio Grande, and altering the railroad bridge to convey more water, *ceteris paribus*, does not appear to alter that in the with project condition.

Potential rationale for Alternative F plan selection:
It is not expected that this alternative is desirable to the Sponsors, and this alternative serves as a basis for evaluating the impacts of other features.

Table F-28

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR ALT. F

SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

	Base levee	Base levee + 1 ft	Base levee + 2 ft	Base levee + 3 ft	Base levee + 4 ft
Construction Costs (x $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Overbank lowering/LFCC Channel Berm	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	7,178.73	7,178.73	7,178.73	7,178.73	7,178.73
RR Bridge	23,026.39	23,026.39	23,026.39	23,026.39	23,026.39
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	1,298.28	1,298.28	1,298.28	1,298.28	1,298.28
Construction Management	3,624.86	3,624.86	3,624.86	3,624.86	3,624.86
Total First Cost	35,128.26	35,128.26	35,128.26	35,128.26	35,128.26
IDC, Construction (30 months, 4-3/8%)*	1,949.21	1,949.21	1,949.21	1,949.21	1,949.21
Total, Interest During Construction	1,949.21	1,949.21	1,949.21	1,949.21	1,949.21
Total Investment	37,077.47	37,077.47	37,077.47	37,077.47	37,077.47
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	1,838.20	1,838.20	1,838.20	1,838.20	1,838.20
OMRR&R					
Total Avg. Ann. Cost	1,838.20	1,838.20	1,838.20	1,838.20	1,838.20
Project Benefits (x $1,000)					
Levee					
Tiffany Basin (RR and reroutes)	355.40	355.40	355.40	355.40	355.40
RR Bridge	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70
Equivalent Avg. Ann. Benefits	4,662.09	4,662.09	4,662.09	4,662.09	4,662.09
Benefit/Cost Ratio	2.54	2.54	2.54	2.54	2.54
Net Benefits	2,823.90	2,823.90	2,823.90	2,823.90	2,823.90

Table F-29

MARGINAL COSTS, COMPARING ALTERNATIVE F TO ALTERNATIVE E (X $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Overbank lowering/LFCC Channel Berm	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	7,178.73	7,178.73	7,178.73	7,178.73	7,178.73
RR Bridge	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	148.24	148.24	148.24	148.24	148.24
Construction Management	725.15	725.15	725.15	725.15	725.15
Total First Cost	8,052.12	8,052.12	8,052.12	8,052.12	8,052.12
IDC, Construction (30 months, 4-3/8%)*	446.80	446.80	446.80	446.80	446.80
Total, Interest During Construction	446.80	446.80	446.80	446.80	446.80
Total Investment	8,498.92	8,498.92	8,498.92	8,498.92	8,498.92
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	421.35	421.35	421.35	421.35	421.35
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	421.35	421.35	421.35	421.35	421.35
Marginal Benefits (x $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	-124.05	-124.05	-124.05	-124.05	-124.05
RR Bridge	0.00	0.00	0.00	0.00	0.00
Equivalent Avg. Ann. Benefits	-124.05	-124.05	-124.05	-124.05	-124.05
Benefit/Cost Ratio	-0.29	-0.29	-0.29	-0.29	-0.29
Net Benefits	-545.41	-545.41	-545.41	-545.41	-545.41

Table F-30

MARGINAL COSTS, COMPARING ALTERNATIVE D TO ALTERNATIVE F (X $1,000)					
Levee	110,959.88	115,533.27	120,211.17	122,304.66	123,899.09
Overbank lowering/LFCC Channel Berm	4,982.88	4,982.88	4,982.88	4,982.88	4,982.88
Tiffany Basin	-336.49	-336.49	-336.49	-336.49	-336.49
RR Bridge	-49.33	-49.33	-49.33	-49.33	-49.33
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	4,854.00	4,854.00	4,854.00	4,854.00	4,854.00
PED	6,746.15	6,746.15	6,746.15	6,746.15	6,746.15
Construction Management	16,673.08	16,673.08	16,673.08	16,673.08	16,673.08
Total First Cost	143,830.18	148,403.57	153,081.47	155,174.96	156,769.39
IDC, Construction (30 months, 4-3/8%)*	64,231.02	65,922.30	67,652.22	68,426.41	69,016.05
Total, Interest During Construction	64,231.02	65,922.30	67,652.22	68,426.41	69,016.05
Total Investment	208,061.20	214,325.87	220,733.69	223,601.37	225,785.43
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	10,315.08	10,625.67	10,943.35	11,085.52	11,193.80
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	10,315.08	10,625.67	10,943.35	11,085.52	11,193.80
Marginal Benefits (x $1,000)					
Levee	11,919.14	14,648.88	16,119.75	17,007.45	17,267.09
Tiffany Basin	64.98	64.98	64.98	64.98	64.98
RR Bridge	0.00	0.00	0.00	0.00	0.00
Equivalent Avg. Ann. Benefits	11,984.12	14,713.86	16,184.73	17,072.42	17,332.07
Benefit/Cost Ratio	1.16	1.38	1.48	1.54	1.55
Net Benefits	1,669.04	4,088.19	5,241.38	5,986.90	6,138.26

Alternative G Evaluation

Alternative G is the San Marcial railroad bridge plus the Tiffany Basin plus the levee. It is essentially Alternative D plus the extension of the levee along the Tiffany Basin's west side. The purpose of the extension is to protect the railroad track from flooding that may occur in the Tiffany Basin. This feature serves as a trade-off to Alternative D. Table F-31 identifies the costs and benefits of the levee, the replacement railroad bridge and the Tiffany Sediment Basin. Table F-32 compares the marginal benefits and marginal costs of Alternative G to Alternative D, to highlight the impact of extending the levee protection through the Tiffany Sediment Basin.

Alternative G Costs:

This feature represents the combination of a levee extending along the west side of the Tiffany Basin, and serves as a second means of protecting the upstream levee and the railroad tracks from sedimentation and flooding originating in the Tiffany Basin. This additional length of levee would be selected over Alternative D if it achieved the same goals of the project at lower costs. As the following table (Table F-32) shows, this alternative costs roughly $19.4 million more than Alternative D.

Alternative G Benefits:

As described in the economics appendix, the railroad bridge represents a service that, in the without project condition, is threatened with interruption. Extending flood protection past the upstream limits of the Tiffany area ensures continued operations of the railroad down the west side of the Tiffany area. The benefit calculations consider the likelihood of traffic reroutes, tonnage and distance of the reroutes, and the likelihood of needing to repair or replace the existing bridge. Those benefits amount to roughly $4.3 million on an average annual basis. Bureau of Reclamation officials have indicated they spend roughly $2 million annually to remove sediment from nearby reaches of the Rio Grande, and altering the railroad bridge to convey more water, *ceteris paribus*, does not appear to alter that in the with project condition.

As previously described, the Tiffany Basin generates few NED benefits, but there are uncaptured benefits (sediment deposition not requiring Bureau of Reclamation removal, increased avoidable water losses through evaporation) that have an uncertain effect on benefits.

Alternative G would be preferable to Alternative D if it achieved the same results for less cost. As the following table indicates, Alternative G is approximately $26.7

million more than Alternative D.

Potential rationale for Alternative G plan selection:
This alternative would be preferable to Alternative D if it achieved the desired results of the project for less cost than Alternative D.

Table F-31

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR ALT. G SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN (x $1,000 August, 2010 price level)					
	Base levee	Base levee + 1 ft	Base levee + 2 ft	Base levee + 3 ft	Base levee + 4 ft
Construction Costs (x $1,000)					
Levee	125,542.47	130,741.27	137,271.02	140,482.76	143,370.51
Overbank lowering/LFCC Channel Berm	6,837.21	6,837.21	6,837.21	6,837.21	6,837.21
Tiffany Basin	4,981.58	4,981.58	4,981.58	4,981.58	4,981.58
RR Bridge	22,949.45	22,949.45	22,949.45	22,949.45	22,949.45
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	4,854.00	4,854.00	4,854.00	4,854.00	4,854.00
PED	8,050.28	8,050.28	8,050.28	8,050.28	8,050.28
Construction Management	20,297.94	20,297.94	20,297.94	20,297.94	20,297.94
Total First Cost	193,512.94	198,711.73	205,241.49	208,453.22	211,340.98
IDC, Construction (168 months, 4-3/8%)*	71,562.60	73,485.16	75,899.91	77,087.63	78,155.55
Total, Interest During Construction	71,562.60	73,485.16	75,899.91	77,087.63	78,155.55
Total Investment	265,075.54	272,196.89	281,141.39	285,540.86	289,496.52
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	13,141.69	13,494.75	13,938.19	14,156.31	14,352.42
OMRR&R					
Total Avg. Ann. Cost	13,141.69	13,494.75	13,938.19	14,156.31	14,352.42
Project Benefits (x $1,000)					
Levee	11,919.14	14,648.88	16,119.75	17,007.45	17,267.09
Tiffany Basin (RR and reroutes)	431.58	431.58	431.58	431.58	431.58
RR Bridge	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70
Equivalent Avg. Ann. Benefits	16,657.42	19,387.16	20,858.03	21,745.72	22,005.37
Benefit/Cost Ratio	1.27	1.44	1.50	1.54	1.53
Net Benefits	3,515.73	5,892.41	6,919.83	7,589.42	7,652.95

Table F-32

MARGINAL COSTS, COMPARING ALTERNATIVE G TO ALTERNATIVE D (X $1,000)					
Levee	14,582.60	15,208.00	17,059.85	18,178.10	19,471.42
Overbank lowering/LFCC Channel Berm	1,854.33	1,854.33	1,854.33	1,854.33	1,854.33
Tiffany Basin	-1,860.67	-1,860.67	-1,860.67	-1,860.67	-1,860.67
RR Bridge	-27.61	-27.61	-27.61	-27.61	-27.61
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	5.85	5.85	5.85	5.85	5.85
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	14,554.50	15,179.90	17,031.76	18,150.01	19,443.33
IDC, Construction (168 months, 4-3/8%)*	5,382.37	5,613.65	6,298.48	6,712.01	7,190.30
Total, Interest During Construction	5,382.37	5,613.65	6,298.48	6,712.01	7,190.30
Total Investment	19,936.87	20,793.55	23,330.24	24,862.02	26,633.62
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	988.41	1,030.89	1,156.65	1,232.59	1,320.42
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	988.41	1,030.89	1,156.65	1,232.59	1,320.42
Marginal Benefits (x $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	11.21	11.21	11.21	11.21	11.21
RR Bridge	0.00	0.00	0.00	0.00	0.00
Equivalent Avg. Ann. Benefits	11.21	11.21	11.21	11.21	11.21
Benefit/Cost Ratio	0.01	0.01	0.01	0.01	0.01
Net Benefits	-977.20	-1,019.68	-1,145.44	-1,221.38	-1,309.21

Alternative H Evaluation

Alternative H is the Tiffany Basin plus the levee. It is essentially Alternative B plus the extension of the levee along the Tiffany Basin's west side. The purpose of the extension is to protect the railroad track from flooding that may occur in the Tiffany Basin. This feature serves as a trade-off to Alternative B. Table F-33 identifies the costs and benefits of the levee and the Tiffany Sediment Basin. Table F-34 compares the marginal benefits and marginal costs of Alternative H to Alternative B, to highlight the impact of extending the levee protection through the Tiffany Sediment Basin. Table F-35 compares the marginal benefits and marginal costs of Alternative H to Alternative A, to highlight the impact of extending the levee protection and installing the Tiffany Sediment Basin.

Alternative H Costs:

This feature represents the combination of a levee extending along the west side of the Tiffany Basin, and serves as a second means of protecting the upstream levee and the railroad tracks from sedimentation and flooding originating in the Tiffany Basin. This alternative also incorporates restructuring the Tiffany Basin to collect sediment. This additional length of levee would be selected over Alternative B if it achieved the same goals of the project at lower costs. As the following tables show, this alternative costs roughly $25.8 million more than Alternative B.

Alternative B describes how the inclusion of the Tiffany Basin as a project feature increases project costs without increasing project benefits. However, comparing Alternative H to Alt. B indicates that, were there a justification for including the Tiffany Basin, Alt. B would be preferable to Alt. H on a least-cost basis, assuming both alternatives performed identically. Previous analyses (August, 2007) had the opposite result.

Alternative H Benefits:

The benefits from including the Tiffany Basin come from decreasing sediment deposition in the upstream reaches of the Rio Grande. Alt. H has lower future, with project stages than Alt. A, but the calculations indicate those benefits are most appreciable to the smaller project sizes. At the NED plan size (Base levee + 4 feet), the equivalent annual benefits of including the Tiffany Basin, discounting future benefits to present values, are roughly $420,800. At the margin, the benefits do not justify the additional costs of the Tiffany Sediment feature. There is also a small unquantified benefit of rerouting sediment into the Tiffany Basin, saving Bureau of Reclamation personnel the cost of

removing that sediment from the Rio Grande over the 10 to 30 years it takes to fill the basin.

At the NED plan size (Base levee + 4 feet), the equivalent annual benefits of including the Tiffany Basin, discounting future benefits to present values, is roughly $41,400. At the margin, the benefits do not justify the additional costs of the Tiffany Sediment feature. Were the Tiffany Basin feature necessary to achieve the project objectives (as in a multipurpose NED/NER project or as a mitigation requirement), it would be preferable to build Alternative B over Alternative H.

As previously described, the Tiffany Basin has few identified NED benefits, but there are uncaptured benefits (sediment deposition not requiring Bureau of Reclamation removal, increased avoidable water losses through evaporation) that have an uncertain effect on benefits.

Alternative H would be preferable to Alternative B if it achieved the same results for less cost. As the following table indicates, Alternative H is approximately $25.8 million more than Alternative B, and $34.6 million more than Alternative A.

Potential rationale for Alternative H plan selection:

It might be possible to justify the Tiffany Basin through a combination of NED and NER benefits (such as a multipurpose project or through mitigation). To do that, an incremental cost analysis showing that an expenditure of approximately $25.9 million at Tiffany is an efficient and effective means to achieve the NER goal, in which case Alternative B would be the preferred alternative.

Table F-33

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR ALT. H

SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

	Base levee	Base levee + 1 ft	Base levee + 2 ft	Base levee + 3 ft	Base levee + 4 ft
Construction Costs (x $1,000)					
Levee	125,542.48	131,003.96	137,271.03	140,482.76	143,370.52
Overbank lowering/LFCC Channel Berm	4,981.58	4,981.58	4,981.58	4,981.58	4,981.58
Tiffany Basin	6,837.24	6,837.24	6,837.24	6,837.24	6,837.24
RR Bridge	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	4,854.00	4,854.00	4,854.00	4,854.00	4,854.00
PED	8,050.28	8,050.28	8,050.28	8,050.28	8,050.28
Construction Management	20,297.94	20,297.94	20,297.94	20,297.94	20,297.94
Total First Cost	170,563.52	176,024.99	182,292.07	185,503.80	188,391.56
IDC, Construction (168 months, 4-3/8%)*	63,075.72	65,095.42	67,413.03	68,600.76	69,668.67
Total, Interest During Construction	63,075.72	65,095.42	67,413.03	68,600.76	69,668.67
Total Investment	233,639.24	241,120.42	249,705.10	254,104.56	258,060.23
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	11,583.17	11,954.07	12,379.67	12,597.78	12,793.89
OMRR&R					
Total Avg. Ann. Cost	11,583.17	11,954.07	12,379.67	12,597.78	12,793.89
Project Benefits (x $1,000)					
Levee	11,919.14	14,648.88	16,119.75	17,007.45	17,267.09
Tiffany Basin (RR and reroutes)	420.76	420.76	420.76	420.76	420.76
RR Bridge					
Equivalent Avg. Ann. Benefits	12,339.90	15,069.64	16,540.51	17,428.20	17,687.85
Benefit/Cost Ratio	1.07	1.26	1.34	1.38	1.38
Net Benefits	756.73	3,115.57	4,160.84	4,830.42	4,893.95

Table F-34

MARGINAL COSTS, COMPARING ALTERNATIVE H TO ALTERNATIVE B (X $1,000)					
Levee	14,411.10	14,833.80	16,422.62	17,551.20	18,854.87
Overbank lowering/LFCC Channel Berm	-8.02	-8.02	-8.02	-8.02	-8.02
Tiffany Basin	-7.83	-7.83	-7.83	-7.83	-7.83
RR Bridge	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	3.72	3.72	3.72	3.72	3.72
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	14,398.97	14,821.67	16,410.49	17,539.07	18,842.74
IDC, Construction (168 months, 4-3/8%)*	5,324.85	5,481.17	6,068.73	6,486.09	6,968.19
Total, Interest During Construction	5,324.85	5,481.17	6,068.73	6,486.09	6,968.19
Total Investment	19,723.82	20,302.84	22,479.22	24,025.16	25,810.94
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	977.85	1,006.56	1,114.46	1,191.10	1,279.63
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	977.85	1,006.56	1,114.46	1,191.10	1,279.63
Marginal Benefits (x $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	-8.41	-8.41	-8.41	-8.41	-8.41
RR Bridge	0.00	0.00	0.00	0.00	0.00
Equivalent Avg. Ann. Benefits	-8.41	-8.41	-8.41	-8.41	-8.41
Benefit/Cost Ratio	-0.01	-0.01	-0.01	-0.01	-0.01
Net Benefits	-986.26	-1,014.96	-1,122.86	-1,199.51	-1,288.04

Table F-35

MARGINAL COSTS, COMPARING ALTERNATIVE H TO ALTERNATIVE A (X $1,000)					
Levee	15,397.42	16,276.97	17,724.20	18,751.23	19,981.29
Overbank lowering/LFCC Channel Berm	-8.02	-8.02	-8.02	-8.02	-8.02
Tiffany Basin	6,837.24	6,837.24	6,837.24	6,837.24	6,837.24
RR Bridge	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	3.72	3.72	3.72	3.72	3.72
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	20,845.21	21,688.80	23,100.08	24,091.15	25,285.26
IDC, Construction (168 months, 4-3/8%)*	7,708.72	8,020.69	8,542.59	8,909.10	9,350.69
Total, Interest During Construction	7,708.72	8,020.69	8,542.59	8,909.10	9,350.69
Total Investment	28,553.93	29,709.49	31,642.67	33,000.25	34,635.95
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	1,415.62	1,472.91	1,568.75	1,636.06	1,717.15
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	1,415.62	1,472.91	1,568.75	1,636.06	1,717.15
Marginal Benefits (x $1,000)					
Levee	138.55	5.51	-1.02	16.47	-348.34
Tiffany Basin	41.41	41.41	41.41	41.41	41.41
RR Bridge	0.00	0.00	0.00	0.00	0.00
Equivalent Avg. Ann. Benefits	179.96	46.92	40.39	57.88	-306.93
Benefit/Cost Ratio	0.13	0.03	0.03	0.04	-0.18
Net Benefits	-1,235.66	-1,426.00	-1,528.36	-1,578.18	-2,024.08

Alternative I Evaluation

Alternative I is comprised of the San Marcial railroad bridge plus the levee. It is essentially Alternative C plus the extension of the levee along the Tiffany Basin's west side. The purpose of the extension is to protect the railroad track from flooding that may occur in the Tiffany Basin. This feature serves as a trade-off to Alternative C. Table F-36 identifies the costs and benefits of the levee past the Tiffany area and the replacement railroad bridge. Table F-37 compares the marginal benefits and marginal costs of Alternative I to Alternative C, to highlight the impact of extending the levee protection through the Tiffany Sediment Basin. Table F-38 compares the marginal benefits and marginal costs of Alternative H to Alternative A, to highlight the impact of extending the levee protection and installing the replacement railroad bridge.

Alternative I Costs:

This feature represents the combination of a levee extending along the west side of the Tiffany Basin, and serves as a second means of protecting the upstream levee and the railroad tracks from sedimentation and flooding originating in the Tiffany Basin. This additional length of levee would be selected over Alternative C if it achieved the same goals of the project at lower costs. As the following tables show, this alternative costs roughly $25.8 million more than Alternative C.

Alternative I describes how the inclusion of the levee extension along the west side of the Tiffany Basin increases project costs without increasing project benefits. Comparing Alt. I to Alt A, we see that the addition of the levee extension along the Tiffany Basin's west edge, even though the Tiffany sediment basin feature is not included, raises levee construction costs by $18.9 million. Alternative I does not appear to be a low-cost means of achieving flood damage reduction benefits.

Alternative I Benefits:

As described in the economics appendix, the railroad bridge represents a service that, in the without project condition, is threatened with interruption. The benefit calculations consider the likelihood of traffic reroutes, tonnage and distance of the reroutes, and the likelihood of needing to repair or replace the existing bridge. Those benefits amount to roughly $4.3 million on an average annual basis. Bureau of Reclamation officials have indicated they spend roughly $2 million annually to remove sediment from nearby reaches of the Rio Grande, and altering the railroad bridge to convey more water, *ceteris paribus*, does not appear to alter that in the with project condition.

Alternative I does not include the Tiffany Basin as a project feature.

Alternative I would be preferable to Alternative C if it achieved the same results for less cost. As the following table indicates, Alternative I is approximately $25.8 million more than Alternative C.

Potential rationale for Alternative I plan selection:
Given the increased costs for a specific output, it’s highly unlikely that circumstances would align to elevate this plan, at any size, to the NED plan.

Table F-36

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR ALT. I

SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

	Base levee	Base levee + 1 ft	Base levee + 2 ft	Base levee + 3 ft	Base levee + 4 ft
Construction Costs (x $1,000)					
Levee	124,097.97	129,832.35	135,975.23	139,288.24	142,249.39
Overbank lowering/LFCC Channel Berm	4,981.58	4,981.58	4,981.58	4,981.58	4,981.58
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	22,949.45	22,949.45	22,949.45	22,949.45	22,949.45
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	4,854.00	4,854.00	4,854.00	4,854.00	4,854.00
PED	8,050.28	8,050.28	8,050.28	8,050.28	8,050.28
Construction Management	20,297.94	20,297.94	20,297.94	20,297.94	20,297.94
Total First Cost	185,231.22	190,965.60	197,108.48	200,421.49	203,382.64
IDC, Construction (168 months, 4-3/8%)*	68,499.96	70,620.58	72,892.26	74,117.44	75,212.49
Total, Interest During Construction	68,499.96	70,620.58	72,892.26	74,117.44	75,212.49
Total Investment	253,731.18	261,586.18	270,000.74	274,538.92	278,595.13
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	12,579.27	12,968.70	13,385.87	13,610.86	13,811.96
OMRR&R					
Total Avg. Ann. Cost	12,579.27	12,968.70	13,385.87	13,610.86	13,811.96
Project Benefits (x $1,000)					
Levee	11,780.59	14,643.38	16,120.77	16,990.98	17,615.42
Tiffany Basin (RR and reroutes)	569.09	569.09	569.09	569.09	569.09
RR Bridge	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70
Equivalent Avg. Ann. Benefits	16,656.38	19,519.16	20,996.55	21,866.76	22,491.21
Benefit/Cost Ratio	1.32	1.51	1.57	1.61	1.63
Net Benefits	4,077.10	6,550.46	7,610.68	8,255.90	8,679.25

Table F-37

MARGINAL COSTS, COMPARING ALTERNATIVE I TO ALTERNATIVE C (X $1,000)					
Levee	13,952.91	15,105.36	16,428.40	17,556.70	18,860.16
Overbank lowering/LFCC Channel Berm	-8.02	-8.02	-8.02	-8.02	-8.02
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	-50.62	-50.62	-50.62	-50.62	-50.62
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	3.72	3.72	3.72	3.72	3.72
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	13,897.99	15,050.44	16,373.48	17,501.78	18,805.25
IDC, Construction (168 months, 4-3/8%)*	5,139.59	5,565.77	6,055.04	6,472.30	6,954.33
Total, Interest During Construction	5,139.59	5,565.77	6,055.04	6,472.30	6,954.33
Total Investment	19,037.58	20,616.22	22,428.53	23,974.08	25,759.57
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	943.83	1,022.09	1,111.94	1,188.57	1,277.09
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	943.83	1,022.09	1,111.94	1,188.57	1,277.09
Marginal Benefits (x $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	0.00	0.00	0.00	0.00	0.00
Equivalent Avg. Ann. Benefits	0.00	0.00	0.00	0.00	0.00
Benefit/Cost Ratio	0.00	0.00	0.00	0.00	0.00
Net Benefits	-943.83	-1,022.09	-1,111.94	-1,188.57	-1,277.09

Table F-38

MARGINAL COSTS, COMPARING ALTERNATIVE I TO ALTERNATIVE A (X $1,000)					
Levee	13,952.91	15,105.36	16,428.40	17,556.70	18,860.16
Overbank lowering/LFCC Channel Berm	-8.02	-8.02	-8.02	-8.02	-8.02
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	22,949.45	22,949.45	22,949.45	22,949.45	22,949.45
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	3.72	3.72	3.72	3.72	3.72
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	35,512.91	36,629.41	37,916.49	39,008.84	40,276.34
IDC, Construction (168 months, 4-3/8%)*	13,132.95	13,545.84	14,021.82	14,425.77	14,894.51
Total, Interest During Construction	13,132.95	13,545.84	14,021.82	14,425.77	14,894.51
Total Investment	48,645.86	50,175.25	51,938.31	53,434.61	55,170.85
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	2,411.72	2,487.55	2,574.95	2,649.14	2,735.21
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	2,411.72	2,487.55	2,574.95	2,649.14	2,735.21
Marginal Benefits (x $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	189.74	189.74	189.74	189.74	189.74
RR Bridge	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70
Equivalent Avg. Ann. Benefits	4,496.44	4,496.44	4,496.44	4,496.44	4,496.44
Benefit/Cost Ratio	1.86	1.81	1.75	1.70	1.64
Net Benefits	2,084.71	2,008.89	1,921.48	1,847.30	1,761.22

Alternative J Evaluation

Alternative J is the San Marcial railroad bridge plus the levee. It is essentially Alternative C plus the extension of the levee along the Tiffany Basin's east side. The purpose of the extension is to protect the railroad track from flooding that may occur in the Tiffany Basin. This feature serves as a trade-off to Alternatives C and I. Table F-39 identifies the costs and benefits of the levee along the east side of the Tiffany area and the replacement railroad bridge. Table F-40 compares the marginal benefits and marginal costs of Alternative J to Alternative C, to highlight the impact of extending the levee protection through the Tiffany Sediment Basin. Table F-41 compares the marginal benefits and marginal costs of Alternative J to Alternative I, to compare the levee extension along the west side and the east sides of the Tiffany area. Table F-42 compares the marginal benefits and marginal costs of Alternative J to Alternative A, to identify the effects of replacing the railroad bridge and providing a levee along the east side of the Tiffany area.

Alternative J Costs:

This feature represents the combination of a levee extending along the east side of the Tiffany Basin, and serves as a third means of protecting the upstream levee and the railroad tracks from sedimentation and flooding originating in the Tiffany Basin. This additional length of levee would be selected over Alternative C if it achieved the same goals of the project at lower costs. As the following tables show, this alternative costs roughly $3.1 million more than Alternative C.

Alternative J describes how the inclusion of the levee extension along the east side of the Tiffany Basin increases project costs without increasing project benefits. Comparing Alt. J to Alt A, we see that the addition of the levee extension along the Tiffany Basin's east edge, even though the Tiffany sediment basin feature is not included, raises levee construction costs by close to $2.3 million. Alternative J does not appear to be a low-cost means of achieving flood damage reduction benefits.

Alternative J Benefits:

As described in the economics appendix, the railroad bridge represents a service that, in the without project condition, is threatened with interruption. The benefit calculations consider the likelihood of traffic reroutes, tonnage and distance of the reroutes, and the likelihood of needing to repair or replace the existing bridge. Those benefits amount to roughly $4.3 million on an average annual basis. Bureau of Reclamation officials have indicated they spend roughly $2 million annually to remove sediment from nearby

reaches of the Rio Grande, and altering the railroad bridge to convey more water, *ceteris paribus*, does not appear to alter that in the with project condition.

Alternative J does not include the Tiffany Basin as a project feature.

Alternative J would be preferable to Alternative C if it achieved the same results for less cost. As the following table indicates, Alternative J is approximately $3.1 million more than Alternative C.

Potential rationale for Alternative J plan selection:

Given the increased costs for a specific output, it’s highly unlikely that circumstances would align to elevate this plan, at any size, to the NED plan. The only circumstance which would incorporate this alternative is where a railroad bridge were justified, authorized, and heretofore unaccounted damages to the approach tracks to the railroad bridge justified the incremental levee extension. This alternative is cheaper than Alternative I.

Table F-39

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR ALT. J

SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

	Base levee	Base levee + 1 ft	Base levee + 2 ft	Base levee + 3 ft	Base levee + 4 ft
Construction Costs (x $1,000)					
Levee	111,279.11	116,029.51	121,169.66	123,605.98	125,678.91
Overbank lowering/LFCC Channel Berm	4,981.58	4,981.58	4,981.58	4,981.58	4,981.58
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	22,949.54	22,949.54	22,949.54	22,949.54	22,949.54
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	4,854.00	4,854.00	4,854.00	4,854.00	4,854.00
PED	8,050.28	8,050.28	8,050.28	8,050.28	8,050.28
Construction Management	20,297.94	20,297.94	20,297.94	20,297.94	20,297.94
Total First Cost	172,412.44	177,162.85	182,302.99	184,739.32	186,812.24
IDC, Construction (168 months, 4-3/8%)*	63,759.47	65,516.21	67,417.07	68,318.05	69,084.63
Total, Interest During Construction	63,759.47	65,516.21	67,417.07	68,318.05	69,084.63
Total Investment	236,171.92	242,679.06	249,720.06	253,057.37	255,896.87
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	11,708.73	12,031.34	12,380.41	12,545.87	12,686.64
OMRR&R					
Total Avg. Ann. Cost	11,708.73	12,031.34	12,380.41	12,545.87	12,686.64
Project Benefits (x $1,000)					
Levee	11,780.59	14,643.38	16,120.77	16,990.98	17,615.42
Tiffany Basin (RR and reroutes)	568.20	568.20	568.20	568.20	568.20
RR Bridge	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70
Equivalent Avg. Ann. Benefits	16,655.49	19,518.27	20,995.66	21,865.87	22,490.32
Benefit/Cost Ratio	1.42	1.62	1.70	1.74	1.77
Net Benefits	4,946.76	7,486.93	8,615.25	9,320.00	9,803.68

Table F-40

MARGINAL COSTS, COMPARING ALTERNATIVE J TO ALTERNATIVE C (X $1,000)					
Levee	1,134.05	1,302.53	1,622.83	1,874.45	2,289.68
Overbank lowering/LFCC Channel Berm	-8.02	-8.02	-8.02	-8.02	-8.02
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	-50.54	-50.54	-50.54	-50.54	-50.54
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	3.72	3.72	3.72	3.72	3.72
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	1,079.21	1,247.69	1,567.99	1,819.61	2,234.85
IDC, Construction (168 months, 4-3/8%)*	399.10	461.41	579.86	672.91	826.46
Total, Interest During Construction	399.10	461.41	579.86	672.91	826.46
Total Investment	1,478.32	1,709.09	2,147.85	2,492.52	3,061.31
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	73.29	84.73	106.48	123.57	151.77
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	73.29	84.73	106.48	123.57	151.77
Marginal Benefits (x $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	-0.89	-0.89	-0.89	-0.89	-0.89
RR Bridge	0.00	0.00	0.00	0.00	0.00
Equivalent Avg. Ann. Benefits	-0.89	-0.89	-0.89	-0.89	-0.89
Benefit/Cost Ratio	-0.01	-0.01	-0.01	-0.01	-0.01
Net Benefits	-74.18	-85.62	-107.37	-124.46	-152.66

Table F-41

MARGINAL COSTS, COMPARING ALTERNATIVE J TO ALTERNATIVE I (X $1,000)					
Levee	-12,818.86	-13,802.84	-14,805.57	-15,682.25	-16,570.48
Overbank lowering/LFCC Channel Berm	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	0.08	0.08	0.08	0.08	0.08
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	0.00	0.00	0.00	0.00	0.00
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	-12,818.78	-13,802.75	-14,805.49	-15,682.17	-16,570.40
IDC, Construction (168 months, 4-3/8%)*	-4,740.48	-5,104.37	-5,475.19	-5,799.39	-6,127.86
Total, Interest During Construction	-4,740.48	-5,104.37	-5,475.19	-5,799.39	-6,127.86
Total Investment	-17,559.26	-18,907.12	-20,280.68	-21,481.56	-22,698.26
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	-870.54	-937.36	-1,005.46	-1,064.99	-1,125.32
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	-870.54	-937.36	-1,005.46	-1,064.99	-1,125.32
Marginal Benefits (x $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	-0.89	-0.89	-0.89	-0.89	-0.89
RR Bridge	0.00	0.00	0.00	0.00	0.00
Equivalent Avg. Ann. Benefits	-0.89	-0.89	-0.89	-0.89	-0.89
Benefit/Cost Ratio	0.00	0.00	0.00	0.00	0.00
Net Benefits	869.65	936.47	1,004.57	1,064.11	1,124.43

Table F-42

MARGINAL COSTS, COMPARING ALTERNATIVE J TO ALTERNATIVE A (X $1,000)					
Levee	1,134.05	1,302.53	1,622.83	1,874.45	2,289.68
Overbank lowering/LFCC Channel Berm	-8.02	-8.02	-8.02	-8.02	-8.02
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	22,949.54	22,949.54	22,949.54	22,949.54	22,949.54
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	3.72	3.72	3.72	3.72	3.72
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	22,694.14	22,826.65	23,111.00	23,326.67	23,705.94
IDC, Construction (168 months, 4-3/8%)*	8,392.47	8,441.48	8,546.63	8,626.38	8,766.64
Total, Interest During Construction	8,392.47	8,441.48	8,546.63	8,626.38	8,766.64
Total Investment	31,086.60	31,268.13	31,657.63	31,953.05	32,472.59
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	1,541.19	1,550.19	1,569.50	1,584.14	1,609.90
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	1,541.19	1,550.19	1,569.50	1,584.14	1,609.90
Marginal Benefits (x $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	188.85	188.85	188.85	188.85	188.85
RR Bridge	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70
Equivalent Avg. Ann. Benefits	4,495.55	4,495.55	4,495.55	4,495.55	4,495.55
Benefit/Cost Ratio	2.92	2.90	2.86	2.84	2.79
Net Benefits	2,954.36	2,945.36	2,926.05	2,911.41	2,885.65

Alternative K Evaluation

Alternative K is the upstream levee plus the extension of the levee along the Tiffany Basin's east side. The purpose of the extension is to protect the railroad track from flooding that may occur in the Tiffany Basin. This feature serves as a trade-off to Alternatives A. Table F-43 identifies the costs and benefits of the levee past the Tiffany area. Table F-44 compares the marginal benefits and marginal costs of Alternative K to Alternative A, to highlight the impact of extending the levee protection along the east side of the Tiffany area. An alternative extending the levee along the west side of the Tiffany Basin without reconfiguring the Tiffany Basin to collect sediment, is not technically feasible, and introduces an uncontrolled headcut into the Rio Grande as water flows in an uncontrolled fashion into the basin.

Table F-44 does indicate that extending the levee along the Tiffany Basin produces small net benefits. This would suggest that extending the levee, at a lower crest elevation, through Tiffany would be cost justified. However, according to Table F-57, the hydraulic reaches by Tiffany represent the locations of the most severe sediment accumulations in the study area. The likelihood of the Base levee + 1' levee containing the 1% chance exceedance event starts at 76.8% in the present, with-project condition, and drops to less than 4.3% in the future, with-project condition. Any levee through the Tiffany reach isn't expected to last as long as the upstream levees.

Alternative K Costs:

This feature represents the combination of a levee extending along the east side of the Tiffany Basin, and serves as a third means of protecting the upstream levee and the railroad tracks from sedimentation and flooding originating in the Tiffany Basin. This additional length of levee would be selected over Alternative A if it achieved the same goals of the project at lower costs. As the following tables show, this alternative costs roughly $1.7 million more than Alternative A.

Alternative K describes how the inclusion of the levee extension along the east side of the Tiffany Basin increases project costs without increasing project benefits. Comparing Alt. K to Alt A, we see that the addition of the levee extension along the Tiffany Basin's east edge, even though the Tiffany sediment basin feature is not included, raises levee construction costs by $1.7 million. Alternative K does appear to be a low-cost means of achieving flood damage reduction benefits.

Alternative K Benefits:

Alternative K represents the upstream levees described in Alternative A plus the extension of the levee along the Tiffany Basin’s east edge, between it and the river. The Tiffany Basin has no damageable properties outside of a length of railroad track that forms the western border of the Tiffany Basin. As previously stated, the Tiffany Basin sits roughly 10’ lower than the adjacent Rio Grande. Alternative K does not include the Tiffany Basin as a project feature.

Alternative K would be preferable to Alternative A if it achieved the same results for less cost. As the following table indicates, Alternative K is approximately $1.7 million more than Alternative A.

Potential rationale for Alternative K plan selection:
Alternative K, at the Base levee + 4 foot levee height, provides similar net benefits to the equivalent levee in Alternative A. It would appear that, in some cases, Alternative K provides even more net benefits and could be the plan which maximizes net benefits consistent with the flood risk management goals of this project. However, it is not desirable to cut the Tiffany Basin off from the Rio Grande floodway without substantial mitigation costs. Cutting Tiffany off from the Rio Grande perpetually would require extensive mitigation of over 2000 acres of land that once received river flows (albeit sporadically). Prior experience on other projects indicates mitigation would require 4 acres for every one impacted. The current Real Estate appendix indicates that an acre of land in the study area goes from $460 to $13,000 per acre, meaning that 8000 acre mitigation LAND ACQUISITION COSTS start at $3.7 million. If the unit cost of mitigation land (that's acquisition plus any modifications needed to accomplish the mitigation goal) exceeds $2,338.18 per acre then Alternative K gets too expensive, and Alternative A rises as the plan with the highest net benefits.

The net equivalent annual benefits for Alternative A at Base levee +4' is $6.8 million (August, 2010 dollars). The net equivalent annual benefits of the equivalent configuration of Alternative K is practically identical at $6.8 million (project benefits differ by only about $13,000 on an equivalent annual basis). Prior evaluations indicated Alternative K produced greater average annual net benefits difference is $259,000 which is a fairly thin margin. That figure could justify roughly $5.2 million in construction to support any mitigation efforts. That number goes down really quickly once marginal O&M costs is figured in, as one dollar in O&M is worth about $20 in first costs.

