MIDDLE RIO GRANDE
"OVERBANK MONITORING STUDY"

Prepared for:

MRG ESA COLLABORATIVE PROGRAM

Through: U.S. Army Corps of Engineers

Prepared by:

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PROJECT SUMMARY

Within recent history numerous spatial data sets and computer models have been developed to study and monitor the Rio Grande between Cochiti Dam and Elephant Butte Reservoir. It is the intent of this project to provide the Albuquerque District a database, pertinent information, and recommendations regarding these data and analysis tools. Specific emphasis is placed on the recently developed Middle Rio Grande (MRG) FLO-2D computer model. This finite difference, two-dimensional, flood routing model covers the Rio Grande and its active flood plain from Cochiti Dam to Elephant Butte. The MRG model, developed in the late 1990's, has been evolving and improving ever since. Many detailed, wide area topographic and aerial photographic data sets were used to develop the basic geometric structure and attributes in the model.

The FLO-2D model predicts the spatial and temporal distribution of flows in the river. When the active channel capacity is exceeded the model then distributes and tracks flows in the overbank. The prediction and monitoring of these overbank flows is important so that researchers, scientists, and engineers have information which can help optimize river operations, restoration efforts, and potential water salvage in this reach. Accurate, current predictive model results, as well as an organized data collection plan should Cochiti releases capable of producing overbank flooding be available, contribute to a successful overbank flood monitoring effort.

This report is divided into three sections. Section one provides a review of the various spatial data sets available in the MRG reach. Existing hydraulic, topographic and other mapping data such as aerial photography, vegetation mapping, and river cross section data are categorized. A concerted effort was made to be as thorough as possible during this review, however; it is likely that not all relevant data sets have been identified. The information collected is presented in a Microsoft Access Database and is intended to establish a framework for organizing and archiving background and monitoring data to help document overbank flooding.

Section two of the report describes the existing MRG FLO-2D model and identifies opportunities to enhance the model and its ability to predict flooding by adding additional ground surveyed cross sections. Existing model cross sections along with recommended cross section locations are tabulated. This same information is presented graphically in Appendix A.

In the final section of the report a detailed overbank monitoring plan is presented. The goal of this plan is to develop and coordinate hydrographic and photographic data collection activities in the Middle Rio Grande during a high flow release from Cochiti Dam. The plan identifies where data collection should be focussed, recommended methods and equipment for the data collection, and a suggested sequence (temporal) for the collection. An underlying goal of this plan, or any data collection effort, is to insure collected data is spatially referenced so it will integrate and be compatible with existing hydraulic models and GIS applications.

This report is a component of the Middle Rio Grande Endangered Species Act Collaborative Program (Program) and is intended to assist the Corps of Engineers and other stakeholders within the middle valley in their management of this vital resource. The Fish and Wildlife Service has identified overbank flow monitoring as an important and necessary activity in its recent Biological Opinion of Corps of Engineers and Bureau of Reclamation water operations in the Middle Rio Grande.

SECTION 1 – MRG SPATIAL DATA INVENTORY AND DATABASE

1.1 Introduction

There are numerous spatial data sets that have been developed over the years supporting the understanding of the Rio Grande and its adjacent Bosque throughout New Mexico. Many of these products have been collected and/or developed between Cochiti Dam and Elephant Butte Reservoir. The types of data available include; detailed digital terrain model data, topographic mapping, controlled aerial photography, field surveyed data such as river cross sections, and processed/interpreted data, such as vegetation mapping, to name a few.

In addition, various theoretical computer models have been developed using these data sets to better understand and predict the response of the river and riparian corridor to various flow scenarios. The Middle Rio Grande FLO-2D flood routing model is one such model. Numerous other hydrologic, hydraulic, and sediment transport models have been developed between Cochiti Dam and Elephant Butte. The Corps of Engineers software (HEC-1, HEC-2, HEC-6, HEC-RAS, and HEC-HMS) is most often used for these modeling efforts. Due to the general lack of spatial data sets capturing and depicting overbank flooding, most of the calibration of these models has been accomplished using USGS historic stream flow records.

A Microsoft Access database, categorizing available spatial data and hydraulic computer models, has been developed as the first part of this project. The intent of this database is to establish a framework for organizing and archiving background and monitoring data to document overbank flooding along this reach of the Rio Grande.

1.2 Data Inventory

The primary agencies and universities responsible for acquiring and/or developing many of the spatial data products along the Rio Grande and its adjacent floodplain are listed in Table 1. The Corps of Engineers (Corps), Bureau of Reclamation (Reclamation), and the New Mexico Interstate Stream Commission (ISC) are most often responsible for the water resources computer model development within this reach of the Rio Grande.

Table 2 lists the name and contact information for the three primary, private mapping consulting firms in Albuquerque which have acquired source photography and field surveyed data used in the production of the various spatial mapping products. During the previous 10 to 15 years, it is very probable that one of these firms produced the available detailed, digital terrain model data and/or digital topographic mapping along the Rio Grande from low level controlled aerial photography. All three of these firms were contacted and subsequently provided information to populate the database developed for this project.

The Bureau of Reclamation and its hydrographic data collection contractors have acquired most of the field-surveyed river cross sectional data. Tetra Tech, Infrastructure Services Group (TTISG), formally FLO Engineering, has been the primary data collection contractor for Reclamation during the past 12 years. Table 2 also lists contact information for TTISG.

In addition, the Earth Data Analysis Center (EDAC), affiliated with the University of New Mexico, provides services in geospatial technologies. The EDAC clearinghouse provides users with numerous spatial data sets and/or corresponding metadata. Additional information on this resource can be found at www.edac.unm.edu .

Table 1. Entities with Spatial Data

Agency/Organization	Contact	Telephone No.	General Information
Corps of Engineers Albuquerque District	Clay Mathers	505-342-3255	GIS Coordinator
	Alvin Toya	505-342-3337	Mapping Coordinator
	Bruce Beach	505-342-3331	H & H Data
Bureau of Reclamation Albuquerque Office	Kristi Smith	505-465-3631	River Cross-Sections
	Robert Padilla	505-465-3626	H & H Data
Bureau of Reclamation Denver, TSC	Debra Callahan	303-445-3645	GIS Data
	Travis Bauer	303-445-3672	River Data
New Mexico State Engineers Office / Interstate Stream Commission	Gar Clark	505-827-6175	GIS Data
	Nabil Shafike	505-764-3868	H & H Data
Middle Rio Grande Conservancy District	Doug Stretch	505-247-0234	GIS Data
	David Ginsler		H & H Data
Fish and Wildlife Service Albuquerque Office	Mike Buntjer	505-346-2525	GIS / H & H Data
	Ric Riester		
University of New Mexico	Julie Coonrod	505-277-3233	H & H / GIS
	Mark Schmidt		
New Mexico Technological Institute	Rob Bowman	505-835-5992	H & H

Table 2. Private Mapping/ Consulting Firms

Firm Name	Contact	Telephone No.
Bohannnan Huston, Inc	Dennis Sandin	505-823-1000
Thomas R. Mann & Associates	Tom Mann	505-266-7757
Pacific Western Technologies (formerly Koogle & Pouls Engineering)	Dick Coffey	505-294-5051
Tetra Tech, ISG	Doug Wolf /Walt Kuhn	505-881-3188

1.3 MRG Spatial Database

A Microsoft Access (version 2000) database has been developed which catalogs the metadata obtained from the aforementioned data inventory. This database is intended to be a starting point and has been designed to be a dynamic product, adaptable to future needs. The information contained in the database will be used to establish a framework for organizing and archiving background and monitoring data to better understand the river and its adjacent Bosque.

The top level in the database is segmented consistent, with the river reaches developed for the Upper Rio Grande Water Operations Review (URGWOPS) and EIS. Figure 1 shows an overall view of the Rio Grande Basin in Colorado, New Mexico, and western Texas. The URGWOPS river reaches are shown on this figure. Figures 2 and 3 show the first and second level "switchboards" in the Microsoft Access database. Metadata included in the database (when available) are; source; project name and number; contact details; related reports/documents; date when obtained; extent; resolution; format; applicable map projections, units, and datums; as well as available information on data quality and accuracy.

1.4 1992 Data Set

On May 12, 1992, Reclamation obtained aerial photography of the river and its adjacent floodplain in an effort to document the area of inundation resulting from a "higher than normal" release from Cochiti Reservoir. The average daily discharge from this release was measured at approximately 7,000 cfs at the Albuquerque gage, approximately 5,700 cfs at San Acacia, and approximately 5,000 cfs at San Marcial. The visible area of inundation has been digitized from this photographic data set.

This product is one of the few data sets that are available for use in calibrating flood routing/hydraulic models in this reach of the Rio Grande. (such as the MRG FLO-2D model) In 1999, a hard copy of this data set was used to calibrate the area of inundation predicted by the FLO-2D model between San Acacia and San Marcial, New Mexico. Results of this calibration indicated a reasonable correlation exists between the FLO-2D predicted area of inundation and what was observed in the photography. This data set will serve as an important and valuable resource for future research and hydraulic modeling efforts on the Middle Rio Grande.

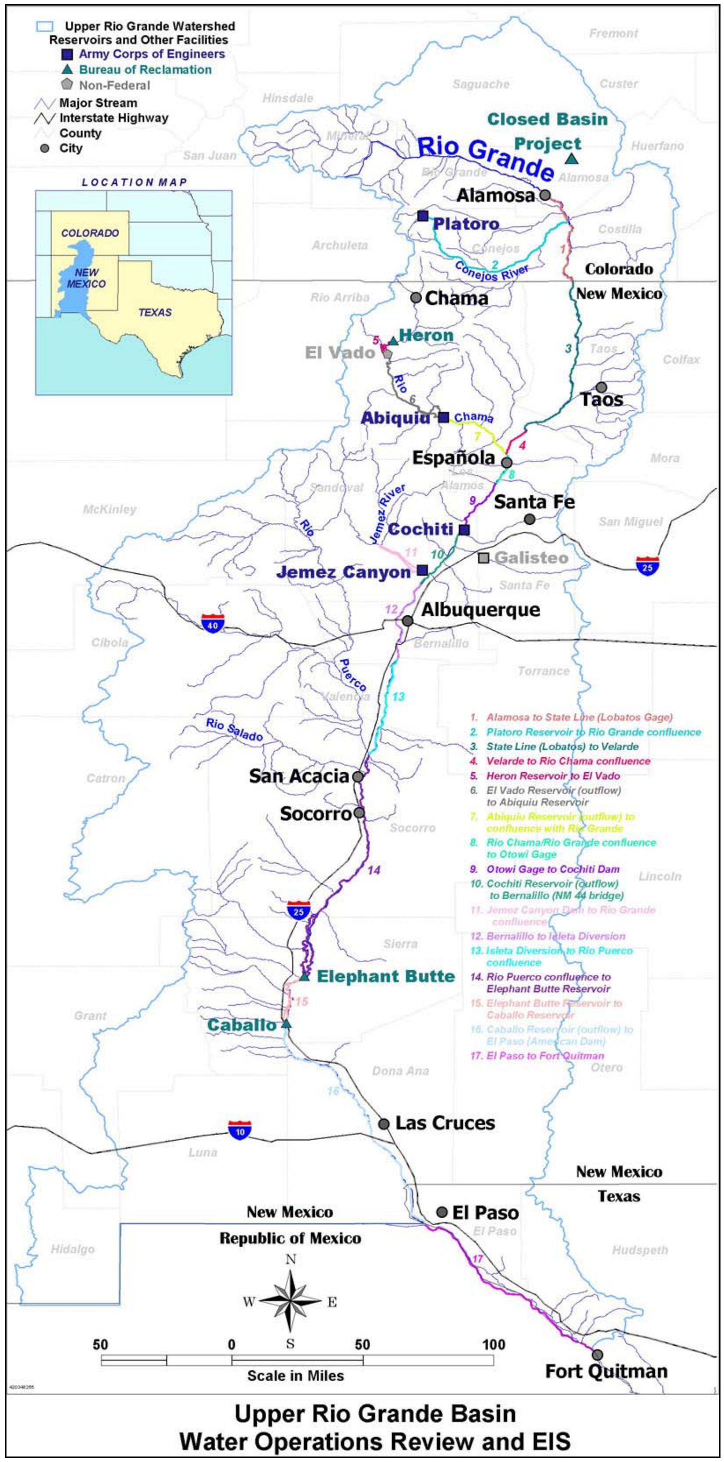

Figure 1 - (developed by the URGWOPS GIS team)