It is unlikely that one can mitigate over 2000 acres for less than $5.2 million. The land acquisition costs start at $3.7 million and will rise with plantings and any other mitigation efforts. Extending the levee down the west side of the Tiffany area is $21.8 million MORE (With an average annual cost of $1.1 million MORE) than doing the extension

down the east side of the Tiffany area. This "Alternative Q" is discussed in detail later in this appendix. Consequently, it appears that Alternative A, the 43 mile levee, at Base levee + 4' is the plan which maximizes net benefits.

Present analysis indicates that Alternative K produces slightly fewer net benefits than Alternative A. Alternative A was updated to include $1.4-1.5 million in mitigation costs across the various levee heights, which was not available at the time of the alternative screening.

Table F-43

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR ALT. K

SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

	Base levee	Base levee + 1 ft	Base levee + 2 ft	Base levee + 3 ft	Base levee + 4 ft
Construction Costs (x $1,000)					
Levee	110,641.20	115,389.70	120,508.24	122,972.57	125,053.52
Overbank lowering/LFCC Channel Berm	4,974.86	4,974.86	4,974.86	4,974.86	4,974.86
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	4,854.00	4,854.00	4,854.00	4,854.00	4,854.00
PED	8,048.15	8,048.15	8,048.15	8,048.15	8,048.15
Construction Management	20,297.94	20,297.94	20,297.94	20,297.94	20,297.94
Total First Cost	148,816.15	153,564.65	158,683.19	161,147.52	163,228.47
IDC, Construction (168 months, 4-3/8%)*	55,033.38	56,789.41	58,682.29	59,593.62	60,363.17
Total, Interest During Construction	55,033.38	56,789.41	58,682.29	59,593.62	60,363.17
Total Investment	203,849.53	210,354.06	217,365.47	220,741.14	223,591.64
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	10,106.28	10,428.76	10,776.36	10,943.72	11,085.04
OMRR&R					
Total Avg. Ann. Cost	10,106.28	10,428.76	10,776.36	10,943.72	11,085.04
Project Benefits (x $1,000)					
Levee	11,780.59	14,643.38	16,120.77	16,990.98	17,615.42
Tiffany Basin (RR and reroutes)	374.74	374.74	374.74	374.74	374.74
RR Bridge					
Equivalent Avg. Ann. Benefits	12,155.34	15,018.12	16,495.51	17,365.72	17,990.17
Benefit/Cost Ratio	1.20	1.44	1.53	1.59	1.62
Net Benefits	2,049.06	4,589.36	5,719.15	6,422.00	6,905.13

Table F-44					
MARGINAL COSTS, COMPARING ALTERNATIVE K TO ALTERNATIVE A (X $1,000)					
Levee	496.15	662.71	961.41	1,241.04	1,664.30
Overbank lowering/LFCC Channel Berm	-14.74	-14.74	-14.74	-14.74	-14.74
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	1.59	1.59	1.59	1.59	1.59
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	-902.16	-771.54	-508.80	-265.13	122.17
IDC, Construction (168 months, 4-3/8%)*	-333.62	-285.32	-188.16	-98.05	45.18
Total, Interest During Construction	-333.62	-285.32	-188.16	-98.05	45.18
Total Investment	-1,235.78	-1,056.87	-696.96	-363.17	167.35
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	-61.27	-52.40	-34.55	-18.01	8.30
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	-61.27	-52.40	-34.55	-18.01	8.30
Marginal Benefits (x $1,000)					
Levee	0.00	0.00	0.00	0.00	0.00
Tiffany Basin	-4.60	-4.60	-4.60	-4.60	-4.60
RR Bridge	0.00	0.00	0.00	0.00	0.00
Equivalent Avg. Ann. Benefits	-4.60	-4.60	-4.60	-4.60	-4.60
Benefit/Cost Ratio	0.08	0.09	0.13	0.26	-0.55
Net Benefits	56.66	47.79	29.95	13.40	-12.90

Alternate configuration of the Tiffany Sediment Basin (Alternatives L, M, N, O and P)

An alternative configuration for the Tiffany Basin was developed on the concern that the recommended configuration, which contains weirs, would entrap the Rio Grande Silvery Minnow (a Federally-listed Endangered species) within the Basin. Minnows trapped within the Basin would be cut off from the Rio Grande. The alternative configuration contained in Alternatives L-P uses Streamside Systems' sediment collectors to collect and remove sediment from the Rio Grande and then distributes that sediment throughout the Tiffany Basin. Five alternatives were created as substitutes for alternatives using the Tiffany Basin weir structures, as follows:

Alternative B = Alternative L.
Alternative D = Alternative M.
Alternative F = Alternative N.
Alternative G = Alternative O.
Alternative H = Alternative P.

These alternatives generally have a lower installation cost (about $900,000 to $1.5 million less, August, 2010 prices) but extraordinarily high operations and maintenance costs (over $16 million). Those costs are attributed to dispersing the equivalent of four dump trucks worth of sediment DAILY. Alternatives L-P have the same performance characteristics, and the same benefits identified for Alternatives B, D, F, G, H were used for L-P. The higher costs associated with Alternatives L-P are attributed solely to the alternative configuration using the sediment collector and manually distributing the accumulated sediment. Table F-45 identifies the Alternatives that include Tiffany, and the alternatives that include the alternative Tiffany configuration.

Table F-45

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR ALTS. B, D, F, G, H

AND ALTS. L, M, N, O, P

SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

	Alternative B	Alternative L	Alternative D	Alternative M	Alternative F	Alternative N	Alternative G	Alternative O	Alternative H	Alternative P
	Base levee + 4 ft.	Base levee + 4 ft.	Base levee + 4 ft.	Base levee + 4 ft.	Base levee + 4 ft.	Base levee + 4 ft.	Base levee + 4 ft.	Base levee + 4 ft.	Base levee + 4 ft.	Base levee + 4 ft.
Construction Costs (x $1,000)										
Levee	124,515.64	123,001.48	123,899.09	123,001.48	0.00	0.00	143,370.51	142,249.39	143,370.52	142,249.39
Overbank lowering/LFCC Channel Berm	4,989.60	4,981.58	4,982.88	4,981.58	0.00	0.00	6,837.21	4,981.58	4,981.58	4,981.58
Tiffany Basin	6,845.08	0.00	6,842.25	0.00	7,178.73	0.00	4,981.58	0.00	6,837.24	0.00
RR Bridge	0.00	0.00	22,977.07	22,949.45	23,026.39	23,026.39	22,949.45	22,949.45	0.00	0.00
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LERRD	4,854.00	4,854.00	4,854.00	4,854.00	0.00	0.00	4,854.00	4,854.00	4,854.00	4,854.00
PED	8,046.56	8,050.28	8,044.43	8,050.28	1,298.28	1,298.28	8,050.28	8,050.28	8,050.28	8,050.28
Construction Management	20,297.94	20,297.94	20,297.94	20,297.94	3,624.86	3,624.86	20,297.94	20,297.94	20,297.94	20,297.94
Total First Cost	169,548.82	161,185.28	191,897.65	184,134.73	35,128.26	27,949.53	211,340.98	203,382.64	188,391.56	180,433.18
Sediment Collection System	62,700.48	24,262.06	70,965.25	24,262.06	1,949.21	24,343.40	78,155.55	24,262.06	69,668.67	24,262.06
IDC, Construction (168 months, 4-3/8%)*	62,700.48	68,579.88	70,965.25	77,066.77	1,949.21	2,901.65	78,155.55	84,184.79	69,668.67	75,697.90
Total Investment	232,249.29	229,765.15	262,862.90	285,463.56	37,077.47	55,194.57	289,496.52	311,829.49	258,060.23	280,393.15
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	11,514.26	11,391.10	13,032.00	14,152.47	1,838.20	2,736.39	14,352.42	15,459.62	12,793.89	13,901.10
OMRR&R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	11,514.26	11,391.10	13,032.00	14,152.47	1,838.20	2,736.39	14,352.42	15,459.62	12,793.89	13,901.10
Project Benefits (x $1,000)										
Levee	17,267.09	17,267.09	17,267.09	17,267.09	0.00	0.00	17,267.09	17,267.09	17,267.09	17,267.09
Tiffany Basin (RR and reroutes)	429.16	429.16	420.37	420.37	355.40	355.40	431.58	431.58	420.76	420.76
RR Bridge	0.00	0.00	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70	4,306.70	0.00	0.00
Equivalent Avg. Ann. Benefits	17,696.25	17,696.25	21,994.16	21,994.16	4,662.09	4,662.09	22,005.37	22,005.37	17,687.85	17,687.85
Benefit/Cost Ratio	1.54	1.55	1.69	1.55	2.54	1.70	1.53	1.42	1.38	1.27
Net Benefits	6,181.99	6,305.15	8,962.16	7,841.68	2,823.90	1,925.70	7,652.95	6,545.74	4,893.95	3,786.75

Alternative Q Evaluation

Alternative Q is the upstream levee plus the extension of the levee along the Tiffany Basin's west side. The purpose of the extension is to protect the railroad track from flooding that may occur in the Tiffany Basin. This feature serves as a trade-off to Alternatives K. Alternative K was identified previously as the plan which maximizes net NED benefits consistent with the objectives of the project, but has the undesirable side effect of isolating the Tiffany Area from the Rio Grande floodway. This Alternative serves as a comparison to Alternative K by running the extended levee down the west side of the Tiffany Area instead of the east side. For purposes of this analysis, Alternative Q is identical in performance and cost to Alternative H, less the Tiffany Basin feature. Table F-46 identifies the costs and benefits of the levee past the Tiffany area. Table F-47 compares the marginal benefits and marginal costs of Alternative Q to Alternative A, to highlight the impact of extending the levee protection along the west side of the Tiffany area. An alternative extending the levee along the west side of the Tiffany Basin without reconfiguring the Tiffany Basin to collect sediment, is not technically feasible, and introduces an uncontrolled headcut into the Rio Grande as water flows in an uncontrolled fashion into the basin. Alternative Q is presented here as a means to identify the cost of relocating the extended levee versus mitigating for the Tiffany Area's separation from the floodway. Table F-45 makes that comparison explicitly.

Alternative Q Costs:

This Alternative represents the combination of the original 43 mile levee (identified in Alternative A) plus a levee extending along the west side of the Tiffany Basin. This additional length of levee would be selected over Alternative A if it achieved the same goals of the project at lower costs. As the following tables show, this alternative costs roughly $25.3 million more than Alternative A. There are unidentified costs that would be associated with protecting the proposed levees from an uncontrolled flow into the Tiffany Area and the resultant headcut that would work its way up the Rio Grande. The existing Tiffany Area sits approximately 10' below the elevation of the Rio Grande channel.

Alternative Q Benefits:

Alternative Q represents the upstream levees described in Alternative A plus the extension of the levee along the Tiffany Basin's west edge. The Tiffany Basin has no damageable properties outside of a length of railroad track that forms the western border of the Tiffany Basin. As previously stated, the Tiffany Basin sits roughly 10' lower than the adjacent Rio Grande. Alternative Q does not include the Tiffany Basin as a project feature.

Alternative Q provides an additional $244,300 (August, 2010 prices) in equivalent annual benefits due to the extended length of the levee along the west side of the Tiffany Basin.

Potential rationale for Alternative Q plan selection:

Alternative Q, at the Base levee + 4 foot levee height, provides the greatest net benefits among all the levee sizes evaluated. However, Alternative K is cheaper at every levee height than Q, and would be preferential when selecting the plan which maximizes net NED benefits. Unfortunately, the extensive mitigation costs associated with Alternative K would drive down the net NED benefits to the point where Alternative A (where the levee terminates just upstream of the Tiffany Area) becomes the plan which maximizes net NED benefits. It is highly unlikely that any extension of the levee around either side of the Tiffany Area would make sense when viewed with the NED account.

Table F-46

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR ALT. Q

SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

	Base levee	Base levee + 1 ft	Base levee + 2 ft	Base levee + 3 ft	Base levee + 4 ft
Construction Costs (x $1,000)					
Levee	125,542.48	131,003.96	137,271.03	140,482.76	143,370.52
Overbank lowering/LFCC Channel Berm	4,981.58	4,981.58	4,981.58	4,981.58	4,981.58
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	4,854.00	4,854.00	4,854.00	4,854.00	4,854.00
PED	8,050.28	8,050.28	8,050.28	8,050.28	8,050.28
Construction Management	20,297.94	20,297.94	20,297.94	20,297.94	20,297.94
Total First Cost	163,726.28	169,187.75	175,454.82	178,666.56	181,554.31
IDC, Construction (168 months, 4-3/8%)*	60,547.26	62,566.96	64,884.57	66,072.29	67,140.21
Total, Interest During Construction	60,547.26	62,566.96	64,884.57	66,072.29	67,140.21
Total Investment	224,273.53	231,754.71	240,339.39	244,738.85	248,694.52
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	11,118.85	11,489.74	11,915.35	12,133.46	12,329.57
OMRR&R					
Total Avg. Ann. Cost	11,118.85	11,489.74	11,915.35	12,133.46	12,329.57
Project Benefits (x $1,000)					
Levee	11,919.14	14,648.88	16,119.75	17,007.45	17,267.09
Tiffany Basin (RR and reroutes)	420.76	420.76	420.76	420.76	420.76
RR Bridge					
Equivalent Avg. Ann. Benefits	12,339.90	15,069.64	16,540.51	17,428.20	17,687.85
Benefit/Cost Ratio	1.11	1.31	1.39	1.44	1.43
Net Benefits	12,339.90	15,069.64	16,540.51	17,428.20	17,687.85

Table F-47

MARGINAL COSTS, COMPARING ALTERNATIVE Q TO ALTERNATIVE A (X $1,000)					
Levee	15,397.42	16,276.97	17,724.20	18,751.23	19,981.29
Overbank lowering/LFCC Channel Berm	-8.02	-8.02	-8.02	-8.02	-8.02
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	3.72	3.72	3.72	3.72	3.72
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	14,007.97	14,851.56	16,262.84	17,253.91	18,448.02
IDC, Construction (168 months, 4-3/8%)*	5,180.26	5,492.22	6,014.12	6,380.63	6,822.22
Total, Interest During Construction	5,180.26	5,492.22	6,014.12	6,380.63	6,822.22
Total Investment	19,188.22	20,343.78	22,276.96	23,634.54	25,270.24
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	951.30	1,008.59	1,104.43	1,171.73	1,252.83
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	951.30	1,008.59	1,104.43	1,171.73	1,252.83
Marginal Benefits (x $1,000)					
Levee	138.55	5.51	-1.02	16.47	-348.34
Tiffany Basin	41.41	41.41	41.41	41.41	41.41
RR Bridge	0.00	0.00	0.00	0.00	0.00
Equivalent Avg. Ann. Benefits	179.96	46.92	40.39	57.88	-306.93
Benefit/Cost Ratio	0.19	0.05	0.04	0.05	-0.24
Net Benefits	-771.34	-961.67	-1,064.04	-1,113.85	-1,559.75

Table F-48

MARGINAL COSTS, COMPARING ALTERNATIVE Q TO ALTERNATIVE K (X $1,000)					
Levee	14,901.27	15,614.25	16,762.79	17,510.19	18,317.00
Overbank lowering/LFCC Channel Berm	6.72	6.72	6.72	6.72	6.72
Tiffany Basin	0.00	0.00	0.00	0.00	0.00
RR Bridge	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Inner Alignment	0.00	0.00	0.00	0.00	0.00
Levee to Bridge Outer Alignment	0.00	0.00	0.00	0.00	0.00
LERRD	0.00	0.00	0.00	0.00	0.00
PED	2.13	2.13	2.13	2.13	2.13
Construction Management	0.00	0.00	0.00	0.00	0.00
Total First Cost	14,910.12	15,623.10	16,771.63	17,519.04	18,325.84
IDC, Construction (168 months, 4-3/8%)*	5,513.88	5,777.55	6,202.28	6,478.68	6,777.04
Total, Interest During Construction	5,513.88	5,777.55	6,202.28	6,478.68	6,777.04
Total Investment	20,424.00	21,400.65	22,973.92	23,997.72	25,102.88
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	1,012.56	1,060.98	1,138.98	1,189.74	1,244.53
OMRR&R	0.00	0.00	0.00	0.00	0.00
Total Avg. Ann. Cost	1,012.56	1,060.98	1,138.98	1,189.74	1,244.53
Marginal Benefits (x $1,000)					
Levee	138.55	5.51	-1.02	16.47	-348.34
Tiffany Basin	46.01	46.01	46.01	46.01	46.01
RR Bridge	0.00	0.00	0.00	0.00	0.00
Equivalent Avg. Ann. Benefits	184.56	51.52	44.99	62.48	-302.32
Benefit/Cost Ratio	0.18	0.05	0.04	0.05	-0.24
Net Benefits	-828.00	-1,009.46	-1,093.99	-1,127.26	-1,546.85

Evaluation of Alternatives, Conclusions:

Alternative K, which is comprised of a levee along the west bank of the Rio Grande plus an extension of that levee downstream, past the east border of the Tiffany Area, is the plan which maximizes NED benefits in previous evaluations. The height of the levee corresponds to approximately the elevation of the 1% chance event water surface elevation plus four feet, referred throughout this appendix as the ‘‘Base levee + 4’ levee.’’ This levee would extend past the Tiffany Basin, and include features to prevent an uncontrolled spill from the perched river channel into that basin, and a subsequent headcut situation up the Rio Grande. However, uncaptured mitigation costs associated with replacing over 2,000 acres that was once part of the Rio Grande floodway will select Alternative K out of further consideration. Alternative A, which is a levee which terminates just north of the Tiffany Area, is the remaining plan which maximizes net benefit, at the Base levee + 4’ levee height. Because of the uncaptured costs to implement Alternative K, plus the undesirable impact to the environment, there is no further reason to consider Alternative K.

The San Marcial railroad bridge replacement is justified using the most recent cost estimates, but is not authorized. The west approach to the existing San Marcial bridge isn’t threatened by flooding. BNSF railroad officials have commented they do not perceive damages from waters against the existing embankment. The existing railroad embankment does not meet USACE levee safety standards, but absent a second opinion that the railroad approaches are threatened by Rio Grande flooding at water surface elevations below the trackbed, damages to the railroad approaches remain at zero for the floods described. While there are positive net NED benefits associated with Alternatives including a replacement railroad bridge, statutory authority limits Corps involvement in replacing this bridge only to situations where the proposed project induces flooding in severity or frequency. Hydraulic analyses indicates the proposed project will not impact the existing railroad bridge beneficially or adversely. Therefore, Alternatives containing the railroad bridge are beyond this study’s authority, and were dropped from further consideration.

The Tiffany Basin has some attributable benefits and represents an additional cost to the flood damage reduction plans described here. Including the Tiffany Basin as a project feature limits the aggradation of the upstream Rio Grande, as well as ameliorates the sedimentation and aggradation enhancements to the flood risk to the railroad track (inundation damages, service interruption) and LFCC adjacent to the Tiffany Basin. Including the Tiffany Basin as a project feature limits the Rio Grande’s aggradation over the project life, but at the NED plan’s size,

that benefit is roughly $429,000 on an equivalent average annual basis. There are unquantified benefits (sedimentation occurring in the basin over 10 to 30 years that BuRec would not have to remove) and costs (increased evaporative water losses due to the larger surface area). Net effect of these two forces on NED plan selection is indeterminate. This analysis also examined trade-off conditions where the inclusion of the Tiffany Basin lowers levee costs upstream. That didn’t pan out as expected, but it did identify costs applicable to NER project purposes (such as restoration or mitigation). Any inclusion of the Tiffany Basin for NER purposes or mitigation would then have to be justified as an efficient and effective means to achieve the desired output.

The levee extensions along the eastern and western edge of the Tiffany Basin were developed as a means of limiting any headcut situation to the upstream levees, protecting the existing railroad approaches, and preserving the Tiffany Basin from Rio Grande flooding. As described above, extending the levee along the east side of the Tiffany Area (but without creating the Tiffany Basin sediment management feature) would produce positive net NED benefits, but would incur substantial mitigation costs due to replacing 2,000 acres that were removed from the Rio Grande floodway. Those costs price levee extension alternatives out of consideration.

Considering all the issues presented here, the alternative feature which maximizes net NED benefits, is the 43 mile levee system described in Alternative A, at the Base levee + 4 foot levee height.

F-14 Average Annual Cost:

Table F-18 shows, for each alternative and the aggraded channel future situation considered, construction cost, interest during construction, total investment cost, interest and amortization costs, OMRR&R costs, and total average annual costs. The period of construction is assumed to be 168 months with equal mid-monthly payments and no project benefits until the project phase is complete. The August, 2010 Federal interest rate of 4.375% was used in the calculations to further refine the cost of the tentatively selected plan.

Following internal reviews, and as the NED plan's design was clarified, and more accurate pricing data was developed, a revised project cost estimate was developed (March, 2012 prices and 4% interest rate for discounting purposes). Many assumptions have changed since the alternative screening.

F-15 Average Annual Benefits:

Tables F-50-A and F-50-B show benefits for the analyzed levee heights in the present and future conditions. Equivalent annual benefit computations for the flood control alternatives considered are depicted in Tables F-50-A-1 to F-50-A-5. Average annual residual damages calculations for those alternatives considered are presented in Tables F-50-B-1 to F-50-B-5 and F-50-C-1 to F-50-C-5. Tables F-50-A-1 to F-50-A-5 discount the benefit stream of future damages and benefits to present value to present an Equivalent Annual Damage figure to serve as the basis of project benefits. Tables F-51-A and F-51-B show the expected net benefits of structures and contents in the baseline year and the project year 50 condition. Benefit determination for the post project condition was computed by changing the proposed levee height to remove damageable property from lesser magnitude events. Tables F-52-A and F-52-B show the expected B/C ratio for structures and contents in the baseline year and the project year 50 condition. It was not possible to show the distribution of residual damages, net benefits, or the benefit/cost ratio in Tables F-49(A and B), F-50(all 15 instances), F-51(A and B), and F-52(A and B).

Administrative costs of flood insurance policies represent an NED loss. Those administrative costs are approximately $192 per flood insurance policy (fiscal year 2006). Those administrative costs have not been updated since fiscal year 2006. FEMA has reported that while Socorro County does not participate in the Flood Insurance Program, property owners within the City of Socorro have purchased 123 policies. A benefit of the structural alternatives considered is the savings of those administrative costs. If a levee or floodwall captures the 1% chance exceedance event less than 95% of the time, those administrative costs

cannot be claimed as benefits, unless the project is built to the mean 1% ACE water surface elevation + 3'. Those losses are roughly $23,600/year and do not appear in any tables in this appendix. The plan which maximizes net benefits is the Base levee + 4' height levee, and savings in flood insurance policies are a claimable benefit, but were not claimed in this evaluation.

Benefits attributable to the Bureau of Reclamation's Low Flow Conveyance Channel (LFCC) as well as benefits attributable to the Bosque Del Apache National Wildlife Refuge (NWR) serve as benefits to other Federal properties. Tables F-50-A-1 to F-50-A-5 outline the benefits attributable to Federal properties, which is roughly 31.6% of the total benefits of the project. As the size of the project increases and its performance against the flood events improves, there is a small decrease in the proportion of benefits to the Federal properties. The LFCC and the NWR are immediately adjacent to the Rio Grande, so the percentage decrease simply demonstrates that non-Federal properties within the floodplain further away from the Rio Grande receive benefits from flood protection. Sensitivity studies indicate that excluding benefits to Federal properties does not affect plan selection nor size of plan which maximizes net benefits.

F-16 Benefit-Cost Comparisons and Plan Selection:

Table F-18 displays annualized equivalent annual benefit and cost information, discounting future benefits of flood control (which increases due to sediment aggradation along most reaches) and amortizing those benefits over the project life. Figure F-9 displays the optimization curve for the recommended Alternative and all sizes considered.

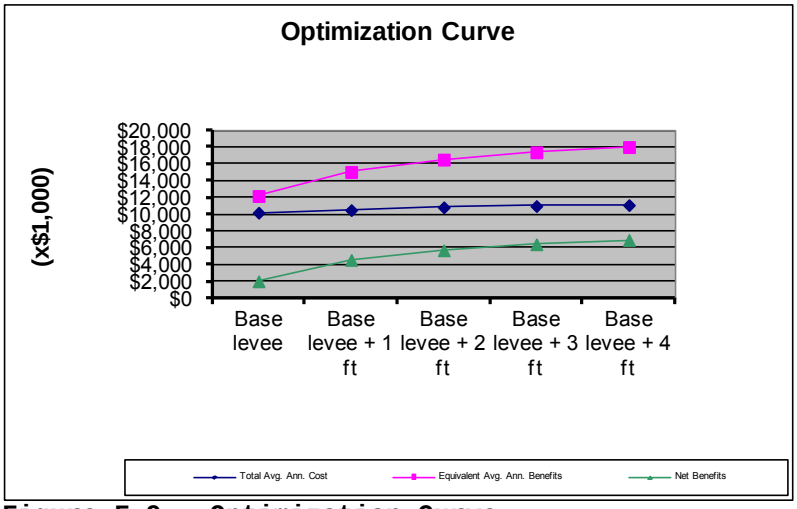

Figure F-9 - Optimization Curve

Tables F-51-A and F-51-B show the average annual benefits,

average annual costs, net average annual benefits, for levee alternatives considered for project baseline year and project baseline +50 years. Tables F-52-A and F-52-B display the benefit/cost ratio for alternatives considered as applied to the floodplain inventory structures and contents.

Sensitivity studies indicate that neither alternative selection nor alternative sizing is impacted by the inclusion or deletion of Federal properties such as the Low Flow Conveyance Channel or the Bosque Del Apache National Wildlife Refuge.

As noted in Paragraph F-12 of this appendix, the cost estimates for the levees, the Tiffany basin, and the San Marcial railroad bridge replacement are entwined in some unusual fashions which makes plan selection challenging. As stated in Paragraph F-08, the existing levee on the west bank of the Rio Grande is uncompacted and provides no protection to the floodplain. The construction plan calls for removal of the existing embankment followed by placement of the same material with additional features and the compaction necessary to enable the project to withstand flood stages up against it. The new levee will be a lower height than the existing spoilbank structures, meaning that there are excess material disposal costs for several levee heights evaluated. Disposal costs decrease as the levee height increases.

The study team was proceeding on the assumption that the bridge needed to be built before the levees upstream, but the benefits of replacing the bridge do not support the costs to borrow soil plus the other features necessary to install the replacement bridge. Earlier studies, assuming the bridge were built prior to the levee, show that costs increased to the point of threatening the Benefit-Cost Ratio (BCR). Alternatives analyzed that included the replacement railroad bridge assumed that borrow materials for the approaches come from levee waste materials.

It is inefficient to borrow dirt to construct the approaches to a bridge while subsequently wasting dirt when constructing the levee. Corps structural engineers have indicated that the waste material from the existing spoilbank levee is suitable to build the necessary railroad embankments.

When the levees are constructed prior to the railroad bridge, the waste costs identified for the levee are eliminated, and the borrow quantities for the railroad embankments are reduced by the waste quantities. The savings are fairly substantial, and in concert with providing minimum approach lengths to minimize the need for embankments, provide for a cost-effective means to replace the San Marcial railroad bridge. Cost estimates for Alternatives including the railroad bridge are generated using these assumptions, and have a positive BCR (above 1.0) in some circumstances.

If the mean Base levee +4′ levee were to be constructed, there are minimal waste costs, and the railroad bridge costs revert to those values expressed in Table F-27, above. Currently, all railroad bridges, regardless of width (expressed by number of bays) or height perform the same, and generate the same equivalent annual benefits. Therefore, plan selection for the railroad bridge appears to be limited to picking the cheapest bridge design.

Several alternatives evaluated included the replacement railroad bridge, and were the railroad bridge authorized, Alternative C, which would be comprised of the levee at the Base levee + 4′ elevation plus the replacement railroad bridge at San Marcial, would be the plan which maximizes net benefits.

The plan that maximizes net benefits has a height approximating the mean 1% ACE event's water surface elevation plus 4.0 feet, with a benefit/cost ratio of 1.6:1 and net benefits equal to $6,900,000. It's unlikely that a larger levee would generate even more net for several reasons. First, levee costs for most levees use the existing spoilbank levee along the west bank of the Rio Grande as source material for new levee construction. Above the Base levee + 4′ levee height, the project incurs substantial (and presently uncaptured) borrow costs for material, real estate costs to accommodate the wider footprint, and potentially higher mitigation costs. Second, the levee captures over 97% of EAD, and additional costs are expected to substantially offset, and even overshadow, the benefits remaining. Remaining benefits are from the severe and rare events, which would be capturable only through levee height increases, which would increase construction costs at increasing rates as the required volume of materials necessary to support a trapezoidal levee of specific side slopes increases.

F-17 Benefits and Costs of the Proposed Project Prior to the Base Year:

Generally, benefits are only anticipated after plan implementation, but for some projects, benefits can occur during the construction period. The problem is to convert the varying benefit and cost streams to the equivalent and comparable average annual measures over a common time period that is the period of analysis. The present value, in terms of the base year, is determined for benefits derived prior to the base year.

Benefits accruing prior to the base year should be documented and included in the benefit evaluation. These benefits should be brought forward from the time the benefits begin to the beginning of the period of analysis, using the project interest rate. All benefits and costs are stated in present worth terms as of the period of analysis.

Due to the time length required for construction of all alternatives for the study, benefits that accrue prior to the base year are substantial. Several elements of each project start to provide some limited flood control benefit prior to the 2032 base year. The following will estimate the benefits during construction for the alternatives being considered.

Some elements of the proposed project will be completed and provide some protection prior to the 2032 base year. The current construction schedule calls for completion of the levees adjacent to the Town of Socorro first, followed by construction of the levees, upstream to downstream. The Socorro reaches of the proposed levee tie into geographic features, such that benefits accrue when the phase is completed. For the rest of the study area, the threat of backwater flows downstream of the protected reaches delay project benefits until the subsequent phase is completed. Backwater flows are a significant threat to the study area, especially considering the perched nature of the Rio Grande. Each project phase is one year in duration and approximately 1.5-3 river miles in length.

All benefits that accrue prior to the base year of 2032 must be brought forward in the same manner as all costs prior to the base year. Those benefits are then amortized over the period of analysis. The following tables display this process.

Table F-53
INCREMENTAL BENEFITS PRIOR TO BASE YEAR
(x $1,000, March, 2012 Prices)

period in years =	50
interest rate =	0.04
capital recovery factor	0.0465502

		Benefits prior to 2032				Benefits brought foward to Base Year			
Phase	Year	West Bank		East Bank	Total Benefits TB=	Interest Rate Factor 1+r=	Period to 2032 n=	Factor r^n	Benefit in 2032 value TB*r^n
1	2013	0.00		0.00	0.00	1.04	19.5	2.148573	0.00
2	2014	7,864.87		-0.37	7,864.50	1.04	18.5	2.065936	16,247.55
3	2015	7,864.87		-0.37	7,864.50	1.04	17.5	1.986477	15,622.64
4	2016	7,864.87		-0.37	7,864.50	1.04	16.5	1.910074	15,021.77
5	2017	7,864.87		-0.37	7,864.50	1.04	15.5	1.836609	14,444.01
6	2018	8,728.07		-0.37	8,727.70	1.04	14.5	1.76597	15,412.86
7	2019	11,027.99		-0.37	11,027.62	1.04	13.5	1.698048	18,725.43
8	2020	12,593.33		-2.08	12,591.25	1.04	12.5	1.632739	20,558.23
9	2021	13,441.86		-2.08	13,439.78	1.04	11.5	1.569941	21,099.66
10	2022	13,729.34		-2.08	13,727.26	1.04	10.5	1.509559	20,722.11
11	2023	15,290.62		1.30	15,291.92	1.04	9.5	1.451499	22,196.21
12	2024	15,290.62		1.30	15,291.92	1.04	8.5	1.395672	21,342.50
13	2025	15,393.52		1.30	15,394.82	1.04	7.5	1.341992	20,659.74
14	2026	15,619.14		-2.65	15,616.49	1.04	6.5	1.290377	20,151.17
15	2027	15,662.15		-2.65	15,659.50	1.04	5.5	1.240747	19,429.49
16	2028	16,769.24		-2.65	16,766.59	1.04	4.5	1.193026	20,002.98
17	2029	16,769.24		-2.65	16,766.59	1.04	3.5	1.147141	19,233.64
18	2030	17,618.08		-2.65	17,615.43	1.04	2.5	1.10302	19,430.17
19	2031	17,618.08		-2.65	17,615.43	1.04	1.5	1.060596	18,682.86
20	2032	17,618.08		-2.65	17,615.43	1.04	0.5	1.019804	17,964.29
	2032 TO 2082	17,618.08		-2.65	17,615.43				
	Total								**356,947.31**

The value of all benefits prior to the base year are equal to $356.9 million when brought forward to the year 2032. When these benefits are amortized over the 50 year period of analysis, they provide an additional $16.6 million in average annual benefits.

The proposed levee will be constructed in 20, 1-year phases. The ‘‘Program Year’’ project cost estimate was used to develop costs for each of the phases of construction. Interest during construction was computed for each phase using equal, mid-monthly payments at the FY 2012 interest rate (4.0%).

Table F-54
CONSTRUCTION COSTS (PROGRAM YEAR, NOT FULLY FUNDED)
March 2012 Price Level
Base + 4' levee

	1/1/2013	1/1/2014	1/1/2015	1/1/2016	1/1/2017	1/1/2018	1/1/2019	1/1/2020	1/1/2021	1/1/2022	1/1/2023	1/1/2024	1/1/2025	1/1/2026	1/1/2027	1/1/2028	1/1/2029	1/1/2030	1/1/2031	1/1/2032
Project Cost	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8	Phase 9	Phase 10	Phase 11	Phase 12	Phase 13	Phase 14	Phase 15	Phase 16	Phase 17	Phase 18	Phase 19	Phase 20
Levee	11,188.00	10,214.00	13,022.00	9,668.00	9,371.00	9,300.00	9,049.00	20,989.00	8,655.00	8,151.00	8,048.00	7,937.00	7,979.00	7,701.00	7,676.00	12,940.00	7,211.00	6,993.00	6,899.00	11,212.00
Channels & Canals								4,818.00												
Lands and Damages	477.00	62.00	33.00	56.00	23.00	66.00	67.00	41.00	43.00	44.00	50.00	31.00	45.00	43.00	45.00	66.00	50.00	37.00	36.00	25.00
PED	536.00	534.00	534.00	534.00	534.00	534.00	534.00	534.00	534.00	534.00	534.00	534.00	534.00	534.00	534.00	534.00	534.00	534.00	534.00	534.00
Construction Management	923.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00
Mitigation	28.32	28.32	64.04	64.04	64.04	64.04	73.92	127.00	64.04	119.26	118.85	83.13	83.13	83.13	108.97	99.09	71.64	71.64	26.42	25.84
Total First Cost	13,152.32	11,761.32	14,576.04	11,245.04	10,915.04	10,887.04	10,646.92	27,432.00	10,219.04	9,771.26	9,673.85	9,508.13	9,564.13	9,284.13	9,286.97	14,562.09	8,789.64	8,558.64	8,418.42	12,719.84
IDC, Construction (12 months, 4%)*	261.34	233.70	289.63	223.44	216.88	216.33	211.56	545.08	203.05	232.99	192.22	188.93	190.04	184.48	184.53	289.35	174.65	170.06	167.28	252.75
Total, Interest During Construction	261.34	233.70	289.63	223.44	216.88	216.33	211.56	545.08	203.05	232.99	192.22	188.93	190.04	184.48	184.53	289.35	174.65	170.06	167.28	252.75
Study Sunk Costs	12,422.00																			
Total Investment	25,835.66	11,995.02	14,865.67	11,468.48	11,131.92	11,103.36	10,858.47	27,977.08	10,422.09	10,004.24	9,866.07	9,697.06	9,754.17	9,468.60	9,471.50	14,851.44	8,964.29	8,728.70	8,585.69	12,972.59

Table F-55
INCREMENTAL COSTS PRIOR TO BASE YEAR
(x $1,000, March, 2012 Prices)

period in years = 50
interest rate = 0.04
capital recovery factor 0.0465502

		Costs prior to 2032				Costss brought foward to Base Year			
Phase	Year				Total Costs TC=	Interest Rate Factor 1+r=	Period to 2032 n=	Factor r^n	Cost in 2032 value TB*r^n
1	2013				25,835.66	1.04	19.5	2.148573	55,509.79
2	2014				11,995.02	1.04	18.5	2.065936	24,780.93
3	2015				14,865.67	1.04	17.5	1.986477	29,530.30
4	2016				11,468.48	1.04	16.5	1.910074	21,905.64
5	2017				11,131.92	1.04	15.5	1.836609	20,444.99
6	2018				11,103.36	1.04	14.5	1.76597	19,608.21
7	2019				10,858.47	1.04	13.5	1.698048	18,438.21
8	2020				27,977.08	1.04	12.5	1.632739	45,679.26
9	2021				10,422.09	1.04	11.5	1.569941	16,362.07
10	2022				10,004.24	1.04	10.5	1.509559	15,102.00
11	2023				9,866.07	1.04	9.5	1.451499	14,320.59
12	2024				9,697.06	1.04	8.5	1.395672	13,533.91
13	2025				9,754.17	1.04	7.5	1.341992	13,090.02
14	2026				9,468.60	1.04	6.5	1.290377	12,218.07
15	2027				9,471.50	1.04	5.5	1.240747	11,751.74
16	2028				14,851.44	1.04	4.5	1.193026	17,718.16
17	2029				8,964.29	1.04	3.5	1.147141	10,283.30
18	2030				8,728.70	1.04	2.5	1.10302	9,627.93
19	2031				8,585.69	1.04	1.5	1.060596	9,105.95
20	2032				12,972.59	1.04	0.5	1.019804	13,229.49
	2032 TO 2082				0.00				
	Total								**392,240.55**

The following table presents project costs and benefits brought forward to the base year (2032).

Table F-56

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR BASE + 4' LEVEE SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN (x $1,000 March, 2032 price level)	
Construction Costs (x $1,000)	
Total Investment	392,240.55
Avg. Ann. Cost (4%, 50 yr. project life)	18,258.88
OMRR&R	618.02
Total Avg. Ann. Cost	18,876.90
Project Benefits (x $1,000)	
Levee	34,231.40
Tiffany Basin (RR and reroutes)	0.00
RR Bridge	0.00
Equivalent Avg. Ann. Benefits	34,231.40
Benefit/Cost Ratio	1.81
Net Benefits	15,354.51

F-18 Impact of Addressing Flood Risk in Four Accounts (NED, NER, OSE, RED):

The Principles and Guidelines establish four accounts to facilitate the evaluation and display of effects of alternative plans. They are described in ER 1105-2-100, para. 2-3. The evaluation of the tentatively selected plan against those accounts follows:

- The National Economic Development (NED) Account displays changes in the economic value of the national output of goods and services. The damages and benefits described in this appendix describe NED impacts of flooding in the study area and the effects of alternatives designed to address the flood threat.
- The Environmental Quality (EQ) account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans. The array of plans described in this appendix have flood risk management as their stated goals. EQ benefits or impacts are identified within the Environmental appendix to this report. Implementing the levee system identified in Alternative A (at the Base levee + 4’ height) is expected to add 60 acres to the Rio Grande

floodway. The levee also has the impact of protecting the Bureau of Reclamation's Low Flow Conveyance Channel (LFCC) which provides water to critical habitat of the Threatened and Endangered species found within the study area.

- The Regional Economic Development (RED) account displays changes in the distribution of regional economic activity (e.g., income and employment). This account is typically used to capture the regional impacts of a large capital infusion of project implementation dollars on income and employment throughout the study area through the use of income and employment multipliers. A recent study for the Nuclear Watch of New Mexico suggests that public sector multipliers tend to be below 1.5, while the Department of Energy claimed multipliers of 2.4 to 3.5 in fiscal year 1998. (Dumas, L.J., Economic Multipliers and the Economic Impact of DOE Spending in New Mexico, March 2003) The important point to be made here is that a large infrastructure project in the Middle Rio Grande Valley will have a positive impact on local income and employment.
- The Other Social Effects (OSE) account displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation and others. In most cases, impacts of proposed projects not covered in other accounts are described and evaluated here. Generally, the plans described here meet USACE criteria for project adequacy (completeness, effectiveness, efficiency, and acceptability). Residual risk of implementing levees of various heights is described in Para. F-17 of this appendix. In the unfortunate circumstance that the proposed levees were exceeded, the resultant flood magnitude, timing, and duration is not expected to become even more severe than the without-project and without-project, future condition.

The Bosque Del Apache National Wildlife Refuge represents a significant recreation opportunity in the study area that is important to both the region and the Nation. Providing flood protection to the Refuge (in the form of levees) preserves this recreation opportunity for continued enjoyment by visitors. Alternatives that excluded the levees provided no means to preserve this recreation opportunity.

The floodplain is roughly 1.5 to 2 miles wide, and sits below the perched Rio Grande. In the event of a flood, warning times may prevent evacuation, but flood velocities are not expected to be sufficient to dislodge vehicles using local roads, however, the field inventory did not identify any high water marks as the floodplain is generally flat, and does not include low water crossings, although there may be unexpected areas with more flood depth due to local topography. Most flood fatalities occur in vehicles moving through the floodplain

(http://www.nws.noaa.gov/oh/hic/flood_stats/recent_individual_deaths.shtml, accessed 4/5/12).

The flood hydrograph described in the H&H appendix outlines two flood scenarios. Floods generated by local thunderstorms have short warning, rapid onset, relatively short duration (3-4 days) with the flood peak passing within hours. Floods generated by snowmelt in uncontrolled drainages downstream of Cochiti dam have considerably more warning time, but the volume and duration suggests a 90-100 day inundation duration. Only a small portion of the urbanized areas of the Town of Socorro will be impacted, as most of the Town sits above the floodplain. Public services are not expected to be disrupted outside of the floodplain. The flood impacts will fall mostly upon the rural areas outside of the Town. Evacuations will be necessary, and reoccupation and cleanup time and costs from New Orleans and Mississippi River floods (longer duration, though much deeper than projected for this study) suggest that the emergency costs used in this report (from Carlsbad, NM) are fairly conservative.

F-19 Project Performance:

Besides a strict benefit/cost comparison, another measure of the effectiveness of flood protection is its ability to contain damaging floods where there was limited protection before. Limitations of the analysis package preclude a rigorous analysis of project performance, but inspection of the available data could provide decision makers a glimpse of the nature of the flood problem and how the project will act to contain it. Table F-54 presents the likelihood of flood stages being exceeded by specific flood events at each cross section used within the study in the without and with-project, future conditions. One scenario was developed to describe the effectiveness of the various alternatives considered.

Vulnerable location identified –

A reference point was selected in the without project scenario where the flood flow would exceed the start of damages first, or most often. Project performance was evaluated at that reference point for all project sizes that effect that location. For each alternative and project size, that reference point was selected in the protected area where residual flows for the events analyzed would exceed the start of damages most often, wherever that reference point may be. For purposes of this analysis, this reference point is important in that start of damages flows occur most frequently, thus the term "vulnerable location" is applied. The vulnerable location does not move to other reference points as various project sizes are applied to the floodplain. With

that in mind, project performance tables indicate only where the preproject condition is worst, as there are several other reference points where levee protection is much improved. describe project performance within the most vulnerable location within the study area as a set of probabilities of structural alternatives containing various damaging flood events.

Table F-57 presents the probability that the recommended alternative, and various sizes of that alternative, would contain the specified events, for the specified scenarios. Table F-58 presents the probability that each evaluated alternative would be exceeded on an annual basis damaging flood events. Tables F-59-A presents the long term risk of exceedance (likelihood that project will be exceeded over an extended time frame) for indicated time frames.

Worst case scenario –

Given that each flood protection project could affect several of the reference points that collectively describe the flooding problem, a single reference point was selected where the flood flow would exceed the start of damages first, or most often. For each alternative and project size, a new reference point was selected in the protected area where residual flows for the events analyzed would exceed the start of damages most often, wherever that reference point might be. This scenario tends to discount expected performance of structural alternatives more than the vulnerable location scenario.

Table F-60 presents the probability that the alternative, and various sizes of that alternative, would contain the specified events, for the specified scenarios. Table F-58 present the probability that each evaluated alternative would be exceeded on an annual basis damaging flood events. Table F-59-B presents the long term risk of exceedance (likelihood that project will be exceeded over an extended time frame) for indicated time frames.

Table F-61 displays, for the future hydraulic condition, the probability of non-damaging stages occurring, by cross-section, for the without project and all levee heights considered. This table serves as the basis for the analyses described in Paragraph F-19.

F-20 Evaluation of Non-Structural Alternatives:

A variety of non-structural flood damage reduction measures were identified, which could be used to meet the planning objectives. The initial evaluation of these measures is discussed below.

Floodplain Management Regulations

Socorro County does not participate in the National Flood

Insurance Program (NFIP), which is administered through the Federal Emergency Management Agency (FEMA). FEMA has published Flood Insurance Rate Maps (FIRMs) for both jurisdictions that identify Special Flood Hazard Areas for the Rio Grande River and tributaries. For local jurisdictions to maintain eligibility in the NFIP, minimum levels of floodplain management regulations must be adopted and enforced. Floodplain management regulations and enforcement would have the effect of mitigating flood damages in tne future due to new development, but does nothing for the exiting flood problem, nor the future flooding condition. Floodplain management is considered a reasonable and prudent measure with or without a constructed flood risk management feature, but this measure was not carried forward for alternative evaluation in this appendix. The future conditions in this economic evaluation does not include any future development in the floodplain for reasons described in Para. F-06.

Flood Warning Systems

A flood warning and preparedness system is often the most cost effective flood mitigation measure comprised of computer hardware, software, technical activities and/or organizational arrangements aimed at decreasing flood hazards. Advanced warning is not generally effective in reducing structural damages (outside of sandbagging efforts given early warning); the primary benefits of such a system are credited for providing early evacuation of residents and reduction in damages to vehicles and structure contents.

The evaluation presented in the Economics Appendix assumes that 1.0 of the 1.74 vehicles per capita in Socorro County residences have been evacuated, and that all operable commercial and public vehicles have already been evacuated prior to any flooding. A flood warning system would present benefits by reducing the amount of residential contents subject to flooding. Assuming that residential contents were half the Residential EAD presented in Table F-6C, that would indicate an effective and understood flood warning system would decrease EAD by at most 7.8%. The high residual damages, and the flood threat to Federal properties (the Low Flow Conveyance Channel and the Bosque Del Apache National Wildlife Refuge) as well as the other infrastructure (roads, agriculture, utilities, public and commercial properties) suggests that a flood warning system is ineffective and incomplete on its own. Further, relative to the structural alternative presented (Alternative A, with a levee height corresponding to Base levee +4’ elevation and net benefits of over $23.0 million), it’s impossible for a flood warning system to provide greater net benefits.

Flood Proofing

Flood proofing offers the opportunity to provide flood protection on an individual structure-by-structure basis or a group of structures. Flood proofing techniques typically include buyouts,

relocation, elevation, floodwalls or levees, and dry flood proofing. Elevation, buyout, and relocation are the most dependable of these flood proofing methods. Flood proofing costs can vary substantially depending on the type of flood proofing method being considered and the type, size, age, and location of the structure(s). Flood proofing techniques considered for alternative development are:

1) Relocation of Existing Structures: Relocation is perhaps the most dependable flood proofing technique since it totally eliminates flood damages, minimizes the need for flood insurance and allows for the restoration/reclamation of the floodplain. This technique requires the physical relocation of flood prone structures outside of the identified flood hazard area. This also requires purchase of the flood prone property; selecting and purchasing a new site; and lifting/moving the structure to the new site.

   Corps experience has indicated that relocations and buyouts only work when the land left behind is repurposed to some other public good, such as a public park or reuniting the acquired land with the floodway. The Federal Emergency Management Agency estimates relocation costs at between $99 and $116 per square foot (1999 dollars), which exceeds the depreciated replacement costs of just about every structure in the floodplain. (FEMA, Homeowner's Guide to Retrofitting, December 2009, page 3-28, Table 3-9).The study area floodplain extends for over 43 river miles, and represents a wide and flat area next to the perched Rio Grande main channel. Reuniting the overbank with the channel, which sits higher than the overbank, exacerbates the flooding problem, and this measure is considered impractical. Relocations also do nothing for the flood risk to public properties and Federal properties (the Low Flow Conveyance Channel and the Bosque Del Apache National Wildlife Refuge), and is therefore an incomplete solution to the flood problem.

2) Buyout or Acquisition: This technique requires the purchase of the flood prone property and structure; demolition of the structure; relocation assistance; and applicable compensation required under Federal and State law. This alternative typically requires voluntary relocation by the property owners and/or eminent domain rights exercised by the non-federal sponsor.

   As stated previously with relocations, acquiring properties in a floodplain next to a perched channel has limited utility. The acquired land cannot be returned to the floodway without exacerbating the flood problem. Further, the study area's floodplains extend over 43 river miles, and is over 1 mile wide in parts. Repurposing land for a public good like a park is also infeasible, as it would represent

an incomplete solution to the flood problem.

3) Retrofitting or Dry Flood Proofing: Dry flood proofing of existing structures is a common flood proofing technique applicable for flood depths of three (3) feet or less on buildings that are structurally sound. Installation of temporary closures or flood shields is a commonly used flood proofing technique. A flood shield is a watertight barrier designed to prevent the passage of floodwater though doors, windows, ventilating shafts, and other openings of the structure exposed to flooding. Such shields are typically made of steel or aluminum and are installed on structures only prior to expected flooding. However, flood shields can only be used on structures with walls that are strong enough to resist the flood-induced forces and loadings. Exterior walls must be made watertight in addition to the use of flood shields. This technique is not applicable areas subject to flash flooding (less than one hour) or where flow velocities are greater than three (3) feet per second. It would also not be applicable to mobile homes, due to the type of construction and typical lack of anchoring to a foundation.

   Aside from the cost, dry flood proofed homes and businesses can still suffer flood damages due to the potentially incomplete nature of the solution. Enclosures for windows and doors require human intervention in order to fully implement the solution and, this action would have to occur in a relatively short time frame. Tables F-2A and F-2B in the economics appendix display the water surface elevations associated with various events. In many locations, flood stages are expected to exceed 3’, rendering the flood proofing measures ineffective. Due to the incomplete nature and limited applicability of this flood proofing method, it was not carried forward for alternative evaluation.

4) Localized Levees or Floodwalls: Ring levees or floodwalls can be built around individual structures to protect single or small groups of structures. Ring levees are earthen embankments with stable or protected side slopes and a wide top. Floodwalls are generally constructed of masonry or concrete and are designed to withstand varying heights of floodwaters and hydrostatic pressure. Closures (e.g., for driveway access) are typically manually operated based on flood forecasting and prediction that would alert the operator. Disadvantages of levees or berms are: 1) can impede or divert flow of water in a floodplain; 2) can block natural drainage; 3) susceptible to scour and erosion; 4) give a false sense of security; and 5) take up valuable property space. Disadvantages of floodwalls are: 1) high cost; 2) closures for openings required, and 3) give a false sense of security.

In this evaluation, the Town of Socorro represents a relatively concentrated location receiving flood damages. The study team used the methods described in the Economics appendix to identify, locate, elevate, and compute equivalent annual damages, and residual damages to only the hydraulic cross sections proximate to the town. Table F-55 presents the equivalent annual damages applicable only to the town. Table F-56 presents the residual damages attributable to a levee with a height corresponding to the 1% chance event (present condition). Alternative levee heights were computed for benefit computation, but are not presented in this appendix.

A ring levee surrounding the Town of Socorro was not designed, but some simplifying assumptions were made to estimate a project cost. It's assumed that the ''Socorro ring levee would have a northern tieback of 1 mile, and a southern tieback of 1.5 miles. The cross sections identified in the hydraulic analysis applicable to the Town stretch for 3.25 river miles. Assuming a ring levee costs 13% of the cost of an equivalent levee extending 43 river miles, and shortening the construction period to 30 months (down from the 96 months for the longer levee), Table F-57 presents an estimate of benefits and costs of the hypothetical ring levees.

The ring levee is not suitable for further consideration on several grounds. First, the benefits to the Town of Socorro are approximately 35% of the benefits of a longer levee to the entire study area. Second, localized protection does little to nothing to protect the Federal properties (the Low Flow Conveyance Channel and the Bosque Del Apache National Wildlife Refuge) impacted by flooding in the study area. Lastly, while a ring levee would meet USACE benefit/cost criteria, the plan that would be recommended for implementation is the one with the greatest net benefits, consistent with environmental protection goals. The 43 mile levees produce greater net benefits than equivalent levees only surrounding the Town of Socorro.

Alternative levee lengths were also considered, such as cutting off the Bosque Del Apache National Wildlife Refuge. This would have the impact of removing from project benefits structures and contents south of NM highway 380, and losing the recreation benefits attributable to the refuge. Analysis of shorter levee lengths, considering the longer tie back to high ground upstream of the current tie back, suggests the Refuge has sufficient benefits to ''carry'' the levee past the refuge, before tying back the levee to high ground.

5) Elevation of Structures: Existing structures can be elevated or raised above the potential flood elevation. Structures

can be raided on concrete columns, metal posts, piles, compacted earth fill, or extended foundation walls. Elevated structures must be designed and constructed to withstand anticipated hydrostatic and hydrodynamic forces and debris impact resulting from flooding. The access and utility systems of the structures to be raised would need to be modified to ensure they are safe from flooding.

FEMA has estimated that elevation in place for slab-on-grade homes (the most common foundation type in the study area) can cost $80-88 per square foot (2009 dollars) for a frame home, and $88-96 per square foot for a masonry home (FEMA, Homeowner's Guide to Retrofitting, December 2009, page 3-20, Table 3-3). That value exceeds the per square foot depreciated replacement cost of most of the improvements in the floodplain, which makes this alternative infeasible.

Alternatives which considered replacing the San Marcial railroad bridge with a replacement bridge (and a higher water crossing) could be considered a nonstructural alternative in the sense that the action alters the property's susceptibility to flooding, rather than impact the nature of the flood threat (flow, stage, etc…) As previously discussed, a replacement railroad bridge would only be authorized for Corps involvement if it could be demonstrated that the proposed project impacted the flood threat facing the bridge, which is not the case in this analysis.

F-21 Comparison of the Tentatively Selected Plan to the Authorized Plan:

The authorized plan was last presented in a 1993 Decision Document, which describes a 58 mile levee which would reduce risk of flooding from a 0.5% chance exceedance flood event starting from the San Acacia Diversion Dam down the west bank of the Rio Grande down to Elephant Butte Reservoir. Table F-65 compares the benefits and costs of the tentatively selected plan to the Authorized Project. Table F-59 identifies the changes in cost apportionment between the authorized project and this tentatively selected plan.

There have been several changes in the damages and benefit computations between the Authorized Plan (1993) and the tentatively selected plan (2010). Table F-66 outlines, by damage category, the equivalent annual damages by property type for both the 1993 and the present analysis. Table F-68 describes the benefits attributable to the authorized plan (1993) and the tentatively selected plan (2010).

1993

The economic analysis performed for the 1993 Appendix to Update Project Decision Document was done in a non-risk and uncertainty based model called LA Damages, which was consistent with guidance at the time, but is no longer used by the Army Corps of Engineers. The 1993 analysis used floodplain data from 4 events (10%, 2%, 1%, and 0.5% chance exceedance) to compute equivalent annual damages.

2010

As described in this economics appendix, the 2010 economic analysis was performed using the Corps' certified risk and uncertainty tool, HEC-FDA version 1.2.4. The 2010 analysis uses 8 events for the without-project condition, and 5 events for the with-project condition. Several other factors in this present evaluation differ from the evaluation supporting the Authorized Plan, which are highlighted below:

New hydraulics and hydrology - The 2010 analysis includes factors that weren't evaluated in 1993, such as the perched channel, and significant sediment accumulations over the study time period, which substantially alters the future without- and future with-project conditions. Sediment accumulations have the effect of increasing future damages for a given flow, and attenuating any project's performance in the future, with-project condition. There was also significant evaluation of the impact of a proposed levee on the east bank of the Rio Grande, and downstream properties, such as the San Marcial railroad bridge.

New economic evaluation guidance - The Corps' shift from a deterministic, point-estimate of damages and benefits attributable to specific-frequency events to an evaluation incorporating concepts of risk and uncertainty has had the impact of increasing damages and benefits attributable to projects. Experience with prior Albuquerque District studies in the mid-1990s suggested that merely shifting from a deterministic model to a risk and uncertainty-based model increased EAD and benefits by 25%. The biggest boost to EAD came from the variability surrounding the probability economic damages began (the ''start of damages'' condition).

Another factor serving to increase EAD and claimable benefits came from Economic Guidance Memorandum (EGM) 04-01, which provided generic depth-damage relationships for residential structures and contents. Studies conducted prior to the memo used FIA claims data to populate depth-damage relationships, where the newer curves used research conducted by the Corps' Institute for Water Resources (IWR) evaluation of factors such as warning time, inundation duration, etc... The curves were developed for nation-wide applicability, and per the EGM, site-specific depth-damage relationships, content valuations, and content-to-structure ratios are not required to be developed when using these newer curves. This saves study dollars. The newer

curves also differ from prior studies in that non-zero damages start at -2′ for a one-story, no basement structure, which is the predominant residential structure type in the study area. A direct comparison of the IWR curves, which contain a mean and standard deviation of damages for each inundation depth, to the curves used in the 1993 analysis demonstrated slightly higher damages for each inundation depth. Curve selection served to increase EAD about 60% for residential structures and contents, holding other factors constant.

New floodplain inventory of damageable properties and NED benefits - Since the 1993 evaluation, several changes to the nature of the economic evaluation took place. The 1993 evaluation contains a pair of property types (Transportation Facilities and Rural Improvements) that weren’t directly correlated to the present evaluation. In the 2010 evaluation, significant lengths of railroad track were in the study area floodplain, which doesn’t seem to be the case with the 1993 analysis. The 1993 ‘‘Rural improvements’’ damage category seems to most directly align with the 2010 ‘‘Outbuildings’’ property type, but there’s room for interpretation there. Several structures (97) were hay storage shelters, and were coded as ‘‘Commercial.’’ Those structures had content values up to 10 times structure value, and were located close to the river and LFCC. Further, those contents (bales of hay) use depth-% damage curves that show 85% damage with three feet of inundation. In the present evaluation, outbuildings referred to material storage sheds, shelters for vehicles or covered storage, like hay storage buildings. In some cases, a storage shed on a residential property would merely be coded ‘‘Residential’’ during the field inventory. The outbuildings category served as a catch-all to identify structures and contents, where ownership and use (public or commercial) was not easily identifiable.

There was a significant change in the recreation damages and benefits, largely due to new visitation data, and the inclusion of specialized recreation values during the winter, when visitation is significantly higher, due to the Bosque Del Apache National Wildlife Refuge’s unique role as winter home for migratory waterfowl.

Since the 1993 evaluation, the Sediment benefit category was dropped, as the most recent sediment studies indicate the Rio Grande is aggrading south of the Town of Socorro. No sediment management features are proposed in the tentatively selected plan, although sediment management was evaluated as a potential benefit category in the alternative formulation.

The 1993 evaluation did not include an evaluation of potential induced damages on the east bank of the Rio Grande as a result of installing a levee on the west bank, which was included in the 2010 analysis.

The agricultural damages and benefits changed slightly from 1993 to 2010, which is largely attributable to new crop budget data showing increased input costs, and relatively flat revenues per acre relative to 17 years ago. Subsequently, there appears to be less acreage in production.

F-22 Plan for Updating Project Benefits in the Future:

At the time that a project update is required, the significant assumptions regarding hydrology and hydraulics will be reviewed. All pertinent economic assumptions shall be reviewed. After determining whether there have been changes in the basic assumptions, the following shall be analyzed:

Residential neighborhoods shall be sampled to determine current values. Real estate agents, appraisers and the Marshall and Swift Valuation Service will be used in updating residential values.

Discussions with local realtors and businessmen combined with field sampling will be made to determine if major changes have occurred to businesses existing at the time of the initial inventory. Important changes affecting structure or content values will be included in the update. As is the case of residential values, the Marshall and Swift Valuation Service and local appraisers and realtors will be contacted regarding commercial values.

After consultation with city planners and examining city building permits; residential, public and commercial growth since the inventory was taken shall be sampled as needed within the flood plain. The growth shall be included, as appropriate, in the updated benefit computations.

The results of the reanalysis shall be documented in a "Special Evaluation Report" (SER).

Tables

Table F-1

DEPTH-DAMAGE RELATIONSHIPS

(expressed as proportion of property value)

	Stage (ft.)									
	1	2	3	4	5	6	7	8	9	10
Structures										
1 story no bsmt., Residential (mean/SD)	0.233/.016	0.321/.016	0.401/.018	0.471/.019	0.532/.02	0.586/.021	0.632/.022	0.672/.023	0.705/.024	0.732/.027
1 story no bsmt. (comm./public)	0.14	0.21	0.26	0.29	0.30	0.41	0.43	0.44	0.45	0.46
1 story w/ bsmt., Residential (mean/SD)	0.32/.01	0.387/.011	0.455/.014	0.522.016	0.586/.019	0.645/.021	0.698/.024	0.742/.025	0.777/.027	0.801/.028
2 story no bsmt., Residential (mean/SD)	0.152/.03	0.209/.028	0.263/.029	0.314/.032	0.36/.034	0.407/.037	0.449/.039	0.488/.04	0.524/.041	0.557/.042
2 story no bsmt. (comm./public)	0.16	0.28	0.37	0.43	0.47	0.49	0.50	0.51	0.55	0.58
2 story w/ bsmt., Residential (mean/SD)	0.223/.014	0.27.015	0.319/.018	0.369/.02	0.419/.023	0.469.026	0.518/.029	0.564.031	0.608.034	0.648/.037
Mobile home	0.44	0.64	0.73	0.78	0.80	0.81	0.82	0.84	0.86	0.88
Metal	0.07	0.10	0.15	0.18	0.20	0.23	0.28	0.33	0.37	0.40
Outbuilding	0.25	0.35	0.41	0.46	0.54	0.65	0.71	0.80	0.85	0.90
Contents										
1 story no bsmt. (Residential, Mean/SD)*	0.133/.012	0.179/.012	0.22/.014	0.257/.015	0.288/.016	0.315/.016	0.338/.017	0.357/.018	0.372/.019	0.384/.021
2 story no bsmt. (Residential, Mean/SD)*	0.087/.026	0.122/.025	0.155/.025	0.185/.027	0.213/.03	0.239/.032	0.263/.033	0.284/.034	0.303/.035	0.32/.035
1 story w/ bsmt. (Residential, Mean/SD)*	0.189/.008	0.218/.01	0.247/.012	0.274/.014	0.3/.016	0.324/.018	0.345/.02	0.363/.021	0.377/.023	0.386/.024
2 story w/ bsmt. (Residential, mean/SD)*	0.138/.011	0.157/.012	0.177/.014	0.198/.016	0.22/.018	0.243/.02	0.267/.021	0.291/.023	0.317/.024	0.344/.024
Mobile home (Residential)**	0.27	0.50	0.64	0.70	0.76	0.78	0.79	0.81	0.83	0.92
Motel, Office, Church (1 story)**	0.35	0.50	0.60	0.68	0.74	0.78	0.81	0.83	0.85	0.87
Motel, Office, Church (2 story)**	0.26	0.39	0.48	0.55	0.61	0.67	0.73	0.78	0.83	0.87
Food Related**	0.55	0.70	0.85	0.90	0.95	0.95	0.95	0.95	0.95	0.95
Gas Station, Car Service**	0.22	0.43	0.70	0.92	0.95	0.95	0.95	0.95	0.95	0.95
Retail (1 story)**	0.18	0.30	0.59	0.70	0.90	0.95	0.95	0.95	0.95	0.95
Retail (2 story)**	0.12	0.22	0.34	0.54	0.74	0.83	0.87	0.91	0.93	0.95
Clothing Store**	0.35	0.45	0.67	0.83	0.95	0.95	0.95	0.95	0.95	0.95
Car Dealership**	0.10	0.72	0.80	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Furniture Store**	0.75	0.85	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Outbuilding Contents**	0.30	0.51	0.62	0.67	0.69	0.71	0.80	0.85	0.90	0.95
Roads	0.11	0.22	0.35	0.50	0.66	0.76	0.76	0.76	0.76	0.76
Utilities	0.06	0.13	0.22	0.32	0.42	0.52	0.63	0.76	0.88	0.92
Railroad	0.03	0.04	0.12	0.15	0.18	0.21	0.31	0.64	0.76	0.82
(Low Flow Conveyance Channel)	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56	0.63	0.70
Vehicles	0.05	0.17	0.20	0.75	0.80	0.85	0.90	0.95	0.95	0.95

* Content stage-damage function expressed as a percentage of structure value.

** Content stage-damage function expressed as a percentage of content value.

Table F-2A

RATING CURVES BY REACH
WITHOUT PROJECT CONDITIONS (PRESENT)
SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

LEFT (EAST) OVERBANK AND CHANNEL	EVENT							
Station	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
1218	4,661.53	4,661.53	4,661.53	4,661.53	4,664.01	4,665.02	4,665.81	4,667.02
1256	4,644.57	4,644.57	4,644.57	4,644.57	4,644.66	4,645.27	4,645.71	4,646.23
1268	4,634.38	4,634.38	4,635.11	4,635.72	4,636.57	4,637.02	4,637.47	4,637.92
1299	4,622.51	4,622.51	4,624.17	4,625.24	4,625.88	4,626.44	4,626.96	4,627.44
1312	4,617.07	4,617.07	4,619.59	4,620.68	4,621.26	4,621.71	4,622.23	4,622.34
1327	4,607.79	4,607.79	4,612.38	4,612.91	4,613.16	4,613.39	4,614.37	4,614.66
1339	4,604.35	4,604.35	4,605.46	4,605.69	4,605.78	4,606.02	4,606.85	4,607.31
1346	4,597.83	4,597.83	4,602.15	4,602.33	4,602.42	4,602.61	4,602.94	4,603.21
1360	4,594.75	4,595.65	4,595.78	4,595.93	4,596.03	4,596.13	4,596.23	4,596.28
1394	4,581.19	4,582.53	4,583.07	4,583.17	4,583.28	4,583.37	4,583.48	4,583.62
1400	4,581.70	4,581.70	4,581.70	4,581.77	4,581.87	4,581.97	4,582.07	4,582.17
1414	4,573.09	4,574.64	4,574.70	4,574.80	4,574.87	4,575.00	4,575.13	4,575.29
1433	4,567.57	4,567.73	4,567.74	4,567.84	4,567.94	4,568.04	4,568.25	4,568.51
1483	4,549.32	4,549.67	4,549.77	4,549.87	4,549.97	4,550.26	4,550.58	4,550.99
1491	4,541.92	4,545.29	4,545.39	4,545.49	4,545.92	4,546.24	4,546.44	4,546.70
1517	4,533.46	4,535.57	4,535.67	4,535.77	4,535.87	4,535.97	4,536.07	4,536.17
1550	4,520.68	4,522.00	4,522.10	4,522.20	4,522.30	4,522.40	4,522.50	4,522.63
1603	4,503.74	4,504.06	4,504.16	4,504.26	4,504.69	4,504.94	4,505.01	4,505.09
1641	4,495.04	4,495.04	4,495.42	4,495.58	4,495.73	4,495.80	4,495.87	4,495.98

RIGHT (WEST) OVERBANK	EVENT							
Station	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
1218	4,661.96	4,661.96	4,661.96	4,661.96	4,661.96	4,662.83	0.00	4,663.73
1256	4,641.40	4,641.40	4,641.40	4,641.40	4,641.40	4,641.40	4,641.40	4,644.27
1268	4,635.80	4,635.80	4,635.80	4,635.80	4,635.80	4,635.80	4,635.80	4,637.07
1299	4,618.00	4,618.00	4,618.26	4,618.54	4,620.44	4,621.49	4,622.08	4,623.58
1312	4,615.74	4,615.74	4,615.97	4,616.65	4,619.37	4,620.38	4,620.57	4,622.25
1327	4,600.01	4,600.01	4,600.01	4,600.79	4,611.00	4,613.43	4,614.98	4,615.44
1339	4,598.04	4,599.00	4,599.10	4,599.20	4,600.58	4,601.19	4,601.77	4,602.29
1346	4,593.49	4,594.47	4,594.57	4,594.67	4,595.55	4,596.22	4,596.88	4,597.54
1360	4,591.18	4,591.99	4,592.09	4,592.13	4,592.82	4,593.58	4,594.28	4,594.88
1394	4,575.16	4,577.63	4,577.73	4,577.83	4,577.93	4,577.96	4,579.29	4,580.96
1400	4,575.11	4,577.55	4,577.65	4,577.75	4,577.85	4,577.88	4,579.15	4,580.79
1414	4,570.48	4,571.19	4,571.29	4,571.39	4,571.48	4,571.56	4,572.14	4,572.92
1433	4,564.43	4,565.50	4,565.60	4,565.70	4,565.80	4,565.90	4,566.00	4,566.50
1483	4,541.68	4,541.99	4,542.09	4,542.19	4,542.29	4,542.44	4,542.80	4,543.35
1491	4,538.55	4,538.90	4,539.00	4,539.10	4,539.23	4,540.04	4,540.41	4,540.93
1517	4,524.32	4,524.42	4,524.52	4,524.62	4,524.67	4,524.97	4,525.21	4,525.19
1550	4,512.61	4,513.18	4,513.28	4,513.38	4,513.48	4,513.58	4,513.68	4,513.78
1603	4,499.22	4,499.97	4,500.07	4,500.17	4,500.27	4,500.37	4,500.47	4,500.56
1641	4,485.66	4,486.43	4,486.53	4,486.63	4,486.73	4,486.83	4,486.93	4,487.03

Table F-2B

RATING CURVES BY REACH
WITHOUT PROJECT CONDITIONS (FUTURE)
SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

LEFT (EAST) OVERBANK AND CHANNEL	EVENT							
Station	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
1218	4,661.53	4,661.53	4,661.53	4,661.53	4,664.01	4,665.02	4,665.81	4,667.02
1256	4,644.57	4,644.57	4,644.57	4,644.57	4,644.66	4,645.27	4,645.71	4,646.23
1268	4,634.38	4,634.38	4,635.11	4,635.72	4,636.57	4,637.02	4,637.47	4,637.92
1299	4,622.51	4,622.51	4,624.17	4,625.24	4,625.88	4,626.44	4,626.96	4,627.44
1312	4,617.07	4,617.07	4,619.59	4,620.68	4,621.26	4,621.71	4,622.23	4,622.34
1327	4,607.79	4,607.79	4,612.38	4,612.91	4,613.16	4,613.39	4,614.37	4,614.66
1339	4,604.35	4,604.35	4,605.46	4,605.69	4,605.78	4,606.02	4,606.85	4,607.31
1346	4,597.83	4,597.83	4,602.15	4,602.33	4,602.42	4,602.61	4,602.94	4,603.21
1360	4,594.75	4,595.65	4,595.78	4,595.93	4,596.03	4,596.13	4,596.23	4,596.28
1394	4,581.19	4,582.53	4,583.07	4,583.17	4,583.28	4,583.37	4,583.48	4,583.62
1400	4,581.70	4,581.70	4,581.70	4,581.77	4,581.87	4,581.97	4,582.07	4,582.17
1414	4,573.69	4,575.24	4,575.30	4,575.40	4,575.47	4,575.60	4,575.73	4,575.89
1433	4,568.27	4,568.43	4,568.44	4,568.54	4,568.64	4,568.74	4,568.95	4,569.21
1483	4,550.62	4,550.97	4,551.07	4,551.17	4,551.27	4,551.56	4,551.88	4,552.29
1491	4,543.32	4,546.69	4,546.79	4,546.89	4,547.32	4,547.64	4,547.84	4,548.10
1517	4,535.26	4,537.37	4,537.47	4,537.57	4,537.67	4,537.77	4,537.87	4,537.97
1550	4,523.28	4,524.60	4,524.70	4,524.80	4,524.90	4,525.00	4,525.10	4,525.23
1603	4,508.14	4,508.46	4,508.56	4,508.66	4,509.09	4,509.34	4,509.41	4,509.49
1641	4,501.24	4,501.24	4,501.62	4,501.78	4,501.93	4,502.00	4,502.07	4,502.18

RIGHT (WEST) OVERBANK	EVENT							
Station	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
1218	4,661.96	4,661.96	4,661.96	4,661.96	4,661.96	4,662.83	0.00	4,663.73
1256	4,641.40	4,641.40	4,641.40	4,641.40	4,641.40	4,641.40	4,641.40	4,644.27
1268	4,635.80	4,635.80	4,635.80	4,635.80	4,635.80	4,635.80	4,635.80	4,637.07
1299	4,618.00	4,618.00	4,618.26	4,618.54	4,620.44	4,621.49	4,622.08	4,623.58
1312	4,615.74	4,615.74	4,615.97	4,616.65	4,619.37	4,620.38	4,620.57	4,622.25
1327	4,600.01	4,600.01	4,600.01	4,600.79	4,611.00	4,613.43	4,614.98	4,615.44
1339	4,598.04	4,599.00	4,599.10	4,599.20	4,600.58	4,601.19	4,601.77	4,602.29
1346	4,593.49	4,594.47	4,594.57	4,594.67	4,595.55	4,596.22	4,596.88	4,597.54
1360	4,591.18	4,591.99	4,592.09	4,592.13	4,592.82	4,593.58	4,594.28	4,594.88
1394	4,575.16	4,577.63	4,577.73	4,577.83	4,577.93	4,577.96	4,579.29	4,580.96
1400	4,575.11	4,577.55	4,577.65	4,577.75	4,577.85	4,577.88	4,579.15	4,580.79
1414	4,570.48	4,571.19	4,571.29	4,571.39	4,571.48	4,571.56	4,572.14	4,572.92
1433	4,564.43	4,565.50	4,565.60	4,565.70	4,565.80	4,565.90	4,566.00	4,566.50
1483	4,541.68	4,541.99	4,542.09	4,542.19	4,542.29	4,542.44	4,542.80	4,543.35
1491	4,538.55	4,538.90	4,539.00	4,539.10	4,539.23	4,540.04	4,540.41	4,540.93
1517	4,524.32	4,524.42	4,524.52	4,524.62	4,524.67	4,524.97	4,525.21	4,525.19
1550	4,512.61	4,513.18	4,513.28	4,513.38	4,513.48	4,513.58	4,513.68	4,513.78
1603	4,499.22	4,499.97	4,500.07	4,500.17	4,500.27	4,500.37	4,500.47	4,500.56
1641	4,485.66	4,486.43	4,486.53	4,486.63	4,486.73	4,486.83	4,486.93	4,487.03

Table F-2C

RATING CURVES BY REACH
WITH PROJECT CONDITIONS (PRESENT)
SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

LEFT (EAST) OVERBANK AND CHANNEL	EVENT							
Station	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
1218	4,656.97		4,660.10		4,662.90	4,664.19	4,665.54	4,667.94
1256	4,640.68		4,643.32		4,645.66	4,647.17	4,648.42	4,648.77
1268	4,635.10		4,636.50		4,637.74	4,638.56	4,639.24	4,639.53
1299	4,622.29		4,625.24		4,627.38	4,628.45	4,629.57	4,630.57
1312	4,618.31		4,620.76		4,623.36	4,623.65	4,624.90	4,626.32
1327	4,609.17		4,610.67		4,612.06	4,612.54	4,612.76	4,613.59
1339	4,605.69		4,606.48		4,607.68	4,608.25	4,608.97	4,609.68
1346	4,602.03		4,602.94		4,603.96	4,604.60	4,605.49	4,606.48
1360	4,595.56		4,596.02		4,596.88	4,598.00	4,598.59	4,599.51
1394	4,581.91		4,582.91		4,584.82	4,585.88	4,587.11	4,588.44
1400	4,581.91		4,582.91		4,584.82	4,585.88	4,587.11	4,588.44
1414	4,574.90		4,574.98		4,576.10	4,576.78	4,577.57	4,578.45
1433	4,567.11		4,567.66		4,568.39	4,568.98	4,569.64	4,570.39
1483	4,548.64		4,549.25		4,550.02	4,550.79	4,551.54	4,552.40
1491	4,545.98		4,546.86		4,547.58	4,548.32	4,549.05	4,549.89
1517	4,536.58		4,537.18		4,537.84	4,538.54	4,539.21	4,540.00
1550	4,522.43		4,523.08		4,523.69	4,524.34	4,524.99	4,525.75
1603	4,505.77		4,506.62		4,507.28	4,508.53	4,509.47	4,510.44
1641	4,497.48		4,498.25		4,498.81	4,499.87	4,500.66	4,501.42