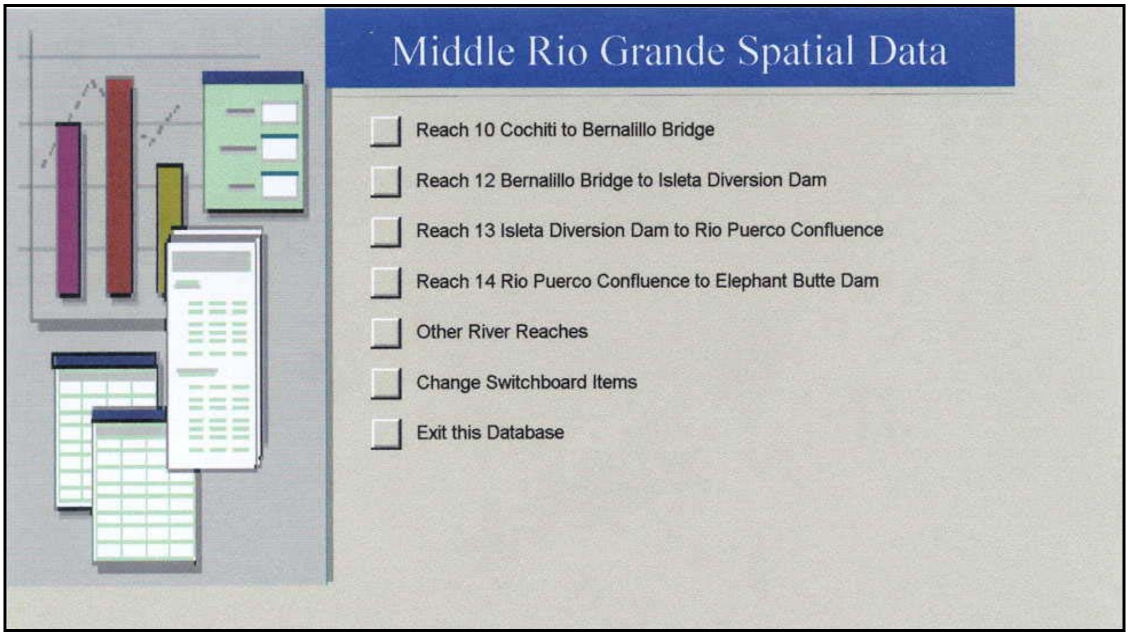

Figure 2 - First Level - Access Database

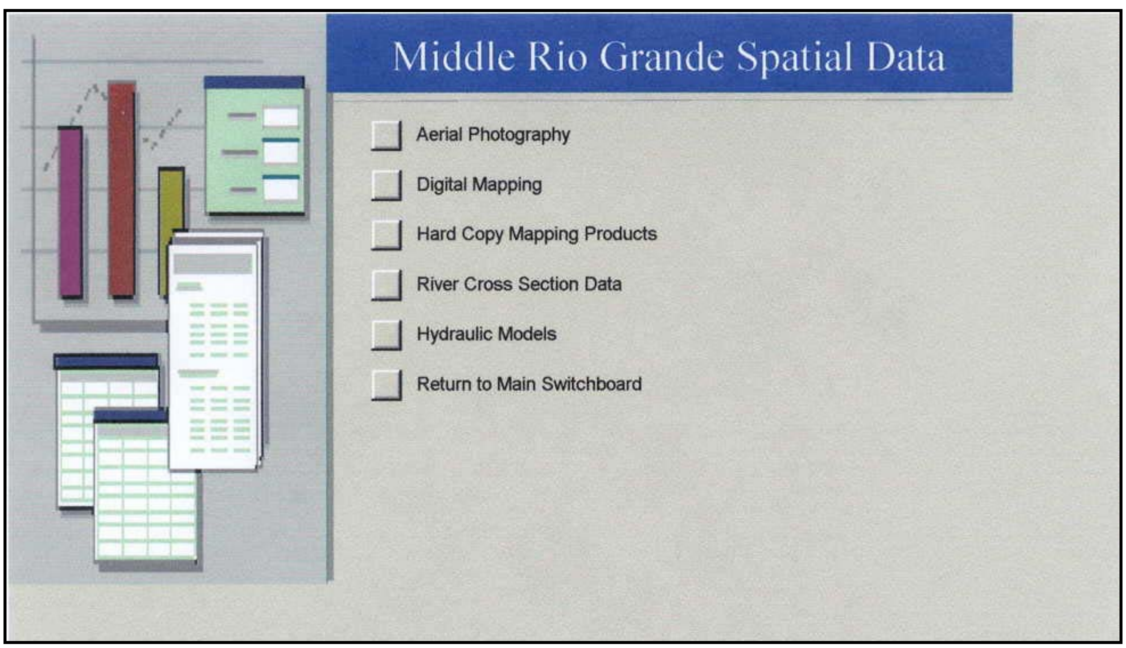

Figure 3 - Second Level - Access Database

SECTION 2 - FLO-2D MODEL AND RIVER CROSS SECTION ANALYSIS

2.1 Introduction

Over 400 cross sections have been surveyed on the Middle Rio Grande from Cochiti Dam to Elephant Butte Reservoir. Most of these cross sections have been surveyed in conjunction with the Bureau of Reclamation's river maintenance program. For the last ten years, the Bureau of Reclamation and its hydrographic data collection contractors have been responsible for surveying the majority of the cross sections. Many of the cross sections are located in groups throughout the Middle Rio Grande, with concentrations centered around specific project areas. When Cochiti Dam was under construction in the early 1970's, a series of cross sections were established and surveyed to monitor changes in river morphology over the long term. These cross sections are referred to as the Cochiti Lines and are labeled "CO" followed by a number. The first thirty-eight of these lines are numbered sequentially starting at 1 (which is actually within the pool at Cochiti). CO-38 is located upstream of the Interstate 25 Bridge over the Rio Grande just south of Albuquerque. From this location the "CO's" continue down to Elephant Butte with the numeric label corresponding to the Bureau's Aggradation – Degradation (Agg/Deg) Range Lines (ex. CO-668). Most of the other cross sections within this reach have labels that refer to the nearby community such as Santa Domingo (SD), Isleta (IS), or Socorro (SO). The numeric labels for these "sets" of lines vary between sequential numbering and Agg/Deg correlation. For the most part, recently established lines follow the Agg/Deg numbering scheme. Table 3 provides a key for the cross section abbreviations.

The existing cross section end points have been monumented with rebar and cap and have an adjacent fence post, often referred to as a "tag line" post. The location and elevation of the end points have been established with control surveys spatially referenced to the New Mexico State Plane Coordinate Grid System (NMSPCGS). All elevation data for the end points was initially referenced to the National Geodetic Vertical Datum (NGVD) of 1929. Subsequently, this elevation data has been adjusted to the North American Vertical Datum (NAVD) of 1988 using the coordinate conversion software "Corpscon".

All cross section point data within the current Middle Rio Grande (MRG) FLO-2D model is horizontally referenced to the NMSPCGS Central zone NAD 83 ft. All elevations are referenced to NAVD 88 ft. There are 354 surveyed cross sections currently in the MRG FLO-2D model. These sections have been assigned to over 1,600 "channel" grid elements within the model. Table 4 is a list of these sections. The locations of the cross sections in the model along with the FLO-2D grid are displayed on the 79 plates included in Appendix A.

Accurate river channel hydraulic modeling requires adequate cross section coverage. In a few reaches the number of cross sections exceeds what is necessary for hydraulic modeling, but there some reaches where the cross sections are spaced too far apart and additional cross section surveys are necessary to improve the model. For flood routing purposes, cross sections should be located at hydraulic controls or where the channel transitions from a wide to narrow cross section or vice versa. The MRG FLO-2D model has been developed with a grid system consisting of almost thirty thousand 500-ft grid elements. FLO-2D is a two-dimensional, finite difference, flood routing model with a one-dimensional channel routing component. The channel lengths (measured distance of active river through a given grid element) in the model range from roughly 450 ft to 700 ft. For that reason, it is not necessary to space the cross sections closer than 500 feet. For further information regarding the FLO-2D model the reader is encouraged to review the FLO-2D Manual (available from the Tetra Tech ISG Albuquerque office).

2.2 Additional Cross Section Needs

Ideally, there would be a distinct surveyed cross section available for each of the 1,637 channel grid elements within the MRG FLO-2D model. The cost of such a proposition, coupled with the incremental additional accuracy obtained, preclude this from being a recommendation at this time. However, there are locations within the reach where spacing is limited and additional cross sections should be surveyed. Incorporation of these recommended new lines would create a higher resolution FLO-2D flood routing model from Cochiti Dam to Elephant Butte.

Table 5 contains a list of recommended new cross sections along with their approximate location. The table provides a brief description of the role that the cross section will have in the reach. The table begins at Cochiti Dam and proceeds downstream to Elephant Butte. The proposed naming for this set is “CEB”. The recommended new cross sections are shown on the Plates in Appendix A.

In addition to the 58 recommended new cross sections shown in Table 5, there are 14 existing and 27 soon to be existing cross sections that can be added to the MRG FLO-2D model. The 14 existing lines are generally located between Cochiti Dam and Isleta Pueblo and vary as to when they were last surveyed. The 27 new sections, identified by Reclamation, are in the Albuquerque reach and are summarized in Table 6. The numeric designation of these lines corresponds with the Agg/Deg lines. These lines should have their initial surveys completed by the spring of 2004.

Table 3. Cross Section Abbreviations

Abbreviation	Description
CO	Original Cochiti Lines – initially established in 1972 – extend from Cochiti Dam to San Acacia
CI	Cochiti Lines (within and near Cochiti Pueblo (below dam))
SD	Santa Domingo Lines (within and near Santa Domingo Pueblo)
SFP	San Felipe Lines (within and near San Felipe Pueblo)
AR	Angostura Lines – near Angostura Diversion Dam
TA	Santa Ana Lines (within and near Santa Ana Pueblo)
BI	Bernalillo Island Lines – Near NM 44 bridge
BB	Below Bernalillo Lines – Below the village of Bernalillo
CR	Corrales Lines – Near Corrales
CA	Calabacillas Arroyo Lines - Near the confluence
A	Albuquerque Lines (between Bridge Blvd & Rio Bravo)
AQ	Proposed additional Albuquerque Lines (between Moñtano and Isleta diversion Dam)
IS	Isleta Lines (within and near Isleta Pueblo)
LL	Los Lunas Lines – Near Los Lunas restoration site
CC	Casa Colorado Lines
AH	Abeyta’s Heading Lines
LJ	La Joya Lines – within and near La Joya Wildlife Refuge
RP	Rio Puerco Lines – Near the confluence
SA	San Acacia Lines – D/S of the diversion dam to ~ Socorro
SO	Socorro Lines – Socorro to the San Marcial RR bridge
FC	Fort Craig Lines – Below San Marcial RR bridge – near the old Fort Craig
EB	Elephant Butte Lines – Between the San Marcial RR bridge & the Reservoir
CEB	Proposed new lines between Cochiti dam and Elephant Butte Reservoir