Table F-3A

NUMBER OF STRUCTURES
WITHOUT PROJECT CONDITIONS (PRESENT)
FLOODPLAIN

Land Use Category	EVENT 10% Mean	10% SD	2% Mean	2% SD	1% Mean	1% SD	0.20% Mean	0.20% SD
Residential	372.00		532.00		564.00		735.00	
Commercial	109.00		178.00		189.00		213.00	
Public	6.00		14.00		14.00		15.00	
Apartment	2.00		3.00		3.00		6.00	
Outbuildings	249.00		409.00		424.00		455.00	
Agriculture (acres)	5160.4		8062.5		8860.8		10942.3	
TOTAL STR.	**738.00**		**1136.00**		**1194.00**		**1424.00**	

Table F-3B

NUMBER OF STRUCTURES
WITHOUT PROJECT CONDITIONS (FUTURE)
SAN ACACIA TO BOSQUE DEL APACHE

Land Use Category	EVENT 10% Mean	10% SD	2% Mean	2% SD	1% Mean	1% SD	0.20% Mean	0.20% SD
Residential	371.00		531.00		563.00		734.00	
Commercial	109.00		178.00		189.00		213.00	
Public	6.00		14.00		14.00		15.00	
Apartment	2.00		3.00		3.00		6.00	
Outbuildings	247.00		407.00		422.00		453.00	
Agriculture (acres)	5160.4		8062.5		8860.8		10942.3	
TOTAL STR.	**735.00**		**1133.00**		**1191.00**		**1421.00**	

Table F-3C

PROPERTIES EXCLUDED FROM BENEFIT CALCULATIONS

	Identified within 5/17/1988 FIRM	Elevated clear of 1% chance WSEL	Remainder	Structures excluded from benefit calculations
Number of Structures	1446	1138	308	13

Table F-4A

VALUE OF DAMAGEABLE PROPERTY
WITHOUT PROJECT CONDITIONS (PRESENT)
SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

Land Use Category	EVENT							
	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
$/str	$33.55		$36.29		$35.62		$31.17	
Residential	12,481		19,305		20,092		22,911	
Res. Content	6,138		9,519		9,908		11,272	
$/str	$106.70		$119.14		$113.51		$111.04	
Commercial	11,630		21,208		21,454		23,652	
Comm. Content	22,922		33,242		33,503		37,164	
$/str	$190.81		$106.50		$106.50		$105.26	
Public	1,145		1,491		1,491		1,579	
Pub. Content	283		565		565		574	
$/str	$21.87		$46.72		$46.72		$40.90	
Apartment	44		140		140		245	
Apt. Contents	22		70		70		123	
$/str	$2.25		$2.28		$2.26		$2.37	
Outbuilding	560		934		959		1,078	
Out.. Contents	279		478		491		550	
Total	**55,504**		**86,951**		**88,673**		**99,146**	

Table F-4B

VALUE OF DAMAGEABLE PROPERTY
WITHOUT PROJECT CONDITIONS (FUTURE)
SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

(x $1,000 August, 2010 price level)

Land Use Category	EVENT 10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
$/str	$33.60		$36.33		$35.66		$31.19	
Residential	12,467		19,291		20,078		22,896	
Res. Content	6,131		9,511		9,901		11,265	
$/str	$106.70		$119.14		$113.51		$111.04	
Commercial	11,630		21,208		21,454		23,652	
Comm. Content	22,922		33,242		33,503		37,164	
$/str	$190.81		$106.50		$106.50		$105.26	
Public	1,145		1,491		1,491		1,579	
Pub. Content	283		565		565		574	
$/str	$21.87		$46.72		$46.72		$40.90	
Apartment	44		140		140		245	
Apt. Contents	22		70		70		123	
$/str	$2.24		$2.28		$2.26		$2.37	
Outbuilding	554		929		954		1,073	
Out.. Contents	273		472		485		544	

Table F-5A

SINGLE OCCURRENCE DAMAGES
WITHOUT PROJECT CONDITIONS (PRESENT)
FLOODPLAIN

(x $1,000 August, 2010 price level)

Land Use Category	EVENT 10% Mean	SD	2% Mean	SD	1% Mean	SD	0.20% Mean	SD
Residential	4,584		7,025		7,874		9,956	
Res. Content	1,457		2,235		2,539		3,193	
Commercial	1,962		3,924		4,685		6,005	
Comm. Content	15,792		21,256		23,998		29,017	
Public	152		203		240		281	
Pub. Content	133		183		248		356	
Apartments	1		1		3		16	
Apt. Contents	0		1		1		5	
Outbuildings	108		174		199		259	
Out. Contents	73		108		124		162	
Subtotal - Structures	**6,806**		**11,328**		**13,000**		**16,518**	
Subtotal - Contents	**17,455**		**23,783**		**26,909**		**32,734**	
Subtotal - Structures and Contents	**24,261**		**35,110**		**39,910**		**49,252**	
Streets, roads	10,466		21,720		25,021		36,715	
Utilities	232		762		898		1,317	
Railroad	1,693.65		1,838.59		1,927.93		2,829.59	
Vehicles	2,705		3,430		4,086		5,075	
Agriculture	704		1,100		1,209		1,493	
Irr. Drains	210		396		440		798	
LFCC	14,386.06		18,960.99		20,746.66		27,275.17	
Avoided Water Losses	0.00		0.00		0.00		0.00	
Recreation	2,837.38		2,837.38		2,837.38		2,837.38	
East Bank	285.57		372.63		401.21		482.24	
Emergency Costs	599.83		957.80		1093.90		1447.79	
Total	**58,380**		**87,486**		**98,570**		**129,522**	

Table F-5B

SINGLE OCCURRENCE DAMAGES
WITHOUT PROJECT CONDITIONS (FUTURE)
SAN ACACIA TO BOSQUE DEL APACHE

(x $1,000 August, 2010 price level)

Land Use	EVENT 10% Mean	SD	2% Mean	SD	1% Mean	SD	0.20% Mean	SD
Residential	4,572		7,014		7,863		9,945	
Res. Content	1,451		2,229		2,533		3,187	
Commercial	1,962		3,924		4,685		6,005	
Comm. Content	15,792		21,256		23,998		29,017	
Public	152		203		240		281	
Pub. Content	133		183		248		356	
Apartments	1		1		3		16	
Apt. Contents	0		1		1		5	
Outbuildings	105		170		195		256	
Out. Contents	71		106		122		160	
Subtotal -	**6,791**		**11,313**		**12,985**		**16,503**	
Subtotal -	**17,447**		**23,775**		**26,901**		**32,726**	
Subtotal -	**24,238**		**35,087**		**39,887**		**49,228**	
Streets, roads	10,466		21,720		25,021		36,715	
Utilities	232		762		898		1,317	
Railroad	1,693.65		1,838.59		1,927.93		2,829.59	
Vehicles	2,705		3,430		4,086		5,075	
Agriculture	704		1,100		1,209		1,493	
Irr. Drains	210		396		440		798	
LFCC	14,392.51		18,967.44		20,753.11		27,275.17	
Avoided Water Losses	0.00		0.00		0.00		0.00	
Recreation	2,837.38		2,837.38		2,837.38		2,837.38	
East Bank	285.57		372.63		401.21		482.24	
Emergency Costs	599.53		957.49		1093.58		1447.47	

Table F-6A

AVERAGE ANNUAL DAMAGES (PRESENT) BY LAND USE CATEGORY

(x $1,000 August, 2010 price level)

LAND USE CATEGORY	Average Annual Damages (x $1,000 August, 2010 price level)					
Residential	2196.44					
Commercial	5591.67					
Public	119.94					
Apartments	1.49					
Outbuildings	77.31					
Subtotal - Structures and Contents	**7,986.85**					
Streets, roads	1893.89					
Utilities	60.73					
Railroad	193.28					
Vehicles	343.28					
Agriculture	101.00					
Irr. Drains	36.01					
LFCC	6366.42					
Avoided Water Losses	0.00					
Recreation	822.84					
East Bank	237.53					
Emergency Costs	158.69					
TOTAL	**18,200.51**					

Table F-6B

AVERAGE ANNUAL DAMAGES (FUTURE) BY LAND USE CATEGORY

(x $1,000 August, 2010 price level)

LAND USE	Average Annual Damages (x $1,000 August, 2010 price level)	Probability Avg. Ann. Damages Exceed Indicated Amount				
		0.95	0.75	0.5	0.25	0.05
Residential	2200.30					
Commercial	5594.91					
Public	119.94					
Apartments	1.49					
Outbuildings	77.45					
Subtotal - Structures and Contents	**7,994.09**					
Streets, roads	1893.89					
Utilities	60.73					
Railroad	193.28					
Vehicles	343.28					
Agriculture	101.00					
Irr. Drains	36.01					
LFCC	6386.84					
Avoided Water Losses	0.00					
Recreation	822.84					
East Bank	294.28					
Emergency Costs	158.79					
TOTAL	**18,285.03**					

Table F-6C

EQUIVALENT ANNUAL DAMAGES BY LAND USE CATEGORY

(x $1,000 August, 2010 price level)

LAND USE CATEGORY	Equivalent Annual Damages (x $1,000 August, 2010 price level)		
	Total	Federal	
Residential	2,198.80		
Commercial	5,593.65		
Public	119.94		
Apartment	1.49		
Outbuildings	77.40		
East Bank			
Subtotal - Structures and Contents	**7,991.28**		
Streets, roads	1,893.89		
Utilities	60.73		
Railroad	193.28		
Vehicles	343.28		
Agriculture	101.00		
Irrigation Drains	36.01		
LFCC	6,366.73	6,366.73	
Avoided Water Losses	0.00	0.00	
Recreation	822.84	822.84	
East Bank	272.25		
Emergency Costs	157.59		
			Federal % of Total
TOTAL	**18,161.47**	**7,189.57**	**39.59%**

Table F-49-A EXPECTED VALUE AND PROBABILISTIC VALUES OF EAD AND EAD REDUCED FOR PROPOSED PROJECTS
PRESENT CONDITIONS

Plan	Expected Annual Damage (x $1,000)			Probability Residual Damages Exceeds Indicated Amount (x $1,000)				
	Without Plan*	With Plan**	Benefits	0.95	0.75	0.5	0.25	0.05
No Action	7,986.85	7,986.85	0.00					
Base levee	7,986.85	1,426.73	6,560.12					
Base levee + 1 ft	7,986.85	420.58	7,566.27					
Base levee + 2 ft	7,986.85	131.51	7,855.34					
Base levee + 3 ft	7,986.85	34.62	7,952.23					
Base levee + 4 ft	7,986.85	6.45	7,980.40					

Alternative 1 doesn't include flood insurance savings of $19.01 for 1191 structures

* From Subtotal - Structures and Contents in Table F-6A

** Residual damages for Structures and Contents.

Table F-49-B EXPECTED VALUE AND PROBABILISTIC VALUES OF EAD AND EAD REDUCED FOR PROPOSED PROJECTS
FUTURE CONDITIONS

Plan	Expected Annual Damage (x $1,000)			Probability Residual Damages Exceeds Indicated Amount (x $1,000)				
	Without Plan*	With Plan**	Benefits	0.95	0.75	0.5	0.25	0.05
No Action	7,994.09	7,994.09	0.00					
Base levee	7,994.09	4,470.36	3,523.73					
Base levee + 1 ft	7,994.09	2,124.27	5,869.82					
Base levee + 2 ft	7,994.09	901.50	7,092.59					
Base levee + 3 ft	7,994.09	343.81	7,650.28					
Base levee + 4 ft	7,994.09	122.75	7,871.34					

Alternative 1 doesn't include flood insurance savings of $19.01 for 1191 structures

* From Subtotal - Structures and Contents in Table F-6B

** Residual damages for Structures and Contents.

Table F-50-A-1

EQUIVALENT ANNUAL BENEFITS BY LAND USE CATEGORY

Base levee

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Avg. Ann. Damages Exceed Indicated Amount				
	EAD	Residual Damages	Benefits	0.95	0.75	0.5	0.25	0.05
Residential	2,198.80	1,059.49	1139.31					
Commercial	5,593.65	2,233.81	3359.84					
Public	119.94	79.27	40.67					
Apartments	1.49	1.90	-0.41					
Outbuildings	77.40	35.78	41.62					
Subtotal - Structures and Contents	7,991.28	3,410.25	4581.03					
Streets, roads	1,893.89	599.59	1294.31					
Utilities	60.73	20.05	40.68					
Railroad	193.28	55.79	137.49					
Vehicles	343.28	101.21	242.07					
Agriculture	101.00	14.40	86.61	*Federal Benefits*				
Irr. Drains	36.01	11.69	24.32					
LFCC	6,366.73	1,927.02	4439.71	*4439.71*				
Avoided Water Losses	0.00	0.00	0.00	*0.00*				
Recreation	822.84	29.79	793.05	*793.05*				
East Bank	272.25	274.89	-2.64					
Emergency Costs	157.59	13.62	143.97		*Federal % of Total*			
TOTAL	**18,238.87**	**6458.28**	**11,780.59**	***5232.76***	***44.97%***			

Table F-50-A-2

EQUIVALENT ANNUAL BENEFITS BY LAND USE CATEGORY

Base levee + 1 ft

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Avg. Ann. Damages Exceed Indicated Amount				
	EAD	Residual Damages	Benefits	0.95	0.75	0.5	0.25	0.05
Residential	2198.80	444.42	1754.38					
Commercial	5593.65	933.19	4660.46					
Public	119.94	49.19	70.75					
Apartments	1.49	0.70	0.79					
Outbuildings	77.40	14.51	62.89					
Subtotal - Structures and Contents	7991.28	1,442.01	6549.27					
Streets, roads	1893.89	413.70	1480.20					
Utilities	60.73	13.81	46.92					
Railroad	193.28	41.46	151.82					
Vehicles	343.28	68.83	274.45					
Agriculture	101.00	8.96	92.05	*Federal Benefits*				
Irr. Drains	36.01	8.26	27.75					
LFCC	6366.73	1,297.40	5069.33	*5069.33*				
Avoided Water Losses	0.00	0.00	0.00	*0.00*				
Recreation	822.84	17.02	805.82	*805.82*				
East Bank	272.25	274.89	-2.64					
Emergency Costs	157.59	9.17	148.42		*Federal % of Total*			
TOTAL	**18238.87**	**3595.50**	**14643.38**	***5875.14***	***40.53%***			

Table F-50-A-3

EQUIVALENT ANNUAL BENEFITS BY LAND USE CATEGORY

Base levee + 2 ft

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Avg. Ann. Damages Exceed Indicated Amount				
	EAD	Residual Damages	Benefits	0.95	0.75	0.5	0.25	0.05
Residential	2,198.80	176.29	2022.51					
Commercial	5,593.65	367.43	5226.22					
Public	119.94	34.39	85.55					
Apartments	1.49	0.26	1.23					
Outbuildings	77.40	5.90	71.50					
Subtotal - Structures and Contents	7,991.28	584.27	7407.01					
Streets, roads	1,893.89	260.33	1633.56					
Utilities	60.73	8.35	52.38					
Railroad	193.28	26.57	166.71					
Vehicles	343.28	54.67	288.60					
Agriculture	101.00	11.43	89.57	*Federal Benefits*				
Irr. Drains	36.01	4.95	31.06					
LFCC	6,366.73	876.68	5490.05	*5490.05*				
Avoided Water Losses	0.00	0.00	0.00	*0.00*				
Recreation	822.84	9.93	812.91	*812.91*				
East Bank	272.25	274.89	-2.64					
Emergency Costs	157.59	6.03	151.56		*Federal % of Total*			
TOTAL	**18,238.87**	**2118.11**	**16,120.77**	***6302.96***	***39.47%***			

Table F-50-A-4

EQUIVALENT ANNUAL BENEFITS BY LAND USE CATEGORY

Base levee + 3 ft

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Avg. Ann. Damages Exceed Indicated Amount				
	EAD	Residual Damages	Benefits	0.95	0.75	0.5	0.25	0.05
Residential	2,198.80	64.78	2134.02					
Commercial	5,593.65	133.82	5459.83					
Public	119.94	21.91	98.03					
Apartments	1.49	0.09	1.40					
Outbuildings	77.40	2.32	75.08					
Subtotal - Structures and Contents	7,991.28	222.92	7768.36					
Streets, roads	1,893.89	154.02	1739.87					
Utilities	60.73	4.94	55.79					
Railroad	193.28	15.72	177.56					
Vehicles	343.28	33.00	310.27					
Agriculture	101.00	7.34	93.66	*Federal Benefits*				
Irr. Drains	36.01	2.93	33.08					
LFCC	6,366.73	518.62	5848.10	*5848.10*				
Avoided Water Losses	0.00	0.00	0.00	*0.00*				
Recreation	822.84	9.93	812.91	*812.91*				
East Bank	272.25	274.89	-2.64					
Emergency Costs	157.59	3.59	154.00		*Federal % of Total*			
TOTAL	**18,238.87**	**1247.90**	**16,990.98**	***6661.01***	***39.56%***			

Table F-50-A-5

EQUIVALENT ANNUAL BENEFITS BY LAND USE CATEGORY

Base levee + 4 ft

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Avg. Ann. Damages Exceed Indicated Amount				
	EAD	Residual Damages	Benefits	0.95	0.75	0.5	0.25	0.05
Residential	2,198.80	22.72	2176.08					
Commercial	5,593.65	46.84	5546.81					
Public	119.94	12.90	107.04					
Apartments	1.49	0.04	1.45					
Outbuildings	77.40	0.87	76.53					
Subtotal - Structures and Contents	7,991.28	83.37	7907.91					
Streets, roads	1,893.89	126.73	1767.16					
Utilities	60.73	4.06	56.66					
Railroad	193.28	12.93	180.35					
Vehicles	343.28	27.84	315.43					
Agriculture	101.00	6.15	94.86	*Federal Benefits*				
Irr. Drains	36.01	2.41	33.60					
LFCC	6,366.73	72.26	6294.46	*6294.46*				
Avoided Water Losses	0.00	0.00	0.00	*0.00*				
Recreation	822.84	9.93	812.91	*812.91*				
East Bank	272.25	274.89	-2.64					
Emergency Costs	157.59	2.87	154.72		*Federal % of Total*			
TOTAL	**18,238.87**	**623.45**	**17,615.42**	***7107.37***	***40.70%***			

Table F-50-B-1

AVERAGE ANNUAL BENEFITS (PRESENT) BY LAND USE CATEGORY

Base levee

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Residual Avg. Ann. Damages Exceed Indicated Amount				
	Avg. Ann. Damages	Residual Damages	Benefits	0.95	0.75	0.5	0.25	0.05
Residential	2,196.44	428.17	1,768.27					
Commercial	5,591.67	966.41	4,625.26					
Public	119.94	21.58	98.36					
Apartments	1.49	0.61	0.88					
Outbuildings	77.31	9.96	67.35					
Subtotal - Structures and Contents	7,986.85	1,426.73	6,560.12					
Streets, roads	1,893.89	332.89	1,561.01					
Utilities	60.73	11.94	48.79					
Railroad	193.28	25.65	167.63					
Vehicles	343.28	48.84	294.44					
Agriculture	101.00	14.40	86.61					
Irr. Drains	36.01	6.77	29.24					
LFCC	6,366.42	976.35	5,390.07					
Avoided Water Losses	0.00	0.00	0.00					
Recreation	822.84	29.79	793.05					
East Bank	237.53	221.68	15.85					
Emergency Costs	158.69	6.99	151.70					
TOTAL	**18,200.51**	**3,102.03**	**15,098.49**					

Table F-50-B-2

AVERAGE ANNUAL BENEFITS (PRESENT)
BY LAND USE CATEGORY

Base levee + 1 ft

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Avg. Ann. Damages Exceed Indicated Amount				
	EAD	Residual Damages	Benefits	0.95	0.75	0.5	0.25	0.05
Residential	2,196.44	129.52	2,066.92					
Commercial	5,591.67	281.81	5,309.86					
Public	119.94	6.07	113.87					
Apartments	1.49	0.19	1.30					
Outbuildings	77.31	2.99	74.32					
Subtotal - Structures and Contents	7,986.85	420.58	7,566.27					
Streets, roads	1,893.89	220.29	1,673.60					
Utilities	60.73	7.90	52.82					
Railroad	193.28	21.32	171.96					
Vehicles	343.28	30.45	312.82					
Agriculture	101.00	8.96	92.05					
Irr. Drains	36.01	4.79	31.22					
LFCC	6,366.42	592.44	5,773.98					
Avoided Water Losses	0.00	0.00	0.00					
Recreation	822.84	17.02	805.82					
East Bank	237.53	221.68	15.85					
Emergency Costs	158.69	4.47	154.21					
TOTAL	**18,200.51**	**1,549.90**	**16,650.61**					

Table F-50-B-3

AVERAGE ANNUAL BENEFITS (PRESENT)
BY LAND USE CATEGORY

Base levee + 2 ft

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Avg. Ann. Damages Exceed Indicated Amount				
	EAD	Residual Damages	Benefits	0.95	0.75	0.5	0.25	0.05
Residential	2,196.44	41.04	2,155.40					
Commercial	5,591.67	87.48	5,504.19					
Public	119.94	1.99	117.95					
Apartments	1.49	0.06	1.43					
Outbuildings	77.31	0.94	76.37					
Subtotal - Structures and Contents	7,986.85	131.51	7,855.34					
Streets, roads	1,893.89	178.60	1,715.29					
Utilities	60.73	5.73	55.00					
Railroad	193.28	18.23	175.05					
Vehicles	343.28	43.90	299.37					
Agriculture	101.00	9.53	89.57					
Irr. Drains	36.01	3.40	32.61					
LFCC	6,366.42	600.38	5,766.04					
Avoided Water Losses	0.00	0.00	0.00					
Recreation	822.84	9.93	812.91					
East Bank	237.53	221.68	15.85					
Emergency Costs	158.69	3.88	154.80					
TOTAL	**18,200.51**	**1,226.77**	**16,971.84**					

Table F-50-B-4

AVERAGE ANNUAL BENEFITS (PRESENT)
BY LAND USE CATEGORY

Base levee + 3 ft

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Avg. Ann. Damages Exceed Indicated Amount				
	EAD	Residual Damages	Benefits	0.95	0.75	0.5	0.25	0.05
Residential	2,196.44	10.90	2,185.54					
Commercial	5,591.67	22.92	5,568.75					
Public	119.94	0.54	119.40					
Apartments	1.49	0.01	1.48					
Outbuildings	77.31	0.25	77.06					
Subtotal - Structures and Contents	7,986.85	34.62	7,952.23					
Streets, roads	1,893.89	111.35	1,782.54					
Utilities	60.73	3.57	57.16					
Railroad	193.28	11.36	181.92					
Vehicles	343.28	28.01	315.26					
Agriculture	101.00	5.94	93.66					
Irr. Drains	36.01	2.12	33.89					
LFCC	6,366.42	374.31	5,992.11					
Avoided Water Losses	0.00	0.00	0.00					
Recreation	822.84	9.93	812.91					
East Bank	237.53	221.68	15.85					
Emergency Costs	158.69	2.42	156.27					
TOTAL	**18,200.51**	**805.30**	**17,393.81**					

Table F-50-B-5

AVERAGE ANNUAL BENEFITS (PRESENT)
BY LAND USE CATEGORY

Base levee + 4 ft

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Avg. Ann. Damages Exceed Indicated Amount				
	EAD	Residual Damages	Benefits	0.95	0.75	0.5	0.25	0.05
Residential	2,196.44	2.06	2,194.38					
Commercial	5,591.67	4.24	5,587.43					
Public	119.94	0.10	119.84					
Apartments	1.49	0.00	1.49					
Outbuildings	77.31	0.05	77.26					
Subtotal - Structures and Contents	7,986.85	6.45	7,980.40					
Streets, roads	1,893.89	92.03	1,801.87					
Utilities	60.73	2.95	57.77					
Railroad	193.28	9.39	183.89					
Vehicles	343.28	28.01	315.26					
Agriculture	101.00	4.91	94.86					
Irr. Drains	36.01	1.75	34.26					
LFCC	6,366.42	10.54	6,355.88					
Avoided Water Losses	0.00	0.00	0.00					
Recreation	822.84	9.93	812.91					
East Bank	237.53	221.68	15.85					
Emergency Costs	158.69	2.06	156.62					
TOTAL	**18,200.51**	**389.70**	**17,809.57**					

Table F-50-C-1

AVERAGE ANNUAL BENEFITS (FUTURE, NO TIFFANY) BY LAND USE CATEGORY

Base levee

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Residual Avg. Ann. Damages Exceed Indicated Amount				
	Avg. Ann. Damages	Residual Damages	Benefits	0.95	0.75	0.50	0.25	0.05
Residential	2,200.30	1,459.94	740.36					
Commercial	5,594.91	3,037.74	2,557.17					
Public	119.94	115.86	4.08					
Apartments	1.49	2.71	-1.22					
Outbuildings	77.45	52.16	25.29					
Subtotal - Structures and Contents	7,994.09	4,668.41	3,325.68					
Streets, roads	1,893.89	1,093.74	800.15					
Utilities	60.73	35.07	25.66					
Railroad	193.28	111.62	81.66					
Vehicles	343.28	198.24	145.03					
Agriculture	101.00	14.40	1,561.01					
Irr. Drains	36.01	20.80	15.21					
LFCC	6,386.84	3,688.45	2,698.39					
Avoided Water Losses	0.00	0.00	0.00					
Recreation	822.84	29.79	793.05					
East Bank	294.28	308.64	-14.36					
Emergency Costs	158.79	24.36	134.44					
TOTAL	**18,285.03**	**10,193.51**	**9,565.92**					

Table F-50-C-2

AVERAGE ANNUAL BENEFITS (FUTURE, NO TIFFANY) BY LAND USE CATEGORY

Base levee + 1 ft

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Avg. Ann. Damages Exceed Indicated Amount				
	EAD	Residual Damages	Benefits	0.95	0.75	0.50	0.25	0.05
Residential	2,200.30	644.16	1,556.14					
Commercial	5,594.91	1,346.37	4,248.54					
Public	119.94	76.54	43.40					
Apartments	1.49	1.03	0.46					
Outbuildings	77.45	21.81	55.64					
Subtotal - Structures and Contents	7,994.09	2,089.91	5,904.18					
	0.00							
Streets, roads	1,893.89	772.04	1,121.85					
Utilities	60.73	24.75	35.97					
Railroad	193.28	78.79	114.49					
Vehicles	343.28	139.94	203.34					
Agriculture	101.00	8.96	1,673.60					
Irr. Drains	36.01	14.68	21.33					
LFCC	6,386.84	2,603.58	3,783.26					
Avoided Water Losses	0.00	0.00	0.00					
Recreation	822.84	17.02	805.82					
East Bank	294.28	308.64	-14.36					
Emergency Costs	158.79	16.86	141.94					
TOTAL	**18,285.03**	**6,075.17**	**13,791.41**					

Table F-50-C-3

AVERAGE ANNUAL BENEFITS (FUTURE, NO TIFFANY) BY LAND USE CATEGORY

Base levee + 2 ft

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Avg. Ann. Damages Exceed Indicated Amount				
	EAD	Residual Damages	Benefits	0.95	0.75	0.50	0.25	0.05
Residential	2,200.30	262.08	1,938.22					
Commercial	5,594.91	545.01	5,049.90					
Public	119.94	54.95	64.99					
Apartments	1.49	0.38	1.11					
Outbuildings	77.45	9.05	68.40					
Subtotal - Structures and Contents	7,994.09	871.47	7,122.62					
	0.00							
Streets, roads	1,893.89	411.77	1,482.13					
Utilities	60.73	13.20	47.52					
Railroad	193.28	42.02	151.26					
Vehicles	343.28	74.63	268.64					
Agriculture	101.00	14.97	1,715.29					
Irr. Drains	36.01	7.83	28.18					
LFCC	6,386.84	1,388.62	4,998.22					
Avoided Water Losses	0.00	0.00	0.00					
Recreation	822.84	9.93	812.91					
East Bank	294.28	308.64	-14.36					
Emergency Costs	158.79	9.31	149.48					
TOTAL	**18,285.03**	**3,152.40**	**16,761.89**					

Table F-50-C-4

AVERAGE ANNUAL BENEFITS (FUTURE, NO TIFFANY) BY LAND USE CATEGORY

Base levee + 3 ft

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Avg. Ann. Damages Exceed Indicated Amount				
	EAD	Residual Damages	Benefits	0.95	0.75	0.50	0.25	0.05
Residential	2,200.30	98.96	2,101.34					
Commercial	5,594.91	204.16	5,390.75					
Public	119.94	35.47	84.47					
Apartments	1.49	0.15	1.34					
Outbuildings	77.45	3.64	73.81					
Subtotal - Structures and Contents	7,994.09	342.38	7,651.71					
	0.00							
Streets, roads	1,893.89	233.08	1,660.81					
Utilities	60.73	7.47	53.25					
Railroad	193.28	23.79	169.49					
Vehicles	343.28	42.25	301.03					
Agriculture	101.00	9.94	1,782.54					
Irr. Drains	36.01	4.43	31.58					
LFCC	6,386.84	786.02	5,600.82					
Avoided Water Losses	0.00	0.00	0.00					
Recreation	822.84	9.93	812.91					
East Bank	294.28	308.64	-14.36					
Emergency Costs	158.79	5.34	153.46					
TOTAL	**18,285.03**	**1,773.26**	**18,203.25**					

Table F-50-C-5

AVERAGE ANNUAL BENEFITS (FUTURE, NO TIFFANY) BY LAND USE CATEGORY

Base levee + 4 ft

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
				Probability Avg. Ann. Damages Exceed Indicated Amount				
	EAD	Residual Damages	Benefits	0.95	0.75	0.50	0.25	0.05
Residential	2,200.30	35.82	2,164.48					
Commercial	5,594.91	73.86	5,521.05					
Public	119.94	21.02	98.92					
Apartments	1.49	0.05	1.44					
Outbuildings	77.45	1.40	76.05					
Structures and Contents	7,994.09	132.15	7,861.94					
	0.00							
Streets, roads	1,893.89	191.03	1,702.87					
Utilities	60.73	6.13	54.60					
Railroad	193.28	19.50	173.78					
Vehicles	343.28	34.62	308.65					
Agriculture	101.00	8.44	1,801.87					
Irr. Drains	36.01	3.63	32.38					
LFCC	6,386.84	186.62	6,200.22					
Avoided Water Losses	0.00	0.00	0.00					
Recreation	822.84	9.93	812.91					
East Bank	294.28	308.64	-14.36					
Emergency Costs	158.79	4.23	154.56					
TOTAL	**18,285.03**	**904.92**	**19,089.42**					

Table F-51-A EXPECTED VALUE AND PROBABILISTIC VALUES OF NET BENEFITS FOR PROPOSED PROJECTS
PRESENT CONDITIONS

Plan	Expected Annual NED Benefit and NED Cost (x $1,000)			Probability Net Benefit Exceeds Indicated Amount (x $1,000)				
	Benefits*	Cost	Net Benefits	0.05	0.25	0.5	0.75	0.95
No Action	0.00	0.00	0.00					
Base levee	6,560.12	10,167.55	-3,607.43					
Base levee + 1 ft	7,566.27	10,481.15	-2,914.88					
Base levee + 2 ft	7,855.34	10,810.92	-2,955.58					
Base levee + 3 ft	7,952.23	10,961.72	-3,009.49					
Base levee + 4 ft	7,980.40	11,076.74	-3,096.34					

* From Benefits in Table F-11-A.

Table F-51-B EXPECTED VALUE AND PROBABILISTIC VALUES OF NET BENEFITS FOR PROPOSED PROJECTS
FUTURE CONDITIONS

Plan	Expected Annual NED Benefit and NED Cost (x $1,000)			Probability Net Benefit Exceeds Indicated Amount (x $1,000)				
	Benefits*	Cost	Net Benefits	0.05	0.25	0.5	0.75	0.95
No Action	0.00	0.00	0.00					
Base levee	3,523.73	10,167.55	-6,643.82					
Base levee + 1 ft	5,869.82	10,481.15	-4,611.33					
Base levee + 2 ft	7,092.59	10,810.92	-3,718.33					
Base levee + 3 ft	7,650.28	10,961.72	-3,311.44					
Base levee + 4 ft	7,871.34	11,076.74	-3,205.40					

* From Benefits in Table F-11-B.

Table F-52-A EXPECTED VALUE AND PROBABILISTIC VALUES OF BENEFIT/COST RATIOS FOR PROPOSED PROJECTS

PRESENT CONDITIONS

Plan	Expected Benefit/Cost Ratio	Probability Benefit/Cost Ratio Exceeds Indicated Value				
		0.05	0.25	0.5	0.75	0.95
No Action						
Base levee	1.20					
Base levee + 1 ft	1.43					
Base levee + 2 ft	1.53					
Base levee + 3 ft	1.58					
Base levee + 4 ft	1.62					

Table F-52-B EXPECTED VALUE AND PROBABILISTIC VALUES OF BENEFIT/COST RATIOS FOR PROPOSED PROJECTS

FUTURE CONDITIONS

Plan	Expected Benefit/Cost Ratio	Probability Benefit/Cost Ratio Exceeds Indicated Value				
		0.05	0.25	0.5	0.75	0.95
No Action						
Base levee	0.35					
Base levee + 1 ft	0.56					
Base levee + 2 ft	0.66					
Base levee + 3 ft	0.70					
Base levee + 4 ft	0.71					

Table F-57	CONDITIONAL PROBABILITY OF DESIGN NON-EXCEEDANCE			
FLOODPLAIN				
FUTURE CONDITIONS				
	Conditional Probability of Design			
	Containing Indicated Event			
	(vulnerable location identified)			
Plan	10%	2%	1%	0.20%
XSEC 1394				
No Action	0.000	0.000	0.000	0.000
Base levee	0.943	0.685	0.501	0.206
Base levee + 1 ft	0.982	0.822	0.661	0.339
Base levee + 2 ft	0.995	0.912	0.795	0.500
Base levee + 3 ft	0.999	0.962	0.890	0.662
Base levee + 4 ft	1.000	0.986	0.949	0.797

Table F-58	CONDITIONAL PROBABILITY OF DESIGN NON-EXCEEDANCE	
	SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN	
	FUTURE CONDITIONS	
Plan	Annual Performance (Expected Annual Probability of Design Being Exceeded - vulnerable location)	Annual Performance (Expected Annual Probability of Design Being Exceeded - worst case scenario)*
	XSEC 1394	
No Action	0.999	0.999
Base levee	0.032	0.430
Base levee + 1 ft	0.015	0.178
Base levee + 2 ft	0.007	0.170
Base levee + 3 ft	0.003	0.098
Base levee + 4 ft	0.002	0.005
* Includes unpopulated areas.		

Table F-59-A	ANNUAL PERFORMANCE AND EQUIVALENT LONG-TERM RISK					
	SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN					
Plan	Annual Performance (Expected Annual Probability of Design being Exceeded - vulnerable location identified)	Equivalent Long-term Risk (Probability of Exceedance Over Indicated Time Period)				
		10 years	20 years	25 years	30 years	50 years
	XSEC 1394					
No Action	0.999	1.000	1.000	1.000	1.000	1.000
Base levee	0.032	0.277	0.477	0.555	0.622	0.802
Base levee + 1 ft	0.015	0.140	0.261	0.315	0.365	0.530
Base levee + 2 ft	0.007	0.071	0.136	0.167	0.197	0.307
Base levee + 3 ft	0.003	0.033	0.066	0.082	0.097	0.157
Base levee + 4 ft	0.002	0.019	0.037	0.046	0.055	0.091

Table F-59-B	ANNUAL PERFORMANCE AND EQUIVALENT LONG-TERM RISK					
	SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN					
Plan	Annual Performance (Expected Annual Probability of Design being Exceeded - worst case scenario)*	Equivalent Long-term Risk (Probability of Exceedance Over Indicated Time Period)				
		10 years	20 years	25 years	30 years	50 years
No Action	0.999	1.000	1.000	1.000	1.000	1.000
Base levee	0.430	0.996	1.000	1.000	1.000	1.000
Base levee + 1 ft	0.178	0.858	0.980	0.992	0.997	1.000
Base levee + 2 ft	0.170	0.846	0.976	0.991	0.996	1.000
Base levee + 3 ft	0.098	0.643	0.873	0.924	0.955	0.994
Base levee + 4 ft	0.005	0.048	0.094	0.116	0.137	0.218

* Includes unpopulated areas

Table F-60	CONDITIONAL PROBABILITY OF DESIGN NON-EXCEEDANCE			
FLOODPLAIN				
FUTURE CONDITIONS				
	Conditional Probability of Design			
	Containing Indicated Event			
	(worst case scenario)*			
Plan	10%	2%	1%	0.20%
No Action	0.000	0.000	0.000	0.000
Base levee	0.088	0.053	0.014	0.001
Base levee + 1 ft	0.182	0.123	0.043	0.005
Base levee + 2 ft	0.330	0.234	0.101	0.021
Base levee + 3 ft	0.508	0.388	0.197	0.055
Base levee + 4 ft	0.678	0.563	0.336	0.126
* Includes unpopulated areas.				