Table 4. Existing Middle Rio Grande FLO-2D Cross Sections

Reach	*Cross Section*	*Date*	*Reach*	*Cross Section*	*Date*	*Reach*	*Cross Section*	*Date*
CI	27.1	8/24/98	SFP	194	10/20/89	CO	28	8/13/99
CI	29.1	8/24/98	CO	19	9/17/98	BI	284	5/31/00
CI	36.1	8/23/98	SFP	197	10/20/89	BI	286	5/31/00
CI	37.2	8/24/98	SFP	198	10/20/89	BI	289	5/31/00
CI	40	8/26/98	SFP	199	10/20/89	BI	291	8/14/99
CI	41	8/26/98	SFP	200	10/20/89	BI	292	8/15/99
CI	M1	9/13/99	AR	203	1/18/00	BI	293	8/15/99
CI	M4	9/13/99	AR	204	1/18/00	BI	294	8/18/99
CI	M7	9/14/99	AR	205	1/18/00	CO	29	8/15/99
CI	M10	9/14/99	AR	206	1/18/00	BI	296	8/18/99
CO	5	9/18/98	AR	207	1/18/00	CO	30	9/15/98
CO	6	9/18/98	AR	209	1/18/00	CO	31	9/24/98
CO	7	9/18/98	AR	211	1/18/00	CO	32	9/24/98
CO	8	9/18/98	AR	214.5	1/18/00	CO	33	9/24/98
SD	M1	8/10/99	AR	215	1/19/00	CO	34	9/29/98
SD	M3	8/10/99	AR	216	1/19/00	CA	1	6/2/96
SD	M6	8/10/99	AR	216.5	1/19/00	CA	2	6/2/96
SD	M10	9/2/99	AR	217.5	1/19/00	CA	3	6/2/96
CO	9	9/17/98	AR	219.5	1/19/00	CA	4	6/2/96
CO	10	9/17/98	AR	220.5	1/19/00	CA	5	6/3/96
SD	1	6/25/92	AR	222	1/19/00	CA	6	6/3/96
SD	3	6/25/92	AR	224	1/20/00	CA	9	6/3/96
SD	5	6/25/92	CO	22	9/17/98	CA	10	6/4/96
SD	7	2/28/93	AR	227.5	1/20/00	CA	11	6/4/96
SD	8	2/28/93	AR	229	1/20/00	CA	12	6/1/00
SD	10	6/26/92	AR	230	1/20/00	CA	13	6/4/96
SD	12	6/26/92	AR	232	1/21/00	CO	35	6/1/00
SD	14	6/26/92	AR	233	1/21/00	CA	36	6/2/00
SD	16	6/26/92	AR	234	1/21/00	A	1	5/19/99
SD	17	3/1/93	AR	235	1/21/00	A	4	5/20/99
SD	19	3/1/93	CO	23	9/18/98	A	6	5/20/99
SD	20	6/27/92	CO	24	8/18/99	CO	37	6/2/00
SD	22	6/27/92	TA	249	8/18/99	IS	658	6/22/98
SD	25	6/27/92	TA	250	8/18/99	CO	668	6/22/98
SD	27	6/27/92	TA	252	8/4/99	IS	675	6/22/98
SD	30	3/1/93	TA	253	8/4/99	IS	678	6/22/98
SD	32	3/1/93	TA	253.9	8/19/99	IS	688	6/22/98
SD	33	3/1/93	TA	255	8/5/99	IS	689	6/22/98
SD	34	3/2/93	CO	25	8/5/99	IS	691	6/22/98
SD	35	3/2/93	TA	258.2	8/12/99	IS	705	6/22/98
SD	36	3/2/93	TA	259	8/11/99	CO	713	6/22/98
SD	37	3/2/93	TA	259.4	8/19/99	CO	724	6/22/98
SD	39	3/2/93	CO	26	5/30/00	CO	738.1	6/21/98
SD	43	3/3/93	TA	262	8/19/99	IS	741	6/21/98
SD	44	3/3/93	TA	263	5/30/00	IS	748	6/21/98
SD	45	6/28/92	TA	264	8/19/99	IS	752	6/21/98
SD	47	6/28/92	TA	265	5/30/00	IS	765	6/21/98
CO	14	9/16/98	TA	267	5/30/00	IS	772	6/21/98
CO	15	9/16/98	CO	27	5/30/00	IS	782	6/20/98
CO	16	9/16/98	TA	269	5/30/00	IS	787	6/20/98
SFP	170	6/29/92	TA	270	5/30/00	IS	797	6/20/98
SFP	172	8/25/98	TA	273	6/2/00	IS	801	6/20/98
SFP	173	6/29/92	TA	274	6/2/00	IS	806	6/20/98
SFP	178	10/18/89	TA	276	6/2/00	IS	815	6/19/98
SFP	179	10/19/89	TA	278	5/31/00	IS	833	6/19/98
SFP	180	10/19/89	TA	279	8/13/99	IS	841	6/19/98
SFP	181	10/20/89	TA	280	5/31/00	IS	849	6/18/98
CO	18	9/17/98	TA	281	8/13/99	IS	849	6/18/98
SFP	193	10/20/89	TA	282	5/31/00	CO	858.1	6/18/98
IS	860	6/19/98	SA	1215	01/02	SO	1491	5/02

IS	864	6/19/98	SA	1218	01/02	SO	1496	5/02
IS	872	6/19/98	SA	1221	01/02	SO	1499	5/02
CO	877	6/17/98	SA	1223	01/02	SO	1502	5/02
IS	880	6/17/98	SA	1224	01/02	SO	1508.9	5/02
IS	884	6/17/98	SA	1225	01/02	SO	1517.2	5/02
IS	885	6/17/98	SA	1226	01/02	SO	1524	5/02
IS	887	6/17/98	SA	1228	01/02	SO	1531	5/02
CO	895	6/18/98	SA	1229	01/02	SO	1536	5/02
IS	899	6/18/98	SA	1230	01/02	SO	1539	5/02
IS	908	6/18/98	SA	1231	01/02	SO	1550	5/02
CO	926	9/1/98	SA	1232	01/02	SO	1554	5/02
CC	924	3/25/96	SA	1236	01/02	SO	1557	5/02
CC	927	3/25/96	SA	1243	01/02	SO	1560.5	5/02
CC	930	3/25/96	SA	1246	01/02	SO	1566	5/02
CC	932	3/25/96	SA	1252	01/02	SO	1572.5	5/02
CC	934	3/25/96	SA	1256	01/02	SO	1576	5/02
CC	936	3/25/96	SA	1259	01/02	SO	1581	5/02
CC	939	3/26/96	SA	1262	01/02	SO	1583	5/02
CC	941	3/28/96	SA	1268	01/02	SO	1584	5/02
CC	943	3/25/96	SA	1274	01/02	SO	1585	5/02
CC	945	3/25/96	SA	1280	01/02	SO	1596.6	5/02
CO	966	9/13/98	SA	1292	01/02	SO	1603.7	5/02
CO	986	9/1/98	SO	1298	5/02	SO	1626	5/02
CO	1006	9/1/98	SO	1302	5/02	SO	1641	5/02
AH	1	2/11/94	SO	1306	5/02	SO	1645	5/02
AH	2	2/10/94	SO	1308	5/02	SO	1650	5/02
AH	3	2/10/94	SO	1310	5/02	SO	1652.7	5/02
AH	4	2/10/94	SO	1311	5/02	SO	1660	5/02
AH	5	2/11/94	SO	1312	5/02	SO	1662	5/02
AH	6	2/11/94	SO	1313	5/02	SO	1663	5/02
AH	7	2/11/94	SO	1314	5/02	SO	1664	5/02
CO	1026	9/1/98	SO	1316	5/02	SO	1666	5/02
CO	1044	9/1/98	SO	1320	5/02	SO	1667	5/02
CO	1064	9/3/98	SO	1327	5/02	SO	1668	5/02
CO	1091	9/2/98	SO	1339	5/02	SO	1670	5/02
RP	1100	10/5/00	SO	1342.5	5/02	SO	1673	5/02
CO	1104	9/2/98	SO	1346	5/02	SO	1683	5/02
RP	1108	10/5/00	SO	1349	5/02	SO	1692	5/02
LJ	5	9/26/00	SO	1352	5/02	SO	1701.3	5/02
LJ	9	9/26/00	SO	1360	5/02	EB	10	5/02
RP	1128	9/26/00	SO	1371	5/02	EB	12	5/02
LJ	15	10/5/00	SO	1380	5/02	EB	13	5/02
LJ	20	9/26/00	SO	1394	5/02	EB	14	5/02
RP	1144	12/19/00	SO	1396.5	5/02	EB	15	5/02
RP	1150	10/5/00	SO	1398	5/02	EB	16	6/02
RP	1160	9/29/00	SO	1401	5/02	EB	17	6/02
CO	1164	9/2/98	SO	1410	5/02	FC	1754	6/02
RP	1170	9/29/00	SO	1414	5/02	EB	18	6/02
CO	1179	9/3/98	SO	1420	5/02	EB	19	6/02
RP	1184	9/29/00	SO	1428	5/02	EB	20	6/02
RP	1190	10/5/00	SO	1437.9	5/02	EB	21	6/02
CO	1194	9/2/98	SO	1443	5/02	EB	34	6/02
RP	1201	9/29/00	SO	1450	5/02	EB	23	6/02
RP	1205	9/28/00	SO	1456	5/02	EB	24	6/02
SA	1207	7/13/98	SO	1462	5/02	EB	25	6/02
SA	1209	7/13/98	SO	1464.5	5/02	EB	26	6/02
SA	1210	01/02	SO	1470.5	5/02	EB	27	6/02
SA	1212	01/02	SO	1482.6	5/02			

Table 5. Suggested New Middle Rio Grande Cross Section Surveys

Reach and Cross Section No.	Location	Grid No.	Need for Cross Section
Cochiti Dam to Highway 44			Cobble Bed Reach
CEB-1	Downstream of Cochiti Dam	59	Stabilize the model inflow
CEB-2	Downstream of CO-5	400	Represent reach between CO-5 and CO-6
CEB-3	Upstream of CO-8	504	Channel constriction on bend
CEB-4	Upstream of CO-14	731	Sharp bend and constriction
CEB-5	Between CO-14 and CO-15	819	Long reach without cross section
CEB-6	Between CO-15 and CO-16	890	Long split channel flow
CEB-7	Between CO-23 and CO-24	1191	Long reach without cross section
Highway 44 to Isleta Diversion			
CEB-8	Upstream of Alameda Bridge	2290	Alameda Bridge hydraulics
CEB-9	Downstream of Alameda Bridge	2319	Alameda Bridge hydraulics
CEB-10	Upstream of Montaño Bridge	3574	Montaño Bridge hydraulics
CEB-11	Downstream of Montaño Bridge	3612	Montaño Bridge hydraulics
CEB-12	Upstream of I-40 Bridge	4576	I-40 Bridge hydraulics
CEB-13	Downstream of I-40 Bridge	4608	I-40 Bridge hydraulics
CEB-14	Upstream of Central Avenue Bridge	5032	Central Ave. Bridge hydraulics
CEB-15	Upstream of Bridge Blvd.	5485	Bridge Blvd. Bridge hydraulics
CEB-16	Downstream of Bridge Blvd.	5517	Bridge Blvd. Bridge hydraulics
CEB-17	Upstream of Rio Bravo Bridge	6661	Rio Bravo Bridge hydraulics
CEB-18	Downstream of Rio Bravo Blvd. Bridge	6790	Long reach between cross sections
CEB-19	Downstream of South Diversion Channel	7331	Monitor effects of South Diversion Channel sediment load
CEB-20	Downstream of South Diversion Channel	7439	Monitor effects of South Diversion Channel sediment load
CEB-21	Upstream of I-25 Bridge	8601	I-25 Bridge hydraulics
CEB-22	Downstream of I-25 Bridge	8629	I-25 Bridge hydraulics
CEB-23	Downstream of I-25 Bridge	8774	Long reach between cross sections
CEB-24	Upstream of Railroad Bridge	8867	Long reach between cross sections
CEB-25	Upstream of Railroad Bridge	8999	Railroad Bridge hydraulics
CEB-26	Downstream of Railroad Bridge	9026	Railroad Bridge hydraulics
CEB-27	Upstream of Isleta Diversion	9334	Monitor channel upstream of diversion
Isleta to Highway 60 Bridge			
CEB-28	Downstream of CO-877	16913	Bridge hydraulics

CEB-29	Downstream of IS-908, First gas pipeline	17787	Long reach between cross sections
CEB-30	Upstream of Bridge	18490	Bridge hydraulics
CEB-31	Downstream of bridge	18490	Bridge hydraulics
CEB-32	Downstream of CC-945	18541	Long reach between cross sections
CEB-33	Downstream of CC-945	18663	Long reach between cross sections
CEB-34	Downstream of CO-966	18898	Long reach between cross sections
CEB-35	Upstream of CO-986	19081	Transition to narrower channel
CEB-36	Downstream of CO-986	19335	Transition to wider channel
CEB-37	Upstream of CO-1006	19472	Long reach between cross sections
CEB-38	Downstream of CO-1006	20355	Constriction
CEB-39	Upstream of CO-1044	20484	Transition to wider channel
CEB-40	Upstream of Highway 60 Bridge	21036	Highway 60 Bridge hydraulics
CEB-41	Downstream of Highway 60 Bridge	21082	Highway 60 Bridge hydraulics
Highway 60 Bridge to San Acacia Diversion Dam			
CEB-42	Downstream of Highway 60 Bridge	21304	Highway 60 Bridge hydraulics
CEB-43	Downstream of CO-1064	21614	Long reach between cross sections, wide channel
CEB-44	Upstream of CO-1091	21843	Transition to narrower channel
CEB-45	Upstream of CO-1091	21901	Constriction
CEB-46	Upstream of CO-1091	22020	Constriction
CEB-47	Upstream of Rio Puerco	22138	Monitor effects of Rio Puerco confluence
CEB-48	Downstream of Rio Puerco	22198	Monitor effects of Rio Puerco confluence
CEB-49	Downstream of RP-1108	22496	Transition to wider channel
CEB-50	Upstream of RP-1150	23188	Transition to narrower channel
CEB-51	Downstream of RP-1150	23224	Constriction
CEB-52	Downstream of RP-1184	23476	Wide channel
CEB-53	Downstream of RP-1194	23657	Fast transition, wide to narrow channel
CEB-54	Upstream of San Acacia Diversion Dam	23727	Sediment storage upstream of San Acacia Dam
San Acacia Diversion Dam to San Marcial Bridge			
CEB-55	Downstream of SA-1280	24724	Long reach no cross section, transition to wider channel
CEB-56	Downstream of SO-1327	25047	Wide channel
CEB-57	Upstream of SO-1339	25071	Transition to narrow cross section
CEB-58	Downstream of SO-1371	25284	Wide channel

Table 6. Proposed USBR Cross Sections in Albuquerque Reach	
Line	**USBR River Mile designation**
AQ-467	187.6
AQ-472	187.1
AQ-476	186.7
AQ-480	186.3
AQ-487	185.6
AQ-492	185.2
AQ-496	184.2
AQ-503	184
AQ-507	183.6
AQ-520	182.3
AQ-526	181.7
AQ-531	181.2
AQ-535	180.8
AQ-567	177.8
AQ-572	177.3
AQ-577	176.9
AQ-582	176.4
AQ-589	175.7
AQ-595	175.2
AQ-600	174.7
AQ-606	174.1
AQ-610	173.7
AQ-621	172.7
AQ-625	172.4
AQ-637	171.2
AQ-643	170.5
AQ-648	170

2.3 Discussion

A total of 58 cross sections have been located for potential survey. Many of the recommended new cross sections are located in and around the Albuquerque Reach from the Bernalillo Highway 44 Bridge to the U.S. Highway 60 Bridge at Bernardo. A number of these proposed cross sections are situated immediately upstream and downstream of the various bridge crossings in this reach. These sections coupled with the new Bureau sections will improve the model in this heavily urbanized area of the river valley. The reach from the Highway 60 Bridge to the San Acacia Diversion Dam also has a significant number of recommended new cross sections. Most of the new cross sections are based on the distance between existing cross sections. A number of these new cross sections have been suggested on the basis of river transitions.

Generally, the recommended cross sections have been positioned so that a given cross section will not represent more than 5 or 6 grid elements in the FLO-2D model. The exception to this rule is where the channel appears reasonably uniform in width. The actual location of the cross section at the time of survey will depend on access constraints, land ownership and availability of survey control. The use of Global Positioning Survey (GPS) methodology will help facilitate survey control issues. Control surveys for the new lines should originate from the existing control network along the river maintained by the Bureau and its terrestrial surveying contractor(s). The suggested locations on the maps in the appendix can be varied in the field depending on vegetation or bank conditions.

We recommend that the cross sections be surveyed at high flow. This provides a better estimate of the cross section flow area at bankfull discharge. It also facilitates access for locating, clearing and establishing the cross section. The new cross sections can be surveyed prior to the establishment of end point control. In many cases this is a preferable alternative, as it allows some in-field flexibility on the initial survey. The additional lines being proposed span the active channel plus about 50-ft on each floodplain. Extending these lines to the levees is unnecessary as the floodplain elevations are established in the model with the DTM database.

Assuming that three cross sections can be surveyed per day, it would take one field crew approximately 20 days to survey all the cross sections. If two field crews and boats are utilized, the cross sections could be surveyed in about 10 days. At current field crew data collection rates, all the cross sections could be located, surveyed, and the data reduced for about $60,000. Some of the new cross sections are located some distance from other new cross sections, thus logistics between cross sections will contribute to the time required to complete the surveys.

SECTION 3 - OVERBANK DATA COLLECTION PLAN

3.1 Introduction

The goal of this plan is to develop and coordinate hydrographic data collection activities in the Middle Rio Grande during a high flow release from Cochiti Dam. The study river reach extends from Cochiti Dam to Elephant Butte Reservoir. The data collection logistics will be prioritized to benefit research related to the ESA collaborative support program. This will be accomplished by monitoring the high flow impacts on restoration areas, by collecting data in reaches that have no or limited hydrographic data or channel cross section surveys, and by calibrating the FLO-2D model for high flow floodplain inundation.

There are a significant number of river studies that are currently being conducted or are planned throughout the Middle Rio Grande related to channel and riparian restoration, ESA research, groundwater investigation, low flow depletions, and water resource allocation. Two examples are the ESA Collaborative Program's Habitat Restoration Plan and the Save Our Bosque (SOB) Restoration Plan for the San Acacia to San Marcial reach. The majority of these projects involve some facet of overbank flooding. Overbank flooding issues are multifarious and include habitat restoration for the Rio Grande Silvery Minnow, the Southwestern Willow Flycatcher, and cottonwood Bosque regeneration. Two key flooding issues are floodwave attenuation and water depletion or loss associated with open water evaporation. In order to optimize Middle Rio Grande (MRG) water resource planning and management for overbank flooding; it is expedient to simulate high flow releases from Cochiti Dam. A FLO-2D model of the Middle Rio Grande has been developed to simulate channel routing, overbank flooding and potential system losses to infiltration and evaporation. The model has been applied to the San Acacia – San Marcial reach to plan channel and riparian restoration activities and determine the potential impacts of implementing restoration.

To increase the accuracy and resolution of the FLO-2D flood routing model, it is necessary to calibrate the model at bankfull conditions. This will include conducting channel cross section surveys, surveying high water surface elevations, photographing and surveying overbank flooding and obtaining aerial video of overbank flooding. While there are hundreds of MRG surveyed cross sections, very few of them have been surveyed at bankfull discharge and higher. There is almost no aerial photography of the inundation areas at known discharges. Although the FLO-2D model has been calibrated to historical gage records, the reach by reach area of inundation has not been calibrated. The proposed tasks are designed to provide a complete database that will more accurately identify the area of inundation and assess floodwave attenuation associated with a known release from Cochiti Dam. All survey data collected will be geo-referenced and after post processing will be fully compatible with GIS and CADD.

The data collection plan presented herein is comprehensive and is somewhat dependent on available volume and magnitude of flow in the river. If river flows are limited or funding constraints prohibit significant data collection, it is still of great value to researchers and modelers to have some data collected. As a general rule, it is better to collect some hydrographic data in many reaches, rather than focusing collection efforts on any specific reach.

3.2 High Flow Hydrograph Releases from Cochiti Dam

The purpose of designing and implementing a flood pulse release from Cochiti Dam is to document the potential response of channel and riparian restoration activities to high flows. This data will be used to calibrate the FLO-2D model. Two possible high flow scenarios were considered; a 5,000 cfs and a 7,000 cfs release from Cochiti Dam. The 5,000 cfs release is a minimum release to generate some overbank flooding in the Isleta, Belen and lower San Acacia to San Marcial reach. The 7,000 cfs Cochiti Dam release is based on a "current" maximum prescribed discharge measured at the Albuquerque gage to avoid any downstream adverse impacts. Historical high flow releases have exceeded 8,000 cfs (measured at Albuquerque). It is suggested that flows greater than 7,000 cfs should be considered when planning the potential high flow releases. It would be advantageous if a prescribed high flow release could be conducted during a period when other inflows to the system are minimized such as Jemez Dam release and Rio Salado and Rio Puerco flows. It would also be beneficial to have the releases mimic the historical timing of seasonal spring high flows to support cottonwood regeneration. Table 7 shows high flow releases greater than 5,000 cfs and 7,000 cfs since the construction of Cochiti Dam in 1973.

Table 7. COCHITI DAM HIGH FLOW RELEASES

Year	Maximum Discharge at Cochiti (cfs)	Maximum Discharge at San Marcial (cfs)*	Average Discharge at Cochiti (cfs)	Number of Days**	Total Volume (acre-ft)
Flows > 5,000 cfs release					
1979	6,820	6260	5,850	100	1,160,300
1980	6,840	6040	6,250	51	632,300
1983	6,670	4990	6,060	38	457,000
1992	5,580	5150	5,210	19	145,400
1994	6,230	5440	5,200	49	505,300
1995	6,410	4880	5,520	59	646,100
1997	6,610	4320	5,850	29	336,800
Flows > 7,000 cfs release					
1973	8,100	5970[1]	7,660	5	75,980
1984	8,000	5330[2]	7,580	23	345,800
1985	8,290	6550	7,440	30	442,500
1993	7,230	5440	7,140	7	99,200

*Within 12 days of max. discharge at Cochiti
**Number of days from start to end of 5,000 cfs (discharge occasionally dropped below 5,000 cfs during this time) or 7,000 cfs release
[1] 1,790 cfs in LFCC on date of max. discharge at San Marcial
[2] 1,540 cfs in LFCC on date of max. discharge at San Marcial

Table 7 shows the Cochiti releases that were greater than 5,000 cfs, but less than 7,000 cfs and those releases that were over 7,000 cfs. These two flows were selected to estimate the potential areas of inundation for a moderate amount of flooding (5,000 cfs) for a long duration and a higher Cochiti release (>7,000 cfs) for a shorter duration. Flows greater than 5,000 cfs occurred 11 times in 28 years during the period from 1973 to 2001. Flows greater than 5,000 cfs typically occurred for a month or more with the shortest flow duration being two weeks. The 7,000 cfs high flow releases from Cochiti had shorter durations, with two of these historic releases lasting only 5 and 7 days. This illustrates that Cochiti Dam releases constituting a volume of approximately 100,000 acre-ft could generate a 7,000 cfs flow for 7 days or a volume of 150,000 acre-ft could result in a 5,000 cfs flow for 14 days. This does not include the volume associated with the rising and recessional limbs of the release hydrographs that will be discussed later in this report.