Table F-61
CONDITIONAL PROBABILITY OF DESIGN NON-EXCEEDANCE BY EVENT AND DAMAGE CENTER
SAN ACACIA TO BOSQUE DEL APACHE FLOODPLAIN

		Preproject		Base, no Tiffany		Base + 1', no Tiffany		Base + 2', no Tiffany		Base + 3', no Tiffany		Base + 4', no Tiffany	
Damage Center	Event	**Start of Damages (stage)**	Non-Exceedance Probability (decimal)	**Start of Damages (stage)**	Non-Exceedance Probability (decimal)	**Start of Damages (stage)**	Non-Exceedance Probability (decimal)	**Start of Damages (stage)**	Non-Exceedance Probability (decimal)	**Start of Damages (stage)**	Non-Exceedance Probability (decimal)	**Start of Damages (stage)**	Non-Exceedance Probability (decimal)
XSEC 1190	10%	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0
future	4%		0		0		0		0		0		0
	1%		0		0		0		0		0		0
	0.20%		0		0		0		0		0		0
XSEC 1218	10%	**4661.9**	0	**4661.96**	0.9977	**4661.96**	0.9997	**4661.96**	1	**4661.96**	1	**4661.96**	1
future	4%		0		0.7284		0.8407		0.9147		0.9576		0.9803
	1%		0		0.5081		0.6473		0.7654		0.8557		0.9195
	0.20%		0		0.1629		0.2624		0.3876		0.5339		0.6796
XSEC 1256	10%	**4641.4**	0	**4641.4**	0.9946	**4641.4**	0.999	**4641.4**	0.9998	**4641.4**	1	**4641.4**	1
future	4%		0		0.7664		0.8772		0.9412		0.9748		0.9904
	1%		0		0.5168		0.6716		0.7981		0.8905		0.9479
	0.20%		0		0.3337		0.4913		0.6539		0.7921		0.8926
XSEC 1268	10%	**4635.8**	0	**4635.8**	0.8646	**4635.8**	0.9497	**4635.8**	0.9848	**4635.8**	0.9964	**4635.8**	0.9993
future	4%		0		0.6482		0.7993		0.9014		0.9585		0.9849
	1%		0		0.5051		0.6715		0.8085		0.9032		0.9592
	0.20%		0		0.3927		0.5652		0.7248		0.8485		0.9297
XSEC 1299	10%	**4620.57**	0	**4618.26**	0.9791	**4619.28**	0.9953	**4620.31**	0.9991	**4621.34**	0.9998	**4622.37**	1
future	4%		0		0.7099		0.8421		0.9245		0.9679		0.9883
	1%		0		0.4865		0.6455		0.7802		0.8779		0.9396
	0.20%		0		0.2921		0.4417		0.6031		0.7486		0.8602
XSEC 1312/1316	10%	**4616.03**	0	**4615.97**	0.9427	**4617.17**	0.9806	**4618.38**	0.9953	**4619.58**	0.9987	**4620.78**	0.9998
future	4%		0		0.6539		0.7809		0.8839		0.9467		0.9783
	1%		0		0.5057		0.6623		0.7956		0.8907		0.9396
	0.20%		0		0.1798		0.3053		0.4624		0.6218		0.8602
XSEC 1327	10%	**4604.12**	0	**4600.01**	0.8229	**4606.44**	0.9272	**4612.87**	0.9759	**4619.29**	0.9937	**4625.72**	0.9985
future	4%		0		0.6126		0.7702		0.881		0.9468		0.9793
	1%		0		0.5127		0.6791		0.8131		0.9053		0.9602
	0.20%		0		0.2749		0.4324		0.6038		0.7565		0.8707
XSEC 1339	10%	**4598.85**	0	**4599.1**	0.8129	**4600.14**	0.9213	**4601.18**	0.9727	**4602.22**	0.9924	**4603.26**	0.998
future	4%		0		0.6113		0.7696		0.8829		0.9491		0.9808
	1%		0		0.5018		0.6713		0.8102		0.9056		0.9607
	0.20%		0		0.3092		0.4739		0.6446		0.7898		0.8933
XSEC 1346	10%	**4594.19**	0	**4594.57**	0.8311	**4595.09**	0.9284	**4595.61**	0.9749	**4596.13**	0.9929	**4596.65**	0.9983
future	4%		0		0.67		0.8154		0.9106		0.963		0.9869
	1%		0		0.5331		0.6972		0.8282		0.9161		0.9651
	0.20%		0		0.3057		0.4696		0.6408		0.7865		0.8908
XSEC 1360	10%	**4591.6**	0	**4592.09**	0.9649	**4592.57**	0.9913	**4593.06**	0.9983	**4593.54**	0.9998	**4594.03**	0.9999
future	4%		0		0.6947		0.8318		0.9191		0.9657		0.9873
	1%		0		0.5032		0.6643		0.7978		0.8924		0.9495
	0.20%		0		0.2065		0.3386		0.4997		0.6624		0.7961
XSEC 1394	10%	**4576.95**	0	**4577.73**	0.7162	**4577.81**	0.8641	**4577.89**	0.9463	**4577.97**	0.9834	**4578.04**	0.9955
future	4%		0		0.5154		0.69		0.828		0.9183		0.9674
	1%		0		0.3942		0.5691		0.7273		0.8493		0.9281
	0.20%		0		0.2098		0.3502		0.5182		0.6836		0.8165
XSEC 1400	10%	**4577.03**	0	**4577.65**	0.6208	**4577.69**	0.8508	**4577.73**	0.9594	**4577.77**	0.9921	**4577.81**	0.9987
future	4%		0		0.4293		0.6283		0.7929		0.9023		0.9616
	1%		0		0.3313		0.5069		0.6776		0.8164		0.9099
	0.20%		0		0.1888		0.3239		0.4921		0.6614		0.8004
XSEC 1414	10%	**4570.7**	0	**4571.29**	0.5412	**4571.41**	0.7285	**4571.54**	0.8651	**4571.66**	0.9449	**4571.78**	0.9816
future	4%		0		0.3985		0.5837		0.747		0.8693		0.9446
	1%		0		0.2787		0.4396		0.6137		0.7663		0.8761
	0.20%		0		0.1222		0.2274		0.3787		0.5502		0.7106
XSEC 1433/1450	10%	**4564.82**	0	**4565.6**	0.5055	**4565.79**	0.6903	**4565.98**	0.8335	**4566.17**	0.925	**4566.36**	0.9718
future	4%		0		0.3722		0.5519		0.719		0.8483		0.9307
	1%		0		0.2612		0.4188		0.593		0.7493		0.8633
	0.20%		0		0.1152		0.2166		0.3643		0.5358		0.6978
XSEC 1473/1477/1	10%	**4541.42**	0	**4542.19**	0.4086	**4542.2**	0.598	**4542.21**	0.761	**4542.22**	0.8791	**4542.23**	0.95
future	4%		0		0.3023		0.473		0.6478		0.7949		0.8973
	1%		0		0.209		0.3524		0.5231		0.6901		0.8203
	0.20%		0		0.0904		0.1774		0.3115		0.4793		0.648
XSEC 1491	10%	**4538.4**	0	**4539**	0.2585	**4539.18**	0.9998	**4539.36**	0.6117	**4539.53**	0.7702	**4539.71**	0.8834
future	4%		0		0.181		0.9998		0.4909		0.6627		0.8013
	1%		0		0.1194		0.9999		0.3731		0.5456		0.7055
	0.20%		0		0.0423		0.9998		0.1961		0.3361		0.5047
XSEC 1517.2	10%	**4523.84**	0	**4524.52**	0.0883	**4524.65**	0.1824	**4524.78**	0.3302	**4524.91**	0.5075	**4525.04**	0.6782
future	4%		0		0.0527		0.1234		0.2339		0.3884		0.56332
	1%		0		0.0143		0.0425		0.1008		0.1968		0.3357
	0.20%		0		0.0013		0.0053		0.0209		0.0553		0.126
XSEC 1550	10%	**4512.6**	0	**4513.28**	0	**4613.49**	0	**4513.71**	0	**4513.92**	0	**4514.14**	0
future	4%		0		0		0		0		0		0
	1%		0		0		0		0		0		0
	0.20%		0		0		0		0		0		0
XSEC 1603.7	10%	**4499.22**	0	**4500.07**	0	**4500.29**	0	**4500.52**	0	**4500.74**	0	**4500.97**	0
future	4%		0		0		0		0		0		0
	1%		0		0		0		0		0		0
	0.20%		0		0		0		0		0		0
XSEC 1641	10%	**0**	1	**0**	1	**0**	1	**0**	1	**0**	1	**0**	1
future	4%		1		1		1		1		1		1
	1%		1		1		1		1		1		1
	0.20%		1		1		1		1		1		1

Non-exceedance probability is the likelihood of events being less than or equal to the start of damages volume.
is15 Alt. 1 project is less effective at containing the 0.2% event, but is more effective than smaller projects at containing more frequent events.

Table F-62

EQUIVALENT ANNUAL DAMAGES BY LAND USE CATEGORY

TOWN OF SOCORRO ONLY

LAND USE CATEGORY	Average Annual Damages (x $1,000 August, 2010 price level)					
	Total	XSEC 6 1327	XSEC 7 1339	XSEC 8 1346	XSEC 9 1360	
Residential	1,426.64	16.69	9.39	18.06	1,382.50	
Commercial	4,696.06	8.55	2.02	5.11	4,680.38	
Public	76.13	0.00	0.00	0.00	76.13	
Apartments	0.34	0.00	0.28	0.00	0.06	
Outbuildings	21.80	0.07	0.06	0.08	21.59	
East Bank						
Subtotal - Structures and	**6,220.97**	**25.31**	**11.75**	**23.25**	**6,160.66**	
Streets, roads	427.42					
Utilities	29.72					
Railroad	11.64					
Vehicles	253.80					
Agriculture	0.00					
Irr. Drains	4.42					
LFCC	538.41	167.39	3.43	163.59	204	
Avoided Water Losses	0.00					
Recreation	0.00					
East Bank	0.00					
Emergency Costs	104.15					
TOTAL	**7,590.52**					

Table F-63

EQUIVALENT ANNUAL BENEFITS
BY LAND USE CATEGORY

TOWN OF SOCORRO ONLY

Base levee

LAND USE CATEGORY	Average Annual Benefits (x $1,000 August, 2010 price level)							
	EAD	Residual Damages	Benefits	XSEC 6 1327	XSEC 7 1339	XSEC 8 1346	XSEC 9 1360	
Residential	1,426.64	350.96	1075.68	5.10	6.18	15.54	324.14	
Commercial	4,696.06	871.28	3824.78	1.97	1.29	7.03	860.99	
Public	76.13	16.92	59.21	0.00	0.00	0.00	16.92	
Apartments	0.34	0.33	0.01	0.00	0.28	0.00	0.05	
Outbuildings	21.80	3.54	18.26	0.01	0.06	0.05	3.42	
Subtotal - Structures and Contents	6,220.97	**1,243.03**	4977.94	**7.08**	**7.81**	**22.62**	**1,205.52**	
Streets, roads	427.42	100.91	326.50					
Utilities	29.72	6.81	22.91					
Railroad	11.64	2.52	9.12					
Vehicles	253.80	35.69	218.10					
Agriculture	0.00	0.00	0.00					
Irr. Drains	4.42	1.11	3.31					
LFCC	538.41	0.97	537.44	0.54	0.01	0.24	0.18	
Avoided Water Losses	0.00	0.00	0.00					
Recreation	0.00	0.00	0.00					
East Bank	0.00	0.00	0.00					
Emergency Costs	104.15	2.50	101.65					
TOTAL	**7,590.52**	**1393.54**	**6,196.98**					

Table F-64

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR RING LEVEE

TOWN OF SOCORRO ONLY

(x $1,000 August, 2010 price level)

	100 yr levee	100 yr levee + 1 ft	100 yr levee + 2 ft	100 yr levee + 3 ft	100 yr levee + 4 ft
Construction Cost	14,232.23	14,824.27	15,447.06	15,729.36	15,943.55
Tiffany Basin					
LFCC reroute					
PED (9%)	1,280.90	1,334.18	1,390.24	1,415.64	1,434.92
Total First Cost	15,513.13	16,158.46	16,837.30	17,145.00	17,378.47
IDC, Construction (30 months, 4-3/8%)*	692.37	729.20	767.99	787.39	802.25
Total, Interest During Construction	692.37	729.20	767.99	787.39	802.25
Total Investment	16,205.50	16,887.66	17,605.29	17,932.39	18,180.72
Avg. Ann. Cost (4-3/8%, 50 yr. project life)	803.42	837.24	872.82	889.04	901.35
OMRR&R					
Total Avg. Ann. Cost	803.42	837.24	872.82	889.04	901.35
Equivalent Avg. Ann. Benefits	6,196.98	6,343.95	7,015.73	7,292.38	7,391.63
Benefit/Cost Ratio	7.71	7.58	8.04	8.20	8.20
Net Benefits	5,393.56	5,506.70	6,142.91	6,403.35	6,490.28

Table F-65

COMPARISON OF RECOMMENDED PLAN TO AUTHORIZED PLAN - BENEFITS AND COSTS

Category	Authorized Project			LRR/SEIS (August 2010)
	1988 Decision Document	**1993 Decision Document**	**Values in Current Prices[3]**	**Preliminary Preferred Plan**
Structures or Parcels in 0.2% probability floodplain	Not available	Not available	Not available	1,828
Structures or Parcels in 1% probability floodplain	884	Not available	884	1,522
Total Value of Damageable Property	216.3 million	Not available	363.95	231.8 million[5]
Damages 1% Probability Event	150.5 million	Not available	253.24	238.4 million
Damage 0.5% Probability Event	Not available	Not available	Not available	282.4 million
Price Level	Feb-87	Oct-93	Aug-10	Aug-10
Interest Rate	$8^5/_8$%	$8^1/_4$%	$4\text{-}^3/_8$%	$4\text{-}^3/_8$%
Period of Analysis	100 years	50 years	50 years	50 years
Risk-Based	No	No	No	Yes
EAD – Without-Project (existing)	Not available	12.996 million	Not available	18.2 million4
EAD – With-Project	Not available	967 thousand	Not available	0.2 million4
Benefits	10.98 million[1]	12,029 thousand	18.48	18 million4
Annual Costs	3.31 million[1]	5.11 million	5.57	223.4 million4
Net Benefits	7.67 million[1]	6.92 million[1]	12.91	6.9 million4
B/C	3.3	2.3	3.3	1.62

[1] October 1988 Price Level, $8^5/_8$%

[2] October 1993 Price Level, $8^1/_4$%

[3] Will incorporate information in subsequent submittals.

[4] Based on the NED Levee Plan – 100-Year Levee + 4 feet.

[5] Structures and contents only

Table F-66

COMPARISON OF RECOMMENDED PLAN TO AUTHORIZED PLAN - COST APPORTIONMENT

Item	Authorized Project (October 1993 Prices)		Authorized Project (August 2010 Prices)		Preliminary Preferred Plan (March 2012 Prices)	
	Federal	Non-Federal	Federal	Non-Federal	Federal	Non-Federal
Construction[a] (Flood Risk Management)	$54,499,000		$91,702,000		344,347.17	
LERRDs		0		0	1,340.00	-[c]
Total First Cost (Flood Risk Management)	**$54,499,000**	**$0**	**$91,702,000**		**$345,687**	**$0**
Mandatory 5% Cash	($1,697,050)	$2,725,000	($4,585,100)	$4,585,100	($17,300)	$17,300
Subtotals	$52,801,950	$2,725,000	$87,116,900	$4,585,100	$328,387	$17,300
Percentage of Total Cost-Shared Amount	*95%*	*5%*	*95%*	*5%*	*95%*	*5%*
Additional Cash to Provide Minimum Non-Federal Share of Total Project Costs	($10,899,800)	$10,899,800	($18,340,400)	$18,340,400	($69,100)	$69,100
Subtotals	$25,455,750	$8,485,250	$68,776,500	$22,925,500	$259,287	$86,400
Percentage of Total Cost-Shared Amount	*75%*	*25%*	*75%*	*25%*	*75%*	*25%*
Adjustment due to Benefits to Federal Properties	$5,091,150[d]	($5,091,150)	$8,566,600	($8,566,600)	$35,200	($35,200)
TOTALS	**$30,546,900**	**$3,394,100**	**$77,343,100**	**$14,358,900**	**$294,487**	**$51,200**
Percentage of Total Cost-Shared Amount	*90%*	*10%*	*84%*	*16%*	*85%*	*15%*

[a] Does not include OMRR&R, which is a 100% non-Federal cost.

[b] Total construction costs includes construction management.

[c] LERRDs costs were not incorporated to match information as presented in the Economic Appendix.

[d] Provisions of PL 99-662 as identified in 1988 Decision Document.

Table F-67

COMPARISON OF RECOMMENDED PLAN TO AUTHORIZED PLAN - EAD

Category	Authorized Project (x$1,000)					LRR/SEIS (August 2010)		
	1988 Decision Document	**1993 Decision Document**	**Price Level Update Factor**	**Values in Current Prices3**	**Basis of Price Level update**	**Preliminary Preferred Plan**	**Difference**	**Basis of Difference**
Residential Structure		429	1.69	725.3229483	ENR Construction Cost Index	2,200	1033	Additional structures evaluated, perched channel evaluation, new structure and content curves, risk based analysis, new H&H data, price level update of structures, content damages a function of structure value
Residential Content		293	1.51	442.43	CPI-U (annual average)			
Commercial Structure		84	1.69	142.0212766	ENR Construction Cost Index	5,593.65	5151	Additional structures evaluated, perched channel evaluation, new structure, risk based analysis, new H&H data, price level update of structures and contents
Commercial Content		199	1.51	300.49	CPI-U (annual average)			
Public Structure		45	1.69	76.08282675	ENR Construction Cost Index	119.94	-128	Additional structures evaluated, perched channel evaluation, new structure, risk based analysis, new H&H data, price level update of structures and contents
Public Content		114	1.51	172.14	CPI-U (annual average)			
Vehicles		179	1.05	188.6166738	CPI (New and Used Motor Vehicles, US City Average, Not seasonally adjusted)	343.28	155	Price level update of vehicles, risk based analysis, vehicles a function of additional structures in floodplain, perched channel evaluation
Transportation Facilities		676	1.69	1142.933131	ENR Construction Cost Index	2,087.17	944	Railroad track length included in floodplain
Utilities		253	1.69	427.7545593	ENR Construction Cost Index	60.73	-367	
Crops		128	1.42	182.2955854	PPI (Farm Products, US Average, Not seasonally adjusted)	101.00	-81	Updated crop budgets yield lower revenues on per acre basis. Less acreage in production as a result.
Irrigation Facilities		378	1.69	639.0957447	ENR Construction Cost Index	36.01	-603	
RG LFCC		7,760	1.69	13120.06079	ENR Construction Cost Index	6,366.73	-6753	Perched channel evaluation
Avoided Water Losses		696	1.42	991.2322457	PPI (Farm Products, US Average, Not seasonally adjusted)	0.00	-991	Value of water in Middle Rio Grande basin increased, new volume of water saved.
Rural Improvements		326	1.69	551.1778116	ENR Construction Cost Index	77.40	-474	Potential damage category mismatch,. Present evaluation put "Outbuildings" in this category.
Recreation (Bosque Del Apache)		37	1.51	55.87	CPI-U (annual average)	822.84	767	Price level changes. Also inclusion of specialized recreation values for winter visitation.
Sediment		1,198	1.69	2025.493921	ENR Construction Cost Index	0.00	-2025	Current recommended plan does not include sediment management features.
Emergency Costs		201	1.51	303.51	CPI-U (annual average)	157.59	-146	
East Bank		Not evaluated				272.25	272	Prior studies did not examine potential for induced damages.
TOTAL		12,996		21486.52751		18,238.87	-3248	

Table F-68

COMPARISON OF RECOMMENDED PLAN TO AUTHORIZED PLAN - AVERAGE ANNUAL BENEFITS

Category	Authorized Project (x$1,000)					LRR/SEIS (August 2010)	
	1988 Decision Document	**1993 Decision Document**	**Price Level Update Factor**	**Values in Current Prices3**	**Basis of Price Level update**	**Preliminary Preferred Plan**	**Difference**
Residential Structure		352	1.69	595.1367781	ENR Construction Cost Index	2,178	1225
Residential Content		237	1.51	357.87	CPI-U (annual average)		
Commercial Structure		65	1.69	109.8974164	ENR Construction Cost Index	5546.81	5207
Commercial Content		152	1.51	229.52	CPI-U (annual average)		
Public Structure		36	1.69	60.8662614	ENR Construction Cost Index	107.04	-106
Public Content		101	1.51	152.51	CPI-U (annual average)		
Vehicles		147	1.05	154.8974919	CPI (New and Used Motor Vehicles, US City Average, Not seasonally adjusted)	315.43	161
Transportation Facilities		560	1.69	946.8085106	ENR Construction Cost Index	1,947.51	1001
Utilities		213	1.69	360.1253799	ENR Construction Cost Index	56.66	-303
Crops		114	1.42	162.3570058	PPI (Farm Products, US Average, Not seasonally adjusted)	94.86	-68
Irrigation Facilities		317	1.69	535.9612462	ENR Construction Cost Index	33.60	-502
RG LFCC		7,440	1.69	12579.02736	ENR Construction Cost Index	6,294.46	-6285
Avoided Water Losses		667	1.42	949.9309021	PPI (Farm Products, US Average, Not seasonally adjusted)	0.00	-950
Rural Improvements		280	1.69	473.4042553	ENR Construction Cost Index	76.53	-397
Recreation (Bosque Del Apache)		34	1.51	51.34	CPI-U (annual average)	812.91	762
Sediment		1,149	1.69	1942.648176	ENR Construction Cost Index		-1943
Emergency Costs		165	1.51	249.15	CPI-U (annual average)	154.72	-94
East Bank		Not evaluated				-2.64	-3
TOTAL		12,029		19911.45078		17,615.42	-2296

NOTE: The August 2010 analysis combines structure and content information into the applicable Structure category.

DRAFT

GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-11

Real Estate

RIO GRANDE FLOODWAY

SAN ACACIA TO BOSQUE DEL APACHE

UNIT PROJECT

SOCORRO COUNTY, NEW MEXICO

REAL ESTATE PLAN

06 APRIL 2012

US Army Corps
of Engineers
Albuquerque District
South Pacific Division

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RIO GRANDE RIVER FLOODWAY FLOOD RISK MANAGEMENT PLAN
REAL ESTATE PLAN ANALYSIS

1. INTRODUCTION:

The Albuquerque District's integrated General Reevaluation Report (GRR) and Supplemental Environmental Impact Statement II (SEIS-II) addresses alternative plans to provide higher levels of flood risk management to floodplain communities along the Rio Grande River from the San Acacia Diversion Dam (SADD) downstream to Elephant Butte Lake, New Mexico, within the San Acacia to Bosque del Apache Unit of the Rio Grande River Floodway. This reach of the Rio Grande River was included in a comprehensive plan for flood risk management in the Rio Grande basin, originally authorized in 1948.

This GRR/SEIS-II is the final response to determine (1) whether the authorized project is still implementable; (2) if any changes are necessary for implementation; and (3) if the changes are within the approval authority delegated to the Division Commander, the Chief of Engineers, or if they require additional Congressional authorization. This GRR/SEIS-II presents recommendations on future actions to best meet the flood risk management needs within the study area. This Real Estate Plan (REP) is prepared under the general guidelines of ER 405-1-12, Chapter 2 and Chapter 12.

Measures and alternatives evaluated in the current and previous analysis efforts can be found in detail in the GRR Report at Table 4.1. A Limited Reevaluation Report and Supplemental EIS were completed in 1992.

The Tentatively Selected Plan (TSP) is the National Economic Development (NED) Plan. This Real Estate Plan focuses on the TSP or National Economic Development (NED) Plan.

The TSP consists of an earthen levee extending approximately 43 miles along the west bank of the Rio Grande, from the San Acacia Diversion Dam to Tiffany Junction, which is approximately 3 miles north of the Railroad Bridge at San Marcial and ancillary features to the engineered levee. See Section 3 of the REP for further description of TSP.

a. INTERESTED PARTIES AND STAKEHOLDERS:

The principal land and facility managers in the Middle Rio Grande Valley include the Middle Rio Grande Conservancy District (MRGCD), Bureau of Reclamation (BOR) and the US Fish and Wildlife Service (FWS). The State of New Mexico (State Engineer and Interstate Stream Commission and Department of Game and Fish and Environmental Department) also has management roles and responsibilities in the project area.

This Proposed Project is being prepared in partnership with MRGCD and the New Mexico Interstate Stream Commission (NMISC), who are the interested non-federal cost sharing partners and would be the signatories to a Project Partnership Agreement. The Middle Rio Grande Conservancy District (MRGCD) and the State of New Mexico Interstate Stream Commission (NMISC) support the Tentatively Selected Plan (TSP). Partnership interests follow:

MRGCD: Local sponsor responsible for obtaining and granting access and easements for all phases of levee construction which fall under their jurisdiction, consisting of approximately 444.36 acres in project Segments 1 through 4 and a portion of Segment 5, provides input to USACE and non-federal cost share. MRGCD will assume operation and maintenance of levees which fall under their jurisdiction after construction and have done so historically using their cooperative agreement with BOR.

NMISC: Local Sponsor responsible for obtaining and granting access and easements for all phases of levee construction which fall under their jurisdiction, consisting of approximately 363.41 acres in a portion of project Segment 6, provides input to USACE, non-federal cost share and review of overall project design and to ensure the project does not have implications to New Mexico obligations to the Rio Grande Compact. NMISC will assume responsibility for levee operation and maintenance in areas which fall under their jurisdiction after construction and have done so historically using their cooperative agreement with BOR.

BOR: The Bureau is a federal stakeholder for the project and is the managing federal agency of the lands of the Rio Grande channel and Low Flow Conveyance Channel (LFCC) for a large portion of the project consisting of approximately 608.95 acres in Segments 1 through 5 and a portion of Segment 6. The lands ownership is currently in dispute with the local sponsor, MRGCD, as explained in Section 4, paragraph 4 of this plan. As the ownership dispute is not resolved, the Bureau's approval for the project is necessary. Additionally, the Bureau constructed and maintains the low flow conveyance channel (LFCC) which exists throughout the entire project area and accounts for all of the federal benefits on the project.

DOI, U.S. Fish and Wildlife Service: The Service is an interested party for the portions of the project, consisting of approximately 164.59 acres that will be constructed and maintained within the Sevilleta and Bosque del Apache National Wildlife Refuges (NWR) located in Segments 3 and portions of Segments 5 and 6. NWR cooperation for the project is necessary. Additionally, there are a few NWR facilities that will be protected by the project.

The U.S. Army Corps of Engineers will be responsible for all engineering design, analysis, permitting and compliance, NEPA and ESA compliance, and construction and oversight.

b. BACKGROUND:

The study area has a long history of flood damage. Recorded flood history in the study area dates back to the 1920s. Before that time, newspaper accounts identify major floods that occurred in July 1895 and September 1904. Recorded major floods, which would have exceeded

the methods for accomplishing flood risk management in the study area have been evaluated for compliance with Corps planning policy as well as the National Environment Protection Act (NEPA), both of which were established after 1948.

MRGCD was formed in 1925, primarily because of concerns over a decrease in irrigated areas in the Middle Rio Grande Valley resulting from water shortages, poor drainage, inadequate irrigation facilities, and periodic flooding. From 1925 to 1935 the MRGCD constructed El Vado Dam, a storage reservoir on the Rio Chama, four major irrigation diversion dams on the Rio Grande one of which is San Acacia, two canal headings, 345 miles of main irrigation canals, and rehabilitated old irrigation ditches. The San Acacia Diversion Dam (SADD) diverts water from the Rio Grande to provide irrigation water to fields in the Socorro area. MRGCD operates and maintains irrigation and flood control management facilities in the Middle Rio Grande Valley.

Endangered Species of the project area are the Silvery Minnow and Southwestern Willow Flycatcher.

2. PROJECT AUTHORITY:

The Rio Grande Floodway, San Acacia to Bosque del Apache Unit flood control project was authorized for construction by section 203 of the Flood Control Act of 1948, as amended by section 204 of the Flood Control Act of 1950, and in accordance with the Chief of Engineers Report dated April 5, 1948, as found in House Document No. 243, 81st Congress, 1st Session.

The Flood Control Act of 1948 concluded the flood problems of the Rio Grande Basin were severe and could be addressed under the Corps' flood risk management program in conjunction with the Bureau of Reclamation which would strive to provide a stable channel having a lower river bed so that controlled releases of 5,000 cfs could be efficiently carried and also provide a lower river bed so that the channel effectively drains the river valley lands and results in a lower water table. Due to changes within the basin over the years, including budgetary requirements, real estate constraints, flood risk management features implemented in the upper watershed, and environmental concerns the features of the project have changed several times.

The current levee plan has been divided into 14 phases and 6 segments (see Exhibit C) for funding and manageable construction purposes and phasing would generally occur from North to South beginning at the SADD. Local sponsors have requested that construction begin at the Socorro diversion channel and proceed South to Brown Arroyo. Three activities relating to the proposed work below the ordinary high water mark OHWM are planned and include 1) earthen levee construction; 2) placement of riprap along the riverward slope and toe of the levee and; 3) a temporary river crossing to access the east side of the river to excavate a terrace above the OHWM. Material for the spoil bank levees will be used to build the proposed engineered levee, with some exceptions. The new levee cross section is narrower than the existing spoil bank levee. The new levee design height is equivalent to the water surface elevation corresponding to the 1% chance flow, plus an additional 4 feet (base levee +4 ft).

In 1956 the United States Senate directed a review of the authorized plan (in addition to other elements contained in the Rio Grande Floodway) to determine whether any additions or

modifications should be made. In response to this review an interim report was prepared, resulting in Cochiti and Galisteo Dams being authorized for construction by the Flood Control Act of 1960. In accordance with the recommendation of the Chief of Engineers, as found in House Document No. 243, 81st Congress, 1st Session, dated 5 April 1948, which reads as follows:

"The comprehensive plan for the Rio Grande Basin as set forth in the report of the Chief of Engineers, dated April 5, 1948, and in the report of the Bureau of Reclamation (BOR), dated November 21, 1947, all in substantial accord with the agreement approved by the Secretary of the Army and the Acting Secretary of the Interior on November 21, 1947, is hereby approved except insofar as the recommendations in those reports are inconsistent with the provision of this Act and subject to authorization and limitations set forth herein."

The approval granted above shall be subject to the following conditions and limitations:

a. Construction of the spillway gate at Chamita Dam, later relocated and renamed Abiquiu Dam and Reservoir shall be deferred so long as New Mexico shall have accrued debits as defined by the Rio Grande Compact and until New Mexico shall consistently accrue credits pursuant to the Rio Grande Compact;

b. Chiflo Dam and Reservoir later relocated and renamed Cochiti Dam and Lake Project on the Rio Grande shall be excluded from the Middle Rio Grande Project authorized herein without prejudice to subsequent consideration of Chiflo Dam and Reservoir by the Congress:

c. The BOR, in conjunction with other interested federal agencies, is directed to make studies to determine feasible ways and means of reducing non-beneficial consumption of water by native vegetation in the floodplain of the Rio Grande and its principle tributaries above Caballo Reservoir; and

d. At all times when New Mexico shall have accrued debits as defined by the Rio Grande Compact all reservoirs constructed as part of the project shall be operated solely for flood control except as otherwise required by the Rio Grande Compact, and at all times all project works shall be operated in conformity with the Rio Grande Compact as it is administered by the Rio Grande Compact Commission.

A 1961 Senate Resolution directed further review of the 1948 Chief of Engineers Report to include the Rio Puerco and the Rio Salado.

Title 1 of the Water Resources Development Act (WRDA) of 1992 (Public Law 102-580) revised the project cost sharing as follows: "Notwithstanding any other provision of law, the project for flood control, Rio Grande Floodway, San Acacia to Bosque del Apache Unit, New Mexico, authorized by Section 203 of the Flood Control Act of 1948 (Public Law 80-858) and amended by Section 204 of the Flood Control Act of 1950 (Public Law 81-516), is modified to more equitably reflect the non-federal benefits from the project by reducing the non-federal contribution for the project by that percentage of benefits which is attributable to the federal properties; except that, for purposes of this subsection, Federal property benefits may not exceed

50 percent of the total project benefits" as directed by CECW policy guidance dated 22 February 1993. The cost-sharing for this project reduces the non-Federal share by the percentage of benefits attributed to federal properties.

3. PROJECT DESCRIPTION:

The project area comprises a stretch of the Rio Grande extending from the San Acacia diversion dam (SADD), near the historic community of San Acacia and located 12 miles north of Socorro, south through the Bosque del Apache National Wildlife Refuge to the headwaters of BOR's Elephant Butte Reservoir, south of the former village of San Marcial at Tiffany Junction. The San Acacia to Bosque del Apache Unit is the southern-most section of the Middle Rio Grande Valley, comprising 58 miles between the SADD and the northern end of Elephant Butte Reservoir just below the San Marcial Railroad Bridge. The principal city in this reach is Socorro with a 2010 census population of 9,051. In addition, six small agricultural villages occur on the flood plain: Polvadera, Lemitar, Escondida, Luis Lopez, San Antonio, and San Marcial. The project area is entirely contained within Socorro County, New Mexico.

Throughout the project area, the Rio Grande occupies a physically well-defined channel; however, flows regularly reach a magnitude to inundate portions of the overbank area adjacent to the channel. Much of the flood threat in this unit has been mitigated with the construction of the Cochiti Dam; however, a residual risk exists due to peak floods that occur in the Rio Grande Basin which are of two general types. The spring floods during the period April through June which are the result of snowmelt or snowmelt in combination with precipitation. Also, floods that occur from July through October which result from summer rainfall and thunderstorms that generally produce low-volume, short duration floods that rise sharply to a peak and recede rapidly.

The proposed project would remove approximately 43 miles of non-engineered spoil banks adjacent to the Rio Grande Floodway and replace them with engineered levees along the west bank of the Rio Grande capable of containing at least the 1%-chance flood event. The spoil bank levees were constructed with excess material removed while excavating the adjacent low flow conveyance channel (LFCC).

The San Acacia to Bosque del Apache Unit Project is a single-purpose flood control management project that includes mitigation of adverse effects. The Tentatively Selected Plan (TSP) consists of replacement of the existing spoil banks to form a structurally sound levee paralleling the U.S. Bureau of Reclamation's (Reclamation) Low Flow Conveyance Channel (LFCC).

San Acacia Reach

The San Acacia Division has a markedly different floodway configuration than the two reaches directly to the north. The river here is unconstrained by a levee on its east side. The floodway can be over 2,000 feet wide in places and the river channel quite variable in width (from 100 to over 1,000 feet). Several small discontinuous drains on the east side of the river serve to drain water from relatively small farmed areas back to the river. The LFCC currently serves as the riverside drain on the west side of the floodway. The LFCC is larger and deeper than most other riverside drains in the middle valley. South of Escondida, the LFCC does not return water to the

river. Because of aggradation of the river bed, water in the LFCC is conveyed directly to Elephant Butte Reservoir. Significant bosque flooding can and does occur south of Escondida. Most irrigation, including that on the Bosque del Apache, occurs west of the floodway and is served by the Socorro Main Canal and the LFCC. In sharp contrast to the reaches to the north, sediment is being deposited by the river, and the river bed has aggraded in the reach from just north of NM–380 south. In some places near San Marcial the bed of the river is 5–10 feet higher than the valley floor to the west and 2–3 feet higher than the valley floor to the west, creating a significant flood risk. Levee sloughing, overtopping, and bank erosion of the levee are potential flood threats. Significant amounts of money are spent each year by the Bureau of Reclamation and the ISC to keep the river channel open and reduce the risk of a levee failure. However, the existing flood risks significantly constrain upstream releases from the Corps of Engineers flood control reservoirs, which limits the potential for flooding of the bosque in upstream reaches.

Low Flow Conveyance Channel

The Middle Rio Grande LFCC is an artificial riprap lined channel that parallels the Rio Grande on the westside and extends the length of a 54-mile reach of the Rio Grande from San Acacia to San Marcial. The LFCC collects river seepage and irrigation surface and subsurface return flows, thus reducing evaporation. It is part of the 1948 Rio Grande Basin authorization for the purpose of reducing consumption of water, providing more effective sediment transport, improving valley drainage, and to aid delivery of Rio Grande compact waters. The LFCC has not actively diverted water from the Rio Grande since the 1980's but does deliver water to the MRGCD's Socorro diversion and to wetlands in the Bosque del Apache NWR. The LFCC is owned, operated, and maintained by the Bureau of Reclamation. Construction began in 1951 and was completed in 1959. BOR estimates it spends $2M annually on levee maintenance and the Interstate Stream Commission has spent $11.3M over the past 9 years to dredge and maintain a pilot channel through the main stem of the Rio Grande to mitigate sediment accumulation at the headwaters of the Elephant Butte Reservoir, at the southern extent of the study area.

The usefulness of the LFCC is dependent upon the water level of Elephant Butte Reservoir. Depending upon the condition of the outfall, a maximum of 2,000 cfs can be diverted into the LFCC at San Acacia. Diversions from the river into the LFCC began in 1953, and diversions at San Acacia began in 1960. With above average water years the reservoir was relatively full through the 1980s. During this time the lowest reaches of the LFCC, which were inundated by the reservoir, became filled with sediment. This made the outfall of the LFCC difficult to maintain, and therefore diversions ceased in 1985. Since that time the LFCC has carried only drainage and irrigation return flows, with minor exceptions. Currently the spoil dike that protects the LFCC (and surrounding lands such as the Bosque del Apache National Wildlife Refuge) from Rio Grande flooding is threatened by overtopping downstream of the Bosque del Apache Wildlife Refuge because of sediment deposition in the river channel. Environmental groups have also raised concerns about the impacts of future LFCC operations on the bosque, wildlife resources, and endangered species in the river below San Acacia Diversion Dam. The states of Colorado, New Mexico, and Texas, and farmers in the lower Rio Grande have raised concerns that compact deliveries will be impaired if the LFCC is not operated. Due to these factors and the condition of the channel outlet, operations of the LFCC as originally intended are not currently possible.

In order to meet needs of the endangered Rio Grande silvery minnow, the Bureau of Reclamation began pumping from the LFCC into the Rio Grande at four locations in 2000. These pump sites begin approximately 20 miles downstream of San Acacia Diversion Dam at the Neil Cupp pump site are located at the northern and southern boundaries of the Bosque del Apache National Wildlife Refuge, approximately 6 and 16 miles downstream respectively from the Neil Cupp location. Finally pumping occurs at the Fort Craig site approximately 10 miles downstream from the southern boundary of the Bosque del Apache National Wildlife Refuge. Fifteen pumps are currently available to supplement Rio Grande flows and manage river recessions consistent with the current Biological Opinion.

Low Flow Conveyance Channel Near Socorro NM

Current Land Uses

The Rio Grande corridor in Socorro County contains the largest contiguous undeveloped tracts of farmland in the Middle Rio Grande valley. The river and adjacent farmland function as a linked hydrologic and ecologic system, providing habitat to the endangered silvery minnow and southwestern willow flycatcher and some of the most significant remaining cottonwood–willow forest or "bosque" in the Rio Grande basin (in fact in the entire southwestern U.S.). The farmland in this reach, together with the managed field crops and wetland habitat at Bosque del Apache National Wildlife Refuge, provides winter habitat to more than 100,000 migratory waterfowl of the Rio Grande flyway. Farmland in the Middle Rio Grande valley is managed as small (less than 50 acres), medium (50 to 500 acres), and large (500 to 1,000 or more acres) farms. Socorro County operates more medium and large farms than the more populated counties of Valencia, Bernalillo, and Sandoval and cultivates more than 20,000 irrigated acres. The productive bottom lands of the Rio Grande produce some of New Mexico's most delicious green chile and melons, and most nutritious alfalfa hay. The San Acacia reach stretches from the San Acacia Diversion Dam near the village of San Acacia southward to the Bosque del Apache National Wildlife Refuge and is contiguous with the Socorro Division of the Middle Rio Grande Conservancy District.

Tentatively Selected Plan
The San Acacia to Bosque del Apache Unit Project is a single-purpose flood control management project that includes mitigation of adverse effects. The Tentatively Selected Plan (TSP) consists of replacement of the existing spoil banks to form a structurally sound levee paralleling the U.S. Bureau of Reclamation's (Reclamation) Low Flow Conveyance Channel (LFCC).

The engineered levees will run approximately 43 miles along the west bank of the Rio Grande, from the San Acacia Diversion Dam (SADD) to Tiffany Junction, which is approximately 3 miles north of the Railroad Bridge at San Marcial. The TSP is located along the same alignment as the existing spoil bank system and parallels the LFCC.

The TSP is the National Economic Development (NED) Plan, which maximizes net economic benefits according to the GRR consistent with protecting the Nation's environment, as follows:

- The proposed levee embankment would have a crest width of 15 feet with 1V:2.5H and 1V:3H depending on the height of the levee. The levee height corresponds to 4 feet above the water surface elevation of the 1% chance mean exceedance event and levee height ranges from 1 foot at the northern end to 15.5 feet at the southern end.
- Material for the project would be obtained from existing spoil banks.
- For levee heights greater than 5 feet, 6-inch perforated pipe toe drain, discharge pipes into the LFCC, and risers as well as an 8-foot-wide by 4-foot-high inspection trench with 1V:1H side slopes would be required. In addition, a 2-foot-wide bentonite slurry trench would extend from 2-feet below the levee embankment crest to 5 feet into the foundation material.
- Ancillary features to the engineered levee in the project are 655 linear feet (LF) of concrete floodwall, approximately 3300 LF of overbank excavation, 2300 LF of channel excavation, approximately 6000 LF of soil cement bank armoring, approximately 395 LF roller compacted concrete, and rip-rap for erosion control at locations vulnerable to erosion from high stream velocities.

Earthen Levee Construction: The existing spoil bank will be removed, approximately one mile at a time, with bulldozers, scrapers, or excavators and the materials for the proposed levee will be stockpiled and mixed within the footprint of the levee alignment.

Riprap would be used for erosion protection along a total of 6.4 miles in various locations as determined by scour analysis of the riverward slope and toe for the proposed levee. Riprap would be installed in the areas most susceptible to scour during flood events and would be buried at depths of between 1 and 12 feet. It would be placed during levee construction when the area is dry.

Infrared aerials of the Rio Grande east bank were examined to determine the extent, if any, of induced damages which may be caused by placement of the proposed levee on the west bank. Those properties identified were then evaluated in the field for structure value and first floor elevation. Fifty (50) residential and commercial structures were located within the 100 year floodplain. The east bank inventory was generally limited to the small community of Pueblito, immediately upstream of Socorro, which sits on the west bank. The second area is northeast of the Village of San Antonio, consisting of residential and commercial structures along Bosquecito Road.

Aerial photos of floodplains downstream of the downstream extent of the proposed project were examined to determine the extent of induced flooding downstream attributable to the project. No properties were found. Any downstream flooding is more likely to occur because of changes in the Elephant Butte Reservoir stage rather than the Rio Grande flood stage.

4. DESCRIPTION OF LERRD'S:

The LERRD's appraised will include easements and rights of way required for a levee maintenance road, the levee footprint, a riverside 15' wide vegetation free zone (levee), staging areas, construction areas, disposal areas, a mitigation area, and ancillary features with a total acreage of 980.06. See following table. The Albuquerque District Engineering Division confirmed the acreage. Map is enclosed.

Area	Feature	Estate	Acreage	Current Interest	Needed Interest	Owner
All Segments 1, 2, 3, 4, & 5 North of NWR	Levee	Fee	433.36	Easement	Easement/ROW	BOR
Segments 3, 5 & 6 of NWR	Levee	Fee	164.59	Easement	Easement/ROW	US Fish&Wildlife/ BOR
Segments 6	Levee	Fee	61.41	Easement	Easement	Private
Segment 3	Levee	Fee	11.0	Easement	Easement/ROW	TBD/BOR
Segment 1	Levee	Fee	5.0	Easement	Easement	City of Socorro
Segment 6 in Tiffany Basin	Spoil/Disposal /Mitigation Sites	Fee	302.00	Easement	Easement	N M Ranches Inc., Wesley Bruton, Jack Bruton
Segment 6	Temp Staging Areas	Temp Easement	TBD	[2]Fee	[1]TWAE	NMISC TBD
Segment 6	Temp Construction Areas	Temp Easement	TBD	[2]Fee	[1]TWAE	NMISC TBD
Segment 3 San Acacia Diversion Dam	Ancillary features: Diversion Dam	Temp Easement	1.2	[2]Fee	[1]TWAE	TBD
Segment 3 San Acacia Diversion Dam	Ancillary features: Diversion Dam	Fee	1.5	[2]Fee	[2]Fee	TBD
	Total		**980.06**			

Table 1.

[1]TWAE = Temporary Work Area Easement will be determined at a later date in coordination with the construction contractor. Note: The total of the existing ownership acreage is 980.06

shown in the tract register (Exhibit B). [2]The underlying estates are assumed to be held in Fee Interest and the actual estate status determination will be made by the non federal sponsor (NFS) in advance of the project's progress. The risk of not knowing the estate status at this time may be low as only temporary easements will be acquired for the project for most of the locations. A fee estate is necessary for the permanent structure to be constructed at the San Acacia Diversion Dam located in Segment 3.

The extreme northern portion of the project is located adjacent to the central-southern portion of the Sevilleta National Wildlife Refuge. The Town of Socorro Land Grant, the Bosque del Apache National Wildlife Refuge, and the Pedro Armendaris Land Grant have not been completely cadastral surveyed. The surveyed portions of the project area include:

According to the Socorro County Assessor Office, Township 7 South, and Range 1 West: Sections 16, 17, 19, 20, 21 and 22, is the area the Tiffany Sedimentation Basin is located. As of this date, this area has not been surveyed. Until a Cadastral Survey has been completed, ownership to the Tiffany area is an estimate.

The MRGCD maintains and operates the project area from the SADD to an area north of the Bosque del Apache National Wildlife Refuge (NWR) as part of its contractual obligations outlined in the 1951 Agreement between BOR and the MRGCD for the Middle Rio Grande (MRG) Project. MRGCD will confirm its lands interests stretching from Brown Arroyo to the northern boundary of the Bosque del Apache NWR. There is on-going dispute between the Bureau of Reclamation and the MRGCD regarding ownership of the land in (segments 1 through 4 and a portion of segment 5) of the project. Therefore, the Corps will enter into an agreement with the Bureau to allow the use of the land for project purposes in the event that the Bureau prevails in the dispute.

MRGCD acknowledges that, at this time, it will not receive a credit for the disputed lands. BOR does not object to the use of the lands for this project. Authorization for Entry for disputed lands will be obtained from both parties and MRGCD, as Non-Federal Sponsor (NFS), remains responsible for provision of all LERRDs required for this project within their jurisdiction. The total of this existing ownership acreage is 433.36.

Examples of areas where BOR only holds easement ownership are lands administered by the United States Fish and Wildlife Service (USFWS) and areas where BOR has only acquired easement interests from the landowner(s).

The new lands required for the project are identified as:

a. Approximately 302 acres are required at Tiffany Sedimentation Basin which has an approximate total of 2,052.35 acres. The new lands will be used for waste required for the project, and for one mitigation site. Any waste soil not appropriate for reuse in the engineered levee is currently planned for disposal at Tiffany Basin in accordance with local, state, and Federal Government regulations governing this activity. The local sponsor will receive credit for acquisition of the 302 acres at Tiffany Sedimentation Basin and the mitigation site that are under private ownership.

b. Approximately 2.7 acres will be needed north of the SADD for construction of ancillary features to engineered levee consisting of 1.2 acres for a temporary construction easement and 1.5 acres in fee or permanent easement at the SADD.

c. Approximately 11 acres at San Lorenzo Arroyo, located approximately 3 miles South of the SADD, are required for a levee tie back at the San Lorenzo drainage basin in permanent easement.

d. Approximately 5.0 acres at North Socorro Diversion/Arroyo, located in vicinity of Socorro, NM are required for a levee tie back in permanent easement.

e. Approximately 61.41 acres South of the Bosque del Apache Refuge for levee construction.

Real Estate requirements for the levee construction and temporary work areas include approximately 980.06 acres. Approximately 15 feet in width, would be required along the entire length of the 43 miles of the levee project next to the riverside toe for a vegetation-free zone width, which is the maximum width required under existing vegetation on levee regulations. Additionally, an area of approximately 22 feet in width and 25 feet riverward of the LFCC, the existing maintenance road, is required for the approximately 43 miles of the project. Exact locations for construction staging areas have not yet been determined; however, the areas will be within the existing MRGCD/BOR area of the LFCC. The existing haul road adjacent to and between the existing spoil-banks will be used for levee construction purposes. Turn-around areas will be located on the levee; therefore, no additional road easements and no new roads will be required.

The Sevilleta National Wildlife Refuge and Bosque del Apache NWR, managed by U.S. Fish and Wildlife Service, are a part of the National Wildlife Refuge System and subject to the provisions of the National Wildlife Refuge System Administration Act of 1966 (PL 89-669), which provides guidelines for administrations of lands and resources within the National Wildlife Refuge System. This Act authorizes the Secretary of the Interior to "permit the use of, or grant easements in, over, across, upon, through, or under any areas within the System for purposes such as, but not necessarily limited to, power lines, telephone lines, canals, ditches, pipelines, and roads, including the construction, operation, and maintenance thereof, whenever he determines that such uses are compatible with the purposes for which these areas are established." A compatibility determination has previously been received from the Fish and Wildlife Service reflecting a finding of project interrelationship with refuge purposes and goals. Approximately 20 acres of the Sevilleta NWR, located just south of the SADD, on the east side of the river, will be needed for overbank and channel excavation purposes. The Non-Federal sponsors (NFS) will acquire any real property interest necessary to use these federal lands to include a temporary construction easement from the Sevilleta NWR for this purpose. In the south-central reach of the project, the project cuts through the length of the Bosque del Apache NWR. The refuge would be temporarily affected by all construction activities, including dust, noise, personnel, and the movement of large construction equipment. NMISC will acquire any real property interest necessary to use these federal lands for this purpose.

The project has been divided into 6 segments and within each segment there are multiple phases. Currently, the phases are defined into 14 geographical areas due to the nature of the construction project and the federal appropriations mechanism. Each phase ends as funding is depleted in the fiscal year and each subsequent phase begins in the new fiscal year as funding is authorized. Exhibit C is a map of the proposed segments. Real Estate certification of sufficient real property interests to support construction will be accomplished adequately in advance of the project's sequential phased progress and solicitations for construction contracts.

5. LERRD'S OWNED BY THE NFS AND CREDITING:

The project's 43 mile length crosses Federal, Private, Non-Federal Sponsor lands for the construction of an engineered levee, mitigation/spoil sites, and diversion dam utilizing existing access roads for maintenance and operation purposes. The first phase of the tentatively selected plan consists of 41.5 acres in which ownership is in dispute between the Non-Federal Sponsor, MRGCD, and Bureau of Reclamation.

At this time, no credit will be provided for any disputed lands as part of MRGCD's local cost share. MRGCD acknowledges this LERRD"S issue and has agreed that it will not receive a credit for the disputed lands.

Phase 1 LERRDs

Landowners	Feature	Location	Acreage	Value/Acre	Estate to be Acquired	Total Dollar Value
BOR (Segment 3)	Levee	Phase 1	41.5	$750.00	Easement /ROW	$ 31,125.00

Table 2.

Ownership of the project lands and Rio Grande lands is with the United States of America as managed by the Department of the Interior, Bureau of Reclamation.

Middle Rio Grande Project: Congress approved the MRGP under the Flood Control Acts of 1948 and 1950, for flood control and reclamation. Besides improving and stabilizing the economy of the Middle Rio Grande Valley, the proposal sought to rescue and rehabilitate the Middle Rio Grande Conservancy District (MRGCD), organized with private capital in 1925 as a political subdivision of the State, but floundering by the late 1940s because of its originally unsound basis of assessment of benefits. To that end, the United States agreed to acquire the MRGCD's obligations and cancel all indebtedness in exchange for MRGCD's conveying and assigning "all of its property rights, including reservoirs, canals, dams, and flood-control works, together with its water rights, and including title and ownership thereto … such property so conveyed to the United States shall be so held until Congress otherwise directs."

MRGCD Contract: The September 24, 1951 contract between the United States and the MRGCD, entered into pursuant to the Reclamation Acts of 1902, 1948, and 1950 (1951 Repayment Contract), "and acts amendatory thereof and supplementary thereto," incorporated a "comprehensive plan for the control of the Rio Grande" as detailed in the 1947 Bureau of

Reclamation (BOR) Project Report. Central to its terms was the transfer of title to all MRGCD works, defined as:

> those structures, reservoirs, ditches and canals now constructed and operated by the District and those to be constructed or rehabilitated under the terms of this contract for the storage, diversion and distribution of water for use in the District, and the drainage of lands, together with rights of way therefor and for operation thereof.

The 1951 Repayment Contract provided that "title to all works constructed by the United States under this contract is vested in …the United States until otherwise provided for by Congress, notwithstanding the transfer hereafter of any such works to the District for operation and maintenance."

The Federal position is disputed by the MRGCD however, for the purposes of project planning – the Federal position is: The 1951 Repayment Contract assigned all of the MRGCD's water filings to the United States. Not simply full repayment but also approval by Congress must predicate the reversion of title to the MRGCD under the MRG Project Act and the 1951 Repayment Contract. Unless and until a Federal Court of competent jurisdiction decides otherwise, or Congress acts to revert or revest ownership in the MRGCD, we presume title to the MRG Project works remains in the United States.

6. STANDARD FEDERAL ESTATES AND NON-STANDARD ESTATES:

Estates that may be required for this project are as follows: Fee Estate for diversion dam structure, Temporary Easements for levee, spoil/mitigation/disposal areas, construction and staging areas, and Rights of Entries for road access. There are no non-standard estates. The following estates are listed for reference at this time and may be required for the project and will be populated later.

FEE

The fee simple title to (the land described in Acquisition Schedule) (Tract Nos. ___, and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

CHANNEL IMPROVEMENT EASEMENT

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A) (Tracts Nos. __, and __) for the purposes as authorized by the Act of Congress approved _____, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions there from; to excavate, dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering

with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

FLOOD PROTECTION LEVEE EASEMENT

A perpetual and assignable right and easement in (the land described in Schedule A) (Tracts Nos. __, __ and __) to construct, maintain, repair, operate, patrol and replace a flood protection levee, including all appurtenances thereto; reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. __, __ and __), for a period not to exceed _____, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT

A perpetual and assignable right and easement to clear, borrow, excavate and remove soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. __, __ and __); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

ROAD EASEMENT

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. __, __ and __) for the location, construction, operation, maintenance, alternation and replacement of (a) road(s) and appurtenances thereto; together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; (reserving, however, to the owners, their heirs and assigns, the right to cross over or under the right-of-way as access to their adjoining land at the locations indicated in Schedule B); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

MEMORANDUM OF AGREEMENT

A long term agreement between Bureau of Reclamation and Corps of Engineers identifying the manner in which the project will be constructed, operated, repaired, and maintained for the anticipated duration of the project's beneficial existence and operation.

LICENSE

An agreement between Bureau of Reclamation and Corps of Engineers identifying the manner, requirements, restrictions, and guidelines for construction work during each phase of the project.

There are no non-standard estates proposed or anticipated for the project.

7. DESCRIPTION OF ANY EXISTING FEDERAL PROJECTS IN OR PARTIALLY IN THE PROPOSED PROJECT:

The LFCC was constructed by BOR in the 1950's to aid the State of New Mexico in delivery of water obligated to Texas under the Rio Grande Compact (Compact). Prior to LFCC construction, the channel into Elephant Butte Reservoir was obstructed with sediment and vegetation such that no surface flows entered the reservoir, resulting in an estimated water loss of 140,000 acre-feet per year.

The Sevilleta NWR abuts the project area in the San Acacia vicinity and would be temporarily affected by all construction activities associated with the use of a 20-acre overbank area located just south of the SADD. In the south-central reach of the project, the project cuts through the length of the Bosque del Apache NWR. The refuge would be temporarily affected by all construction activities, including dust, noise, personnel, and the movement of large construction equipment. The LFCC is a valuable source of water for the Bosque del Apache NWR, which operates extensive water distribution systems throughout the refuge for waterfowl.

8. DESCRIPTION OF ANY FEDERALLY OWNED LAND NEEDED FOR THE PROJECT:

Federally owned lands required for this project include lands whose ownership is in dispute and is claimed by the Bureau of Reclamation. Phase 1 area lands are discussed in the LERRDs crediting portion of this plan. The total of this existing ownership acreage is approximately 433.36 for the entire project. Portions of the South half of the project exist in the two U.S. Fish and Wildlife Service managed refuges and consists of 30.3 acres for Sevilleta NWR and 134.3 acres in Bosque del Apache NWR. The proposed project areas associated with these refuges contained acres are maintained and operated by Bureau of Reclamation under the authorization of an existing Right of Way agreement with NWR .

In a cost shared project the Corps requires that a Non-Federal Sponsor (NFS): 1) provide assurance (certify that sufficient property rights are owned by the NFS) to the Corps that it has

acquired an interest in land sufficient to allow construction of the project; and 2) execute an agreement requiring the local sponsor to operate and maintain the project in perpetuity.

a. MRGCD will be required to provide the necessary certification and an Authorization for Entry for Construction. A Right of Way will also be acquired from the BOR.

b. MRGCD will have to agree to O&M the project that is located on land for which the Bureau of Reclamation potentially will hold the principal property interest. MRGCD will certify to the Corps that they hold the proper property right (estate) to go to construction and accomplish O&M for the project.

9. APPLICATION OF NAVIGATIONAL SERVITUDE TO THE LERRD'S REQUIREMENT:

N/A

10. PROJECT MAP:

Exhibit A depicts maps of the project area, Exhibit B is the associated land tract register and Exhibit C is the Segment Definition Map of the project area.

11. ANTICIPATED INCREASED FLOODING AND IMPACTS:

Hydraulic analyses performed by the Albuquerque District have indicated that implementation of the TSP, the engineered levee plan upstream of the San Marcial Railroad Bridge, has little to no effect on the likelihood of flooding to private and public lands.

Pre- and post-project floodplains on the East bank were evaluated to determine the change in equivalent annual damages (EAD) attributable to the proposed project. The start of damages was assumed to be the 10% chance exceedance event. The proposed levee projects do not have a measurable impact to the damageable property in the present condition, but a minor impact in the future. Therefore damage is diminimus.

12. COST ESTIMATE:

Realty Specialist market research indicates that undeveloped land prices in the Socorro County, New Mexico area, based on the available information, and without water rights, this land appears to have very little economic potential, but proximity to the river is generally considered a plus in comparison with dry grazing on the mesa land. A range of value from $500 to $1,000/acre is estimated, with a median of $750 per acre. A Gross Appraisal for the project will be initiated once the project alternative plan is ascertained.

The condemnation cost of $30,000 listed in Table 3 is an estimate based upon a consensus of other Districts' experience. The actual condemnation cost can vary depending upon the level of opposition from the private land owner towards the project is not easily determined. $30,000 is a mid range estimate for condemnation cost.

[1]Temporary Construction Easement = 5% of Fee Value per year. Therefore, RE costs are based upon a two year temporary construction easement.

Landowners	Location	Acreage	Value/Acre	Estate to be Acquired	Total Dollar Value
BOR (Segments 1-4 and part of 5)	Various	433.36	$750.00	Easement/ROW	$ 325,020.00
BOR/NWR (Segments 5 &6)	NWR	164.59	$750.00	Easement/ROW	$ 123,442.50
Private (Segment 6)	Various	61.41	$750.00	Easement	$ 46,057.50
N.M. Ranch Properties, Inc., Wesley Bruton, and Jack Bruton (Segment 6)	Tiffany Basin	302.00	$750.00	Easement	$ 226,500.00
*TBD (Segment 3)	[2]SADD	1.5	$750.00	Fee	$ 1,125.00
*TBD (Segment 3)	[2]SADD	1.2	$25.00/yr	2 Year Temp Easement	[1]$ 60.00
BOR	San Lorenzo Arroyo	11.0	$750.00	Easement/ROW	$ 8,250.00
City of Socorro (Segment 1)	North Socorro Arroyo	5.0	$750.00	Easement	$ 3,750.00
Temp Staging Areas	Tiffany Basin	TBD	$25.00/yr	2 Year Temp Easement	TBD
Temp Construction Areas	Tiffany Basin	TBD	$25.00/yr	2 Year Temp Easement	TBD
				Total	$ 734,205.00
				Contingency 30%	$ 220,261.50
	Total	**980.06**		**Sub Total**	**$ 954,466.50**

Table 3.
***MRGCD is currently determining ownership and acreage amounts.**
The 30% Contingency is intended to cover uncertainty of land values costs and unknown resolution of land ownership. [2]San Acacia Diversion Dam

<u>Non-Federal Partner Estimate:</u>

Administrative Costs (MRGCD) 9@ $5000/each	$ 45,000.00
Administrative Costs (NMISC) 5@ $5000/each	$ 25,000.00

MRGCD - Deed Title and Mapping/GIS Research (Final Title Reports based on property value)		$ 30,000.00
NMISC - Preliminary Title Report Reports, 3 @ $550/each (Final Title Reports based on property value)		$ 1,650.00
MRGCD - Condemnations		$ 0.00
NMISC - Condemnations		$ 30,000.00
MRGCD - Certificate of Sufficiency - 9@ $2500/each		$ 22,500.00
NMISC - Certificate of Sufficiency - 5 @ $2500/each		$ 12,500.00
NMISC - Closing Costs 2 @ $3500		$ 7,500.00
Subtotal		$ 174,150.00
Estimated Credit to be provided		$ 174,150.00
Lands and Damages		$ 954,466.50
	Total LERRDS*	$1,128,616.50

Government Administrative Cost Estimate:

Government Costs		$ 175,000.00
	Total Gov't Costs	**$ 175,000.00**
	GRAND TOTAL	**[2] $1,303,616.50**

Typical Federal Real Estate costs include preparation of all Real Estate Reports, acquisition and review of all ownerships materials, review, coordination and planning meetings, review of documents, costs of legal reviews, mapping costs, and general administrative costs associated with the project, including monitoring activities.

[2] MRGCD is currently determining ownership and acreage amounts that could impact cost estimate. The Grand Total does not include estimated costs to relocate communications lines which are captured in the Total Project Cost estimate prepared by Cost Engineering.

RG San Acacia to Bosque del Apache	Acreage	Non-Federal Admin Cost	Federal Admin Cost	LERRD's Cost	Total
Gross Appraisal Pending	980.06	$174,150	$175,000	$954,466.50	$1,303,616.50

13. RELOCATION ASSISTANCE BENEFITS:

There are no residential, tenant, business, or farm operations impacted by this project, i.e., no relocations are required.

14. MINERAL/TIMBER ACTIVITY:

Primary mineral resources that are present in the vicinity consist of sand and gravel. Commercial excavation and developed borrow pits exist in the Region, but not within the project area. Other mineral resources occurring in the area include barite, fluorite, calcite, uranium, silver, iron, perlite, and coal. The existing spoil-bank contains an appreciable quantity of

excavated sand and gravel. There are no Oil and Gas activities/ownership within the project area. There are other mineral resources in the area, but not within the footprint of the project.

15. NON-FEDERAL SPONSOR'S ABILITY TO ACQUIRE:

Assessments of the NMISC's and MRGCD's experience and capability to acquire real estate interest for the project are attached as Exhibit B and Exhibit C.

16. ZONING ANTICIPATED IN LIEU OF ACQUISITION:

There is no zoning modification proposed or anticipated at this time.

17. ACQUISITION SCHEDULE:

The following table is shown with Real Estate activities projected for Fiscal Year 2012. Real Estate activities are planned to continue through the year 2026 to support the fourteen phases of construction that are planned. Schedules for future phases will be developed as funding is made available for this project.

Acquisition Tasks for Phase 1, Segment 3	**Due**
Real Estate Personnel meet with Non-Federal Sponsor (MRGCD)	After the Project Delivery Team has identified a Tentatively Selected Plan (completed)
Real Estate Plan (120 days)	06 Apr 2012
Prepare Acquisition Maps/Legal Descriptions for Phase 1 Construction	19 Oct 2012
Obtain/Review Gross Appraisal	NLT 30 Jun 2012
Obtain Right-of-Entry & License for Phase 1 Construction (MRGCD & BOR)	30 Oct 2012
Send Take Letter to NFS for Proof of LERRDs Ownership	30 Oct 2012
Real Estate Certificate of Sufficiency for Phase 1 Construction	30 Oct 2012
Prepare and Submit Credit Requests	30 Oct 2013
Review/Approve or Deny Credit Requests	30 Oct 2014
Establish Value for Creditable LERRDs	30 Nov 2014

Table 4.

The plans and specifications for phase 1 are being developed concurrently with the preparation, completion and approval of the General Reevaluation Report (GRR) and Environmental Impact Statement Report II. Phase 1 construction will begin 1000 feet west into the Socorro Diversion Channel to tie in the engineered levee to the Socorro Diversion then will proceed south along the existing spoil bank alignment south for approximately 2 miles.

Construction of phase 1 is anticipated to be awarded in December 2012. All the necessary real estate interests for the entire project will be acquired or certification received in phases. The current estimate is that total project will require 14 phases to construct based on an assumed

federal funding level of $10,000,000 per year. The Non-Federal Sponsors will be required to acquire the required real estate interests to support the construction of the project, one phase at a time and prior to advertisement of each phase of construction.

18. DESCRIPTION OF FACILITY AND UTILITY RELOCATIONS:

Utility / Facility subject were identified by District General Engineering Section and are limited to the following:

a. Facility Relocations: There are no facility relocations involved with the proposed project.

b. Utility Relocations: Fiber optic communication lines, owned by CenturyLink (formerly Qwest), are known to exist within the spoil bank and will be physically impacted as a result of construction of the engineered levee. A Preliminary Attorney's Opinion of Compensability has been prepared and used to determine that Qwest does not have a compensable interest in real property and is not entitled to just compensation. Neither the Government nor the Non-Federal Sponsor has a legal obligation to relocate the communication line. As a result, any modification of the line or its location within the levee is not classified as relocation and any associated costs are not included as a LERRDs credit. A final opinion of compensability will be prepared as required by ER 405-1-12, 12-22.

Because of the absence of the hydraulic link between the proposed levee and the existing bridge, the Corps has no authority to reconstruct the railroad bridge and the San Marcial Railroad Bridge is not included in the TSP.

19. HAZARDOUS, TOXIC, AND RADIOLOGICAL WASTE IMPACTS:

According to the Hazardous, Toxic, and Radioactive Waste (HTRW) portion of Chapter 2, Section 2.3, of the Draft General Reevaluation Report and Supplemental Environmental Impact Statement (GRR/SEIS), Echota Technologies Corporation completed a Phase 1 Environmental Site Assessment on July 20 and August 8, 2005, of the project corridor in and around the Tiffany area which, includes the site of a former railroad maintenance facility roundhouse in the former town of San Marcial. Although the site is over 2,000 feet from the proposed levee alignment, the report states “if construction activities are anticipated near the former railroad facility, then a Phase II Environmental Site Investigation is recommended to verify the degradation of petroleum products”.

In addition, BOR operates two maintenance and storage facilities within the project area. The first maintenance facility is located 0.15 miles west of the SADD near the perimeter of the project limits, and the other is located 0.49 miles north-northwest of the LFCC near the Tiffany area. In the past, these two sites were identified as having some underground petroleum storage tanks leaks. BOR reported that the tanks were removed in 1991. The two sites are not expected to pose an HTRW risk unless construction activities are anticipated near either site. If construction activities are anticipated, a Phase II Environmental Site Investigation is recommended. None of these areas will be used for borrow areas, if borrow areas are needed**.**

20. ATTITUDE OF LANDOWNERS:

It is anticipated that there will be some opposition to the project. Within Tiffany Basin, there are known condemnation actions required to clear title to approximately 302 acres needed at Tiffany Basin for spoil waste and one environmental mitigation site. There is a strong possibility, based on past civil project history, that approximately fifteen percent of the remaining 3 owners could oppose the project. As a result, one condemnation action is included in the baseline cost estimate. The possible condemnation action would not occur for ten or more years based upon the location and projected progression of the project and the cost may change accordingly. The condemnation estimated cost is based upon similar actions elsewhere.
The Tiffany Sedimentation Basin consists of 138 tracts held in fee simple title by 36 separate owners. There are seven parcels that are claimed by three owners: N.M. Ranch Properties, Inc., Wesley Bruton, and Jack Bruton and the project would impact these three land owners. Because Tiffany Canyon is on grant lands and never having received a Cadastral Survey, ownership is only an estimate at this time, as per the Socorro County Assessor Office. The acquisition of these seven parcels will require condemnation action to clear the clouded title.

Managers for both the Sevilleta National Wildlife Refuge (NWR) and Bosque del Apache NWR (managed by U.S. Fish and Wildlife Service), support the project as it benefits their refuges.

Prepared by:

Mark K. Turkovich

Mark K. Turkovich
Realty Specialist
06APR2012

Reviewed and approved by:

KENNEDY.KAREN.M.1230934289 Digitally signed by KENNEDY.KAREN.M.1230934289 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=KENNEDY.KAREN.M.1230934289 Date: 2012.04.06 10:00:37 -06'00'

Karen Kennedy
Chief, Real Estate Division
06APR2012

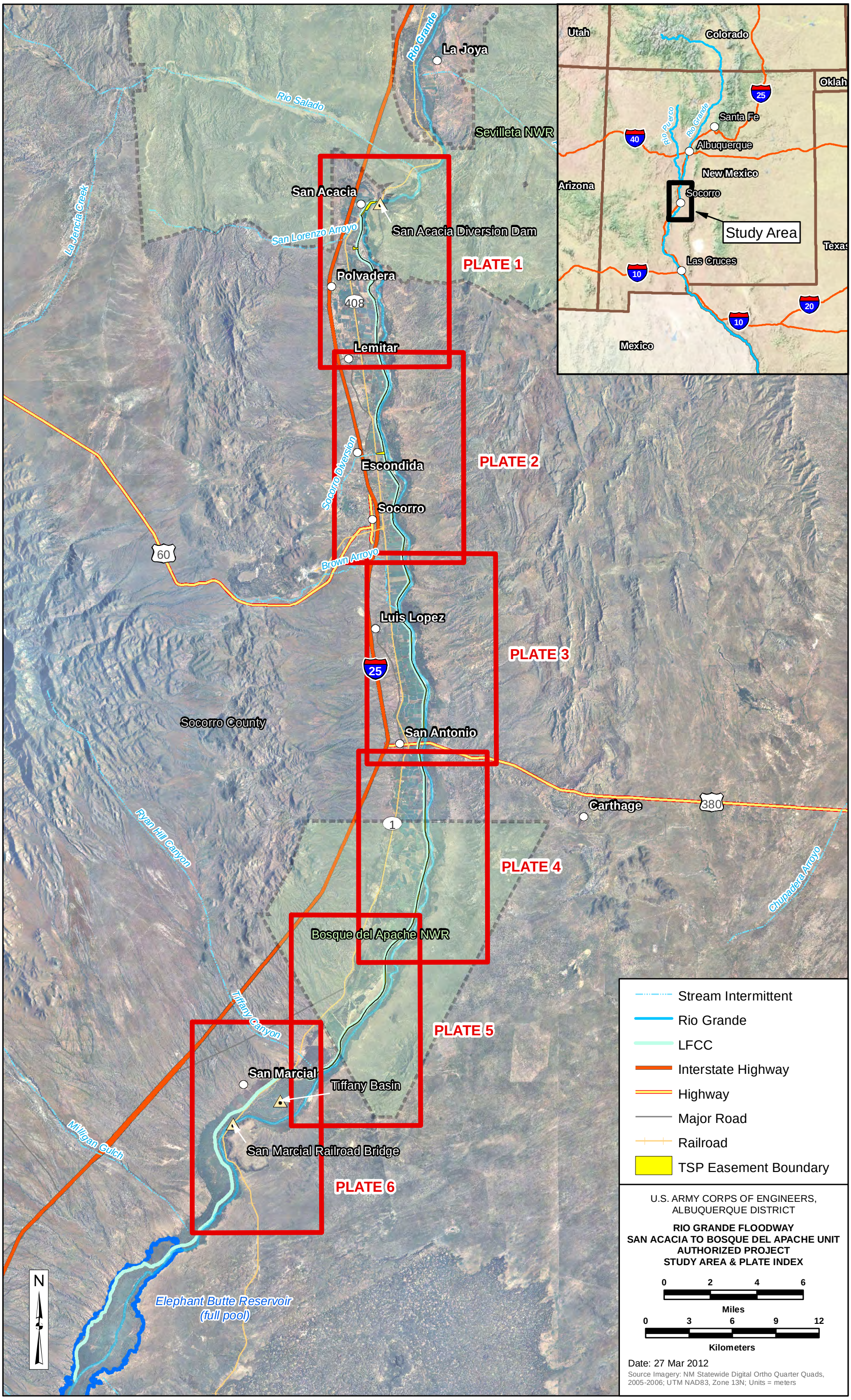

La Joya
Rio Grande
Rio Salado
Sevilleta NWR
San Acacia
San Acacia Diversion Dam
San Lorenzo Arroyo
La Jencia Creek
PLATE 1
Polvadera
408
Lemitar
PLATE 2
Escondida
Socorro Diversion
Socorro
60
Brown Arroyo
Luis Lopez
PLATE 3
25
Socorro County
San Antonio
Carthage
880
1
Ryan Hill Canyon
PLATE 4
Chupadera Arroyo
Bosque del Apache NWR
Tiffany Canyon
PLATE 5
San Marcial
Tiffany Basin
Milligan Gulch
San Marcial Railroad Bridge
PLATE 6
N
Elephant Butte Reservoir
(full pool)
Utah
Colorado
Oklah
Santa Fe
Rio Puerco
Rio Grande
40
Albuquerque
New Mexico
Arizona
Socorro
Study Area
Texas
Las Cruces
10
20
Mexico
Stream Intermittent
Rio Grande
LFCC
Interstate Highway
Highway
Major Road
Railroad
TSP Easement Boundary
U.S. ARMY CORPS OF ENGINEERS,
ALBUQUERQUE DISTRICT
RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT
AUTHORIZED PROJECT
STUDY AREA & PLATE INDEX
0 2 4 6
Miles
0 3 6 9 12
Kilometers
Date: 27 Mar 2012
Source Imagery: NM Statewide Digital Ortho Quarter Quads, 2005-2006; UTM NAD83, Zone 13N; Units = meters