The question posed by this analysis is: 'For a prescribed high flow release from Cochiti Dam, how many days (or hours) are necessary to achieve the maximum benefit from overbank flooding?' The answer can be assessed with the FLO-2D model by reviewing the predicted hydrograph at San Marcial and the predicted floodplain area of inundation. The MRG FLO-2D model from Cochiti to San Marcial was run with peak flow hydrographs of 5,000 cfs and 7,000 cfs. The San Acacia to San Marcial updated database for the SOB study has been incorporated into the existing MRG model. Flow duration of 7 and 10 days were simulated with the model for both 5,000 cfs and 7,000 cfs after an initial ramp-up period of 3 to 4 days. For the 5,000 cfs peak runs the ramp-up lasted 72 hours after which the 5,000 cfs peak was simulated for varied duration. Analysis of model results from these runs showed a steady peak discharge of approximately 2,900 cfs was predicted at San Marcial beginning about at hour 250. For the 7,000 cfs simulated release beginning at hour 96 after a four-day ramp-up, a steady peak discharge of approximately 3,700 cfs was predicted to arrive at San Marcial at about hour 260. It can be inferred from these analyses that about 7.5 days are necessary to completely fill the overbank storage for a 5,000 cfs peak and about 6.5 days are necessary to fill the overbank storage of 7,000 cfs peak.

Table 8 shows that the area of inundation does not significantly increase for flows greater than 8 days for 5,000 cfs or 7 days for 7,000 cfs. The slight increase in the area of inundation associated with longer duration of high flows of 8 to 11 days for 5,000 cfs or 7 to 10 days for 7,000 cfs is related to the predicted gradual filling of the floodplain infiltration storage. There was no appreciable increase in the channel wetted surface area. The total wetted surface area is greater for 7,000 cfs than 5,000 cfs because the water surface elevation is higher both in the channel and on the floodplain.

Table 8. ESTIMATED AREA OF INUNDATION AS FUNCTION OF DISCHARGE AND DURATION

Flow (cfs)	Duration (hours-days)	Channel Wetted Surface Area (acres)	Floodplain Area of Inundation (acres)	Total Wetted Surface Area (acres)
5,000	192 – 8	9,442	4,878	14,320
5,000	264 – 11	9,442	4,915	14,357
7,000	168 – 7	9,733	10,254	19,987
7,000	240 – 10	9,735	10,436	20,171

It is recommended that at least 8 days of 5,000 cfs or 7 days of 7,000 cfs (as measured at Albuquerque) be released from Cochiti Dam to conduct an overbank flood inundation monitoring study. This will ensure that the maximum area of inundation is achieved by the prescribed release.

The prescribed peak discharges of 5,000 cfs and 7,000 cfs will be augmented by the hydrograph rising and recessional limbs. Table 9 displays the maximum daily ramp-up and ramp-down for the spring runoff years in Table 7. A maximum daily increase in discharge was 2,050 cfs or about 85 cfs/hr. The maximum daily decrease was 1,840 cfs or about 77 cfs/hr. The mean annual spring hydrograph at San Acacia for the period from 1936 to 1950 had an average daily rising limb ramp-up of about 175 cfs/day and about 135 cfs/day average daily recessional decrease in discharge.

The post-Cochiti releases have substantially higher discharge increments than the pre-Cochiti spring runoff hydrographs for the rising and recessional limbs.

It is recommended that the ramp-ups and ramp-downs attempt to mimic the natural hydrograph to the maximum extent possible. For limited hydrograph volumes, however, increases and decreases of 1,000 cfs per day and higher have been historically recorded during the post-Cochiti period.

Table 9. MAXIMUM INCREASE AND DECREASE IN COCHITI RELEASE HYDROGRAPHS				
Year	Maximum Daily Increase (cfs/day)	Maximum Daily Decrease (cfs/day)	Fastest Ramp-ups	Fastest Ramp-downs
1973	1300	-1300	4120 in 10 days	
1975	1590	-980		
1979	1510	-1480		3740 in 4 days
1980	600	-560		
1983	750	-1020		
1984	770	-1430		4070 in 5 days
1985	2050	-1511	4770 in 5 days	3580 in 6 days
1991	990	-1180		3536 in 6 days
1992	400	-860		
1993	1670	-1840		3120 in 5 days
1994	1190	-1410		4220 in 5 days
1995	720	-1330		3880 in 5 days
1997	690	-910		3670 in 6 days
1999	740	-560		

3.3 Data Collection Locations

Water release from Cochiti Dam will be limited by volume constraints. The data collection plan during a high flow Cochiti release should be designed to maximize the data collection effort during the limited available release time. Data collection will be planned and organized at selected cross sections, at locations for surveying water surface elevations, at overbank flooding areas, and at restoration sites. Appendix B contains reach maps that display cross section locations, restoration project locations and predicted areas of overbank flooding.

3.3.1 High Flow Cross Section Surveys

There are over 600 established cross sections on the Rio Grande between Cochiti Dam and Elephant Butte Reservoir. They have monumented endpoints with known coordinates (New Mexico State Plane) and almost all of them have been previously surveyed. The majority of the previous cross section surveys, however, were completed during low or moderate in-channel flows and at varied times. Channels adjust their shape to convey bankfull discharge. Cross section surveys at high flows will improve FLO-2D model channel routing through observations of water surface elevations, bed forms and channel scour or deposition. These comparisons would show how the river channel geometry adapts to convey higher (near bankfull) flows.

Approximately 300 cross section surveys could be completed during a seven-day high flow release using four survey crews. The first priority is to survey cross sections in river reaches where there is limited cross section coverage. Other cross section surveys would then be planned where river geomorphology changes are anticipated, at hydraulic structures such as bridges, and in reaches where channel or overbank restoration projects are located. Finally, additional cross sections will be surveyed where there are long distances between cross sections. In some reaches, such as the TA-lines in Santa Ana Pueblo, the cross sections are extremely close together and it is not necessary to survey all the cross sections.

Additional cross sections in reaches where extensive river channel geometry changes are anticipated will minimize the need to interpolate cross sections in the FLO-2D model. In response to high flows, channels may widen or scour/mobilize sandbars which can result in changes in water surface or bed slope. Of particular interest may be channel geometry variation at tributaries and arroyo confluences, at locations where the river has been channeled, or at the location of channel restoration projects. Bridges and diversion dams are hydraulic controls that effect water surface elevation. Four cross sections should be surveyed at each structure; one immediately upstream and downstream at the structure and one several hundred feet upstream and downstream. Cross sections in restored areas will be surveyed to observe the channel response to high flows. Cross sections that have been surveyed pre- and post-restoration should be given priority.

If the volume and magnitude of a spring run off hydrograph is limited, for example a 4,000 cfs for three days from Cochiti, high flow surveys should be scaled back and conducted beginning in the Albuquerque reach and continue downstream. It is recommended that at least two sections be surveyed in each reach at or near peak stage. Selected sections should focus on the aforementioned criteria. It is more valuable to the overall system and calibration of FLO-2D and other hydraulic models if some cross sectional data is collected at numerous locations rather than a very focused effort at one site.

3.3.2 Channel Water Surface Elevation Surveys

High water surface elevations should be surveyed at existing cross sections. This is accomplished most efficiently using a surveyor's level and field rod to survey one of the established endpoint elevations and the nearby water surface elevation. These water surface elevations can be used to calibrate the n-values and adjust the interpolated channel cross sections in the FLO-2D model. Water surface elevations should be surveyed at all existing cross sections if time permits. If run off is limited, as described in the previous paragraph, water surface elevations should be obtained in approximately two-mile increments for the entire reach.

3.3.3 Overbank Flooded Areas

One of the key components of the overbank monitoring study is the observation and recording of areas of inundation outside the active channel. Aerial photography and video will be the primary means of accomplishing this work. Ground inspection of flooded areas can be used to verify aerial videos as well as document flooding in areas of dense vegetative canopies. Ground photography would compliment the aerial photography. A crew would be assigned to driving the levee(s) with a Global Positioning System (GPS) unit to estimate areas of inundation where aerial photography may be compromised by vegetative cover. Observations of floodplain flow depth and velocity would be recorded. Simulations using the current FLO-2D model will be used to identify those areas of potential inundation. Data collection efforts will focus on those areas, as well as areas that are observed to be experiencing flooding.

3.3.4 Channel and Floodplain Restoration Sites

The response of restoration projects to high flows is critical to planning future channel and riparian restoration on the Middle Rio Grande. Restoration project goals include enhancing overbank flooding and mimicking historic river-floodplain connectivity. Restoration activities in conjunction with high flows are designed to reshape the channel, remove sand bar and bank-stabilizing vegetation, redistribute sediment and inundate floodplain areas with increased frequency and duration. It may be necessary to resurvey the floodplain in the restoration project area to identify the response of the project design to high flows. Documenting the high flow impacts in the restored project reaches will enable an assessment of the effectiveness of restoration techniques.

There are a large number of restoration projects in the study reach. These include grade reduction facilities, floodplain lowering, exotic species removal and native species planting, and wetland creation. Most of the projects are limited to vegetation removal and native vegetation planting. These sites are not as likely to be impacted by a high flow event. The governing entity or public agency responsible for the project should implement monitoring of these sites.

At least five restoration projects relocated the river channel or excavated the floodplain. These are the Santa Ana Pueblo Restoration Project, Albuquerque Overbank Restoration Project, San Antonio Oxbow Wetland and Restoration Project, Los Lunas Habitat Restoration Project, and Bosque del Apache National Wildlife Refuge (BDANWR) Pilot Channel Project. High flow cross section surveys at these sites will record the changes caused by the flood. Pre-flood surveys serve as a baseline condition and should be scheduled if the cross sections have not been surveyed recently. Other projects along the study reach are currently in the planning stage.

Santa Ana Pueblo GRF

The Santa Ana Restoration Project consists of a Grade Reduction Facility (GRF), channel relocation, and floodplain excavation. Twenty-four cross sections through the restoration reach were surveyed before construction began in 2000 and again after completion of the GRF and pilot channel in 2001. The project is located north of the community of Bernalillo just downstream from the Jemez River confluence near river mile 208. Two additional GRFs, located just downstream from the existing installation, are planned for construction later this year or early next year. Santa Ana Pueblo and the Corps of Engineers are working on this effort.

San Antonio Oxbow Wetland and Restoration Project

The San Antonio Oxbow Wetland and Restoration Project is located in Albuquerque in the Rio Grande Valley State Park between the Montaño bridge and Interstate 40 near river mile 186. A sediment plug has been cleared from the north end of the oxbow bend allowing high flows to reenter the oxbow channel.

Albuquerque Overbank Restoration Project

The Albuquerque Overbank Restoration Project involved removing exotic vegetation and excavating a portion of the floodplain on an alternate bar in Albuquerque. There are two established cross sections at the site and seven others upstream and downstream for monitoring. The project was constructed in 1998 and is located near river mile 180.

Los Lunas Habitat Restoration Project

The Los Lunas Restoration Project is located near river mile 158. This project consisted of Jetty Jack removal, exotic vegetation removal and overbank excavation along approximately 6000 ft. of channel. There are fourteen established river cross sections that were surveyed and photographed in April of 2002, just as construction was beginning.

Bosque Del Apache National Wildlife Refuge Pilot Channel Project

A 3 mile pilot channel is being constructed on the Bosque del Apache National Wildlife Refuge between river miles 78 and 74 by the Bureau of Reclamation. The goal is to widen the river channel and increase river-floodplain interaction. There are 12 established river cross sections that were surveyed in May 2002 before construction began.

3.3.5 Discharge Measurements

The nature of the Middle Rio Grande sand bed channel causes a frequent loss of calibration of the USGS discharge rating curves at the various gages. Of particular concern are the Albuquerque, Bernardo, San Acacia and San Marcial gages. Additional discharge measurements during the high flow release should be considered to improve the accuracy of the gage record during the high flow releases. This discharge gaging effort can be coordinated with the USGS or field crews can collect the discharge measurements.

Additional discharge measurement sites could be set up for the high flow event. Suggested locations are the narrows upstream at Elephant Butte Reservoir to measure the flow entering the reservoir, and sites upstream and downstream of the Rio Salado to measure any inflows during the event.

3.4 Data Collection Methods

Crews will be assigned to collect a variety of hydrographic survey data. The data collection effort will be designed to maximize the data collected during the limited duration of the high flow. Aerial photos will be used to estimate the area of inundation. Ground surveys and observations will compliment and verify the aerial photography and videos. Channel cross section and high water surface elevation surveys will identity the channel geometry response to high flows and will enable calibration of channel hydraulic roughness in the model. Discharge measurements will verify the accuracy of USGS gage calibration and will help to assess floodwave attenuation.