EXHIBIT A

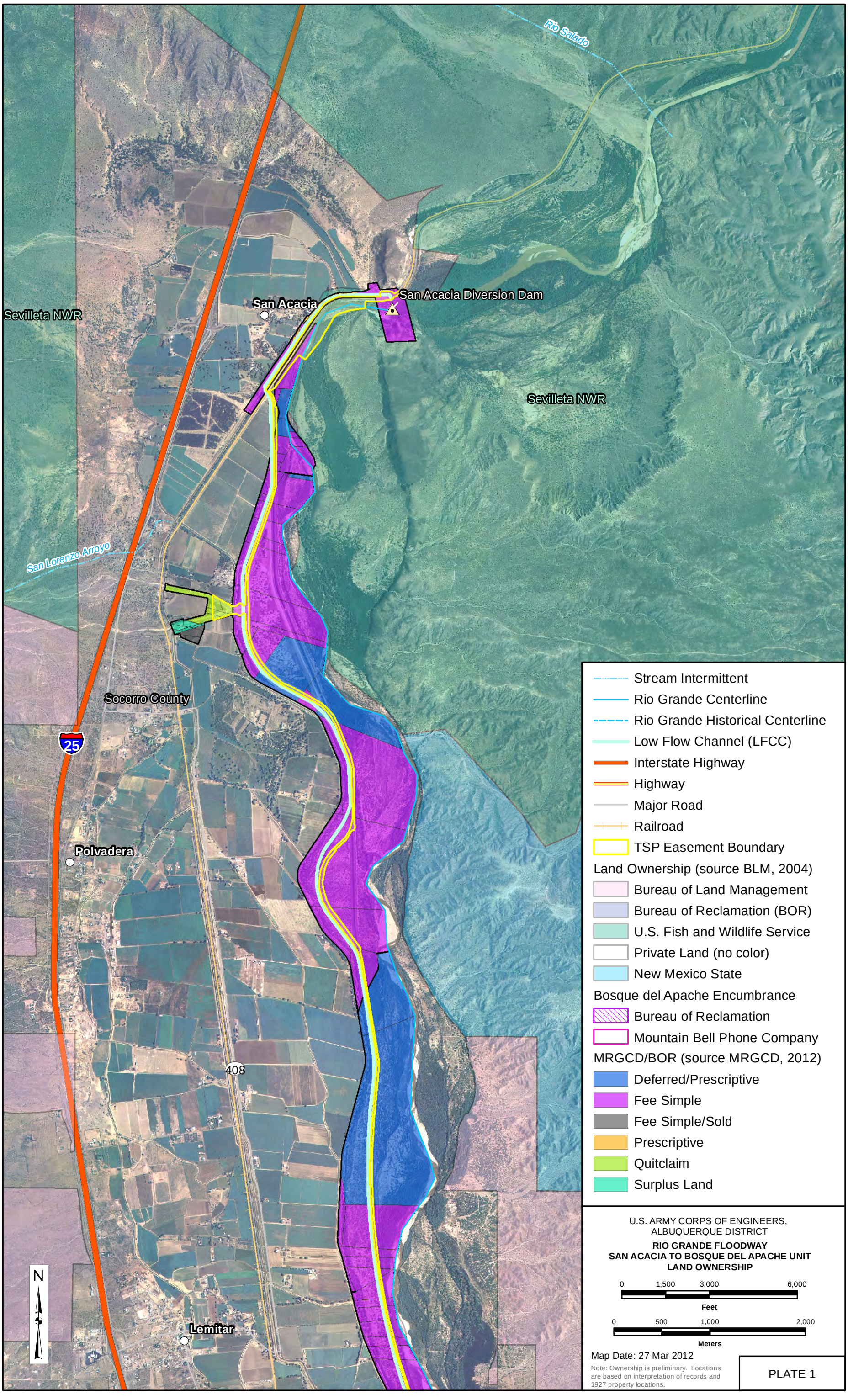
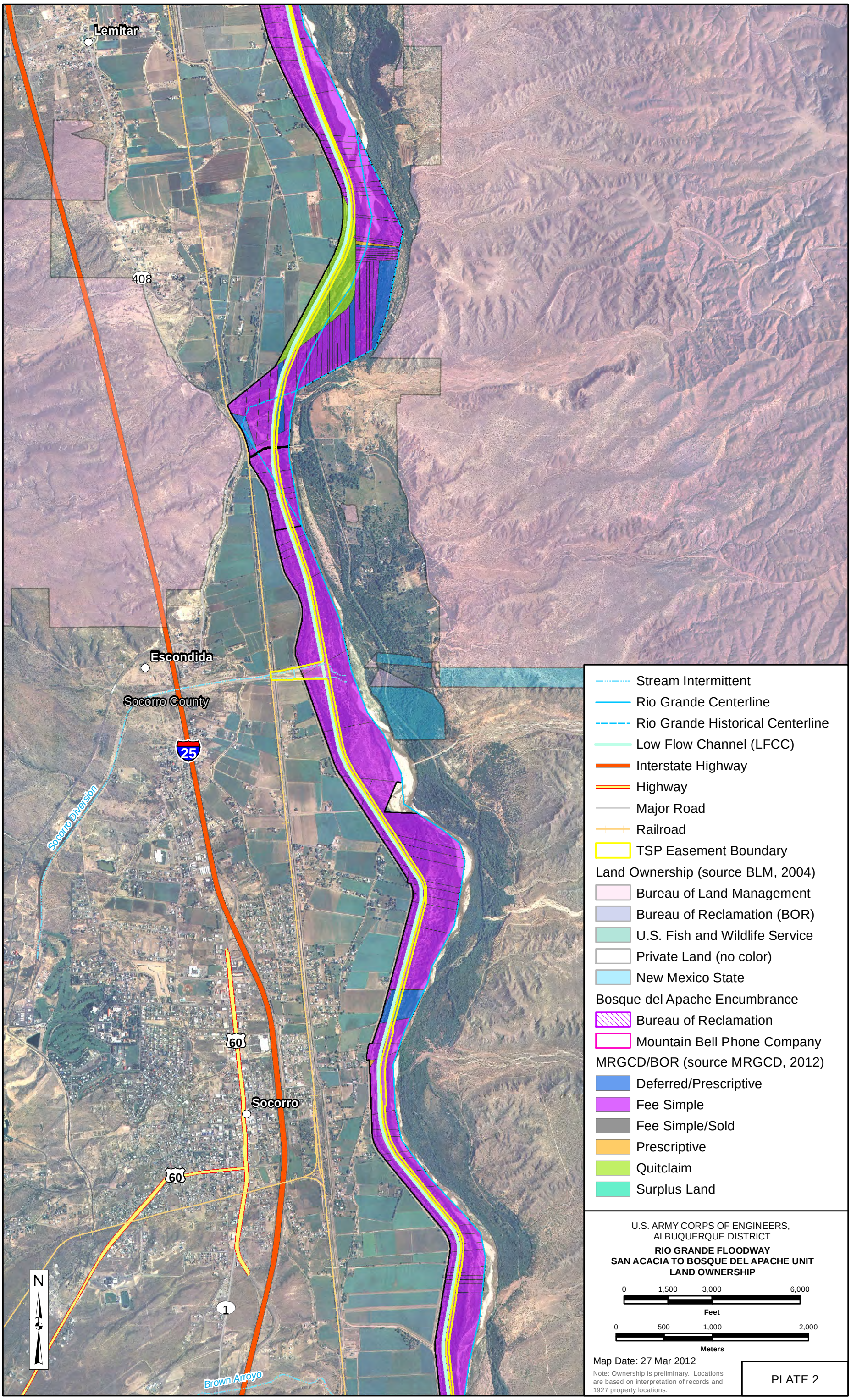

Rio Salado
San Acacia
San Acacia Diversion Dam
Sevilleta NWR
Sevilleta NWR
San Lorenzo Arroyo
Socorro County
25
Polvadera
408
Lemitar
N
Stream Intermittent
Rio Grande Centerline
Rio Grande Historical Centerline
Low Flow Channel (LFCC)
Interstate Highway
Highway
Major Road
Railroad
TSP Easement Boundary
Land Ownership (source BLM, 2004)
Bureau of Land Management
Bureau of Reclamation (BOR)
U.S. Fish and Wildlife Service
Private Land (no color)
New Mexico State
Bosque del Apache Encumbrance
Bureau of Reclamation
Mountain Bell Phone Company
MRGCD/BOR (source MRGCD, 2012)
Deferred/Prescriptive
Fee Simple
Fee Simple/Sold
Prescriptive
Quitclaim
Surplus Land
U.S. ARMY CORPS OF ENGINEERS,
ALBUQUERQUE DISTRICT
RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT
LAND OWNERSHIP
0 1,500 3,000 6,000
Feet
0 500 1,000 2,000
Meters
Map Date: 27 Mar 2012
Note: Ownership is preliminary. Locations are based on interpretation of records and 1927 property locations.
PLATE 1

EXHIBIT A


Lemitar
408
Escondida
Socorro County
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Socorro Diversion
60
Socorro
60
1
Brown Arroyo
N
Stream Intermittent
Rio Grande Centerline
Rio Grande Historical Centerline
Low Flow Channel (LFCC)
Interstate Highway
Highway
Major Road
Railroad
TSP Easement Boundary
Land Ownership (source BLM, 2004)
Bureau of Land Management
Bureau of Reclamation (BOR)
U.S. Fish and Wildlife Service
Private Land (no color)
New Mexico State
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Deferred/Prescriptive
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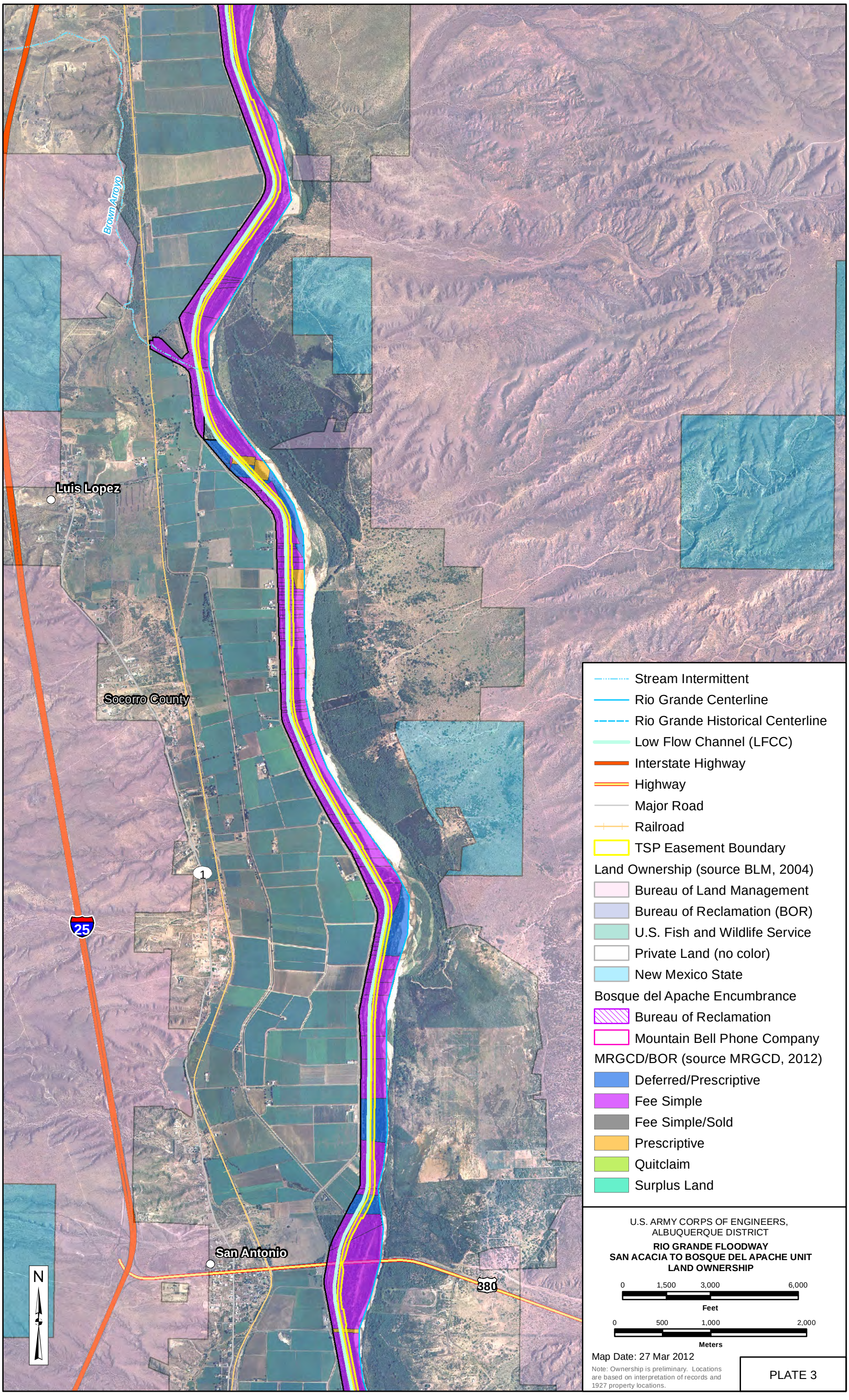
Prescriptive
Quitclaim
Surplus Land
U.S. ARMY CORPS OF ENGINEERS,
ALBUQUERQUE DISTRICT
RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT
LAND OWNERSHIP
0 1,500 3,000 6,000
Feet
0 500 1,000 2,000
Meters
Map Date: 27 Mar 2012
Note: Ownership is preliminary. Locations are based on interpretation of records and 1927 property locations.
PLATE 2

EXHIBIT A


Brown Arroyo
Luis Lopez
Socorro County
1
25
San Antonio
380
N
Stream Intermittent
Rio Grande Centerline
Rio Grande Historical Centerline
Low Flow Channel (LFCC)
Interstate Highway
Highway
Major Road
Railroad
TSP Easement Boundary
Land Ownership (source BLM, 2004)
Bureau of Land Management
Bureau of Reclamation (BOR)
U.S. Fish and Wildlife Service
Private Land (no color)
New Mexico State
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Bureau of Reclamation
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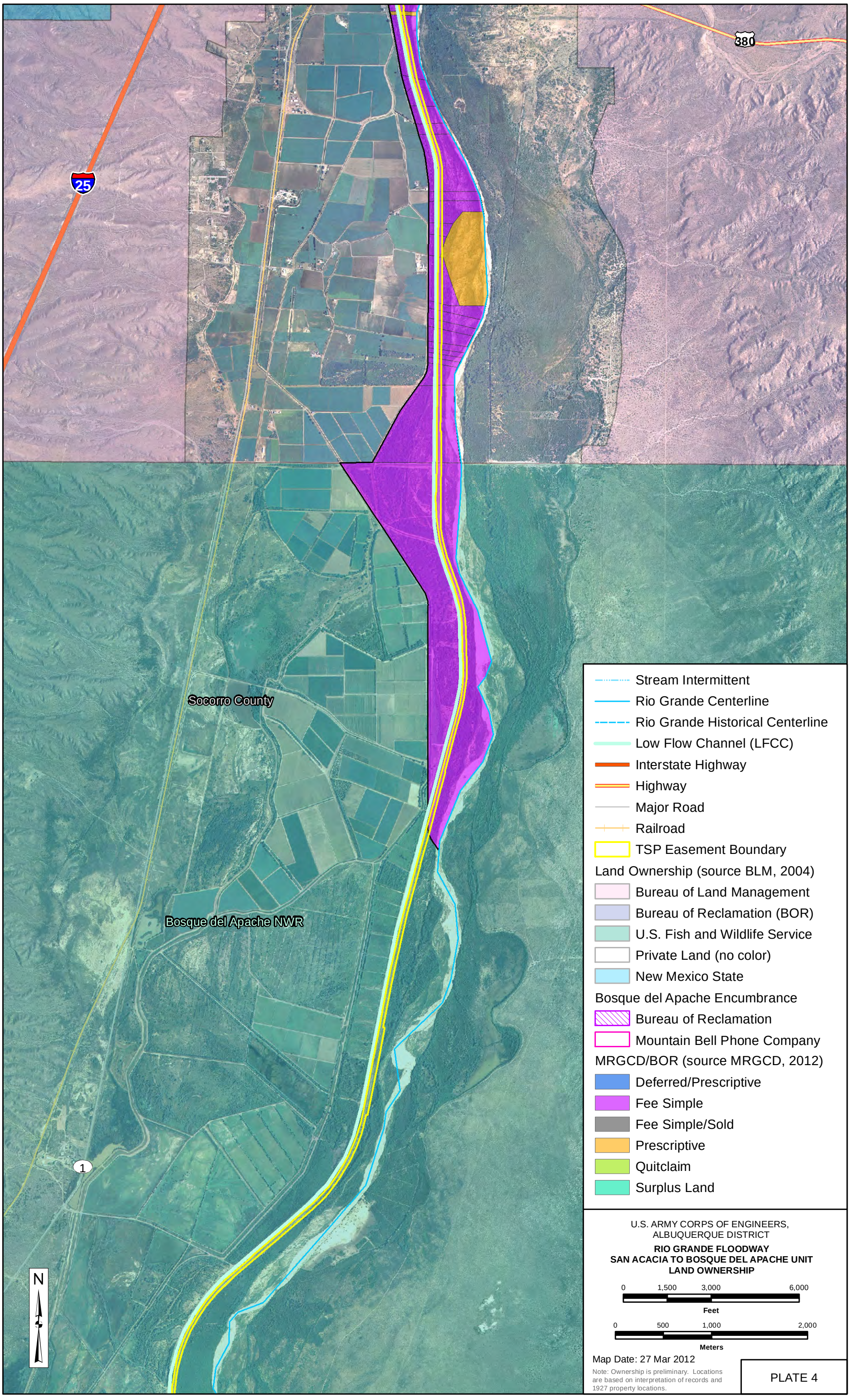
MRGCD/BOR (source MRGCD, 2012)
Deferred/Prescriptive
Fee Simple
Fee Simple/Sold
Prescriptive
Quitclaim
Surplus Land
U.S. ARMY CORPS OF ENGINEERS,
ALBUQUERQUE DISTRICT
RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT
LAND OWNERSHIP
0 1,500 3,000 6,000
Feet
0 500 1,000 2,000
Meters
Map Date: 27 Mar 2012
Note: Ownership is preliminary. Locations are based on interpretation of records and 1927 property locations.
PLATE 3

EXHIBIT A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380
Socorro County
Bosque del Apache NWR
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Stream Intermittent
Rio Grande Centerline
Rio Grande Historical Centerline
Low Flow Channel (LFCC)
Interstate Highway
Highway
Major Road
Railroad
TSP Easement Boundary
Land Ownership (source BLM, 2004)
Bureau of Land Management
Bureau of Reclamation (BOR)
U.S. Fish and Wildlife Service
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New Mexico State
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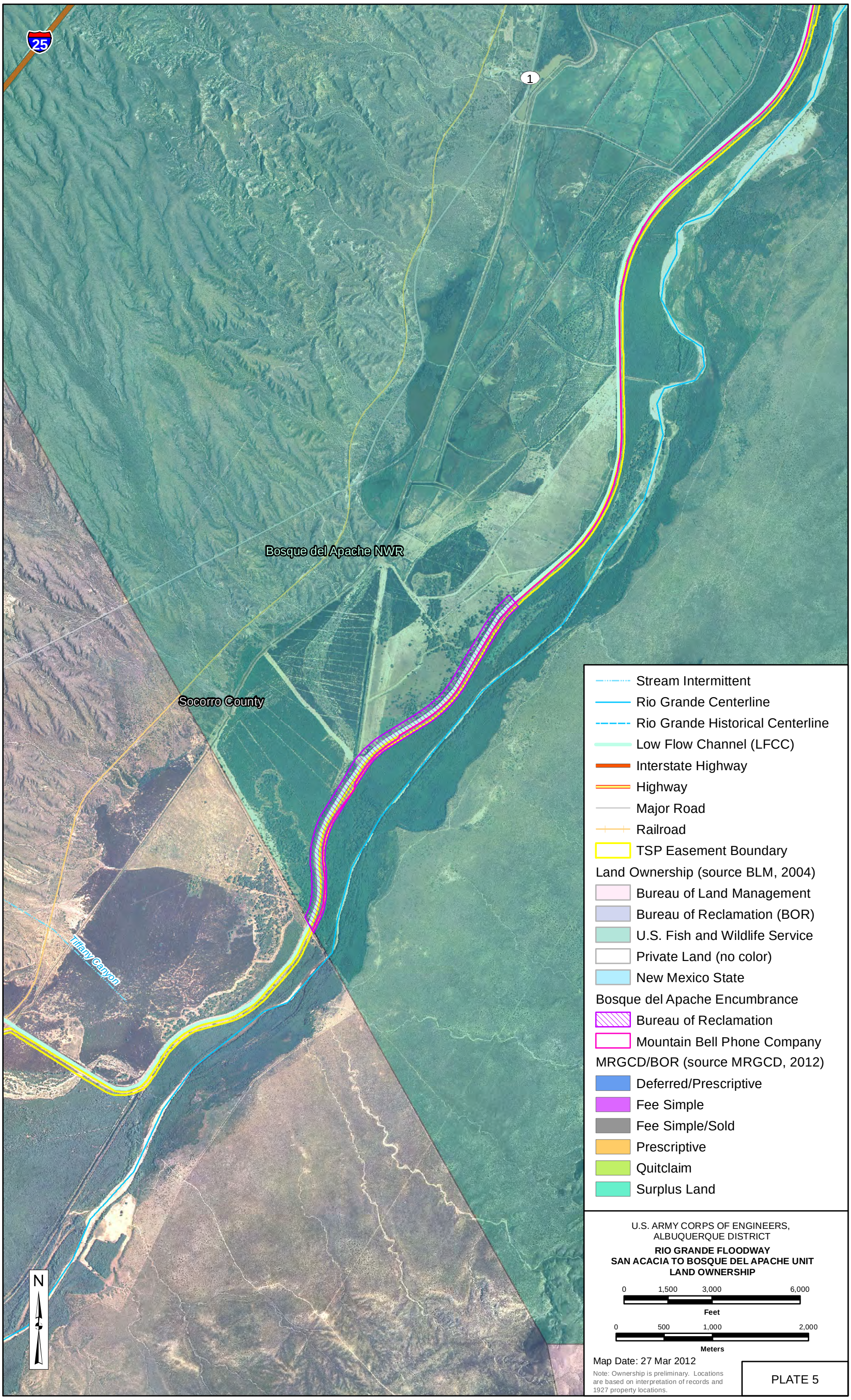
Bureau of Reclamation
Mountain Bell Phone Company
MRGCD/BOR (source MRGCD, 2012)
Deferred/Prescriptive
Fee Simple
Fee Simple/Sold
Prescriptive
Quitclaim
Surplus Land
U.S. ARMY CORPS OF ENGINEERS,
ALBUQUERQUE DISTRICT
RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT
LAND OWNERSHIP
0 1,500 3,000 6,000
Feet
0 500 1,000 2,000
Meters
Map Date: 27 Mar 2012
Note: Ownership is preliminary. Locations are based on interpretation of records and 1927 property locations.
PLATE 4

EXHIBIT A


25
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Bosque del Apache NWR
Socorro County
Tiffany Canyon
N
Stream Intermittent
Rio Grande Centerline
Rio Grande Historical Centerline
Low Flow Channel (LFCC)
Interstate Highway
Highway
Major Road
Railroad
TSP Easement Boundary
Land Ownership (source BLM, 2004)
Bureau of Land Management
Bureau of Reclamation (BOR)
U.S. Fish and Wildlife Service
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MRGCD/BOR (source MRGCD, 2012)
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Fee Simple
Fee Simple/Sold
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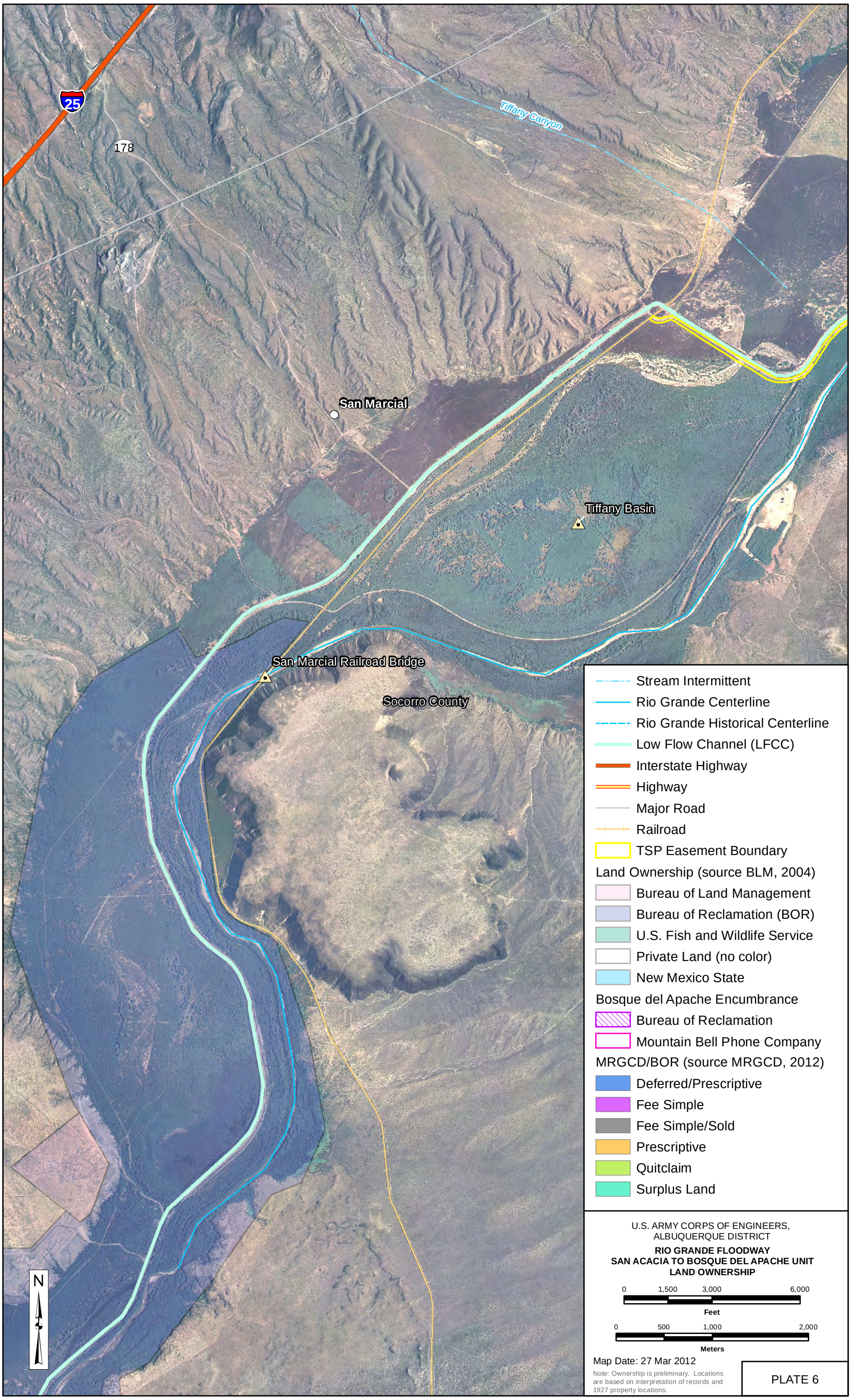
Quitclaim
Surplus Land
U.S. ARMY CORPS OF ENGINEERS,
ALBUQUERQUE DISTRICT
RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT
LAND OWNERSHIP
0 1,500 3,000 6,000
Feet
0 500 1,000 2,000
Meters
Map Date: 27 Mar 2012
Note: Ownership is preliminary. Locations are based on interpretation of records and 1927 property locations.
PLATE 5

EXHIBIT A


25
178
Tiffany Canyon
San Marcial
Tiffany Basin
San Marcial Railroad Bridge
Socorro County
N
Stream Intermittent
Rio Grande Centerline
Rio Grande Historical Centerline
Low Flow Channel (LFCC)
Interstate Highway
Highway
Major Road
Railroad
TSP Easement Boundary
Land Ownership (source BLM, 2004)
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U.S. Fish and Wildlife Service
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MRGCD/BOR (source MRGCD, 2012)
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Fee Simple/Sold
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U.S. ARMY CORPS OF ENGINEERS,
ALBUQUERQUE DISTRICT
RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT
LAND OWNERSHIP
0 1,500 3,000 6,000
Feet
0 500 1,000 2,000
Meters
Map Date: 27 Mar 2012
Note: Ownership is preliminary. Locations are based on interpretation of records and 1927 property locations.
PLATE 6

EXHIBIT A

	A	B	C	D	E	F	G	H	I	J	K	L	N
1	Land Ownership Intersecting San Acacia TSP Easement Boundary					Project Land Requirements							
2	OWNER	OWNER TYPE	OWNER DESCRIPTION	FACILITY NAME	PARCEL AREA	FEE	PCIE Channel	P.R.E. Road	T.W.A.E. Temp Work Area			FPLE Levee	Sum
3					ACRES				Veg	Stage	Constr		by APN
4						ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES
5	MRGCD/BOR	DEFERRED/PRESC	PT OF MAP 148 TR 5	LEMITAR RIVERSIDE DRAIN	0.35								
6	MRGCD/BOR	DEFERRED/PRESC	PT OF MAP 167 TR 62	SOCORRO RIVERSIDE DRAIN "A"	0.93								
7	MRGCD/BOR	DEFERRED/PRESC	PT OF MAP 170 TR 50	SOCORRO RIVERSIDE DRAIN	2.30								
8	MRGCD/BOR	DEFERRED/PRESC	PT OF MAP 172 TR 13	SOCORRO RIVERSIDE DRAIN	4.12								
9	MRGCD/BOR	DEFERRED/PRESC	PT OF MAP 149 TR 60B	LEMITAR RIVERSIDE DRAIN	3.47								
10	MRGCD/BOR	DEFERRED/PRESC	ALL OF MAP 149 TR 60D	LEMITAR RIVERSIDE DRAIN	1.67								
11	MRGCD/BOR	DEFERRED/PRESC	PT OF MAP 162 TR 48	SOCORRO RIVERSIDE DRAIN "B"	2.57								
12	MRGCD/BOR	DEFERRED/PRESC	PT OF MAP 156 TR 67	LEMITAR RIVERSIDE DRAIN	3.86								
13	MRGCD/BOR	DEFERRED/PRESC	PT OF MAP 151 TR 51	LEMITAR RIVERSIDE DRAIN	2.04								
14	MRGCD/BOR	DEFERRED/PRESC	PT OF MAP 152 TR 1	LEMITAR RIVERSIDE DRAIN	8.99								
15	MRGCD/BOR	DEFERRED/PRESC	ALL OF MAP 167 TR 89	SOCORRO RIVERSIDE DRAIN	0.92								
16	MRGCD/BOR	DEFERRED/PRESC	PT OF MAP 173 TRS 7 & 8	SAN ANTONIO RIVERSIDE DRAIN	2.93								
17	MRGCD/BOR	FEE SIMPLE	PT OF MAP 166 TR 4	SOCORRO RIVERSIDE DRAIN "B"	0.29								
18	MRGCD/BOR	FEE SIMPLE	PT OF MAP 166 TR 5	SOCORRO RIVERSIDE DRAIN "B"	0.42								
19	MRGCD/BOR	FEE SIMPLE	PORTION OF MAP 164 TRACT 4	SOCORRO RIVERSIDE DRAIN	0.08								
20	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 59	SOCORRO RIVERSIDE DRAIN "B"	0.28								
21	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 56	SOCORRO RIVERSIDE DRAIN "B"	0.31								
22	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 58	SOCORRO RIVERSIDE DRAIN "B"	0.23								
23	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 57	SOCORRO RIVERSIDE DRAIN "B"	0.41								
24	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 60	SOCORRO RIVERSIDE DRAIN "B"	0.59								
25	MRGCD/BOR	FEE SIMPLE	PT OF MAP 162 TR 46	SOCORRO RIVERSIDE DRAIN "B"	1.32								
26	MRGCD/BOR	FEE SIMPLE	PT OF MAP 158 TR 36	SOCORRO RIVERSIDE DRAIN "B"	0.65								
27	MRGCD/BOR	FEE SIMPLE	PT OF MAP 157 TR 28	SOCORRO RIVERSIDE DRAIN "B"	0.50								
28	MRGCD/BOR	FEE SIMPLE	ALL OF MAP 166 TR 16	SOCORRO RIVERSIDE DRAIN "A"	2.00								
29	MRGCD/BOR	FEE SIMPLE	PT OF MAP 166 TR 3	SOCORRO RIVERSIDE DRAIN "B"	0.26								
30	MRGCD/BOR	FEE SIMPLE	PT OF MAP 157 TR 25	SOCORRO RIVERSIDE DRAIN "B"	1.85								
31	MRGCD/BOR	FEE SIMPLE	PT OF MAP 157 TR 26	SOCORRO RIVERSIDE DRAIN "B"	1.51								
32	MRGCD/BOR	FEE SIMPLE	PT OF MAP 157 TR 27	SOCORRO RIVERSIDE DRAIN "B"	0.36								
33	MRGCD/BOR	FEE SIMPLE	PT OF MAP 158 TR 37	SOCORRO RIVERSIDE DRAIN "B"	1.99								
34	MRGCD/BOR	FEE SIMPLE	PT OF MAP 158 TR 35	SOCORRO RIVERSIDE DRAIN "B"	0.52								
35	MRGCD/BOR	FEE SIMPLE	PT OF MAP 158 TR 42	SOCORRO RIVERSIDE DRAIN "B"	0.35								
36	MRGCD/BOR	FEE SIMPLE	ALL OF MAP 160 TR 4	SOCORRO RIVERSIDE DRAIN "B"	0.89								
37	MRGCD/BOR	FEE SIMPLE	PT OF MAP 159 TR 11	SOCORRO RIVERSIDE DRAIN "B"	1.37								
38	MRGCD/BOR	FEE SIMPLE	PT OF MAP 161 TR 1	SOCORRO RIVERSIDE DRAIN "B"	5.36								
39	MRGCD/BOR	FEE SIMPLE	PT OF MAP 159 TR 7	SOCORRO RIVERSIDE DRAIN "B"	11.84								
40	MRGCD/BOR	FEE SIMPLE	PT OF MAP 160 TR 8	SOCORRO RIVERSIDE DRAIN "B"	0.50								
41	MRGCD/BOR	FEE SIMPLE	PT OF MAP 160 TR 7	SOCORRO RIVERSIDE DRAIN "B"	0.50								
42	MRGCD/BOR	FEE SIMPLE	ALL OF MAP 160 TR 6	SOCORRO RIVERSIDE DRAIN "B"	0.46								
43	MRGCD/BOR	FEE SIMPLE	ALL OF MAP 160 TR 5	SOCORRO RIVERSIDE DRAIN "B"	1.71								
44	MRGCD/BOR	FEE SIMPLE	PT OF MAP 162 TR 18	SOCORRO RIVERSIDE DRAIN "B"	2.33								
45	MRGCD/BOR	FEE SIMPLE	PT OF MAP 162 TR 32D	SOCORRO MAIN CANAL AND SOCORRO RIVERSIDE DRAIN "B"	1.37								
46	MRGCD/BOR	FEE SIMPLE	PT OF MAP 160 TR 9	SOCORRO RIVERSIDE DRAIN "B"	1.74								
47	MRGCD/BOR	FEE SIMPLE	PT OF MAP 160 TR 10	SOCORRO RIVERSIDE DRAIN "B"	5.23								
48	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 28	SOCORRO RIVERSIDE DRAIN "B"	3.60								
49	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 14	SOCORRO RIVERSIDE DRAIN "B"	1.47								
50	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 15	SOCORRO RIVERSIDE DRAIN "B"	1.19								
51	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 12	SOCORRO RIVERSIDE DRAIN "B"	0.65								
52	MRGCD/BOR	FEE SIMPLE	PT OF MAP 159 TR 10	SOCORRO RIVERSIDE DRAIN "B"	4.04								
53	MRGCD/BOR	FEE SIMPLE	PT OF MAP 162 TR 44	SOCORRO RIVERSIDE DRAIN "B"	6.50								
54	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 1	SOCORRO RIVERSIDE DRAIN "B"	0.59								
55	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 2	SOCORRO RIVERSIDE DRAIN "B"	1.42								
56	MRGCD/BOR	FEE SIMPLE	PT OF MAP 158 TR 39	SOCORRO RIVERSIDE DRAIN "B"	9.71								
57	MRGCD/BOR	FEE SIMPLE	PT OF MAP 158 TR 33A	SOCORRO RIVERSIDE DRAIN "B"	0.89								
58	MRGCD/BOR	FEE SIMPLE	PT OF MAP 158 TR 33	SOCORRO RIVERSIDE DRAIN "B"	2.19								
59	MRGCD/BOR	FEE SIMPLE	PT OF MAP 166 TR 10	SOCORRO RIVERSIDE DRAIN "B"	2.08								
60	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 42	SOCORRO RIVERSIDE DRAIN "B"	0.65								
61	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 53	SOCORRO RIVERSIDE DRAIN "B"	1.26								
62	MRGCD/BOR	FEE SIMPLE	PORTION OF MAP 164 TRACT 1	SOCORRO RIVERSIDE DRAIN "B"	0.14								
63	MRGCD/BOR	FEE SIMPLE	PT OF MAP 147 UNPLATTED LD ADJ TO TRS 20 AND 31	SOCORRO MAIN CANAL (NORTH)	0.58								