3.4.1 Aerial Photos

Aerial photos will be taken of the entire reach from Cochiti Dam to the upper end of Elephant Butte Reservoir. There are two alternatives for the aerial photos, fixed wing aircraft and satellite imagery. The fixed wing aircraft photography is more expensive but would result in a higher quality photo resolution. It is noted that a variety of resolutions can be obtained using fixed wing aircraft for the photography. Past experience on the MRG has shown that a combination of flight mission and post processing resulting in digital product with a two-foot pixel resolution is useful for the intended purpose. The resolution of commercially available satellite imagery also can vary but is generally most economical at the 4 meter pixel resolution. Commercial entities are continually pushing the technology envelope regarding satellite imagery and remote sensed data. It is strongly recommended that at least one vendor be contacted at least two months prior to any data collection effort to evaluate the state of the industry and its pricing.

Either method can provide color or color infrared images. Cloud cover or adverse weather is a concern for aerial photography. A satellite could be scheduled to fly over and take photo images of the MRG on a prescribed day. If weather conditions are not reasonable, it would be another two or three days before a second flyover could take place.

The photography should be taken near the end of the high flow release. This will allow for maximum capture of floodplain inundation. The timing of the aerial photography should leave sufficient time to consider a second photographic set or backup flight if there are weather or mechanical problems. Weather forecasts should be monitored to determine flight schedules. In a short duration event it is imperative that early and thorough coordination take place with a perspective data collection contractor.

A digital aerial video of the reach should be taken for the purpose of analyzing flooding in specific reaches. Specific sites of interest can be highlighted with views from multiple angles and zoomed images. If budget is not available for a complete, controlled aerial photographic mission, a digital video should still be obtained to document the area of inundation. A clear, comprehensive video of the study reach would improve the calibration of the MRG FLO-2D model and its ability to predict floodplain areas of inundation. The digital video can be taken from a plane with a door removed or with the camera mounted to the plane. The video should include the river channel; all aerial extents of overbank flooding and zoomed (slowly) images of flooded areas of interest. The flight should be made at an elevation of approximately 1,500 ft above the river in the early morning hours ~ 6 a.m. Caution should be taken to avoid the sun reflection on the camera.

Pertaining to this study, the primary purpose of any aerial photographic mission during high flow is to record or estimate the width of the wetted area as the event/release moves downstream. Since there are existing digital elevation sets of flood plain areas that are fairly current, this type of aerial data acquisition (ex. LIDAR) is not necessary.

3.4.2 High Flow Cross Section Surveys

Cross section surveys will assess changes in channel geometry during high flows. Water surface elevation and bed forms will be recorded. Scour or deposition during high flows can be estimated by comparing the high and low flow cross section surveys. Channel cross section surveys are performed between monumented endpoints on each bank. For existing cross sections, a survey level and rod are used to determine vertical elevation. A tagline is used to locate horizontal position in the cross section. Ground and water surface elevations are surveyed to the nearest 0.01 ft and channel bed elevations below the water surface are surveyed to the nearest 0.1 ft. Horizontal positions are estimated to the nearest foot from the tagline stretched between the endpoints.

Stationing typically starts at the left end point (LEP) at station 0+00, and ends at the right end point (REP). Surveying from the LEP to the REP, ground survey shots are taken when there is an elevation change of greater than 0.5 feet, or at grade breaks on a slope with an elevation change greater than 0.5 feet. For reaches with an elevation change less than 0.5 feet survey ground shots are taken at a maximum spacing of 50 feet. Water depths are measured across the channel at 10-foot intervals. Cross section surveys must close within 0.05 feet based on the known endpoint elevations. If the closure error is greater than 0.05 feet, a level loop is performed which must close within 0.02 feet. If the loop does not meet closure criteria, the cross section is resurveyed until acceptable closure is achieved.

Alternatively, a total station with data collector or GPS can be used to collect coordinates along established cross sections. A clear advantage of using this equipment is the reduced time required for post processing the data collected. A draw back is that elevation data is not as accurate as what can be collected using a survey grade level. Given the availability of end point xyz coordinates (from Reclamation), coupled with an accurate, reliable system or instrument, this method is a viable alternative in a short time frame data collection effort.

The cross section survey and local overbank flooding will be documented with ground photography. Typically a set of photos includes one photo looking upstream and downstream from mid-channel and one photo from each bank looking across the channel resulting in a total of four photos per cross section. The cross section set of photos can be supplemented with photos looking away from the channel to the floodplain to record overbank areas of inundation.

To optimize hydrographic data collection all cross sections will be brushed and flagged prior to the high flow release. Brushing the cross section entails clearing a line of site between the endpoints large enough for effective use of a surveying instrument. Southwestern Willow Flycatcher habitat in the cross section line must be considered before brushing. The cross sections will be flagged so they can be located quickly. Flagging should be visible from the river channel, as the surveys will be conducted from a boat from upstream to downstream.

3.4.3 River Channel Water Surface Elevation Surveys

River channel water surface elevation surveys will be used for calibrating the FLO-2D model n-values. Due to release time limitations, not every cross section can be surveyed. For those cross sections where channel geometry is not surveyed, only the water surface elevation will be surveyed. Survey shots will be taken on one of the cross section endpoints and an adjacent water surface from which the water surface elevation will be calculated from the known endpoint elevation. Once again it is necessary to brush and flag the cross section (with a different color flagging) prior to the high flow release.

3.4.4 Overbank Flooded Areas

In floodplain locations where there are no cross sections, water surface elevations can be estimated with a GPS unit from the levee by vehicle. Floodplain ground elevation data is available from existing DTM mapping or if necessary, it can be surveyed at a later time. The extent of the area of inundation will be estimated from the aerial photos or video. Levee bar and cap elevations can be used to calibrate the GPS unit in a floodplain reach. Ground photos of the area of inundation will complement the aerial photography.

3.4.5 Discharge Measurements

Discharge measurements during the high flow at all the stream gages along the study reach are important. However, measurements at the San Marcial gage are the most important because of the substantial overbank flooding in the San Acacia to San Marcial reach and because of concerns related to the San Marcial Railroad Bridge conveyance capacity. The discharge measurements should be taken downstream of the Railroad Bridge or perhaps using the USGS cableway. Accurate discharge data at San Marcial will be important for calibrating floodwave attenuation in the FLO-2D model. The discharge measurements will be checked against the USGS gage data. Standard USGS discharge measurement methods will be followed. For discharge estimates at sites without a USGS gage, a level sensor can be installed in a PVC pipe. The level logger can be calibrated by taking a series of discharge measurements at the site.

Regardless of the magnitude of the flow available, it is recommended that discharge measurements be made at as many of the existing gages as possible. Preferably as the peak is passing the gage.

3.5 Data Collection Sequence

Due to the limited duration of the high flow event it will be important to collect data in an efficient manner. There are 634 established cross sections in the reach and over 400 of these are included in the FLO-2D model. It will not be possible to survey all of the cross sections and a survey priority has been established. The plan includes coordinating the sequence of the surveys.

3.5.1 Data Collection Priorities

Aerial photography should be taken near the end of the flood event to allow for maximum floodplain inundation and system equilibrium. A backup time interval should be considered as a margin of safety in the event the first photo flight is not completed.

The highest priority cross section surveys are in the MRG reaches with no existing cross section survey data. These high priority reaches are from Central Ave in Albuquerque to the Isleta Diversion Dam, from Bernardo Bridge to the Rio Puerco confluence, and from the Belen Bridge to the Abeyta's Heading (AH-lines). New cross sections need to be established in these reaches. The remaining Rio Grande reaches have adequate established cross sections with historical data collected at low or moderate flows. The reaches from Cochiti Dam to Angostura Diversion Dam and from San Acacia Diversion Dam to cross section SO-1298 are low priority due to the entrenched channel and limited overbank flooding.

Table 10 contains all of the cross sections in the plan area categorized by line name. The cross sections recommended for surveys are highlighted. Water surface elevation surveys will be performed at the remaining cross sections. All of the CO-lines are recommended for surveys because they are evenly distributed from Cochiti to San Acacia and have a large database of historical surveys. The CI-lines, SD-lines, SF-lines, and AR-lines will not be surveyed because they are in the reach above Angostura Diversion Dam where there will be very limited overbank flooding under any controlled flow conditions. The CO-lines in this reach will provide a sufficient high flow database. Some TA-lines and BI-lines will be surveyed to supplement the CO-lines in these reaches so that the Santa Ana Restoration Project is adequately monitored. All of the BB-lines and CR-lines are designated for cross section surveys. These are relatively new survey lines (surveyed for the first time in 2001) and are in a reach with limited cross section coverage. Working downstream, only a few selected CA-lines and A-lines will be surveyed because they are located reasonably close together. The A-lines will be used to monitor the Albuquerque Overbank Restoration Project. All of the AQ-lines are designated for survey because they are in a reach from southern Albuquerque to Isleta where there are no other cross sections. These cross sections were to be established in 2002. In addition, all of the IS-lines should be surveyed. They are evenly distributed through a long reach with limited cross sections. All of the LL-lines should be surveyed to monitor the Los Lunas Habitat Restoration Project. Only a few of the CC-lines, AH-lines, and LJ-lines are recommended for high flow survey. They are located close together and each set represents a small reach. All of the RP-lines should be surveyed. These lines are evenly distributed and will monitor the confluence reaches of the Rio Puerco and Rio Salado. Only a few of the SA-lines will be surveyed. They represent the reach below San Acacia Diversion Dam where there will be very limited overbank flooding due to existing channel incision. The majority of the SO-lines will be surveyed because these lines have a large historic database and extensive overbank flooding will occur in this reach. The Bosque del Apache NWR Pilot Channel Project is located in the SO-lines reach.

The FC-lines and EB-lines are downstream of the San Marcial RR Bridge and San Marcial discharge gage. None of these lines are recommended for cross section surveys during the first high flow release for overbank flood monitoring. The EB and FC lines are located in the reach from the San Marcial RR Bridge to Elephant Butte Reservoir. Data collection in this reach has a lower priority at this time due to the importance of flooding in the upstream reaches. Proposed plans of relocating the river channel to the west of levee in the reach may affect a change of priorities in the future.

In addition to the established lines identified in the paragraphs above, we have identified 58 additional lines known as the CEB lines. These lines are shown on the maps in Appendix A and will all be surveyed as part of the data collection effort.

Once again, if flow conditions are limited to a smaller, shorter duration peak release cross section surveys will have to be scaled back. It is recommended that the CO-lines be given top priority followed by the AQ-lines, LL-lines and IS-lines. This prioritization will provide the most overall benefit to the existing FLO-2D model.