	A	B	C	D	E	F	G	H	I	J	K	L	N
1	Land Ownership Intersecting San Acacia TSP Easement Boundary					Project Land Requirements							
2	OWNER	OWNER TYPE	OWNER DESCRIPTION	FACILITY NAME	PARCEL AREA	FEE	PCIE Channel	P.R.E. Road	T.W.A.E. Temp Work Area			FPLE Levee	Sum
3					ACRES				Veg	Stage	Constr		by APN
4						ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES
64	MRGCD/BOR	FEE SIMPLE	PT OF MAP 147 TR 20	SOCORRO MAIN CANAL (NORTH)	0.05								
65	MRGCD/BOR	FEE SIMPLE	PT OF MAP 147 TR 31	SOCORRO MAIN CANAL (NORTH)	0.01								
66	MRGCD/BOR	FEE SIMPLE	ALL OF MAP 147 TR 35	SOCORRO MAIN CANAL (NORTH)	0.40								
67	MRGCD/BOR	FEE SIMPLE	PT OF MAP 147 TR 38	SOCORRO MAIN CANAL (NORTH)	0.26								
68	MRGCD/BOR	FEE SIMPLE	PT OF MAP 147 TR 40	SOCORRO MAIN CANAL (NORTH)	0.11								
69	MRGCD/BOR	FEE SIMPLE	PT OF MAP 147 TR 102	SOCORRO MAIN CANAL (NORTH)	0.62								
70	MRGCD/BOR	FEE SIMPLE	PT OF MAP 147 TR 101	SOCORRO MAIN CANAL (NORTH)	0.87								
71	MRGCD/BOR	FEE SIMPLE	ALL OF MAP 147 TRS 107 AND 108	LEMITAR RIVERSIDE DRAIN	7.88								
72	MRGCD/BOR	FEE SIMPLE	PT OF MAP 147 TR 109	LEMITAR RIVERSIDE DRAIN	0.00								
73	MRGCD/BOR	FEE SIMPLE	PT OF MAP 148 TR 7	LEMITAR RIVERSIDE DRAIN	1.30								
74	MRGCD/BOR	FEE SIMPLE	PT OF MAP 148 TR 8	LEMITAR RIVERSIDE DRAIN	0.50								
75	MRGCD/BOR	FEE SIMPLE	PT OF MAP 148 TR 9	LEMITAR RIVERSIDE DRAIN	0.51								
76	MRGCD/BOR	FEE SIMPLE	ALL OF MAP 148 TRS 63C, 63D & 63E AND PT OF TR 63B	LEMITAR RIVERSIDE DRAIN	0.76								
77	MRGCD/BOR	FEE SIMPLE	ALL OF MAP 149 TR 2B	LEMITAR RIVERSIDE DRAIN	5.72								
78	MRGCD/BOR	FEE SIMPLE	PT OF MAP 167 TR 88	SOCORRO RIVERSIDE DRAIN	4.68								
79	MRGCD/BOR	FEE SIMPLE	PT OF MAP 165 TR 1	SOCORRO RIVERSIDE DRAIN "B"	30.84								
80	MRGCD/BOR	FEE SIMPLE	PT OF MAP 166 TR 9	SOCORRO RIVERSIDE DRAIN "B"	3.33								
81	MRGCD/BOR	FEE SIMPLE	PT OF MAP 179 TR 3	SAN ANTONIO RIVERSIDE DRAIN	0.59								
82	MRGCD/BOR	FEE SIMPLE	PT OF MAP 147 SEVILETTA GRANT, T 1 S, R 1 W & R 1 E, SE	SAN ACACIA DIVERSION DAM	4.72								
83	MRGCD/BOR	FEE SIMPLE	PT OF MAP 150 TR 36	LEMITAR RIVERSIDE DRAIN	8.99								
84	MRGCD/BOR	FEE SIMPLE	PT OF MAP 151 TR 12	LEMITAR RIVERSIDE DRAIN	2.38								
85	MRGCD/BOR	FEE SIMPLE	PT OF MAP 151 TR 12	LEMITAR RIVERSIDE DRAIN	5.31								
86	MRGCD/BOR	FEE SIMPLE	PT OF MAP 169 TR 13	SOCORRO RIVERSIDE DRAIN	0.87								
87	MRGCD/BOR	FEE SIMPLE	PT OF MAP 170 TR 22B	SOCORRO RIVERSIDE DRAIN	0.02								
88	MRGCD/BOR	FEE SIMPLE	PT OF MAP 170 TR 22C	SOCORRO RIVERSIDE DRAIN	0.07								
89	MRGCD/BOR	FEE SIMPLE	PT OF MAP 170 TR 33	SOCORRO RIVERSIDE DRAIN	1.16								
90	MRGCD/BOR	FEE SIMPLE	PT OF MAP 167 TR 63	SOCORRO RIVERSIDE DRAIN	0.55								
91	MRGCD/BOR	FEE SIMPLE	PT OF MAP 170 TR 34	SOCORRO RIVERSIDE DRAIN	1.12								
92	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 61	SOCORRO RIVERSIDE DRAIN	0.85								
93	MRGCD/BOR	FEE SIMPLE	PT OF MAP 169 TR 4	SOCORRO RIVERSIDE DRAIN	0.80								
94	MRGCD/BOR	FEE SIMPLE	PT OF MAP 176 TR 72	SAN ANTONIO RIVERSIDE DRAIN	1.04								
95	MRGCD/BOR	FEE SIMPLE	PT OF MAP 176 TR 73	SAN ANTONIO RIVERSIDE DRAIN	0.83								
96	MRGCD/BOR	FEE SIMPLE	PT OF MAP 169 TR 12	SOCORRO RIVERSIDE DRAIN	6.46								
97	MRGCD/BOR	FEE SIMPLE	PT OF MAP 169 TR 21	SOCORRO RIVERSIDE DRAIN	0.89								
98	MRGCD/BOR	FEE SIMPLE	PT OF MAP 170 TR 22D	SOCORRO RIVERSIDE DRAIN	0.13								
99	MRGCD/BOR	FEE SIMPLE	PT OF MAP 170 TR 22E	SOCORRO RIVERSIDE DRAIN	0.19								
100	MRGCD/BOR	FEE SIMPLE	PT OF MAP 166 TR 9-A	SAN ANTONITO LATERAL AND LEVEE AND FLOODWAY	0.62								
101	MRGCD/BOR	FEE SIMPLE	PT OF MAP 150 TR 1	LEMITAR RIVERSIDE DRAIN	6.65								
102	MRGCD/BOR	FEE SIMPLE	PT OF MAP 177 TR 2B	SAN ANTONIO RIVERSIDE DRAIN	2.13								
103	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 43	SOCORRO RIVERSIDE DRAIN "B"	0.61								
104	MRGCD/BOR	FEE SIMPLE	PT OF MAP 163 TR 44	SOCORRO RIVERSIDE DRAIN "B"	0.52								
105	MRGCD/BOR	FEE SIMPLE	PT OF MAP 148 TR 62	LEMITAR RIVERSIDE DRAIN	1.05								
106	MRGCD/BOR	FEE SIMPLE	PT OF MAP 148 TR 65	LEMITAR RIVERSIDE DRAIN	1.16								
107	MRGCD/BOR	FEE SIMPLE	PT OF MAP 148 TR 66	LEMITAR RIVERSIDE DRAIN	1.06								
108	MRGCD/BOR	FEE SIMPLE	PT OF MAP 148 TR 67	LEMITAR RIVERSIDE DRAIN	0.61								
109	MRGCD/BOR	FEE SIMPLE	PT OF MAP 149 TR 2	LEMITAR RIVERSIDE DRAIN	2.76								
110	MRGCD/BOR	FEE SIMPLE	PT OF MAP 149 TR 2A	LEMITAR RIVERSIDE DRAIN	5.72								
111	MRGCD/BOR	FEE SIMPLE	PT OF MAP 149 TR 9	LEMITAR RIVERSIDE DRAIN	0.52								
112	MRGCD/BOR	FEE SIMPLE	PT OF MAP 149 TR 13	LEMITAR RIVERSIDE DRAIN	1.27								
113	MRGCD/BOR	FEE SIMPLE	PT OF MAP 149 TR 60A	LEMITAR RIVERSIDE DRAIN	1.95								
114	MRGCD/BOR	FEE SIMPLE	PT OF MAP 173 TR 26	SOCORRO RIVERSIDE DRAIN (NKA SAN ANTONIO RIVERSIDE DRAIN)	0.83								
115	MRGCD/BOR	FEE SIMPLE	PT OF MAP 173 TR 16	SAN ANTONIO RIVERSIDE DRAIN	8.26								
116	MRGCD/BOR	FEE SIMPLE	PT OF MAP 149 TR 60C	LEMITAR RIVERSIDE DRAIN	1.52								
117	MRGCD/BOR	FEE SIMPLE	PT OF MAP 149 TR 60	LEMITAR RIVERSIDE DRAIN	0.04								
118	MRGCD/BOR	FEE SIMPLE	PT OF BOSQUE DEL APACHE GRANT	SAN ANTONIO RIVERSIDE DRAIN & ELMENDORF DRAIN	36.82								
119	MRGCD/BOR	FEE SIMPLE	PT OF MAP 156 TR 4	LEMITAR RIVERSIDE DRAIN	0.11								
120	MRGCD/BOR	FEE SIMPLE	PT OF MAP 169 TR 5	SOCORRO RIVERSIDE DRAIN	1.48								
121	MRGCD/BOR	FEE SIMPLE	PT OF MAP 169 TR 6	SOCORRO RIVERSIDE DRAIN	0.73								
122	MRGCD/BOR	FEE SIMPLE	PT OF MAP 170 TR 2	SOCORRO RIVERSIDE DRAIN	3.77								

	A	B	C	D	E	F	G	H	I	J	K	L	N
1	Land Ownership Intersecting San Acacia TSP Easement Boundary					Project Land Requirements							
2	OWNER	OWNER TYPE	OWNER DESCRIPTION	FACILITY NAME	PARCEL AREA	FEE	PCIE Channel	P.R.E. Road	T.W.A.E. Temp Work Area			FPLE Levee	Sum
3					ACRES				Veg	Stage	Constr		by APN
4						ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES
123	MRGCD/BOR	FEE SIMPLE	PT OF MAP 170 TR 35	SOCORRO RIVERSIDE DRAIN	3.67								
124	MRGCD/BOR	FEE SIMPLE	PT OF MAP 179 TR 31	SAN ANTONIO RIVERSIDE DRAIN "B"	8.34								
125	MRGCD/BOR	FEE SIMPLE	PT OF MAP 179 TR 31	SAN ANTONIO RIVERSIDE DRAIN "B"	8.34								
126	MRGCD/BOR	FEE SIMPLE	PT OF MAP 156 TR 69	LEMITAR RIVERSIDE DRAIN	0.03								
127	MRGCD/BOR	FEE SIMPLE	PT OF MAP 169 TR 20	SOCORRO RIVERSIDE DRAIN	2.98								
128	MRGCD/BOR	FEE SIMPLE	PT OF MAP 157 TR 18	SOCORRO RIVERSIDE DRAIN "B"	0.89								
129	MRGCD/BOR	FEE SIMPLE	PT OF MAP 172 TR 8	SOCORRO RIVERSIDE DRAIN	3.78								
130	MRGCD/BOR	FEE SIMPLE	PT OF MAP 177 TR 2	SAN ANTONIO RIVERSIDE DRAIN	0.90								
131	MRGCD/BOR	FEE SIMPLE	PT OF MAP 176 TR 71	SAN ANTONIO RIVERSIDE DRAIN	0.73								
132	MRGCD/BOR	FEE SIMPLE	PT OF MAP 175 TR 78	SAN ANTONIO RIVERSIDE DRAIN	5.38								
133	MRGCD/BOR	FEE SIMPLE	PT OF MAP 175 TR 4	SAN ANTONIO RIVERSIDE DRAIN	5.96								
134	MRGCD/BOR	FEE SIMPLE	PT OF MAP 169 TR 22	SOCORRO RIVERSIDE DRAIN	0.86								
135	MRGCD/BOR	FEE SIMPLE	PT OF MAP 170 TR 22	SOCORRO RIVERSIDE DRAIN	1.28								
136	MRGCD/BOR	FEE SIMPLE	PT OF MAP 156 TR 66	LEMITAR RIVERSIDE DRAIN	0.81								
137	MRGCD/BOR	FEE SIMPLE	PT OF MAP 173 TR 25	SOCORRO RIVERSIDE DRAIN (NKA SAN ANTONIO RIVERSIDE DRAIN)	3.30								
138	MRGCD/BOR	FEE SIMPLE	PT OF MAP 179 TR 30	SAN ANTONIO RIVERSIDE DRAIN "B"	2.03								
139	MRGCD/BOR	FEE SIMPLE	PT OF MAP 179 TR 30	SAN ANTONIO RIVERSIDE DRAIN "B"	2.03								
140	MRGCD/BOR	FEE SIMPLE	PT OF MAP 156 TR 68	LEMITAR RIVERSIDE DRAIN	2.75								
141	MRGCD/BOR	FEE SIMPLE	PT OF MAP 172 TR 21	SOCORRO RIVERSIDE DRAIN (NKA SAN ANTONIO RIVERSIDE DRAIN)	5.53								
142	MRGCD/BOR	FEE SIMPLE	PT OF MAP 169 TR 23	SOCORRO RIVERSIDE DRAIN	1.72								
143	MRGCD/BOR	FEE SIMPLE	PT OF MAP 179 TR 2A	SAN ANTONIO RIVERSIDE DRAIN	0.48								
144	MRGCD/BOR	FEE SIMPLE	PT OF MAP 155 TR 1A	LEMITAR RIVERSIDE DRAIN	2.11								
145	MRGCD/BOR	FEE SIMPLE	PT OF MAP 177 TR 3	SAN ANTONIO RIVERSIDE DRAIN	2.31								
146	MRGCD/BOR	FEE SIMPLE	PT OF MAP 155 TR 1	LEMITAR RIVERSIDE DRAIN	1.65								
147	MRGCD/BOR	FEE SIMPLE	PTS OF MAP 146 TR 21 AND MAP 147 TR 3	SOCORRO MAIN CANAL (NORTH)	1.42								
148	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 93	SOCORRO RIVERSIDE DRAIN	0.90								
149	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 62	SOCORRO RIVERSIDE DRAIN	1.47								
150	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 87	SOCORRO RIVERSIDE DRAIN	0.39								
151	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 88	SOCORRO RIVERSIDE DRAIN	1.05								
152	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 97	SOCORRO RIVERSIDE DRAIN	0.15								
153	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 96	SOCORRO RIVERSIDE DRAIN	0.26								
154	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 95	SOCORRO RIVERSIDE DRAIN	0.25								
155	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 94	SOCORRO RIVERSIDE DRAIN	0.15								
156	MRGCD/BOR	FEE SIMPLE	PT OF MAP 167 TR 126	SOCORRO RIVERSIDE DRAIN	0.27								
157	MRGCD/BOR	FEE SIMPLE	PT OF MAP 167 TR 124	SOCORRO RIVERSIDE DRAIN	0.75								
158	MRGCD/BOR	FEE SIMPLE	PT OF MAP 167 TR 127	SOCORRO RIVERSIDE DRAIN	0.85								
159	MRGCD/BOR	FEE SIMPLE	PT OF MAP 167 TR 123	SOCORRO RIVERSIDE DRAIN	0.54								
160	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 3	SOCORRO RIVERSIDE DRAIN	0.84								
161	MRGCD/BOR	FEE SIMPLE	ALL OF MAP 153 TR 1	LEMITAR RIVERSIDE DRAIN	2.35								
162	MRGCD/BOR	FEE SIMPLE	ALL OF MAP 153 TR 2	LEMITAR RIVERSIDE DRAIN	0.48								
163	MRGCD/BOR	FEE SIMPLE	PT OF MAP 153 TR 5	LEMITAR RIVERSIDE DRAIN	0.58								
164	MRGCD/BOR	FEE SIMPLE	PT OF MAP 153 TR 6	LEMITAR RIVERSIDE DRAIN	0.53								
165	MRGCD/BOR	FEE SIMPLE	PT OF MAP 153 TR 167	LEMITAR RIVERSIDE DRAIN	1.13								
166	MRGCD/BOR	FEE SIMPLE	PT OF MAP 153 TR 169	LEMITAR RIVERSIDE DRAIN	0.73								
167	MRGCD/BOR	FEE SIMPLE	PT OF MAP 153 TR 170	LEMITAR RIVERSIDE DRAIN	0.41								
168	MRGCD/BOR	FEE SIMPLE	PT OF MAP 153 TR 171	LEMITAR RIVERSIDE DRAIN	0.90								
169	MRGCD/BOR	FEE SIMPLE	PT OF MAP 154 TR 1	LEMITAR RIVERSIDE DRAIN	0.77								
170	MRGCD/BOR	FEE SIMPLE	PT OF MAP 154 TR 15A	LEMITAR RIVERSIDE DRAIN	0.48								
171	MRGCD/BOR	FEE SIMPLE	PT OF MAP 179 TR 2B	SAN ANTONIO RIVERSIDE DRAIN	0.45								
172	MRGCD/BOR	FEE SIMPLE	PT OF MAP 155 TR 17	LEMITAR RIVERSIDE DRAIN	0.35								
173	MRGCD/BOR	FEE SIMPLE	PT OF MAP 155 TR 5	LEMITAR RIVERSIDE DRAIN	0.38								
174	MRGCD/BOR	FEE SIMPLE	PT OF MAP 155 TR 4	LEMITAR RIVERSIDE DRAIN	0.38								
175	MRGCD/BOR	FEE SIMPLE	PT OF MAP 177 TR 2A	SAN ANTONIO RIVERSIDE DRAIN	1.33								
176	MRGCD/BOR	FEE SIMPLE	PT OF MAP 175 TR 8	SAN ANTONIO RIVERSIDE DRAIN	2.35								
177	MRGCD/BOR	FEE SIMPLE	PT OF MAP 155 TR 6	LEMITAR RIVERSIDE DRAIN	0.40								
178	MRGCD/BOR	FEE SIMPLE	PT OF MAP 167 TR 125	SOCORRO RIVERSIDE DRAIN	0.25								
179	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 23	SOCORRO RIVERSIDE DRAIN	0.48								
180	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 24	SOCORRO RIVERSIDE DRAIN	0.35								
181	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 29	SOCORRO RIVERSIDE DRAIN	0.52								

	A	B	C	D	E	F	G	H	I	J	K	L	N
1	Land Ownership Intersecting San Acacia TSP Easement Boundary					Project Land Requirements							
2	OWNER	OWNER TYPE	OWNER DESCRIPTION	FACILITY NAME	PARCEL AREA	FEE	PCIE Channel	P.R.E. Road	T.W.A.E. Temp Work Area			FPLE Levee	Sum
3					ACRES				Veg	Stage	Constr		by APN
4						ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES
182	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 25	SOCORRO RIVERSIDE DRAIN	0.26								
183	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 26	SOCORRO RIVERSIDE DRAIN	0.30								
184	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 30	SOCORRO RIVERSIDE DRAIN	0.29								
185	MRGCD/BOR	FEE SIMPLE	PT OF MAP 175 TR 6	SAN ANTONIO RIVERSIDE DRAIN	1.76								
186	MRGCD/BOR	FEE SIMPLE	PT OF MAP 175 TR 6A	SAN ANTONIO RIVERSIDE DRAIN	0.96								
187	MRGCD/BOR	FEE SIMPLE	PT OF MAP 167 TR 3	SOCORRO RIVERSIDE DRAIN "A"	5.36								
188	MRGCD/BOR	FEE SIMPLE	PT OF MAP 155 TR 11	LEMITAR RIVERSIDE DRAIN	0.08								
189	MRGCD/BOR	FEE SIMPLE	PT OF MAP 155 TR 12	LEMITAR RIVERSIDE DRAIN	1.05								
190	MRGCD/BOR	FEE SIMPLE	PT OF MAP 155 TR 13	LEMITAR RIVERSIDE DRAIN	0.35								
191	MRGCD/BOR	FEE SIMPLE	PT OF MAP 155 TR 15	LEMITAR RIVERSIDE DRAIN	0.30								
192	MRGCD/BOR	FEE SIMPLE	PT OF MAP 156 TR 1	LEMITAR RIVERSIDE DRAIN	1.48								
193	MRGCD/BOR	FEE SIMPLE	PT OF MAP 156 TR 2	LEMITAR RIVERSIDE DRAIN	0.18								
194	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 27	SOCORRO RIVERSIDE DRAIN	0.31								
195	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 28	SOCORRO RIVERSIDE DRAIN	0.52								
196	MRGCD/BOR	FEE SIMPLE	PT OF MAP 172 TR 2	SOCORRO RIVERSIDE DRAIN	2.17								
197	MRGCD/BOR	FEE SIMPLE	PT OF MAP 179 TR 1	SAN ANTONIO RIVERSIDE DRAIN	0.66								
198	MRGCD/BOR	FEE SIMPLE	PT OF MAP 176 TR 48	SAN ANTONIO RIVERSIDE DRAIN	1.40								
199	MRGCD/BOR	FEE SIMPLE	PT OF MAP 177 TR 4	SAN ANTONIO RIVERSIDE DRAIN	4.89								
200	MRGCD/BOR	FEE SIMPLE	PT OF MAP 155 TR 7	LEMITAR RIVERSIDE DRAIN	0.58								
201	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 31	SOCORRO RIVERSIDE DRAIN	0.22								
202	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 32	SOCORRO RIVERSIDE DRAIN	0.49								
203	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 33	SOCORRO RIVERSIDE DRAIN	0.35								
204	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 52	SOCORRO RIVERSIDE DRAIN	1.03								
205	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 53	SOCORRO RIVERSIDE DRAIN	0.44								
206	MRGCD/BOR	FEE SIMPLE	PT OF MAP 175 TR 7	SAN ANTONIO RIVERSIDE DRAIN	0.41								
207	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 54	SOCORRO RIVERSIDE DRAIN	0.62								
208	MRGCD/BOR	FEE SIMPLE	PT OF MAP 168 TR 55	SOCORRO RIVERSIDE DRAIN	0.20								
209	MRGCD/BOR	FEE SIMPLE	PT OF MAP 155 TR 14	LEMITAR RIVERSIDE DRAIN	0.30								
210	MRGCD/BOR	PRESCRIPTIVE	PT OF MAP 147 PUBLIC RD ADJ TO TR 3 AND TR 20	SOCORRO MAIN CANAL (NORTH)	0.05								
211	MRGCD/BOR	PRESCRIPTIVE	PT OF MAP 147 PUBLIC RD ADJ TO TRS 31, 35 & 36	SOCORRO MAIN CANAL (NORTH)	0.12								
212	MRGCD/BOR	PRESCRIPTIVE	PT OF MAP 147 A T & S F RR LDS	SOCORRO MAIN CANAL (NORTH)	0.51								
213	MRGCD/BOR	PRESCRIPTIVE	ALL OF MAP 147 TR 36	SOCORRO MAIN CANAL (NORTH)	0.42								
214	MRGCD/BOR	PRESCRIPTIVE	ALL OF MAP 147 TR 39	SOCORRO MAIN CANAL (NORTH)	0.24								
215	MRGCD/BOR	PRESCRIPTIVE	PT OF MAP 147 UNPLATTED LDS	SOCORRO MAIN CANAL (NORTH)	0.47								
216	MRGCD/BOR	PRESCRIPTIVE	PT OF MAP 148 PUBLIC RD ADJ TO TRS 9 AND 62	LEMITAR RIVERSIDE DRAIN	0.03								
217	MRGCD/BOR	PRESCRIPTIVE	ALL OF MAP 167 TR 46	SOCORRO RIVERSIDE DRAIN	0.99								
218	MRGCD/BOR	PRESCRIPTIVE	ALL OF MAP 167 TR 61	SOCORRO RIVERSIDE DRAIN	0.67								
219	MRGCD/BOR	PRESCRIPTIVE	ALL OF MAP 177 TR 11	SAN ANTONIO RIVERSIDE DRAIN	0.28								
220	MRGCD/BOR	PRESCRIPTIVE	PT OF MAP 173 PUBLIC RD AND R. R. R/W	SAN ANTONIO RIVERSIDE DRAIN	0.33								
221	MRGCD/BOR	PRESCRIPTIVE	PT OF MAP 168 UNPLATTED GOVERNMENT LDS	SOCORRO RIVERSIDE DRAIN	0.08								
222	MRGCD/BOR	QUITCLAIM	PTS OF MAP 156 TRS 1 THRU 15 AND 77 THRU 84	LEMITAR RIVERSIDE DRAIN AND LFCC	12.00								
223	MRGCD/BOR	QUITCLAIM	MAP 149 TR 2A2	SAN LORENZO ARROYO	3.12								
224	MRGCD/BOR	QUITCLAIM	MAP 149 TR 9B2	SAN LORENZO ARROYO	2.07								
225	MRGCD/BOR	QUITCLAIM	MAP 149 TR 7A	SAN LORENZO ARROYO	2.97								
226	MRGCD/BOR	QUITCLAIM	MAP 149 TR 13A2	SAN LORENZO ARROYO	0.73								
227	MRGCD/BOR	QUITCLAIM	ALL OF MAP 156 TR 76	LEMITAR RIVERSIDE DRAIN AND LFCC	0.29								

	A	B	C	D	E	F	G	H	I	J	K	L	N
1	Land Ownership Intersecting San Acacia TSP Easement Boundary					Project Land Requirements							
2	OWNER	OWNER TYPE	OWNER DESCRIPTION	FACILITY NAME	PARCEL AREA	FEE	PCIE Channel	P.R.E. Road	T.W.A.E. Temp Work Area			FPLE Levee	Sum
3					ACRES				Veg	Stage	Constr		by APN
4						ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES
228													
229				TOTAL IN ACRES (MRGCD/BOR) =	438.36								
230													
231													
232													
233	US FISH AND WILI	FEDERAL	US FISH AND WILDLIFE	SEVILLETA NATIONAL WILDLIFE REFUGE	30.34								
234	US FISH AND WILI	FEDERAL	US FISH AND WILDLIFE	BOSQUE DEL APACHE NATIONAL WILDLIFE REFUGE	134.26								
235													
236				TOTAL IN ACRES (FEDERAL) =	164.59								
237													
238	PRIVATE	PRIVATE	PRIVATE		16.97								
239	PRIVATE	PRIVATE	PRIVATE		44.43								
240	PRIVATE	PRIVATE	PRIVATE		11.00								
241	PRIVATE	PRIVATE	PRIVATE		1.20								
242	PRIVATE	PRIVATE	PRIVATE		1.5								
243				SUBTOTAL IN ACRES (PRIVATE)=	75.11								
244	LOWER PROJECT LANDS												
245													
246	PRIVATE	PRIVATE	NM Ranch Properties, Inc. Wesley Bruton, and Ja	Tiffany Canyon/Basin - NMISC's Subtotal	302.00								
247				TOTAL IN ACRES (PRIVATE) =	377.11								
248													
249													
250			LEGEND										
251	FEE =	Fee											
252	P.C.I.E. =	PERMANENT CHANNEL IMPROVEMENT EASEMENT											
253	P.R.E. =	PERMANENT ROAD EASEMENT											
254	T.W.A.E. =	TEMPORARY WORK AREA EASEMENT		TOTAL IN ACRES (ALL OWNERS) =	980.06								
255	F.P.L.E =	FLOOD PROTECTION LEVEE EASEMENT											
256													

EXHIBIT B

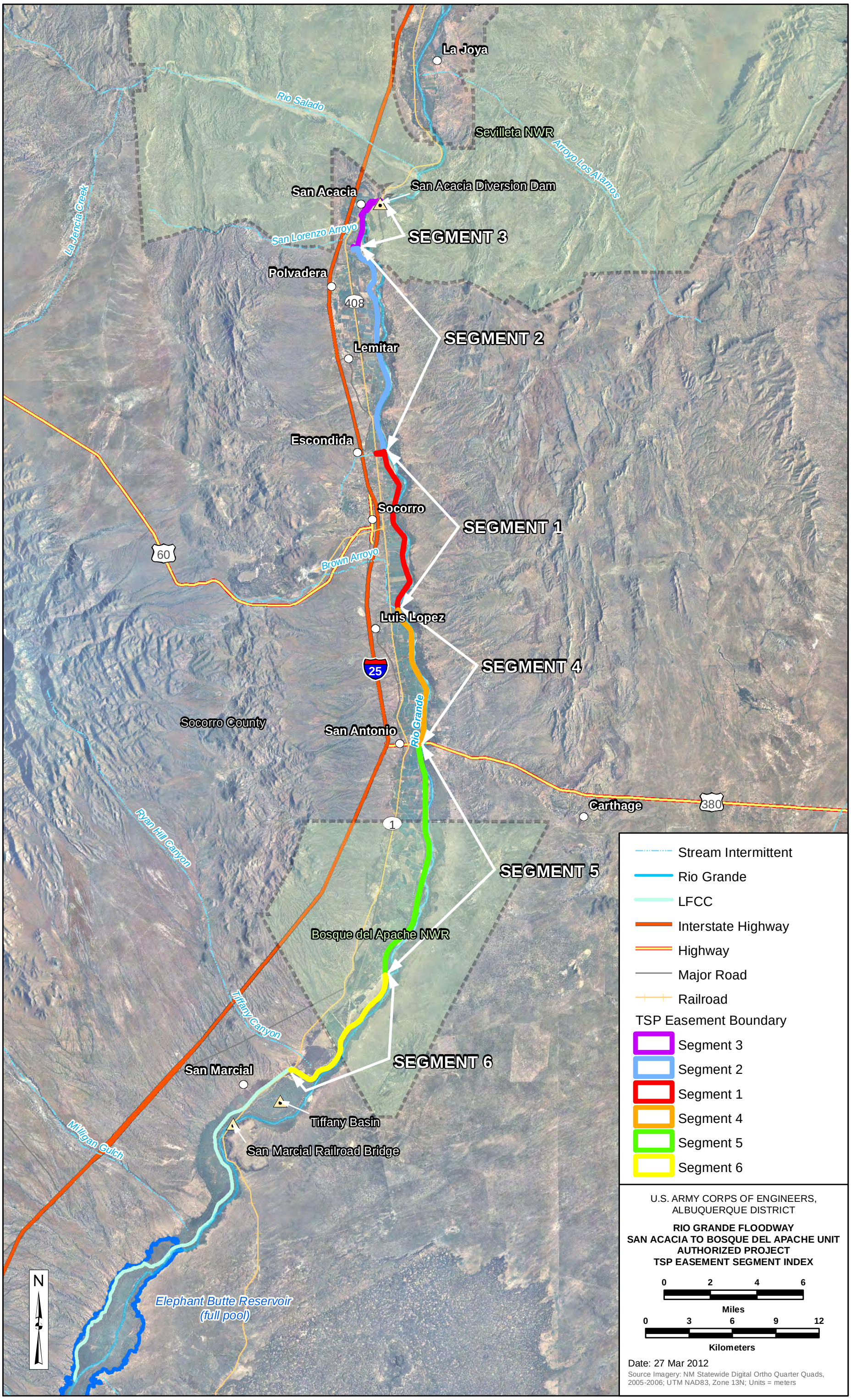
La Joya
Rio Salado
Sevilleta NWR
Arroyo Los Alamos
San Acacia
San Acacia Diversion Dam
La Jencia Creek
San Lorenzo Arroyo
SEGMENT 3
Polvadera
408
SEGMENT 2
Lemitar
Escondida
Socorro
SEGMENT 1
60
Brown Arroyo
Luis Lopez
25
SEGMENT 4
Socorro County
San Antonio
Rio Grande
Carthage
380
Ryan Hill Canyon
1
SEGMENT 5
Bosque del Apache NWR
Tiffany Canyon
SEGMENT 6
San Marcial
Tiffany Basin
Milligan Gulch
San Marcial Railroad Bridge
N
Elephant Butte Reservoir
(full pool)
Stream Intermittent
Rio Grande
LFCC
Interstate Highway
Highway
Major Road
Railroad
TSP Easement Boundary
Segment 3
Segment 2
Segment 1
Segment 4
Segment 5
Segment 6
U.S. ARMY CORPS OF ENGINEERS,
ALBUQUERQUE DISTRICT
RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT
AUTHORIZED PROJECT
TSP EASEMENT SEGMENT INDEX
0 2 4 6
Miles
0 3 6 9 12
Kilometers
Date: 27 Mar 2012
Source Imagery: NM Statewide Digital Ortho Quarter Quads, 2005-2006; UTM NAD83, Zone 13N; Units = meters

EXHIBIT C

EXHIBIT D

ASSESSMENT OF NON-FEDERAL PARTNERS
REAL ESTATE ACQUISITION CAPABILITY

General Reevaluation Report
Rio Grande Floodway
San Acacia to Bosque Del Apache Unit Project
Socorro County, New Mexico

I. LEGAL AUTHORITY

a. Does the Non-Federal Cost-Sharing Partner have legal authority to acquire and hold title to real property for project purposes?

Yes. The Middle Rio Grande Conservancy District's (MRGCD's) Board's power and authority is clearly established by the Conservancy Act of New Mexico at New Mexico State Statutes Annotated (NMSA) 1978 § 73-14-39 (1927). This Act authorizes and empowers the MRGCD to protect life and property within the district from flooding by constructing the necessary works either within or outside of the district. The Board was given authority through the Conservancy Act to acquire real or personal property, public or private, either within or outside of the district, through donation, purchase, or condemnation.

Pursuant to New Mexico State Statute 73-14-39, General Powers: "... a Conservancy District has the authority and power to acquire by purchase or condemnation .., own, use and sell, hold ... any real property."

b. Does the Cost-Sharing Partner have the power of eminent domain for this project?

Yes. Please refer to I.a., above.

c. Does the Cost-Sharing Partner have quick-take authority for this project?

Yes. The New Mexico State Statutes Annotated 42A-I-22, Condemnation Proceedings, " ... court may make an order within 30 days of the condemnation filing authorizing the condemner to take immediate possession of the property ... ", and 42-2-6, Special Alternative Condemnation Procedure, Preliminary Order of Entry, " ... petitioner may obtain a preliminary order permitting the political subdivision to immediately enter and occupy the premises sought to be condemned pending the action and to do such work thereon as may be required."

d. Are any of the lands/interests in land required for the project located outside of the Cost-Sharing Partners political boundary?

Yes. Lands that may be required for excavation near the San Acacia Diversion Dam and potential lands for borrow; disposal, storage and staging areas are privately or federally held. Parts of the project area are located on and adjacent to the Sevilleta National Wildlife Refuge (the Sevilleta de la Joya Land Grant)**,** the Town of Socorro Land Grant, the Bosque del Apache National Wildlife Refuge (NWR) and the Pedro Armendaris Land Grant.

e. Are any of the lands/interests in land required for the project owned by an entity whose property the Cost-Sharing Partner cannot condemn?

Yes. The Cost-Sharing Partner would probably not be successful in condemning property of the Sevilleta and Bosque del Apache NWRs, nor any property owned by Reclamation or U.S. Department of the Interior, Bureau of Land Management. and Burlington Northern and Santa Fe Railroad. lands would be permitted to the cost sharing partner by the corresponding federal agency and the railroad.

II. HUMAN RESOURCE REQUIREMENTS

a. Will the Cost-Sharing Partner's in-house staff require training to become familiar with the real estate requirements of federal projects including P.L.91-646, as amended?

No. The Army Corps of Engineers real estate staff will facilitate MRGCD obtaining a contracted real estate service provider familiar with the real estate requirements of the federal project including P.L. 91-646 as amended.

b. If the answer to II.a. is "yes" has a reasonable plan been developed to provide such training?

No training plan has been developed, nor is the need anticipated.

c. Does the Cost-Sharing Partner's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project?

No. MRGCD has no real estate staff to manage this project and will hire the necessary contracted staff to meet the responsibilities of the project.

d. Is the Cost-Sharing Partner's project in-house staffing level sufficient considering its other work load, if any, and the project schedule?

No, the Corps real estate staff will facilitate MRGCD in obtaining contracted real estate support staff to manage the real estate requirements of this project.

e. Can the Cost-Sharing Partner obtain contractor support, if required, in a timely fashion?

Yes. The Corps will facilitate MRGCD in obtaining Acquisition services for the project. Acquisition services are readily available within the New Mexico area.

f. Will the Partner likely request U.S. Army Corps of Engineers (Corps) assistance in acquiring real estate?

No. The partner will utilize contracted real estate services as necessary for acquiring real estate.

III. OTHER PROJECT VARIABLES

a. Will the Cost-Sharing Partner's staff be located within a reasonable proximity to the project site?

Yes, The Corps has staff within 90 miles of the project.

b. Has the Cost-Sharing Partner approved the project real estate schedule/milestones?

The Cost-Sharing Partner is aware of the status of the project and continues to support project development. MRGCD has reviewed and approved phase one of the project.

IV. OVERALL ASSESSMENT

a. Has the Cost-Sharing Partner performed satisfactorily on other Corps projects?

Yes. Most recently this partner worked with the Corps on the Albuquerque West Levee project. The Cost-Sharing Partner is a well-established, long-standing state service provider to the inhabitants of the area and is empowered under the Conservancy Act of New Mexico at NMSA 1978 § 73-14-39 (1927), New Mexico State Statutes Annotated, which states in part:

". . .the board is authorized and empowered . . . in or out of said district . . . to construct and maintain main and lateral ditches, . . . canals, . . . levees, . . . retarding basins, floodways, . . . and any other works and improvements deemed necessary to construct, preserve, operate or maintain the works in or out of said district; to construct, reconstruct or enlarge or cause to be constructed, reconstructed or enlarged, any and all bridges that may be needed in or out of said district; . . . to construct, reconstruct any and all of said works and improvements in or out of said district; . . . and shall have the right to acquire by donation, purchase or condemnation to construct, own, lease, use and sell, to hold, encumber, control and maintain any easement, water right, acequias, well, railroad right-of-way, canal, sluice, flume, reservoir site, reservoir or retarding basin, mill dam, water power, franchise, park, cemetery or any other public way or place or any real or personal property, public or private in or out of said district, for rights-of-way and such other things, or for materials of construction or for any other use not inconsistent with the purposes of this act; . . ."

Additionally, the New Mexico Interstate Stream Commission has provided statements of financial support to the MRGCD and continues to show interest and support for this project.

b. With regard to this project, is the Cost-Sharing Partner anticipated to be highly capable?

Yes.

V. COORDINATION

a. Has this assessment been coordinated with the Cost-Sharing Partner?

Yes, additionally the Corps will coordinate with the Cost-Sharing Partner during the upcoming conduct of the Engineering Technical Appendix prepared for the General Reevaluation Report, which occurs after the F4A Alternative Formulations Briefing.

b. Does the Cost-Sharing Partner concur with this assessment?

Yes, the Cost-Sharing Partner has previously stated their support of the project. The Cost-Sharing will provide a certification as to their financial capabilities as a part the Project Partnership Agreement.

Prepared by:

Mark K. Turkovich
Realty Specialist
13Jan12

Reviewed and approved by:

Karen Kennedy
Chief, Real Estate Division
13Jan12

EXHIBIT D

EXHIBIT E

ASSESSMENT OF NON-FEDERAL PARTNERS'S
REAL ESTATE ACQUISITION CAPABILITY

General Reevaluation Report
Rio Grande Floodway
San Acacia to Bosque Del Apache Unit Project
Socorro County, New Mexico

I. LEGAL AUTHORITY

a. Does the Non-Federal (Cost-Sharing) Partner have legal authority to acquire and hold title to real property for project purposes?

Yes. Pursuant to NMSA 1978 § 72-14-10, et seq., the New Mexico Interstate Stream Commission (NMISC) has authority to acquire and hold title to real property taken in the name of the Commission.

b. Does the Cost-Sharing Partner have the power of eminent domain for this project?

Yes, Pursuant to NMSA 1978 § 72-14-10 et seq., the NMISC has authority to condemn real property for public use.

c. Does the Cost-Sharing Partner have quick-take authority for this project?

Yes. Pursuant to NMSA 1978 § 42-2-1 et seq., the NMISC has the authority to use special alternative condemnation procedures to enter into possession at the inception of the proceeding and take possession of real property that is necessary for the immediate preservation of the public peace, health, safety, the promotion of the general welfare.

d. Are any of the lands/interests in land required for the project located outside of the Cost-Sharing Partners political boundary?

No, Pursuant to NMSA 1978 § 72-14-3 the NMISC has authority throughout the State of New Mexico.

e. Are any of the lands/interests in land required for the project owned by an entity whose property the Cost-Sharing Partner cannot condemn?

Yes. Some lands are in federal ownership.

II. HUMAN RESOURCE REQUIREMENTS

a. Will the Cost-Sharing Partner's in-house staff require training to become familiar with the real estate requirements of federal projects including P.L.91-646, as amended?

The ISC is willing to have staff trained as indicated above.

b. If the answer to II.a. is "yes" has a reasonable plan been developed to provide such training?

The ISC will develop a plan for the training and coordinate with USACE on such.

c. Does the Cost-Sharing Partner's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project?

With the completion of the above-mentioned training, the NMISC as cost-share sponsor will have sufficient real estate acquisition experience for the project.

d. Is the Cost-Sharing Partner's project in-house staffing level sufficient considering its other work load, if any, and the project schedule?

The planned phasing of the construction of this project assures sufficient in-house staffing levels.

e. Can the Cost-Sharing Partner obtain contractor support, if required, in a timely fashion?

Yes, if required the ISC can obtain contractor support.

f. Will the Partner likely request U.S. Army Corps of Engineers (Corps) assistance in acquiring real estate?

ISC does not plan to ask assistance from USACE for acquiring real estate.

III. OTHER PROJECT VARIABLES

a. Will the Cost-Sharing Partner's staff be located within a reasonable proximity to the project site?

Yes

b. Has the Cost-Sharing Partner approved the project real estate schedule/milestones?

The ISC concurs with the schedule prepared by the Corps and submitted by MRGCD on October 27, 2011 as part of their application for assistance to the New Mexico Water Trust Board.

IV. OVERALL ASSESSMENT

a. Has the Cost-Sharing Partner performed satisfactorily on other Corps projects?

Yes. Most recently this partner worked with the Corps and performed outstandingly on the salinity studies on the Pecos River and Rio Grande River.

b. With regard to this project, is the Cost-Sharing Partner anticipated to be highly capable?

The Cost-Sharing Partner is anticipated to be capable.

V. COORDINATION

a. Has this assessment been coordinated with the Cost-Sharing Partner?

Yes, additionally the Corps will coordinate with the Cost-Sharing Partner during the upcoming conduct of the Technical Appendix prepared for the Limited Reevaluation Report, which occurs between the F4 Alternative Review Conference and the F4 Alternative Formulations Briefing.

b. Does the Cost-Sharing Partner concur with this assessment?

Yes, the Cost-Sharing Partner has previously stated their support of the project. The Cost-Sharing Partner will provide a certification as to their financial capabilities as part of the Project Partnership Agreement.

Prepared by:

Marvin L. Urban
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13Jan12

Reviewed and approved by:

Karen Kennedy
Chief, Real Estate Division
13Jan12

EXHIBIT E