Table 10. CROSS SECTIONS BETWEEN COCHITI DAM AND ELEPHANT BUTTE RESERVOIR

Total Number of Lines = 635
Total Number of Cross Section Survey Lines = 334

Cochiti Lines # of lines 62 # of cr-sec surveys 62	Cochiti Pueblo Lines # of lines 38 # of cr-sec surveys 0	Santa Domingo Lines # of lines 65 # of cr-sec surveys 0	San Felipe Lines # of lines 36 # of cr-sec surveys 0	Angostura Lines # of lines 27 # of cr-sec surveys 0	Santa Ana Lines # of lines 52 # of cr-sec surveys 23	Bernalillo Lines # of lines 9 # of cr-sec surveys 5	Below Bernalillo Lines # of lines 7 # of cr-sec surveys 7	Corrales Lines # of lines 14 # of cr-sec surveys 14	Calabacillas Arroyo Lines # of lines 13 # of cr-sec surveys 8	Albuquerque Lines # of lines 9 # of cr-sec surveys 6	Albuquerque Lines # of lines 27 # of cr-sec surveys 27	Isleta Lines # of lines 27 # of cr-sec surveys 24	Los Lunas Lines # of lines 9 # of cr-sec surveys 9	Casa Colorado Lines # of lines 10 # of cr-sec surveys 3	Abeytas Heading Lines # of lines 7 # of cr-sec surveys 4	La Joya Lines # of lines 15 # of cr-sec surveys 4	Rio Puerco Lines # of lines 11 # of cr-sec surveys 11	San Acacia Lines # of lines 32 # of cr-sec surveys 12	Socorro Lines # of lines 77 # of cr-sec surveys 57	Fort Craig Lines # of lines 5 # of cr-sec surveys 0	Elephant Butte # of lines 25 # of cr-sec surveys 0	CEB-LINES (proposed) # of lines 58 # of cr-sec surveys 58
C0 - 2	CI EAST	SD 96.5	SF-170	AR-203	TA-249	BI-284	BB-301	CR-355	CA-1	A-1	AQ-467	IS-658	LL-774	CC-924	AH-1	LJ-4	RP-1100	SA-1206.5	SO-1299	FC-1749	EB-9	CEB-1
C0 - 3	CI WEST	SD 96.9	SF-170.1	AR-204	TA-250	BI-286	BB-307	CR-361	CA-2	A-2	AQ-472	IS-675	LL-775	CC-927	AH-2	LJ-5	RP-1108	SA-1207	SO-1302	FC-1750	EB-9.2	CEB-2
C0 - 4	CI-27	SD 97.2	SF-171	AR-205	TA-251	BI-289	BB-318	CR-367	CA-3	A-3	AQ-476	IS-678	LL-776	CC-930	AH-3	LJ-6	RP-1128	SA-1208	SO-1305	FC-1752	EB-10	CEB-3
C0 - 5	CI-28	SD 97.5	SF-171.1	AR-206	TA-252	BI-291	BB-323	CR-372	CA-4	A-4	AQ-480	IS-684	LL-778	CC-932	AH-4	LJ-7	RP-1144	SA-1209	SO-1306	FC-1753	EB-10.5	CEB-4
C0 - 6	CI-28.1	SD 97.8	SF-171.9	AR-207	TA-252.5	BI-292	BB-327	CR-378	CA-5	A-5	AQ-487	IS-689	LL-779	CC-934	AH-5	LJ-8	RP-1150	SA-1210	SO-1308	FC-1754	EB-11	CEB-5
C0 - 7	CI-29.1	SD 98.2	SF-172	AR-209	TA-253	BI-293	BB-340	CR-382	CA-6	A-6	AQ-492	IS-691	LL-781	CC-936	AH-6	LJ-9	RP-1160	SA-1212	SO-1310		EB-12	CEB-6
C0 - 8	CI-36.1	SD 98.6	SF-172.1	AR-211	TA-253.4	BI-294	BB-345	CR-388	CA-7	A-7	AQ-496	IS-705	LL-783	CC-939	AH-7	LJ-10	RP-1170	SA-1215	SO-1311		EB-12X	CEB-7
CO-9	CI-36.2	SD 98.9	SF-173	AR-214.5	TA-253.6	BI-295		CR-394	CA-8	A-8	AQ-503	IS-741	LL-784	CC-941		LJ-15	RP-1184	SA-1218	SO-1312		EB-13	CEB-8
CO-10	CI-37.1	SD 99.2	SF-175	AR-215	TA-253.8	BI-296		CR-400	CA-9	A-9	AQ-507	IS-748	LL-792	CC-943		LJ-16	RP-1190	SA-1221	SO-1313		EB-14	CEB-9
CO-11	CI-37.13	SD M-1	SF-176	AR-216	TA-253.9			CR-413	CA-10		AQ-520	IS-752		CC-945		LJ-17	RP-1201	SA-1223	SO-1314		EB-15	CEB-10
CO-12	CI-37.16	SD M-2	SF-177	AR-216.5	TA-254.2			CR-443	CA-11		AQ-526	IS-772				LJ-18	RP-1205	SA-1224	SO-1316		EB-15X	CEB-11
CO-13	CI-37.2	SD M-3	SF-178	AR-217.5	TA-254.6			CR-448	CA-12		AQ-531	IS-782				LJ-19		SA-1225	SO-1320		EB-16	CEB-12
CO-14	CI-38.1	SD M-4	SF-178.3	AR-218.5	TA-255			CR-458	CA-13		AQ-535	IS-797				LJ-20		SA-1226	SO-1327		EB-17	CEB-13
CO-15	CI-39	SD M-5	SF-178.5	AR-219.5	TA-255.2			CR-462			AQ-567	IS-801				LJW-7		SA-1227	SO-1339		EB-18	CEB-14
CO-16	CI-40	SD M-6	SF-179	AR-220.5	TA-255.4						AQ-572	IS-815				LJW-9		SA-1228	SO-1346		EB-19	CEB-15
CO-17	CI-41	SD-1	SF-180	AR-222	TA-255.6						AQ-577	IS-841						SA-1229	SO-1360		EB-20	CEB-16
CO-18	CI-51.4	SD-2	SF-181	AR-224	TA-255.8						AQ-582	IS-849						SA-1230	SO-1371		EB-21	CEB-17
CO-19	CI-51.5	SD-3	SF-183	AR-227	TA-256						AQ-589	IS-854						SA-1231	SO-1380		EB-22	CEB-18
CO-20	CI-52	SD-4	SF-193	AR-227.5	TA-256.2						AQ-595	IS-860						SA-1232	SO-1394		EB-23	CEB-19
CO-21	CI-52.2	SD-5	SF-194	AR-228	TA-256.4						AQ-600	IS-864						SA-1236	SO-1401		EB-24	CEB-20
CO-22	CI-52.3	SD-6	SF-195	AR-229	TA-256.6						AQ-606	IS-872						SA-1243	SO-1410		EB-24-A	CEB-21
CO-23	CI-52.5	SD-7	SF-196	AR-230	TA-256.8						AQ-610	IS-880						SA-1246	SO-1414		EB-25	CEB-22
CO-24	CI-52.7	SD-8	SF-197	AR-231	TA-256.9						AQ-621	IS-884						SA-1252	SO-1420		EB-26	CEB-23
CO-25	CI-52.8	SD-8.1	SF-198	AR-232	TA-257						AQ-625	IS-885						SA-1256	SO-1428		EB-27	CEB-24
CO-26	CI-53	SD-9	SF-199	AR-233	TA-257.2						AQ-637	IS-887						SA-1259	SO-1437.9		EB-34	CEB-25
CO-27	CI-53.3	SD-10	SF-200	AR-234	TA-257.4						AQ-643	IS-899						SA-1262	SO-1443			CEB-26
CO-28	CI-60.9	SD-11	SF-M1	AR-235	TA-257.6						AQ-648	IS-908						SA-1268	SO-1450			CEB-27
CO-29	CI-61.1	SD-12	SF-M2		TA-257.8													SA-1268.8	SO-1456			CEB-28

Shaded areas represent cross section surveys
Non-shaded areas represent water surface elevation surveys

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CO-30	CI-61.4	SD-13	SF-M3		TA-258													SA-1274	SO-1462			CEB-29
CO-31	CI-61.7	SD-14	SF-M4		TA-258.2													SA-1280	SO-1470.5			CEB-30
CO-32	CI-61.9	SD-15	SF-M5		TA-258.5													SA-1292	SO-1482.6			CEB-31
CO-33	CI-62	SD-16	SF-M6		TA-258.75													SA-1298	SO-1491			CEB-32
CO-34	CI-62.4	SD-17	SF-M7		TA-259														SO-1496			CEB-33
CO-35	CI-62.9	SD-18	SF-M8		TA-259.4														SO-1499			CEB-34
CO-36	CI-62.95	SD-18.1	SF-M9		TA-261														SO-1502			CEB-35
CO-37	CI-63	SD-19	SF-M10		TA-262														SO-1508.9			CEB-36
CO-38	CI-63.2	SD-20			TA-263														SO-1517.2			CEB-37
CO-668	CI-63.5	SD-21			TA-264														SO-1524			CEB-38
CO-713		SD-22			TA-265														SO-1531			CEB-39
CO-724		SD-23			TA-267														SO-1536			CEB-40
CO-738.1		SD-24			TA-269														SO-1539			CEB-41
CO-765		SD-24.1			TA-270														SO-1550			CEB-42
CO-787		SD-25			TA-273														SO-1554			CEB-43
CO-806		SD-26			TA-274														SO-1557			CEB-44
CO-833		SD-27			TA-275														SO-1560.5			CEB-45
CO-858.1		SD-28			TA-276														SO-1566			CEB-46
CO-877		SD-29			TA-277														SO -1572.5			CEB-47
CO-895		SD-30			TA-278														SO-1576			CEB-48
CO-926		SD-31			TA-279														SO-1581			CEB-49
CO-945		SD-32			TA-280														SO-1583			CEB-50
CO-966		SD-33			TA-281														SO-1584			CEB-51
CO-986		SD-34			TA-282														SO-1585			CEB-52
CO-1006		SD-35																	SO-1588			CEB-53
CO-1026		SD-36																	SO-1591			CEB-54
CO-1044		SD-37																	SO-1594			CEB-55
CO-1064		SD-38																	SO-1596.6			CEB-56
CO-1091		SD-39																	SO-1600			CEB-57
CO-1104		SD-40																	SO-1603.7			CEB-58
CO-1164		SD-41																	SO-1613			

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CO-1179		SD-42																	SO-1626			
CO-1194		SD-43																	SO-1641			
		SD-44																	SO-1645			
		SD-45																	SO-1650			
		SD-46																	SO-1652.7			
		SD-47																	SO-1660			
																			SO-1662			
																			SO-1663			
																			SO-1664			
																			SO-1665			
																			SO-1666			
																			SO-1667			
																			SO-1668			
																			SO-1670			
																			SO-1673			
																			SO -1683			
																			SO-1692			
																			SO-1701.3			

Shaded areas represent cross section surveys
Non-shaded areas represent water surface elevation surveys

Surveys of water surface elevations in overbank flooded areas, monitoring of restoration area cross sections, and levee flood monitoring should begin at Cochiti Dam and move downstream as the area of overbank flood inundation is maximized. Tables 11 and 12 present descriptions of the areas where overbank flooding is predicted by the FLO-2D model for 5,000 cfs and 7,000 cfs releases from Cochiti. Only a limited amount of overbank flooding is predicted for the 5,000 cfs flow. Areas of substantial overbank flooding are predicted upstream of the San Acacia Diversion Dam, in the Bosque del Apache NWR and upstream of the San Marcial RR Bridge. For the 7,000 cfs release, there are numerous small areas of predicted overbank flooding. Significant flooding is predicted from the South Diversion Channel in Albuquerque to Isleta Diversion Dam, upstream of the San Acacia Diversion Dam, in the Bosque del Apache NWR, and upstream of the San Marcial RR Bridge. The priorities for restoration project monitoring and levee flood monitoring will be based on funding and the participation of interested agencies.

Table 11. OVERBANK FLOODED AREAS FOR 5,000 CFS DISCHARGE AT COCHITI

Area	FLO2D Grid	Description	~ Max Depth (ft)	Comments
1	8367 8459	Upstream of I-25 Br.	1.0	Small Area
2	16839 17141	Belen RR Br.	1.5	Scattered Flooding
3	18266 18435	CC-943 West Bank	2.0	Small Area
4	23651 23838	RP-1190 to RP-1201 Upstream of San Acacia	3.0	Majority Flooded
5	25191 25229	SO-1360 West Bank	1.5	Small Area
6	25418 25614	SO-1401 to SO-1428	2.5	Scattered Flooding
7	25965 27291	SO-1470.5 to SO-1626	5.0	Scattered with Large Flooded Areas
8	28217 28518	SO-1673 to SO-1692	4.5	Scattered Flooding

Table 12. OVERBANK FLOODED AREAS FOR 7,000 CFS RELEASE AT COCHITI

Area	FLO-2D Grid	Description	~ Max Depth (ft)	Comments
1	2665 3573	Paseo del Norte to Montaño	2.5	Scattered Flooding
2	4812 7198	Btw I-40 and Central to South Div Chan	1.5	Scattered Flooding
3	7300 9318	South Div Chan to Isleta Div Dam	2.5	Majority Flooded
4	9598 10219	CO-668 to IS-691	2.5	Scattered Flooding
5	10531 15786	IS-705 to CO-833	2.5	Scattered Flooding
6	16592 18639	IS-864 to CEB-33	2.5	Scattered Flooding
7	22516 23110	CEB-49 to RP-1144	1.5	Scattered Flooding
8	23663 23801	RP-1190 to RP-1201	2.5	Completely Flooded
9	25197 25235	Around SO-1360	2.0	Small Area Completely Flooded
10	25405 25742	SO-1398 to SO-1450	2.5	Scattered with Large Flooded Areas
11	25956 27591	SO-1470.5 to SO-1645	6.5	Majority Flooded
12	28275 28368	SO-1673 to SO-1701.3	5.0	Completely Flooded

3.5.2 Efficient Data Collection

All cross section surveys will be conducted using boats. Three person survey crews will work in a downstream direction, surveying cross sections when the release hydrograph has peaked and stabilized. This will correlate to maximizing the area of inundation. Table 13 shows the time required to reach equilibrium at various locations for 5,000 cfs and 7,000 cfs releases from Cochiti Dam. The peak discharge decreases as the flood event moves downstream due to floodwave attenuation associated with overbank storage. For the 5,000 cfs release, equilibrium is reached at San Acacia in just over 2 days after the peak discharge is released. There is little overbank flooding upstream of San Acacia, so equilibrium is quickly achieved. The peak discharge is not stabilized at San Marcial for 172 hours (7 days) due to the extensive overbank flooding in this reach. For the 7,000 cfs flood, the peak discharge equalizes at the Isleta Diversion Dam at approximately the same time duration as the 5,000 cfs flood, but it takes substantially longer for equilibrium at Bernardo. For both high flow releases the peak discharge should be sustained at San Marcial for at least 5 days after ramp-down begins at Cochiti. The incremental rate of the ramp-down will depend on the total volume of water available for the flood event.

Data collection for the reach will begin at Cochiti one day after peak discharge is reached and will be completed within twelve days. This allows for eleven days of data collection and assumes the ramp-down is slow enough to maintain the maximum discharge at San Marcial for four days after ramp-down begins. Using four survey crews for eleven days to survey approximately 330 high flow cross sections and 300 water surface elevation cross sections results in an average of approximately 8 cross sections and 7 water surfaces per crew per day.

Table 13. TIME REQUIRED TO REACH PEAK DISCHARGE

Reach	Location	FLO2D Grid #	*5,000 cfs Time (hrs)	**7,000 cfs Time (hrs)
1	Cochiti Dam	60	0	0
1	Central Br	5032	23	14
2	Isleta Div Dam	9350	28	29
3	Sec IS-688	9953	28	54
3	Bernardo	21037	48	104
4	San Acacia	23762	53	104
5	San Marcial	28402	178	164

* FLO-2D Model used 72 hour ramp-up for 5,000 cfs
* *FLO-2D Model used 96 hour ramp-up for 7,000 cfs

3.5.3 Data Analysis

Data reduction and report preparation will be initiated after completion of the data collection to disseminate the data to the Corps and other agencies. The cross section surveys will be entered into Excel spreadsheets and saved as ASCII files showing the station and elevation of each point. Water surface elevations at each cross section will be calculated and a water surface profile created. The GPS data showing inundated areas of the floodplain will be reduced, and the discharge measurements will be recorded. All applicable data will be prepared in geo-referenced coordinates. GIS files (ArcView shapefiles), and databases will be produced. The data will be used to calibrate the FLO-2D model, assess high flow responses to restoration activities and to support ESA Collaborative Program research and/or restoration projects.

3.6 Coordination with Agencies and Research Entities

High flow releases from Cochiti Dam will play an increasingly important role in the hydrology of the Middle Rio Grande. For that reason, it will be necessary to coordinate data collection with the various federal, state, and local agencies that are involved with water management in the Middle Rio Grande. Some of the agencies that should be involved in data collection coordination include:

- US Army Corps of Engineers
- Bureau of Reclamation
- Fish and Wildlife Agency
- USGS
- NM Interstate Stream Commission
- Middle Rio Grande Conservancy District
- University of New Mexico
- New Mexico State University
- Albuquerque Open Space Division

3.6.1 Discharge Measurements

The USGS should be informed of the high flow release schedule and encouraged to calibrate gages in the reach during the high flows.

3.6.2 Channel and Floodplain Restoration Reaches

Cross section surveys and water surface elevation surveys in restored areas will be part of the overbank monitoring plan. Agencies and organizations that have implemented the restoration projects should be informed of the high flow release well in advance so that a detailed monitoring plan for each site can be formulated and coordinated with the agencies. Monitoring might include floodplain inundation, bank erosion and removal of spoil piles, sand bar vegetation removal, flow into overbank channels and native vegetation germination.

3.6.3 Levees

The integrity of the levee should be monitored in areas where the river will reach the levee during the high flow event. Close coordination between Reclamation and the Corps should help insure no adverse impacts occur.

3.7 Cost Estimates

Table 14 provides *preliminary* cost estimates for the overbank monitoring data collection program. Options are shown for the different aerial photography methods and for overbank flood surveys as a function of discharge. The costs reflect the implementation of a complete overbank monitoring program. It will be necessary to adjust the tasks to fit the available budget. These cost estimates should be considered as preliminary and should be refined once a budget estimate is proposed. The unit costs presented in the Table 14 will not vary substantially if the effort is scaled back due to funding constraints or lack of sustained flow.

Table 15 provides *preliminary* cost estimates for a data collection program that could be implemented given a peak release of 4,000 cfs from Cochiti sustained for 3 days. While all data collected has value regardless of river conditions, it is not recommended that a plan of the nature presented in this document be executed for a duration shorter than 3 days.

3.8 Conclusions and Recommendations

The goal of this overbank monitoring plan is to develop and coordinate hydrographic data collection activities in the Middle Rio Grande during a high flow release from Cochiti Dam. An overbank monitoring plan has been formulated that is designed to maximize the data collection opportunities. The plan is all inclusive (i.e. all the potential data collection tasks have been outlined in the plan) and should be refined based on agency review of this report and specific hydrologic conditions which are anticipated for a spring run off. One of the crucial aspects of the monitoring plan is agency coordination. Data needs to support the ESA Collaborative Program should be considered.

The most important data collection tasks of the overbank monitoring are the aerial photography (or video) and the high water surface elevation surveys. Surveying at least some cross sections at high flow is also a high priority. High flow cross sections can be compared with low flow cross sections to determine the channel geometry adjustments at high flow. A statistical analysis of the change in the cross sections in a given reach could then be applied to the other cross sections that were surveyed only at low or moderate flows. The list of proposed cross sections is extensive, roughly 300 out of 600 available cross sections. A priority list of proposed cross section surveys has been presented. If available budget for overbank study is limited, further prioritization may be necessary.

The pragmatic, logistical planning for the on ground data collection effort will involve getting the boats running, organizing and purchasing additional equipment, and preparing crews and planning data collection assignments. The lead time required for this detailed planning effort will require at least one month, but two months or more are recommended. The boats and motors require the most attention.

All the agencies should be contacted regarding the high flow release and feedback on the overbank monitoring plan should be requested. The following recommendations are suggested to effectively conduct the overbank monitoring project:

- Notify agencies of potential high flow release at least 2 months in advance.
- Identify the level of available funding and tailor the monitoring program to the budget.
- Coordinate with agency personnel to reduce costs.
- Ask agencies to provide crew personnel.
- Establish protocol for making day to day fieldwork decisions on data collection and crew assignments. If equipment break downs occur, resources and crews will have to be reallocated.
- Have a back-up plan in case the high flow release is longer or shorter than expected.
- Schedule refinement in the overbank monitoring plan once a potential high flow release is announced.

Table 14. PRELIMINARY DATA COLLECTION COST ESTIMATE				
Project	Description	Unit Cost Estimate	Cost	Total Costs
Images				
Aerial Photos	color digital, 2' pixel	$225/mile for 170 mi	38,250.00	38,250.00
Satellite Image (IKONOS)	color, 4 meter pixel	$19.80/sq km for 435 sq km	8,600.00	11,600.00
		$3000 fee for scheduling satellite	3,000.00	
Video	plane rental, 4 hours	$100/hr	400.00	1,160.00
	1 senior crew chief, 8 hrs	$95/hr	760.00	
Data Collection				
Brushing and Flagging	330 x-sec (2 endpoints)	$80 per endpoint	52,800.00	76,800.00
	300 water surf (1 endpoint)	$80 per endpoint	24,000.00	
Surveys	prep work, 1 per, 2 weeks	$2800/wk	5,600.00	148,930.00
	crew travel, 11 crew, 2 day	$560/day	12,320.00	
	4 crews, 11 days*	$2400/crew/day	105,600.00	
	1 project leader, 11 days	$950/day	10,450.00	
	4 boats	$250/boat/day	11,000.00	
	8 veh, 11 days, 100mi/day	$0.45/mi	3,960.00	
OB Flooding				
5,000 cfs	1 crew, 5 days,	$1800/crew/day	9,000.00	13,250.00
	RTK GPS	$200/day	1,000.00	
	Prep work, 5 days	$650/day	3,250.00	
7,000 cfs	1 crew, 11 days,	$1800/crew/day	19,800.00	29,150.00
	RTK GPS	$200/day	2,200.00	
	Prep work, 11 days	$650/day	7,150.00	
Discharge Measurements	1 crew, 8 days	$1800/crew/day	14,400.00	16,400.00
	250 per boat per day	$250/boat/day	2,000.00	
	3 data loggers	$1000 each	3,000.00	
Data Reduction				
Cross section notes	4 weeks	$40/hr	6,400.00	16,480.00
Water surface profile	3 days	$40/hr	960.00	
**GPS 5,000 cfs	1 week	$68/hr	2,720.00	
**GPS 7,000 cfs	2 weeks	$68/hr	5,440.00	
Discharge Measurements	3 days	$40/hr	960.00	

* Field Survey days consist of 12 hours
** Post-processing (differential correction)

Table 15. PRELIMINARY DATA COLLECTION COST ESTIMATE 3 DAY PLAN				
Project	Description	Unit Cost Estimate	Cost	Total Costs
Images				
Satellite Image (IKONOS)	color, 4 meter pixel	$19.80/sq km for 435 sq km	8,600.00	11,600.00
		$3000 fee for scheduling satellite	3,000.00	
Video	plane rental, 4 hours	$100/hr	400.00	1,160.00
	1 senior crew chief, 8 hrs	$95/hr	760.00	
Data Collection				
Brushing and Flagging	62 x-sec (2 endpoints)	$80 per endpoint	9,920.00	11,520.00
	20 water surf (1 endpoint)	$80 per endpoint	1,600.00	
Surveys	prep work, 1 per, 1.5weeks	$2800/wk	4,200.00	47,190.00
	crew travel, 6 crew, 2 day	$560/day	6,720.00	
	3 crews, 4 days*	$2400/crew/day	28,800.00	
	1 project leader, 5 days	$950/day	4,750.00	
	2 boats	$250/boat/day	2,000.00	
	4 veh, 4 days, 100mi/day	$0.45/mi	720.00	
OB Flooding				
4,000 cfs	1 crew, 2 days,	$1800/crew/day	3,600.00	5,300.00
	RTK GPS	$200/day	400.00	
	Prep work, 2 days	$650/day	1,300.00	
Discharge Measurements	1 crew, 4 days	$1800/crew/day	7,200.00	9,200.00
	250 per boat per day	$250/boat/day	2,000.00	
Data Reduction				
Cross section notes	2 weeks	$40/hr	3,200.00	7,520.00
Water surface profile	3 days	$40/hr	960.00	
GPS 4,000 cfs	1 week	$68/hr	2,720.00	
Discharge Measurements	2 days	$40/hr	640.00	

APPENDIX A

MIDDLE RIO GRANDE FLO-2D MODEL
GRID & CROSS SECTION LOCATIONS